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Plutonium HTR Cell Burnup Benchmark

Several Calculation Methods and Their Results

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Plutonium HTR
Cell Burnup Benchmark

Several Calculation Methods and Their Results

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SUMMARY

Results have been presented from NRG's calculations of the HTR-N1 Pu cell burnup benchmark. Calculations were performed for 4 benchmark cases, by means of the code systems WIMS (version 8a with JEF-2.2 based library), OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT (JEF-2.2 based libraries). Generally a good correspondence is observed between the results obtained by different code systems. Some differences arising in the densities of ^{244}Cm and ^{245}Cm, as calculated by WIMS8a on one hand and OCTOPUS-MCNP-ORIGEN on the other, can be explained by the differences in the implementation of the ^{243}Am reaction pathways between WIMS8a and ORIGEN. Further investigation of the OCTOPUS-MCNP-FISPACT route is required, as well as intercomparison with the results from other benchmark participants.

Keywords

HTR fuel element, pebble, WIMS, OCTOPUS

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1. Introduction

In order to validate different code systems for their use in the analysis of Pu-burning HTR systems a plutonium cell burnup benchmark has been defined [2] to assess the behaviour at high burnup (typically 800 GWd/t) of these code systems. This simple benchmark concerns the modeling of a single, 6 cm diameter, spherical HTR fuel element (”pebble”) at a constant power of 1.0 kW. In this benchmark’s neutronics model a white boundary condition at the pebble surface is assumed. Although this configuration is not entirely representative for a full scale pebble bed HTR, it can be used as a basis for intercomparison of codes and data libraries.

Within the project ”HTR-N1” of the European Fifth Framework Program [1] several partners (IRI, CEA, UNIPI and NRG) have agreed to carry out the calculations of this benchmark for intercomparison.

This report presents three different NRG calculation methods (different codes and data libraries) and their intercomparison for each of the four cases of this benchmark. The three calculation methods (one with WIMS, one with OCTOPUS-MCNP-ORIGEN and one with OCTOPUS-MCNP-FISPACT) are described in chapters 2, 3 and 4 respectively. The four cases of this benchmark represent different isotopic compositions: 1st generation plutonium (original and alternative) and 2nd generation plutonium (for two different amounts of plutonium). Each of these cases has one chapter to describe its results from the different calculation methods that were applied. The benchmark specification items to be calculated (flux, k_∞, fission rate, nuclide densities and cross sections for a burnup of 0, 100, 400, 600 and 800 MWd/kgHM) plus an extra item (fuel temparature coefficient) are given for each benchmark case in tables per chapter. Each of these tables is accompanied by a figure that shows the results for each burnup for which the calculations were done. All these tables and figures concerning the same benchmark case are located at the end of the chapter for that case, preceded by the complete text in that chapter.

Chapter 5 handles benchmark case **A1**. This is the original 1st generation plutonium with 1.0 g per fuel element. It has isotopic composition ”case **A**” from [2].

Chapter 6 handles benchmark case **B1**. This is the alternative 1st generation plutonium with 1.0 g per fuel element. It has isotopic composition ”case **B**” from [2].

Chapter 7 handles benchmark case **C1**. This is the 2nd generation plutonium with 1.5 g per fuel element. It has isotopic composition ”case **C**” from [2].

Chapter 8 handles benchmark case **C2**. This is the 2nd generation plutonium with 3.0 g per fuel element. It also has isotopic composition ”case **C**” from [2].

2. The WIMS calculation method

The WIMS calculations were done with version 8A [3] on a UNIX DEC ALPHA platform. The data library was a 172-group JEF2.2 based WIMS8A DATAGRAM LIBRARY with extensions (among other things concerning temperature dependency) that were made by NRG [4].

The modeling in WIMS8A of a spherical HTR fuel element containing coated particles requires some special provisions. The WPROC module is used to calculate collision probabilities, both for subgroup resonance treatment, and 172-group flux/spectrum calculations. As WPROC was designed to model an infinite cylindrical structure containing spherical coated particles, a geometry transformation was applied: the 5 cm diameter inner fuel zone of the spherical fuel element was modeled as an infinite cylinder with the same mean chord length [11]. The outer 0.5 cm graphite shell is also transformed into a cylindrical shell, hereby preserving volume ratios. This method has been applied succesfully in earlier HTR analyses [12].

The following sequence of calculations was repeated many times to calculate the neutron multiplication factor, microscopic cross sections and nuclide concentrations as a function of burnup:

- The module **WHEAD** does temperature interpolation with microscopic cross sections from the multigroup data library. Also corrections for resonances in the energy group are done (resonance self shielding and nuclide overlap resonances).
- The modules **WPRES**, **WPROC** and **WRES** do a subgroup treatment for the nuclides ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu. This leads to an appropriately weighted set of resonance cross sections in 172 groups.
- The module **WPROC** calculates the 172 group collision probabilities (with the XMAS group structure).
- The module **WPIP** calculates fluxes and k_∞ with a 10^{-6} convergence tolerance on changes in eigenvalue (1/k).
- The module **WCON** makes a condensation of cross section data and flux distributions to one energy group.
- The modules **WSMEAR** and **WLED** do a spatial smear of cross section data and flux distributions over the whole fuel element, and write the data to a library that can be used by PANTHER. This side step is only done to be able to show the one-group cross section values. The smeared data are not used for further calculations.
- The module **WBRNUP** uses the one group data to calculate the appropriate number densities after a given time step.

The time step sizes were first chosen according to ”Further Notes” with the module **WBRNUP** in the WIMS User Guide [3]. Then they were slightly adapted after some ”case A” calculations with smaller time steps. Once chosen, the time steps were taken the same for all calculation cases. The time steps are listed in Appendix A.

The average temperatures for this benchmark [2] are 1073 K for the central fuel zone (i.e. kernel, coating and matrix) and 1023 K for the graphite outer zone (0.5 cm shell). All these temperatures were taken 50 K higher for extra k_∞ calculations at the start of some time steps. That was used to calculate the fuel temperature coefficient (FTC) at that particular time.

3. The OCTOPUS calculation method with MCNP and ORIGEN

The OCTOPUS [5] calculations were done on a Linux PC cluster system with the module versions defined by "oct_modules_20030506" [6]. This includes MCNP [7] (version mcnp4C3_20021211) as spectrum code and ORIGEN [8] (version origen_20020222) as inventory code.

The central fuel zone heterogeneity is handled by means of a separate "MCNP universe" that describes a single fuel grain. A cubic ordering of the grains is used as a good approximation to a more realistic stochastic ordering [10].

The following sequence of calculations was repeated many times to calculate the neutron multiplication factor, microscopic cross sections and nuclide concentrations as a function of burnup:

- **MCNP** does the spectrum calculation with temperature interpolated point cross sections. This gives k_∞ and produces flux tallies for the fuel kernels in 18250 energy groups. The stochastic uncertainties in k_∞ and the flux are not handled explicitly in this paper. Their random variation in subsequent cycles (deviation of entirely smooth curves) gives an idea of the magnitude of these uncertainties. Fig. 5.2 shows small deviations in smoothness for k_∞, and in fig. 5.1 the deviations in smoothness for the flux are too small to be seen. The consequences of these uncertainties do show up in cross sections (for example fig. 5.44), number densities (for example fig. 5.39), and very clear in the fuel temperature coefficient (fig. 5.3).
- **MCNP post-processing** produces a 172-group cross section library (including weight flux) from point cross sections and flux tallies.
- **ORIGEN pre-processing** writes the new cross sections to an ORIGEN library (this is a 3 group library).
- **ORIGEN** calculates the number densities after a time step. This is done with constant power.

The time step sizes were taken the same as for the WIMS calculations.

The average temperatures for this benchmark [2] are 1073 K for the central fuel zone (i.e. kernel, coating and matrix) and 1023 K for the graphite outer zone (0.5 cm shell). All these temperatures were taken 50 K higher for extra k_∞ calculations at the start of some time steps. That was used to calculate the fuel temperature coefficient (FTC) at that particular time.

4. The OCTOPUS calculation method with MCNP and FISPACT

The only difference with chapter 3 is the use of FISPACT [9] (version fispact_easy2001_20020312) as inventory code instead of ORIGEN.

This means that the last two items of the calculation sequence are now:

- **FISPACT pre-processing** writes the new cross sections to the FISPACT library (this is a 172-group library).
- **FISPACT** calculates the number densities after a time step. This is done with a constant flux per time step.

5. Case A1 results and discussion

Case A1 of this HTR Plutonium Cell Burnup Benchmark has 1.0 g plutonium per fuel element with the following 1st generation (original) composition for
^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu
in weight %: 1, 62, 24, 8, 5

5.1 Case A1 results

The figures at the end of this chapter show calculation results from all burnup steps. The corresponding tables give numerical values only for the burnup steps that are required by the benchmark specification [2].

Table 5.1 and fig. 5.1 give the neutron flux collapsed to 1 group.

Table 5.2 and fig. 5.2 give k_∞.

Table 5.3 and fig. 5.3 give the fuel temperature coefficient. In this table the OCTOPUS burnup values for which the FTC values are given differ slightly from those of WIMS.

Table 5.4 and fig. 5.4 give the total fission rate.

Tables 5.5 - 5.39 and figs. 5.5 - 5.39 give the nuclide densities.

Tables 5.40 - 5.64 and figs. 5.40 - 5.64 give the 1-group microscopic absorption cross sections. Because WIMS does not count (n,2n) as absorption the figures show the OCTOPUS absorption cross sections with (n,2n) subtracted. The tables give the true OCTOPUS absorption cross sections. The WIMS absorption cross sections in the tables are also given with the (n,2n) OCTOPUS average (from OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT) added to it.

Tables 5.65 - 5.77 and figs. 5.65 - 5.77 give the 1-group microscopic fission cross sections.

5.2 Case A1 discussion

Most results show a good agreement between the different calculation methods, with the largest differences at the end of the burnup. For example the different fluxes (fig. 5.1) start to diverge slightly only after a burnup of 700 MWd/kgHM. The assumed constant power during the whole burnup causes these fluxes to rise.

For k_∞ the differences hardly show up in fig. 5.2. However they lead to more remarkable differences in the fuel temperature coefficient (FTC, fig. 5.3). To obtain this FTC, extra k_∞ calculations were done for a 50 K higher temperature. The rough shape of the OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT curves can only be made more smooth by decreasing the stochastic uncertainty in the k_∞ calculations that are done by MCNP for the OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT routes. This smaller uncertainty is also needed to see where FTC remains below zero. According to the WIMS calculations the FTC remains largely below zero until a burnup of 700 MWd/kgHM.

Because the total fission rate (fig. 5.4) is only calculated with WIMS here, no comparison can be made with the other calculation methods.

For some nuclides the number densities show remarkable differences. A simple way to check the influence of nuclear data on OCTOPUS-MCNP-ORIGEN results is to do the same calculation with data for a different reactor type (an ACTINIDE library for ORIGEN contains data for different reactor types [8]). In general the ORIGEN calculations described in this report are done with nuclear data for reactor type "HTGR". Only the ORIGEN calculation in this chapter is also done with nuclear data for reactor type "LWR". In most cases (except perhaps after a burnup of 700 MWd/kgHM) the OCTOPUS-MCNP-ORIGEN(LWR) densities are closer to the WIMS densities than are the OCTOPUS-MCNP-ORIGEN(HTGR) densities. Details of the remaining most remarkable differences will be described now.

The relative differences between the "HTGR" and "LWR" ORIGEN results are large for ^{243}Pu and ^{244}Pu but the absolute number densities are rather small. ^{243}Pu is ignored in the WIMS and FISPACT calculations. ^{244}Pu is ignored in the WIMS calculation and has a very small amount in the FISPACT calculation.

The ^{242m}Am difference between the HTGR and LWR ORIGEN results is caused by the ^{241}Am value of the fraction of (n,γ) reactions that produce a product nuclide in a metastable state (FNG1). For HTGR is FNG1=0.162 and for LWR is FNG1=0.0995. This last value lies close to the WIMS capture branching ratio of 0.1 for ^{241}Am. The corresponding data in the FISPACT library have not been checked yet.

The ^{243}Am result is different from most other cases: the OCTOPUS-MCNP-ORIGEN(LWR) density is not closer to the WIMS density than is the OCTOPUS-MCNP-ORIGEN(HTGR) density.

For ^{244}Cm and ^{245}Cm the situation is more complex. In both cases no difference is seen between the OCTOPUS-MCNP-ORIGEN(LWR) and the OCTOPUS-MCNP-ORIGEN(HTGR) density, a small difference is seen between the WIMS density and the OCTOPUS-MCNP-FISPACT density, and a big difference is seen between the OCTOPUS-MCNP-FISPACT density and the OCTOPUS-MCNP-ORIGEN densities. The cause of these differences will be explained now by means of splitting the density difference between WIMS and OCTOPUS-MCNP-ORIGEN(LWR) into contributions per nuclear reaction. Because ^{243}Am and ^{243}Cm have no big difference between the WIMS density and the OCTOPUS-MCNP-ORIGEN(LWR) density only the reactions and decays for nuclides on the pathway from these two nuclides to ^{244}Cm and ^{245}Cm are analysed here. Two pathway differences are known to exist between WIMS and ORIGEN:

- ORIGEN uses the reaction ^{243}Am (n,γ) ^{244}Am and the decay ^{244}Am (β) ^{244}Cm.
  WIMS uses the reaction ^{243}Am (n,γ) ^{244}Cm and skips ^{244}Am.
- ORIGEN uses the decay ^{245}Cm (α) ^{241}Pu.
  WIMS has no α decay for ^{245}Cm.

Ignoring possible cross section differences between WIMS and ORIGEN the ^{244}Cm density difference caused by the different pathways is described by

$$\frac{d}{dt}(N_1(Cm244) - N_2(Cm244)) = \tag{5.1}$$
$$+\ \sigma_{n,\gamma}(Am243)\phi N(Am243) - \lambda_\beta(Am244)N_2(Am244) \tag{5.2}$$
$$+\ \sigma_{n,2n}(Cm245)\phi(N_1(Cm244) - N_2(Cm244)) \tag{5.3}$$
$$-\ \lambda_\alpha(Cm244)(N_1(Cm244) - N_2(Cm244)) \tag{5.4}$$
$$-\ \sigma_{n,\gamma}(Cm244)\phi(N_1(Cm244) - N_2(Cm244)) \tag{5.5}$$
$$-\ \sigma_{n,2n}(Cm244)\phi(N_1(Cm244) - N_2(Cm244)) \tag{5.6}$$

$$- \quad \sigma_{fiss}(Cm244)\phi(N_1(Cm244) - N_2(Cm244)) \tag{5.7}$$

Here N_1 stands for a WIMS density and N_2 for an ORIGEN density. For ^{243}Am no distinction is made between WIMS and ORIGEN density.

Fig. 5.78 shows the items 5.1 to 5.7 (without the preceding minus signs) integrated over time. The integrated item 5.1 is given directly by the difference between the WIMS and ORIGEN density of ^{244}Cm. The integrated items 5.2 to 5.7 were obtained by numerical integration after substituting σ, λ, ϕ and N_2 from the ORIGEN calculations and N_1 from the WIMS calculations. The integration of the complete equation only for the WIMS densities (i.e. let all $N_2 \equiv 0$) gives a difference between the left hand side (item 5.1) and the right hand side (items 5.2 to 5.7). Fig. 5.78 shows this difference as a WIMS correction. This correction represents differences between WIMS and ORIGEN cross sections, and perhaps some missing WIMS interactions not covered by the equations that were used here. The accuracy of the analysis used here is demonstrated by the last curve in the figure that is almost identical to the first curve.

The conclusion here is that the big difference between WIMS and OCTOPUS-MCNP-ORIGEN calculated density of ^{244}Cm is caused by skipping ^{244}Am in the WIMS calculation. The flux is high enough to remove some ^{244}Am by capture and fission before β decay can change it into ^{244}Cm.

The ^{245}Cm density difference between WIMS and ORIGEN is described by

$$\frac{d}{dt}(N_1(Cm245) - N_2(Cm245)) \quad = \tag{5.8}$$
$$+ \quad \sigma_{n,\gamma}(Cm244)\phi(N_1(Cm244) - N_2(Cm244)) \tag{5.9}$$
$$+ \quad \lambda_{\alpha}(Cm245)N_2(Cm245) \tag{5.10}$$
$$- \quad \sigma_{n,\gamma}(Cm245)\phi(N_1(Cm245) - N_2(Cm245)) \tag{5.11}$$
$$- \quad \sigma_{n,2n}(Cm245)\phi(N_1(Cm245) - N_2(Cm245)) \tag{5.12}$$
$$- \quad \sigma_{fiss}(Cm245)\phi(N_1(Cm245) - N_2(Cm245)) \tag{5.13}$$

The integrated terms of this equation are shown in fig. 5.79 The big difference between WIMS and OCTOPUS-MCNP-ORIGEN calculated density of ^{245}Cm is mainly caused by the ^{244}Cm density difference. The WIMS ignorance of α decay for ^{245}Cm (No $N_1(Cm245)$ in item 5.11) adds roughly nothing to the ^{245}Cm density difference between WIMS and ORIGEN. The WIMS correction is quite large here and is almost identical to the (n, γ) difference between WIMS and ORIGEN. This needs further investigation.

Further investigation is also needed for the OCTOPUS-MCNP-FISPACT calculated ^{244}Cm and ^{245}Cm densities. They are close to the corresponding WIMS calculated densities. This may have to do with the fact that, just like in WIMS, ^{244}Am is ignored in the FISPACT calculations.

Table 5.1 one group neutron flux [$s^{-1}cm^{-2}$] for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5864e+14	1.6212e+14	1.6212e+14
100.00	1.6940e+14	1.7132e+14	1.7117e+14
400.00	2.0372e+14	2.0809e+14	2.0752e+14
600.00	2.9191e+14	2.9883e+14	3.0409e+14
800.00	5.9454e+15	3.0879e+15	6.7060e+15

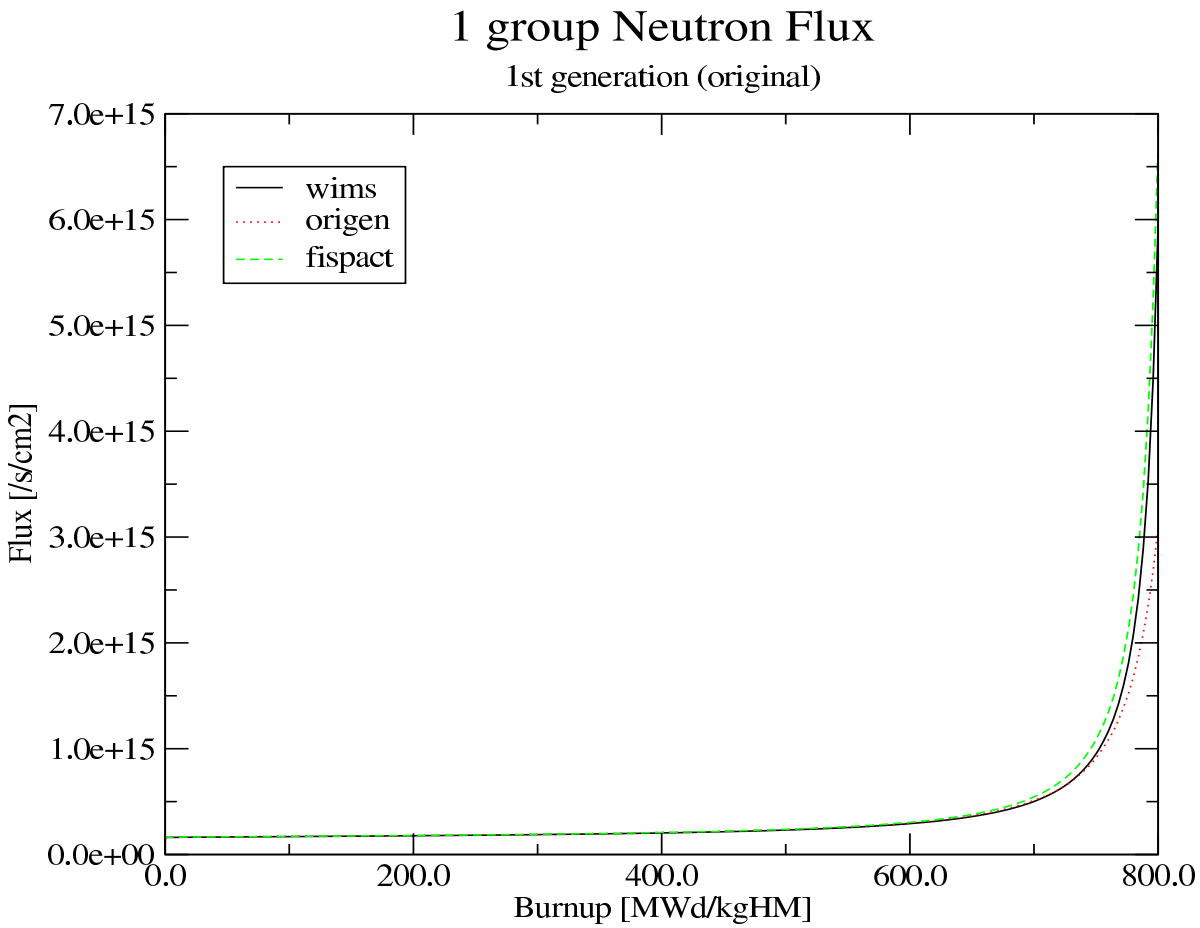


Figure 5.1 one group neutron flux [$s^{-1}cm^{-2}$] for case A1

Table 5.2 k_∞ for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3765	1.3809	1.3809
100.00	1.3071	1.3123	1.3106
400.00	1.2168	1.2119	1.2127
600.00	1.0986	1.1042	1.0899
800.00	0.2245	0.3278	0.1760

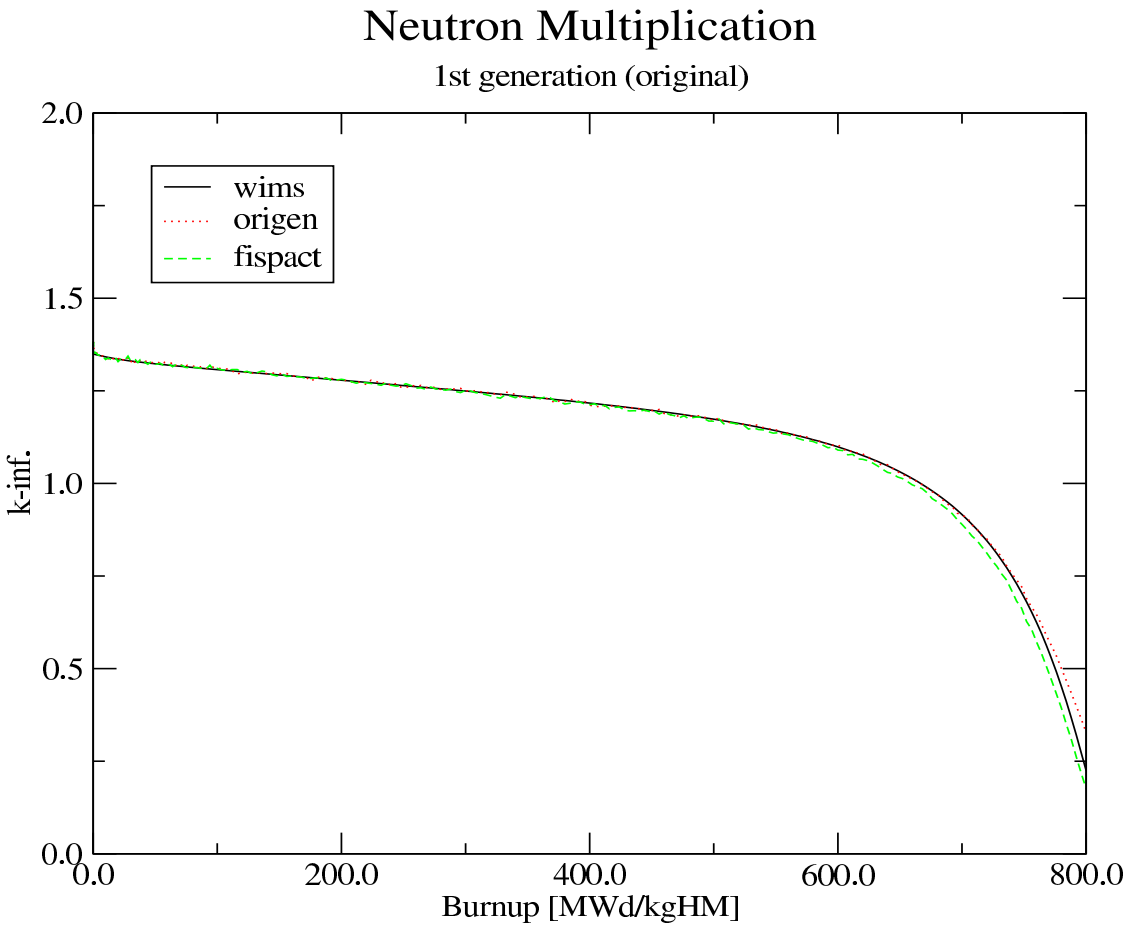


Figure 5.2 k_∞ for case A1

Table 5.3 FTC $[pcm/K]$ for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	-5.46	-10.15	-10.15
98.00		-5.43	1.45
100.00	-4.32		
396.00		-5.89	-0.73
400.00	-5.65		
596.00		-6.48	-17.10
600.00	-6.07		
796.00		13.78	8.81
800.00	53.13		

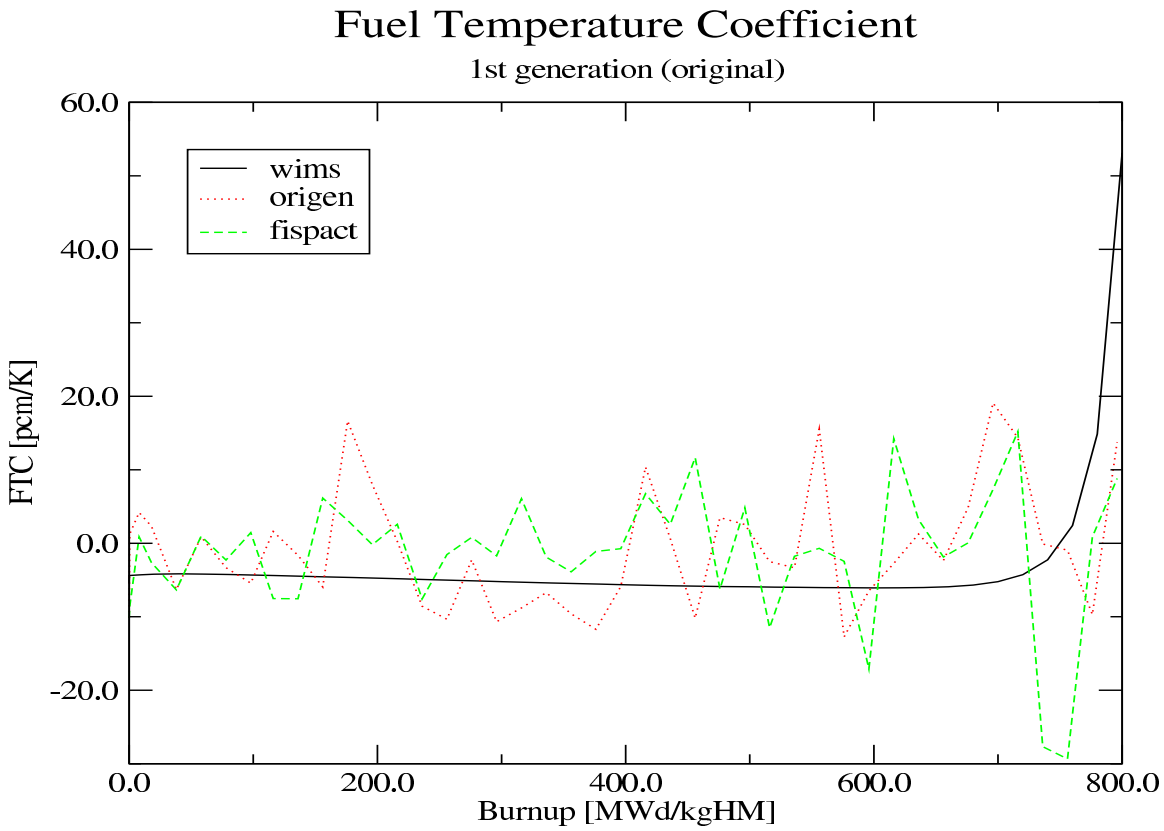


Figure 5.3 FTC $[pcm/K]$ for case A1

Table 5.4 Fission Rate $[s^{-1}]$ for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.9677e+13	–	–
100.00	2.9650e+13	–	–
400.00	2.9535e+13	–	–
600.00	2.9409e+13	–	–
800.00	2.9190e+13	–	–

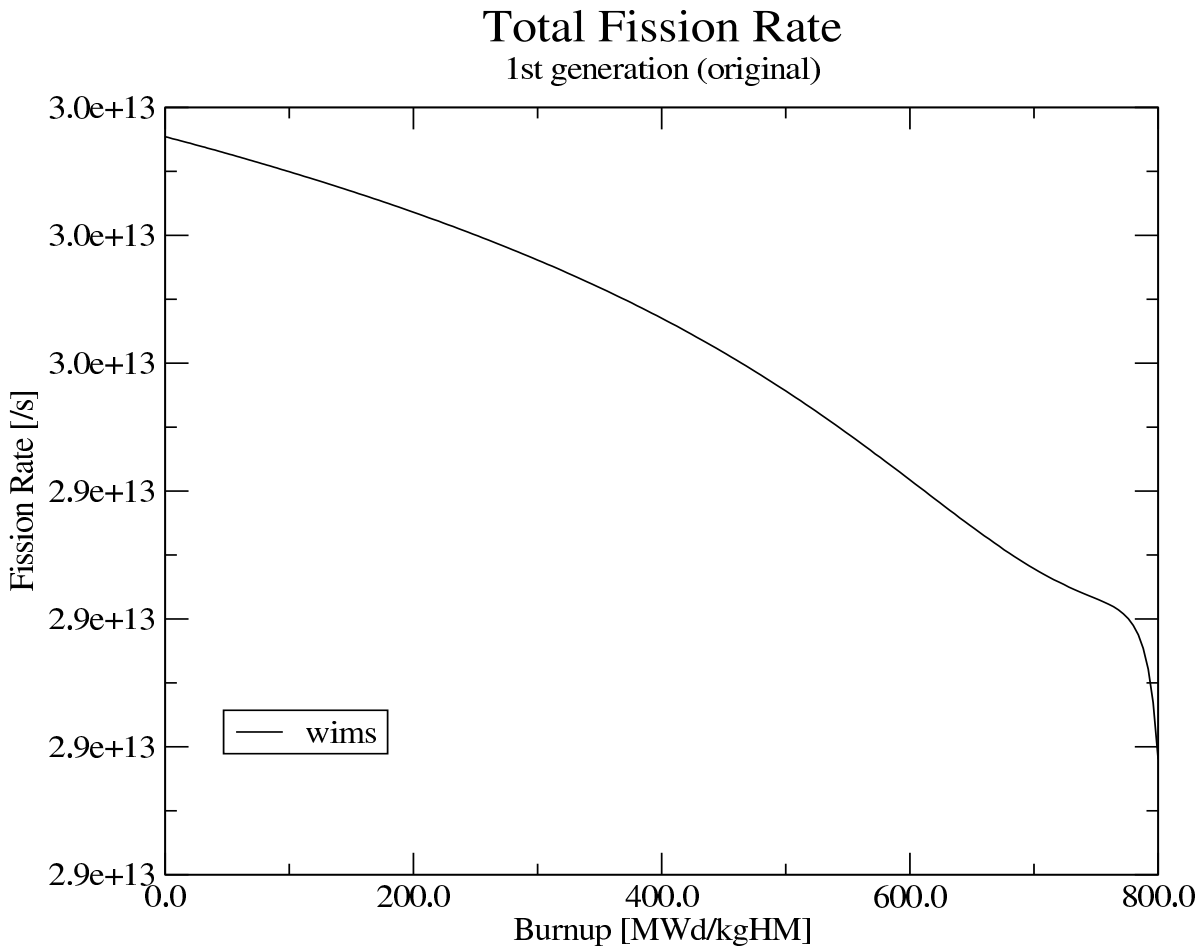


Figure 5.4 Fission Rate $[s^{-1}]$ for case A1

Table 5.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	2.3211e-04	2.3211e-04	2.3211e-04	2.3211e-04
100.00	2.2334e-04	2.2327e-04	2.2332e-04	2.2326e-04
400.00	2.0427e-04	2.0214e-04	2.0338e-04	2.0330e-04
600.00	1.9530e-04	1.8892e-04	1.9287e-04	1.9164e-04
800.00	4.4698e-05	6.3884e-05	8.2656e-05	3.0265e-05

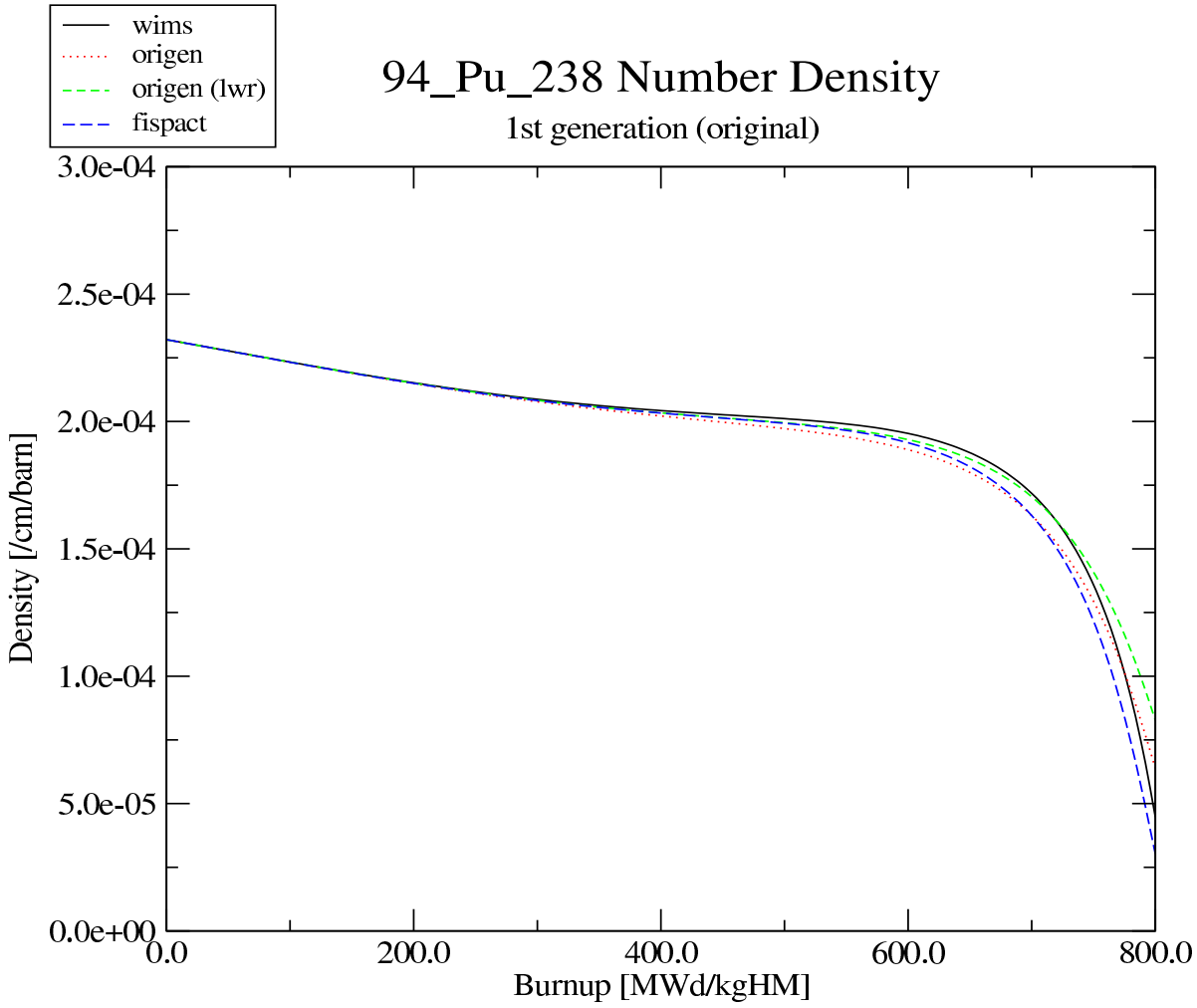


Figure 5.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case A1

Table 5.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.4331e-02	1.4331e-02	1.4331e-02	1.4331e-02
100.00	1.1158e-02	1.1074e-02	1.1083e-02	1.1072e-02
400.00	3.4772e-03	3.2950e-03	3.3252e-03	3.2611e-03
600.00	5.8422e-04	5.2368e-04	5.5083e-04	4.8604e-04
800.00	6.1202e-06	9.0040e-06	1.1609e-05	4.3010e-06

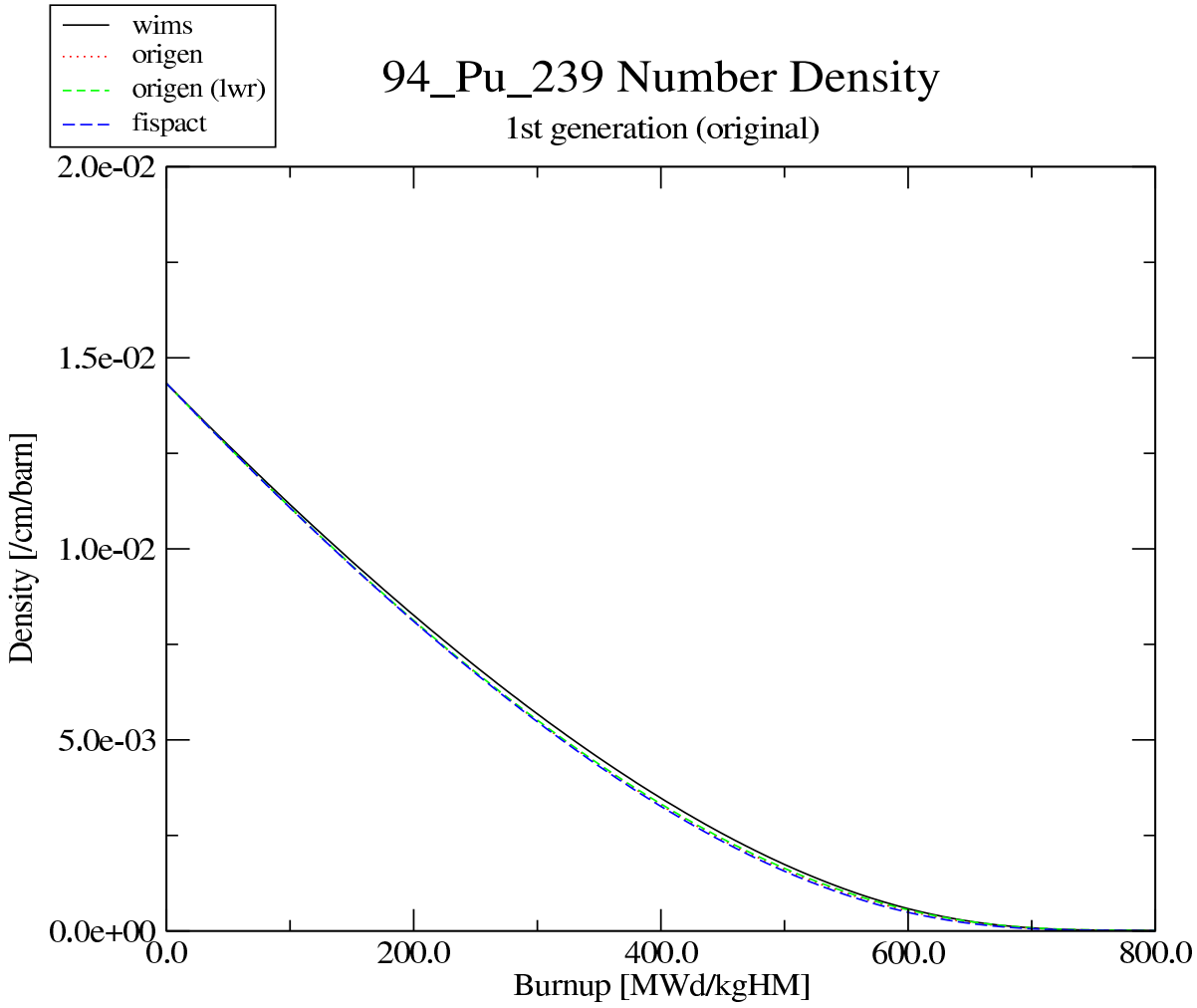


Figure 5.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case A1

Table 5.7 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_240 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	5.5242e-03	5.5242e-03	5.5242e-03	5.5242e-03
100.00	5.5459e-03	5.6077e-03	5.6068e-03	5.6038e-03
400.00	4.6790e-03	4.8001e-03	4.7999e-03	4.7821e-03
600.00	3.0514e-03	3.0970e-03	3.1291e-03	3.0357e-03
800.00	1.3821e-04	2.9268e-04	4.1382e-04	9.4637e-05

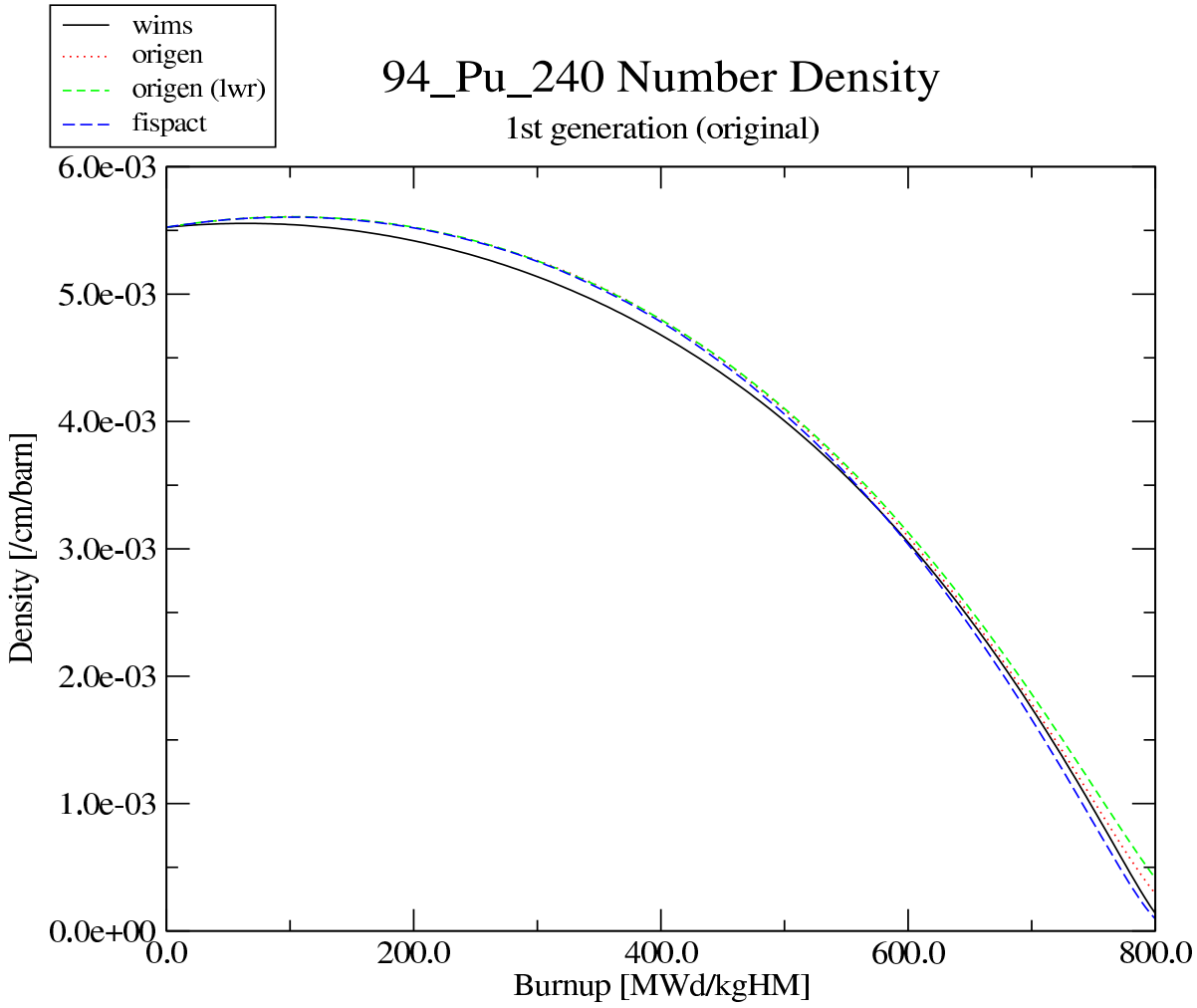


Figure 5.7 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_240 for case A1

Table 5.8 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_241 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.8338e-03	1.8337e-03	1.8337e-03	1.8337e-03
100.00	2.4992e-03	2.4856e-03	2.4847e-03	2.4890e-03
400.00	3.2148e-03	3.1796e-03	3.1884e-03	3.1812e-03
600.00	2.1214e-03	2.0599e-03	2.0941e-03	2.0100e-03
800.00	4.6506e-05	9.8688e-05	1.4658e-04	2.8819e-05

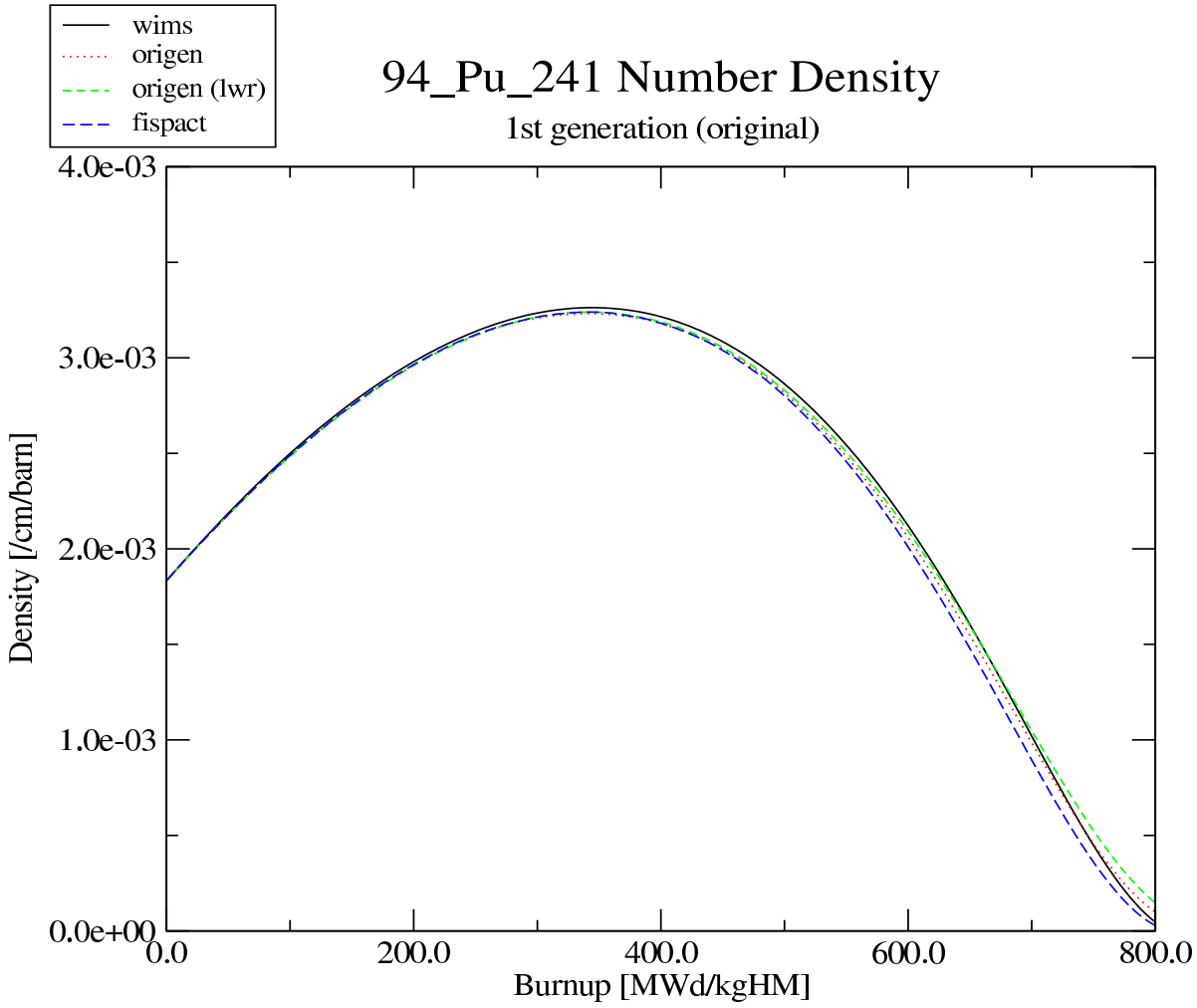


Figure 5.8 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_241 for case A1

Table 5.9 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_242 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.1414e-03	1.1413e-03	1.1413e-03	1.1413e-03
100.00	1.1789e-03	1.1769e-03	1.1764e-03	1.1769e-03
400.00	1.6391e-03	1.6374e-03	1.6339e-03	1.6430e-03
600.00	2.3287e-03	2.3314e-03	2.3183e-03	2.3559e-03
800.00	2.8550e-03	2.9283e-03	2.9642e-03	2.7676e-03

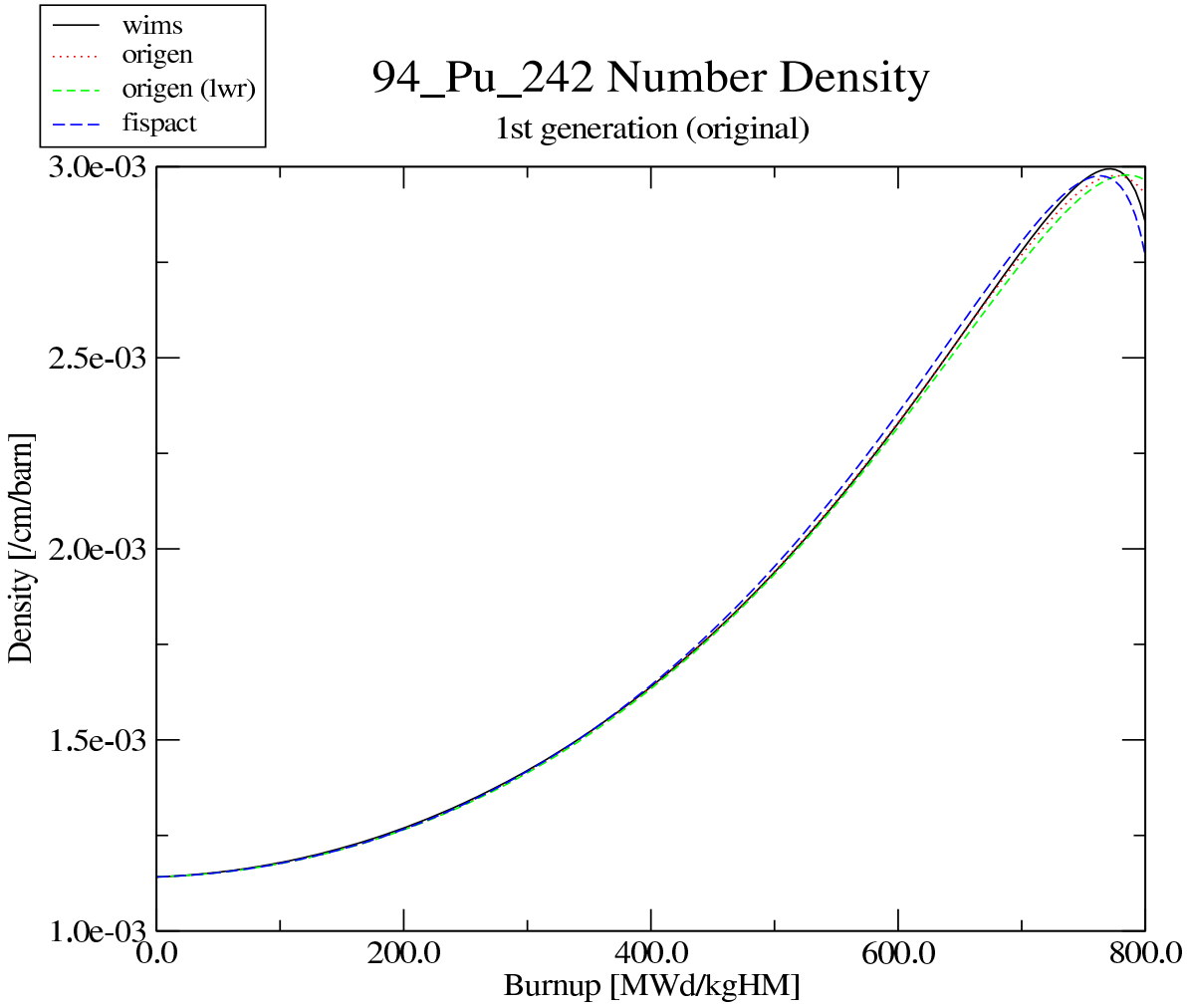


Figure 5.9 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_242 for case A1

Table 5.10 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_243 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	–
100.00	–	2.5031e-07	2.1943e-07	–
400.00	–	3.6679e-07	2.7124e-07	–
600.00	–	5.7813e-07	2.8962e-07	–
800.00	–	2.6898e-06	1.6130e-07	–

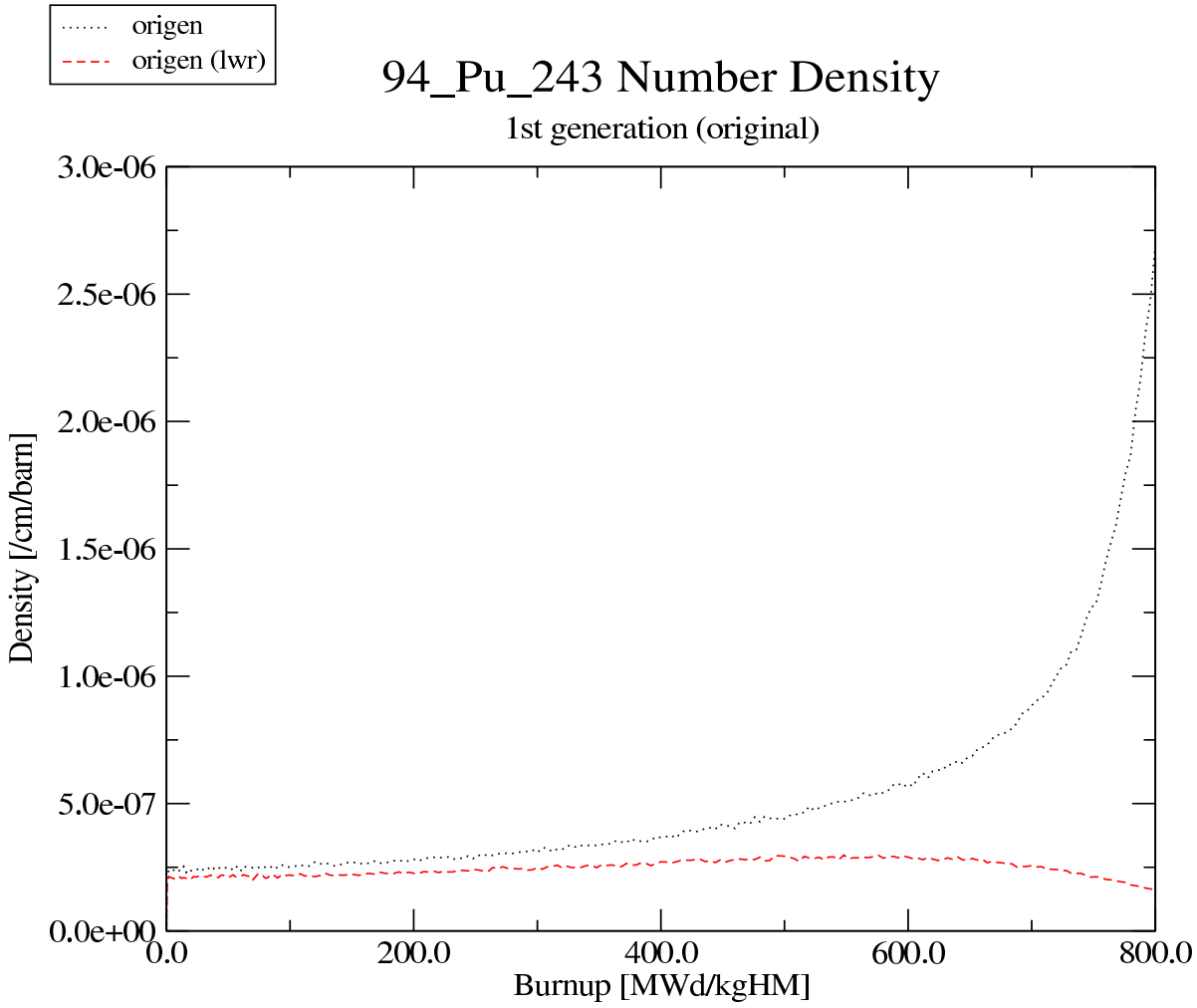


Figure 5.10 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_243 for case A1

Table 5.11 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_244 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	1.0000e-20	3.5823e-06	1.7193e-09
400.00	–	1.5565e-18	2.3038e-05	3.0229e-08
600.00	–	3.5999e-17	5.9618e-05	7.6905e-08
800.00	–	6.9876e-16	2.1267e-04	3.0386e-07

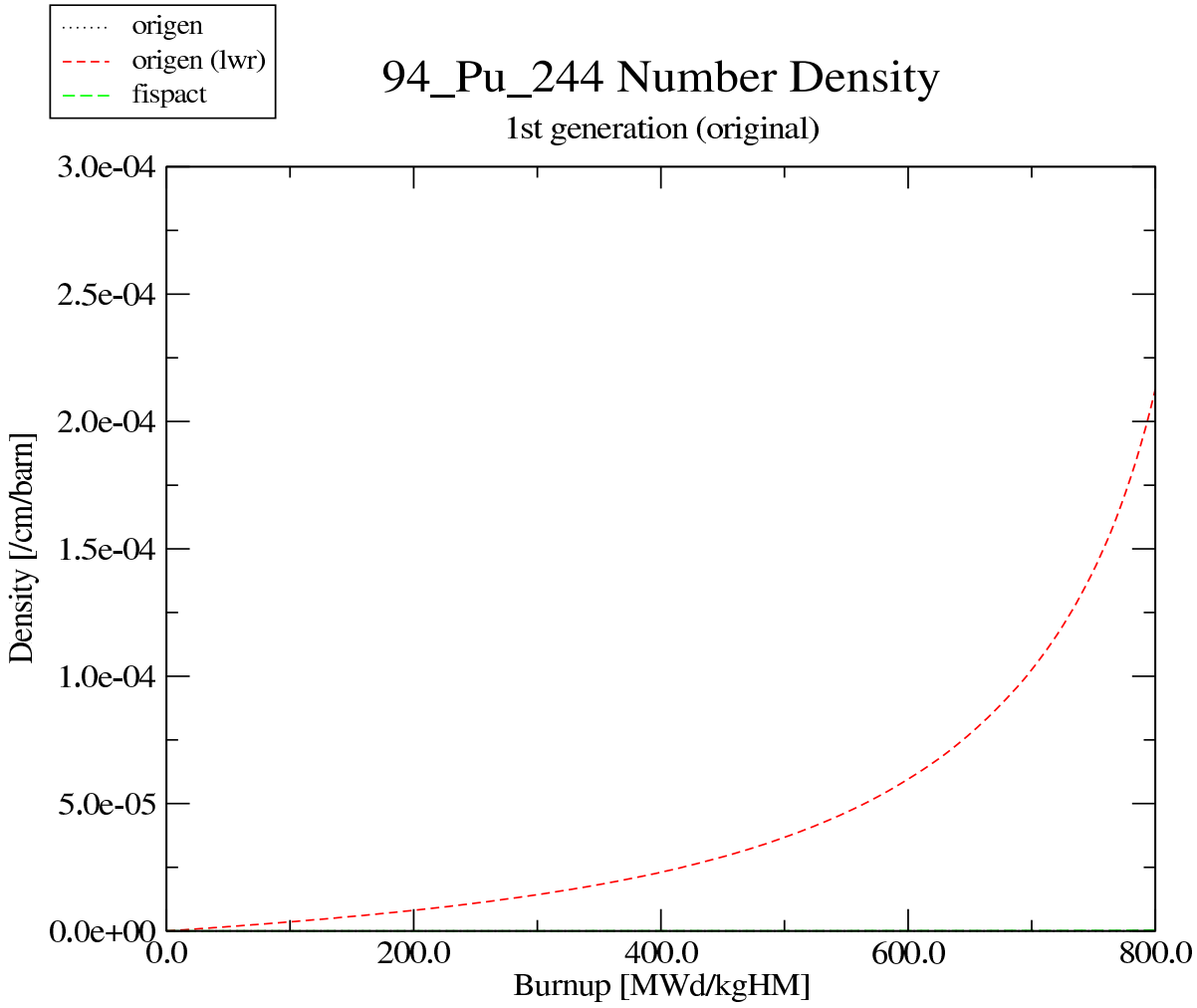


Figure 5.11 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_244 for case A1

Table 5.12 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_240 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	–	–	1.0000e-20
100.00	–	–	–	2.0368e-13
400.00	–	–	–	7.9065e-13
600.00	–	–	–	6.1850e-13
800.00	–	–	–	8.3815e-16

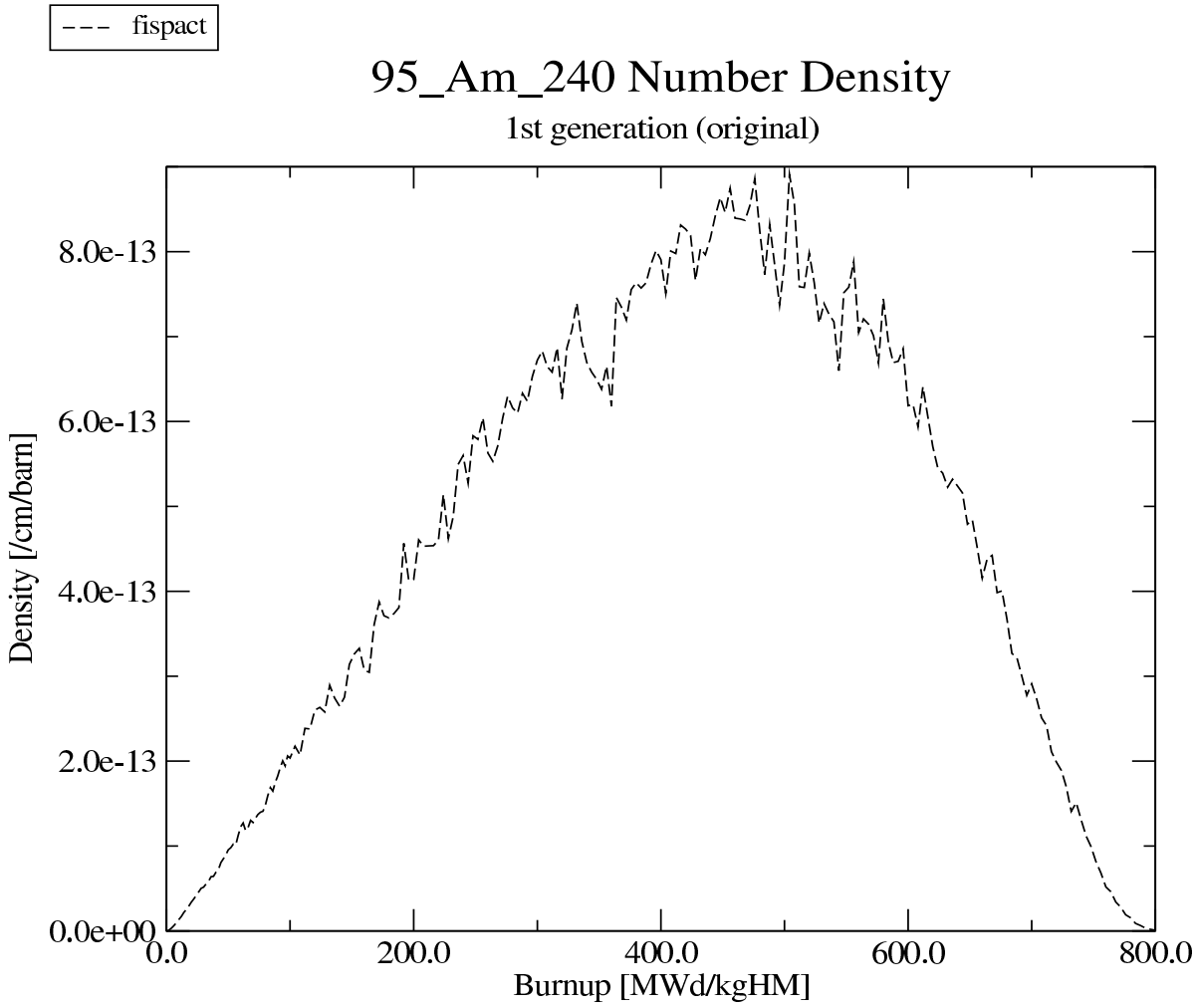


Figure 5.12 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_240 for case A1

Table 5.13 Number Density [$cm^{-1}barn^{-1}$] 95_Am_241 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	2.5804e-05	2.5755e-05	2.5755e-05	2.5762e-05
400.00	8.7112e-05	8.6565e-05	8.6915e-05	8.6204e-05
600.00	6.5208e-05	6.4041e-05	6.5632e-05	6.1643e-05
800.00	8.6859e-08	5.0951e-07	1.1753e-06	3.4974e-08

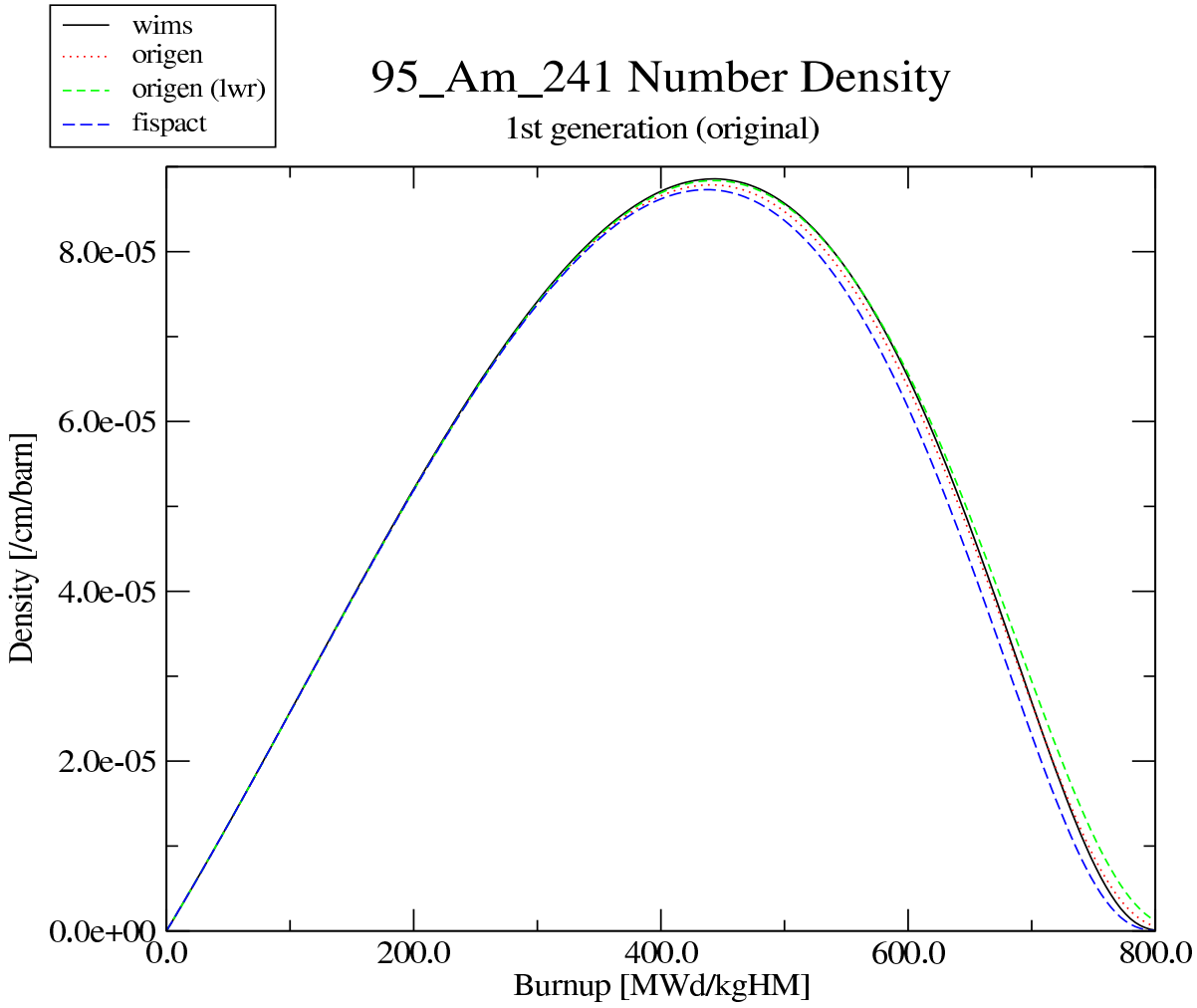


Figure 5.13 Number Density [$cm^{-1}barn^{-1}$] 95_Am_241 for case A1

Table 5.14 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_242 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	4.7718e-08	5.1547e-08	5.2617e-08
400.00	–	2.8021e-07	3.0022e-07	3.1057e-07
600.00	–	4.4652e-07	4.7589e-07	4.9554e-07
800.00	–	3.4483e-08	6.8176e-08	4.4582e-09

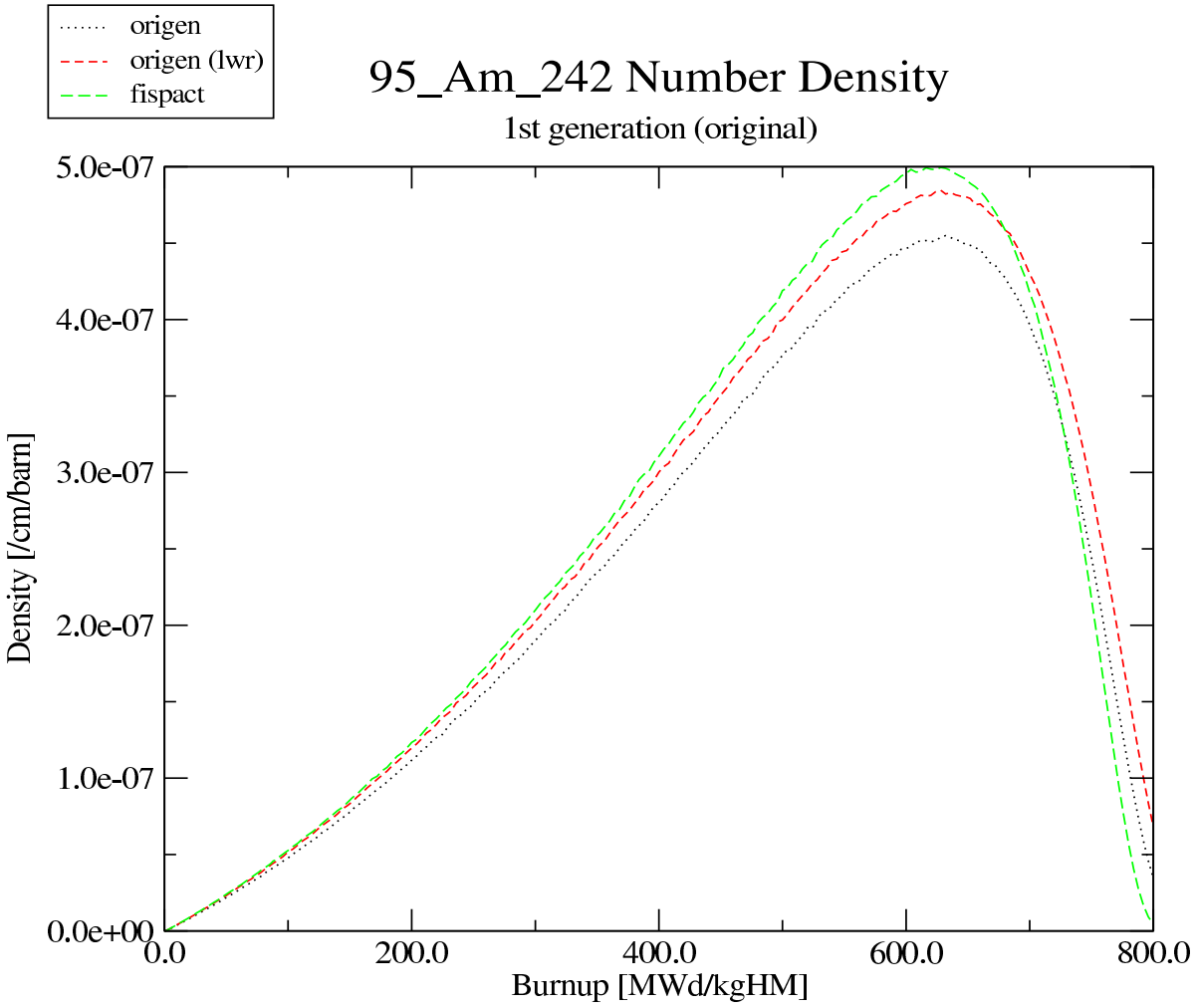


Figure 5.14 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_242 for case A1

Table 5.15 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	2.1535e-07	3.4321e-07	2.1015e-07	1.7119e-07
400.00	1.5719e-06	2.4679e-06	1.5212e-06	1.2280e-06
600.00	1.1736e-06	1.7956e-06	1.1323e-06	8.6048e-07
800.00	1.3313e-09	1.2283e-08	1.7527e-08	4.1483e-10

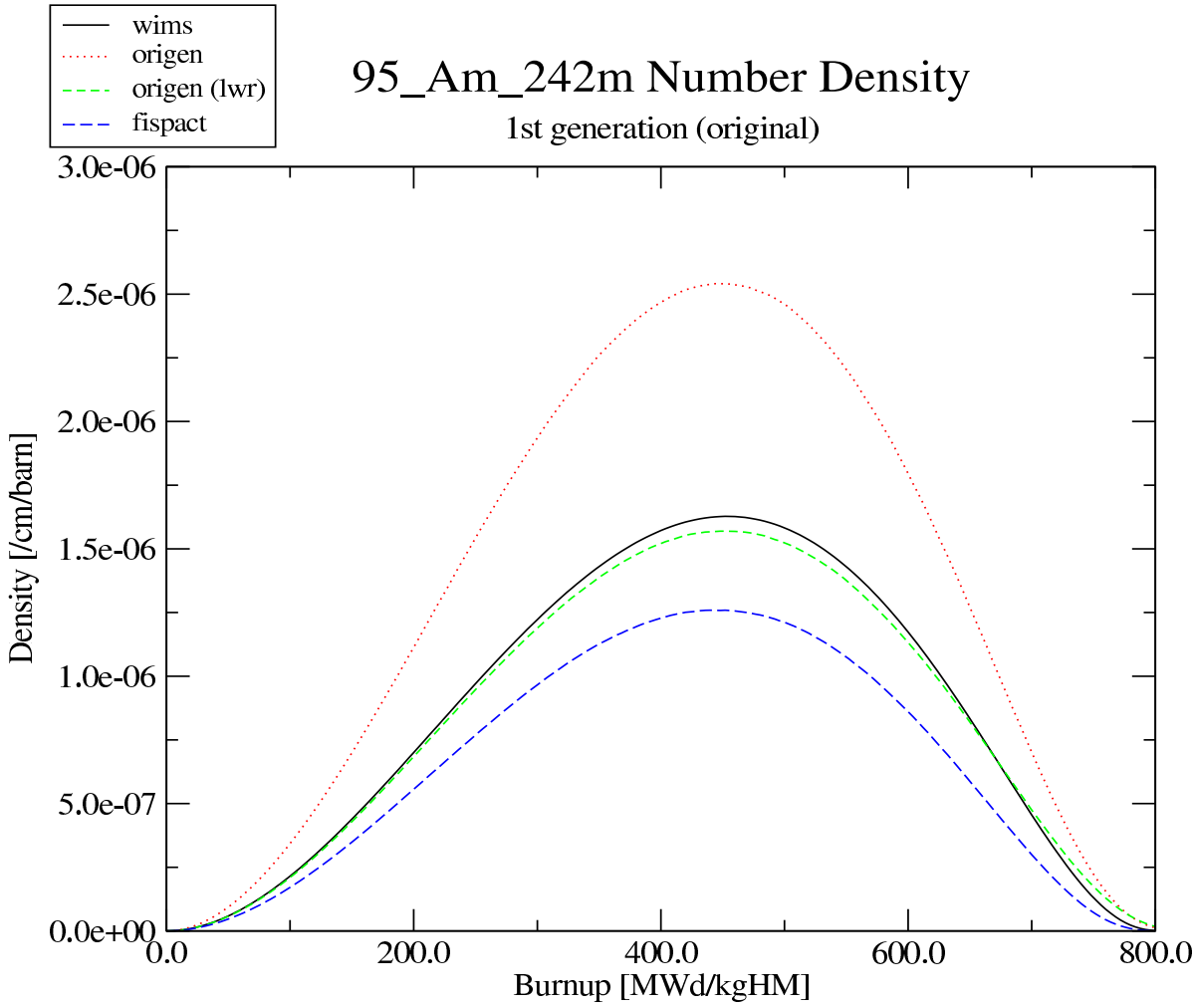


Figure 5.15 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case A1

Table 5.16 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_243 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	7.5536e-05	7.6872e-05	6.6743e-05	6.5398e-05
400.00	2.9201e-04	2.9724e-04	2.3892e-04	2.7247e-04
600.00	4.6721e-04	4.7737e-04	3.3261e-04	4.4343e-04
800.00	7.5717e-04	7.4302e-04	2.8693e-04	7.1246e-04

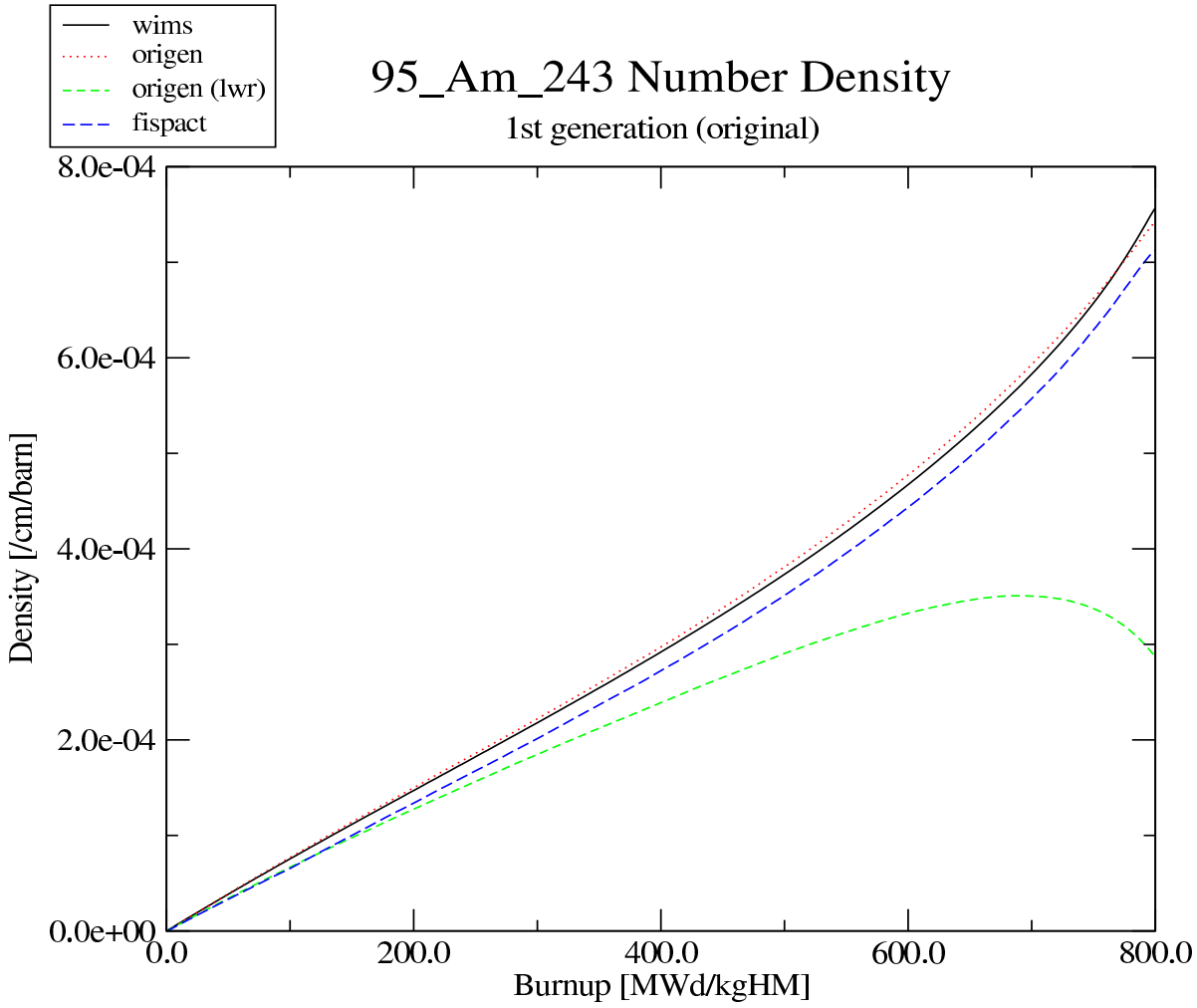


Figure 5.16 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_243 for case A1

Table 5.17 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_244 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	–
100.00	–	1.5726e-08	1.3988e-08	–
400.00	–	3.5184e-08	2.8569e-08	–
600.00	–	2.8646e-08	2.0513e-08	–
800.00	–	1.4754e-08	6.0692e-09	–

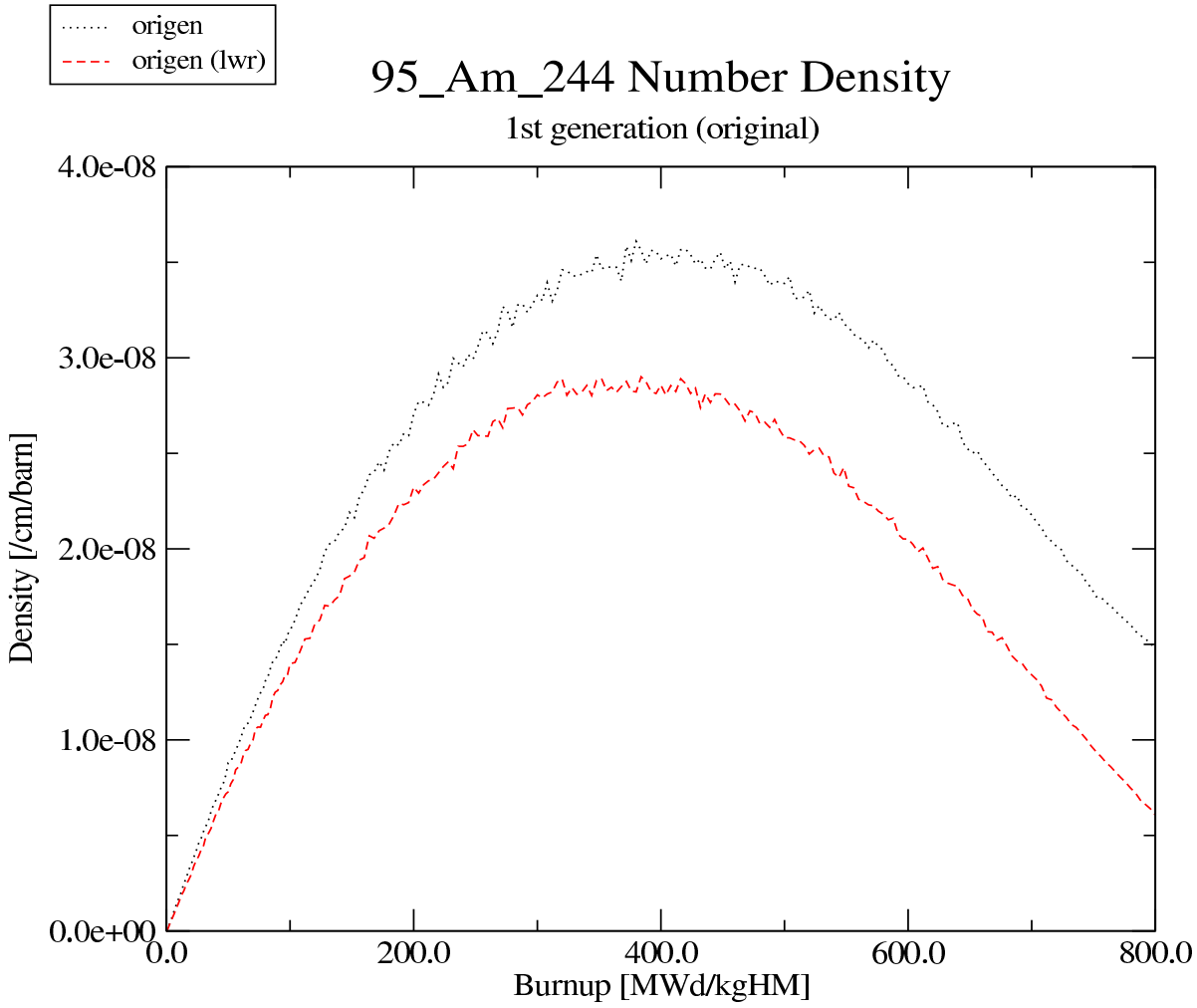


Figure 5.17 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_244 for case A1

Table 5.18 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_241 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	5.3915e-14	5.8963e-14	5.9311e-14
400.00	–	1.5158e-12	1.5491e-12	1.6237e-12
600.00	–	3.0166e-12	3.2265e-12	3.4731e-12
800.00	–	1.2531e-12	1.4839e-12	9.8296e-13

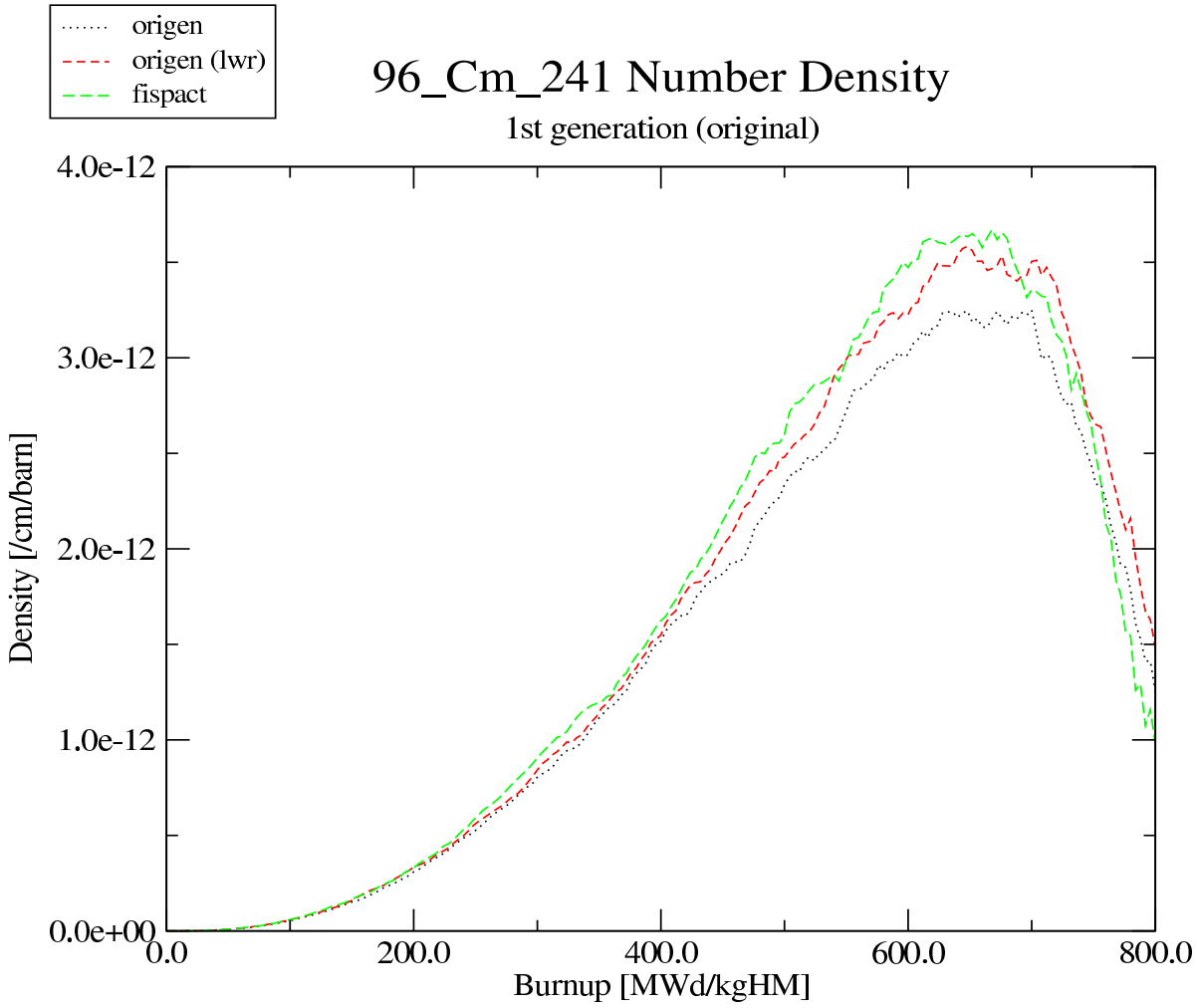


Figure 5.18 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_241 for case A1

Table 5.19 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_242 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	1.8841e-06	1.6851e-06	1.8027e-06	1.8530e-06
400.00	2.8710e-05	2.6162e-05	2.7971e-05	2.8965e-05
600.00	6.0429e-05	5.4599e-05	5.8240e-05	6.0739e-05
800.00	6.0496e-05	5.3721e-05	6.0037e-05	5.3859e-05

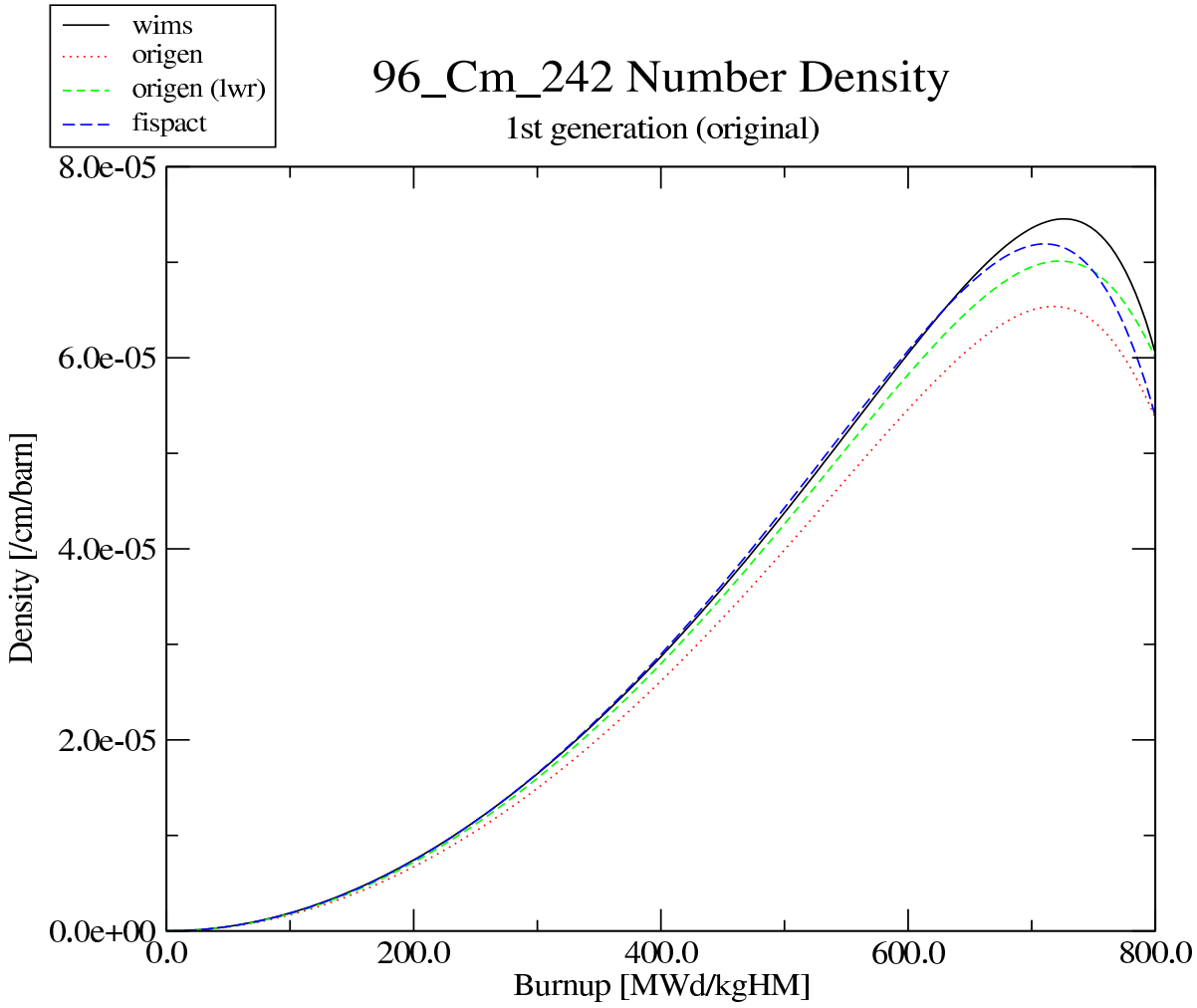


Figure 5.19 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_242 for case A1

Table 5.20 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	5.6317e-09	5.0574e-09	5.3775e-09	5.5802e-09
400.00	3.3419e-07	3.0927e-07	3.2931e-07	3.4532e-07
600.00	1.0916e-06	1.0072e-06	1.0659e-06	1.1371e-06
800.00	1.9105e-06	1.7439e-06	1.9213e-06	1.7139e-06

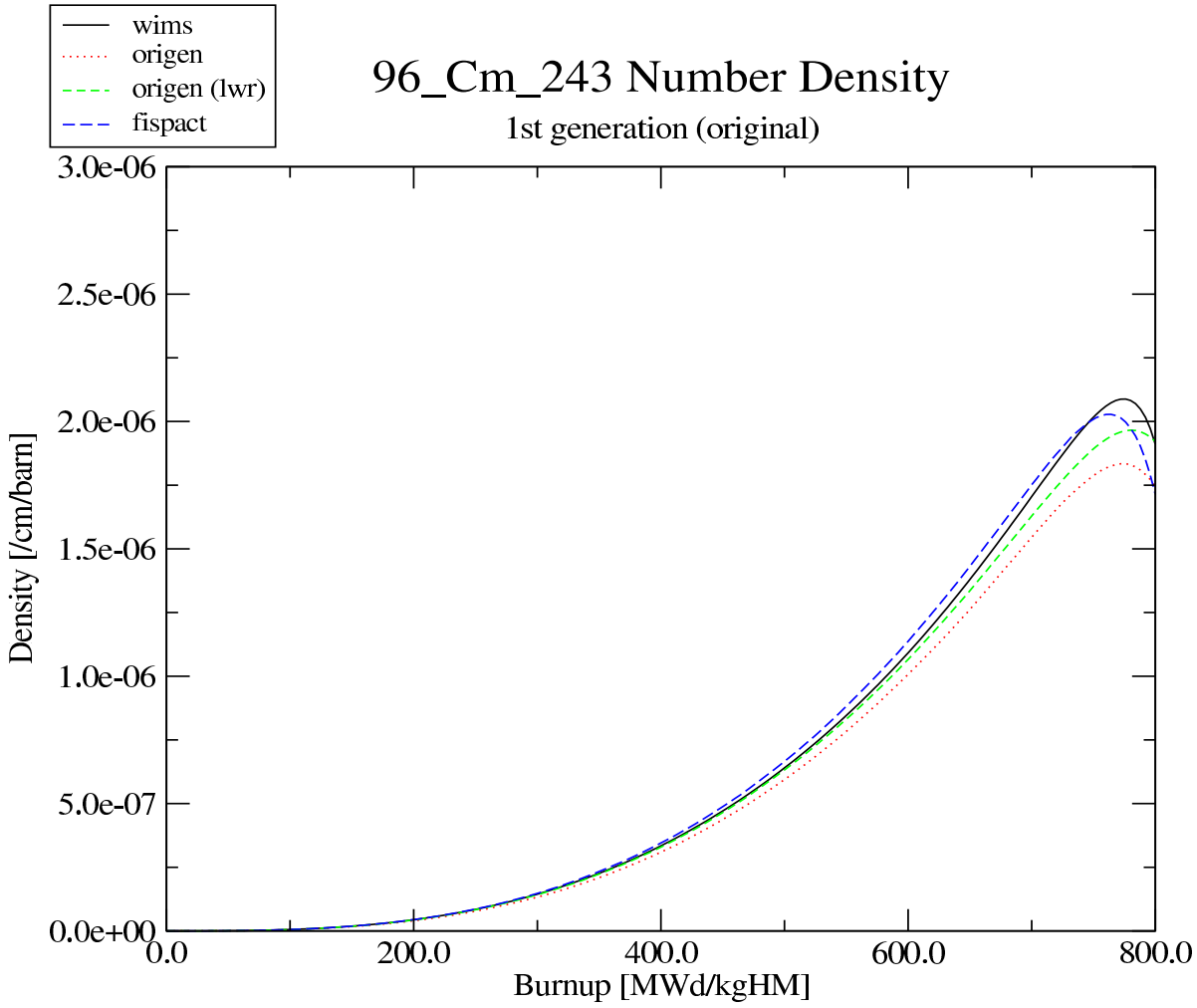


Figure 5.20 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case A1

Table 5.21 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_244 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	5.0925e-06	1.3393e-06	1.1679e-06	4.3271e-06
400.00	7.8242e-05	1.4335e-05	1.2048e-05	7.3183e-05
600.00	1.8788e-04	2.2854e-05	1.8504e-05	1.8045e-04
800.00	6.6038e-04	2.5629e-05	1.9850e-05	6.8973e-04

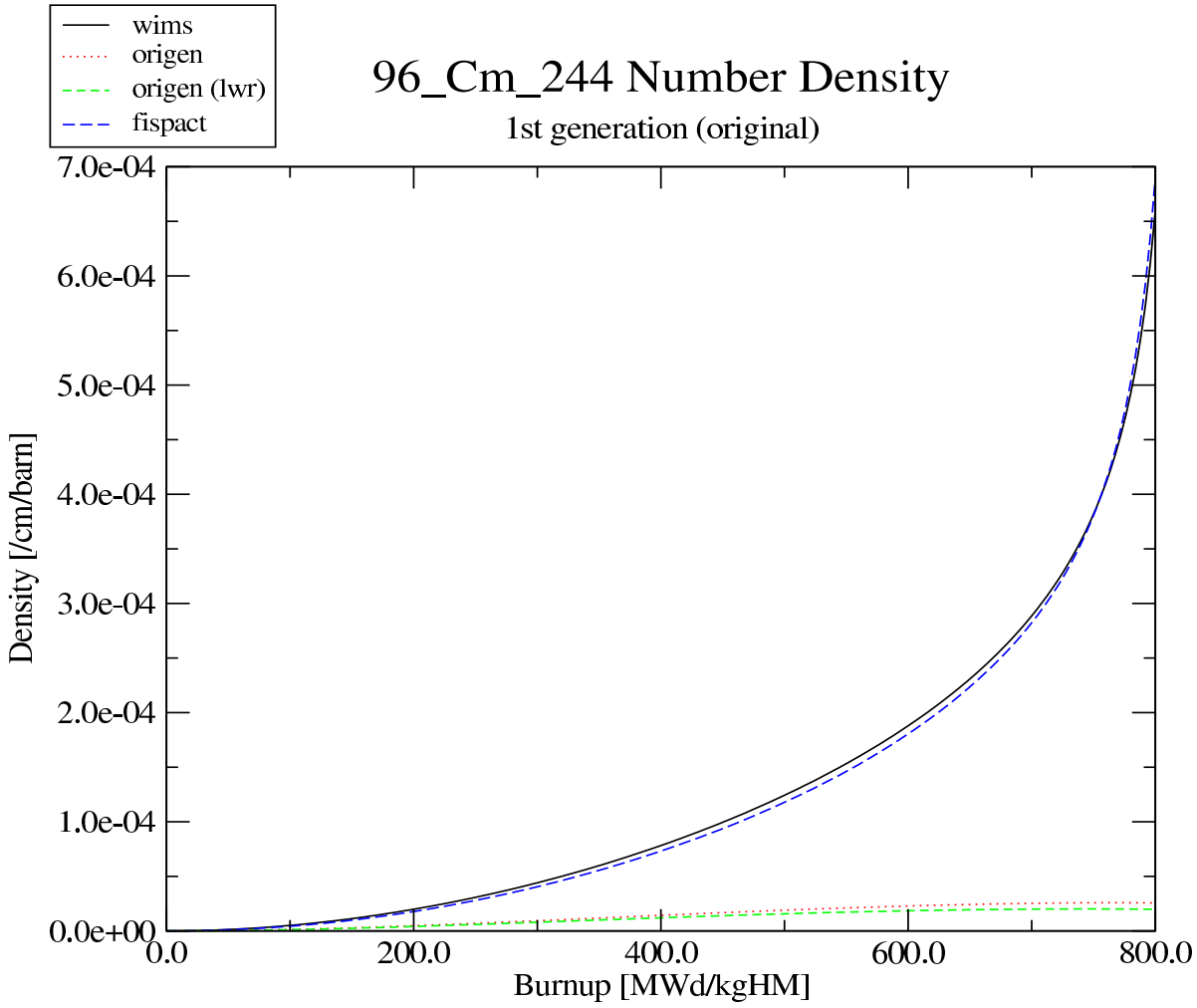


Figure 5.21 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_244 for case A1

Table 5.22 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	7.2343e-08	1.7990e-08	2.4855e-08	5.6831e-08
400.00	3.8583e-06	7.5679e-07	7.7736e-07	3.3797e-06
600.00	9.9846e-06	1.4210e-06	1.4023e-06	8.8340e-06
800.00	1.0312e-05	4.2641e-07	4.0483e-07	8.0606e-06

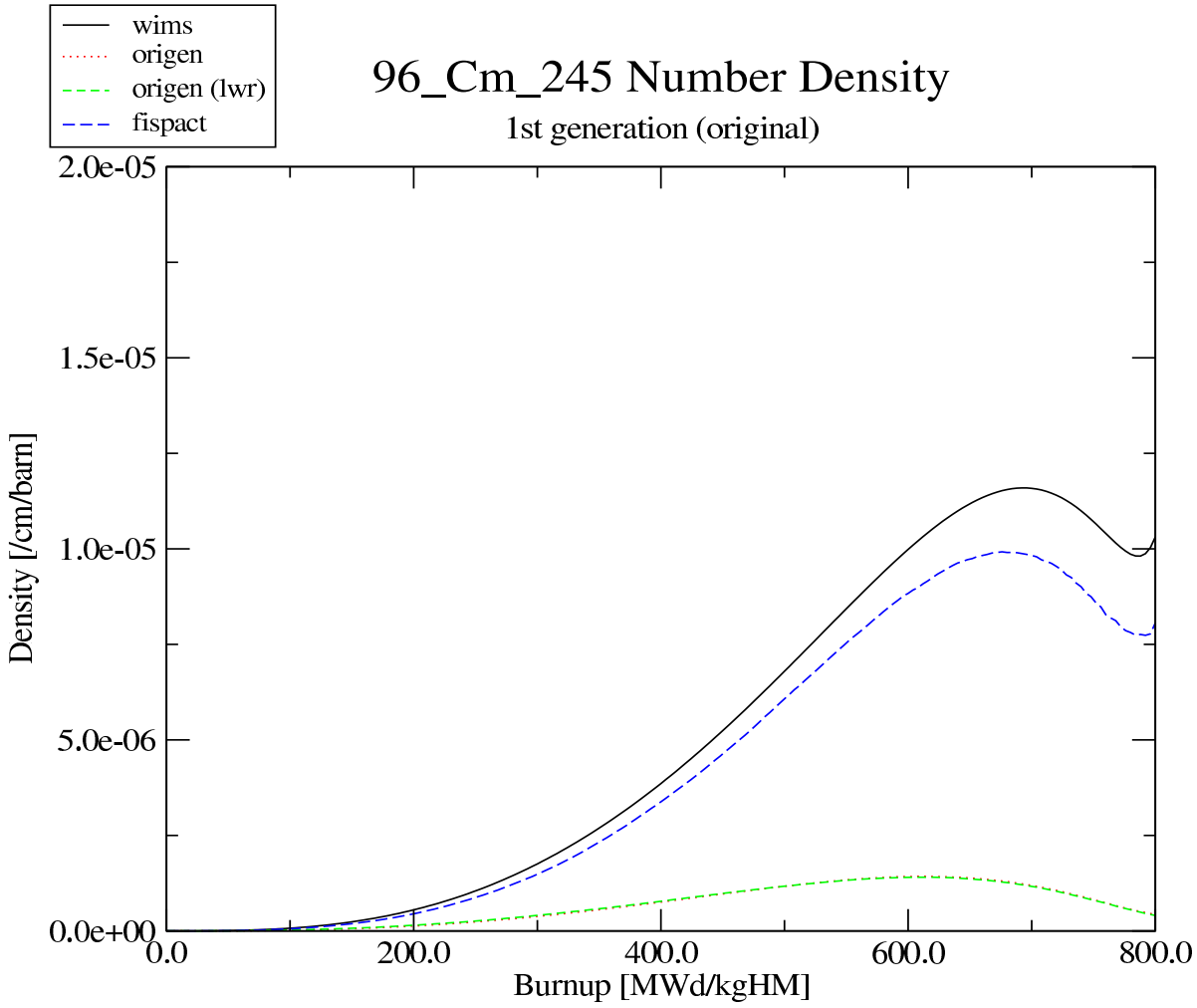


Figure 5.22 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case A1

Table 5.23 Number Density $[cm^{-1}barn^{-1}]$ 34_Se_79 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	9.3209e-07	8.8874e-07	8.3417e-07
400.00	–	3.9112e-06	3.5794e-06	3.0529e-06
600.00	–	5.8151e-06	5.1133e-06	4.2647e-06
800.00	–	7.2744e-06	6.1642e-06	4.9715e-06

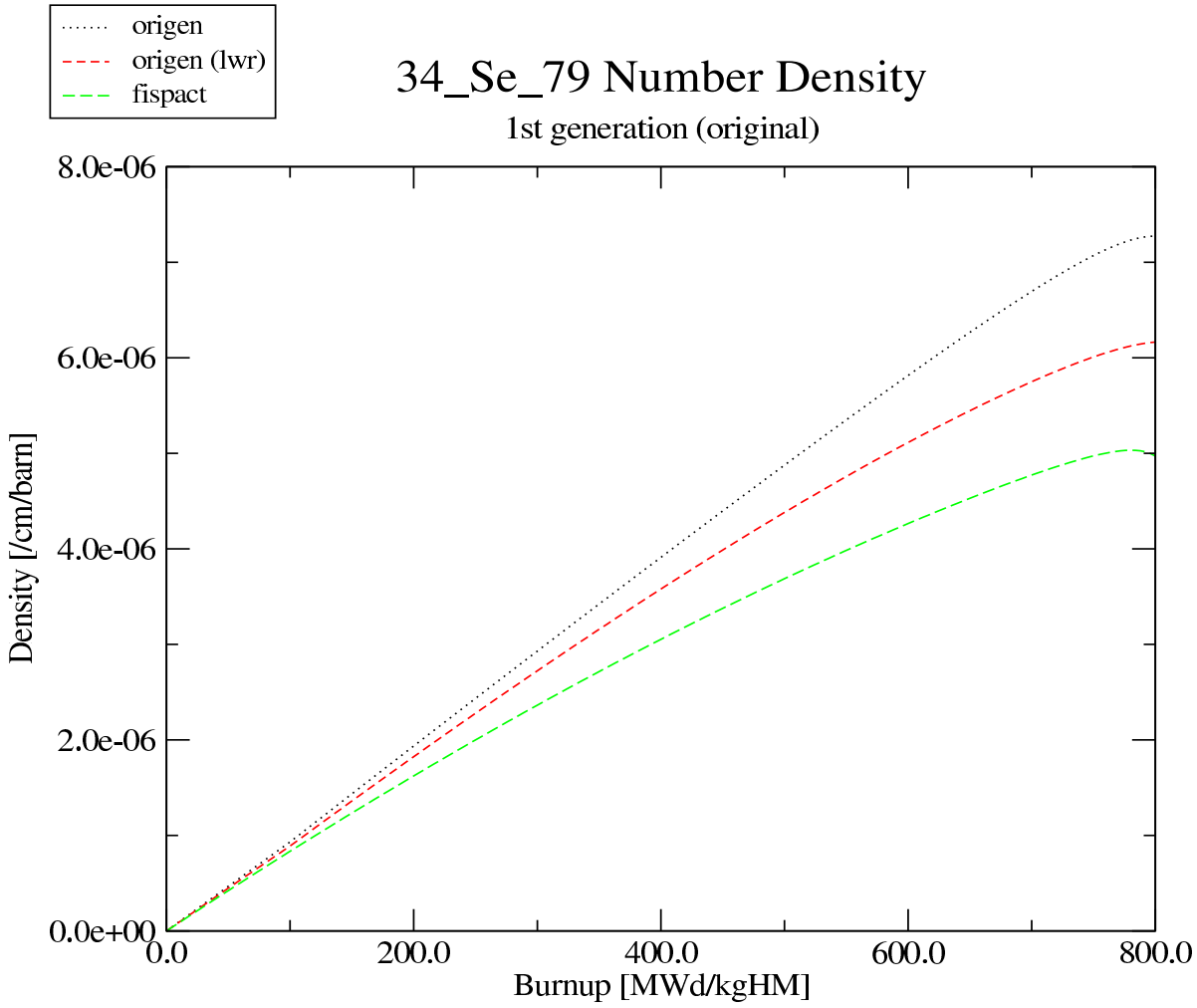


Figure 5.23 Number Density $[cm^{-1}barn^{-1}]$ 34_Se_79 for case A1

Table 5.24 Number Density [$cm^{-1}barn^{-1}$] 37_Rb_87 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	2.2574e-05	1.9877e-05	2.0096e-05
400.00	–	8.9461e-05	7.3530e-05	7.8369e-05
600.00	–	1.3298e-04	1.0063e-04	1.1348e-04
800.00	–	1.7228e-04	1.1323e-04	1.4211e-04

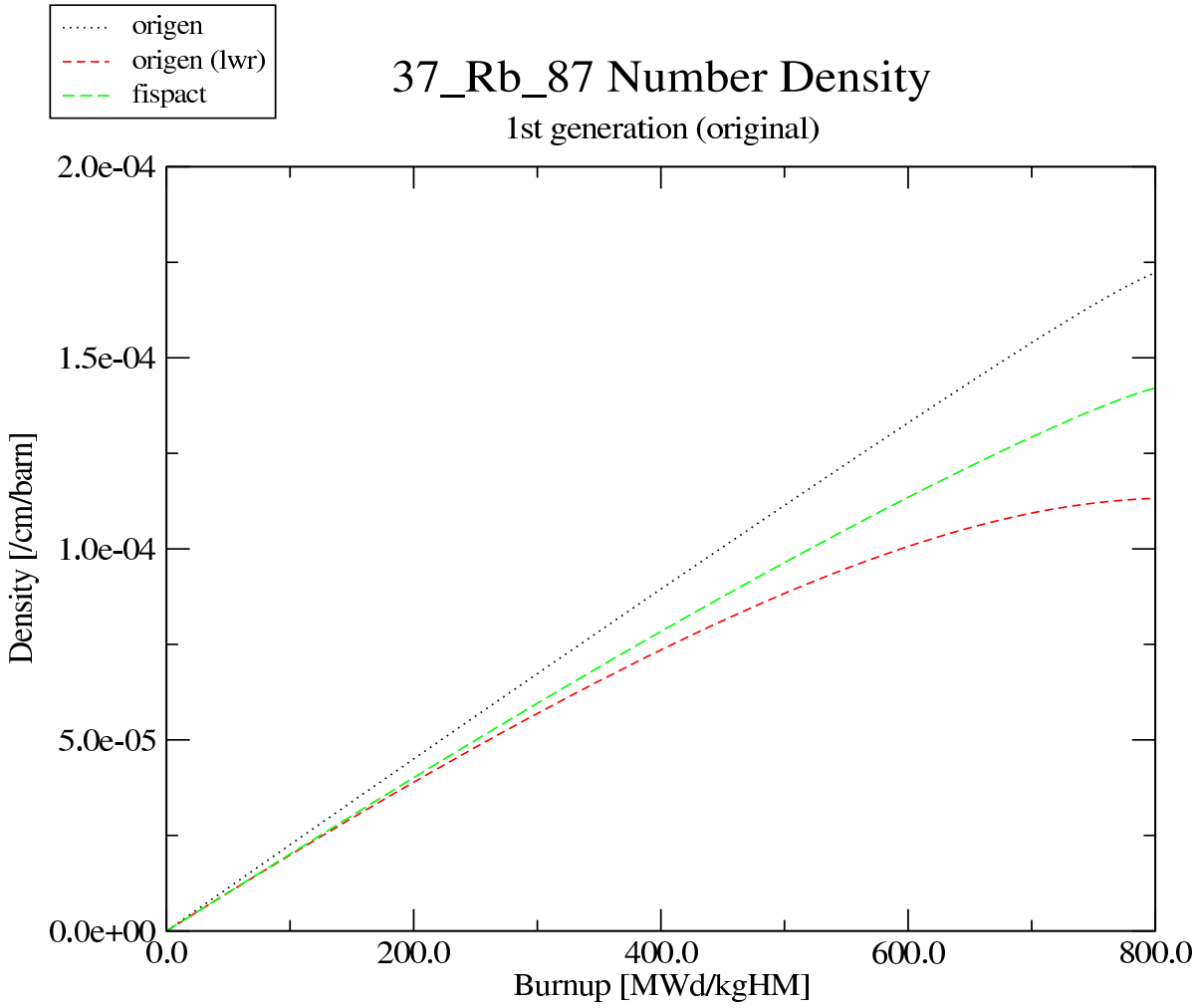


Figure 5.24 Number Density [$cm^{-1}barn^{-1}$] 37_Rb_87 for case A1

Table 5.25 Number Density $[cm^{-1}barn^{-1}]$ 38_Sr_90 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	4.7328e-05	4.5632e-05	4.5014e-05
400.00	–	1.8537e-04	1.7341e-04	1.7247e-04
600.00	–	2.7364e-04	2.4843e-04	2.5033e-04
800.00	–	3.5120e-04	3.0886e-04	3.1622e-04

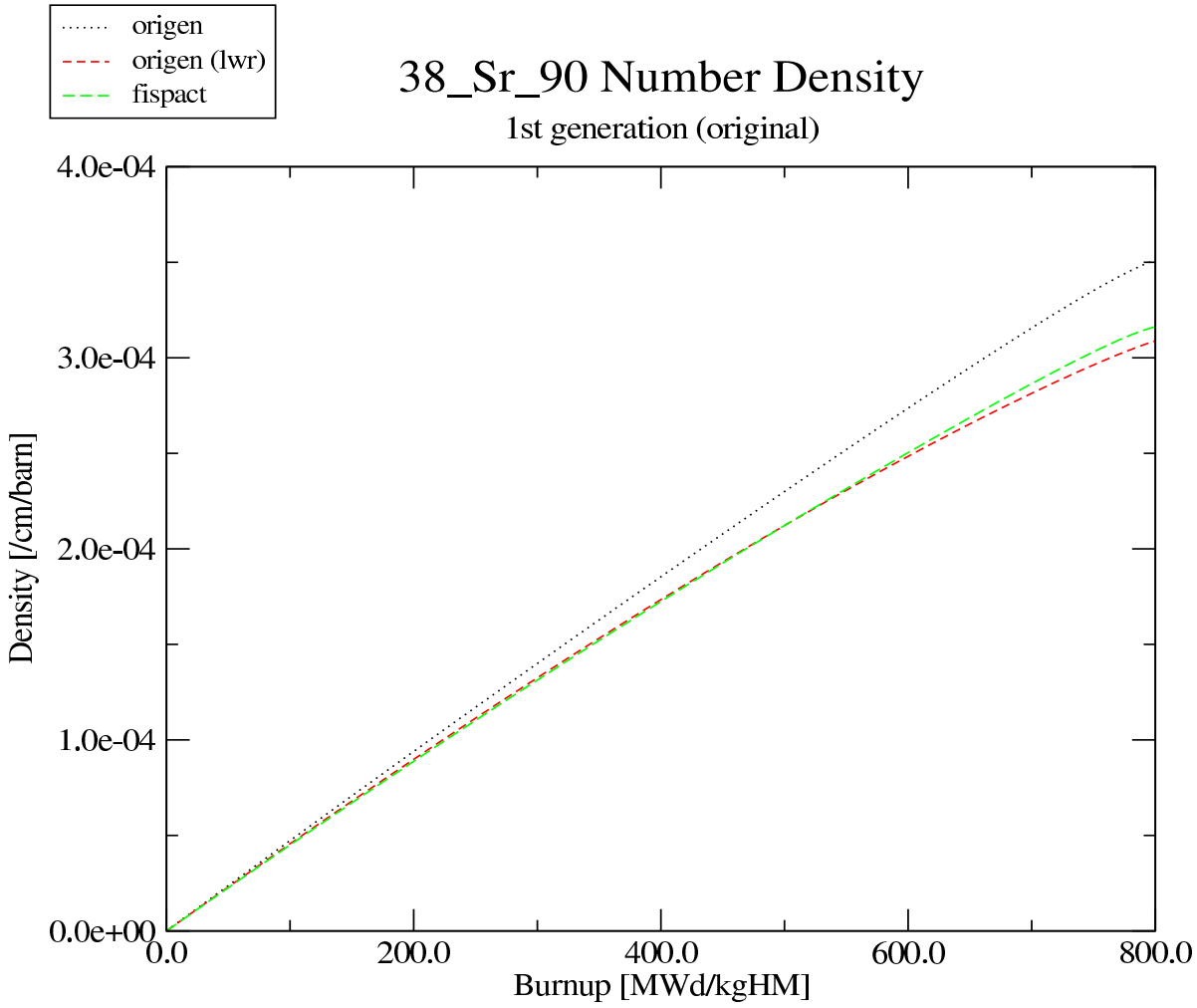


Figure 5.25 Number Density $[cm^{-1}barn^{-1}]$ 38_Sr_90 for case A1

Table 5.26 Number Density $[cm^{-1}barn^{-1}]$ 40_Zr_93 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	8.7983e-05	9.1047e-05	8.7436e-05	5.9761e-05
400.00	3.3836e-04	3.6092e-04	3.3509e-04	2.6581e-04
600.00	4.8933e-04	5.3497e-04	4.8046e-04	3.9085e-04
800.00	6.1510e-04	6.8695e-04	5.9592e-04	4.8984e-04

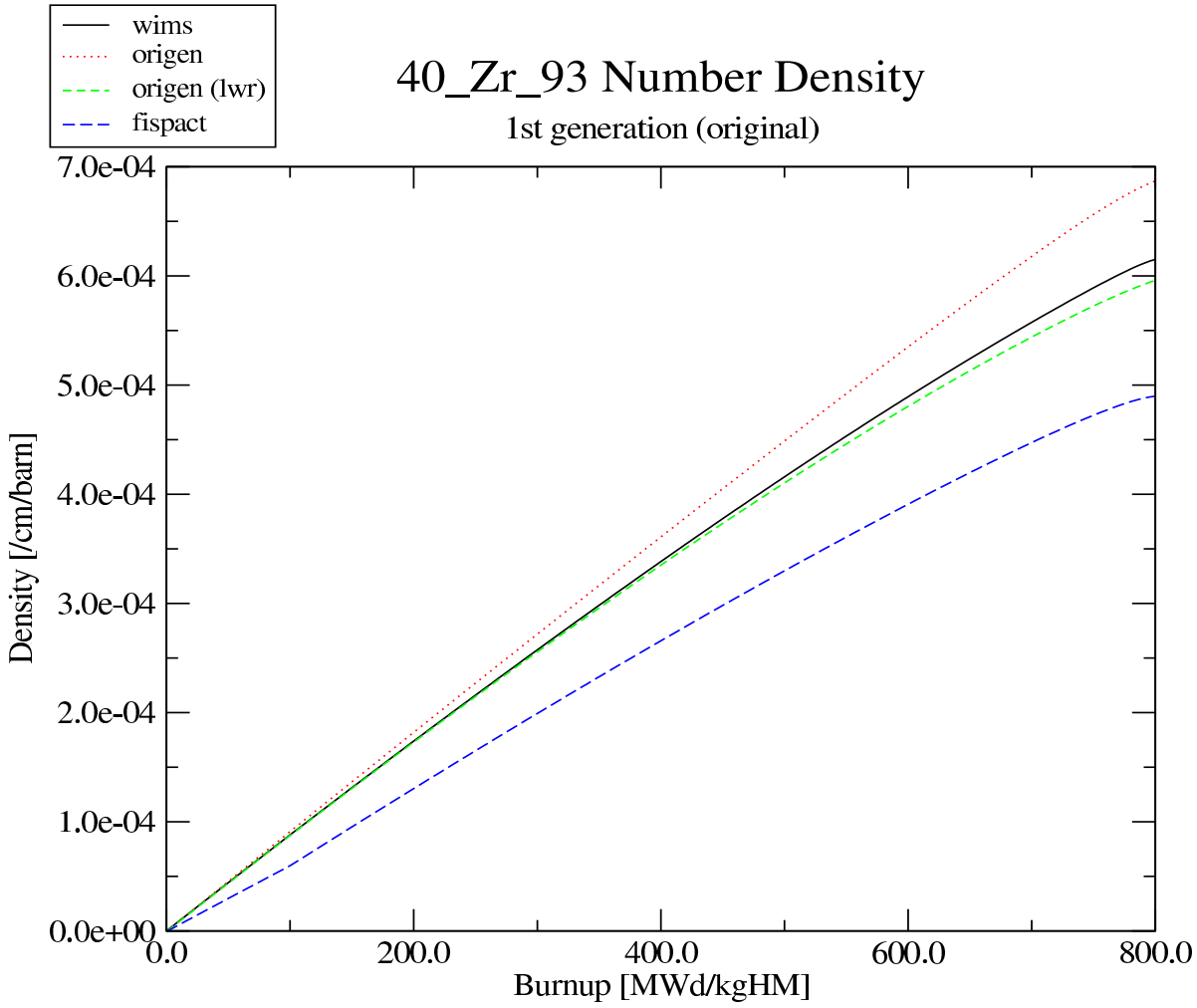


Figure 5.26 Number Density $[cm^{-1}barn^{-1}]$ 40_Zr_93 for case A1

Table 5.27 Number Density $[cm^{-1}barn^{-1}]$ 42_Mo_93 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	1.0000e-20	1.0000e-20	2.0889e-16
400.00	–	1.0000e-20	1.0000e-20	1.7407e-14
600.00	–	1.0000e-20	1.0000e-20	6.4619e-14
800.00	–	1.0000e-20	1.0000e-20	1.7192e-13

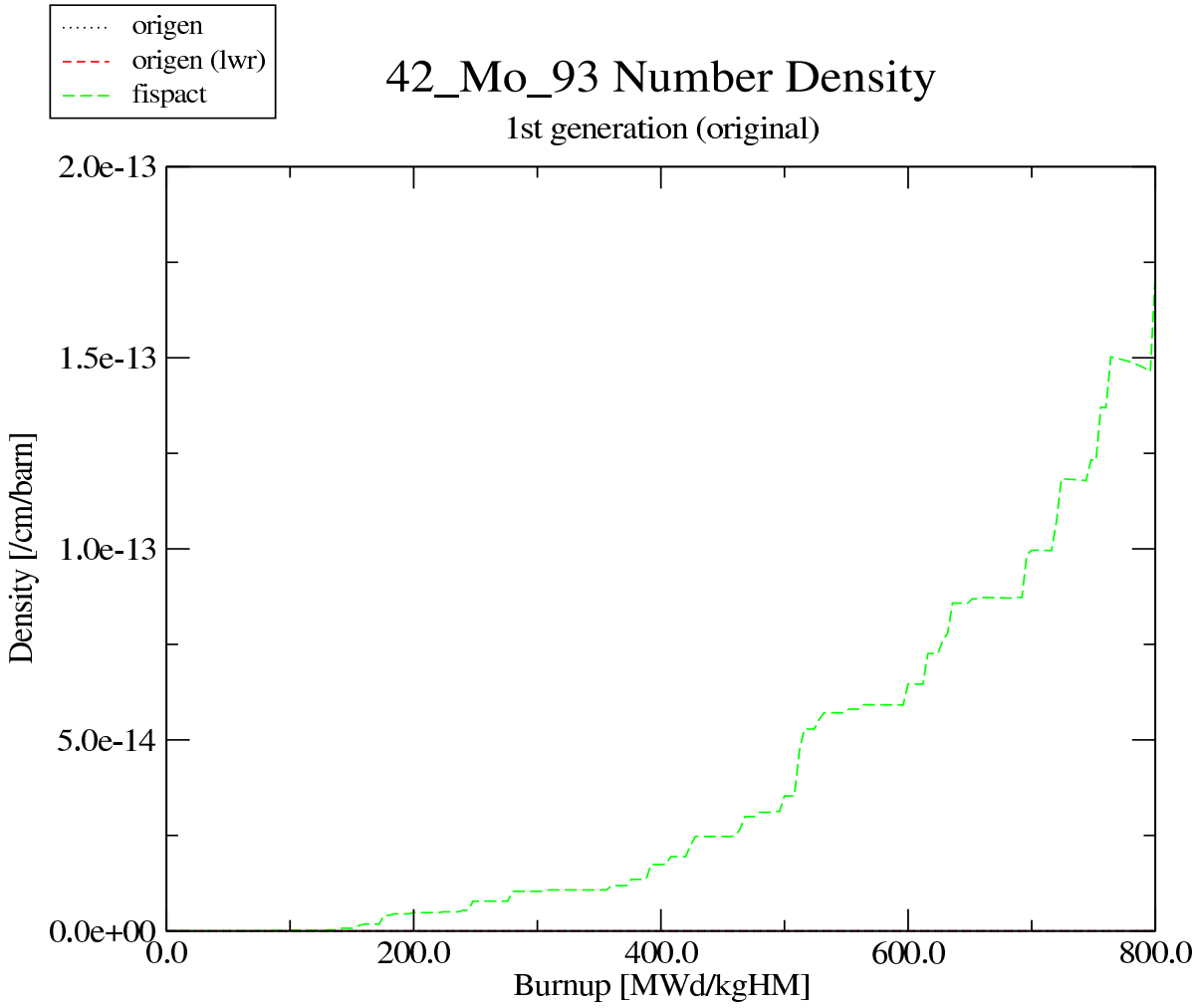


Figure 5.27 Number Density $[cm^{-1}barn^{-1}]$ 42_Mo_93 for case A1

Table 5.28 Number Density $[cm^{-1}barn^{-1}]$ 41_Nb_94 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	2.2611e-10	1.9648e-10	2.0785e-10
400.00	–	9.2823e-10	7.4381e-10	7.7790e-10
600.00	–	1.3813e-09	1.1336e-09	1.1023e-09
800.00	–	1.7259e-09	3.0525e-09	1.3381e-09

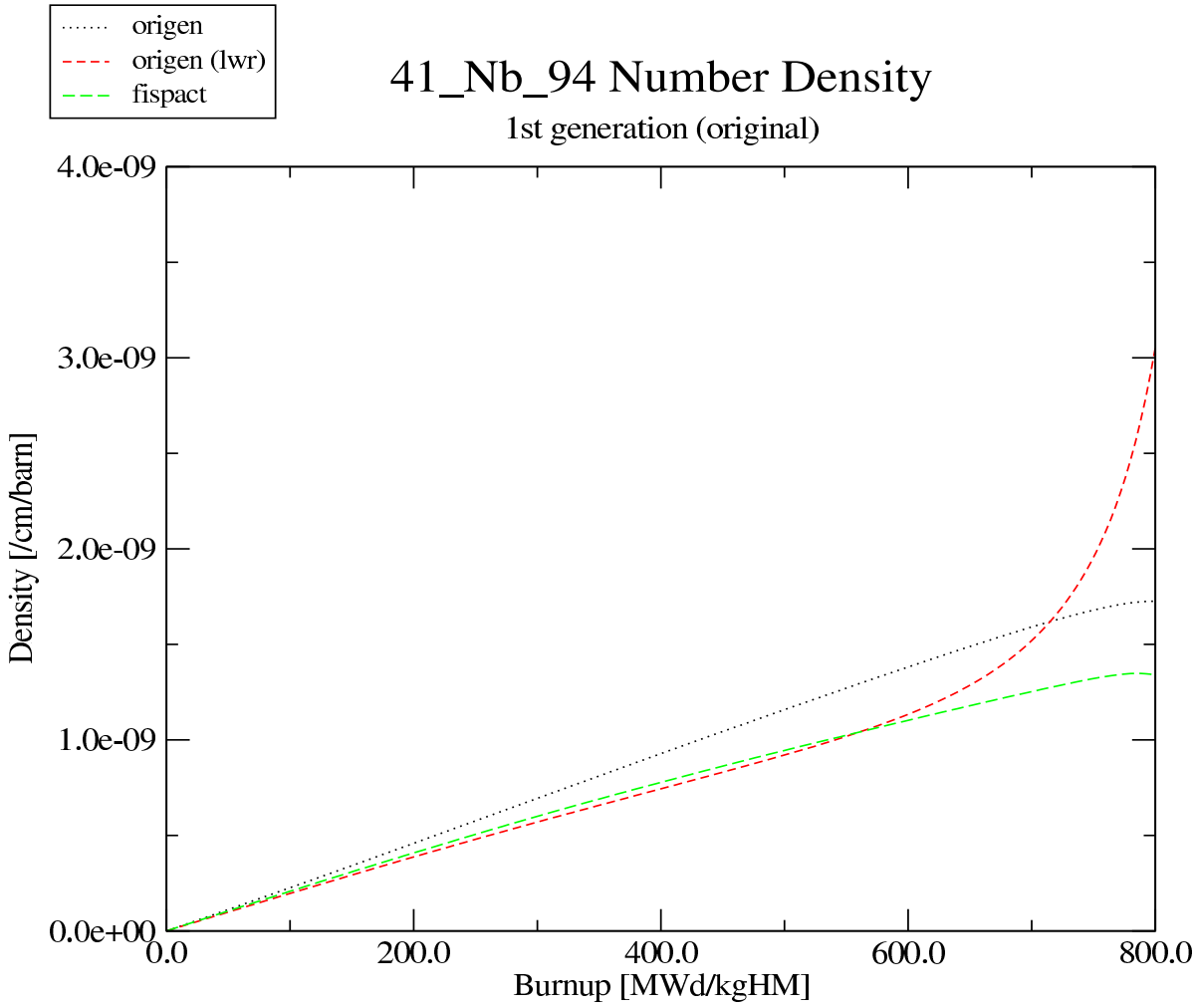


Figure 5.28 Number Density $[cm^{-1}barn^{-1}]$ 41_Nb_94 for case A1

Table 5.29 Number Density $[cm^{-1}barn^{-1}]$ 43_Tc_99 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	1.4181e-04	1.4003e-04	1.3816e-04	1.1479e-04
400.00	5.3963e-04	5.5286e-04	5.4008e-04	4.8280e-04
600.00	7.7468e-04	7.9900e-04	7.7251e-04	6.9764e-04
800.00	8.8430e-04	9.3476e-04	9.0647e-04	7.6600e-04

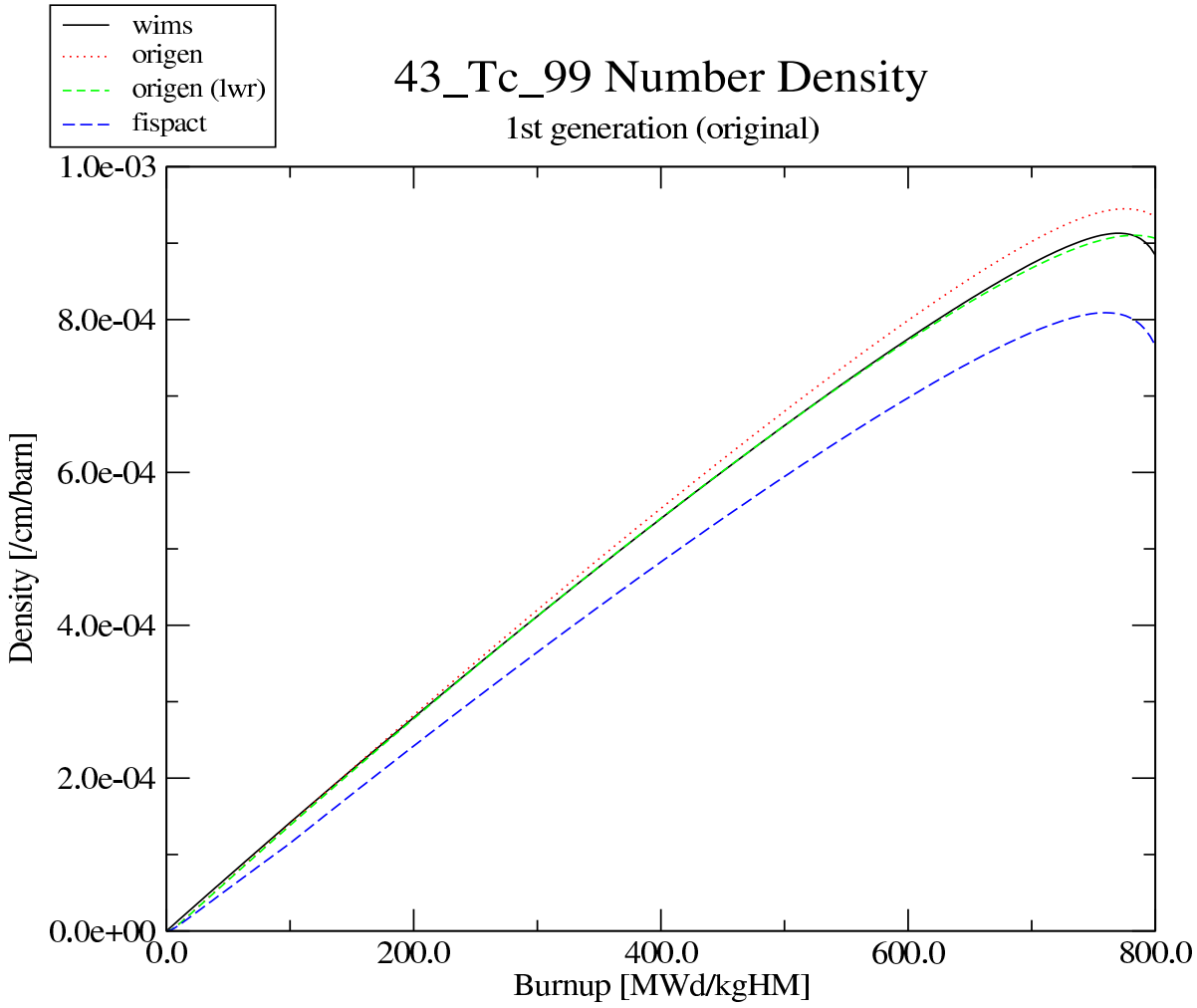


Figure 5.29 Number Density $[cm^{-1}barn^{-1}]$ 43_Tc_99 for case A1

Table 5.30 Number Density $[cm^{-1}barn^{-1}]$ 46_Pd_107 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	8.0727e-05	7.5417e-05	8.1706e-05	8.0701e-05
400.00	3.3911e-04	2.9962e-04	3.4630e-04	3.4117e-04
600.00	5.3162e-04	4.4200e-04	5.3982e-04	5.3807e-04
800.00	7.2888e-04	5.6256e-04	7.2588e-04	7.5877e-04

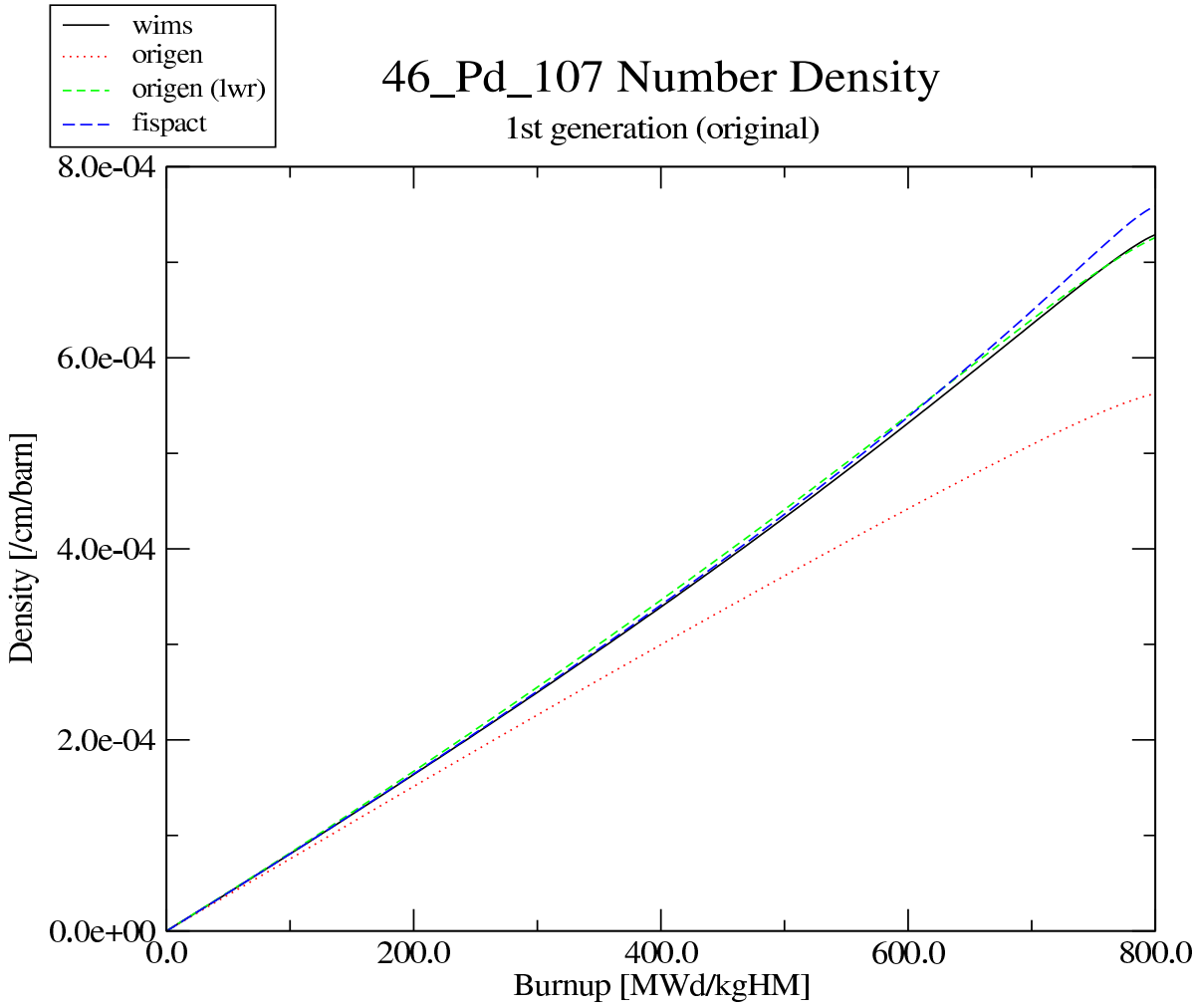


Figure 5.30 Number Density $[cm^{-1}barn^{-1}]$ 46_Pd_107 for case A1

Table 5.31 Number Density $[cm^{-1}barn^{-1}]$ 50_Sn_126 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	7.3568e-06	7.5757e-06	6.3221e-06
400.00	–	2.9145e-05	3.0786e-05	2.5060e-05
600.00	–	4.3323e-05	4.6761e-05	3.7218e-05
800.00	–	5.6098e-05	6.1847e-05	4.8047e-05

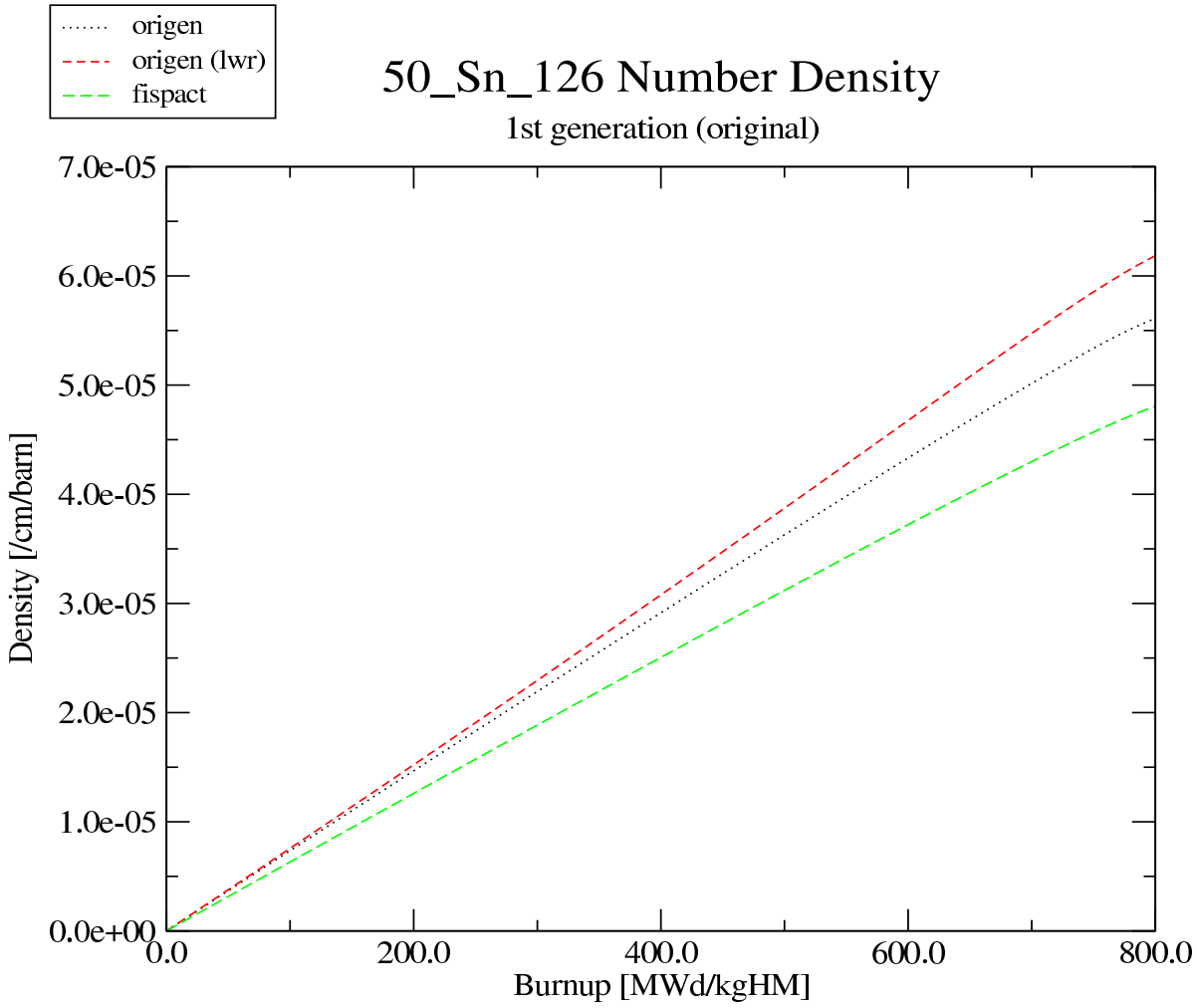


Figure 5.31 Number Density $[cm^{-1}barn^{-1}]$ 50_Sn_126 for case A1

Table 5.32 Number Density $[cm^{-1}barn^{-1}]$ 53_I_129 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	3.2778e-05	3.1068e-05	3.0860e-05	2.6007e-05
400.00	1.2896e-04	1.2838e-04	1.2713e-04	1.1861e-04
600.00	1.8943e-04	1.8920e-04	1.8663e-04	1.7642e-04
800.00	2.1501e-04	2.2065e-04	2.2074e-04	1.9078e-04

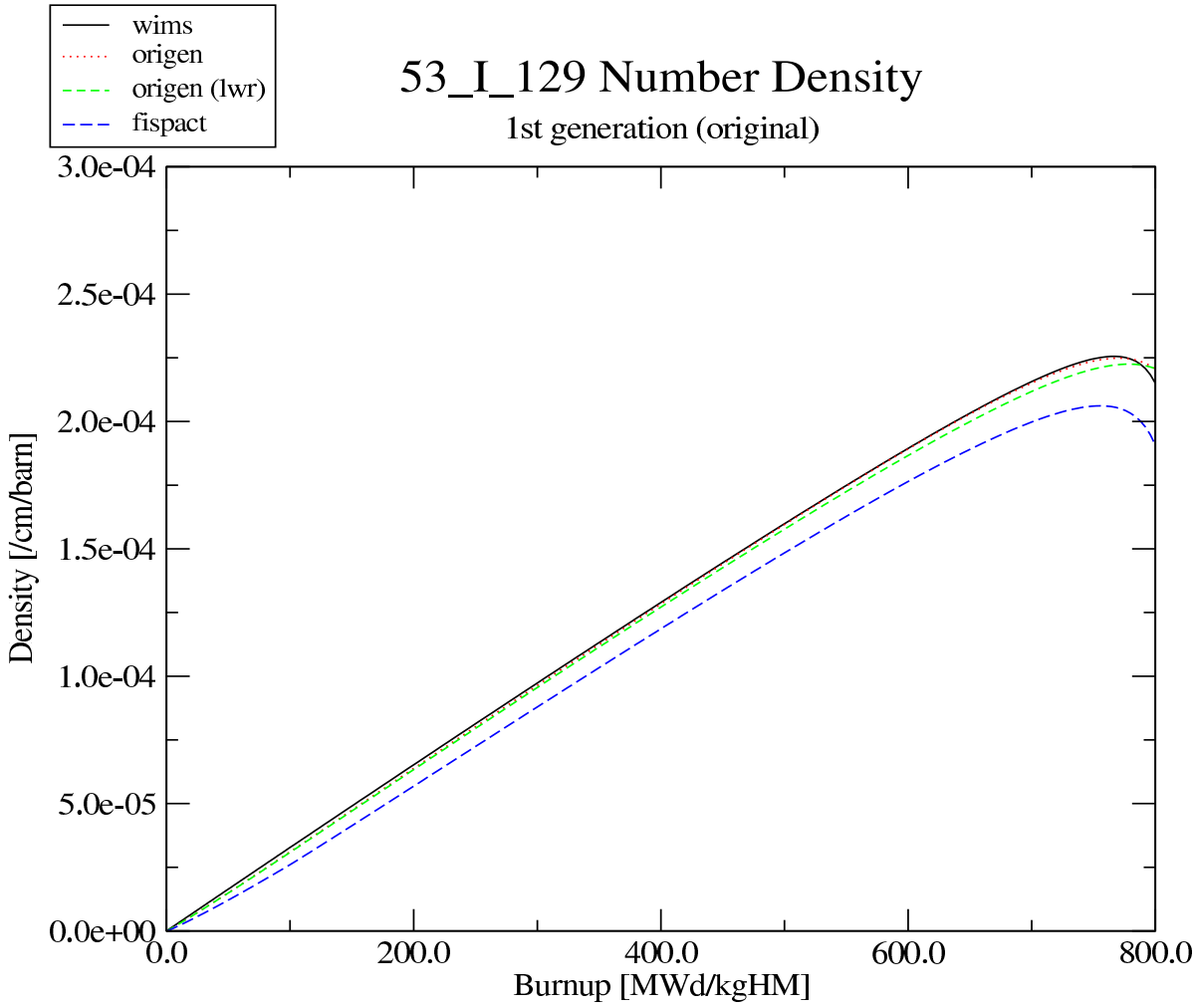


Figure 5.32 Number Density $[cm^{-1}barn^{-1}]$ 53_I_129 for case A1

Table 5.33 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_135 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	8.9056e-05	8.9532e-05	8.9454e-05	9.0054e-05
400.00	2.9688e-04	2.9557e-04	2.9593e-04	2.9778e-04
600.00	3.7335e-04	3.6903e-04	3.6980e-04	3.7070e-04
800.00	4.6978e-04	4.4389e-04	4.3232e-04	4.8520e-04

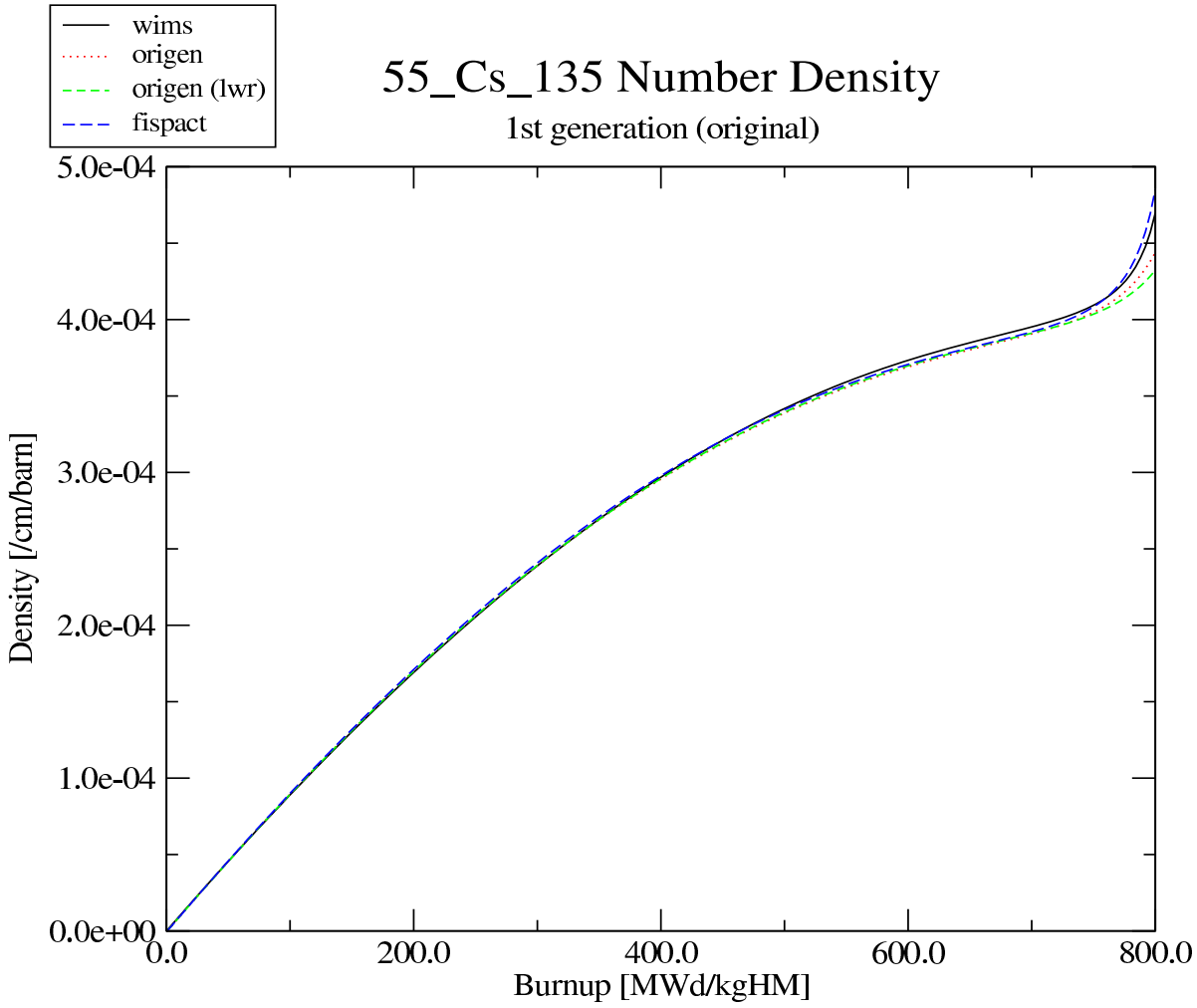


Figure 5.33 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_135 for case A1

Table 5.34 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_137 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	–	1.0000e-20	1.0000e-20	1.0000e-20
100.00	–	1.5766e-04	1.5658e-04	1.5607e-04
400.00	–	6.1844e-04	6.1143e-04	6.1531e-04
600.00	–	9.1352e-04	8.9838e-04	9.1301e-04
800.00	–	1.1766e-03	1.1501e-03	1.1869e-03

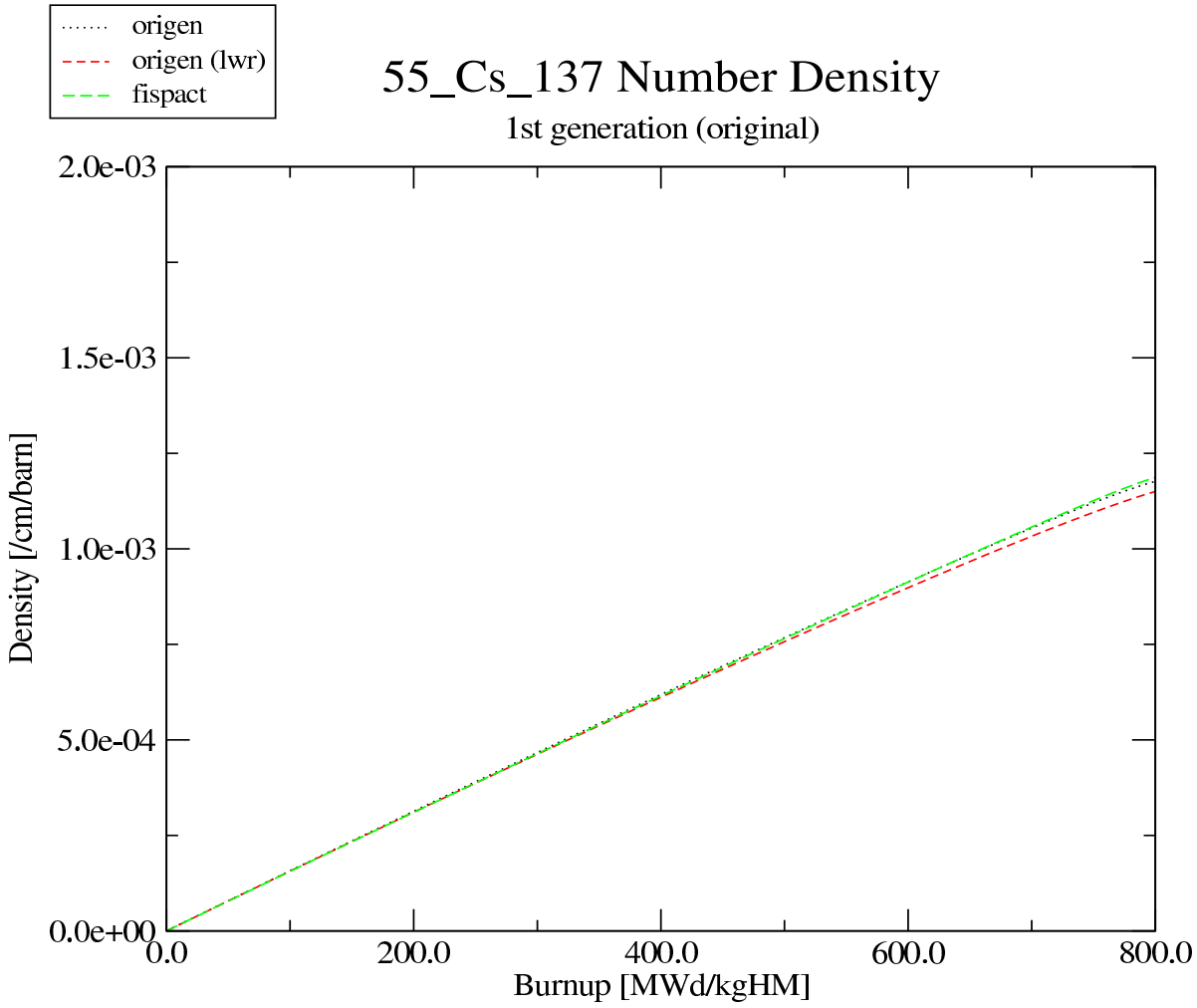


Figure 5.34 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_137 for case A1

Table 5.35 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_147 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	1.1815e-06	1.1859e-06	1.2005e-06	1.1951e-06
400.00	1.7813e-05	1.7596e-05	1.7980e-05	1.7976e-05
600.00	3.3148e-05	3.2259e-05	3.3310e-05	3.3225e-05
800.00	3.3778e-05	3.5689e-05	3.9156e-05	3.1509e-05

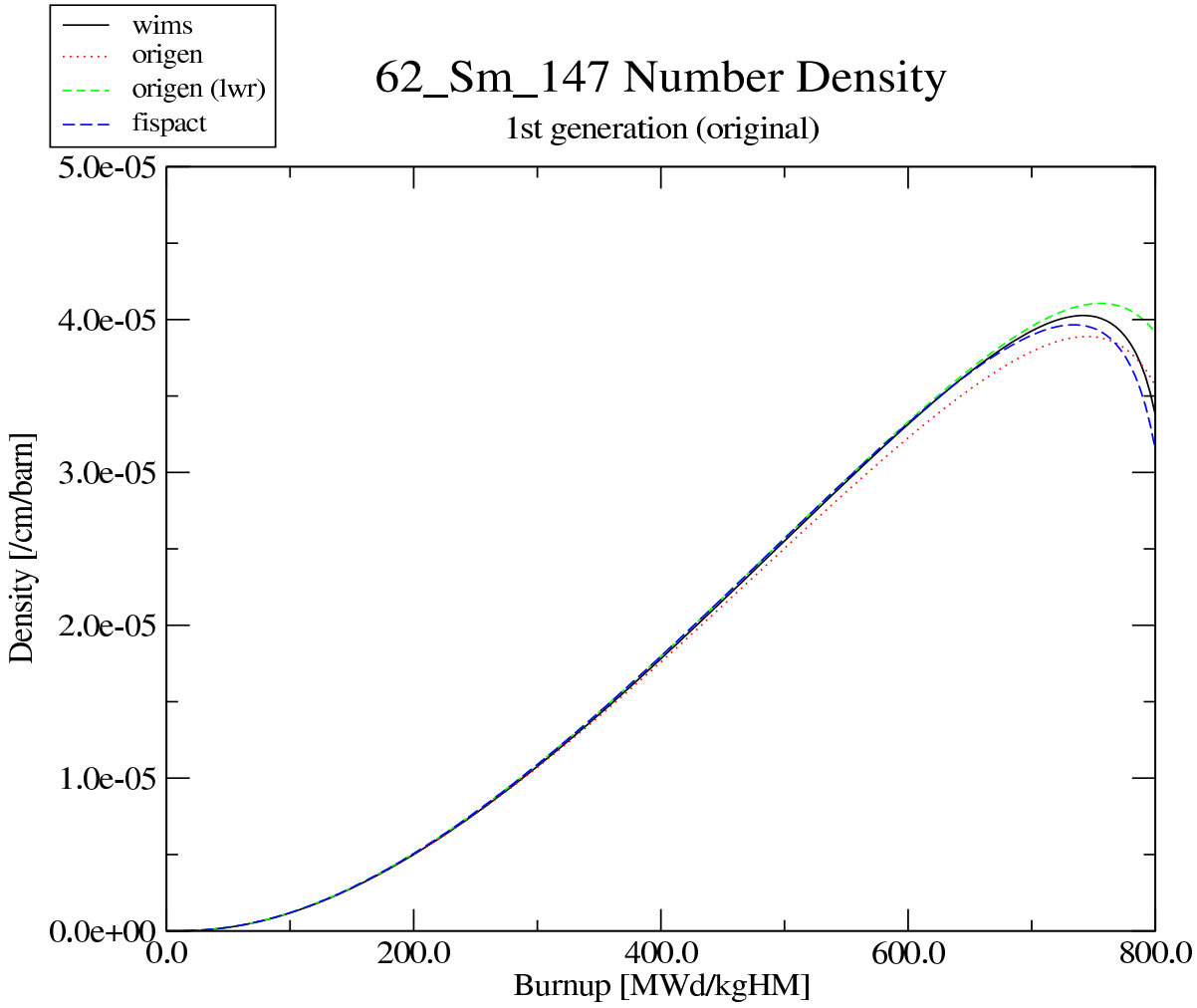


Figure 5.35 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_147 for case A1

Table 5.36 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_149 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	5.0847e-06	5.0135e-06	5.1457e-06	5.1941e-06
400.00	3.0757e-06	2.8467e-06	3.0020e-06	3.0453e-06
600.00	1.4210e-06	1.2607e-06	1.3693e-06	1.3525e-06
800.00	1.2372e-07	1.6412e-07	2.1784e-07	9.3064e-08

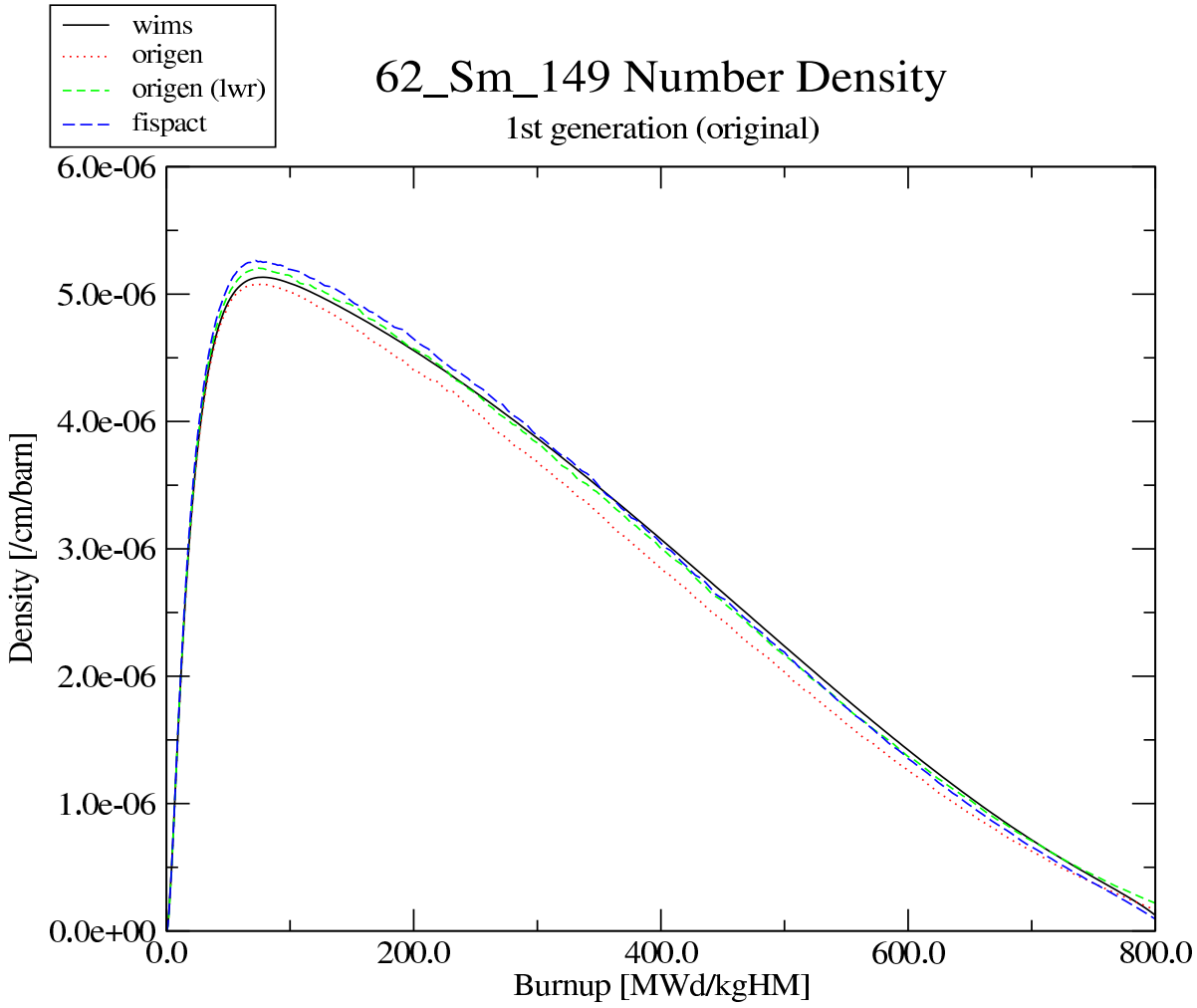


Figure 5.36 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_149 for case A1

Table 5.37 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_151 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	1.3172e-05	1.3106e-05	1.3316e-05	1.3733e-05
400.00	1.9198e-05	1.7998e-05	1.8823e-05	1.9394e-05
600.00	1.1025e-05	9.8322e-06	1.0613e-05	1.0701e-05
800.00	3.5747e-06	3.5675e-06	3.9695e-06	3.4314e-06

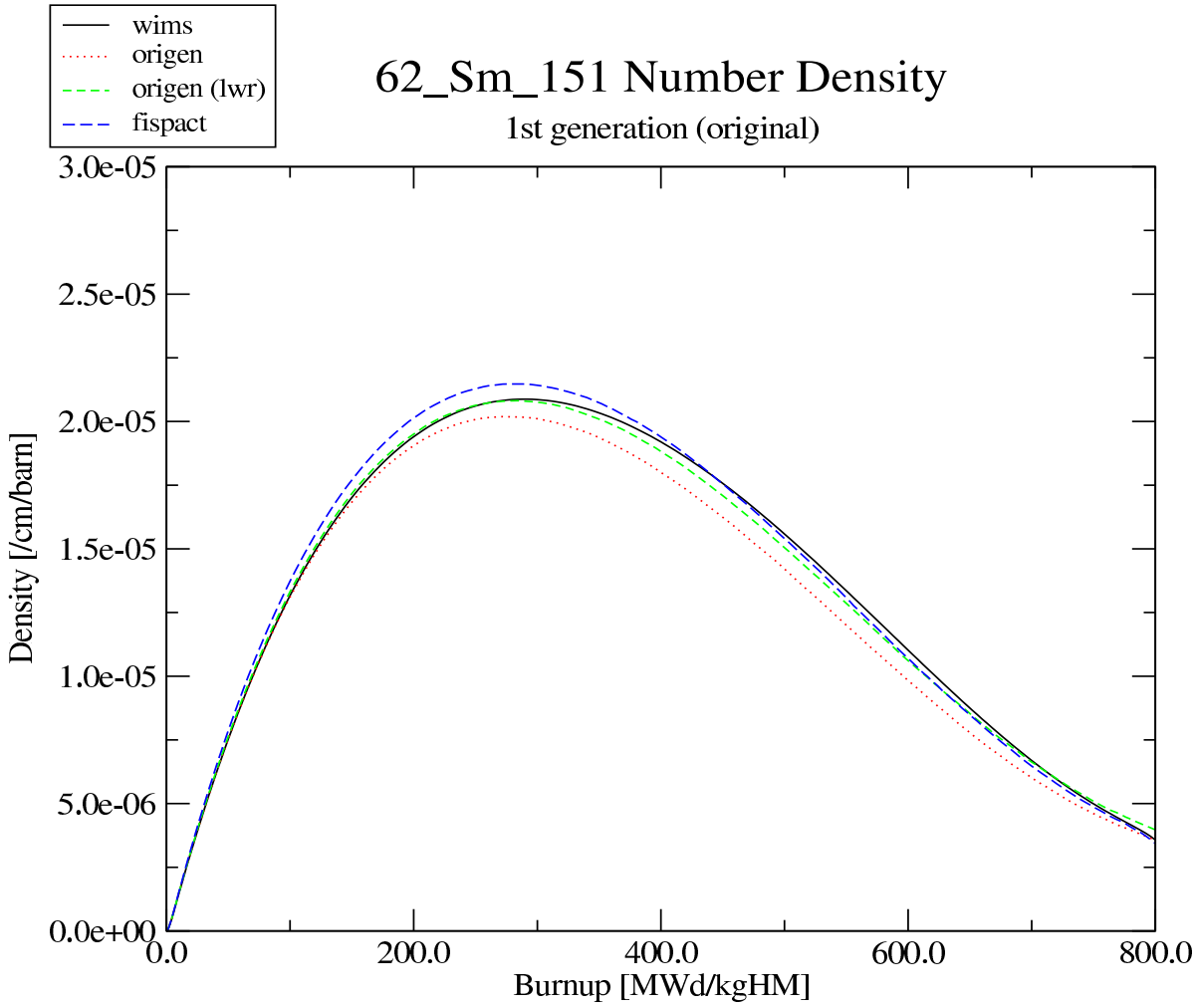


Figure 5.37 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_151 for case A1

Table 5.38 Number Density $[cm^{-1}barn^{-1}]$ 63_Eu_154 for case A1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	5.5396e-07	5.3656e-07	5.5613e-07	6.0532e-07
400.00	1.0877e-05	1.0515e-05	1.1082e-05	1.1828e-05
600.00	2.7552e-05	2.6404e-05	2.8113e-05	2.9852e-05
800.00	4.8263e-05	4.6476e-05	5.1744e-05	4.7436e-05

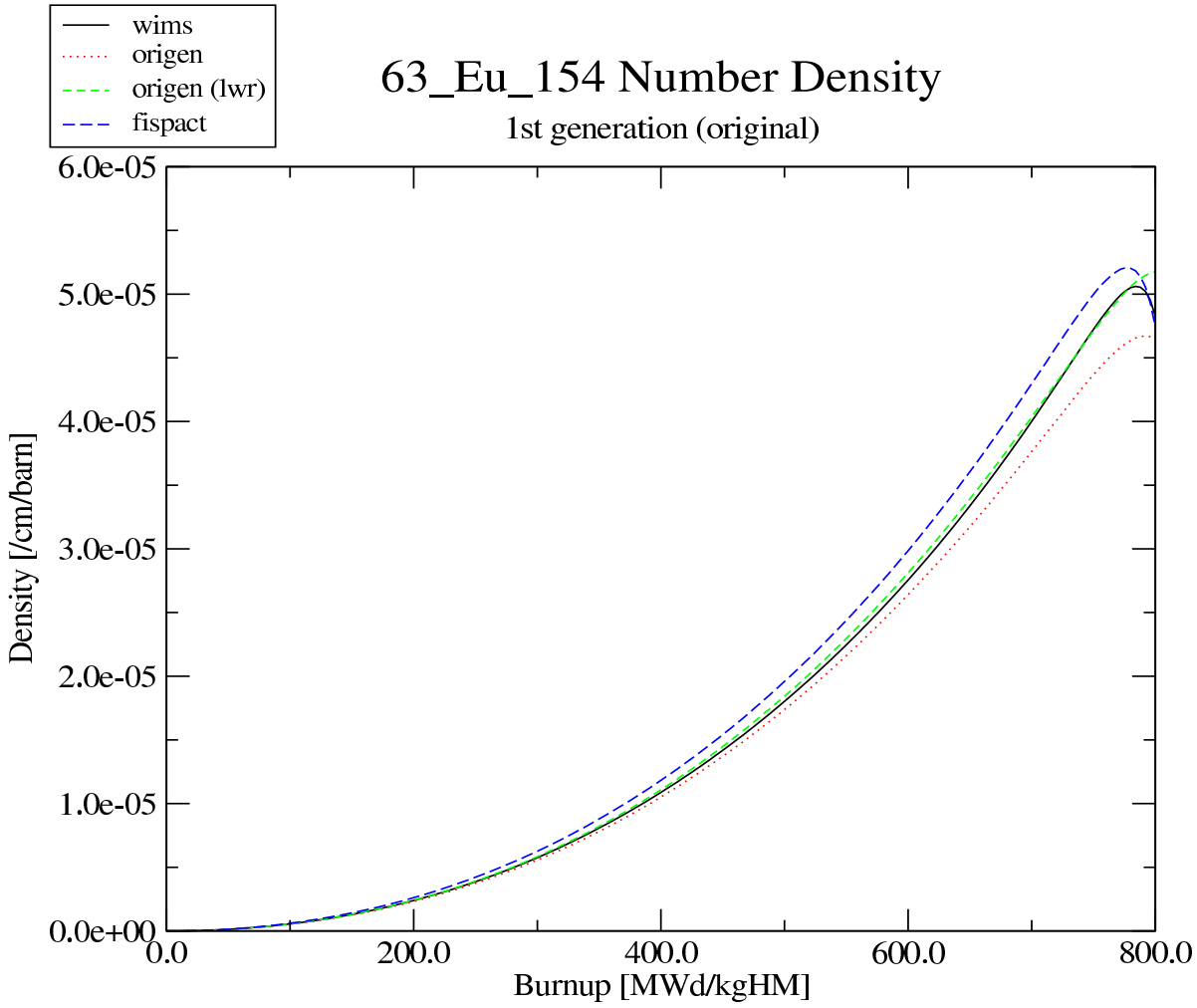


Figure 5.38 Number Density $[cm^{-1}barn^{-1}]$ 63_Eu_154 for case A1

Table 5.39 Number Density [$cm^{-1}barn^{-1}$] 54_Xe_135 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS ORIGEN (LWR)	OCTOPUS FISPACT
0.00	1.0000e-19	1.0000e-20	1.0000e-20	1.0000e-20
100.00	4.6685e-07	4.6660e-07	4.6912e-07	4.7809e-07
400.00	2.8590e-07	2.7562e-07	2.7648e-07	2.8014e-07
600.00	1.2859e-07	1.2004e-07	1.2292e-07	1.1785e-07
800.00	3.1327e-09	5.4624e-09	7.8255e-09	2.1043e-09

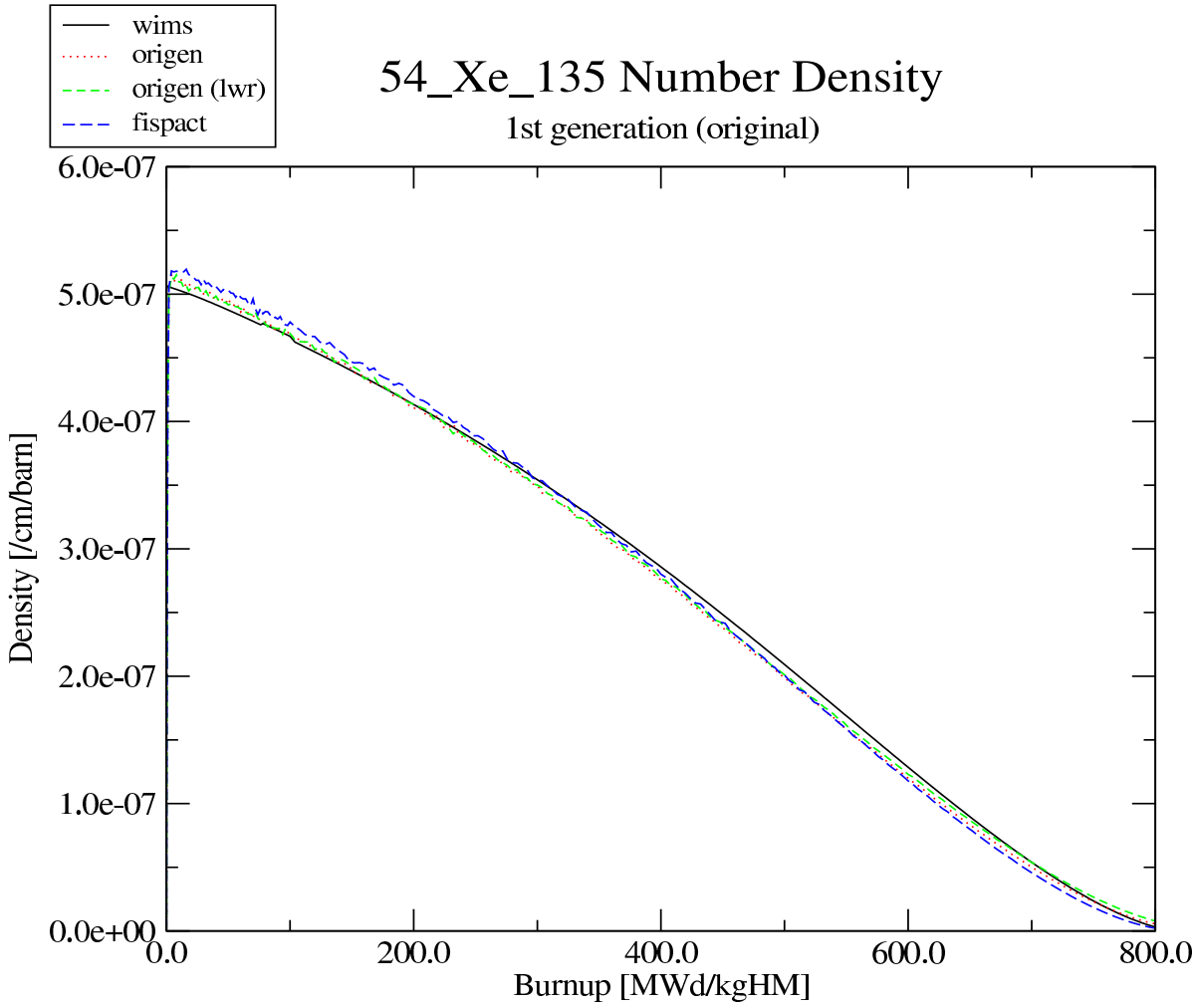


Figure 5.39 Number Density [$cm^{-1}barn^{-1}$] 54_Xe_135 for case A1

Table 5.40 Absorption Cross Section [$barn$] 94_Pu_238 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.5900e+01	2.5900e+01	2.5343e+01	2.5343e+01
100.00	2.7520e+01	2.7520e+01	2.7412e+01	2.7456e+01
400.00	4.2776e+01	4.2776e+01	4.3741e+01	4.4184e+01
600.00	7.3227e+01	7.3227e+01	7.6594e+01	7.7580e+01
800.00	1.5723e+02	1.5723e+02	1.5745e+02	1.6441e+02

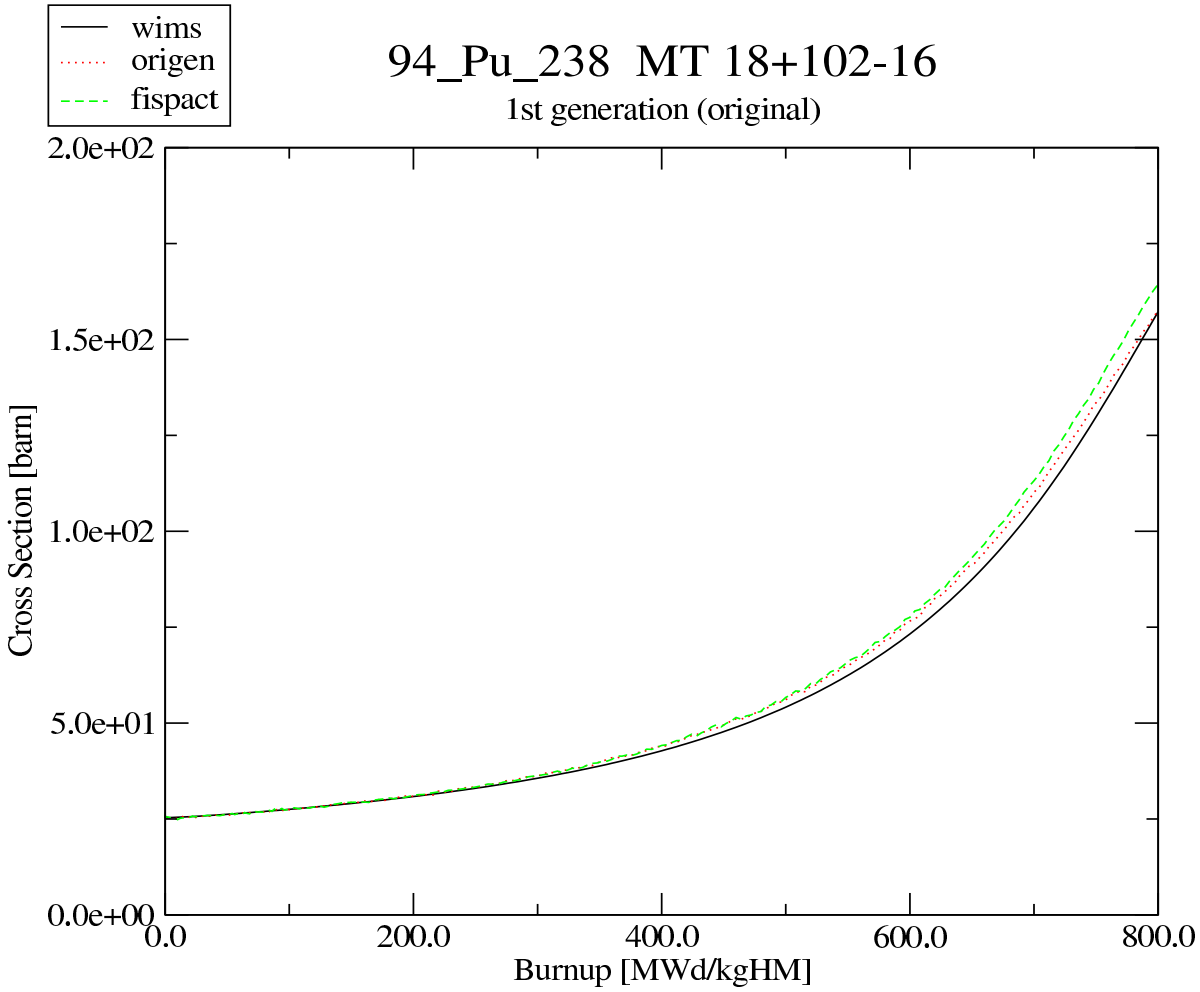


Figure 5.40 Absorption Cross Section [$barn$] 94_Pu_238 for case A1

Table 5.41 Absorption Cross Section [*barn*] 94_Pu_239 for case A1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.6835e+02	1.6835e+02	1.6951e+02	1.6951e+02
100.00	1.8722e+02	1.8722e+02	1.9157e+02	1.9163e+02
400.00	3.2941e+02	3.2941e+02	3.3962e+02	3.4284e+02
600.00	5.9449e+02	5.9449e+02	6.0760e+02	6.1982e+02
800.00	1.2513e+03	1.2513e+03	1.2151e+03	1.2679e+03

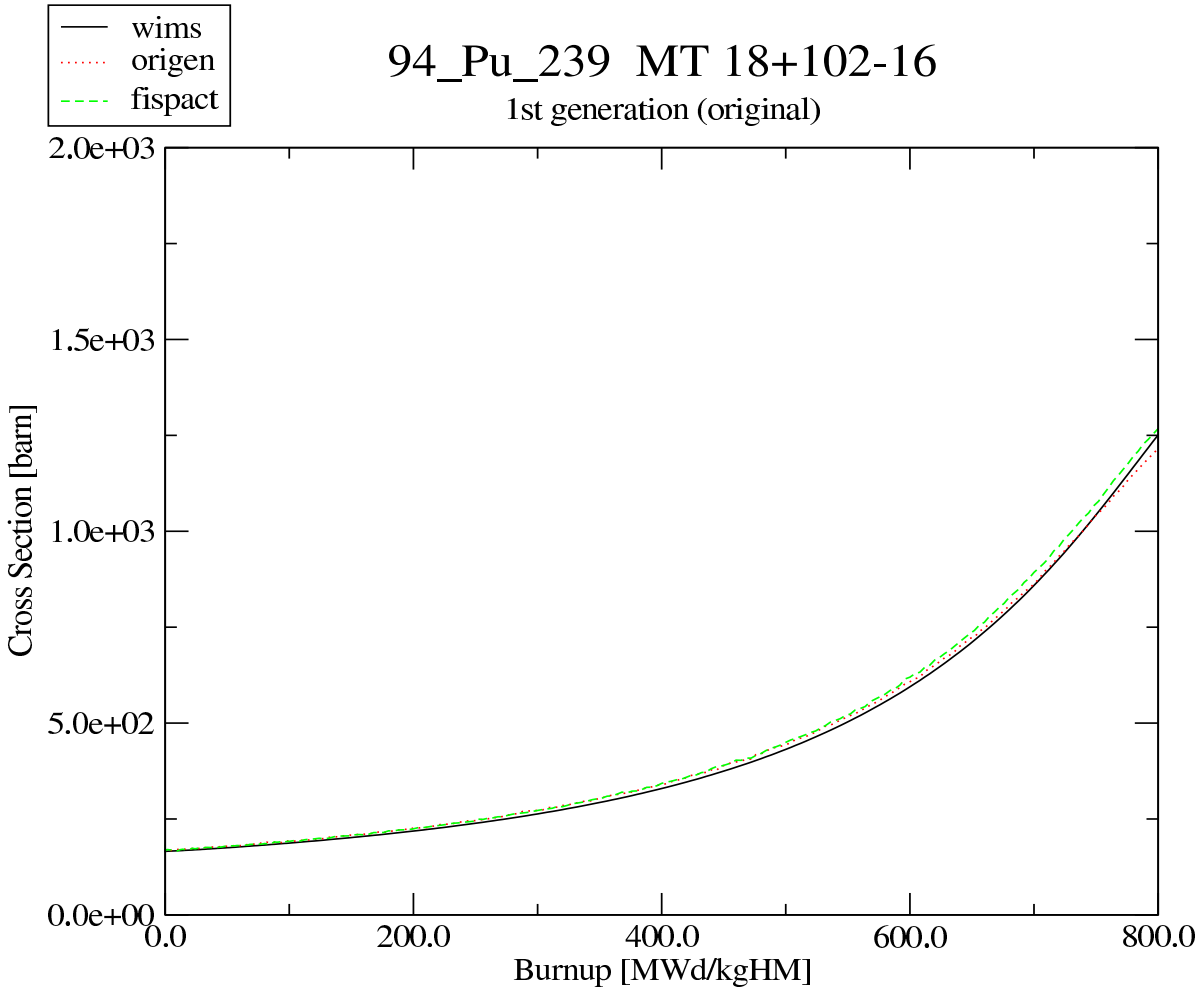


Figure 5.41 Absorption Cross Section [*barn*] 94_Pu_239 for case A1

Table 5.42 Absorption Cross Section [$barn$] 94_Pu_240 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.4663e+02	1.4663e+02	1.4292e+02	1.4292e+02
100.00	1.4629e+02	1.4629e+02	1.4299e+02	1.4244e+02
400.00	1.5940e+02	1.5940e+02	1.5645e+02	1.5522e+02
600.00	1.8936e+02	1.8936e+02	1.8646e+02	1.8857e+02
800.00	2.3815e+02	2.3815e+02	2.3073e+02	2.2996e+02

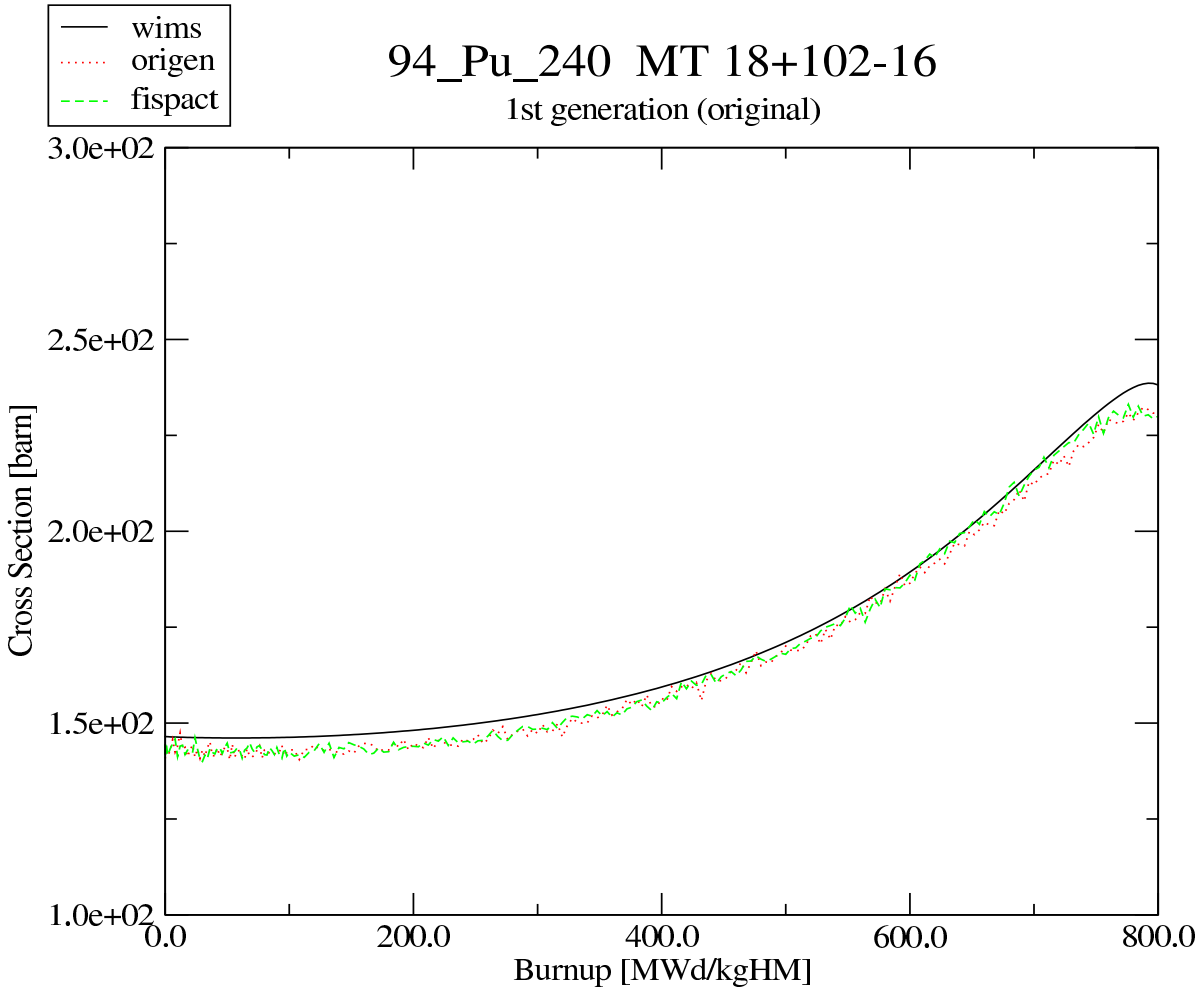


Figure 5.42 Absorption Cross Section [$barn$] 94_Pu_240 for case A1

Table 5.43 Absorption Cross Section [*barn*] 94_Pu_241 for case A1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.4381e+02	1.4381e+02	1.4134e+02	1.4134e+02
100.00	1.5637e+02	1.5637e+02	1.5554e+02	1.5578e+02
400.00	2.5582e+02	2.5582e+02	2.6117e+02	2.6328e+02
600.00	4.4676e+02	4.4676e+02	4.6236e+02	4.6960e+02
800.00	9.4945e+02	9.4945e+02	9.3705e+02	9.7858e+02

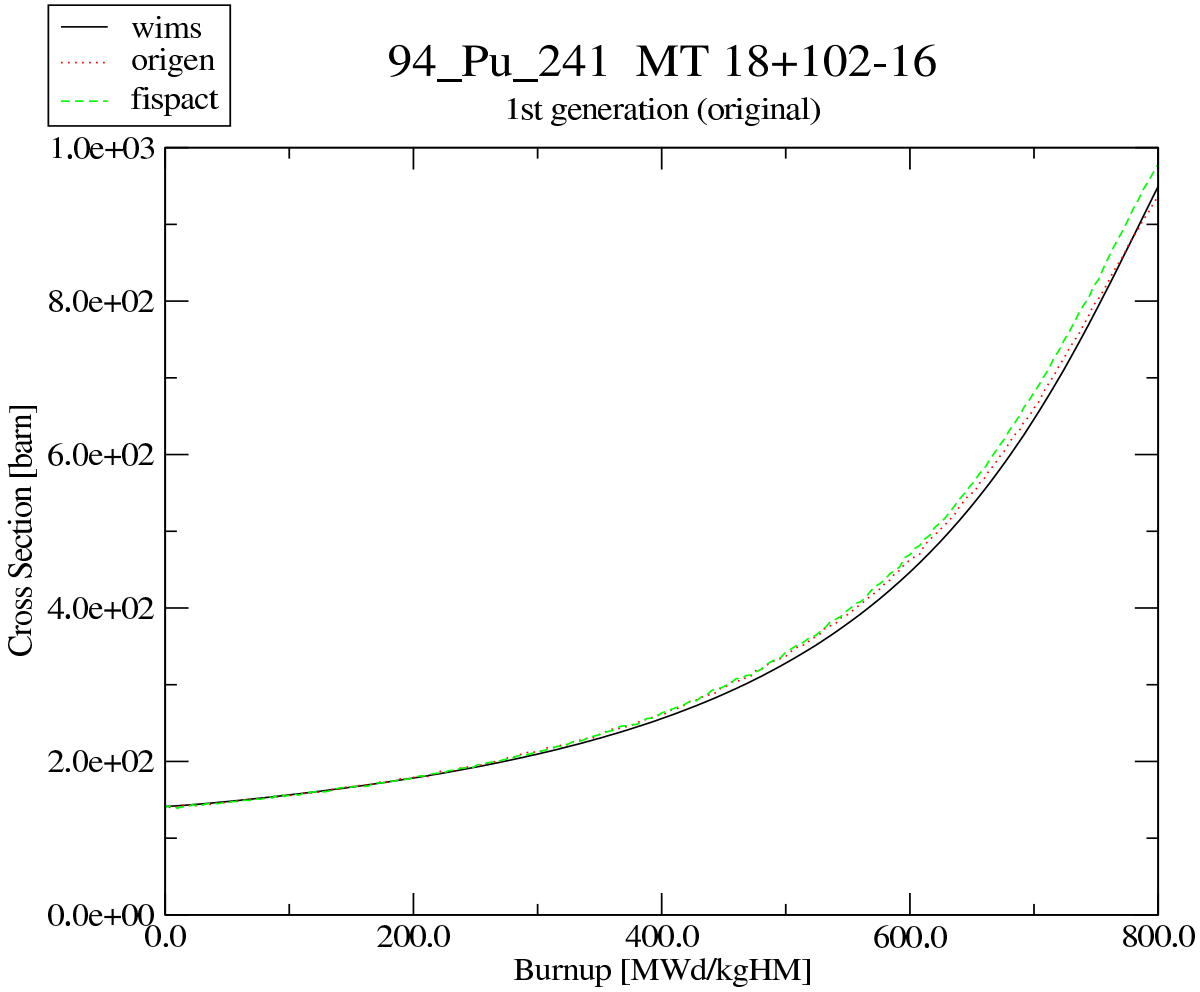


Figure 5.43 Absorption Cross Section [*barn*] 94_Pu_241 for case A1

Table 5.44 Absorption Cross Section [*barn*] 94_Pu_242 for case A1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.9318e+01	4.9319e+01	4.9308e+01	4.9308e+01
100.00	4.8546e+01	4.8547e+01	4.9036e+01	5.0225e+01
400.00	4.2117e+01	4.2118e+01	4.2342e+01	4.2697e+01
600.00	3.2807e+01	3.2808e+01	3.2073e+01	3.2747e+01
800.00	1.5107e+01	1.5107e+01	1.5991e+01	1.4835e+01

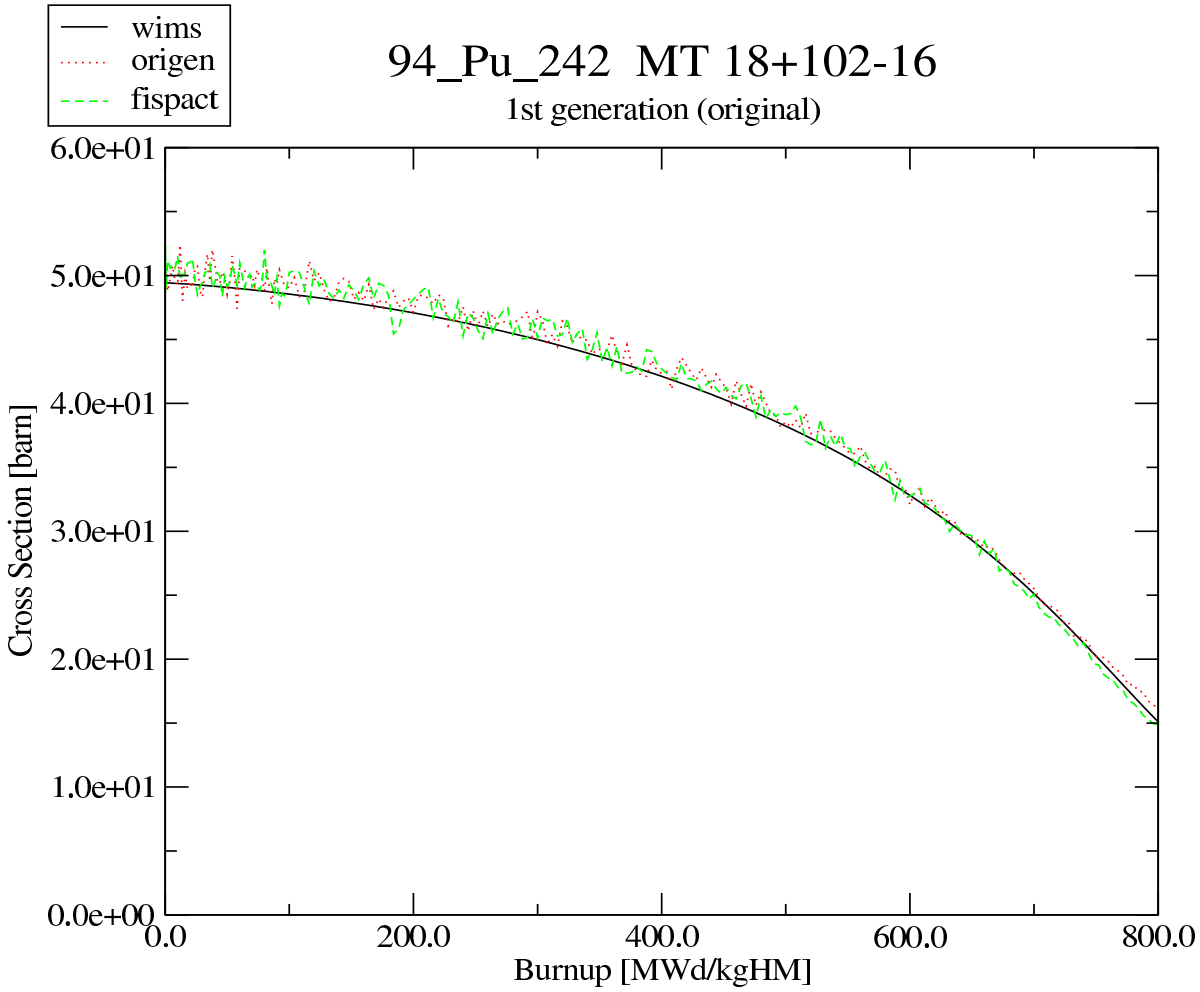


Figure 5.44 Absorption Cross Section [*barn*] 94_Pu_242 for case A1

Table 5.45 Absorption Cross Section [$barn$] 95_Am_241 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5396e+02	1.5396e+02	1.4940e+02	1.4940e+02
100.00	1.6408e+02	1.6408e+02	1.6065e+02	1.6117e+02
400.00	2.3409e+02	2.3409e+02	2.3178e+02	2.3470e+02
600.00	3.6080e+02	3.6080e+02	3.6079e+02	3.6810e+02
800.00	6.7046e+02	6.7046e+02	6.4221e+02	6.6612e+02

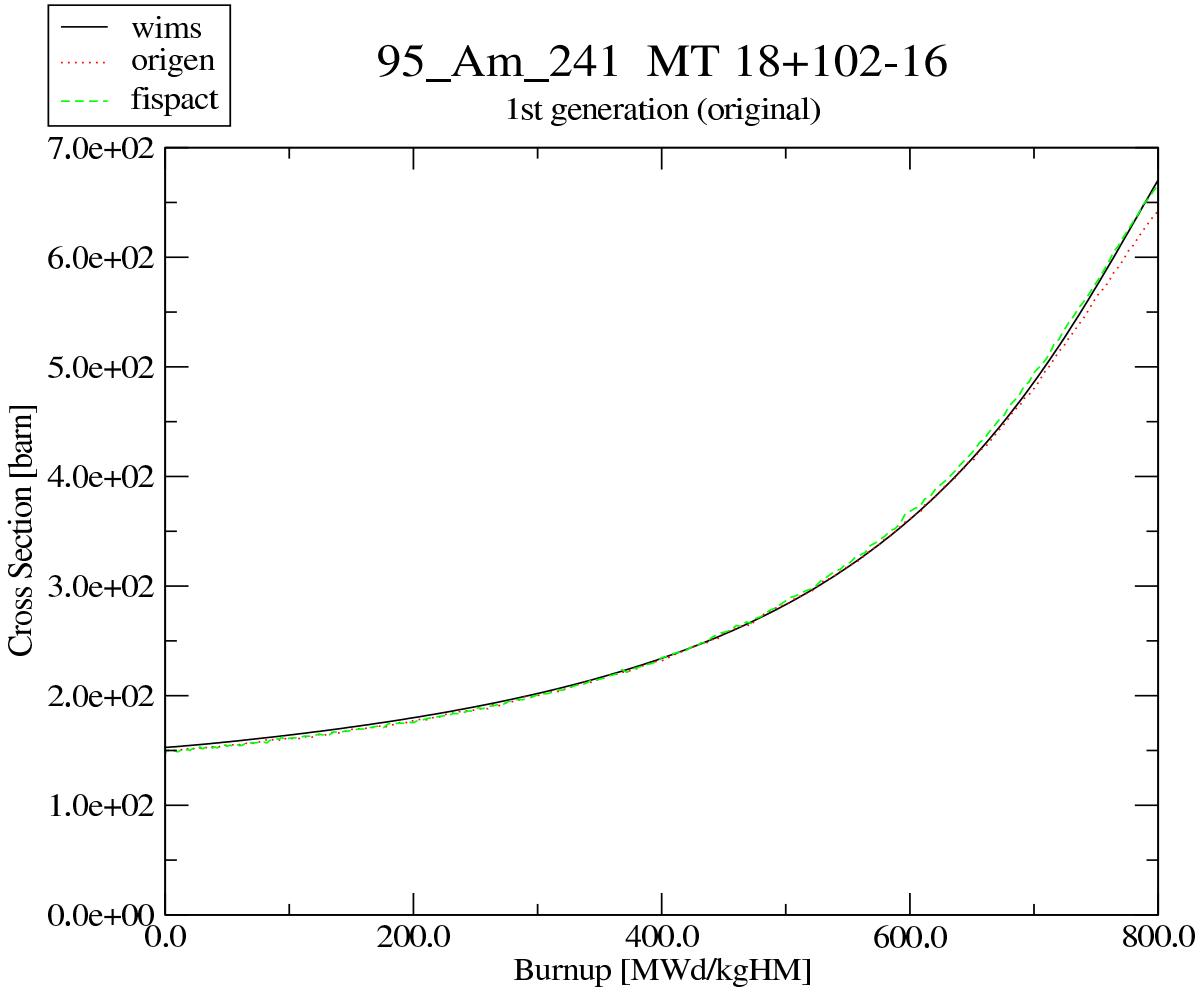


Figure 5.45 Absorption Cross Section [$barn$] 95_Am_241 for case A1

Table 5.46 Absorption Cross Section [$barn$] 95_Am_242 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	3.8512e+02	3.8512e+02
100.00	–	–	4.2137e+02	4.2323e+02
400.00	–	–	7.2333e+02	7.2930e+02
600.00	–	–	1.3202e+03	1.3380e+03
800.00	–	–	2.7739e+03	2.9003e+03

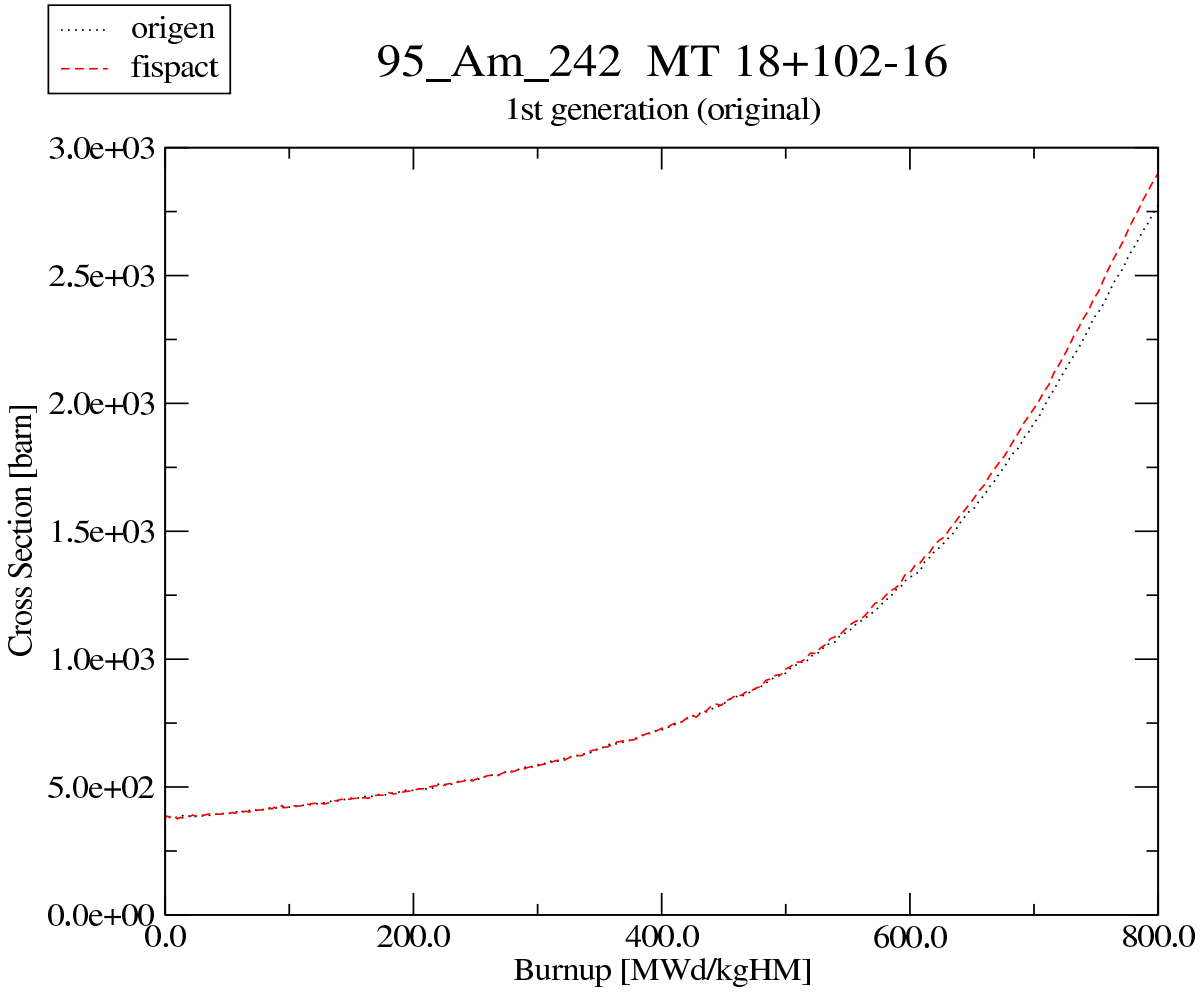


Figure 5.46 Absorption Cross Section [$barn$] 95_Am_242 for case A1

Table 5.47 Absorption Cross Section [$barn$] 95_Am_242m for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.5165e+02	6.5165e+02	6.3744e+02	6.3744e+02
100.00	7.1016e+02	7.1016e+02	7.0299e+02	7.0713e+02
400.00	1.2152e+03	1.2152e+03	1.2429e+03	1.2531e+03
600.00	2.2009e+03	2.2009e+03	2.2909e+03	2.3237e+03
800.00	4.8526e+03	4.8526e+03	4.8135e+03	5.0355e+03

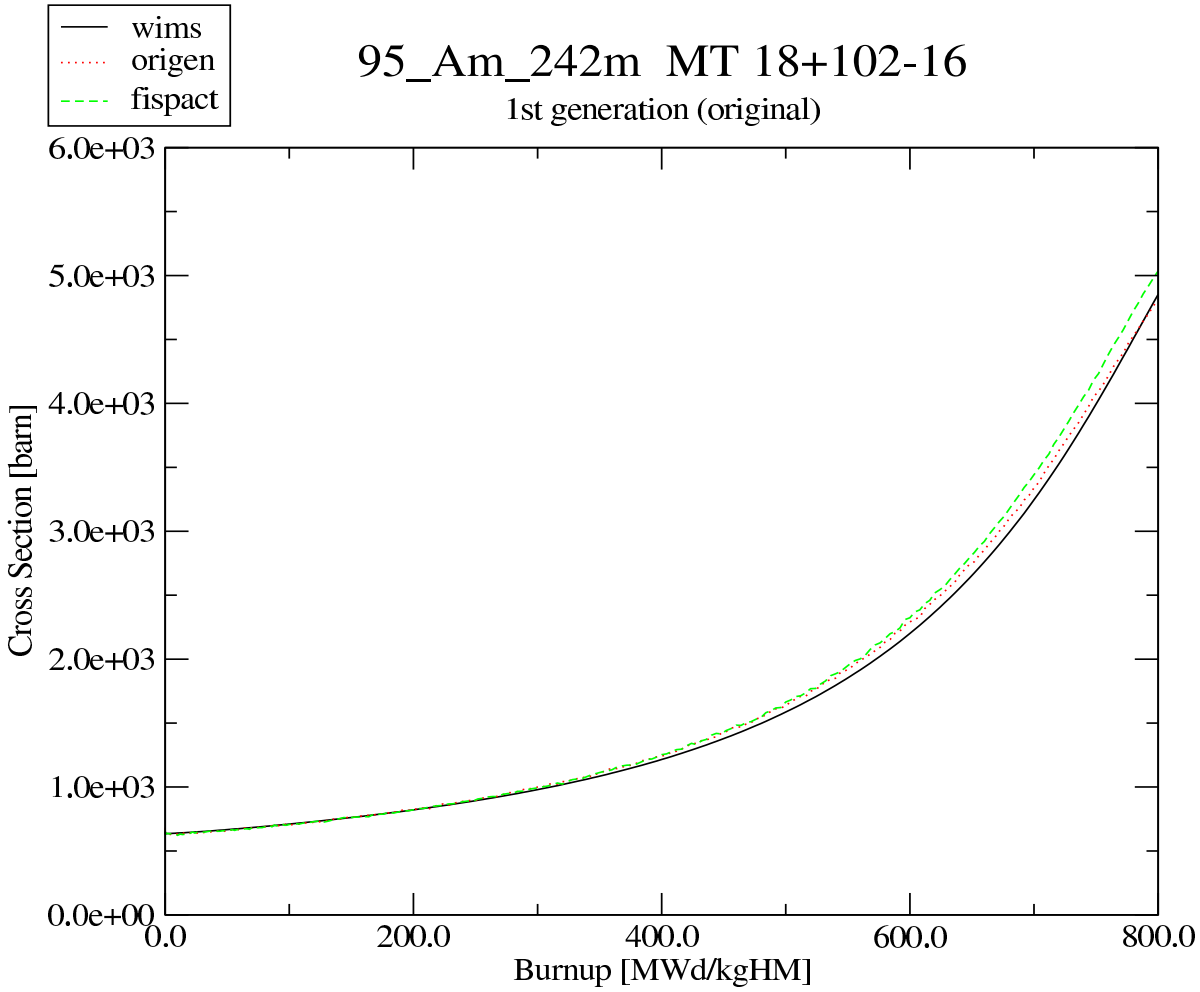


Figure 5.47 Absorption Cross Section [$barn$] 95_Am_242m for case A1

Table 5.48 Absorption Cross Section [$barn$] 95_Am_243 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.5211e+01	9.5212e+01	9.5794e+01	9.5794e+01
100.00	9.3834e+01	9.3835e+01	9.3295e+01	9.5232e+01
400.00	8.6675e+01	8.6675e+01	8.7336e+01	8.7123e+01
600.00	7.6578e+01	7.6578e+01	7.7193e+01	7.7590e+01
800.00	5.0981e+01	5.0981e+01	5.2367e+01	4.9781e+01

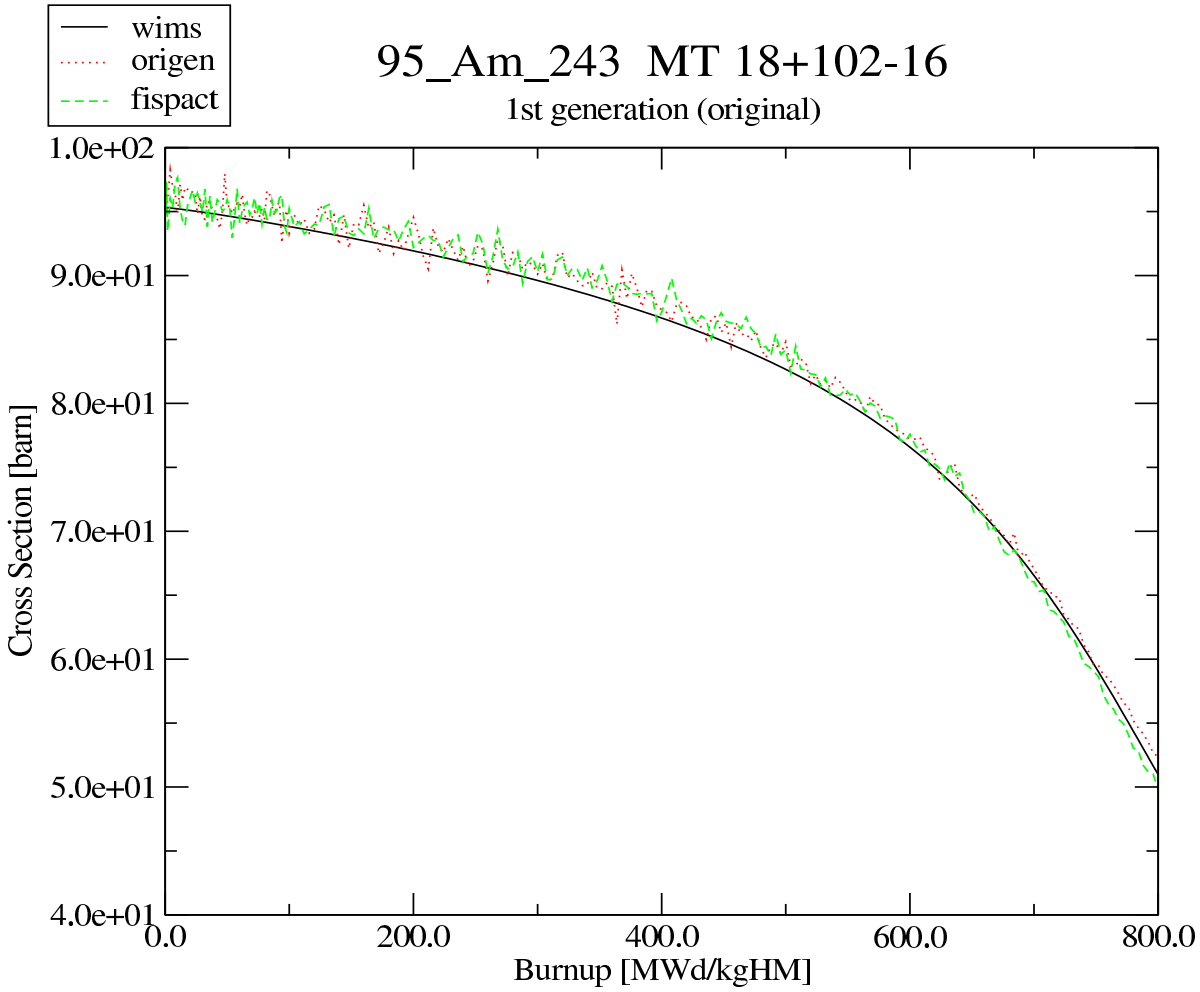


Figure 5.48 Absorption Cross Section [$barn$] 95_Am_243 for case A1

Table 5.49 Absorption Cross Section [$barn$] 96_Cm_242 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.2965e+00	7.2966e+00	7.3578e+00	7.3578e+00
100.00	7.3300e+00	7.3301e+00	7.4340e+00	7.4463e+00
400.00	7.5744e+00	7.5745e+00	7.6437e+00	7.6029e+00
600.00	8.0556e+00	8.0557e+00	8.2613e+00	8.2918e+00
800.00	9.4071e+00	9.4071e+00	9.5161e+00	9.5890e+00

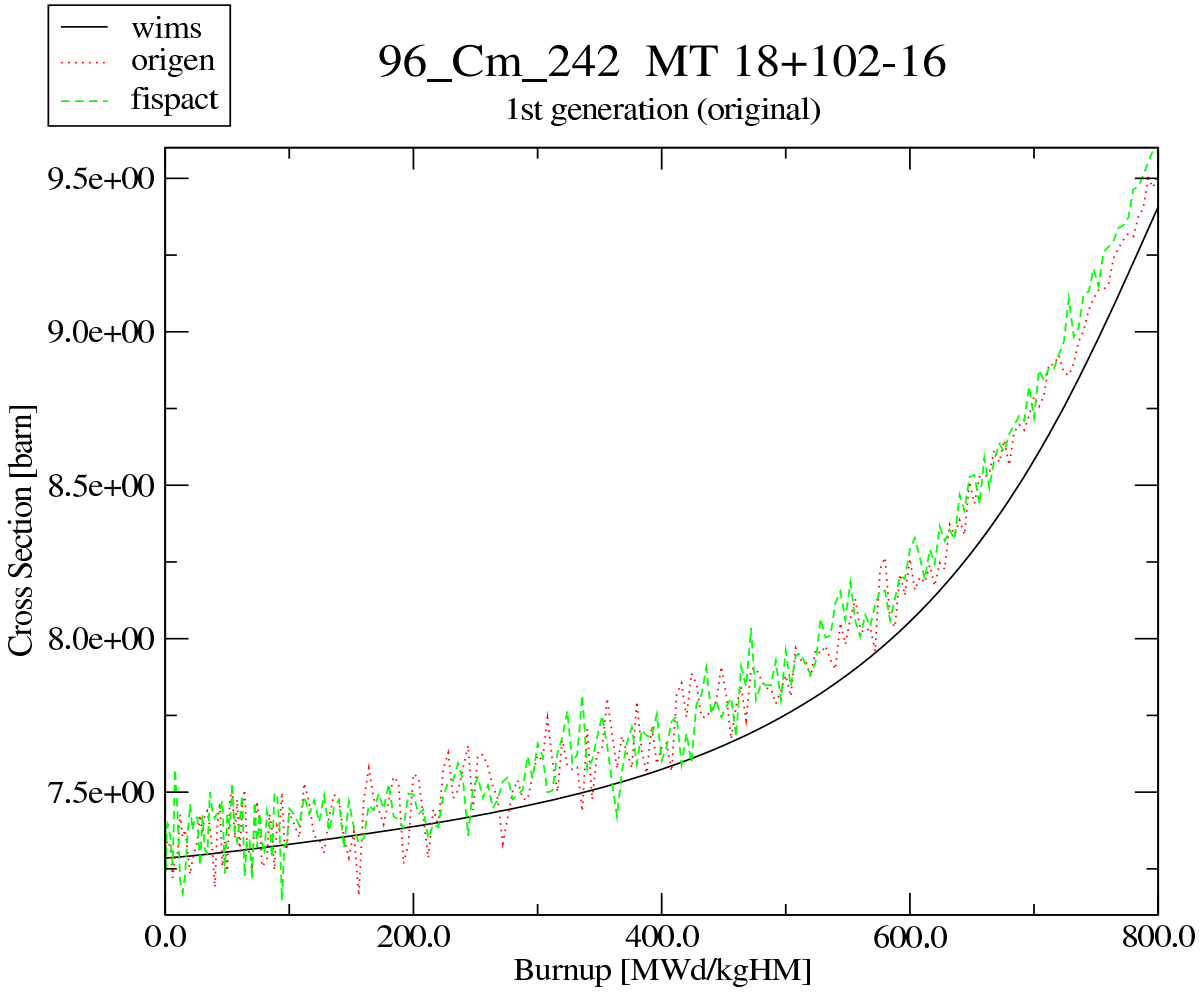


Figure 5.49 Absorption Cross Section [$barn$] 96_Cm_242 for case A1

Table 5.50 Absorption Cross Section [*barn*] 96_Cm_243 for case A1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3068e+02	1.3068e+02	1.2772e+02	1.2772e+02
100.00	1.3203e+02	1.3203e+02	1.2985e+02	1.3004e+02
400.00	1.4486e+02	1.4486e+02	1.4473e+02	1.4489e+02
600.00	1.7166e+02	1.7166e+02	1.7447e+02	1.7546e+02
800.00	2.4437e+02	2.4437e+02	2.4377e+02	2.4951e+02

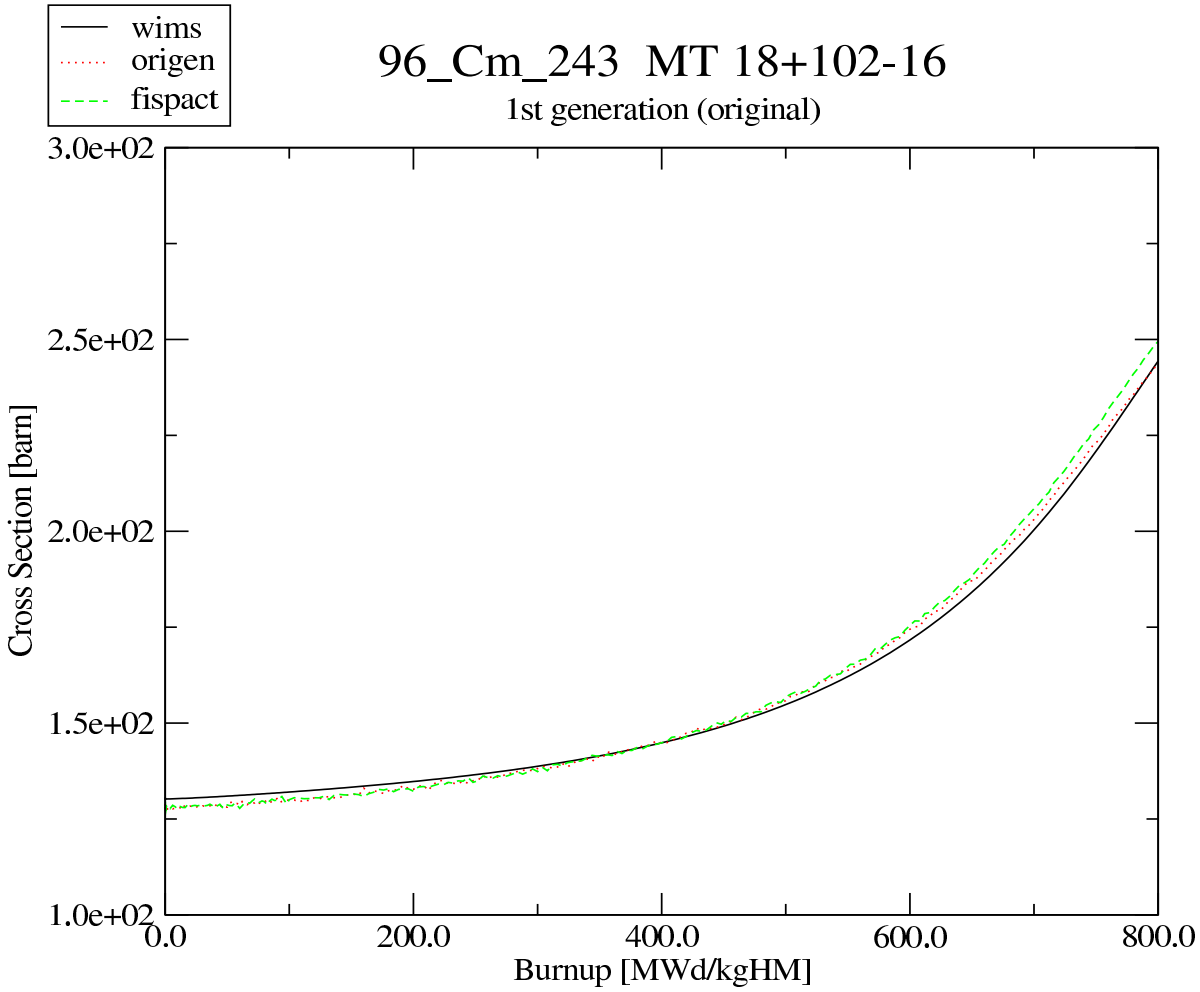


Figure 5.50 Absorption Cross Section [*barn*] 96_Cm_243 for case A1

Table 5.51 Absorption Cross Section [$barn$] 96_Cm_244 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.1503e+01	3.1503e+01	2.8114e+01	2.8114e+01
100.00	3.1466e+01	3.1466e+01	2.9014e+01	2.8763e+01
400.00	2.9031e+01	2.9031e+01	2.7597e+01	2.7250e+01
600.00	2.4129e+01	2.4129e+01	2.2548e+01	2.2250e+01
800.00	1.1433e+01	1.1433e+01	1.0307e+01	8.7317e+00

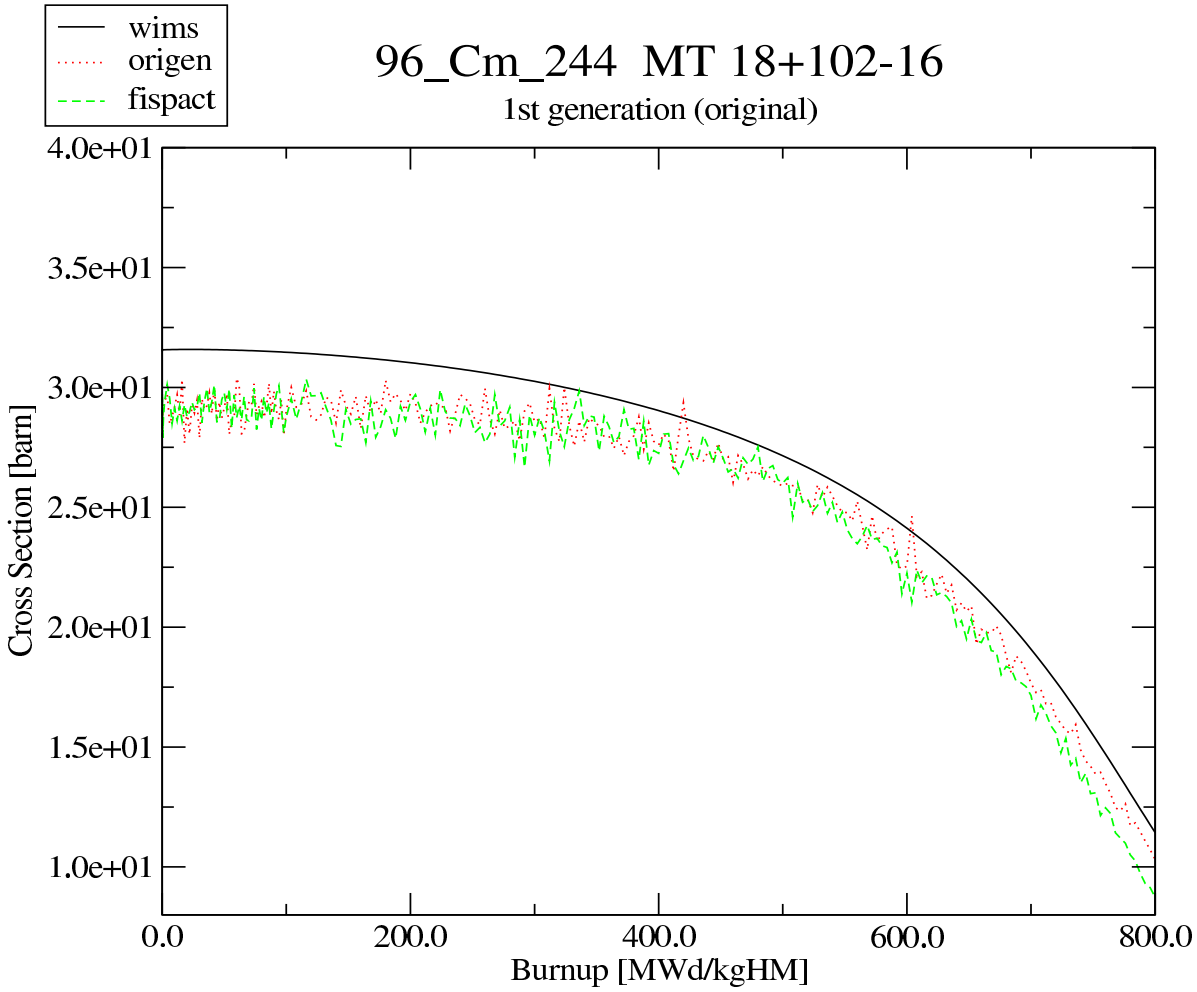


Figure 5.51 Absorption Cross Section [$barn$] 96_Cm_244 for case A1

Table 5.52 Absorption Cross Section [$barn$] 96_Cm_245 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.2049e+02	1.2049e+02	1.1824e+02	1.1824e+02
100.00	1.2768e+02	1.2768e+02	1.2738e+02	1.2748e+02
400.00	1.9483e+02	1.9483e+02	1.9926e+02	2.0070e+02
600.00	3.2866e+02	3.2866e+02	3.4337e+02	3.4753e+02
800.00	6.9605e+02	6.9605e+02	6.9595e+02	7.2621e+02

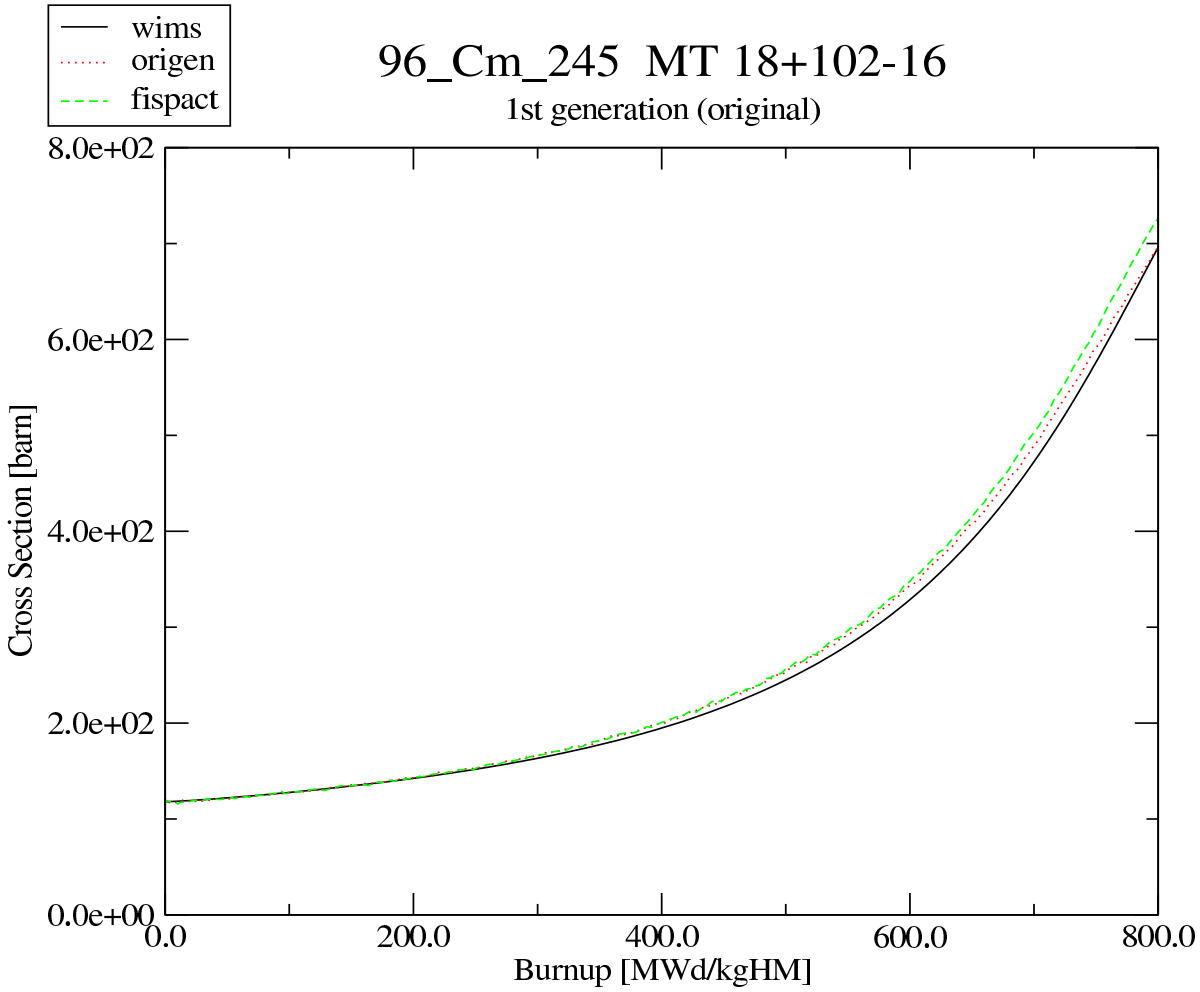


Figure 5.52 Absorption Cross Section [$barn$] 96_Cm_245 for case A1

Table 5.53 Absorption Cross Section [$barn$] 40_Zr_93 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.7777e+00	1.7783e+00	1.8140e+00	1.8140e+00
100.00	1.7661e+00	1.7667e+00	1.7503e+00	1.8712e+00
400.00	1.6691e+00	1.6696e+00	1.6505e+00	1.6902e+00
600.00	1.4812e+00	1.4816e+00	1.4739e+00	1.4849e+00
800.00	9.9757e-01	9.9769e-01	1.0237e+00	9.8169e-01

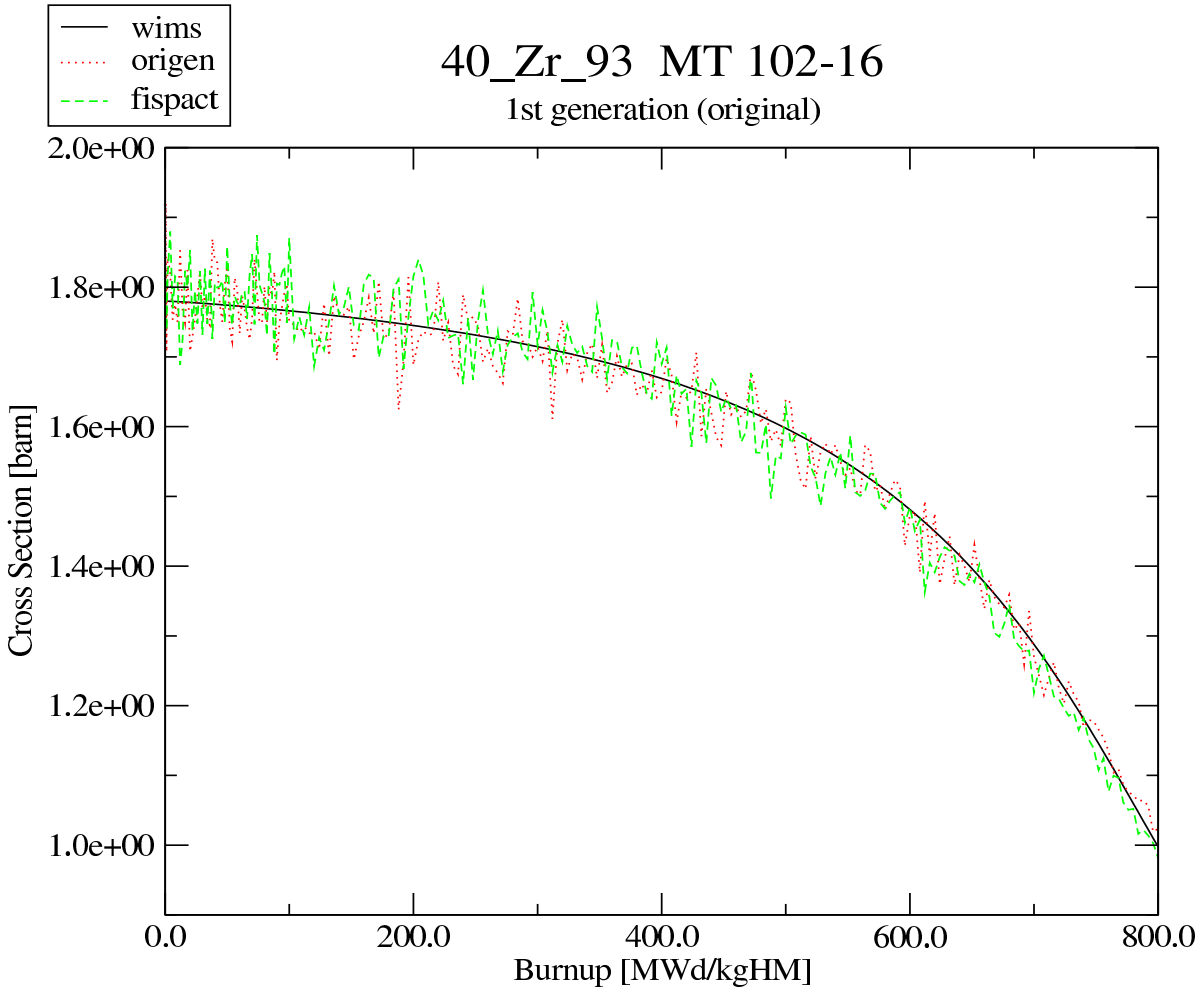


Figure 5.53 Absorption Cross Section [$barn$] 40_Zr_93 for case A1

Table 5.54 Absorption Cross Section [$barn$] 43_Tc_99 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5773e+01	1.5773e+01	1.6079e+01	1.6079e+01
100.00	1.5607e+01	1.5607e+01	1.5667e+01	1.5499e+01
400.00	1.4722e+01	1.4722e+01	1.4573e+01	1.4730e+01
600.00	1.3483e+01	1.3483e+01	1.3974e+01	1.3786e+01
800.00	1.0400e+01	1.0400e+01	1.0967e+01	1.0678e+01

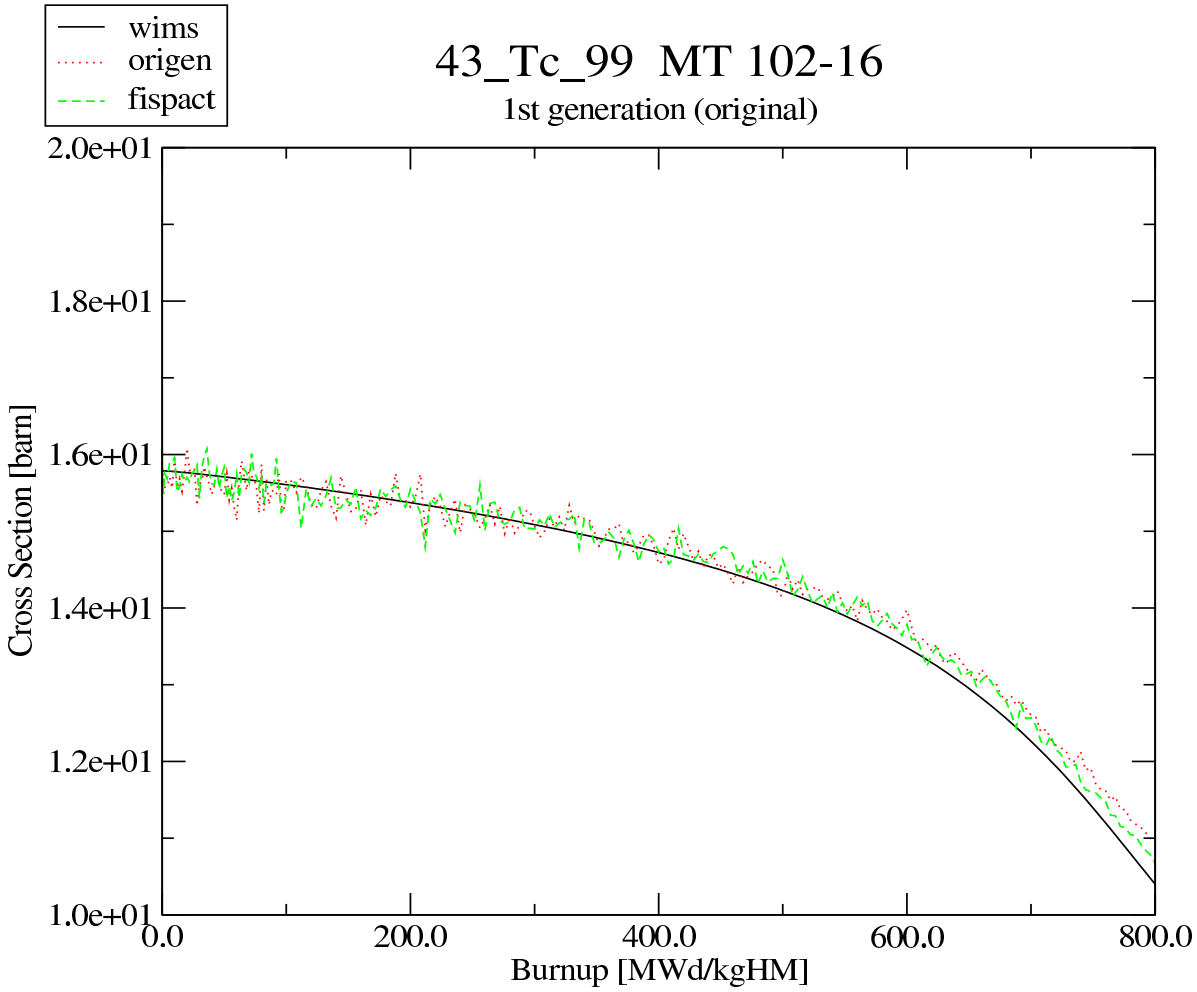


Figure 5.54 Absorption Cross Section [$barn$] 43_Tc_99 for case A1

Table 5.55 Absorption Cross Section [$barn$] 46_Pd_107 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.4550e+00	5.4568e+00	5.5044e+00	5.5044e+00
100.00	5.4080e+00	5.4098e+00	5.3588e+00	5.3023e+00
400.00	4.9471e+00	4.9488e+00	4.9577e+00	4.9290e+00
600.00	4.0409e+00	4.0422e+00	3.9418e+00	3.9846e+00
800.00	1.6554e+00	1.6557e+00	1.7628e+00	1.5687e+00

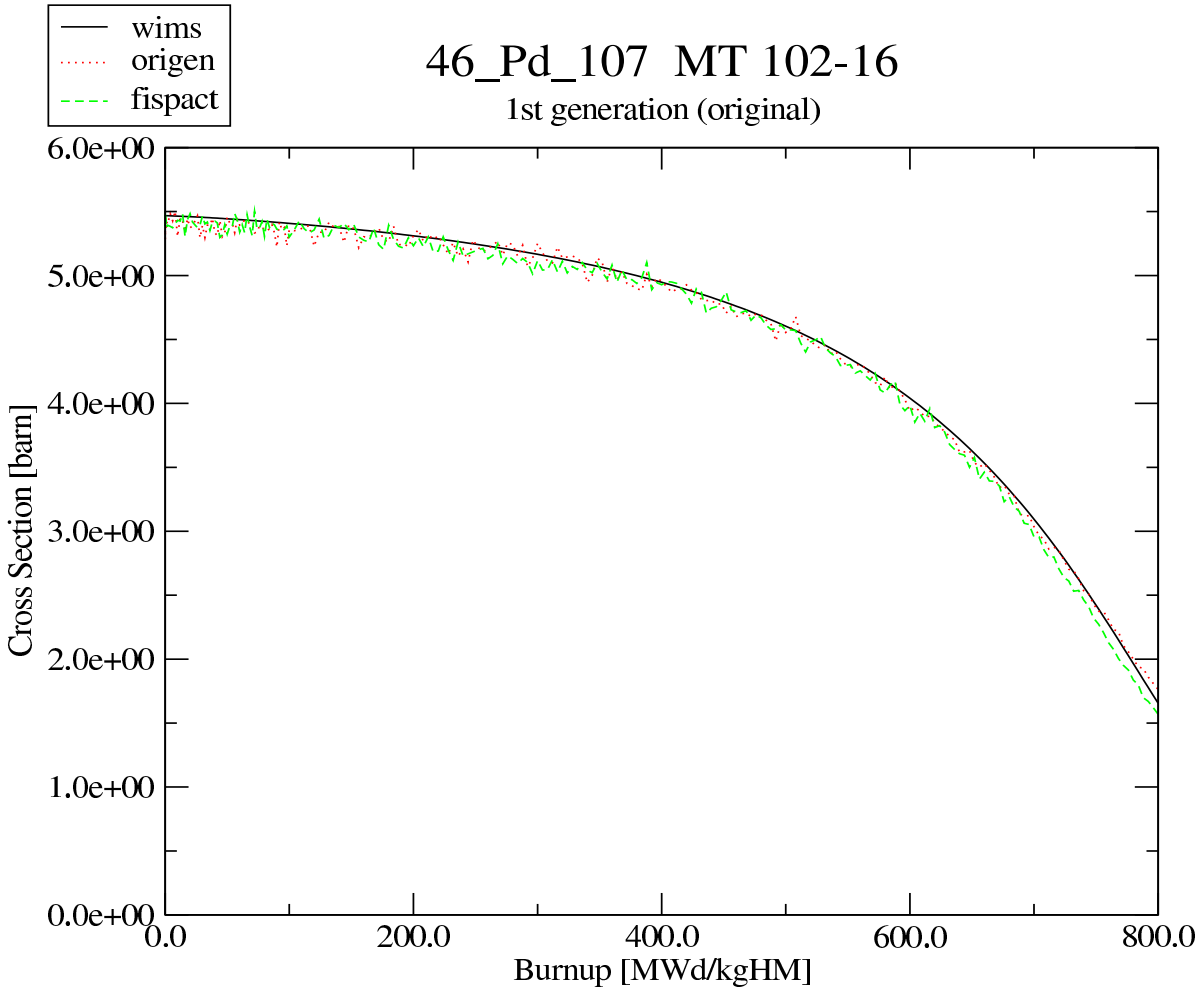


Figure 5.55 Absorption Cross Section [$barn$] 46_Pd_107 for case A1

Table 5.56 Absorption Cross Section [$barn$] 50_Sn_126 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	2.2910e-02	2.2910e-02
100.00	–	–	2.4442e-02	2.4521e-02
400.00	–	–	3.6787e-02	3.7038e-02
600.00	–	–	6.0947e-02	6.1723e-02
800.00	–	–	1.1924e-01	1.2429e-01

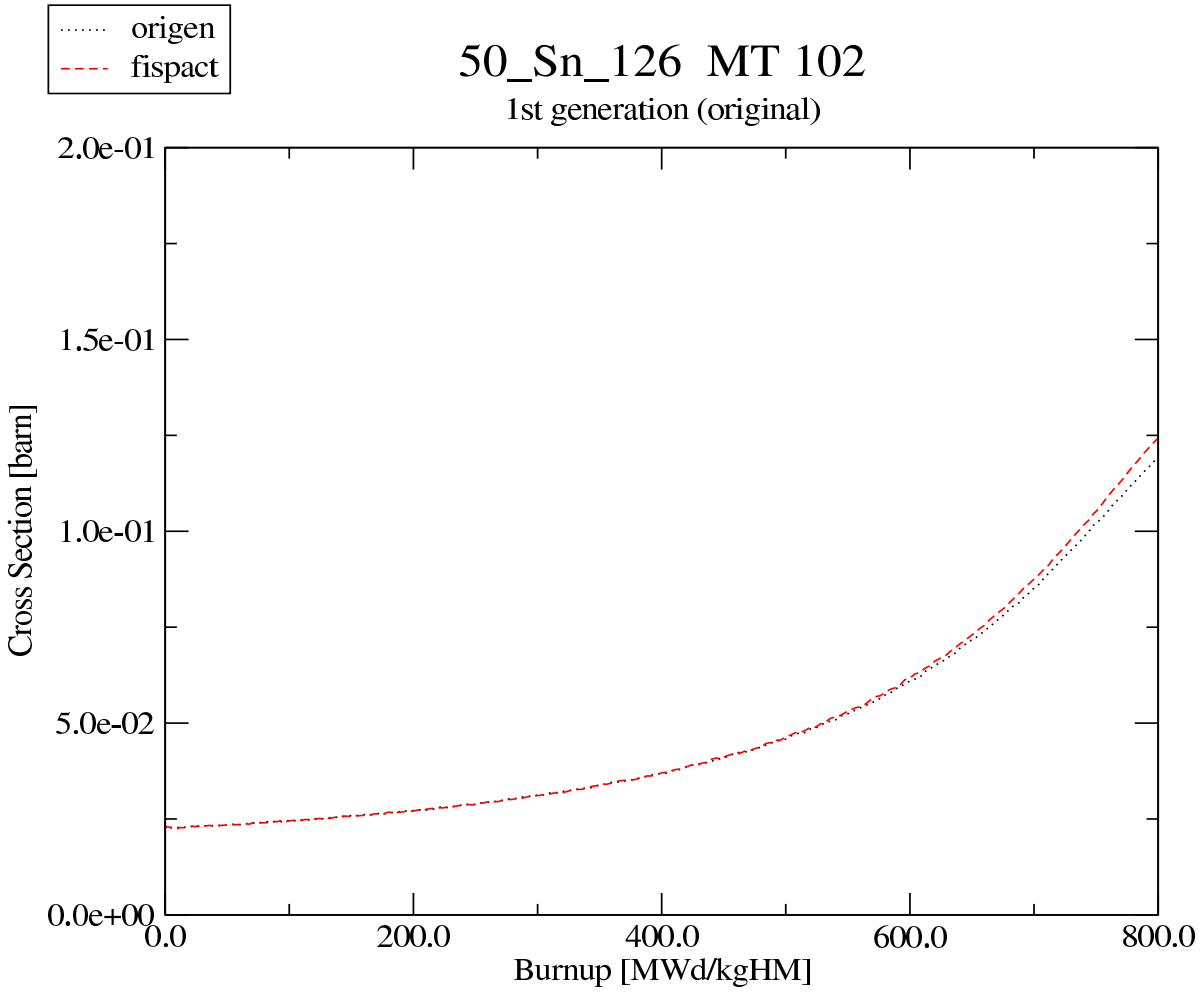


Figure 5.56 Absorption Cross Section [$barn$] 50_Sn_126 for case A1

Table 5.57 Absorption Cross Section [$barn$] 53_I_129 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.0710e+00	–	–	–
100.00	3.2108e+00	–	–	–
400.00	4.4410e+00	–	–	–
600.00	6.8502e+00	–	–	–
800.00	1.3368e+01	–	–	–

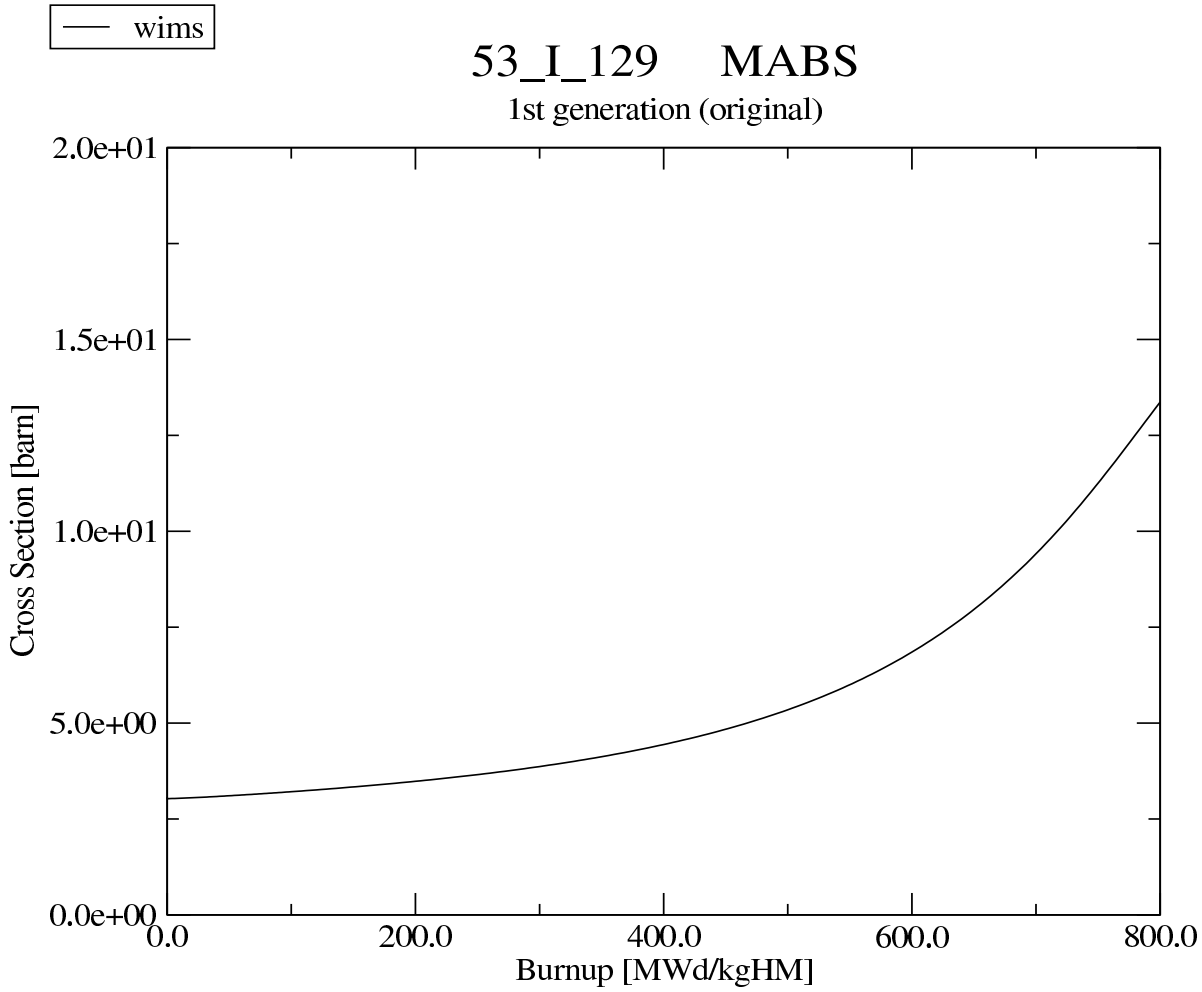


Figure 5.57 Absorption Cross Section [$barn$] 53_I_129 for case A1

Table 5.58 Absorption Cross Section [$barn$] 55_Cs_135 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.5163e+00	3.5164e+00	3.4224e+00	3.4224e+00
100.00	3.5259e+00	3.5260e+00	3.4911e+00	3.4564e+00
400.00	3.5870e+00	3.5871e+00	3.5370e+00	3.5941e+00
600.00	3.7056e+00	3.7058e+00	3.7673e+00	3.6697e+00
800.00	4.0628e+00	4.0628e+00	4.1259e+00	4.1326e+00

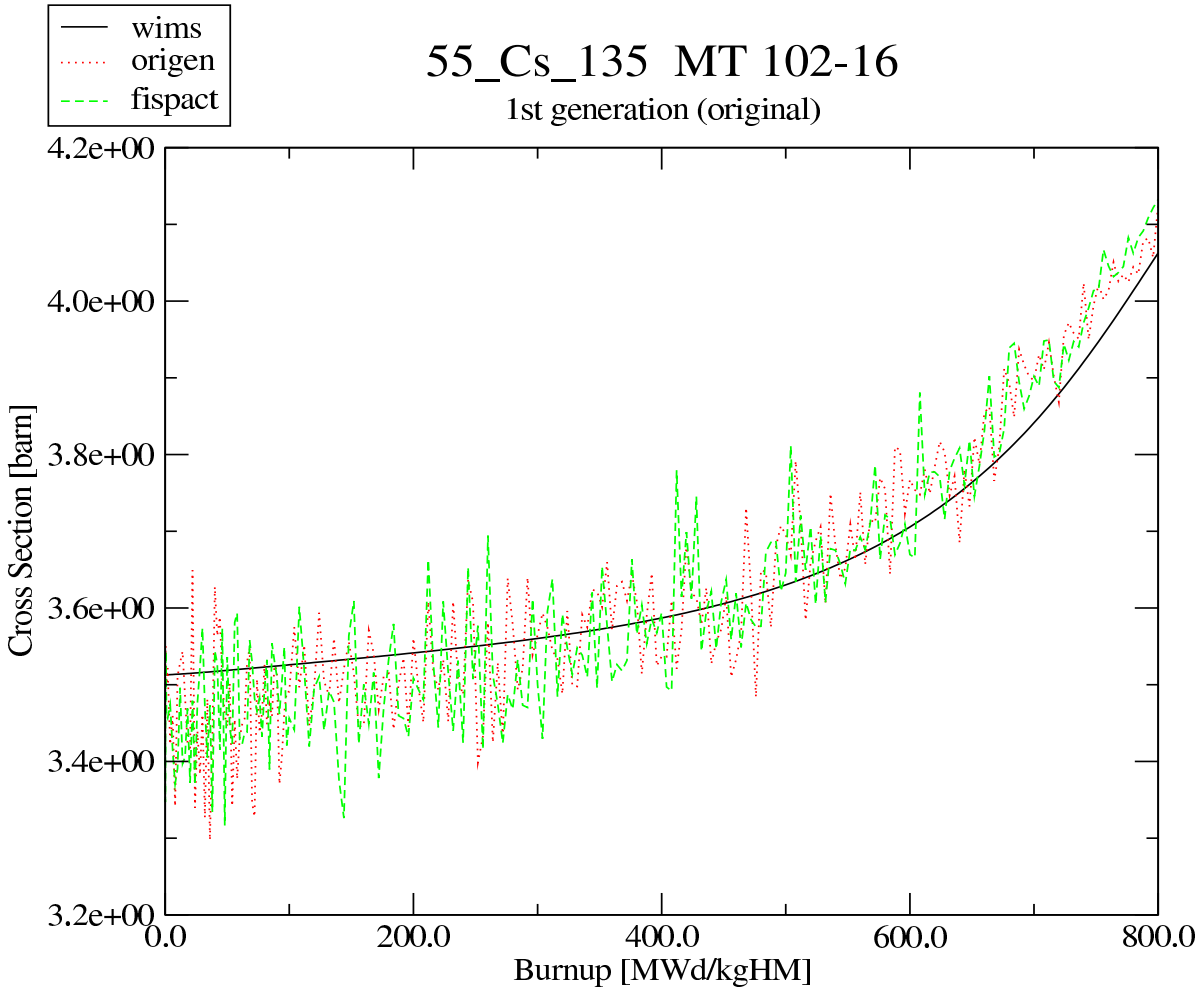


Figure 5.58 Absorption Cross Section [$barn$] 55_Cs_135 for case A1

Table 5.59 Absorption Cross Section [$barn$] 55_Cs_137 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	3.8264e-02	3.8264e-02
100.00	–	–	3.9562e-02	4.0172e-02
400.00	–	–	4.1384e-02	4.2077e-02
600.00	–	–	4.6930e-02	4.7521e-02
800.00	–	–	6.1712e-02	6.2863e-02

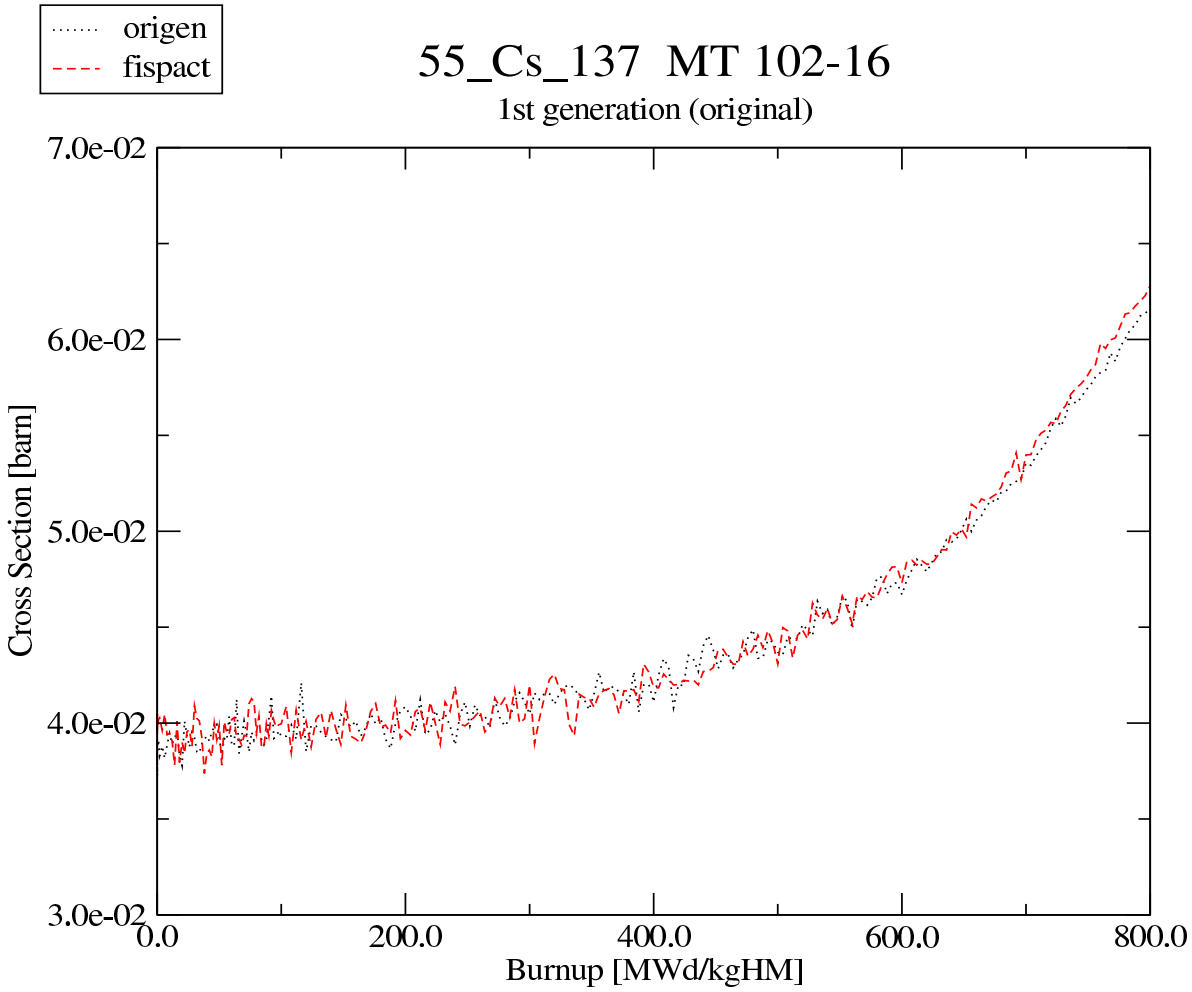


Figure 5.59 Absorption Cross Section [$barn$] 55_Cs_137 for case A1

Table 5.60 Absorption Cross Section [$barn$] 62_Sm_147 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.3569e+01	4.3571e+01	4.2881e+01	4.2881e+01
100.00	4.3373e+01	4.3375e+01	4.2500e+01	4.2511e+01
400.00	4.1608e+01	4.1610e+01	4.2067e+01	4.1566e+01
600.00	3.8379e+01	3.8381e+01	3.7736e+01	3.8118e+01
800.00	2.9942e+01	2.9942e+01	3.0488e+01	2.9831e+01

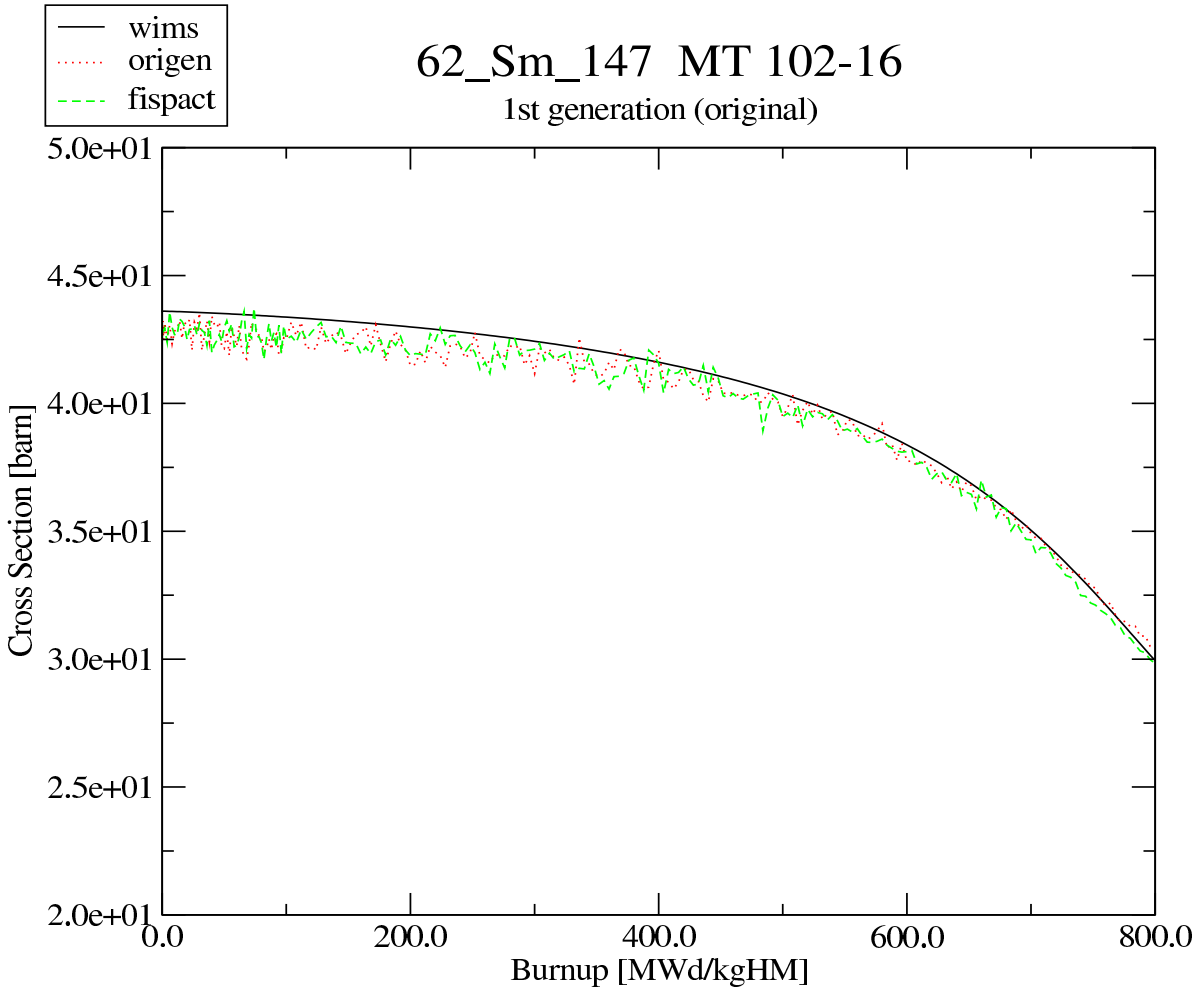


Figure 5.60 Absorption Cross Section [$barn$] 62_Sm_147 for case A1

Table 5.61 Absorption Cross Section [$barn$] 62_Sm_149 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.0089e+03	4.0089e+03	3.9350e+03	3.9350e+03
100.00	4.3646e+03	4.3646e+03	4.3273e+03	4.3570e+03
400.00	7.9401e+03	7.9401e+03	8.2473e+03	8.3186e+03
600.00	1.5084e+04	1.5084e+04	1.5912e+04	1.6124e+04
800.00	3.4743e+04	3.4743e+04	3.4840e+04	3.6512e+04

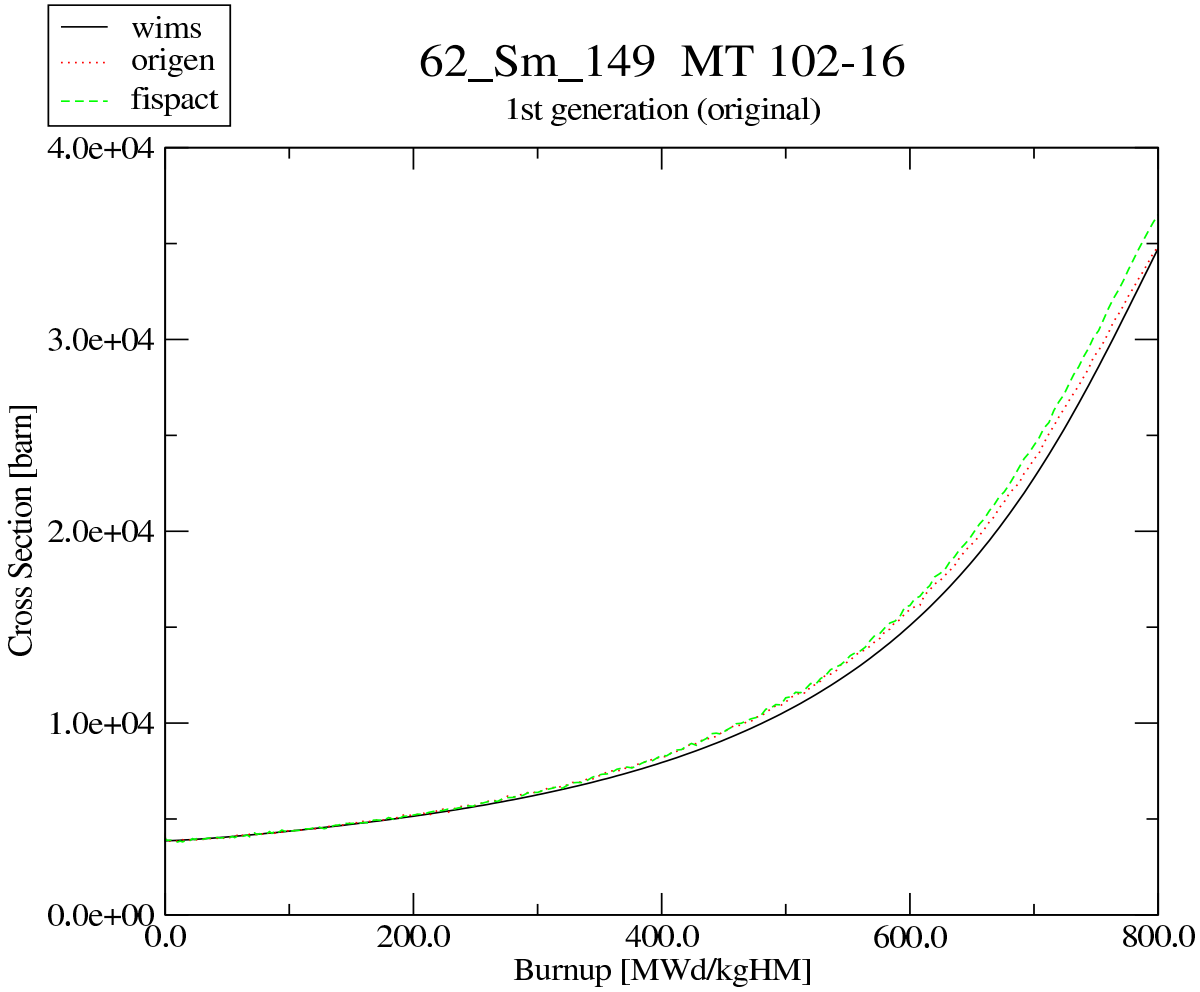


Figure 5.61 Absorption Cross Section [$barn$] 62_Sm_149 for case A1

Table 5.62 Absorption Cross Section [$barn$] 62_Sm_151 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.6949e+02	4.6949e+02	4.6072e+02	4.6072e+02
100.00	5.0019e+02	5.0019e+02	5.0078e+02	4.9961e+02
400.00	8.0602e+02	8.0602e+02	8.2704e+02	8.3315e+02
600.00	1.4252e+03	1.4252e+03	1.4978e+03	1.5155e+03
800.00	3.1493e+03	3.1493e+03	3.1616e+03	3.3019e+03

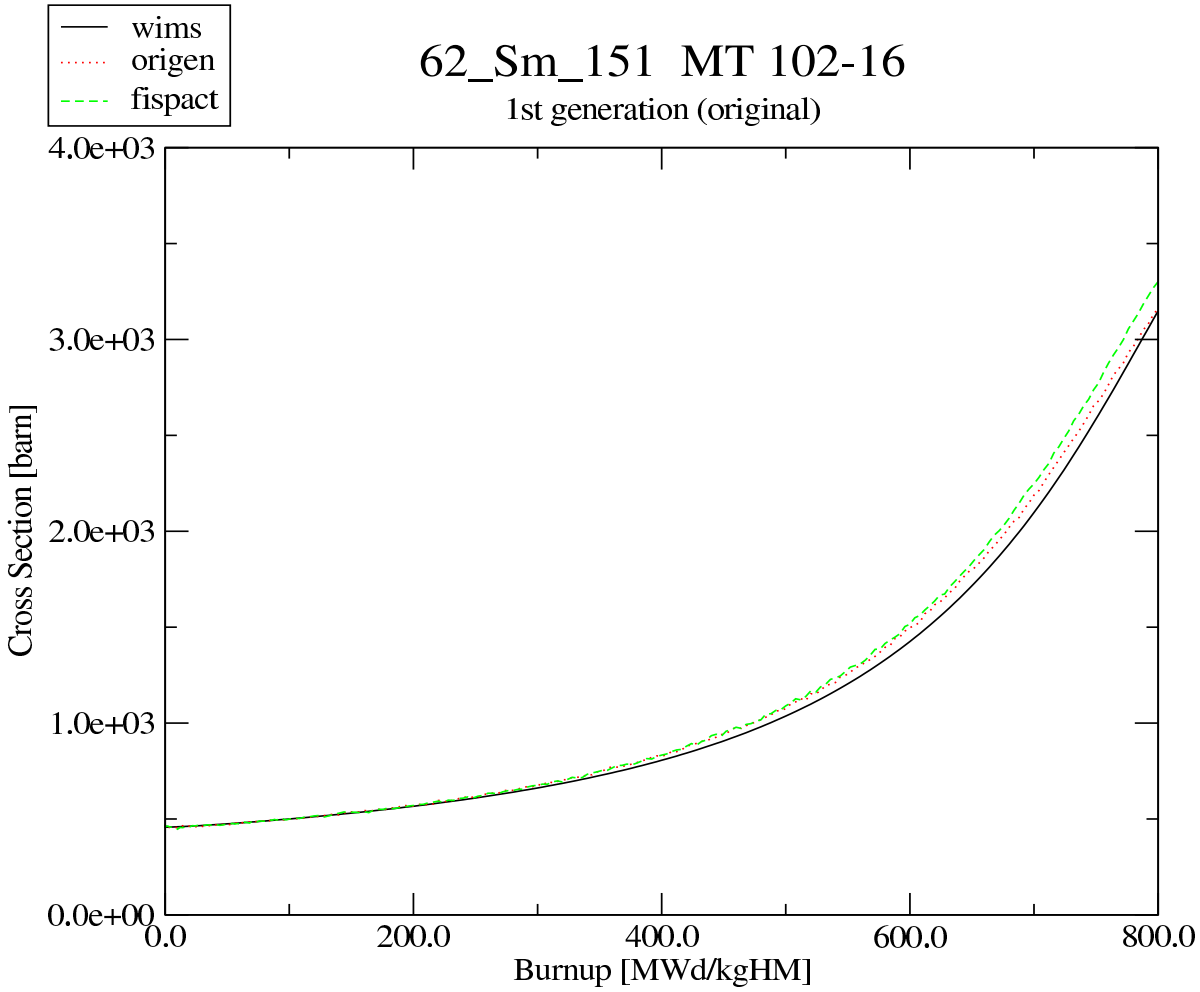


Figure 5.62 Absorption Cross Section [$barn$] 62_Sm_151 for case A1

Table 5.63 Absorption Cross Section [*barn*] 63_Eu_154 for case A1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.4391e+02	1.4391e+02	1.4067e+02	1.4067e+02
100.00	1.4523e+02	1.4523e+02	1.4378e+02	1.4278e+02
400.00	1.6274e+02	1.6274e+02	1.6249e+02	1.6282e+02
600.00	2.0052e+02	2.0052e+02	2.0459e+02	2.0577e+02
800.00	3.0349e+02	3.0349e+02	3.0457e+02	3.1226e+02

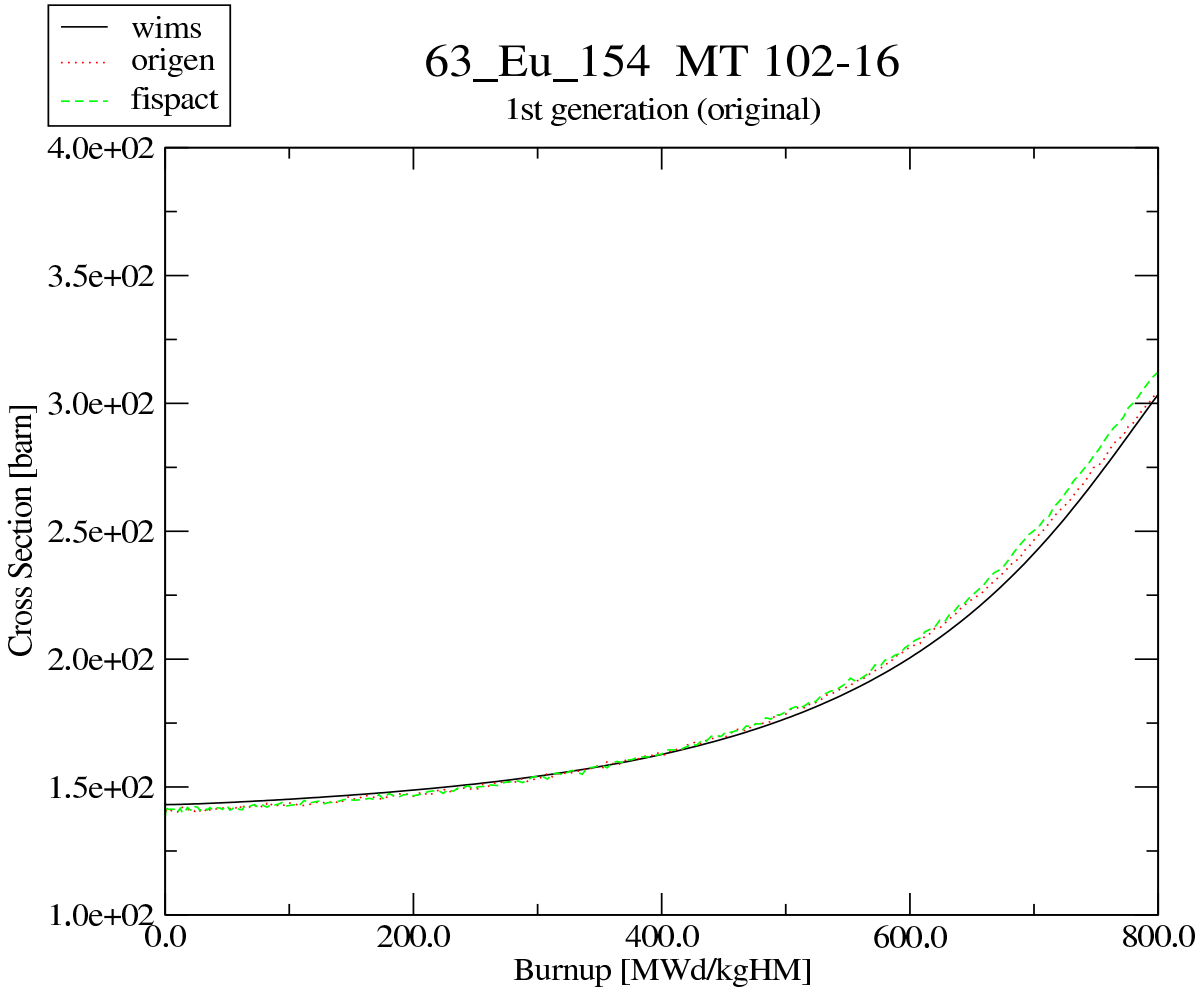


Figure 5.63 Absorption Cross Section [*barn*] 63_Eu_154 for case A1

Table 5.64 Absorption Cross Section [$barn$] 54_Xe_135 for case A1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1415e+05	–	1.1190e+05	1.1190e+05
100.00	1.2491e+05	–	1.2465e+05	1.2512e+05
400.00	2.3296e+05	–	2.4198e+05	2.4416e+05
600.00	4.4992e+05	–	4.7600e+05	4.8266e+05
800.00	1.0509e+06	–	1.0570e+06	1.1076e+06

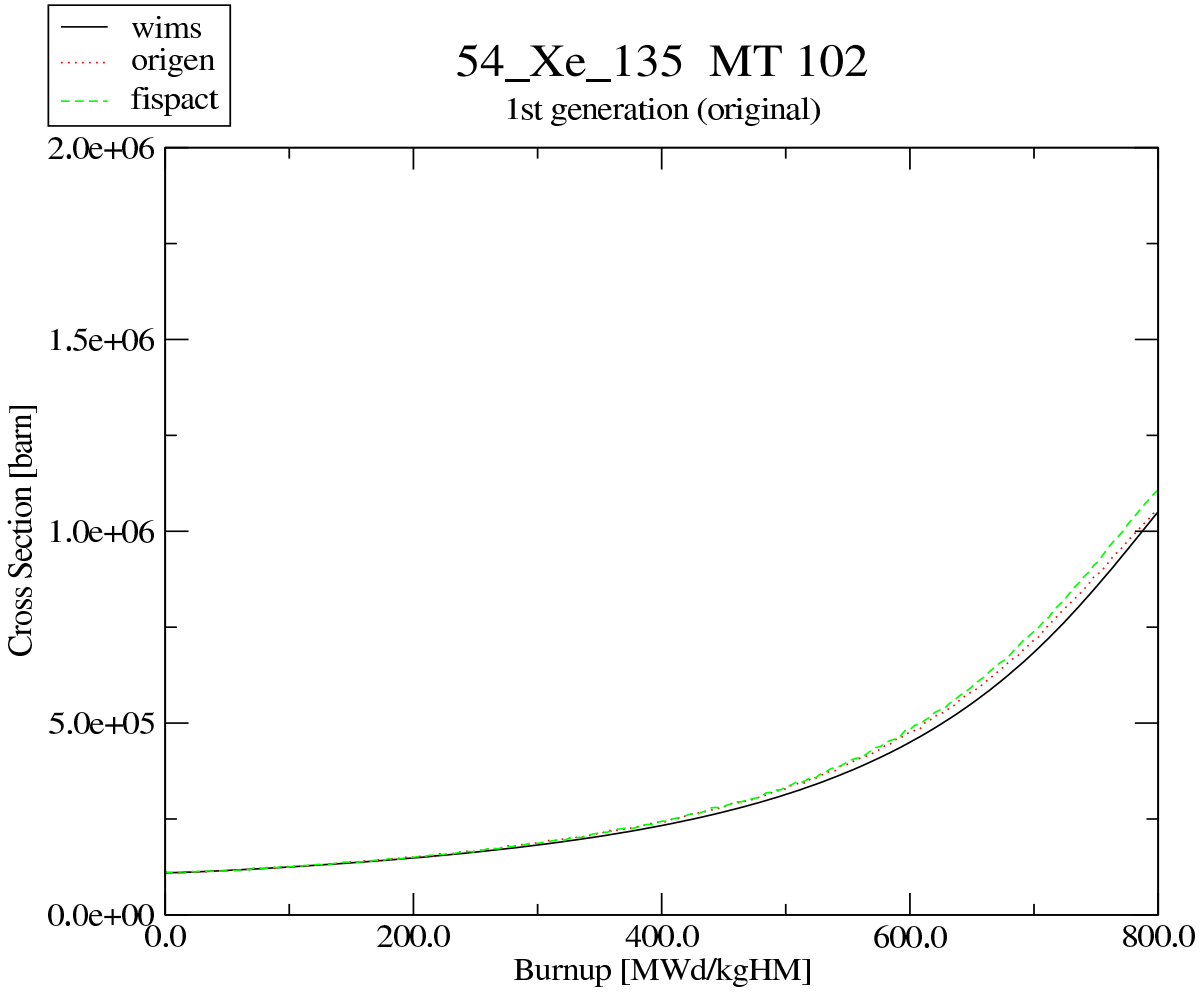


Figure 5.64 Absorption Cross Section [$barn$] 54_Xe_135 for case A1

Table 5.65 Fission Cross Section [$barn$] 94_Pu_238 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.1441e+00	2.1438e+00	2.1438e+00
100.00	2.1812e+00	2.1847e+00	2.1947e+00
400.00	2.5391e+00	2.5509e+00	2.5653e+00
600.00	3.2564e+00	3.3479e+00	3.3779e+00
800.00	5.2621e+00	5.2890e+00	5.4593e+00

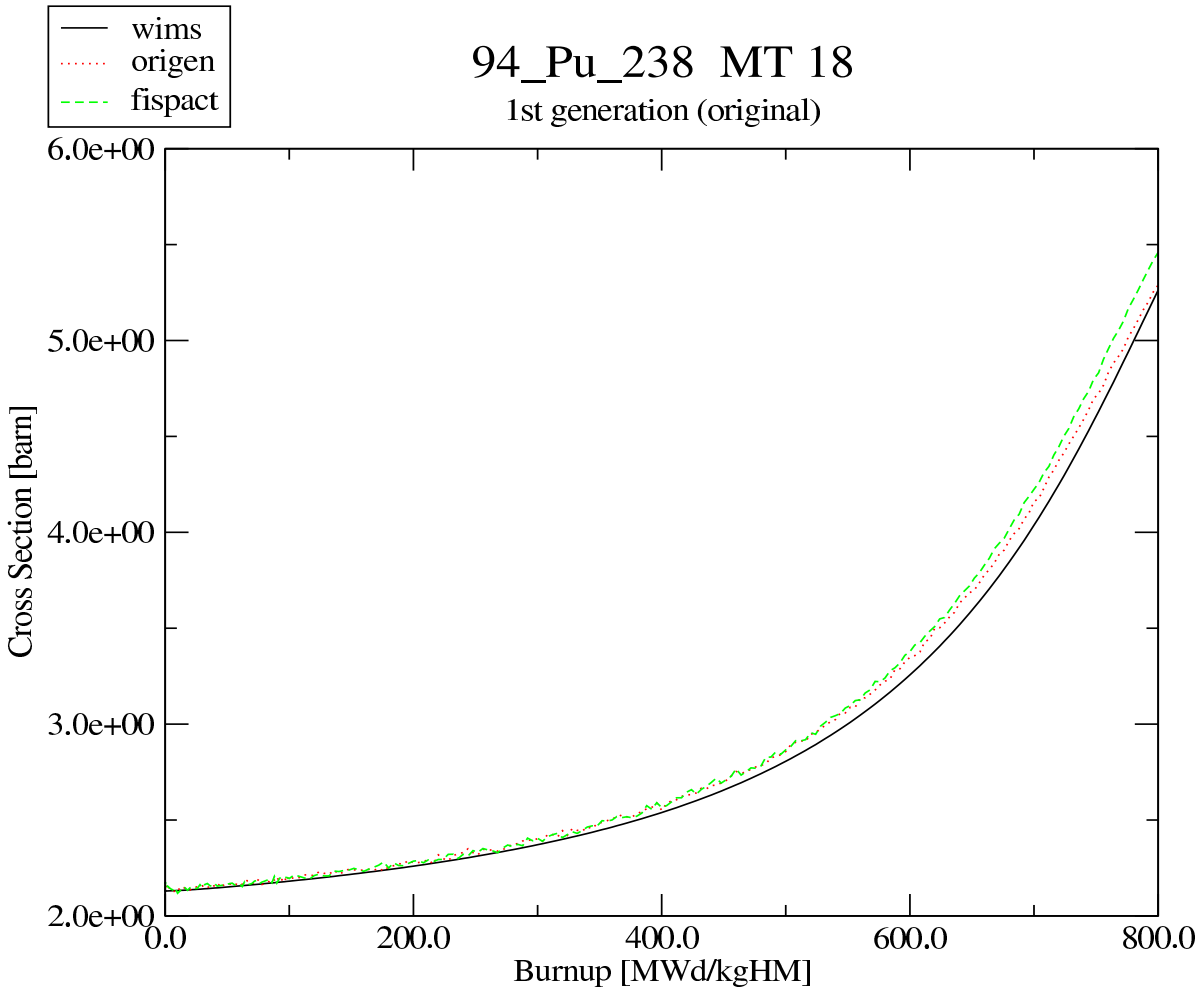


Figure 5.65 Fission Cross Section [$barn$] 94_Pu_238 for case A1

Table 5.66 Fission Cross Section [$barn$] 94_Pu_239 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0585e+02	1.0572e+02	1.0572e+02
100.00	1.1759e+02	1.1934e+02	1.1945e+02
400.00	2.0596e+02	2.1155e+02	2.1350e+02
600.00	3.7077e+02	3.7917e+02	3.8665e+02
800.00	7.8228e+02	7.6060e+02	7.9370e+02

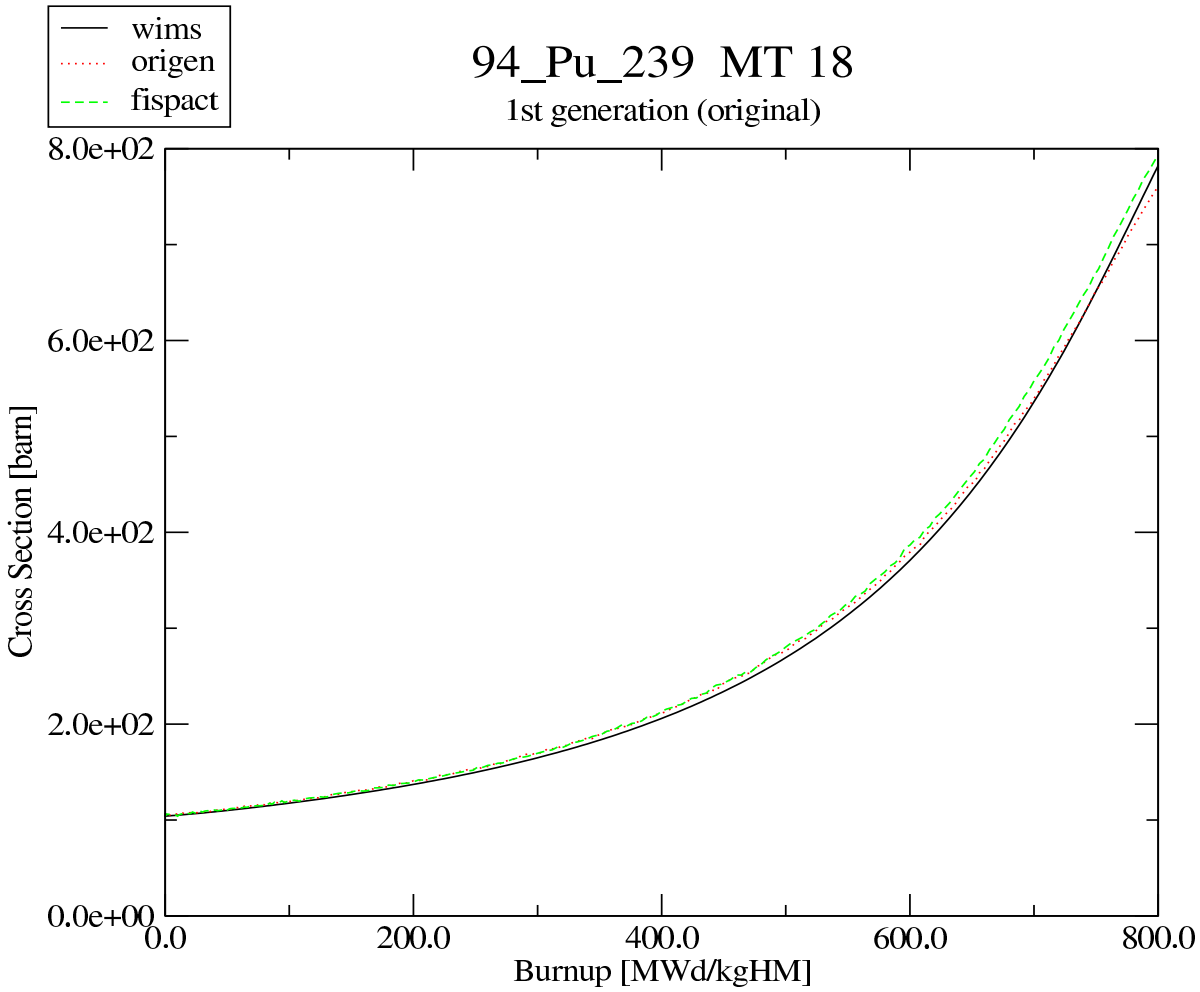


Figure 5.66 Fission Cross Section [$barn$] 94_Pu_239 for case A1

Table 5.67 Fission Cross Section [$barn$] 94_Pu_240 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.8338e-01	3.8476e-01	3.8476e-01
100.00	3.7888e-01	3.8185e-01	3.8101e-01
400.00	3.4625e-01	3.4621e-01	3.4401e-01
600.00	2.8361e-01	2.7827e-01	2.7405e-01
800.00	1.1226e-01	1.1781e-01	1.0289e-01

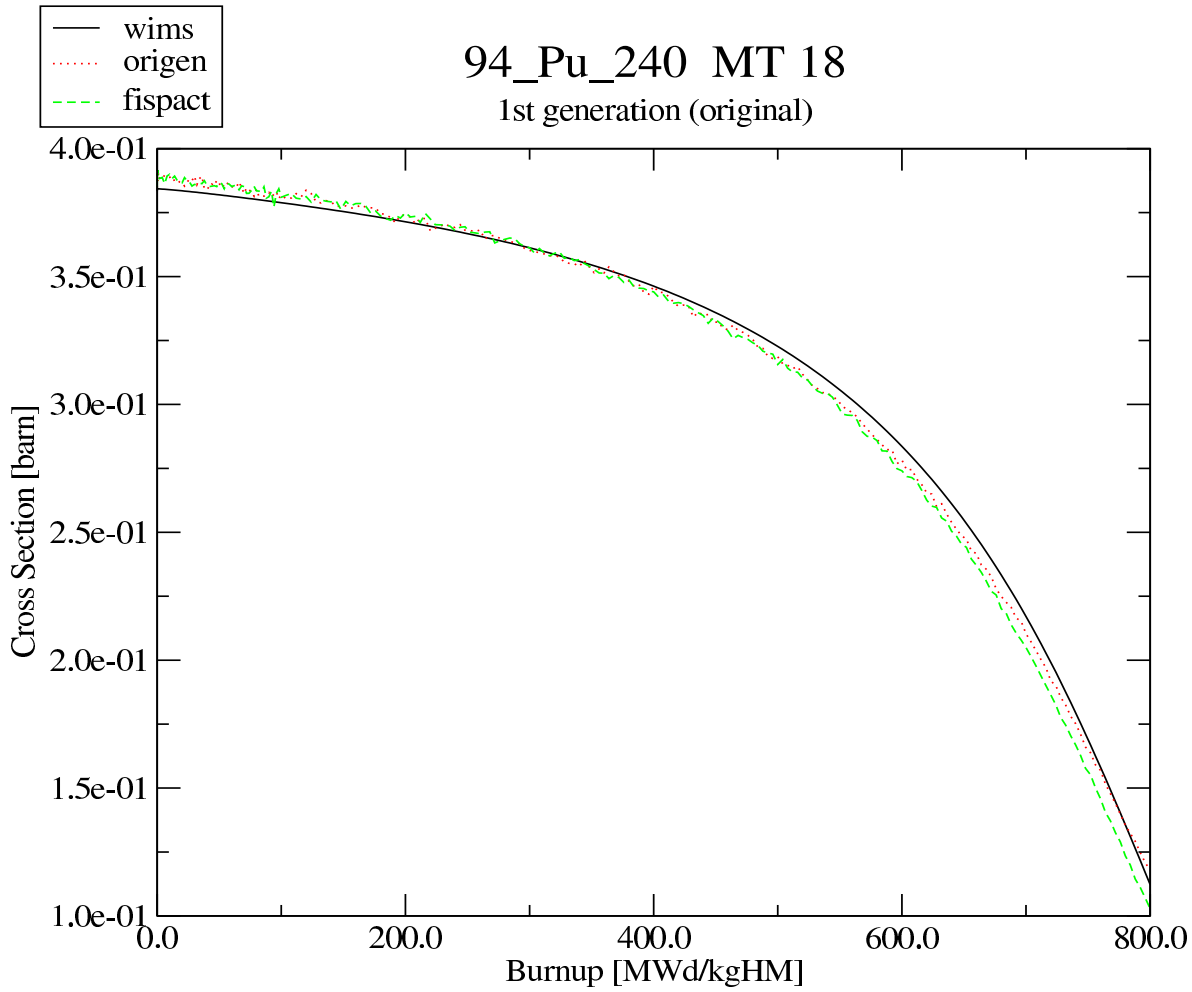


Figure 5.67 Fission Cross Section [$barn$] 94_Pu_240 for case A1

Table 5.68 Fission Cross Section [*barn*] 94_Pu_241 for case A1

burnup [*MWd/kgHM*]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0722e+02	1.0546e+02	1.0546e+02
100.00	1.1637e+02	1.1580e+02	1.1590e+02
400.00	1.8943e+02	1.9349e+02	1.9503e+02
600.00	3.3007e+02	3.4189e+02	3.4715e+02
800.00	7.0134e+02	6.9289e+02	7.2365e+02

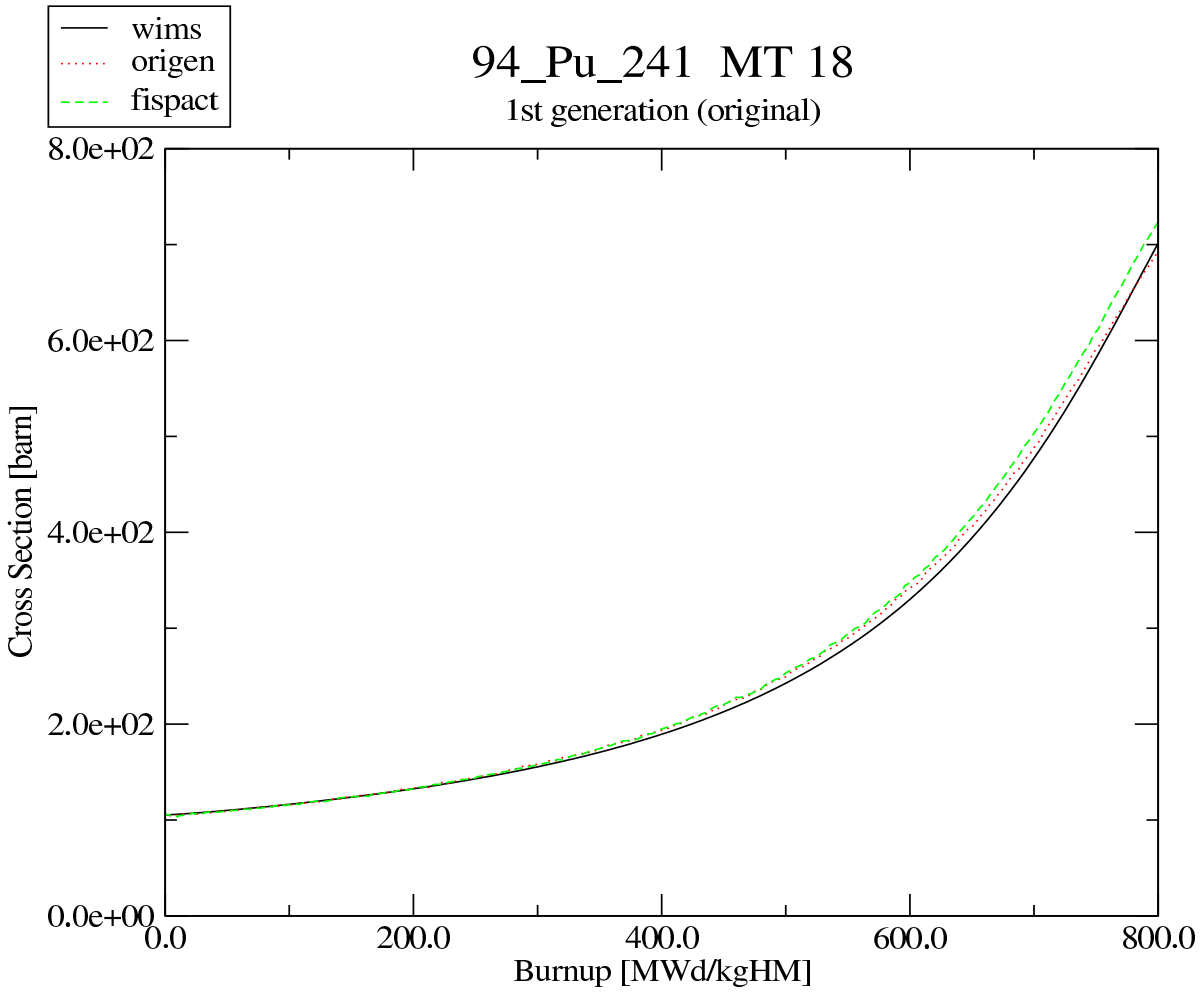


Figure 5.68 Fission Cross Section [*barn*] 94_Pu_241 for case A1

Table 5.69 Fission Cross Section [$barn$] 94_Pu_242 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.4694e-01	2.5247e-01	2.5247e-01
100.00	2.4364e-01	2.4809e-01	2.4889e-01
400.00	2.1745e-01	2.1740e-01	2.1742e-01
600.00	1.6901e-01	1.6528e-01	1.6287e-01
800.00	4.7528e-02	5.1992e-02	4.2461e-02

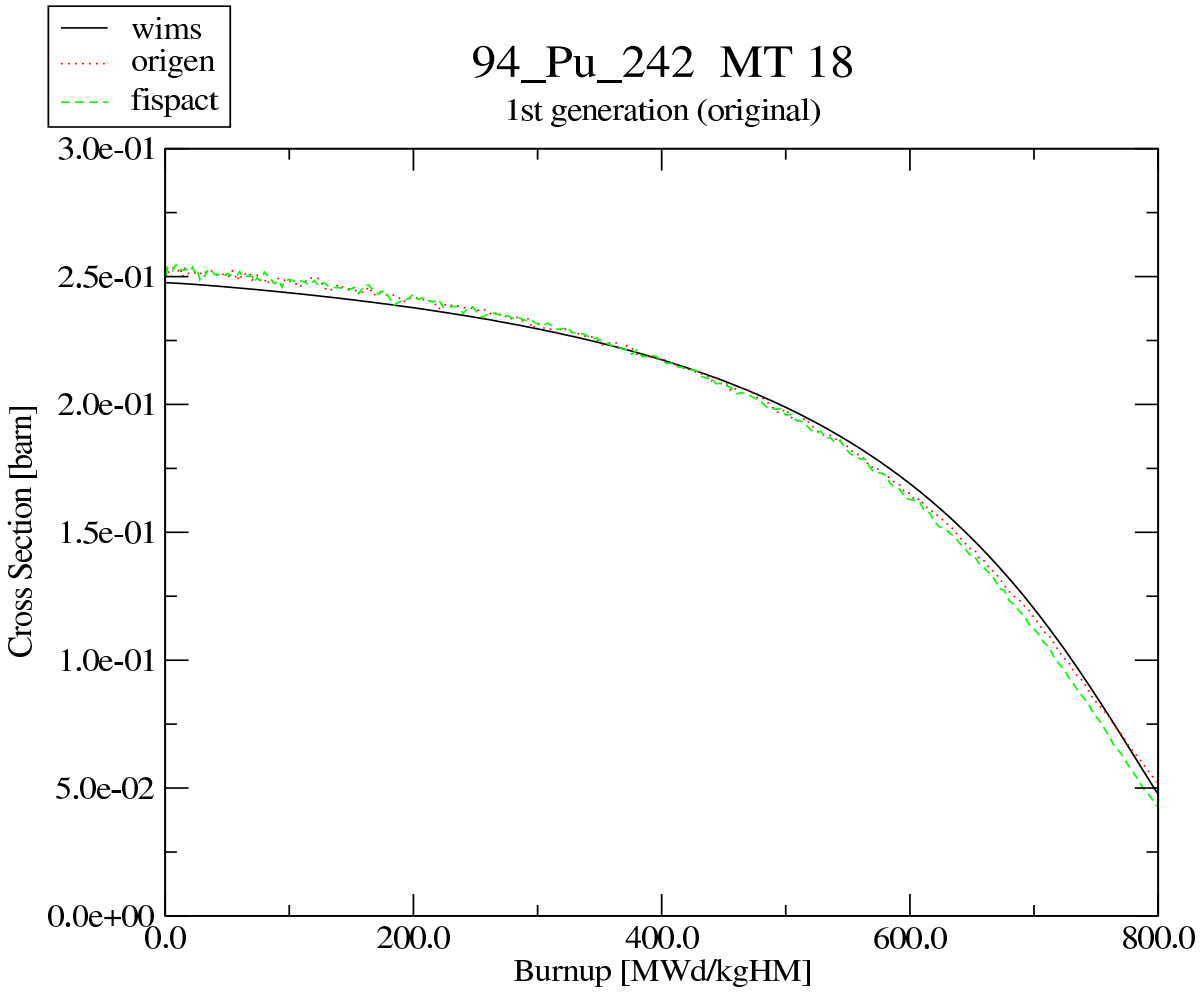


Figure 5.69 Fission Cross Section [$barn$] 94_Pu_242 for case A1

Table 5.70 Fission Cross Section [$barn$] 95_Am_241 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.2870e+00	1.2631e+00	1.2631e+00
100.00	1.3590e+00	1.3399e+00	1.3432e+00
400.00	1.8443e+00	1.8273e+00	1.8488e+00
600.00	2.7123e+00	2.7052e+00	2.7559e+00
800.00	4.8008e+00	4.5912e+00	4.7512e+00

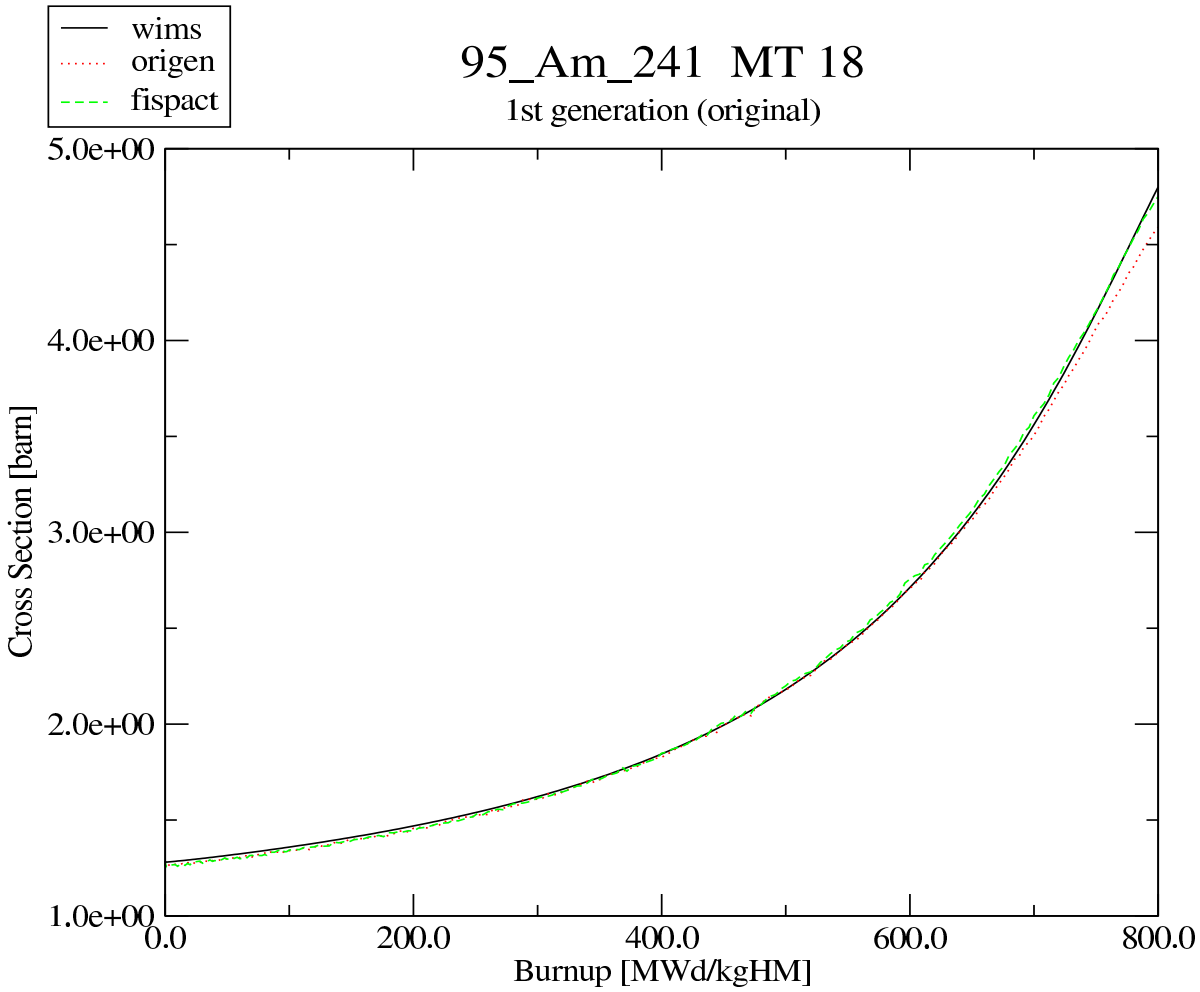


Figure 5.70 Fission Cross Section [$barn$] 95_Am_241 for case A1

Table 5.71 Fission Cross Section [$barn$] 95_Am_242 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	1.6171e+02	1.6171e+02
100.00	–	1.7350e+02	1.7416e+02
400.00	–	2.6643e+02	2.6828e+02
600.00	–	4.4665e+02	4.5273e+02
800.00	–	8.7770e+02	9.1502e+02

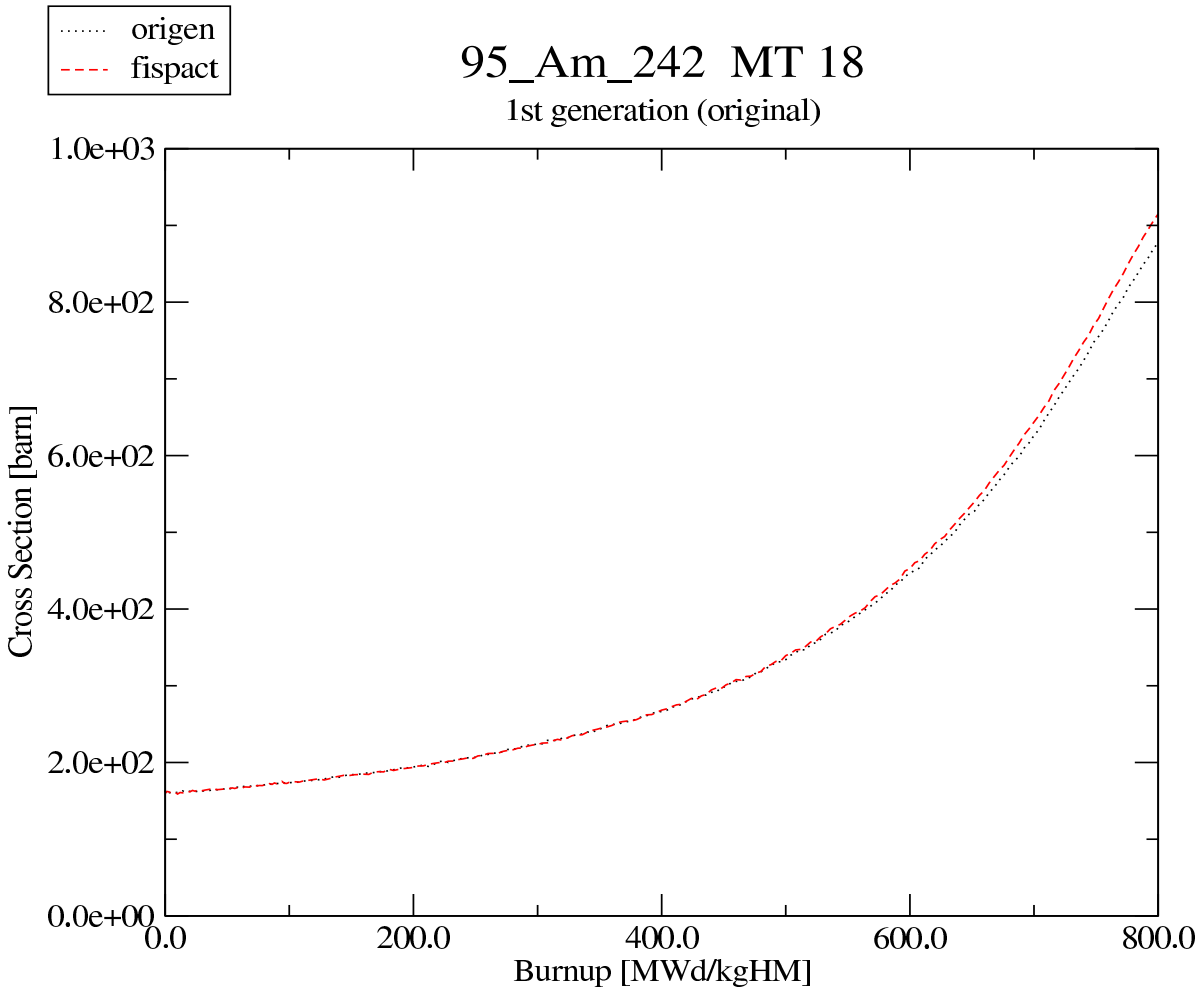


Figure 5.71 Fission Cross Section [$barn$] 95_Am_242 for case A1

Table 5.72 Fission Cross Section [$barn$] 95_Am_242m for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.3406e+02	5.2246e+02	5.2246e+02
100.00	5.8162e+02	5.7567e+02	5.7908e+02
400.00	9.9136e+02	1.0137e+03	1.0220e+03
600.00	1.7907e+03	1.8633e+03	1.8900e+03
800.00	3.9397e+03	3.9070e+03	4.0869e+03

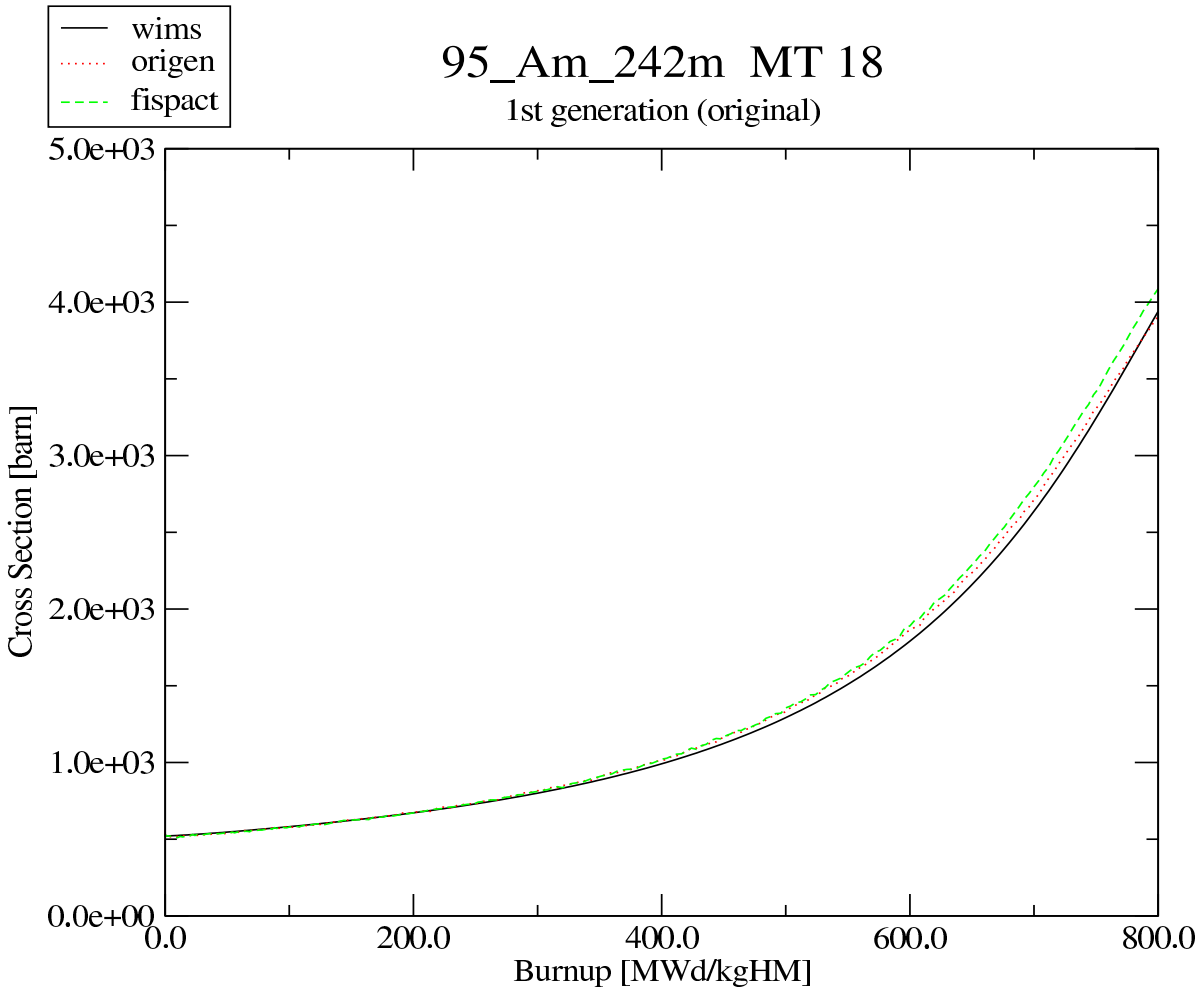


Figure 5.72 Fission Cross Section [$barn$] 95_Am_242m for case A1

Table 5.73 Fission Cross Section [$barn$] 95_Am_243 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.4538e-01	2.5054e-01	2.5054e-01
100.00	2.4209e-01	2.4553e-01	2.4712e-01
400.00	2.1860e-01	2.1931e-01	2.1892e-01
600.00	1.7568e-01	1.7364e-01	1.7104e-01
800.00	6.4537e-02	6.8688e-02	5.9478e-02

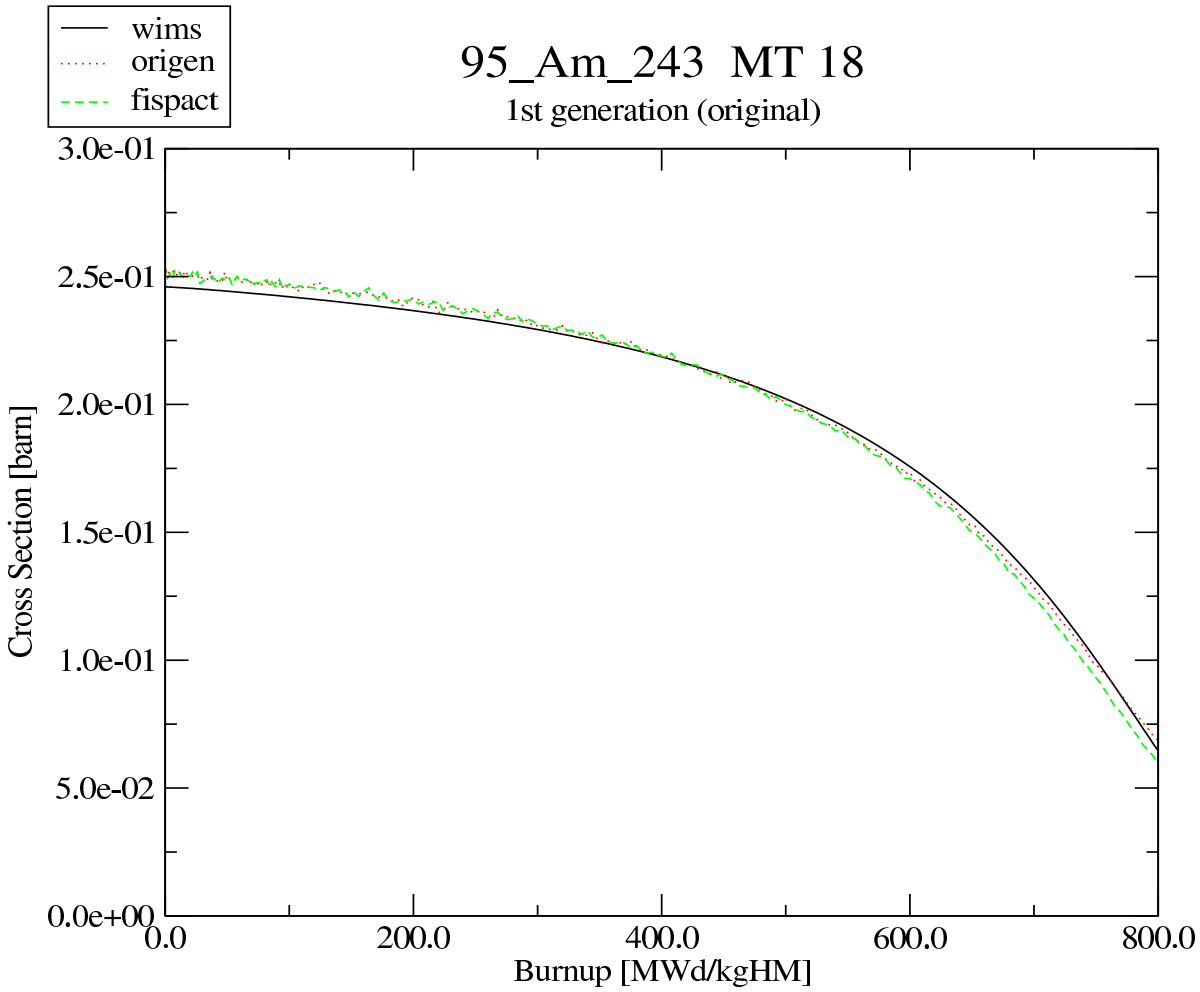


Figure 5.73 Fission Cross Section [$barn$] 95_Am_243 for case A1

Table 5.74 Fission Cross Section [$barn$] 96_Cm_242 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	8.1890e-01	8.1762e-01	8.1762e-01
100.00	8.4007e-01	8.4123e-01	8.4313e-01
400.00	1.0260e+00	1.0355e+00	1.0400e+00
600.00	1.3893e+00	1.4206e+00	1.4319e+00
800.00	2.3690e+00	2.3528e+00	2.4340e+00

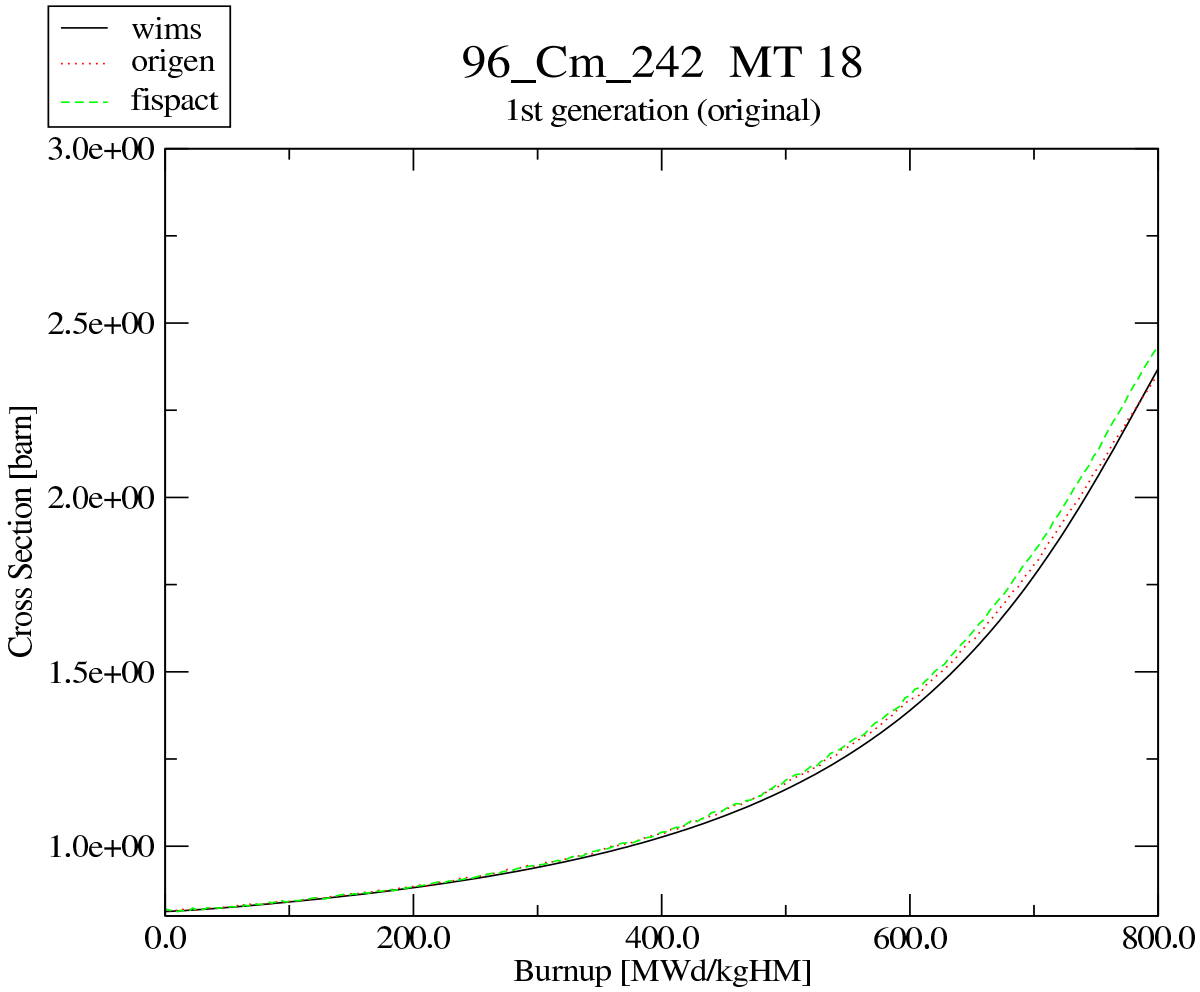


Figure 5.74 Fission Cross Section [$barn$] 96_Cm_242 for case A1

Table 5.75 Fission Cross Section [$barn$] 96_Cm_243 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1189e+02	1.0950e+02	1.0950e+02
100.00	1.1298e+02	1.1127e+02	1.1145e+02
400.00	1.2338e+02	1.2327e+02	1.2346e+02
600.00	1.4512e+02	1.4742e+02	1.4825e+02
800.00	2.0392e+02	2.0325e+02	2.0787e+02

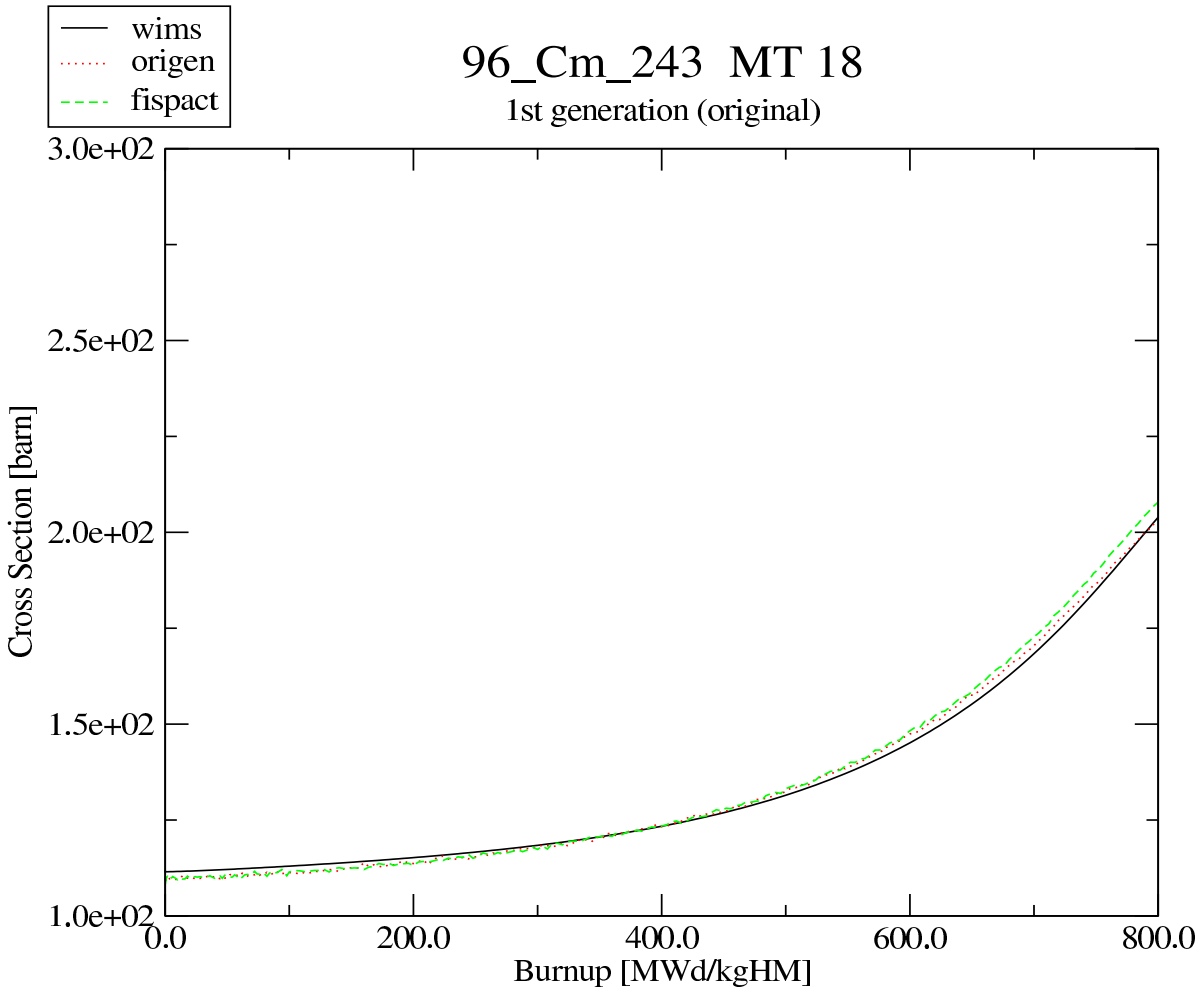


Figure 5.75 Fission Cross Section [$barn$] 96_Cm_243 for case A1

Table 5.76 Fission Cross Section [$barn$] 96_Cm_244 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.1186e-01	8.2410e-01	8.2410e-01
100.00	9.0964e-01	8.3779e-01	8.3548e-01
400.00	8.6319e-01	7.8615e-01	7.8297e-01
600.00	7.7139e-01	6.6521e-01	6.5550e-01
800.00	5.3888e-01	3.7792e-01	3.4674e-01

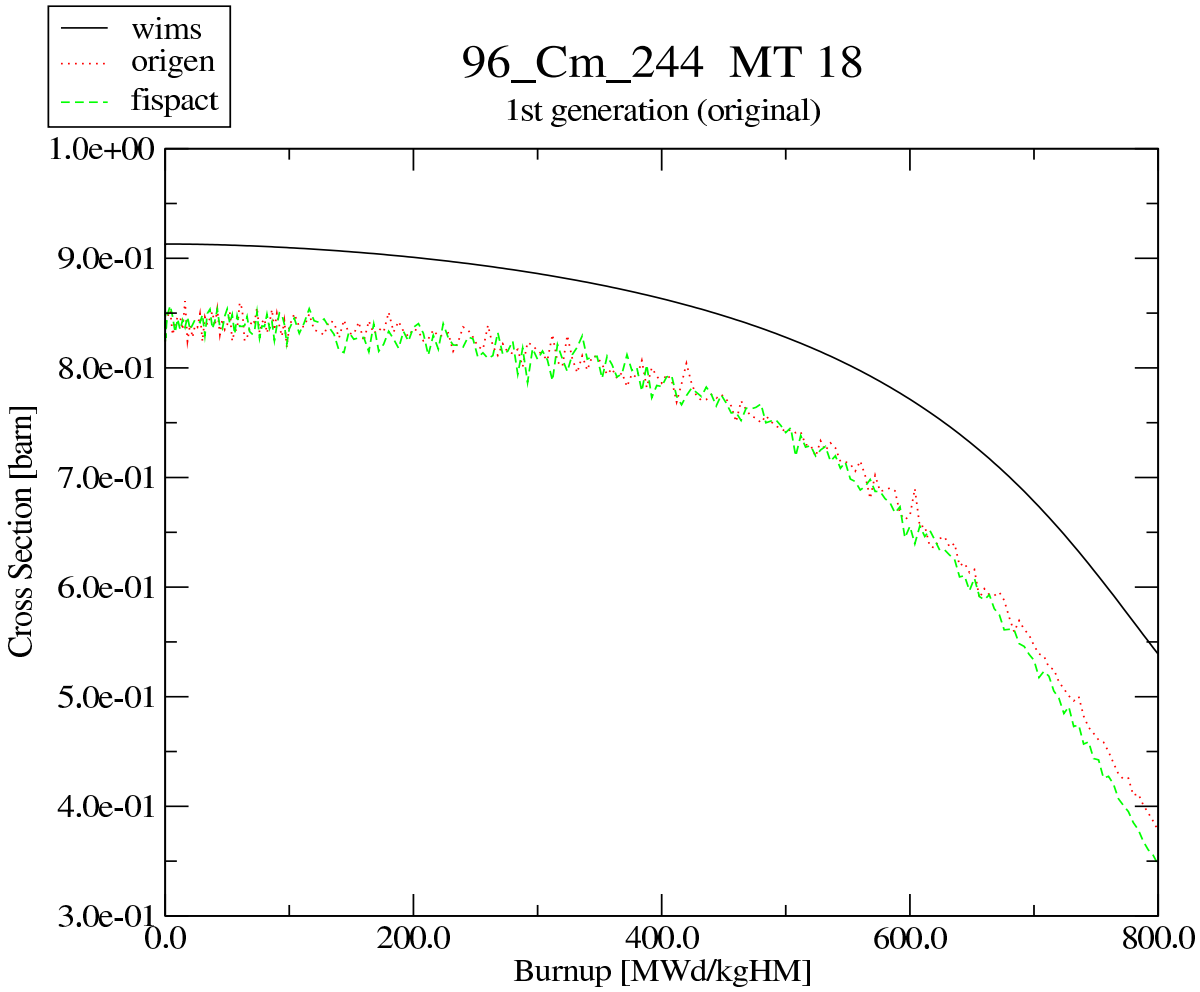


Figure 5.76 Fission Cross Section [$barn$] 96_Cm_244 for case A1

Table 5.77 Fission Cross Section [$barn$] 96_Cm_245 for case A1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0455e+02	1.0257e+02	1.0257e+02
100.00	1.1084e+02	1.1055e+02	1.1066e+02
400.00	1.6933e+02	1.7313e+02	1.7437e+02
600.00	2.8574e+02	2.9836e+02	3.0200e+02
800.00	6.0489e+02	6.0441e+02	6.3068e+02

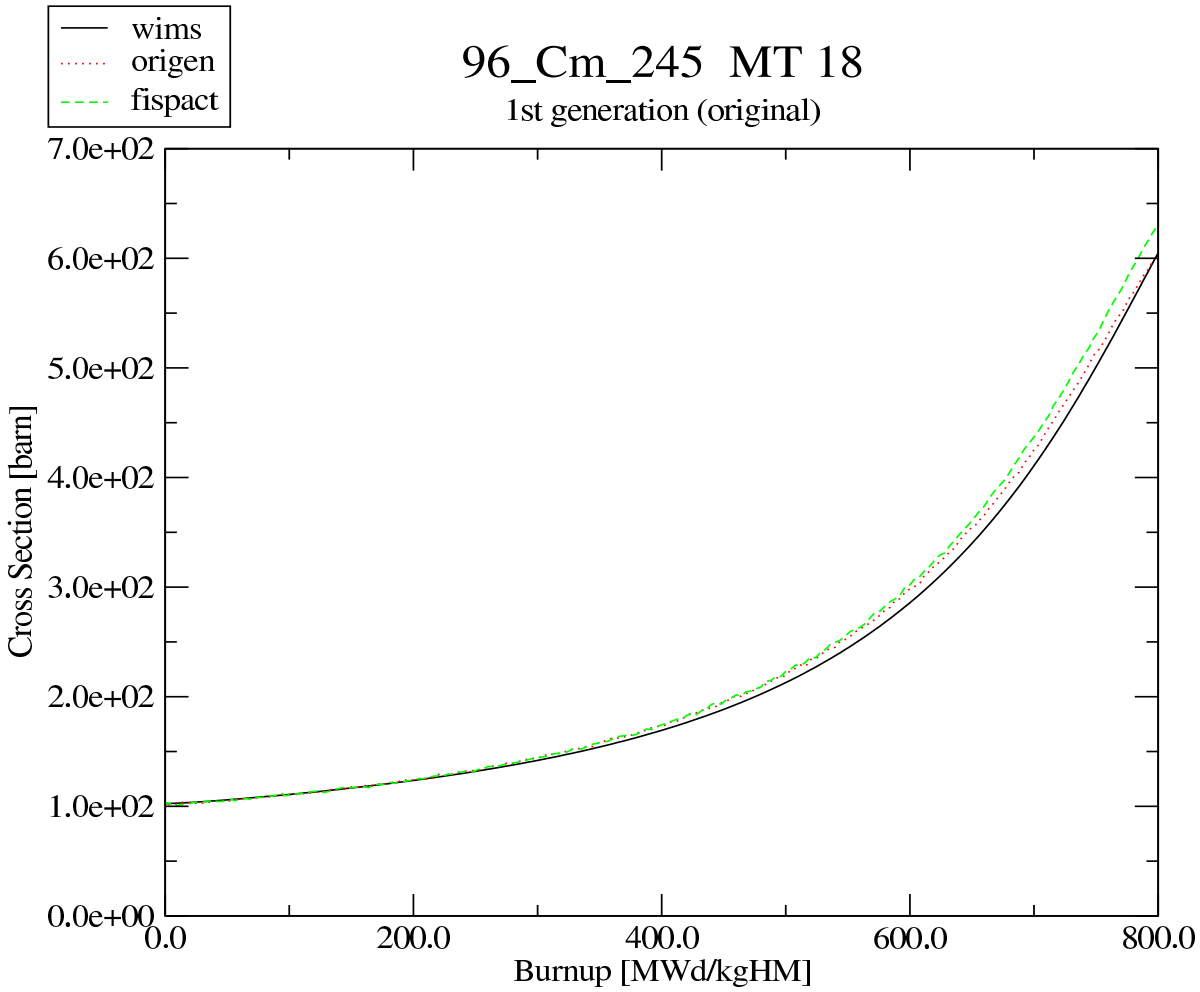


Figure 5.77 Fission Cross Section [$barn$] 96_Cm_245 for case A1

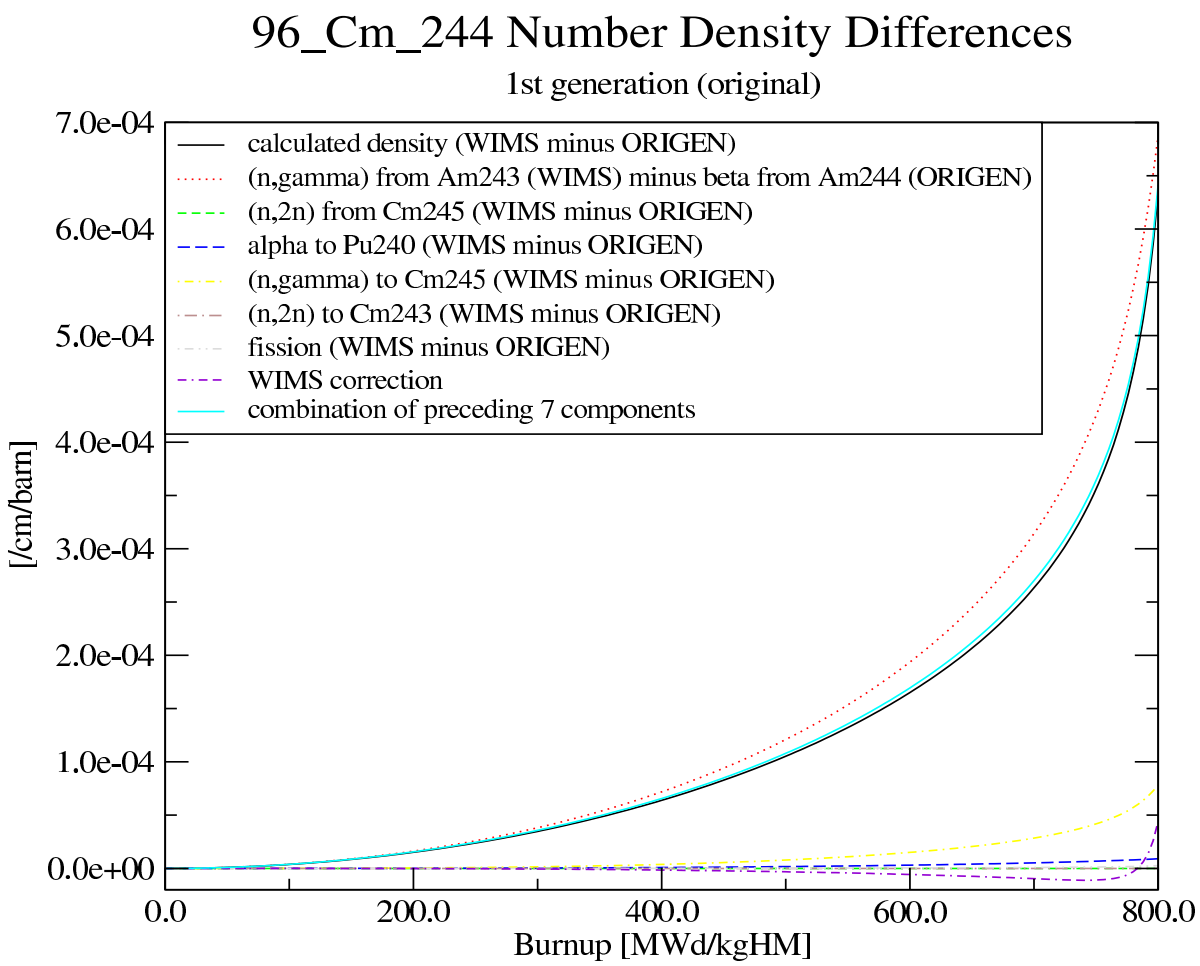


Figure 5.78 Number Density Differences [$cm^{-1}barn^{-1}$] 96_Cm_244 for case A1.
The first 7 curves here represent the equations 5.1 to 5.7 in section 5.1.

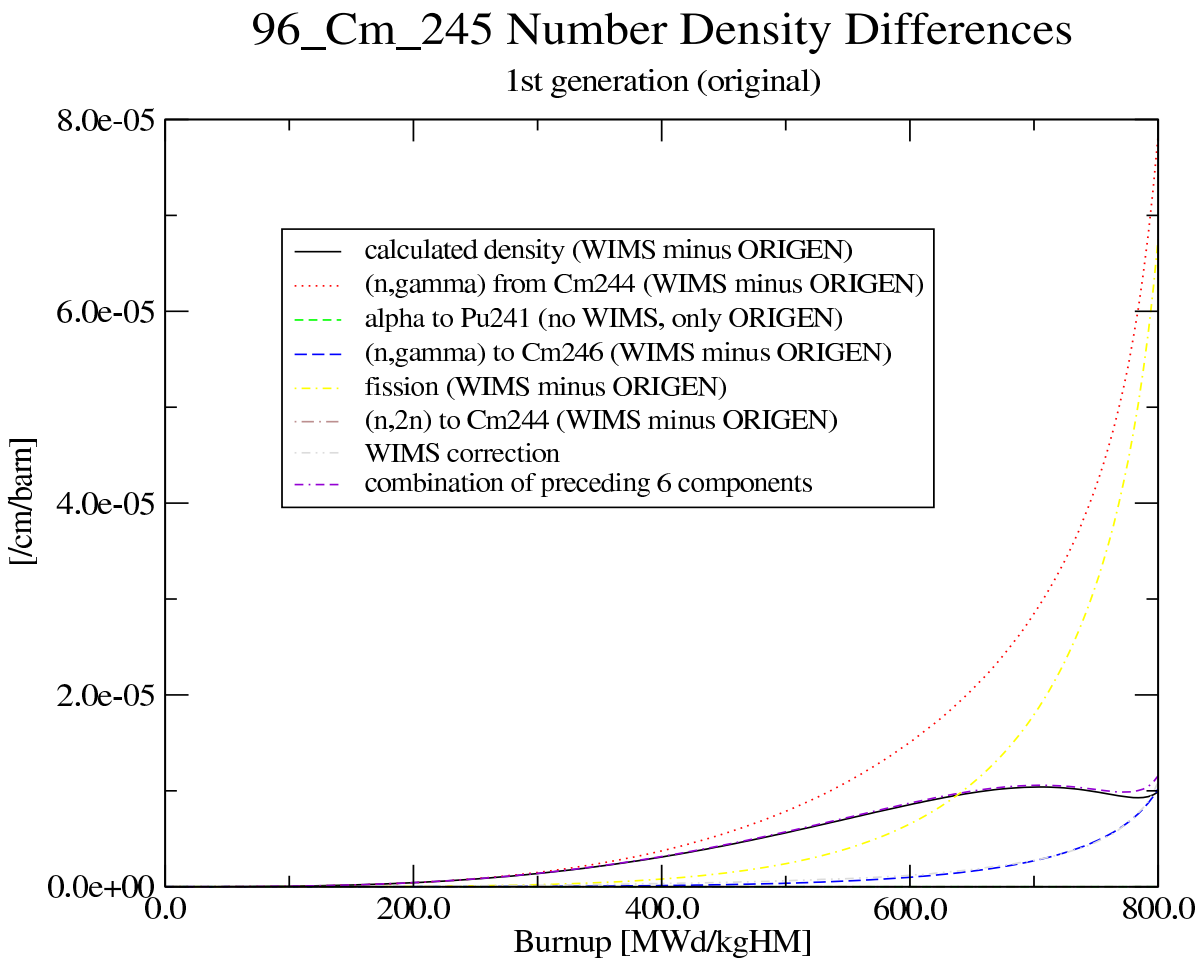


Figure 5.79 Number Density Differences $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case A1.
The first 6 curves here represent the equations 5.8 to 5.13 in section 5.1.

6. Case B1 results and discussion

Case B1 of this HTR Plutonium Cell Burnup Benchmark has 1.0 g plutonium per fuel element with the following 1st generation (alternative) composition for
^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu
in weight %: 2.59, 53.85, 23.66, 13.13, 6.78

6.1 Case B1 results

The figures at the end of this chapter show calculation results from all burnup steps. The corresponding tables give numerical values only for the burnup steps that are required by the benchmark specification [2].

Table 6.1 and figure 6.1 give the neutron flux collapsed to 1 group.

Table 6.2 and figure 6.2 give k_∞.

Table 6.3 and figure 6.3 give the fuel temperature coefficient.

Table 6.4 and figure 6.4 give the total fission rate.

Tables 6.5 - 6.25 and figures 6.5 - 6.25 give the nuclide densities.

Tables 6.26 - 6.46 and figures 6.26 - 6.46 give the 1-group microscopic absorption cross sections. Because WIMS does not count (n,2n) as absorption the figures show the OCTOPUS absorption cross sections with (n,2n) subtracted. The tables give the true OCTOPUS absorption cross sections. The WIMS absorption cross sections in the tables are also given with the (n,2n) OCTOPUS average (from OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT) added to it.

Tables 6.47 - 6.58 and figures 6.47 - 6.58 give the 1-group microscopic fission cross sections.

6.2 Case B1 discussion

Only WIMS calculations were done here, so no comparison can be done with OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT.

Table 6.1 one group neutron flux $[s^{-1}cm^{-2}]$ for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5844e+14	–	–
100.00	1.6983e+14	–	–
400.00	2.0904e+14	–	–
600.00	3.2401e+14	–	–
800.00	1.8096e+16	–	–

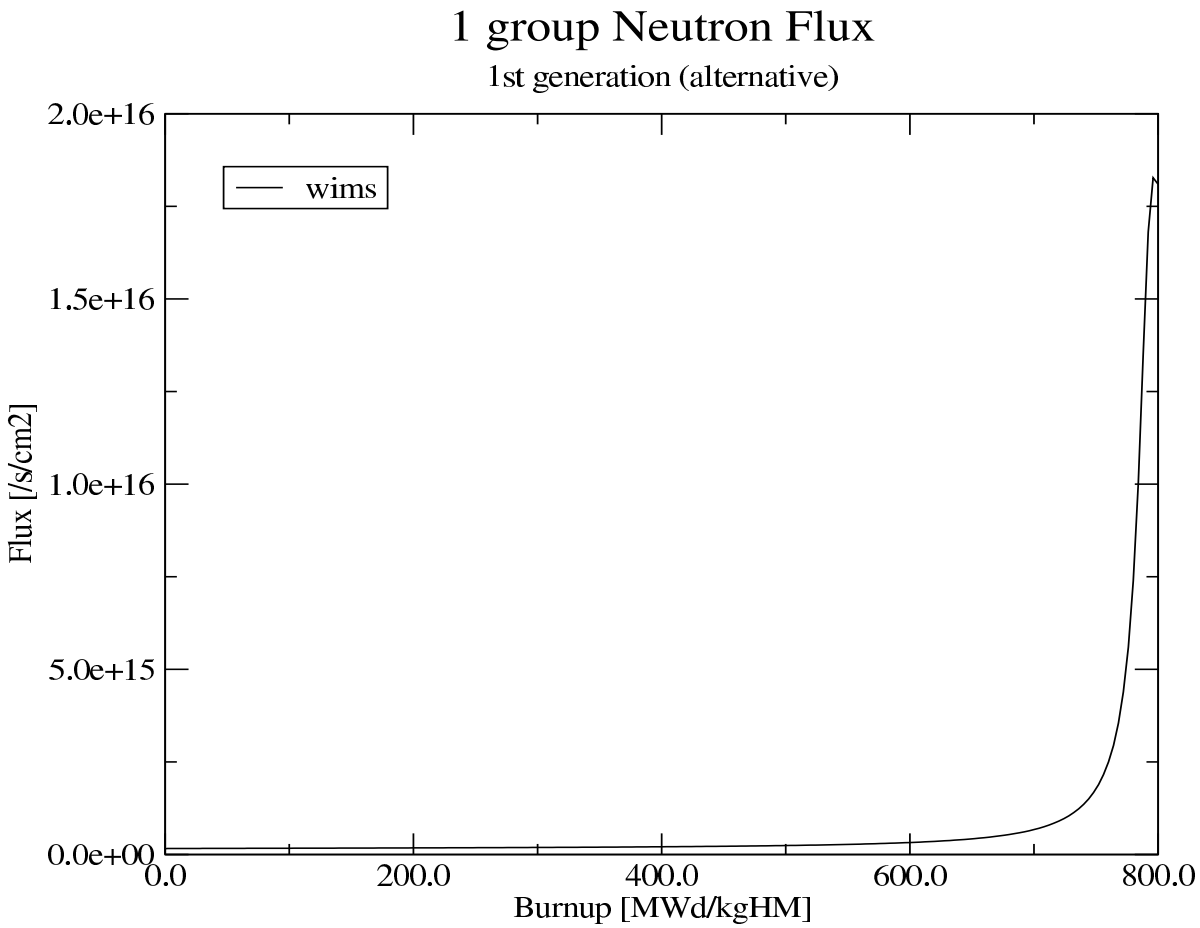


Figure 6.1 one group neutron flux $[s^{-1}cm^{-2}]$ for case B1

Table 6.2 k_∞ for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3857	–	–
100.00	1.3122	–	–
400.00	1.2110	–	–
600.00	1.0623	–	–
800.00	0.1320	–	–

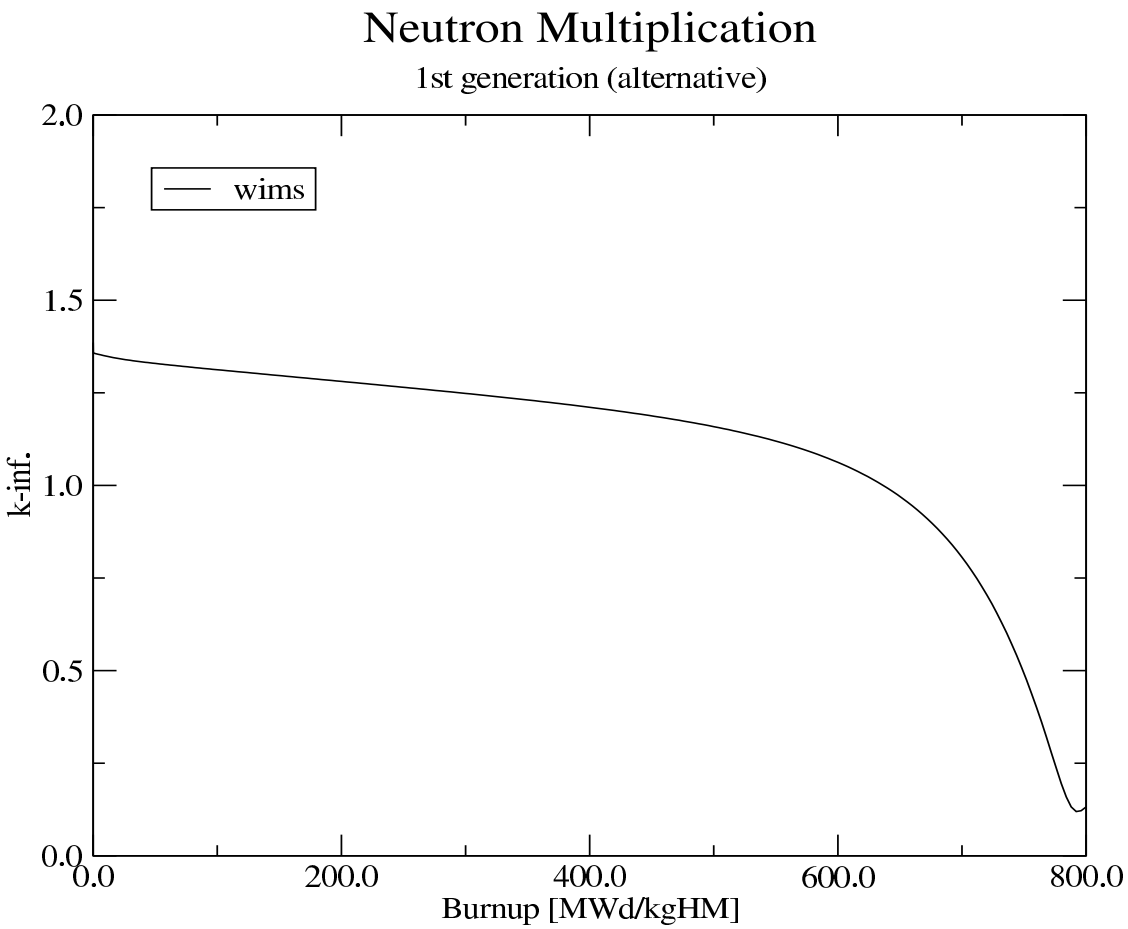


Figure 6.2 k_∞ for case B1

Table 6.3 FTC $[pcm/K]$ for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	-5.60	–	–
100.00	-4.47	–	–
400.00	-5.62	–	–
600.00	-5.49	–	–
800.00	-152.66	–	–

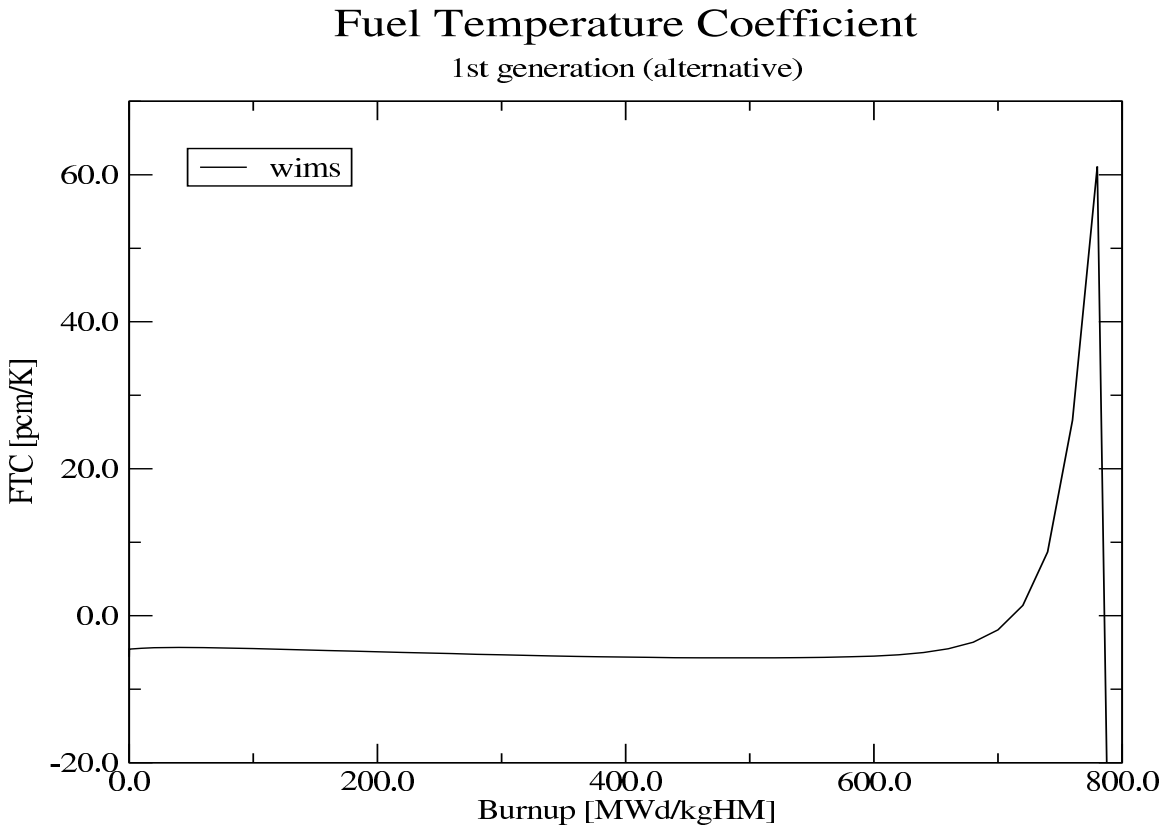


Figure 6.3 FTC $[pcm/K]$ for case B1

Table 6.4 Fission Rate $[s^{-1}]$ for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.9644e+13	–	–
100.00	2.9619e+13	–	–
400.00	2.9508e+13	–	–
600.00	2.9389e+13	–	–
800.00	2.8313e+13	–	–

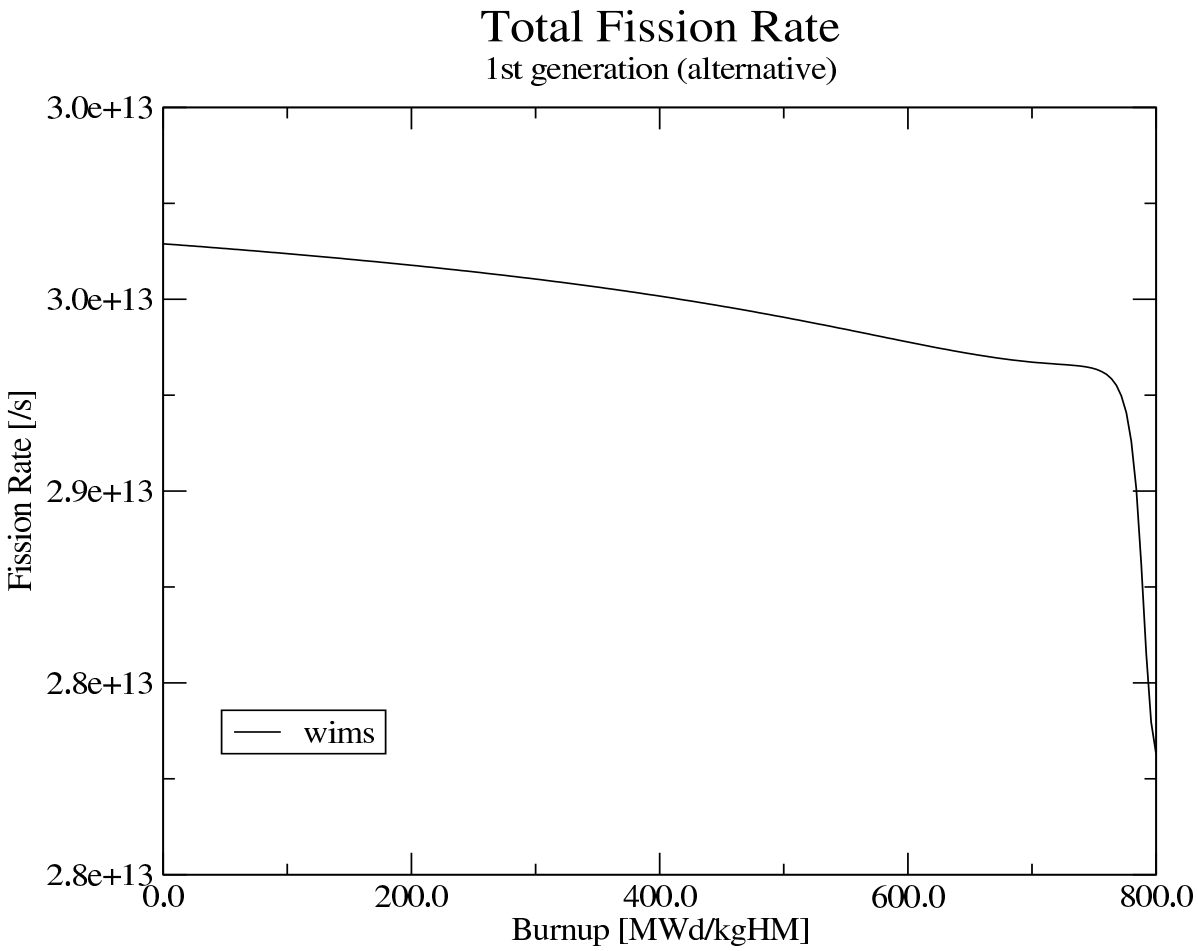


Figure 6.4 Fission Rate $[s^{-1}]$ for case B1

Table 6.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.0116e-04	–	–
100.00	5.7751e-04	–	–
400.00	5.0494e-04	–	–
600.00	4.2745e-04	–	–
800.00	2.2786e-06	–	–

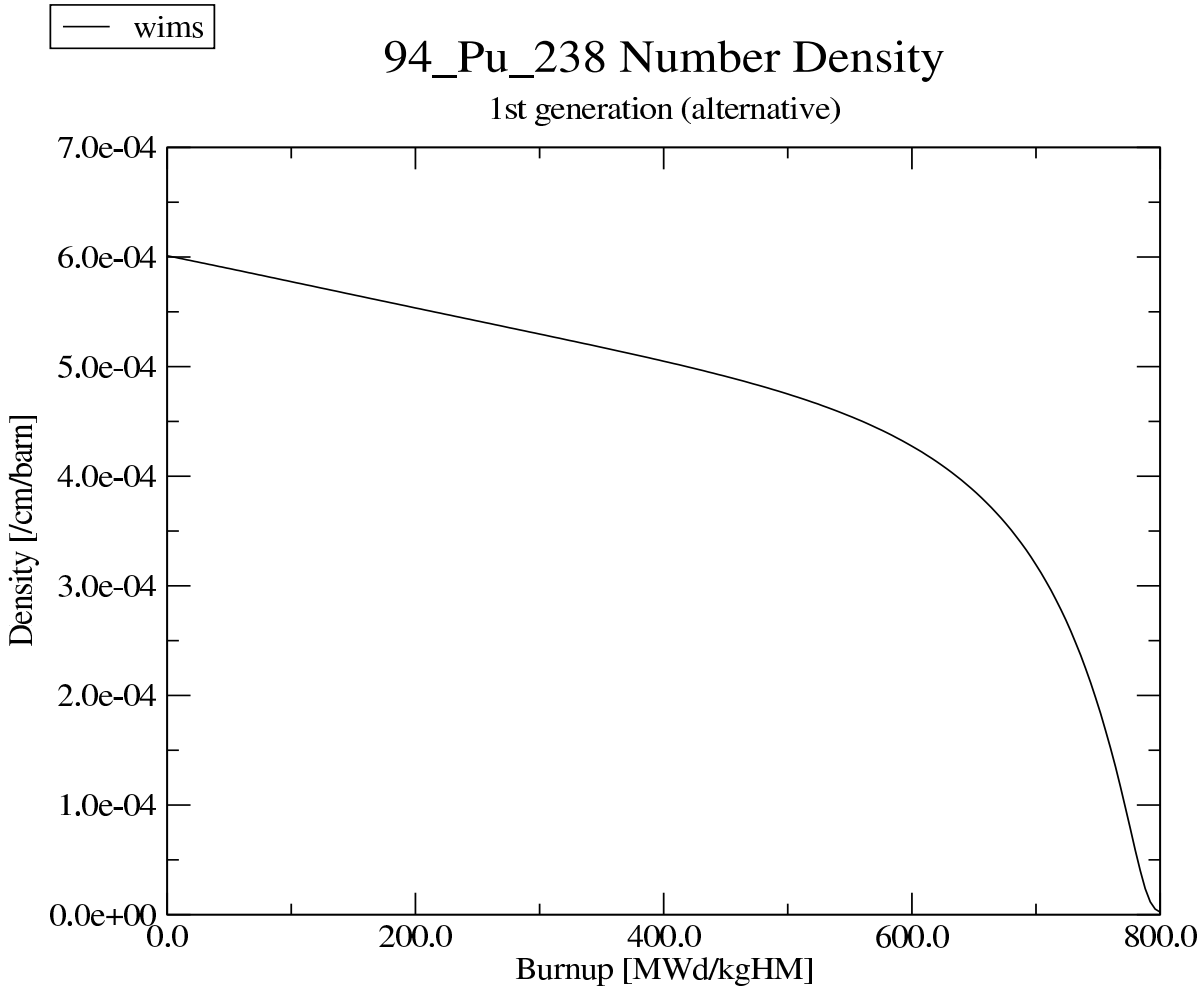


Figure 6.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case B1

Table 6.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.2446e-02	–	–
100.00	9.5818e-03	–	–
400.00	2.7541e-03	–	–
600.00	3.8204e-04	–	–
800.00	3.0506e-07	–	–

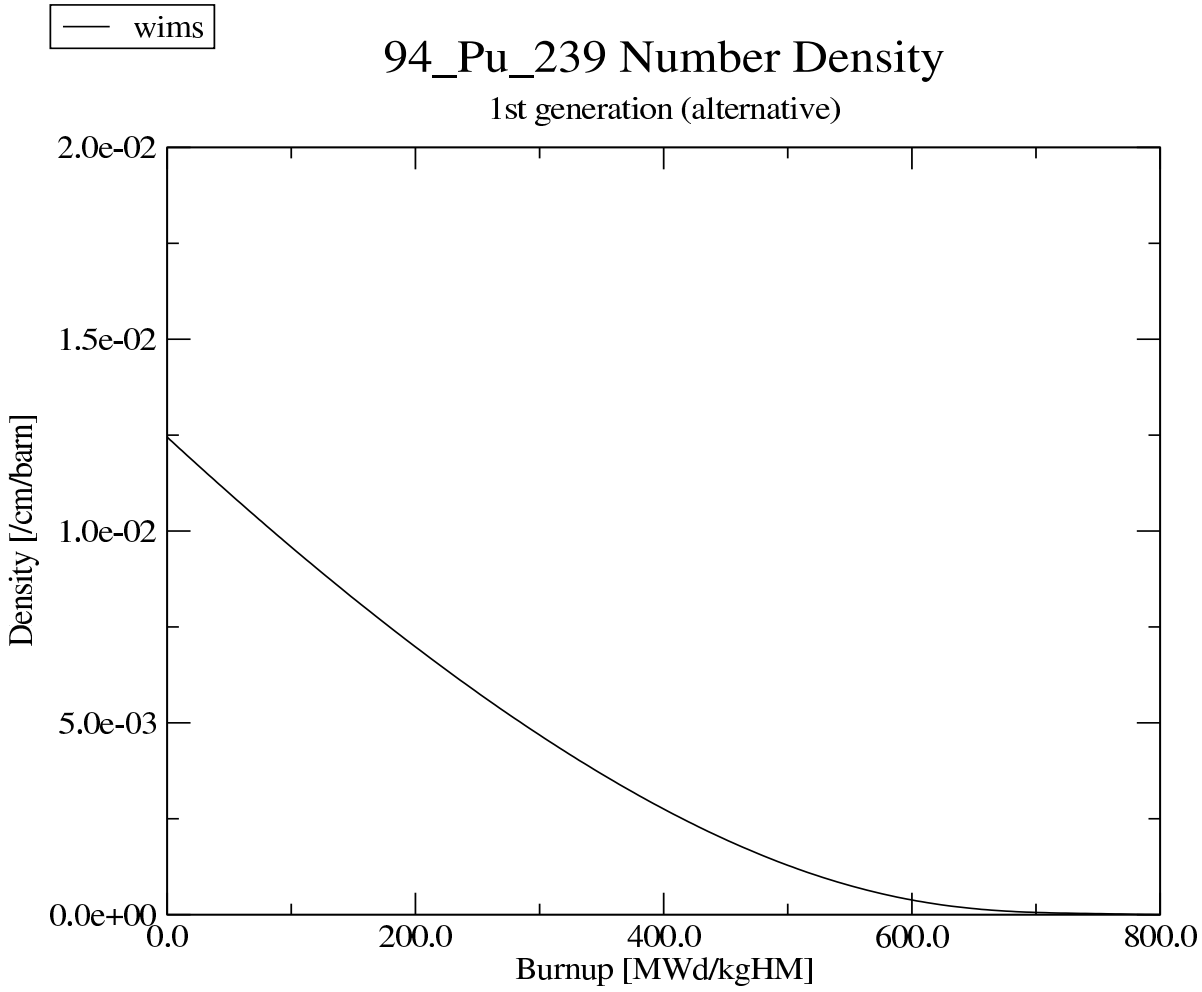


Figure 6.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case B1

Table 6.7 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_240 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.4458e-03	–	–
100.00	5.3755e-03	–	–
400.00	4.2995e-03	–	–
600.00	2.5692e-03	–	–
800.00	2.2204e-06	–	–

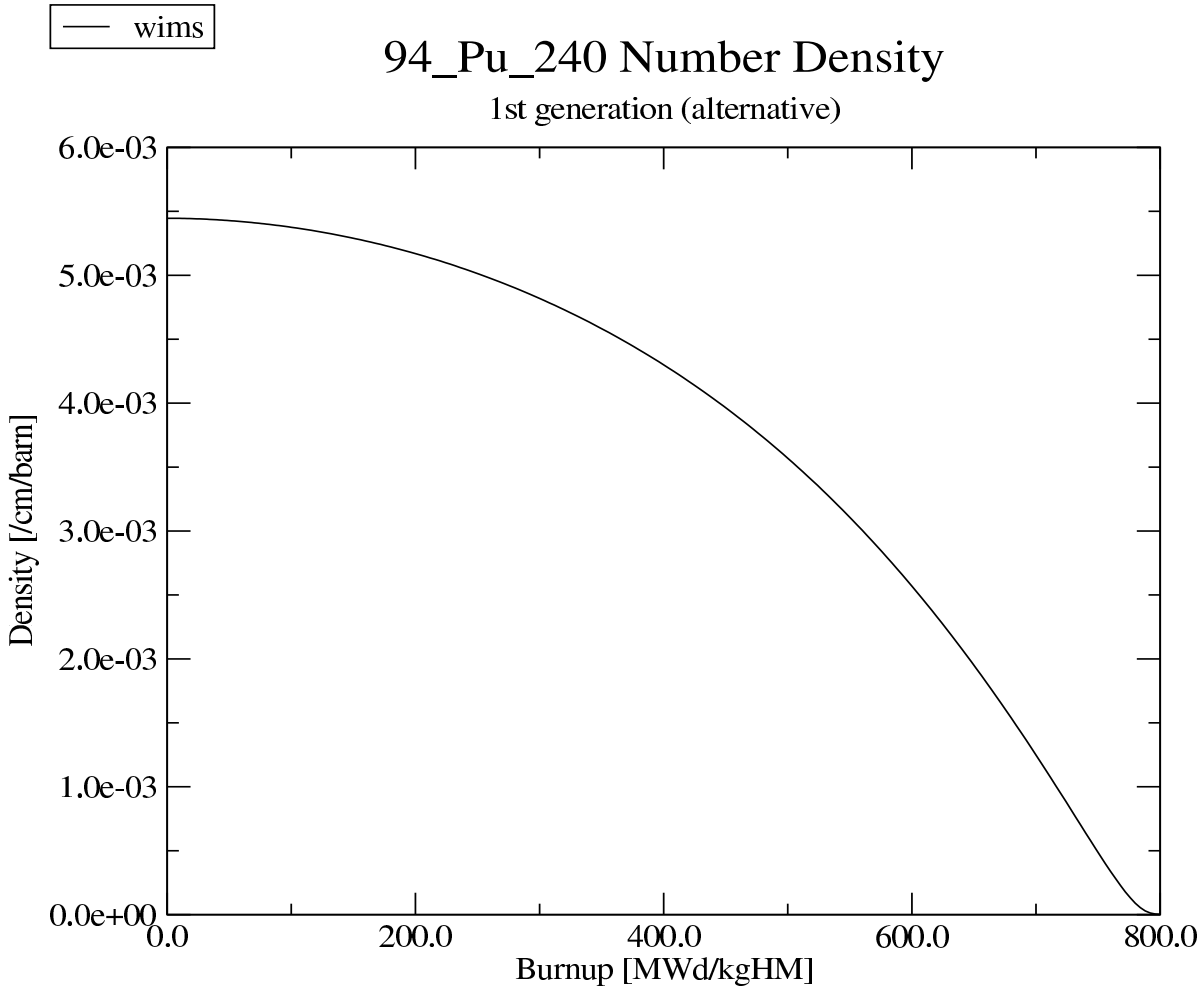


Figure 6.7 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_240 for case B1

Table 6.8 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_241 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.0096e-03	–	–
100.00	3.3990e-03	–	–
400.00	3.3476e-03	–	–
600.00	1.8356e-03	–	–
800.00	5.8545e-07	–	–

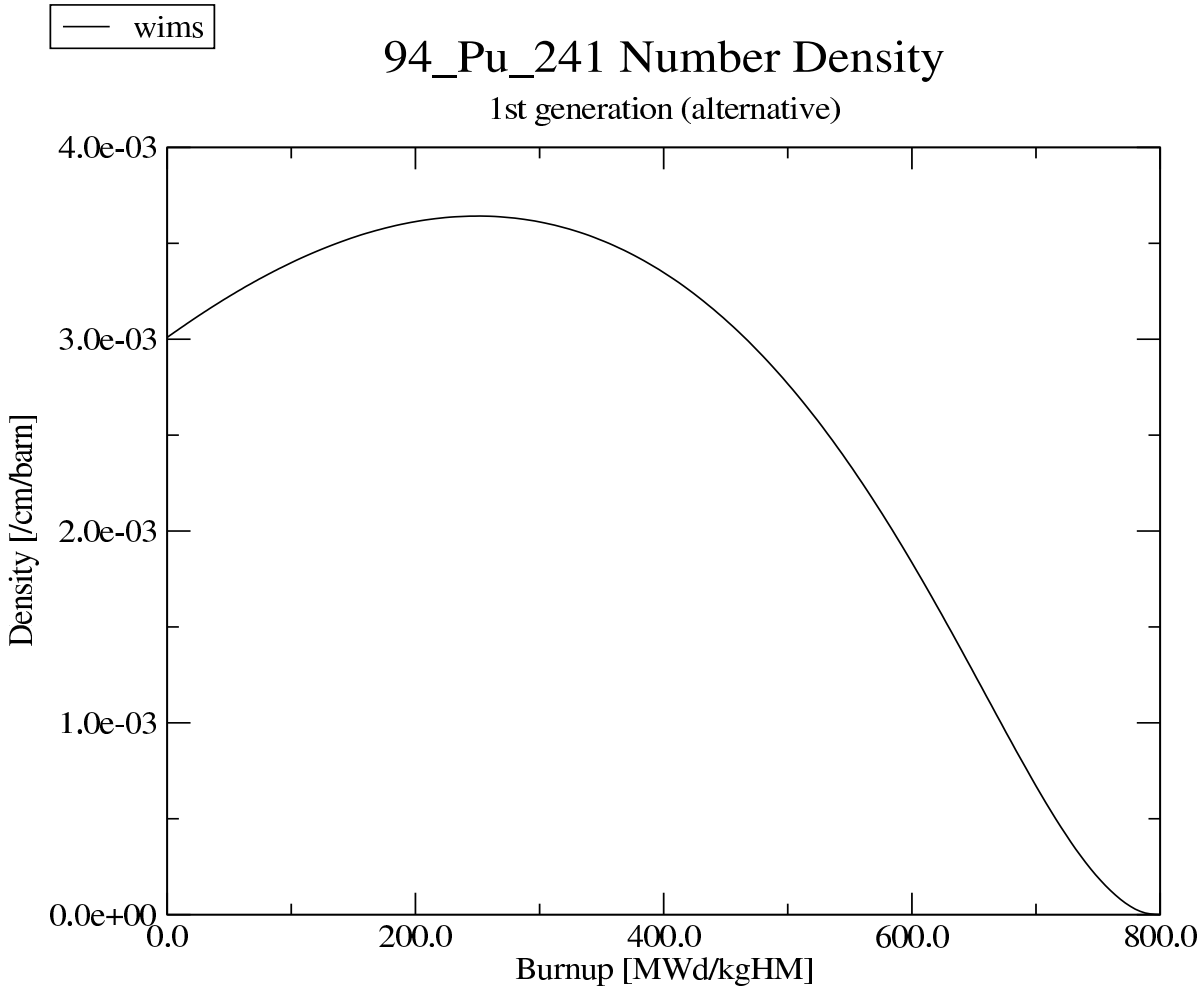


Figure 6.8 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_241 for case B1

Table 6.9 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_242 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5476e-03	–	–
100.00	1.6243e-03	–	–
400.00	2.1730e-03	–	–
600.00	2.8838e-03	–	–
800.00	2.2650e-03	–	–

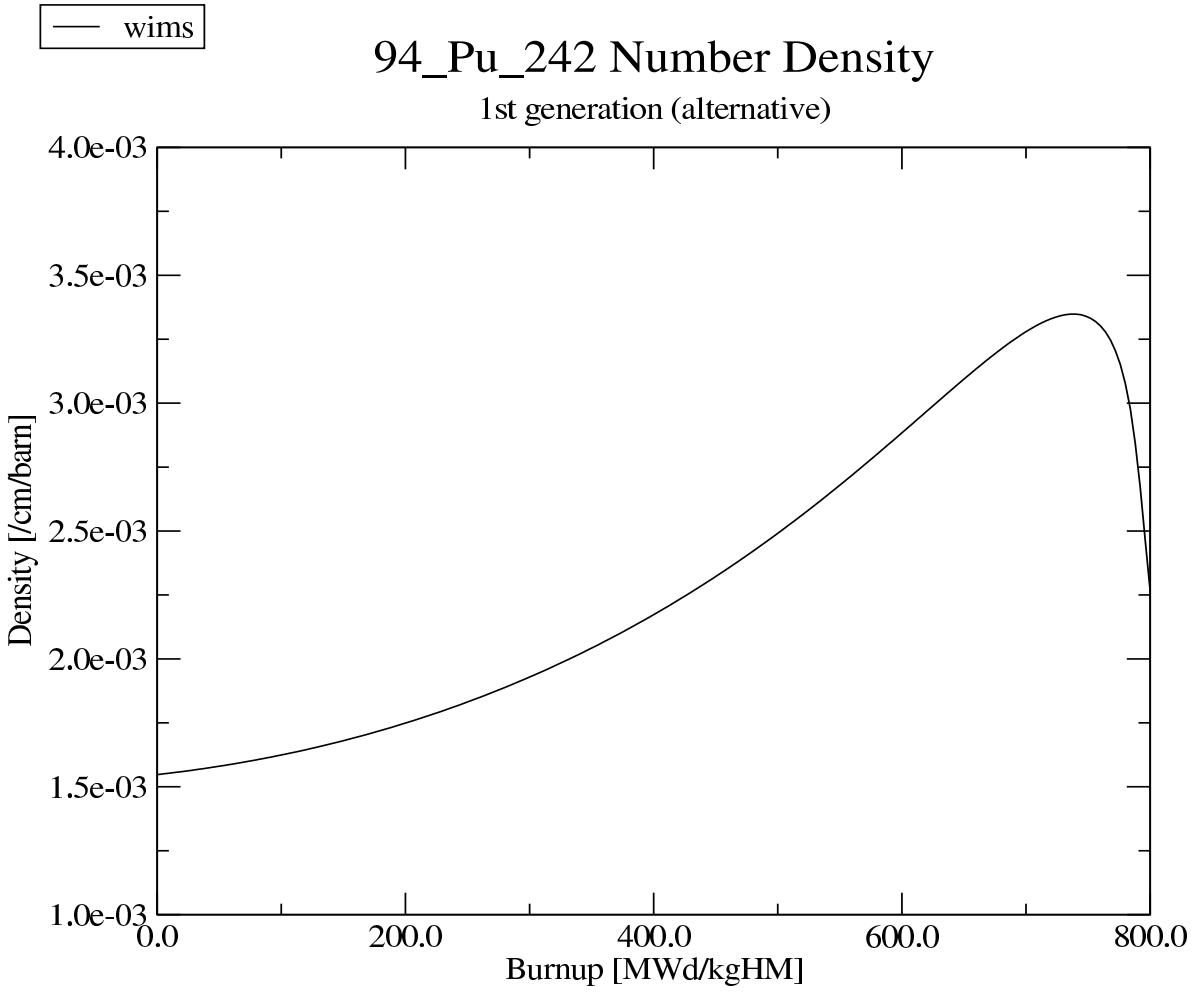


Figure 6.9 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_242 for case B1

Table 6.10 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_241 for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	3.7820e-05	–	–
400.00	9.9989e-05	–	–
600.00	5.9700e-05	–	–
800.00	8.7496e-11	–	–

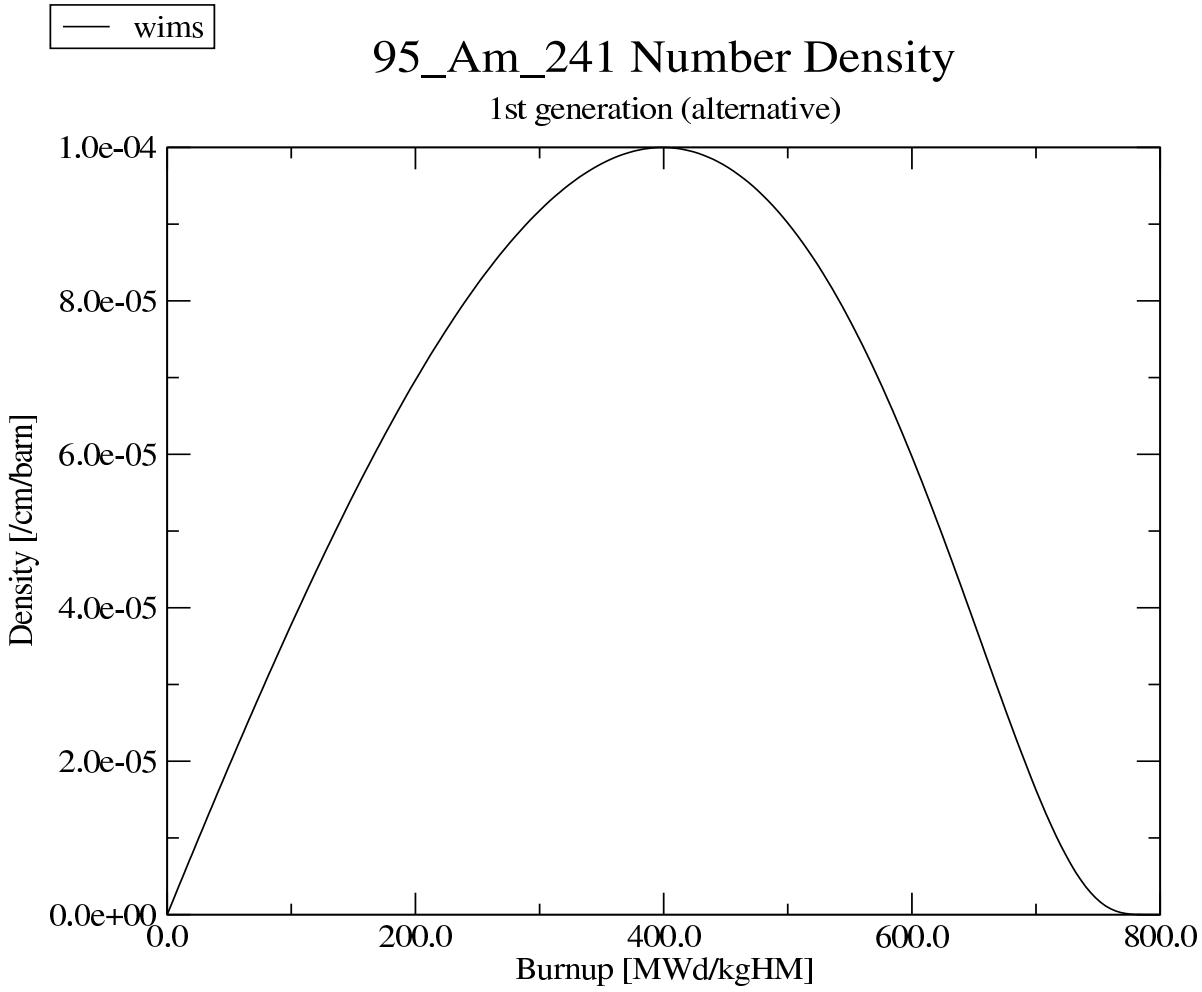


Figure 6.10 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_241 for case B1

Table 6.11 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	3.3128e-07	–	–
400.00	1.8511e-06	–	–
600.00	1.0657e-06	–	–
800.00	1.2202e-12	–	–

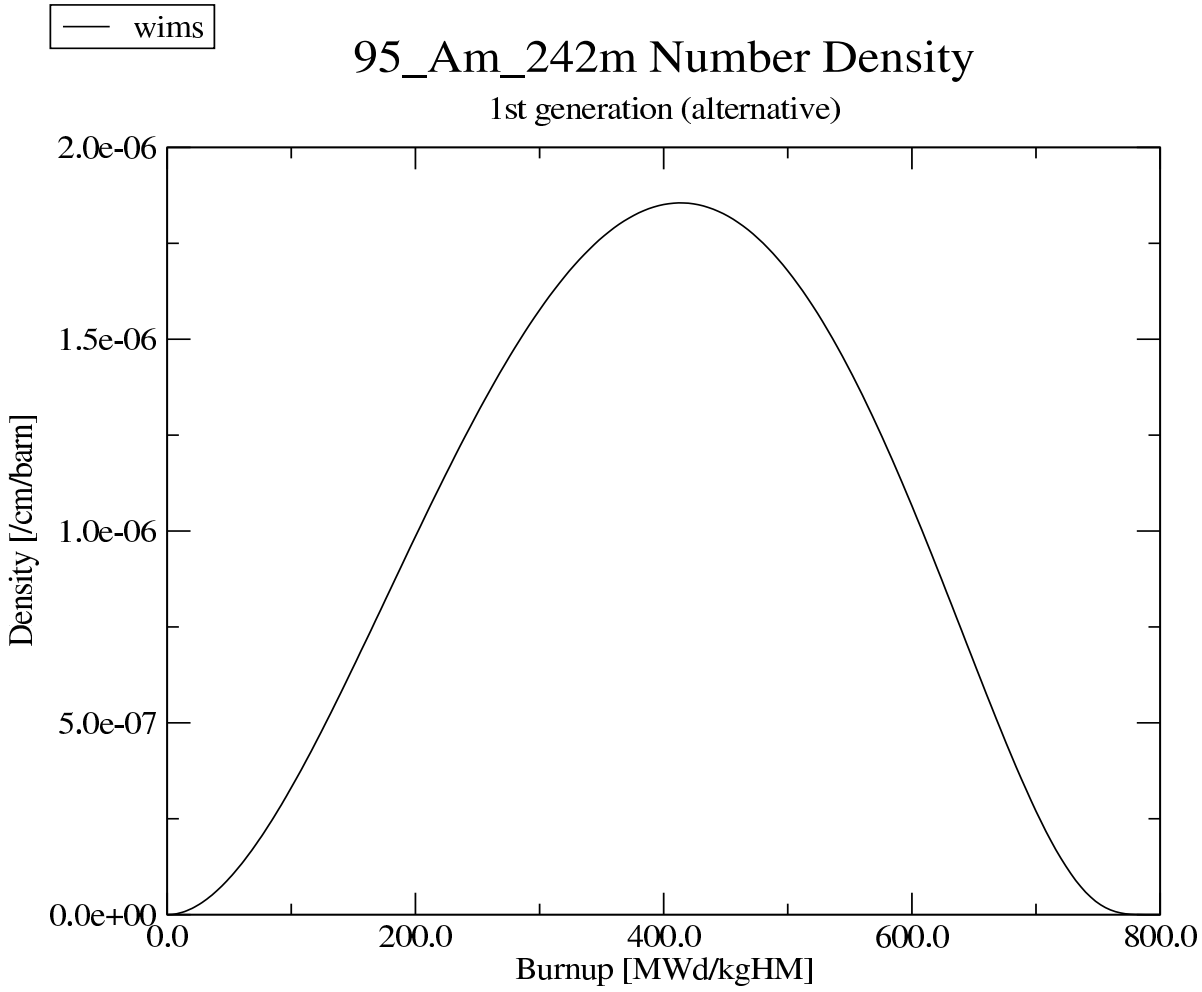


Figure 6.11 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case B1

Table 6.12 Number Density [$cm^{-1}barn^{-1}$] 95_Am_243 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	9.7973e-05	–	–
400.00	3.7722e-04	–	–
600.00	5.8744e-04	–	–
800.00	7.7570e-04	–	–

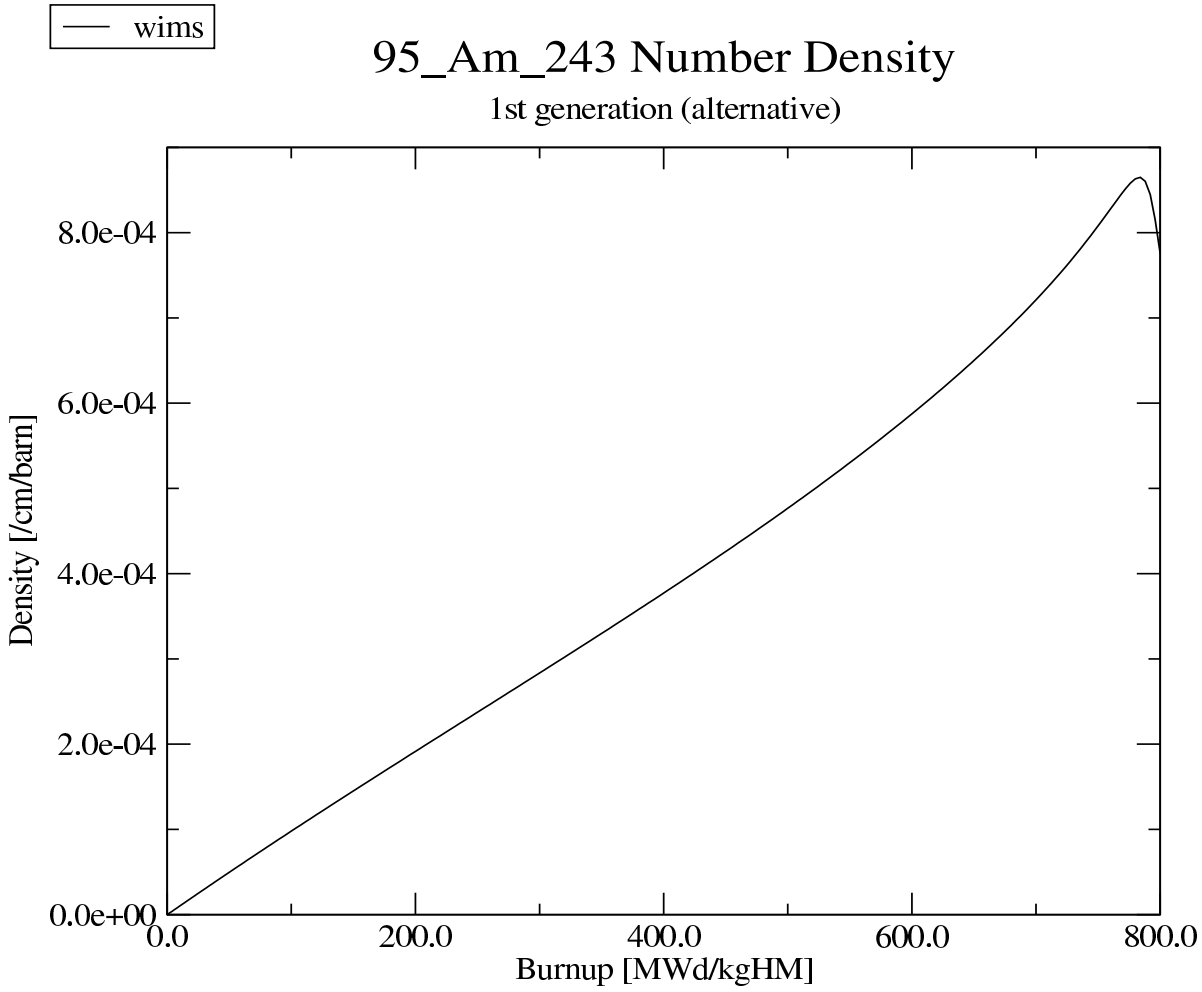


Figure 6.12 Number Density [$cm^{-1}barn^{-1}$] 95_Am_243 for case B1

Table 6.13 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_242 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	2.9417e-06	–	–
400.00	3.7581e-05	–	–
600.00	7.1658e-05	–	–
800.00	4.5368e-05	–	–

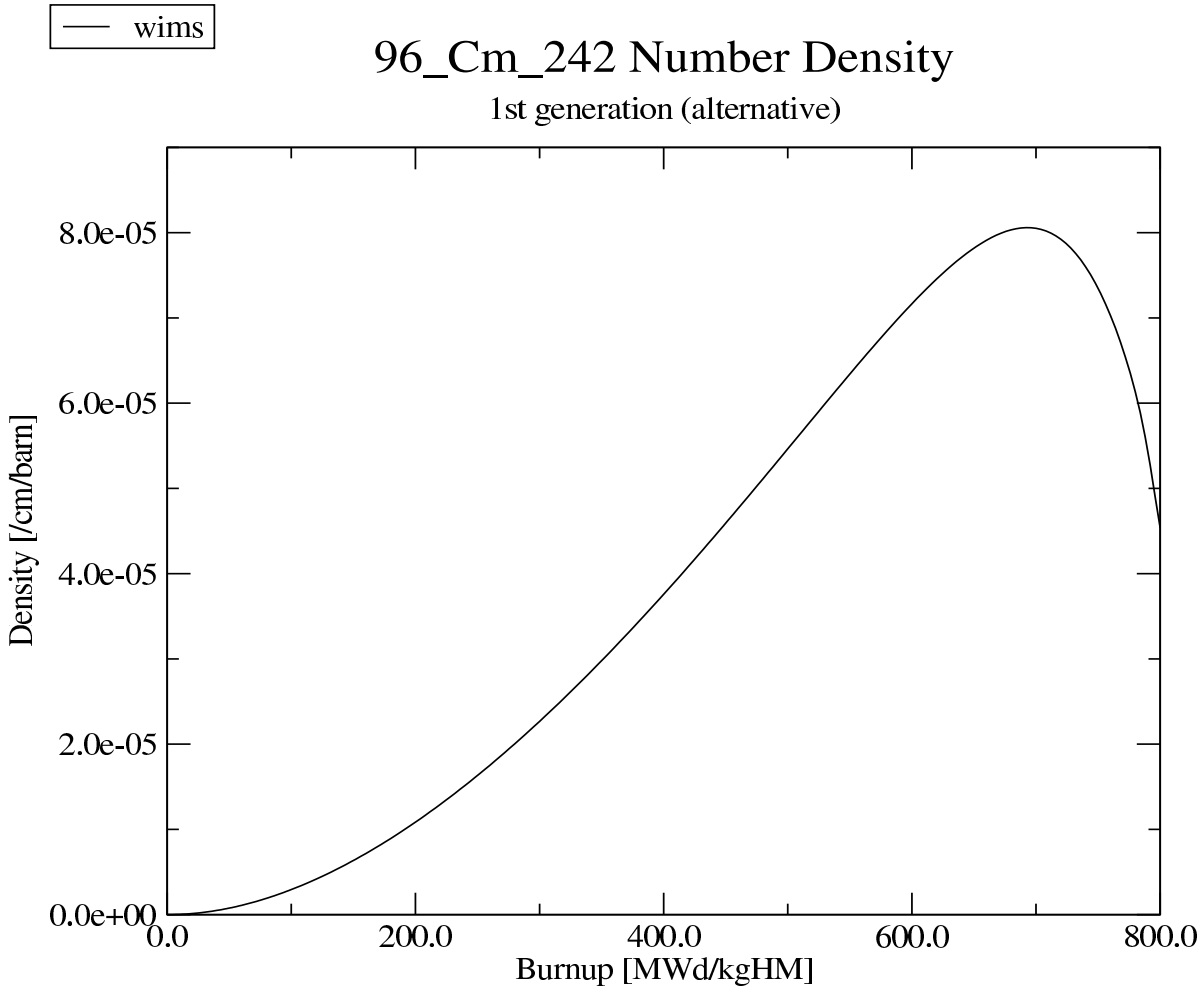


Figure 6.13 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_242 for case B1

Table 6.14 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	8.9696e-09	–	–
400.00	4.6312e-07	–	–
600.00	1.4031e-06	–	–
800.00	1.3441e-06	–	–

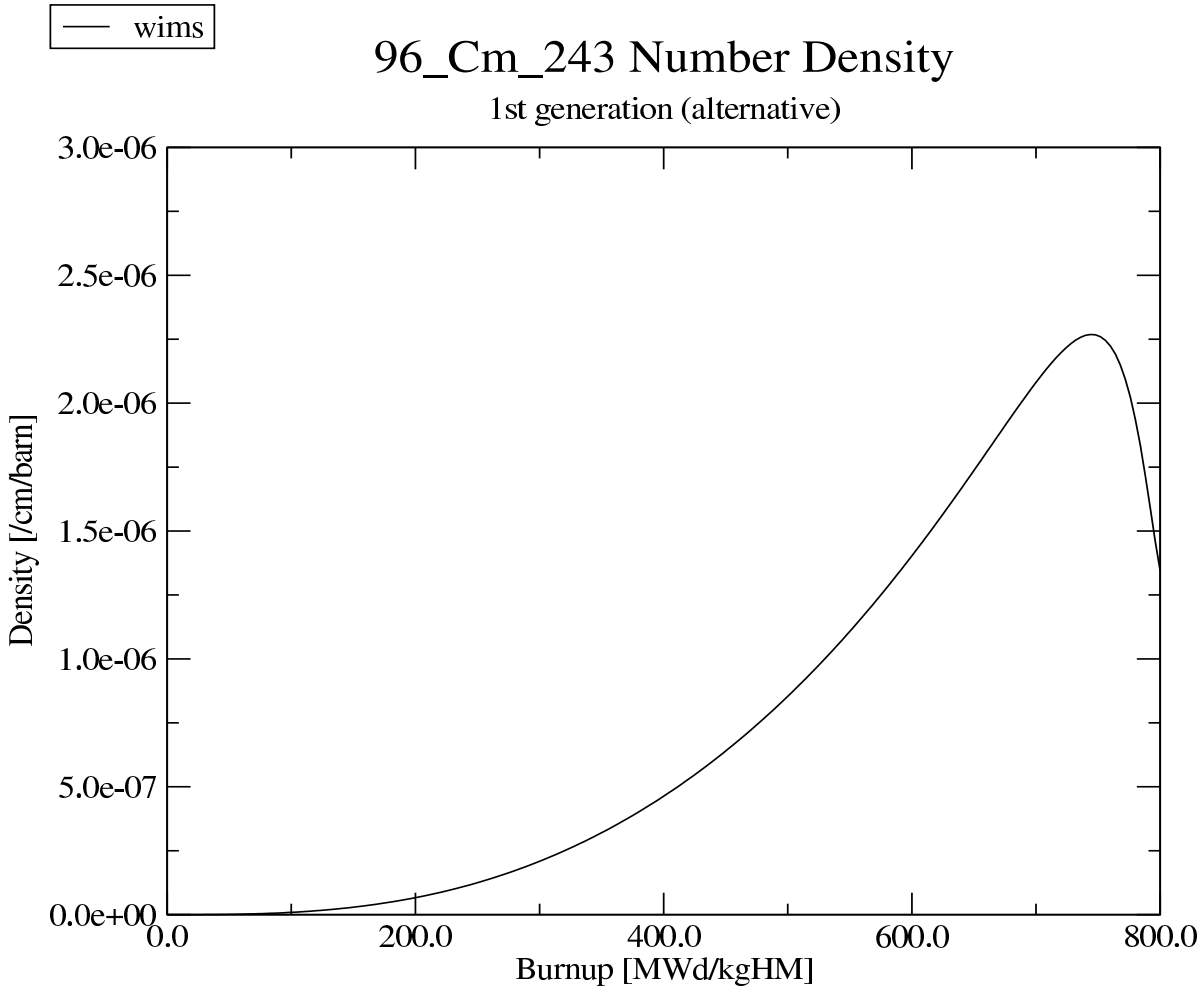


Figure 6.14 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case B1

Table 6.15 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_244 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	6.5403e-06	–	–
400.00	1.0159e-04	–	–
600.00	2.4572e-04	–	–
800.00	1.4946e-03	–	–

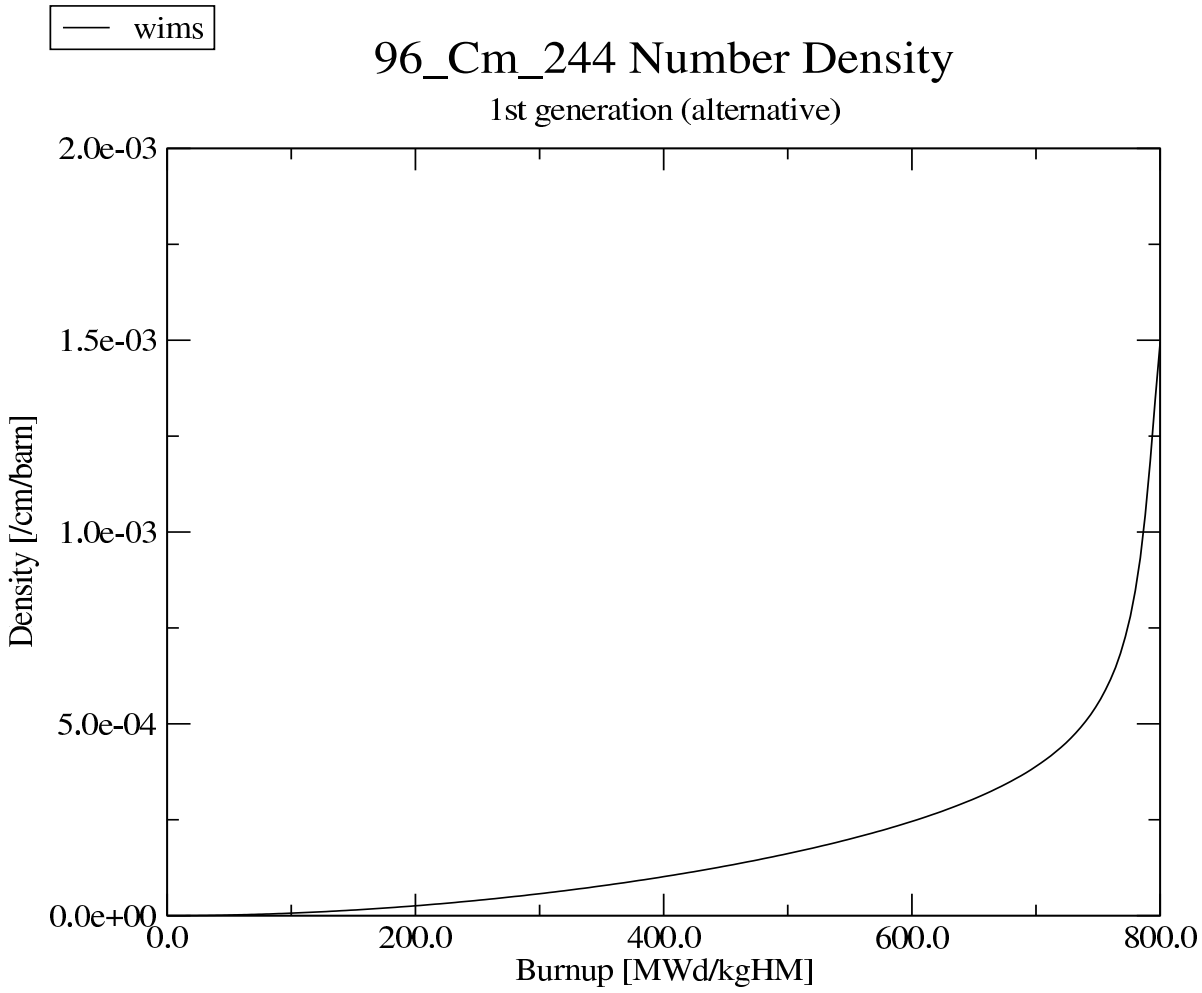


Figure 6.15 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_244 for case B1

Table 6.16 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	9.2716e-08	–	–
400.00	4.9395e-06	–	–
600.00	1.2301e-05	–	–
800.00	1.9166e-05	–	–

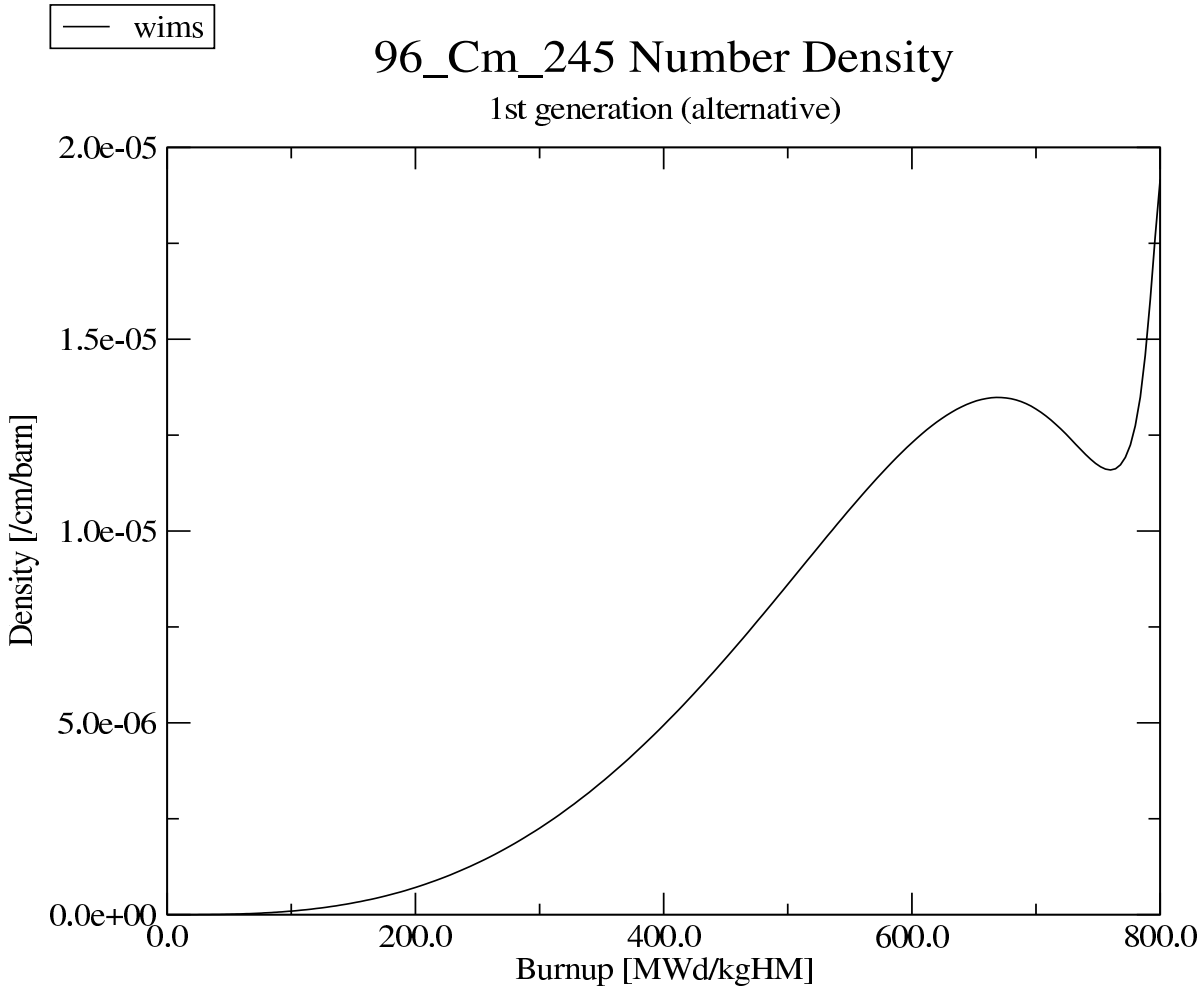


Figure 6.16 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case B1

Table 6.17 Number Density [$cm^{-1}barn^{-1}$] 40_Zr_93 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	8.6157e-05	–	–
400.00	3.3155e-04	–	–
600.00	4.7956e-04	–	–
800.00	5.8744e-04	–	–

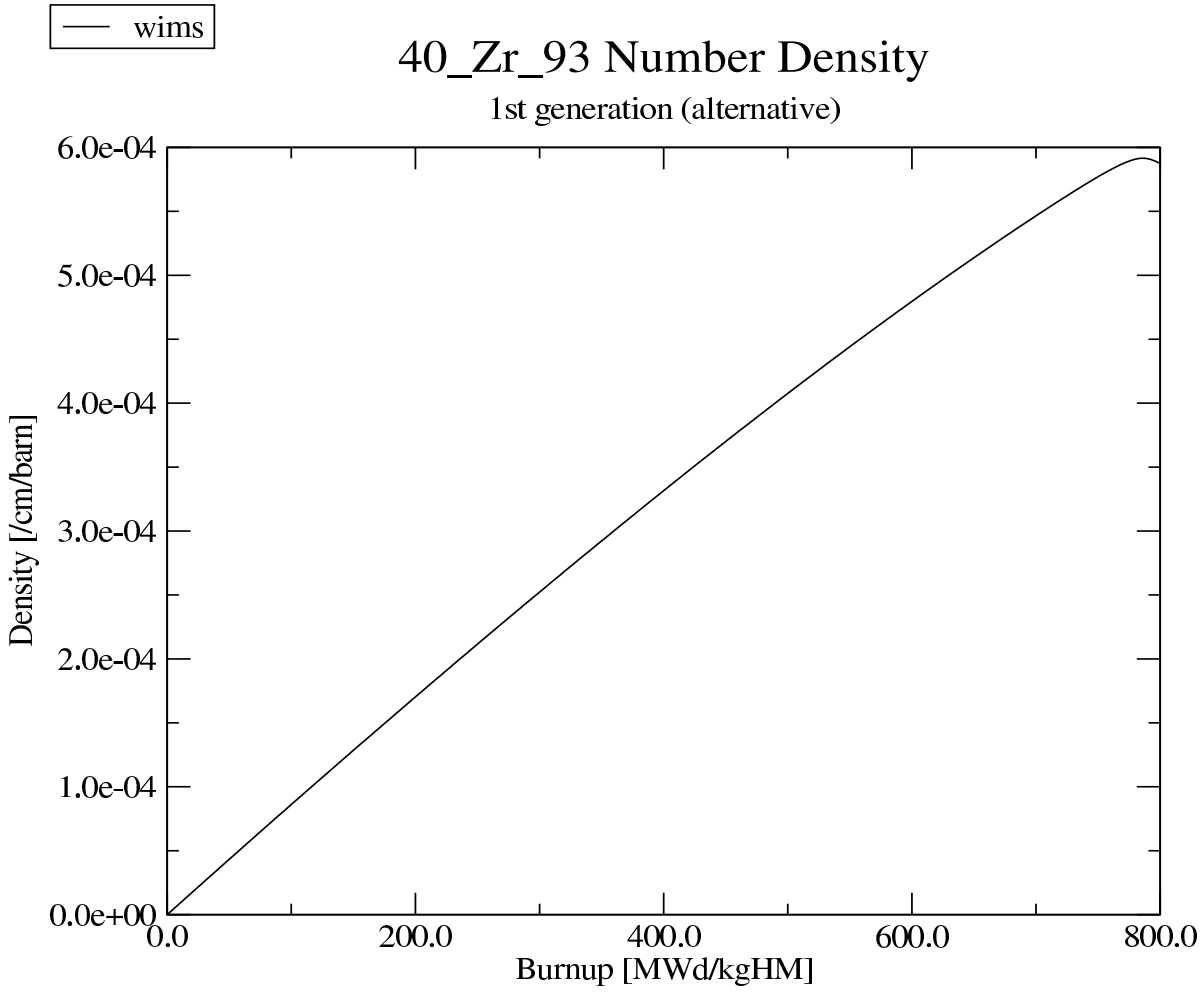


Figure 6.17 Number Density [$cm^{-1}barn^{-1}$] 40_Zr_93 for case B1

Table 6.18 Number Density [$cm^{-1}barn^{-1}$] 43_Tc_99 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.4080e-04	–	–
400.00	5.3572e-04	–	–
600.00	7.6750e-04	–	–
800.00	6.8485e-04	–	–

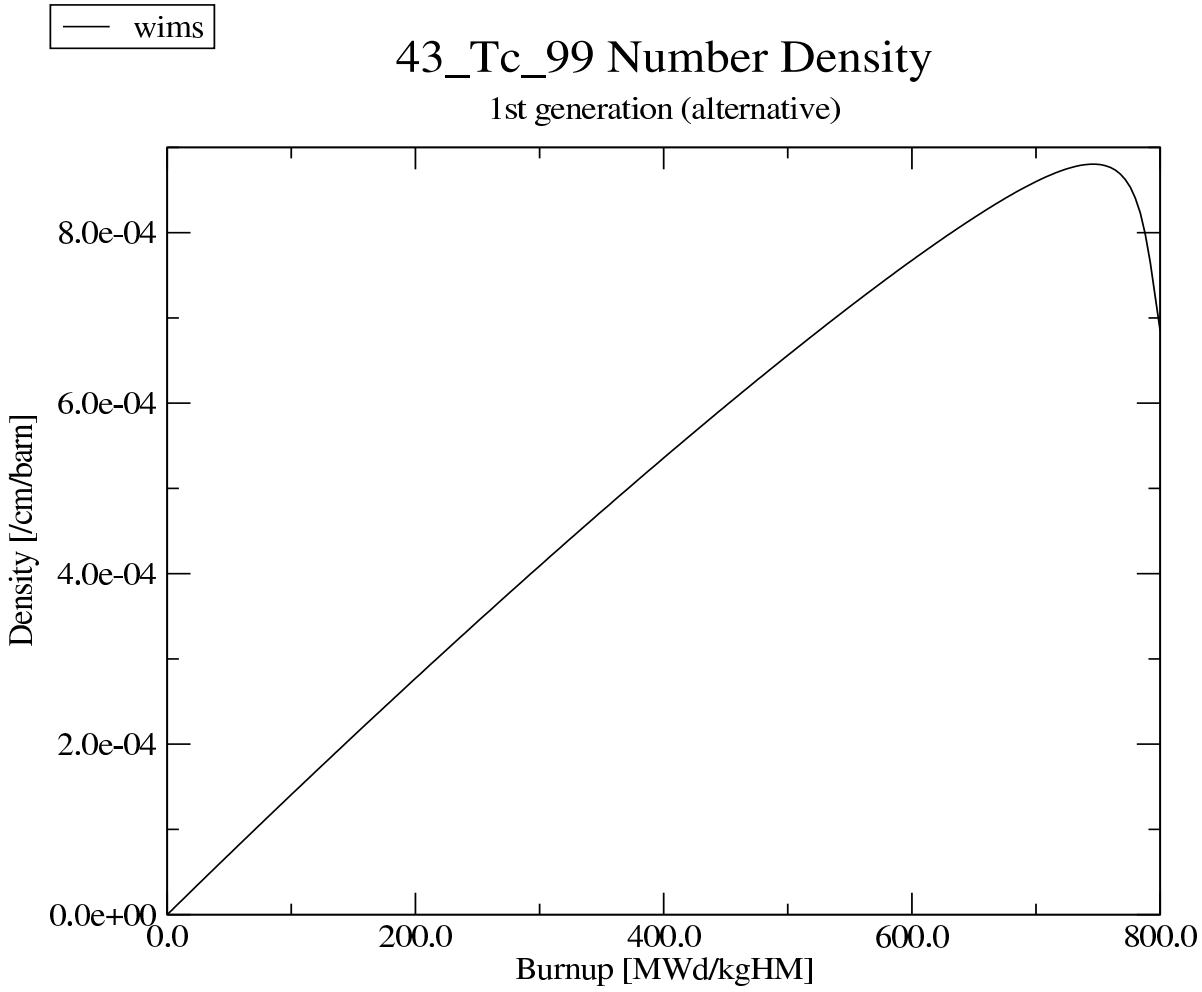


Figure 6.18 Number Density [$cm^{-1}barn^{-1}$] 43_Tc_99 for case B1

Table 6.19 Number Density [$cm^{-1}barn^{-1}$] 46_Pd_107 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	8.4086e-05	–	–
400.00	3.5133e-04	–	–
600.00	5.4823e-04	–	–
800.00	7.2257e-04	–	–

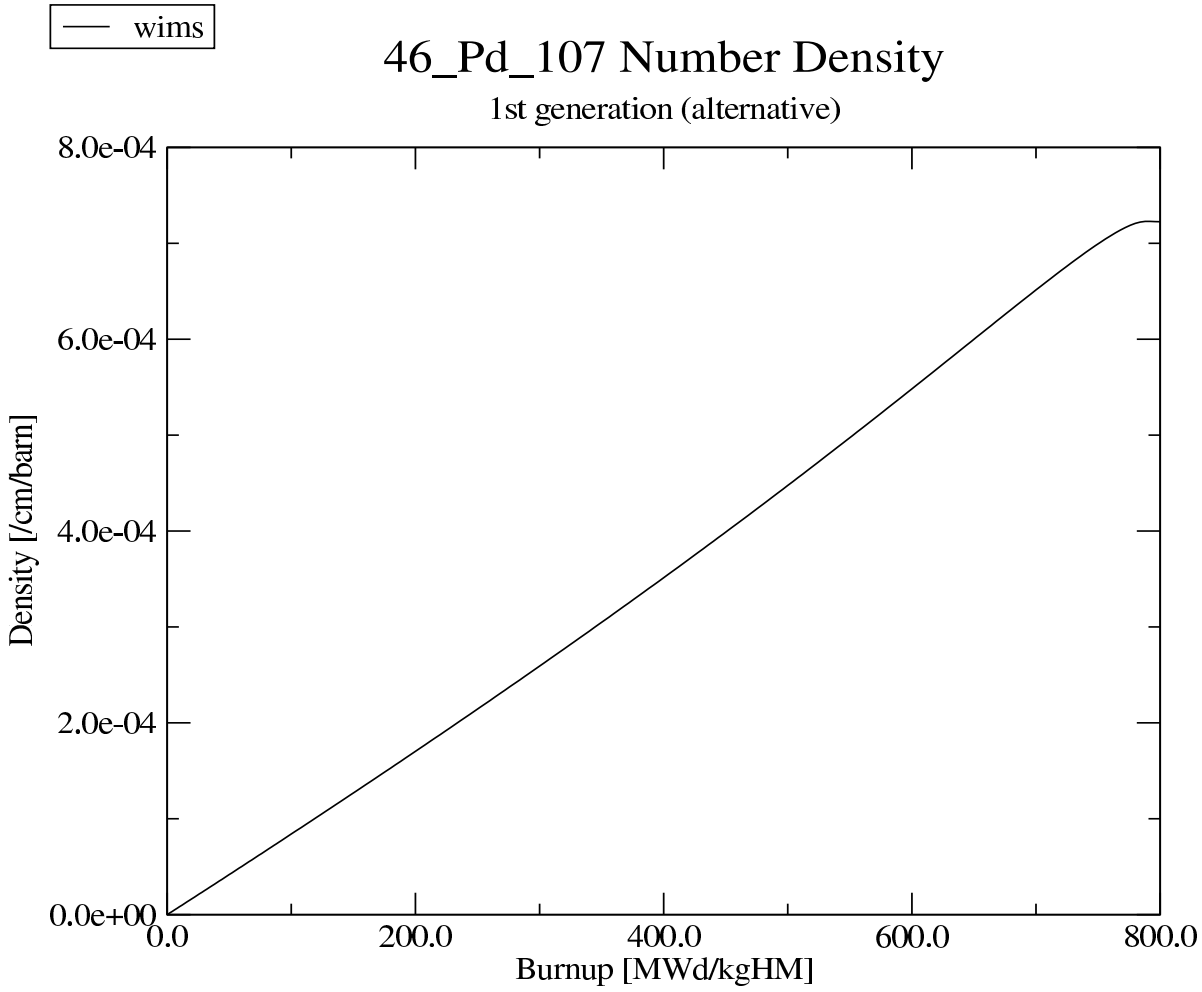


Figure 6.19 Number Density [$cm^{-1}barn^{-1}$] 46_Pd_107 for case B1

Table 6.20 Number Density [$cm^{-1}barn^{-1}$] 53_I_129 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	3.2694e-05	–	–
400.00	1.2855e-04	–	–
600.00	1.8835e-04	–	–
800.00	1.5226e-04	–	–

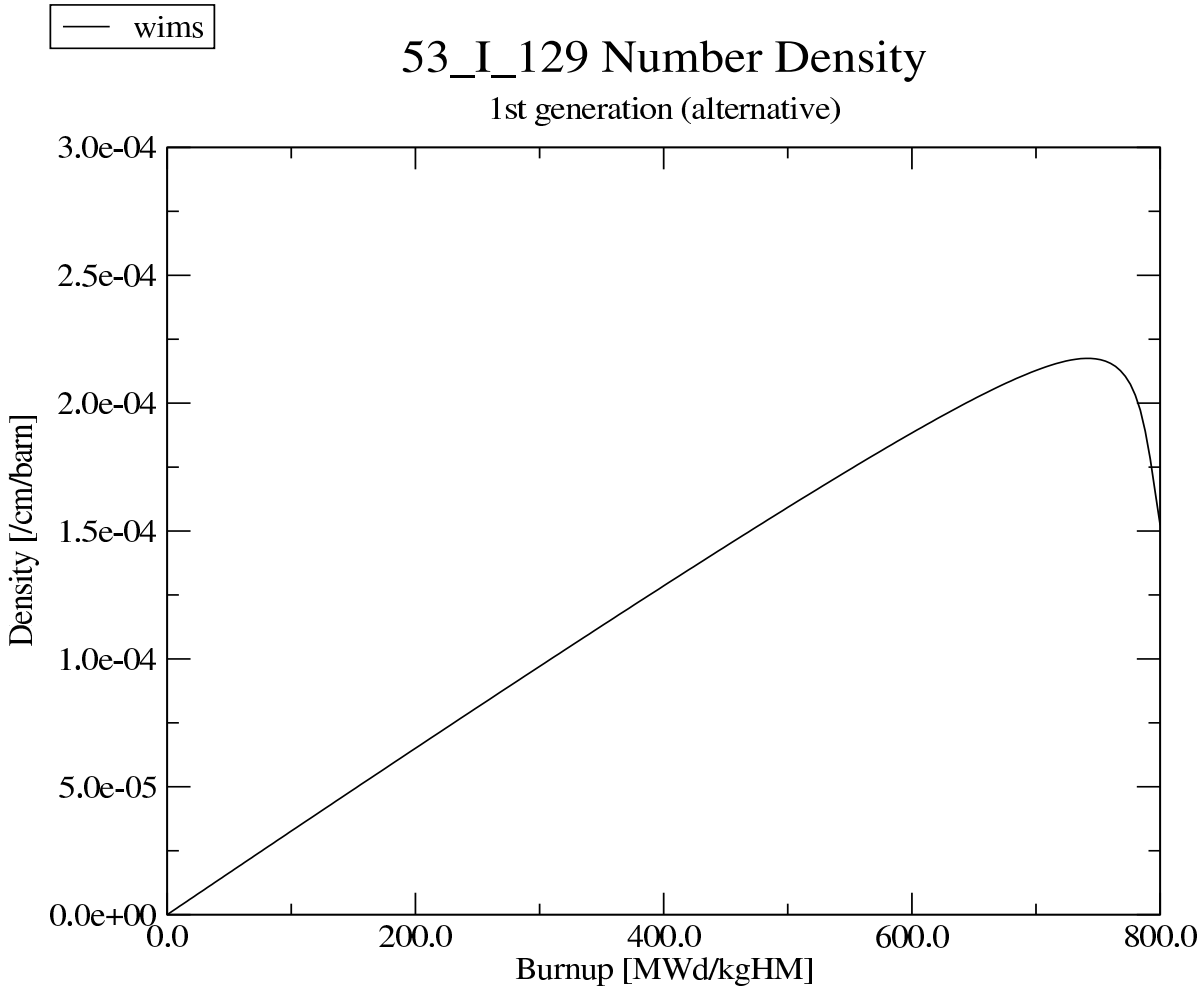


Figure 6.20 Number Density [$cm^{-1}barn^{-1}$] 53_I_129 for case B1

Table 6.21 Number Density [$cm^{-1}barn^{-1}$] 55_Cs_135 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	8.7070e-05	–	–
400.00	2.8619e-04	–	–
600.00	3.5535e-04	–	–
800.00	6.5780e-04	–	–

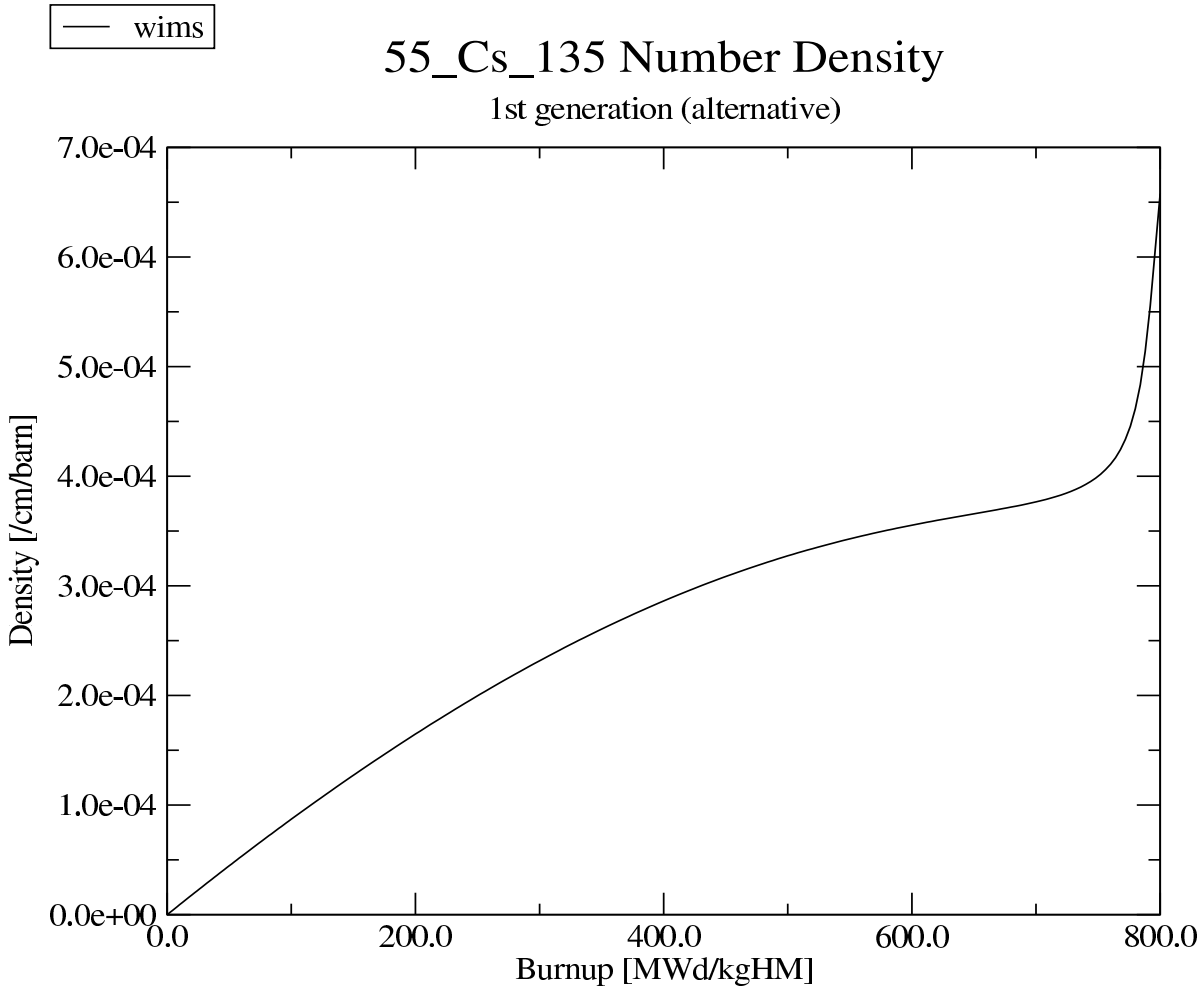


Figure 6.21 Number Density [$cm^{-1}barn^{-1}$] 55_Cs_135 for case B1

Table 6.22 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_147 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.1906e-06	–	–
400.00	1.7906e-05	–	–
600.00	3.2991e-05	–	–
800.00	1.5791e-05	–	–

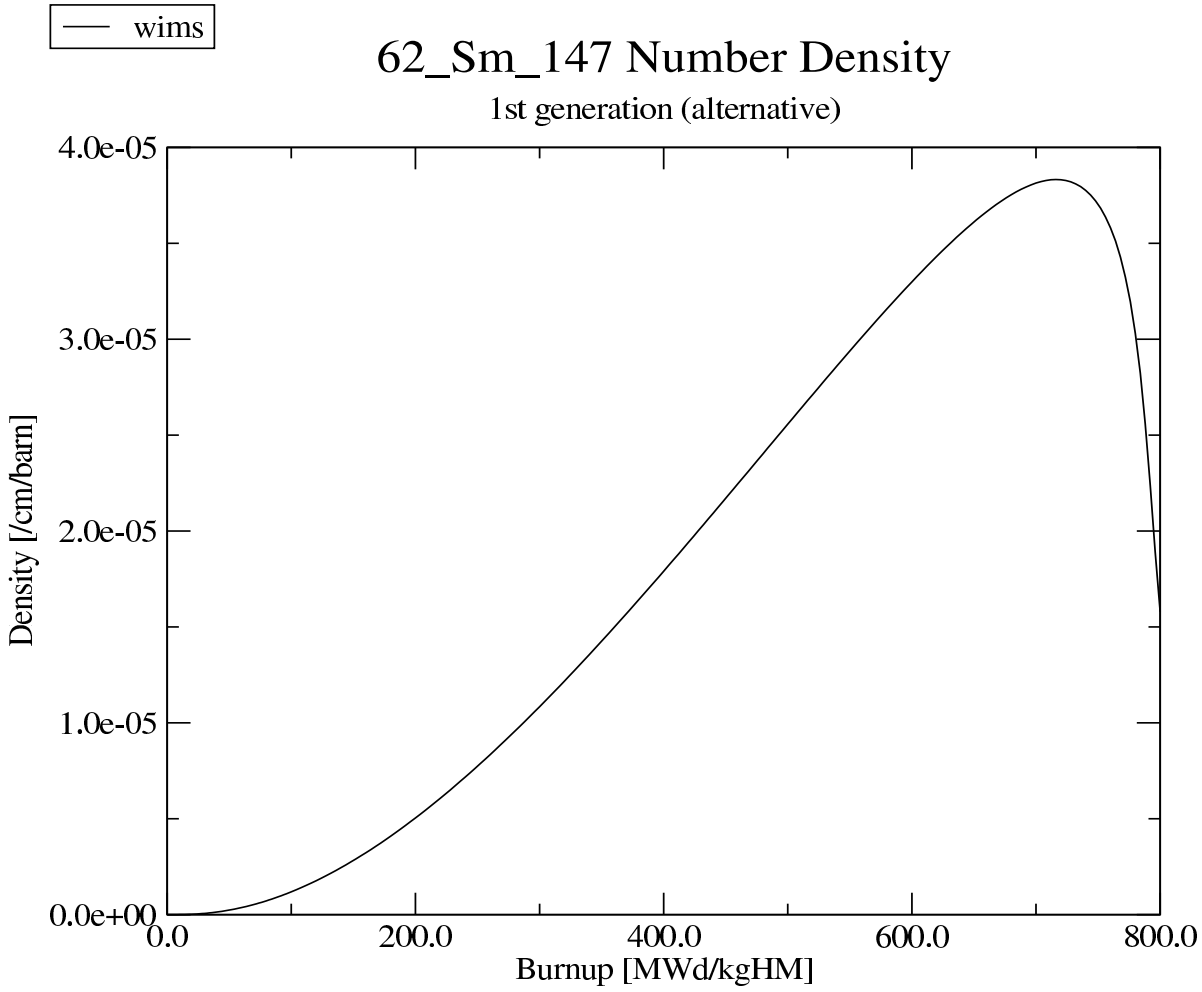


Figure 6.22 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_147 for case B1

Table 6.23 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_149 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	4.9095e-06	–	–
400.00	2.8255e-06	–	–
600.00	1.2023e-06	–	–
800.00	1.5138e-08	–	–

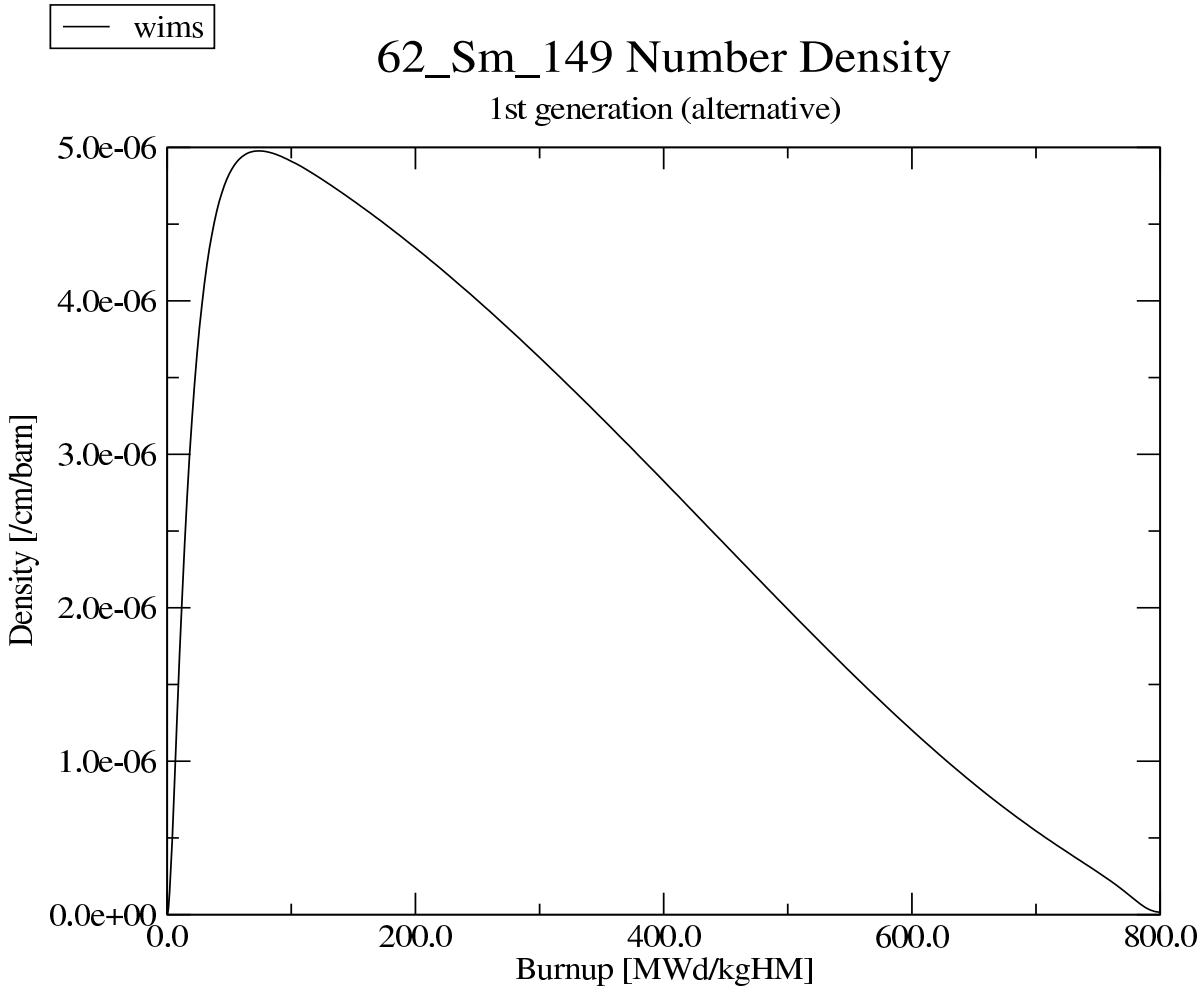


Figure 6.23 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_149 for case B1

Table 6.24 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_151 for case B1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.3150e-05	–	–
400.00	1.8078e-05	–	–
600.00	9.5695e-06	–	–
800.00	1.7539e-06	–	–

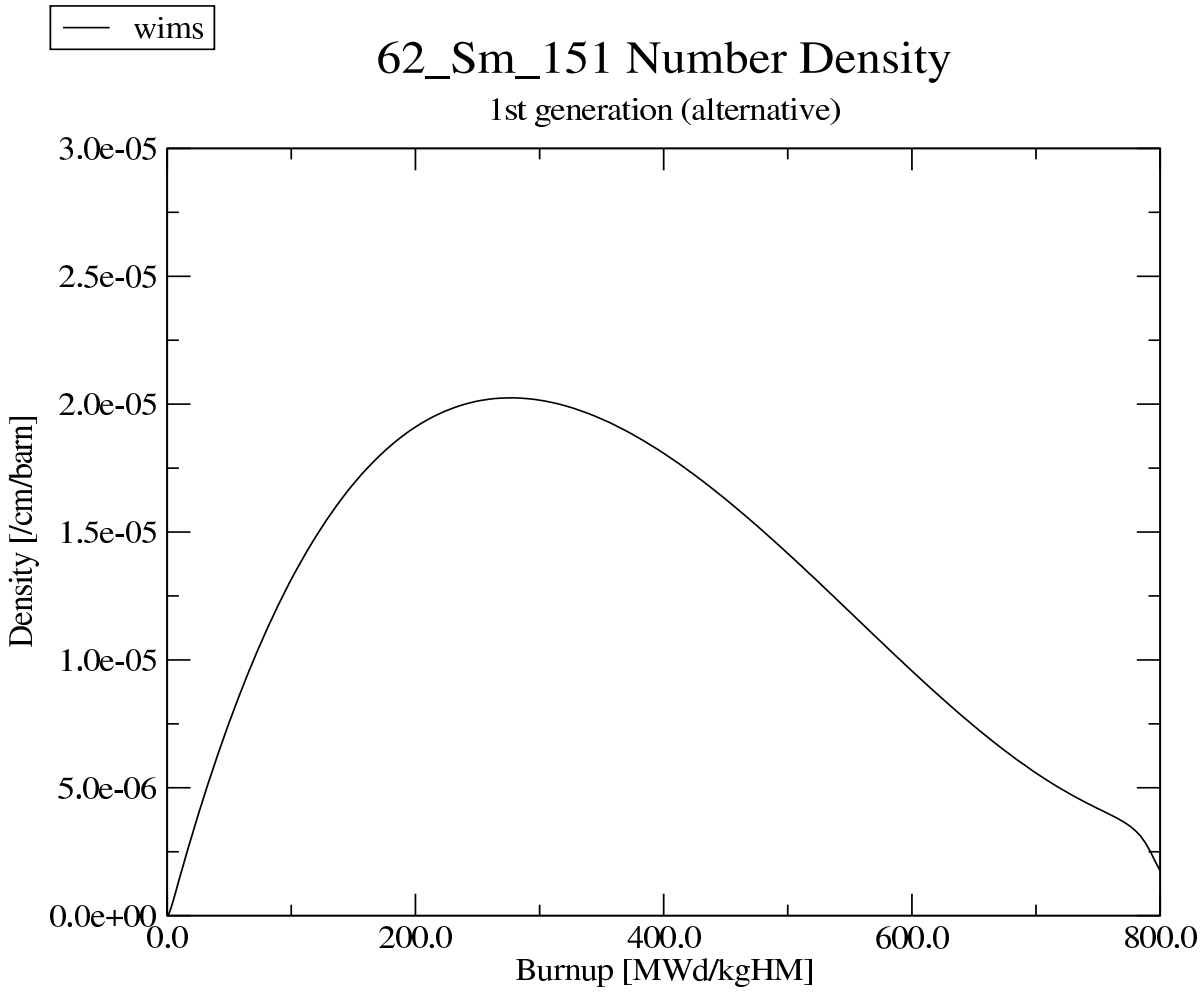


Figure 6.24 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_151 for case B1

Table 6.25 Number Density [$cm^{-1}barn^{-1}$] 63_Eu_154 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	5.6539e-07	–	–
400.00	1.1218e-05	–	–
600.00	2.8804e-05	–	–
800.00	2.2695e-05	–	–

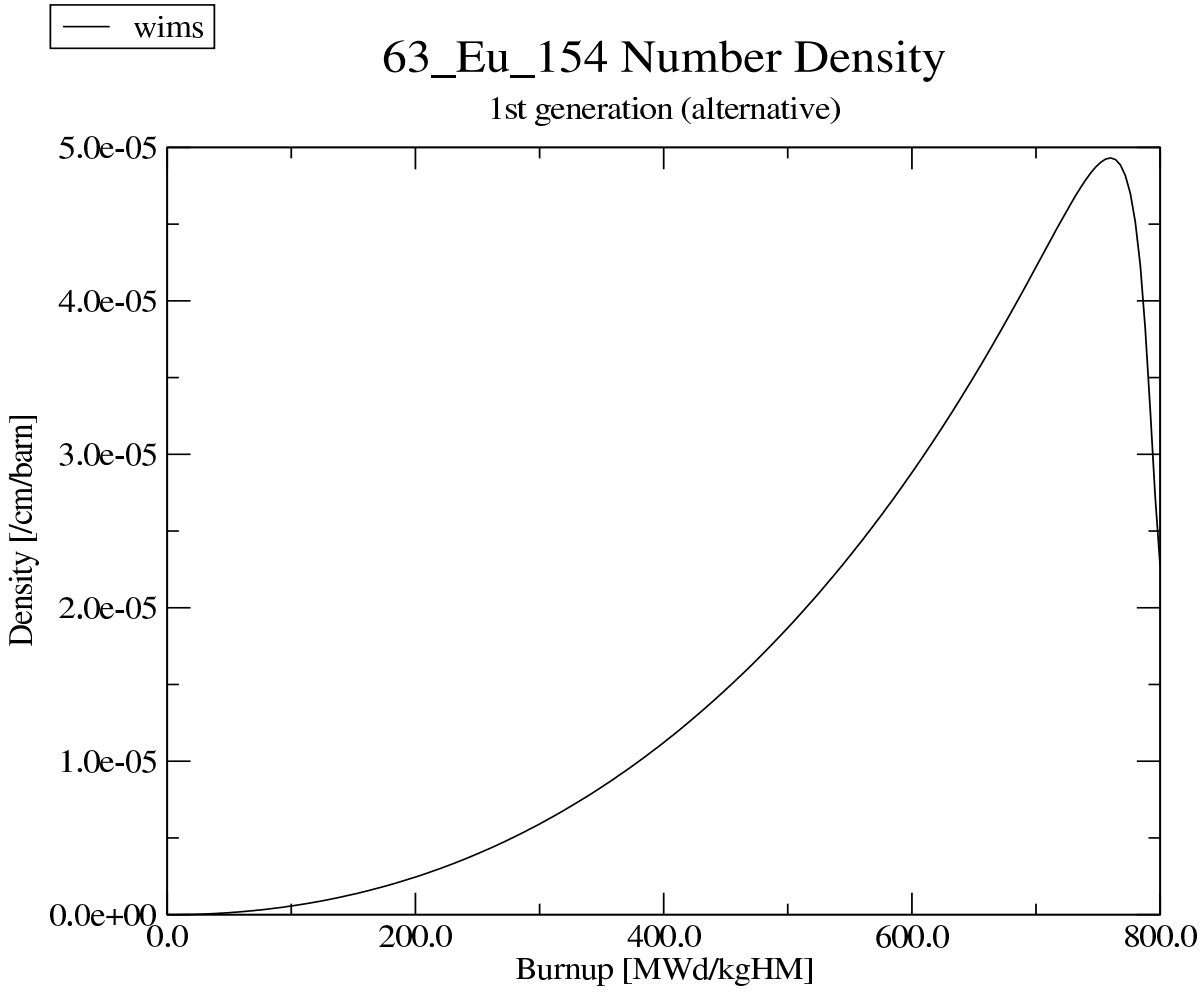


Figure 6.25 Number Density [$cm^{-1}barn^{-1}$] 63_Eu_154 for case B1

Table 6.26 Absorption Cross Section [$barn$] 94_Pu_238 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.6596e+01	–	–	–
100.00	2.8387e+01	–	–	–
400.00	4.5446e+01	–	–	–
600.00	8.0514e+01	–	–	–
800.00	1.6722e+02	–	–	–

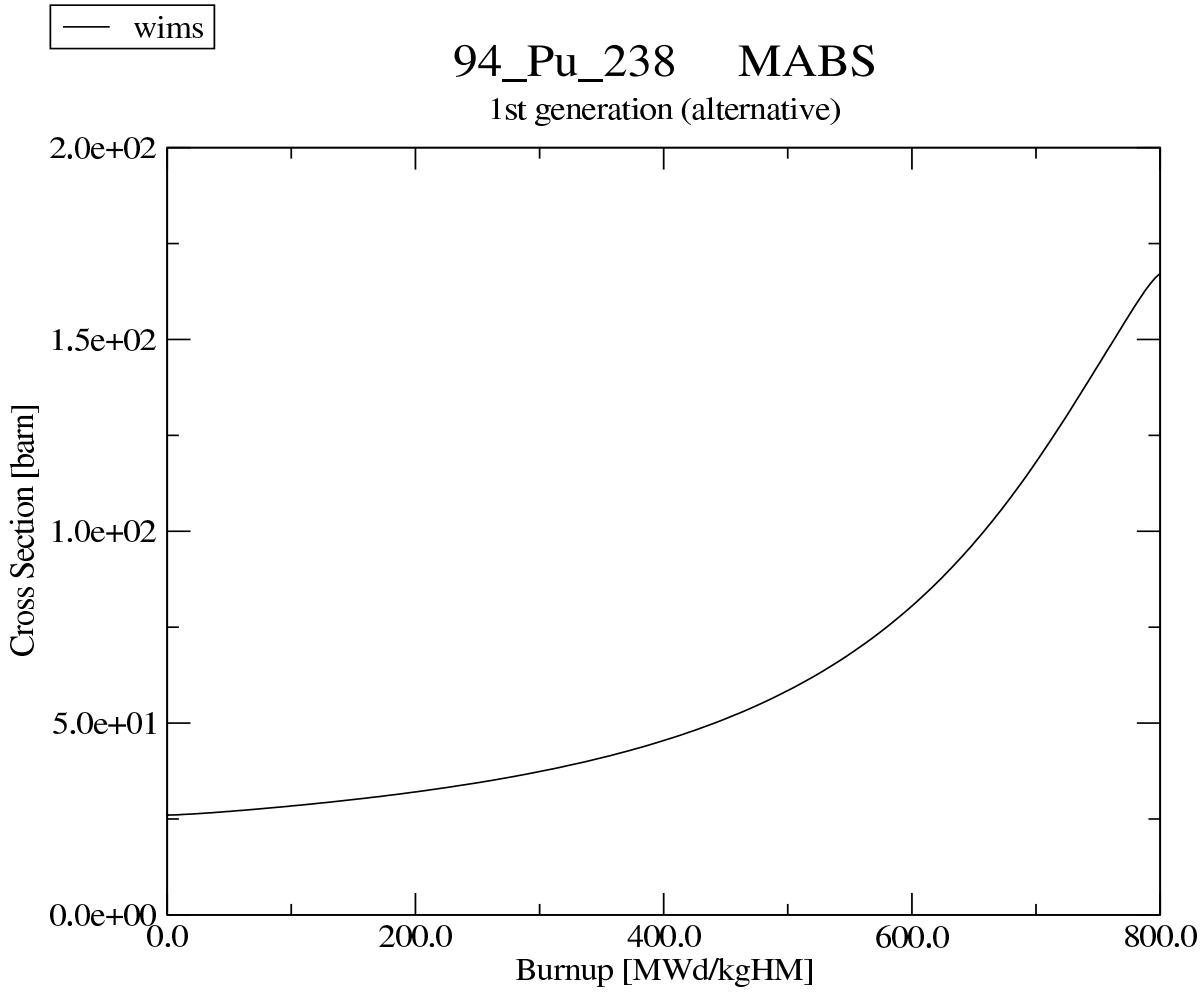


Figure 6.26 Absorption Cross Section [$barn$] 94_Pu_238 for case B1

Table 6.27 Absorption Cross Section [$barn$] 94_Pu_239 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.7626e+02	–	–	–
100.00	1.9700e+02	–	–	–
400.00	3.5527e+02	–	–	–
600.00	6.5503e+02	–	–	–
800.00	1.3244e+03	–	–	–

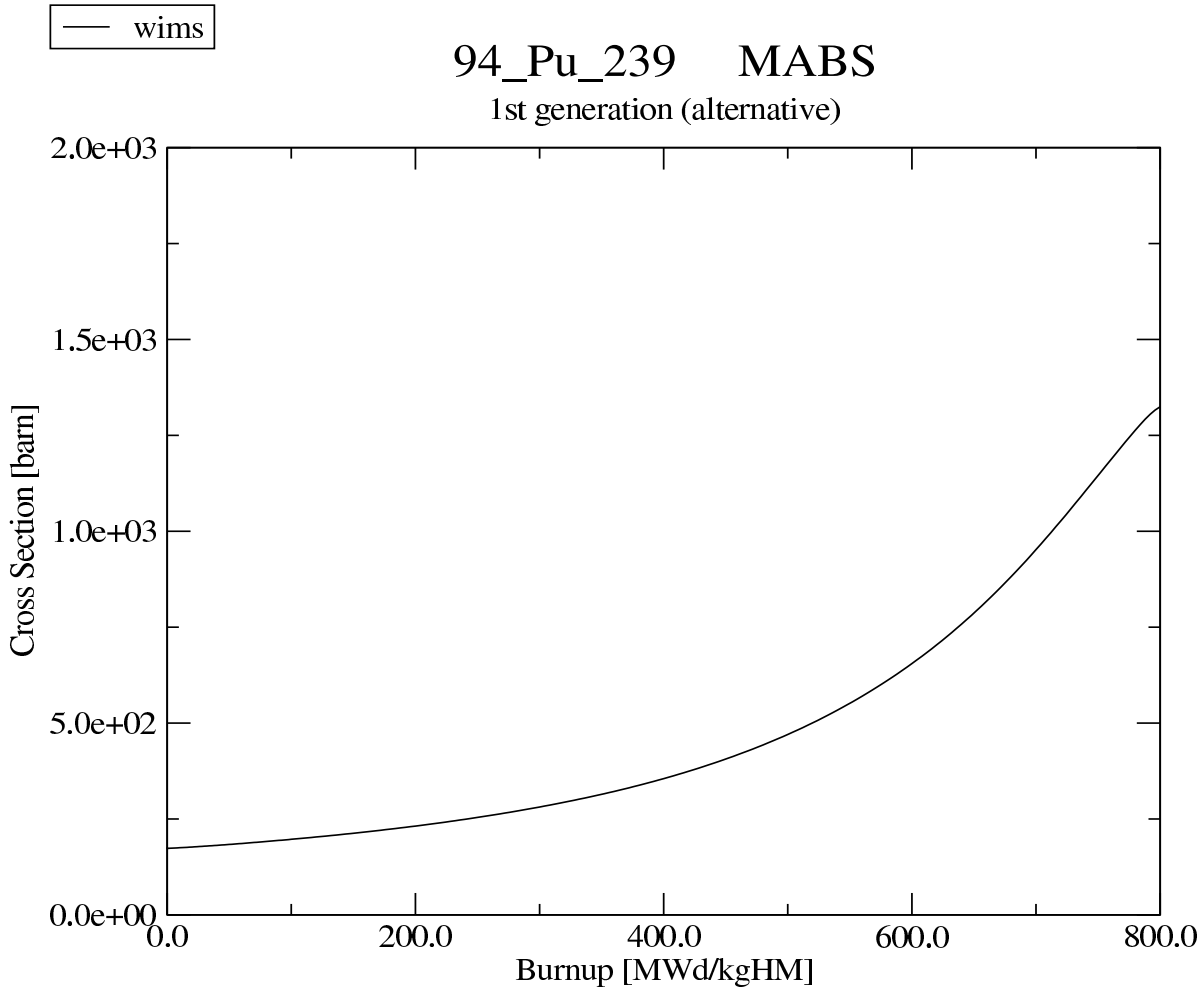


Figure 6.27 Absorption Cross Section [$barn$] 94_Pu_239 for case B1

Table 6.28 Absorption Cross Section [$barn$] 94_Pu_240 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.4713e+02	–	–	–
100.00	1.4791e+02	–	–	–
400.00	1.6485e+02	–	–	–
600.00	1.9920e+02	–	–	–
800.00	2.2910e+02	–	–	–

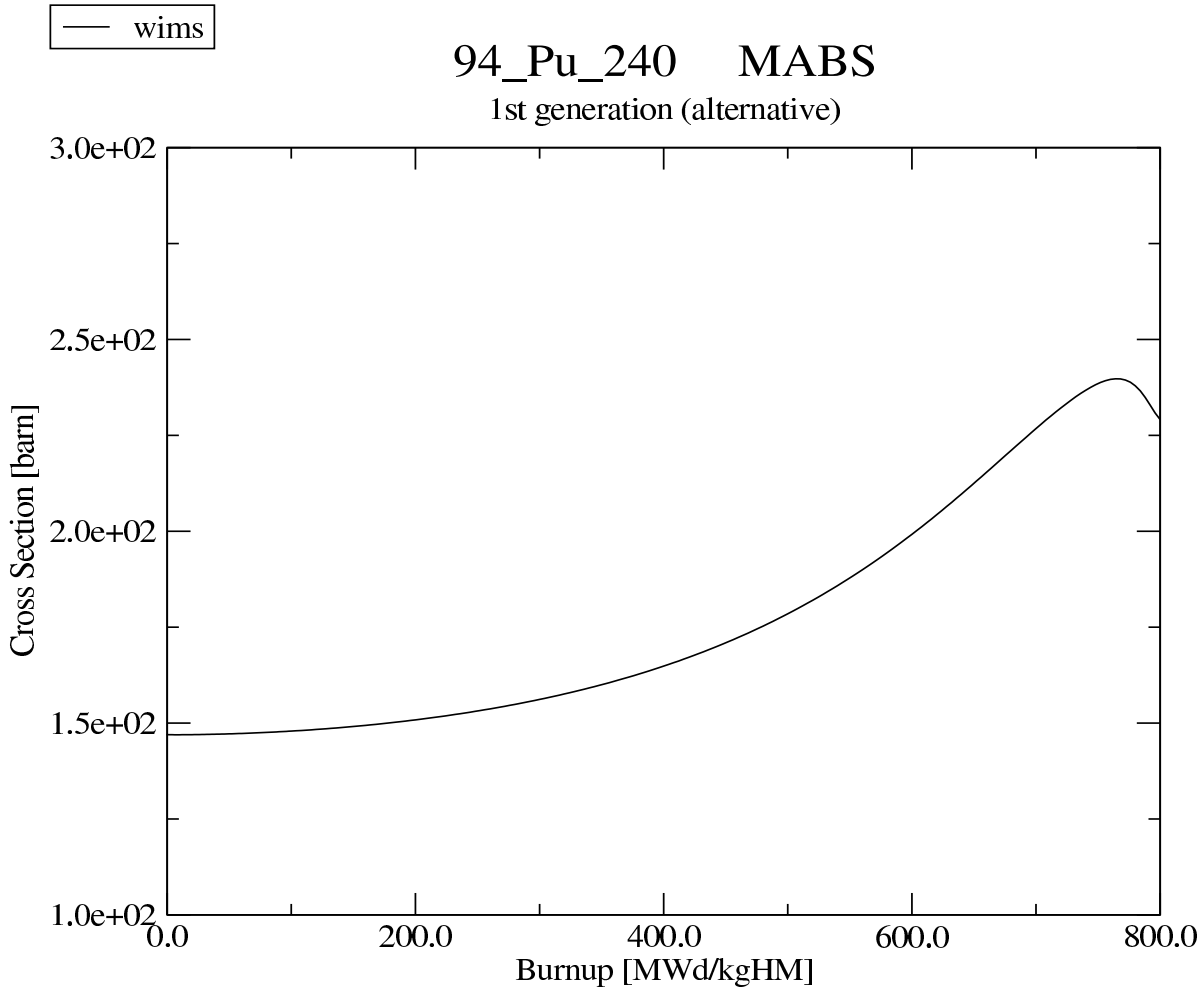


Figure 6.28 Absorption Cross Section [$barn$] 94_Pu_240 for case B1

Table 6.29 Absorption Cross Section [$barn$] 94_Pu_241 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.4893e+02	–	–	–
100.00	1.6267e+02	–	–	–
400.00	2.7342e+02	–	–	–
600.00	4.9171e+02	–	–	–
800.00	1.0069e+03	–	–	–

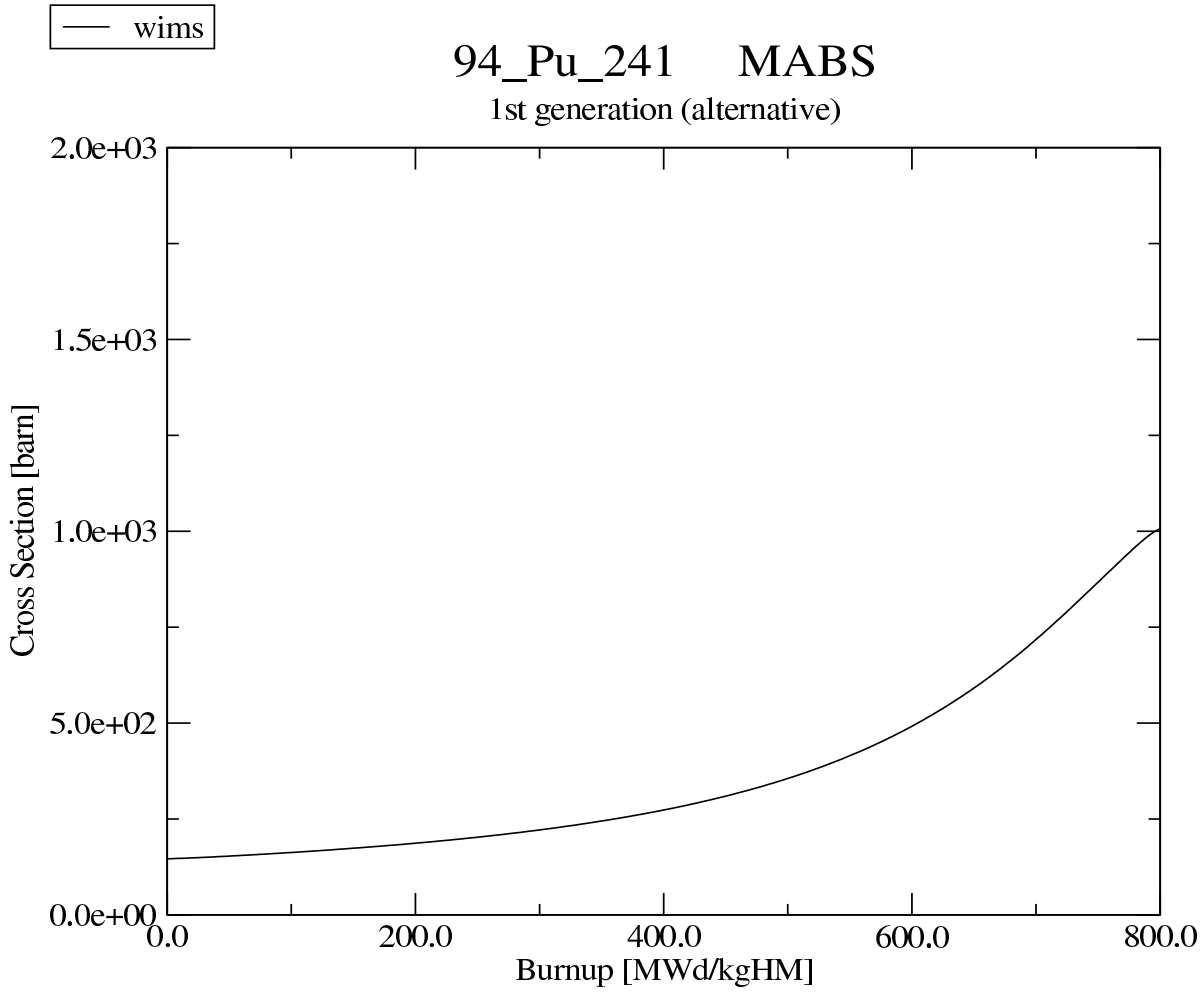


Figure 6.29 Absorption Cross Section [$barn$] 94_Pu_241 for case B1

Table 6.30 Absorption Cross Section [$barn$] 94_Pu_242 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.6785e+01	–	–	–
100.00	4.5825e+01	–	–	–
400.00	3.9239e+01	–	–	–
600.00	2.9846e+01	–	–	–
800.00	1.3530e+01	–	–	–

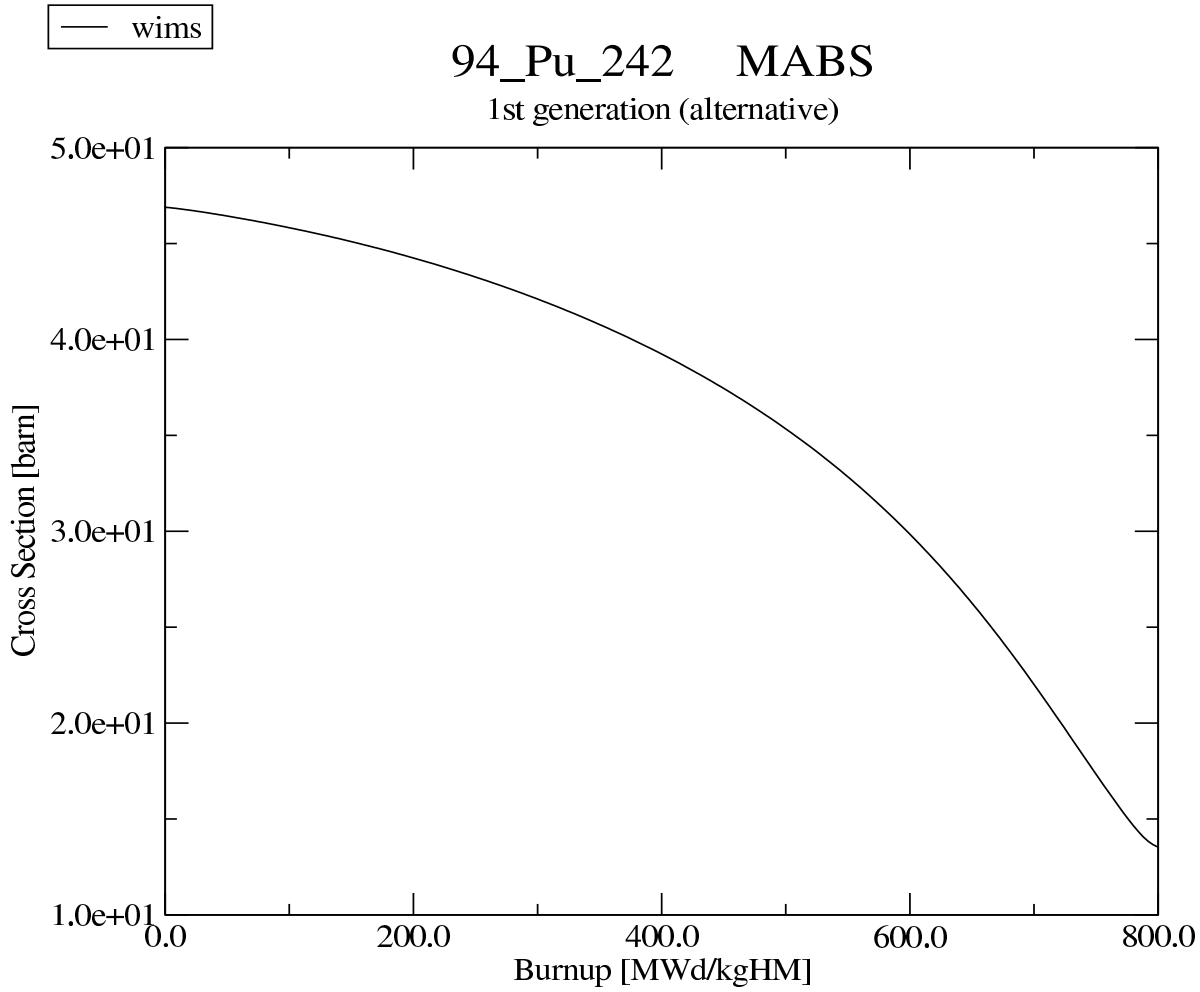


Figure 6.30 Absorption Cross Section [$barn$] 94_Pu_242 for case B1

Table 6.31 Absorption Cross Section [$barn$] 95_Am_241 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5831e+02	–	–	–
100.00	1.6922e+02	–	–	–
400.00	2.4650e+02	–	–	–
600.00	3.8953e+02	–	–	–
800.00	7.0451e+02	–	–	–

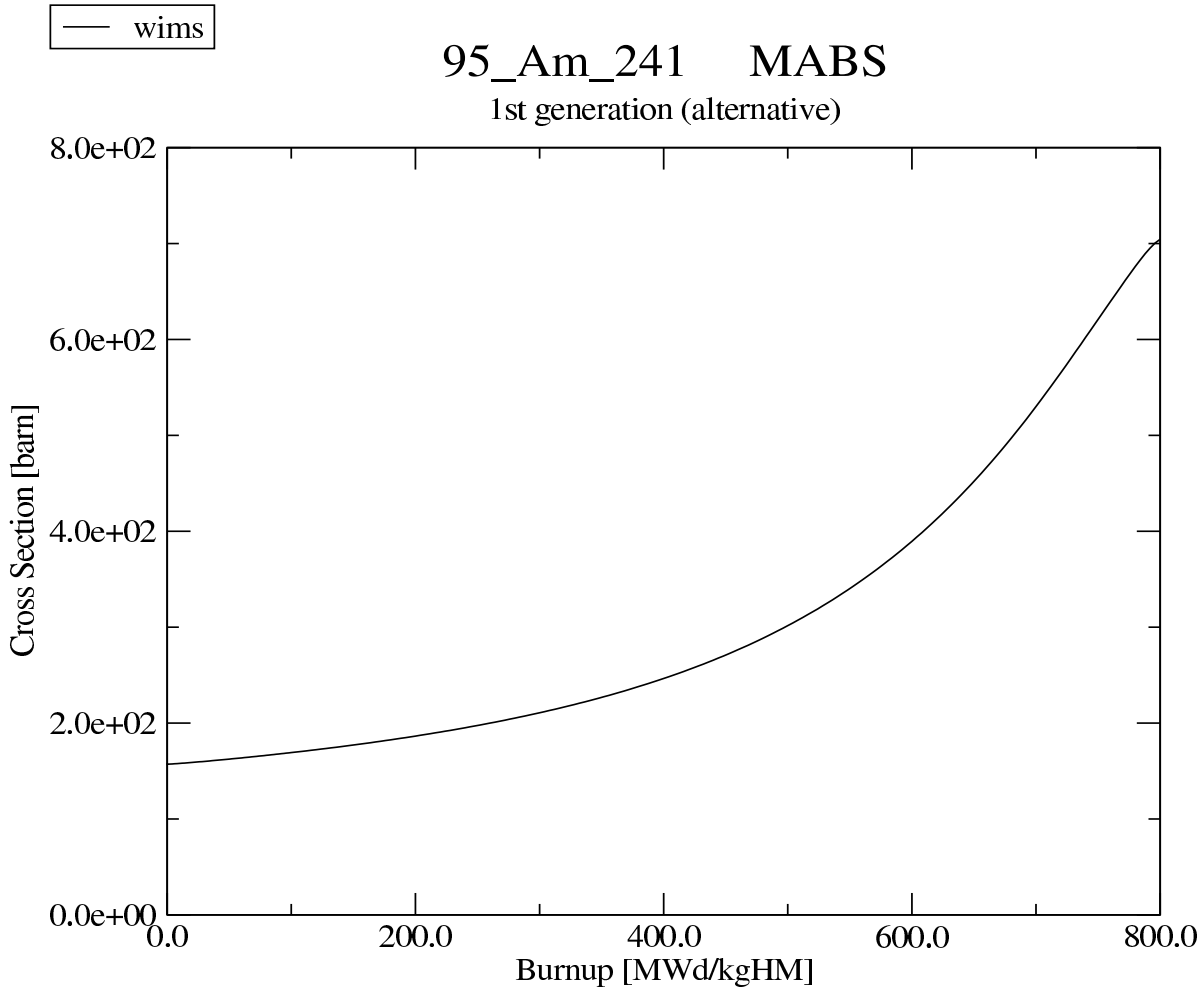


Figure 6.31 Absorption Cross Section [$barn$] 95_Am_241 for case B1

Table 6.32 Absorption Cross Section [$barn$] 95_Am_242m for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.7659e+02	–	–	–
100.00	7.4089e+02	–	–	–
400.00	1.3041e+03	–	–	–
600.00	2.4350e+03	–	–	–
800.00	5.1607e+03	–	–	–

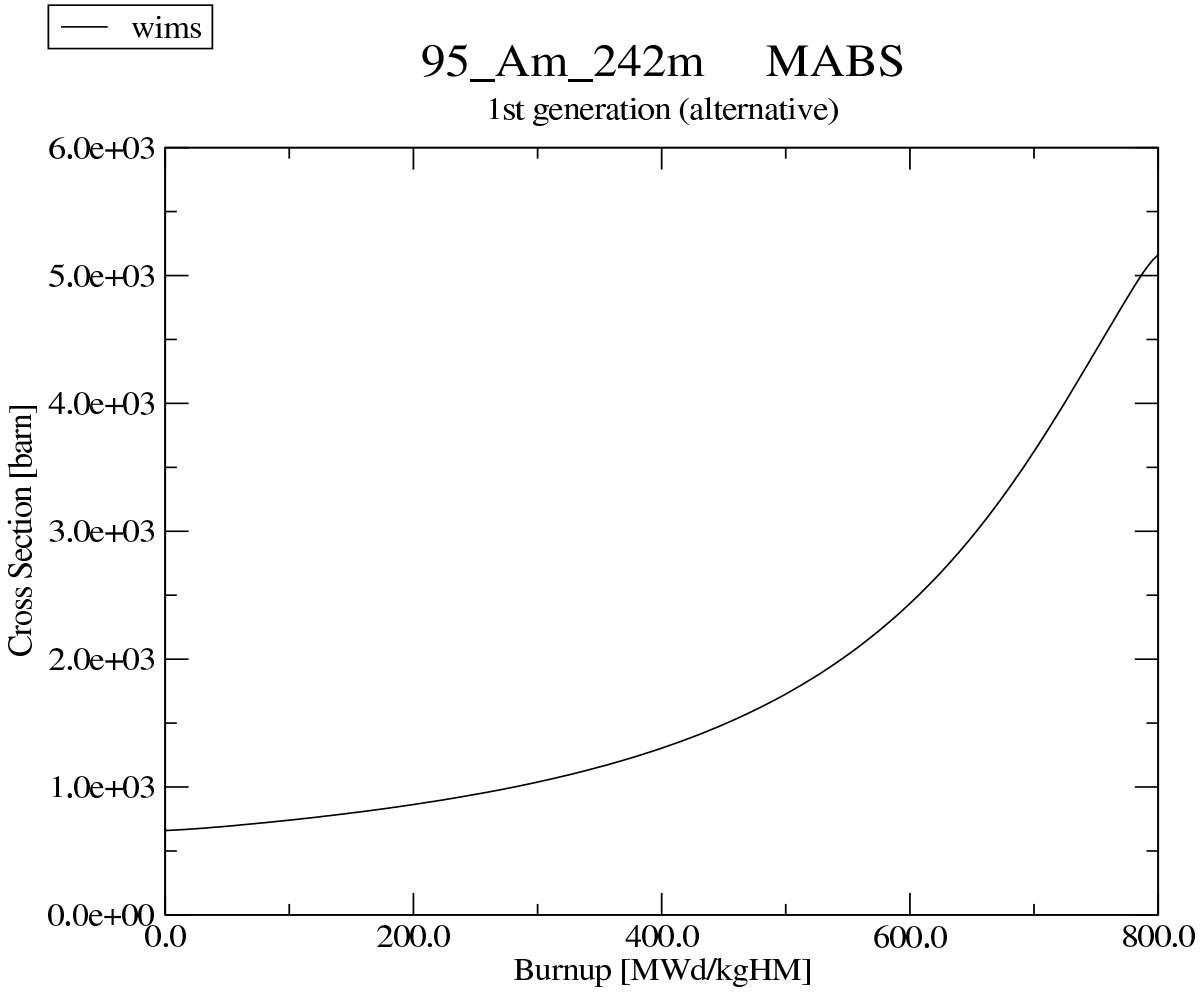


Figure 6.32 Absorption Cross Section [$barn$] 95_Am_242m for case B1

Table 6.33 Absorption Cross Section [$barn$] 95_Am_243 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.4511e+01	–	–	–
100.00	9.2962e+01	–	–	–
400.00	8.5230e+01	–	–	–
600.00	7.3973e+01	–	–	–
800.00	4.8024e+01	–	–	–

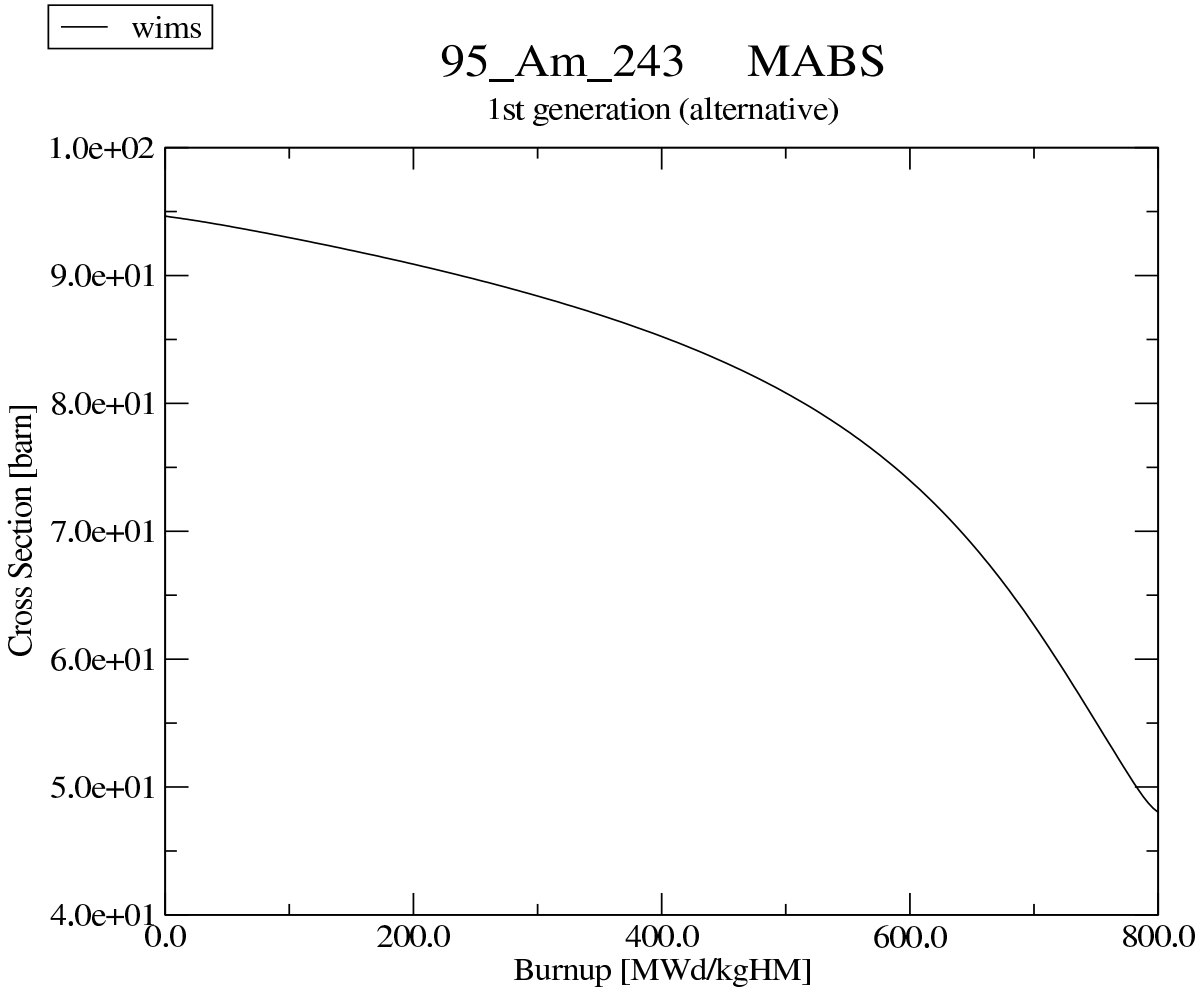


Figure 6.33 Absorption Cross Section [$barn$] 95_Am_243 for case B1

Table 6.34 Absorption Cross Section [$barn$] 96_Cm_242 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.3111e+00	–	–	–
100.00	7.3445e+00	–	–	–
400.00	7.6159e+00	–	–	–
600.00	8.1726e+00	–	–	–
800.00	9.5737e+00	–	–	–

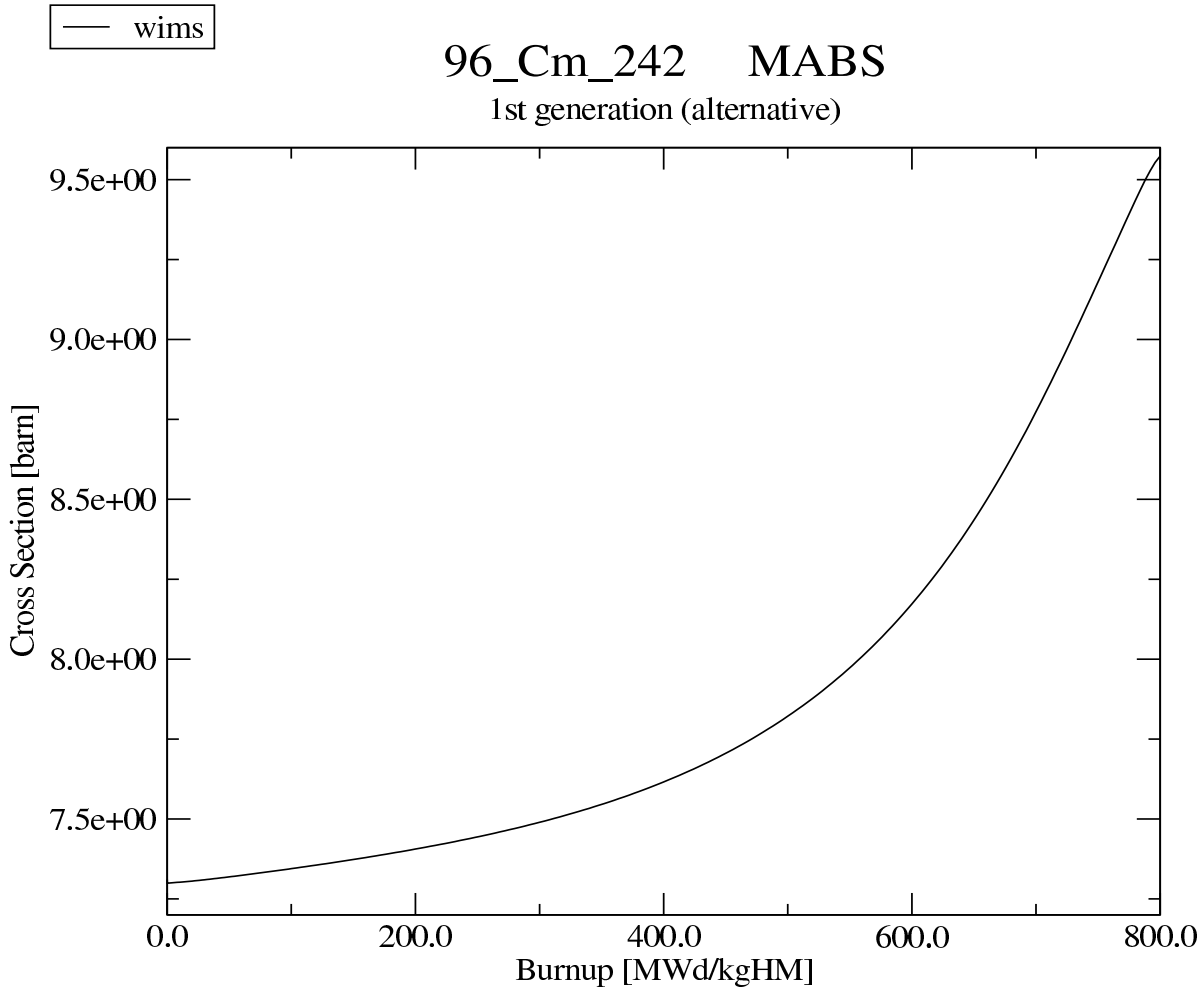


Figure 6.34 Absorption Cross Section [$barn$] 96_Cm_242 for case B1

Table 6.35 Absorption Cross Section [$barn$] 96_Cm_243 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3087e+02	–	–	–
100.00	1.3233e+02	–	–	–
400.00	1.4692e+02	–	–	–
600.00	1.7794e+02	–	–	–
800.00	2.5287e+02	–	–	–

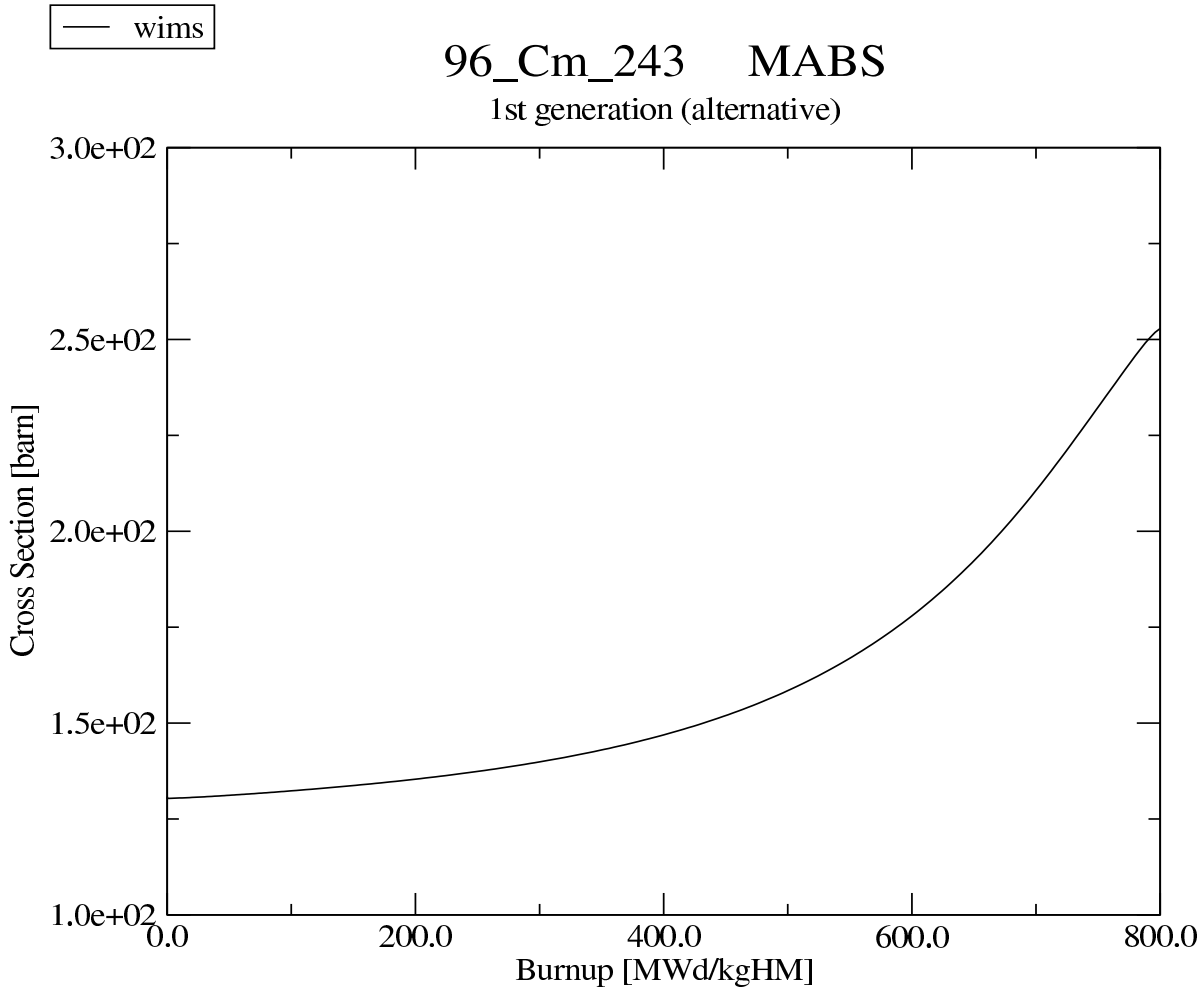


Figure 6.35 Absorption Cross Section [$barn$] 96_Cm_243 for case B1

Table 6.36 Absorption Cross Section [$barn$] 96_Cm_244 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.1554e+01	–	–	–
100.00	3.1411e+01	–	–	–
400.00	2.8565e+01	–	–	–
600.00	2.2959e+01	–	–	–
800.00	9.9636e+00	–	–	–

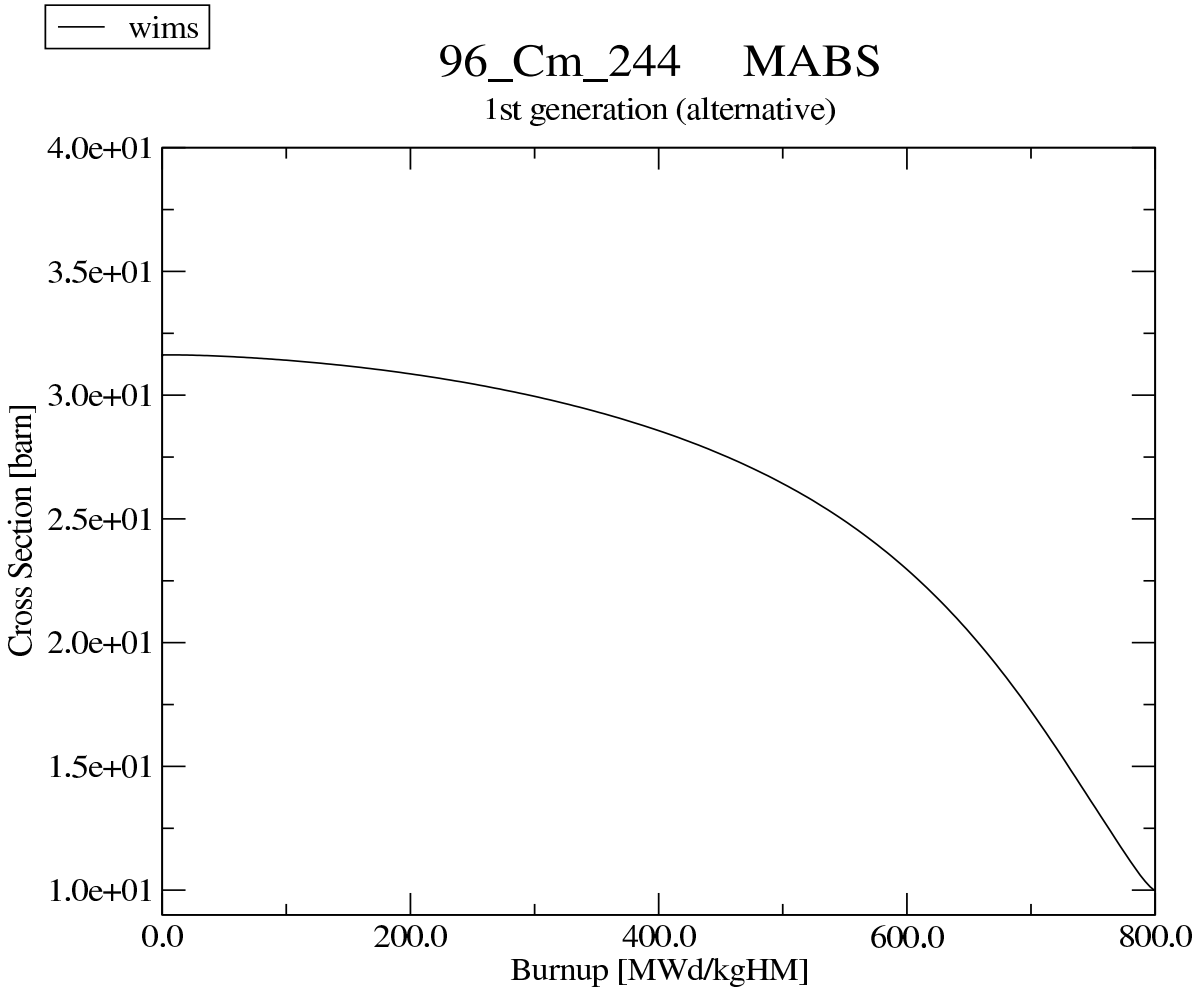


Figure 6.36 Absorption Cross Section [$barn$] 96_Cm_244 for case B1

Table 6.37 Absorption Cross Section [$barn$] 96_Cm_245 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.2354e+02	–	–	–
100.00	1.3149e+02	–	–	–
400.00	2.0661e+02	–	–	–
600.00	3.6064e+02	–	–	–
800.00	7.3956e+02	–	–	–

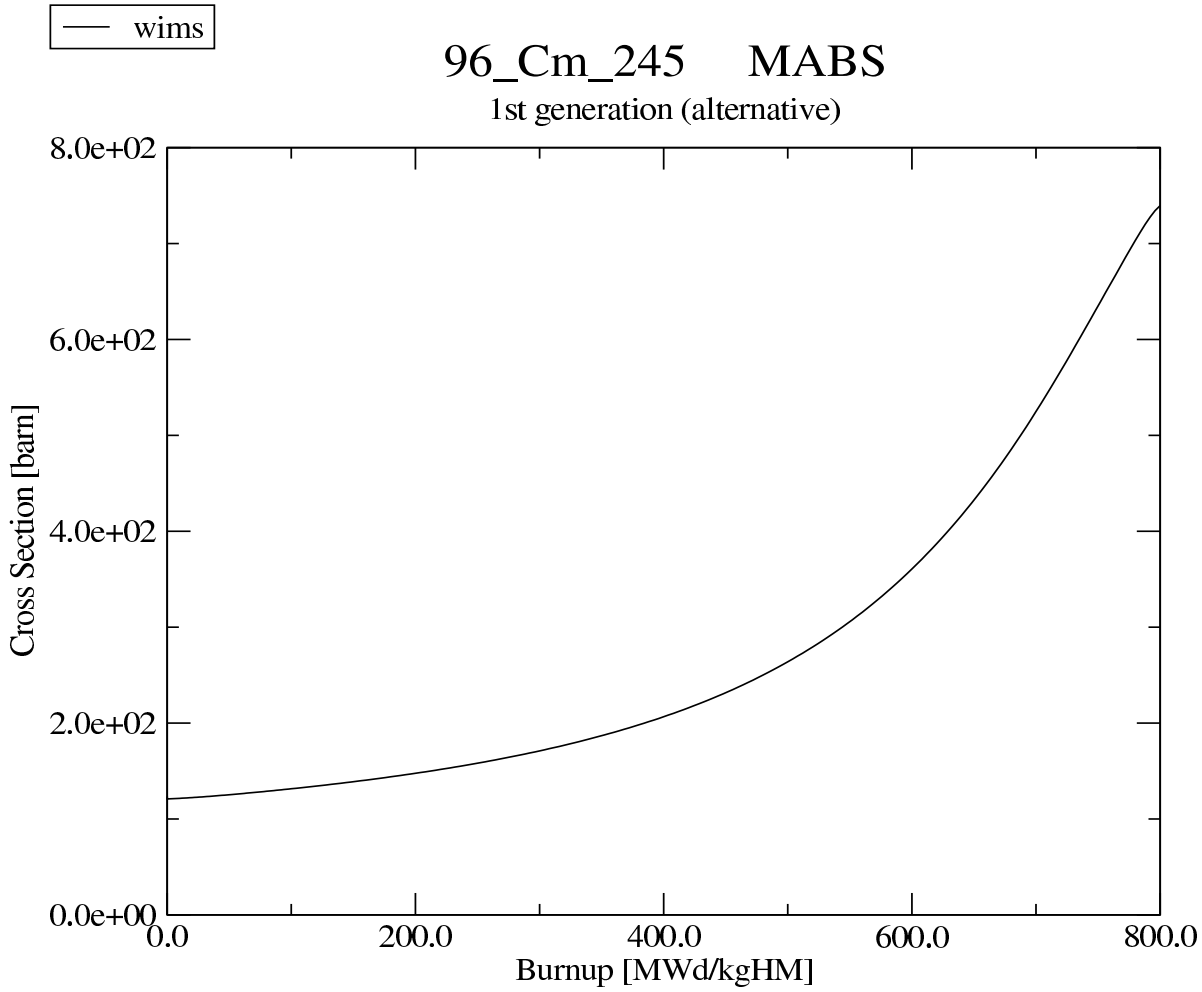


Figure 6.37 Absorption Cross Section [$barn$] 96_Cm_245 for case B1

Table 6.38 Absorption Cross Section [$barn$] 40_Zr_93 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.7733e+00	–	–	–
100.00	1.7603e+00	–	–	–
400.00	1.6517e+00	–	–	–
600.00	1.4373e+00	–	–	–
800.00	9.4382e-01	–	–	–

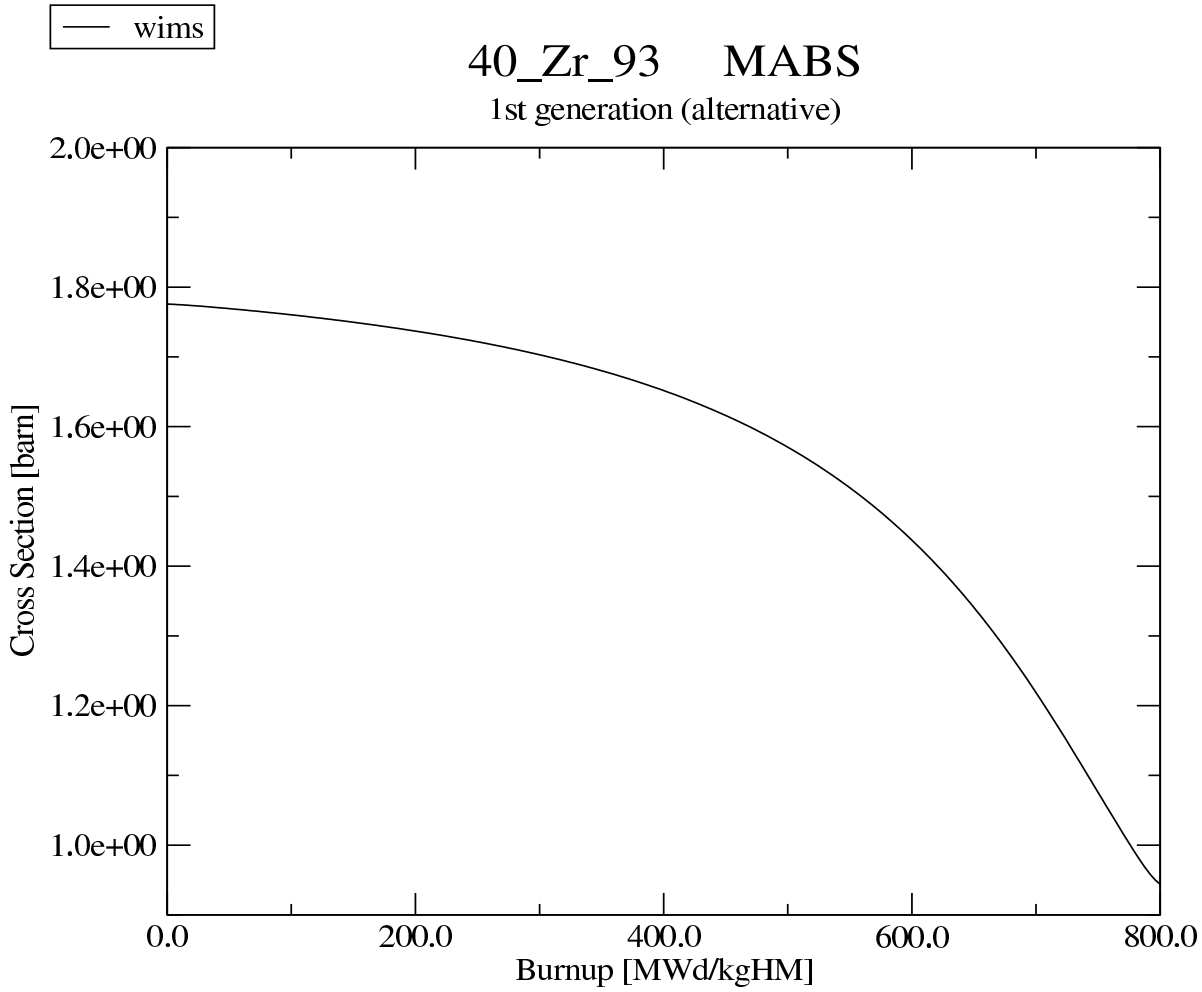


Figure 6.38 Absorption Cross Section [$barn$] 40_Zr_93 for case B1

Table 6.39 Absorption Cross Section [$barn$] 43_Tc_99 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5697e+01	–	–	–
100.00	1.5526e+01	–	–	–
400.00	1.4602e+01	–	–	–
600.00	1.3218e+01	–	–	–
800.00	1.0063e+01	–	–	–

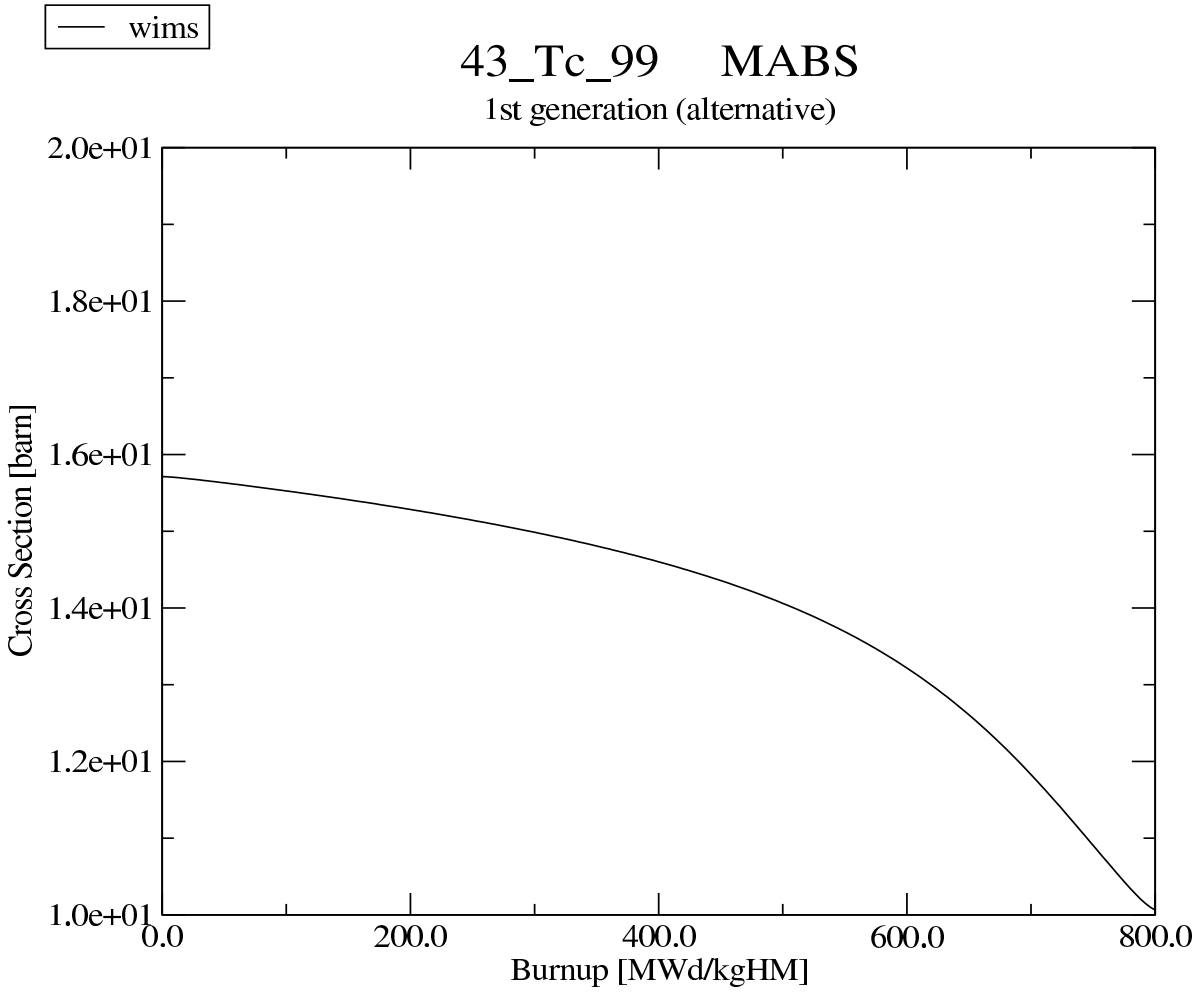


Figure 6.39 Absorption Cross Section [$barn$] 43_Tc_99 for case B1

Table 6.40 Absorption Cross Section [$barn$] 46_Pd_107 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.4388e+00	–	–	–
100.00	5.3837e+00	–	–	–
400.00	4.8655e+00	–	–	–
600.00	3.8285e+00	–	–	–
800.00	1.3850e+00	–	–	–

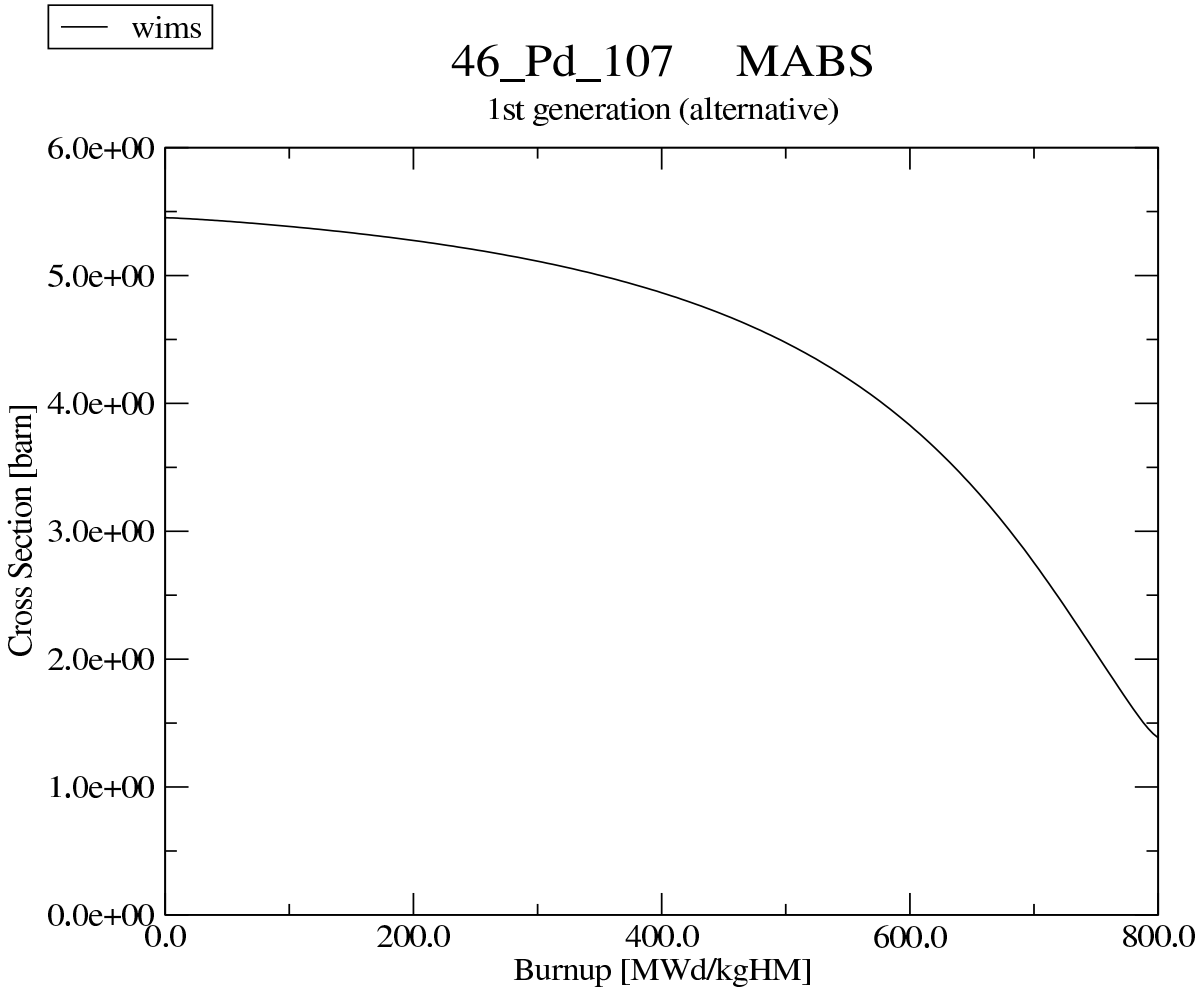


Figure 6.40 Absorption Cross Section [$barn$] 46_Pd_107 for case B1

Table 6.41 Absorption Cross Section [$barn$] 53_I_129 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.1314e+00	–	–	–
100.00	3.2850e+00	–	–	–
400.00	4.6571e+00	–	–	–
600.00	7.4229e+00	–	–	–
800.00	1.4131e+01	–	–	–

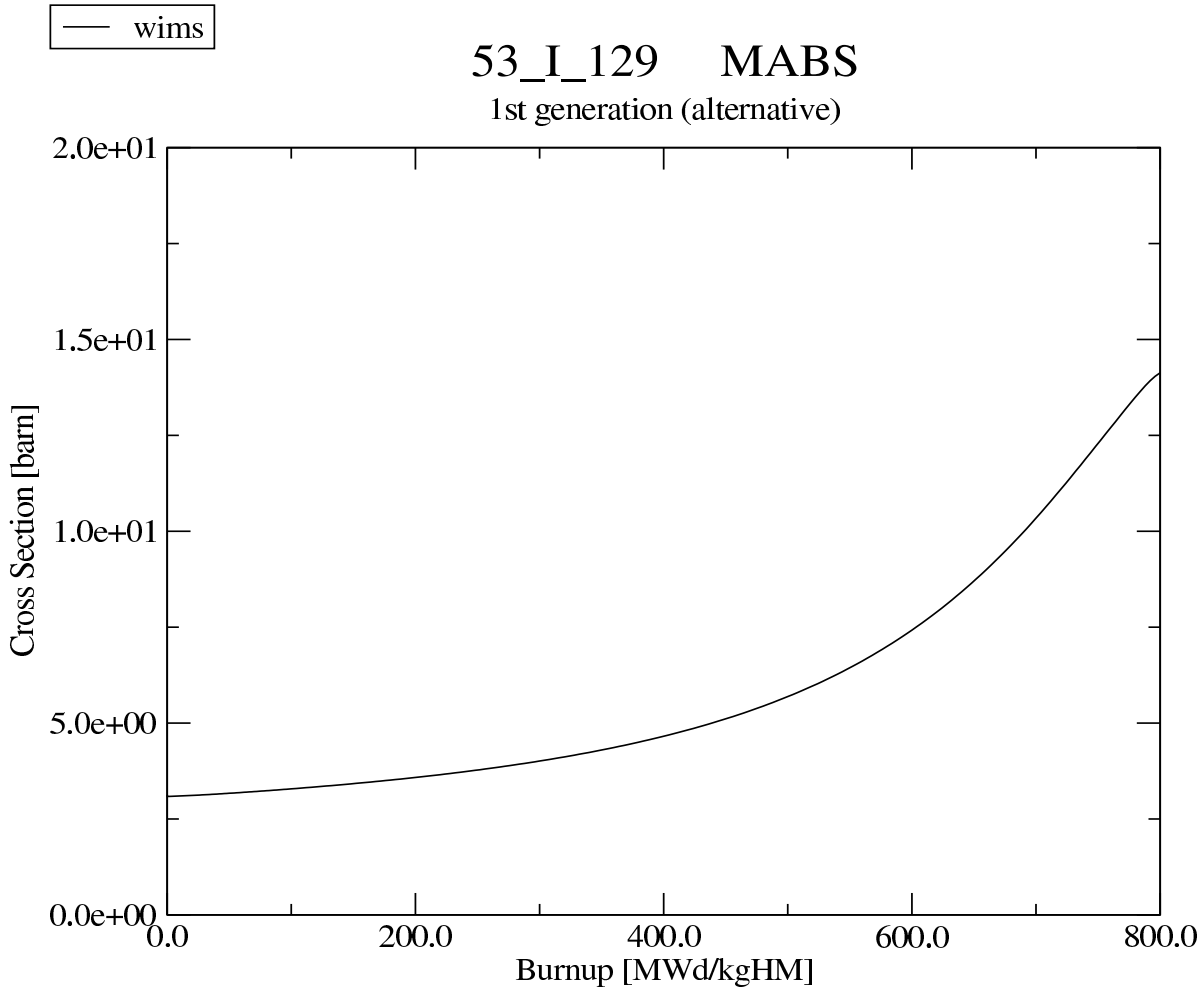


Figure 6.41 Absorption Cross Section [$barn$] 53_I_129 for case B1

Table 6.42 Absorption Cross Section [$barn$] 55_Cs_135 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.5222e+00	–	–	–
100.00	3.5309e+00	–	–	–
400.00	3.5968e+00	–	–	–
600.00	3.7352e+00	–	–	–
800.00	4.1089e+00	–	–	–

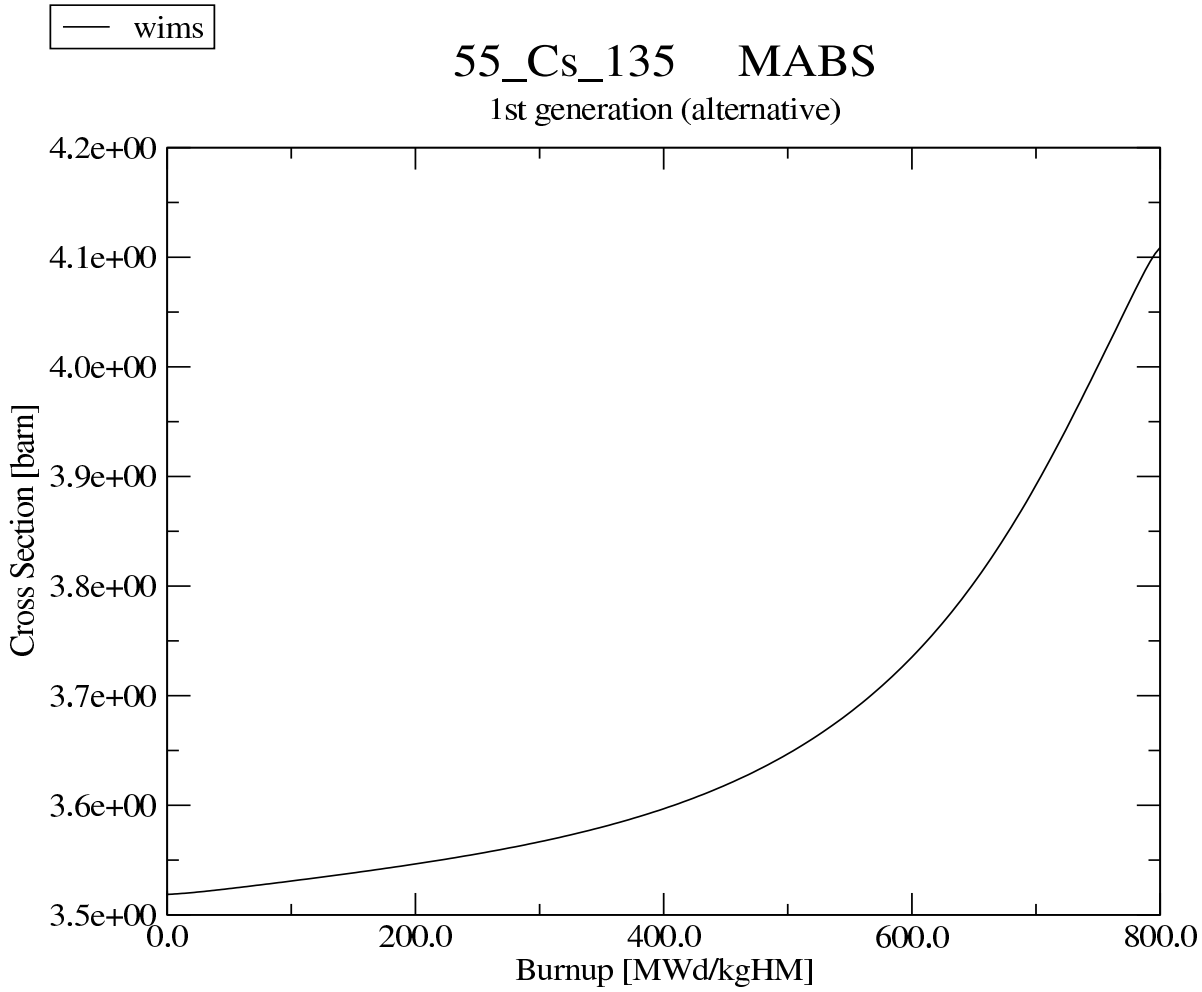


Figure 6.42 Absorption Cross Section [$barn$] 55_Cs_135 for case B1

Table 6.43 Absorption Cross Section [$barn$] 62_Sm_147 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.3441e+01	–	–	–
100.00	4.3213e+01	–	–	–
400.00	4.1281e+01	–	–	–
600.00	3.7623e+01	–	–	–
800.00	2.9003e+01	–	–	–

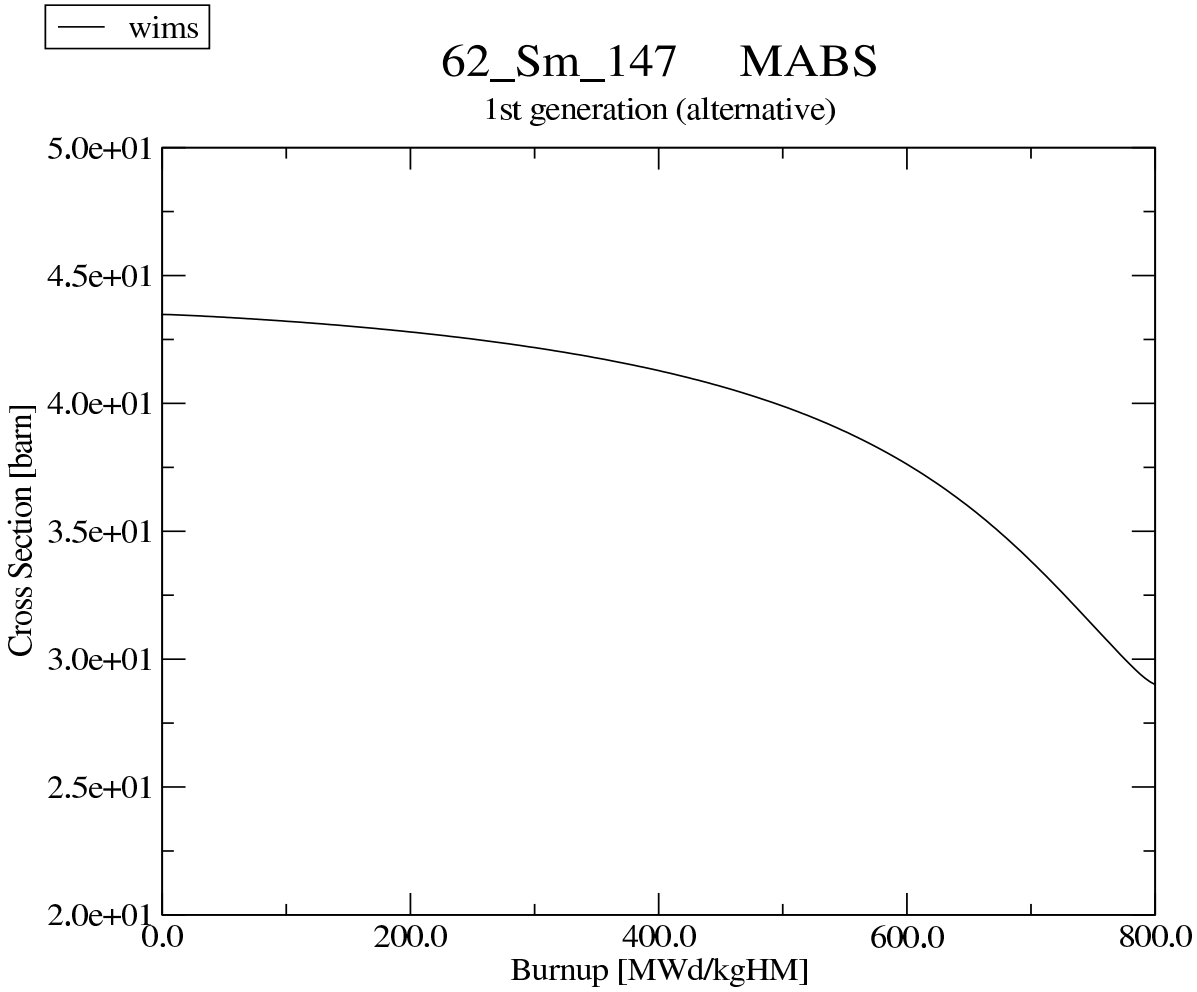


Figure 6.43 Absorption Cross Section [$barn$] 62_Sm_147 for case B1

Table 6.44 Absorption Cross Section [$barn$] 62_Sm_149 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.1729e+03	–	–	–
100.00	4.5691e+03	–	–	–
400.00	8.5699e+03	–	–	–
600.00	1.6796e+04	–	–	–
800.00	3.7064e+04	–	–	–

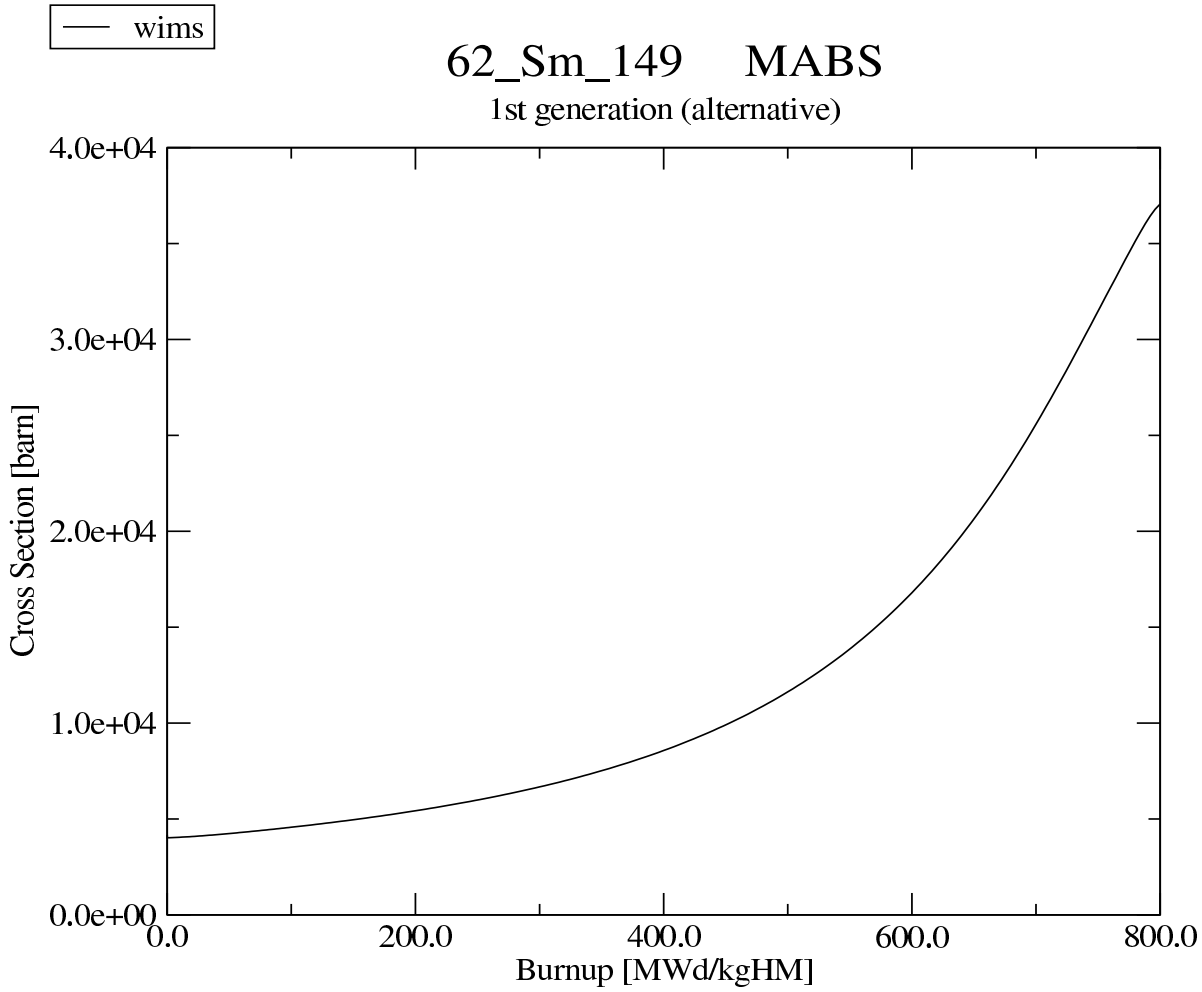


Figure 6.44 Absorption Cross Section [$barn$] 62_Sm_149 for case B1

Table 6.45 Absorption Cross Section [$barn$] 62_Sm_151 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.8289e+02	–	–	–
100.00	5.1715e+02	–	–	–
400.00	8.6005e+02	–	–	–
600.00	1.5744e+03	–	–	–
800.00	3.3546e+03	–	–	–

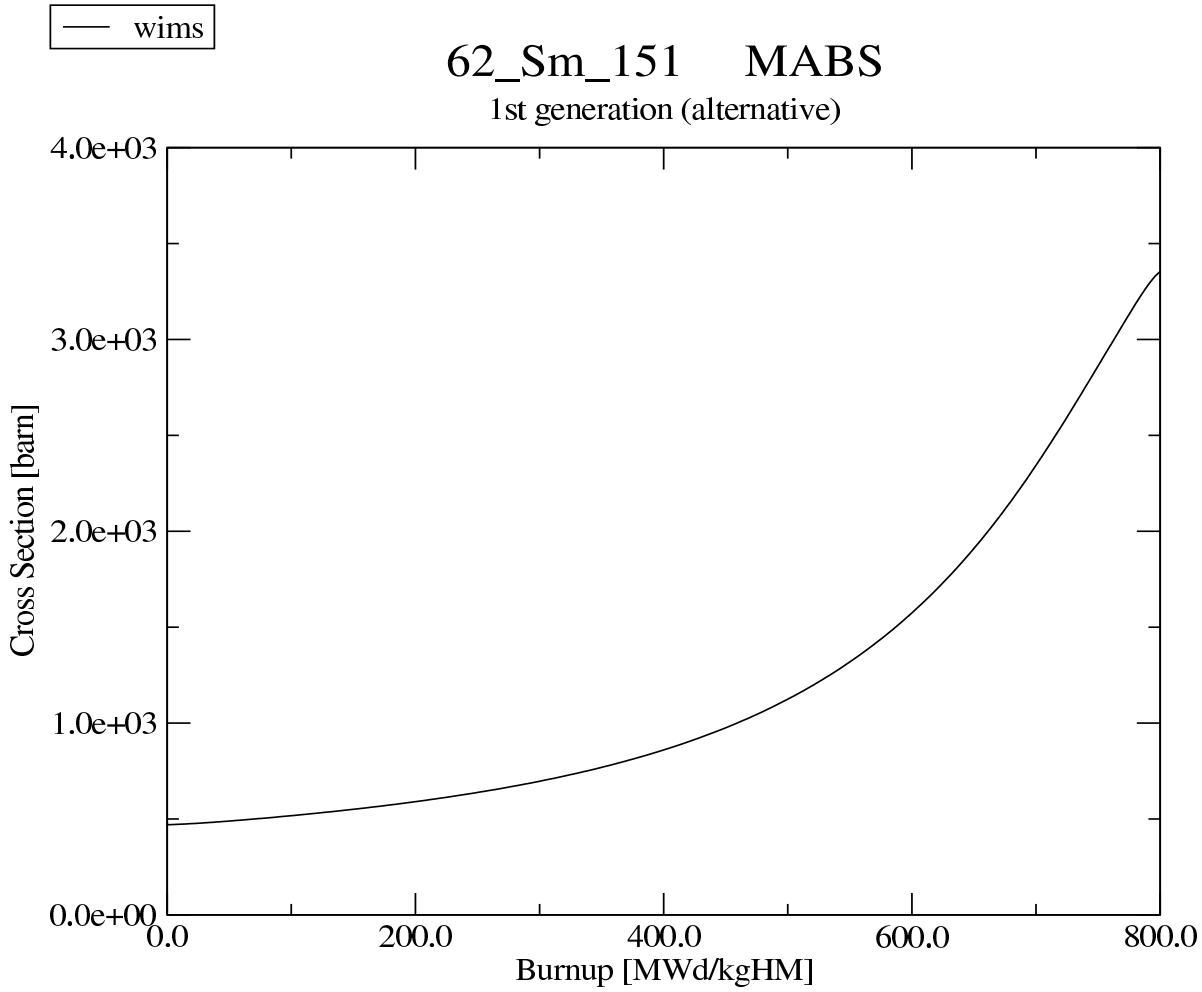


Figure 6.45 Absorption Cross Section [$barn$] 62_Sm_151 for case B1

Table 6.46 Absorption Cross Section [$barn$] 63_Eu_154 for case B1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.4431e+02	–	–	–
100.00	1.4591e+02	–	–	–
400.00	1.6598e+02	–	–	–
600.00	2.0970e+02	–	–	–
800.00	3.1525e+02	–	–	–

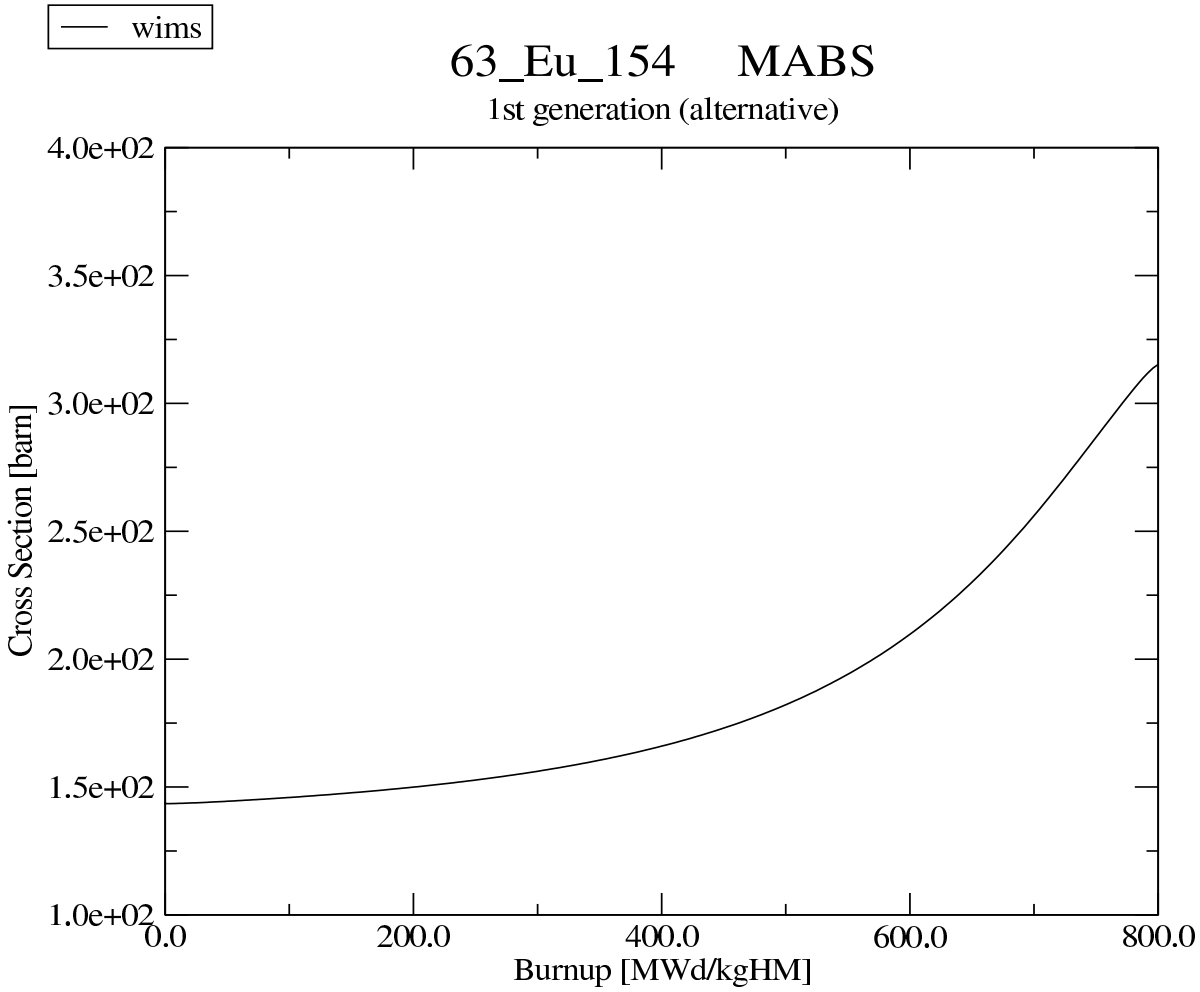


Figure 6.46 Absorption Cross Section [$barn$] 63_Eu_154 for case B1

Table 6.47 Fission Cross Section [$barn$] 94_Pu_238 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.1607e+00	–	–
100.00	2.2016e+00	–	–
400.00	2.6015e+00	–	–
600.00	3.4288e+00	–	–
800.00	5.5034e+00	–	–

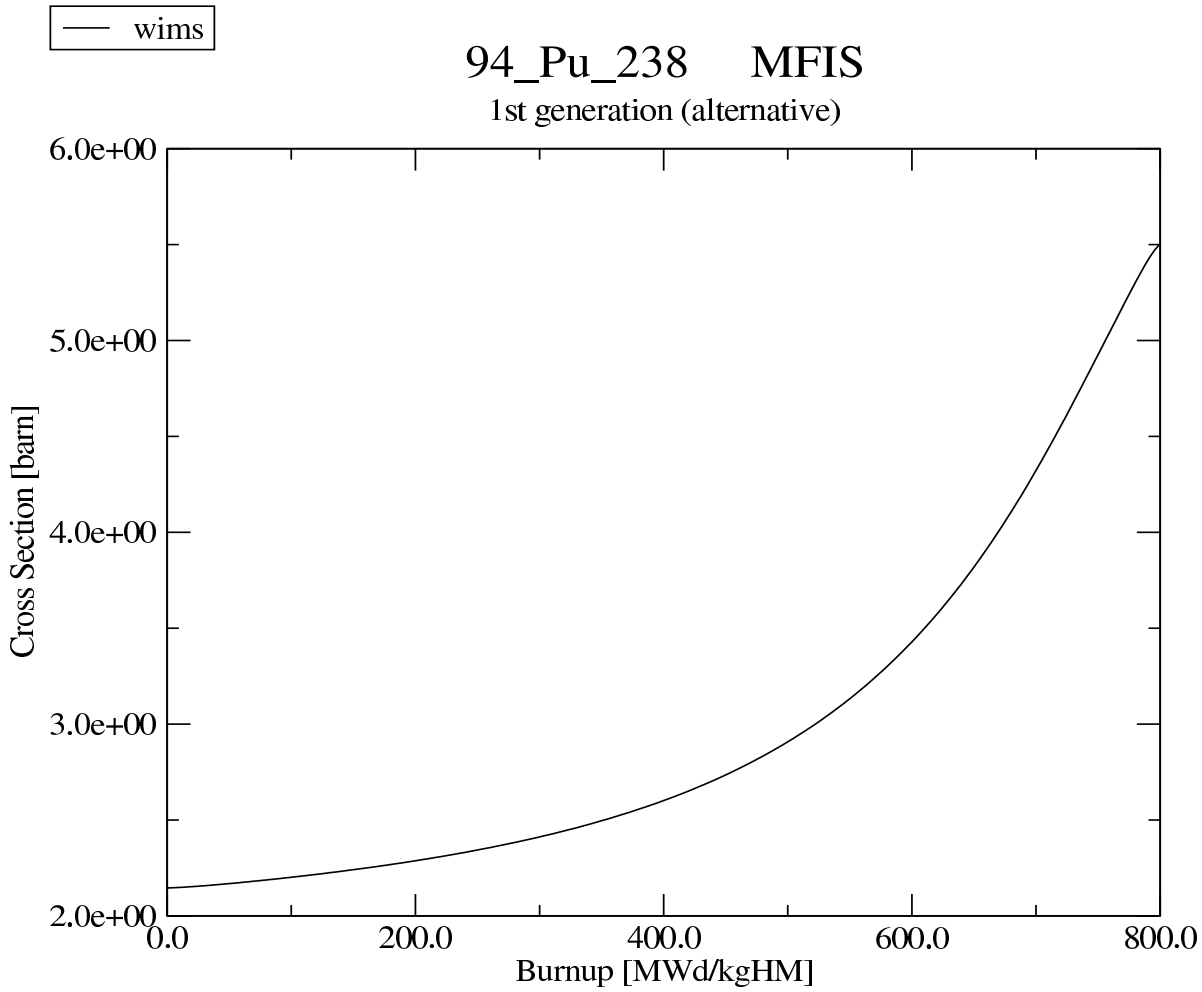


Figure 6.47 Fission Cross Section [$barn$] 94_Pu_238 for case B1

Table 6.48 Fission Cross Section [$barn$] 94_Pu_239 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1080e+02	–	–
100.00	1.2368e+02	–	–
400.00	2.2195e+02	–	–
600.00	4.0856e+02	–	–
800.00	8.2830e+02	–	–

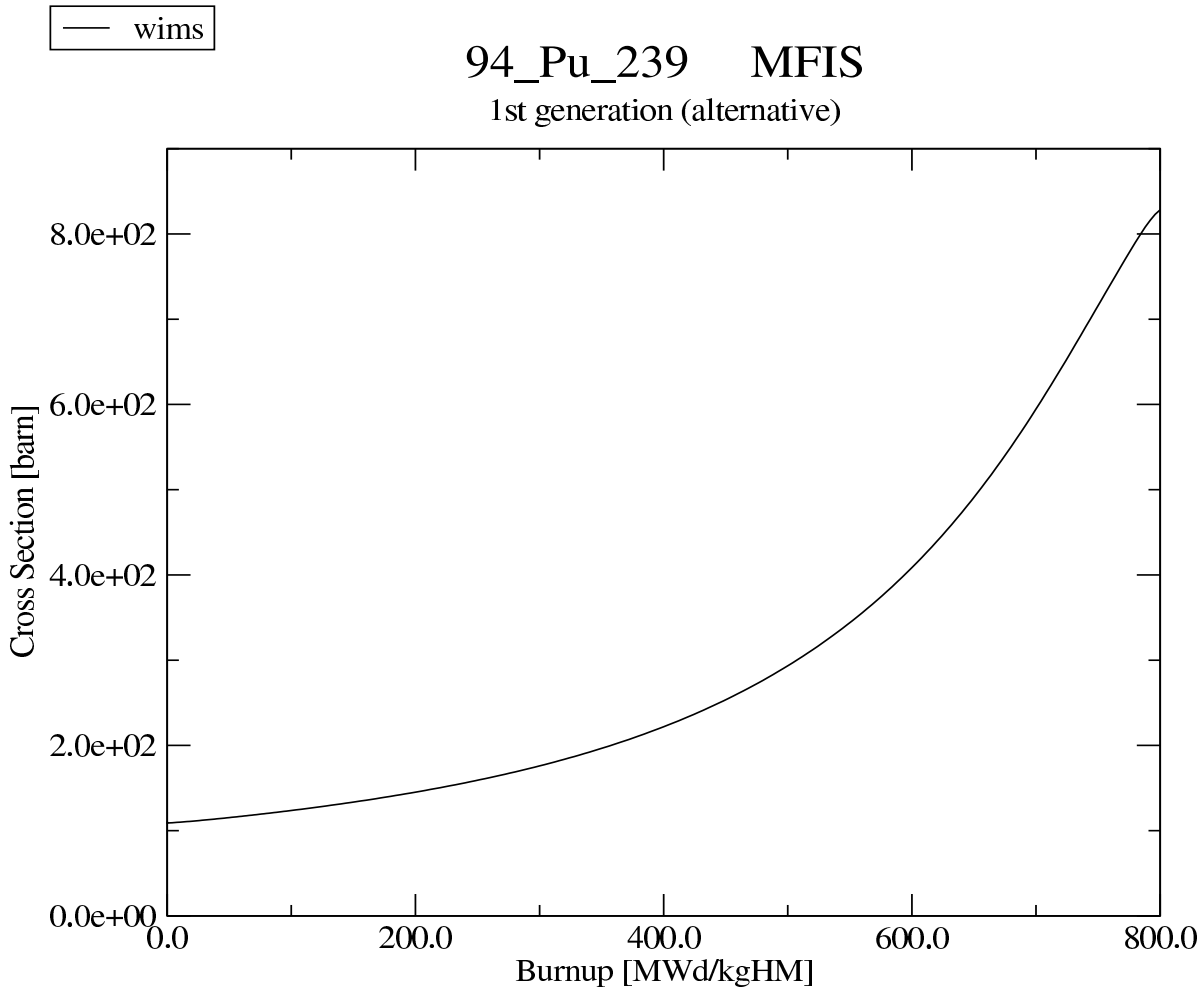


Figure 6.48 Fission Cross Section [$barn$] 94_Pu_239 for case B1

Table 6.49 Fission Cross Section [$barn$] 94_Pu_240 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.8197e-01	–	–
100.00	3.7734e-01	–	–
400.00	3.4134e-01	–	–
600.00	2.6950e-01	–	–
800.00	8.9890e-02	–	–

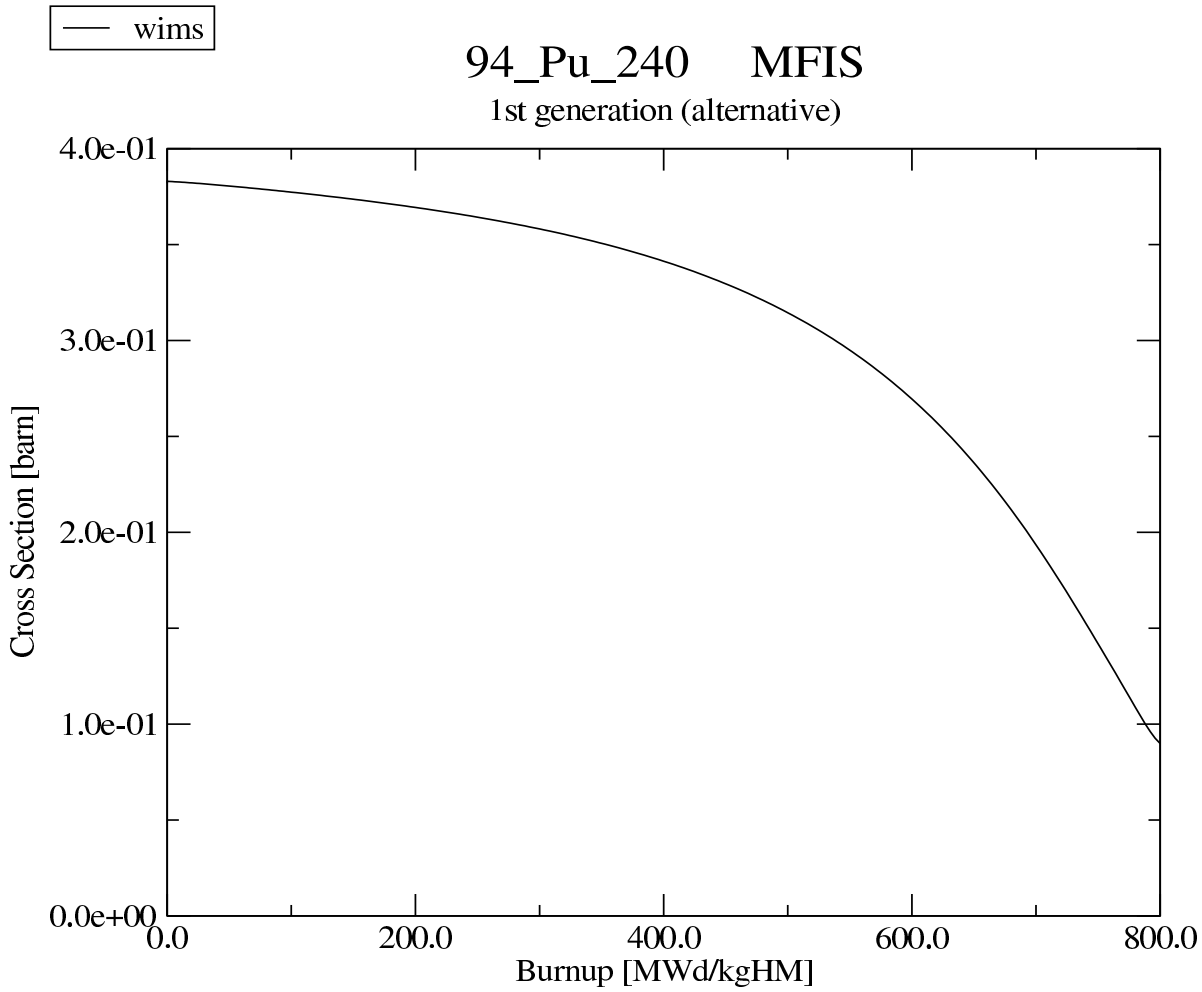


Figure 6.49 Fission Cross Section [$barn$] 94_Pu_240 for case B1

Table 6.50 Fission Cross Section [$barn$] 94_Pu_241 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1096e+02	–	–
100.00	1.2097e+02	–	–
400.00	2.0235e+02	–	–
600.00	3.6322e+02	–	–
800.00	7.4387e+02	–	–

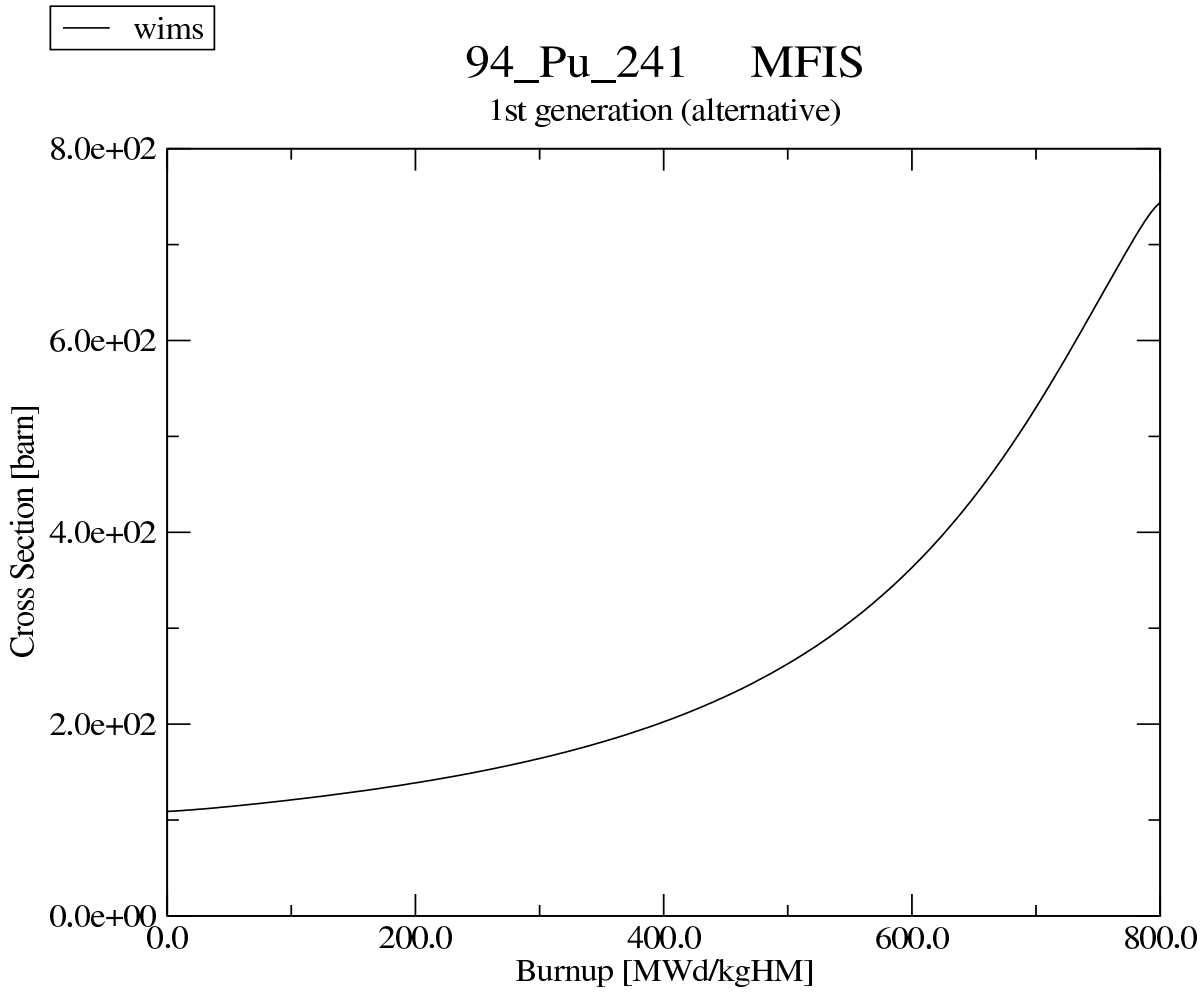


Figure 6.50 Fission Cross Section [$barn$] 94_Pu_241 for case B1

Table 6.51 Fission Cross Section [$barn$] 94_Pu_242 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.4425e-01	–	–
100.00	2.4060e-01	–	–
400.00	2.1173e-01	–	–
600.00	1.5716e-01	–	–
800.00	3.4086e-02	–	–

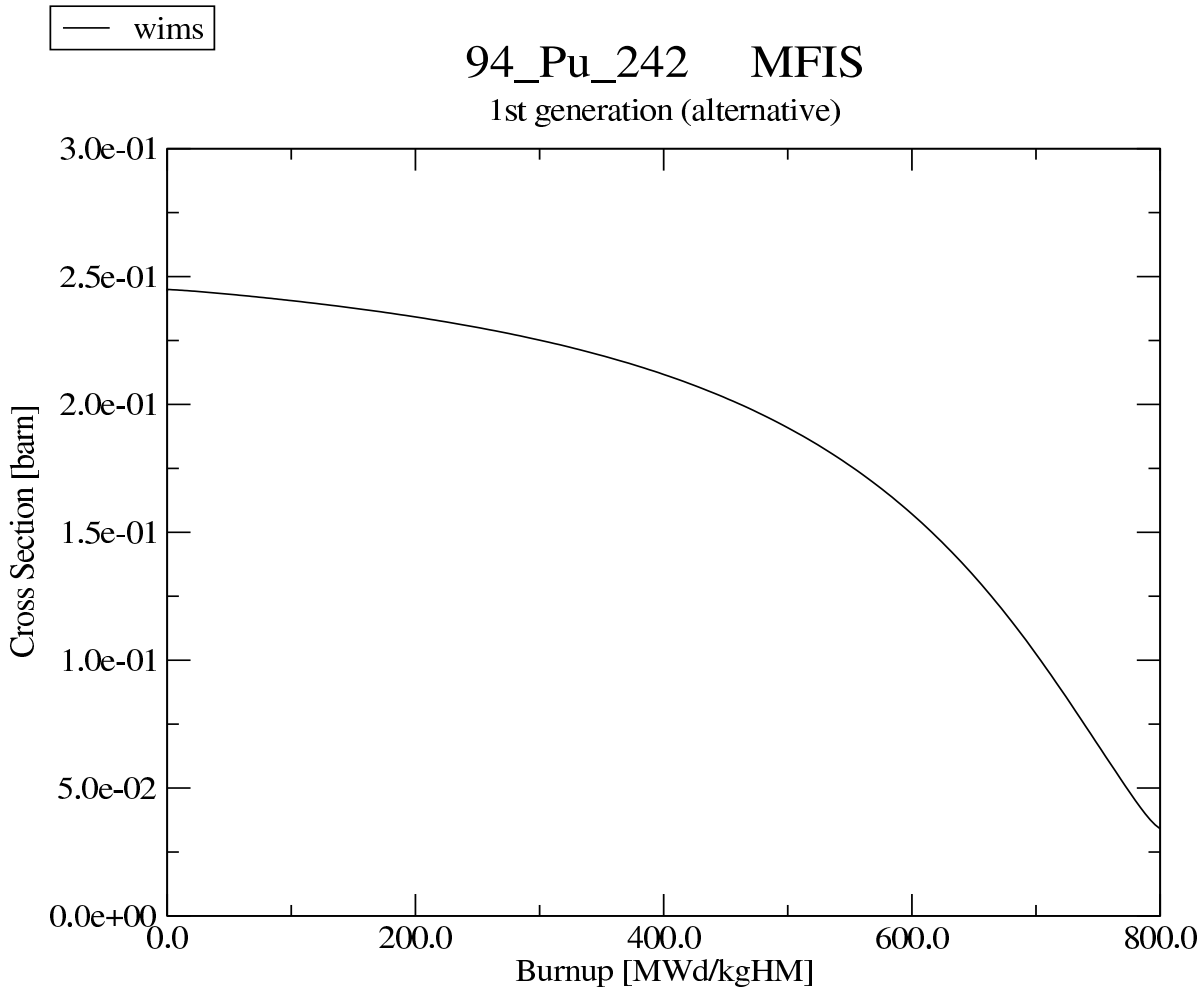


Figure 6.51 Fission Cross Section [$barn$] 94_Pu_242 for case B1

Table 6.52 Fission Cross Section [$barn$] 95_Am_241 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3187e+00	–	–
100.00	1.3963e+00	–	–
400.00	1.9310e+00	–	–
600.00	2.9080e+00	–	–
800.00	5.0281e+00	–	–

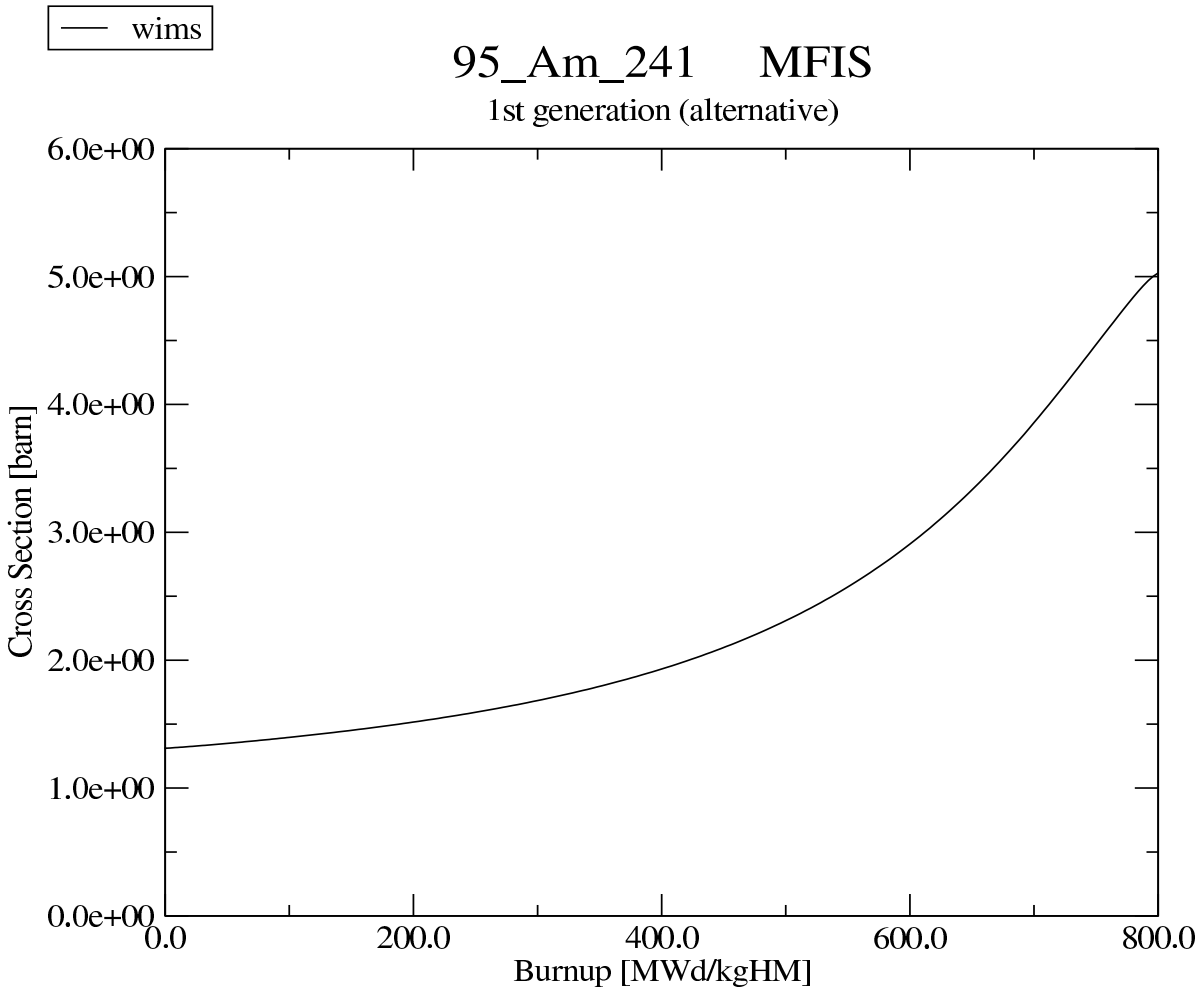


Figure 6.52 Fission Cross Section [$barn$] 95_Am_241 for case B1

Table 6.53 Fission Cross Section [$barn$] 95_Am_242m for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.5432e+02	–	–
100.00	6.0657e+02	–	–
400.00	1.0635e+03	–	–
600.00	1.9805e+03	–	–
800.00	4.1892e+03	–	–

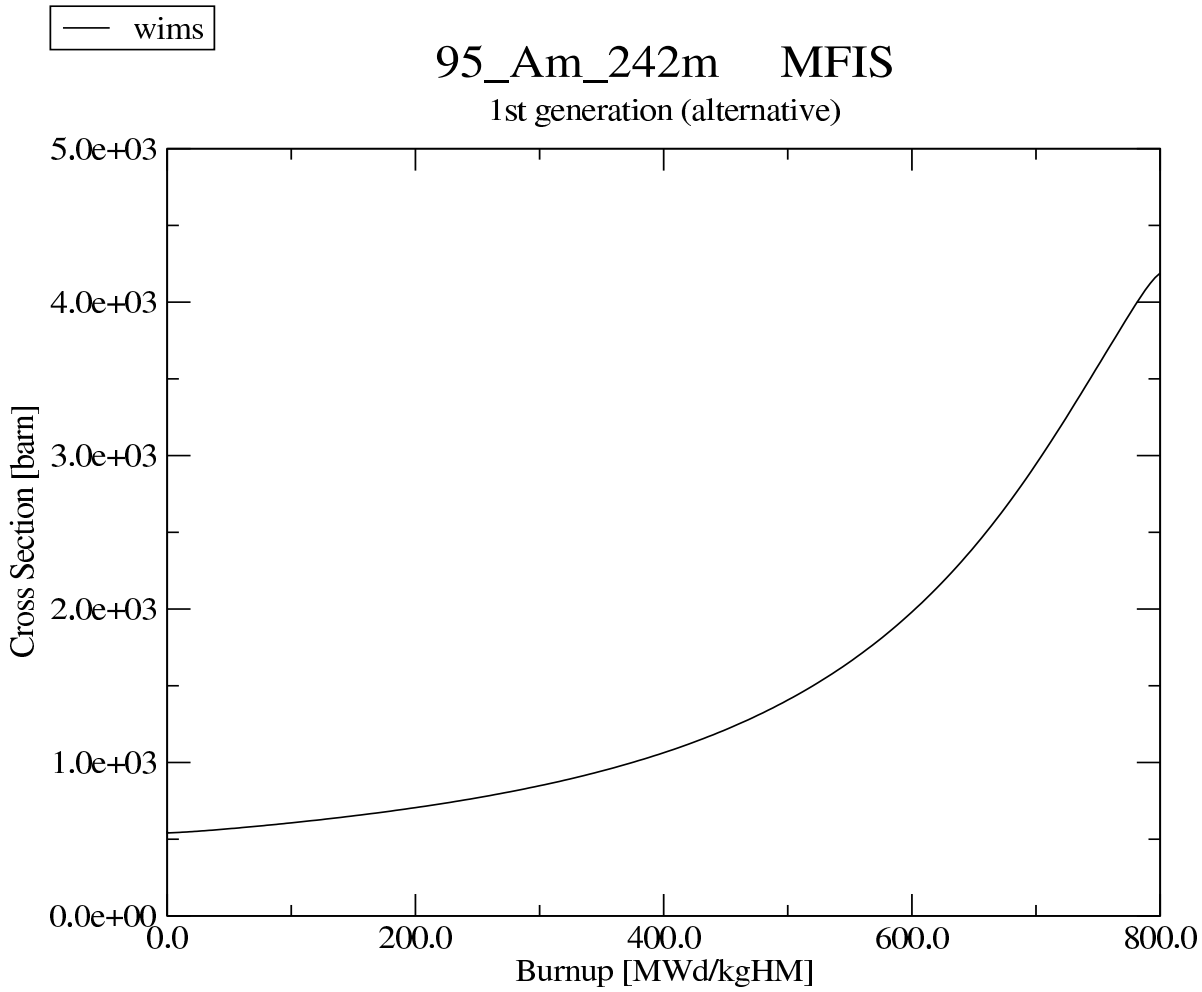


Figure 6.53 Fission Cross Section [$barn$] 95_Am_242m for case B1

Table 6.54 Fission Cross Section [$barn$] 95_Am_243 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.4409e-01	–	–
100.00	2.4050e-01	–	–
400.00	2.1442e-01	–	–
600.00	1.6550e-01	–	–
800.00	5.1932e-02	–	–

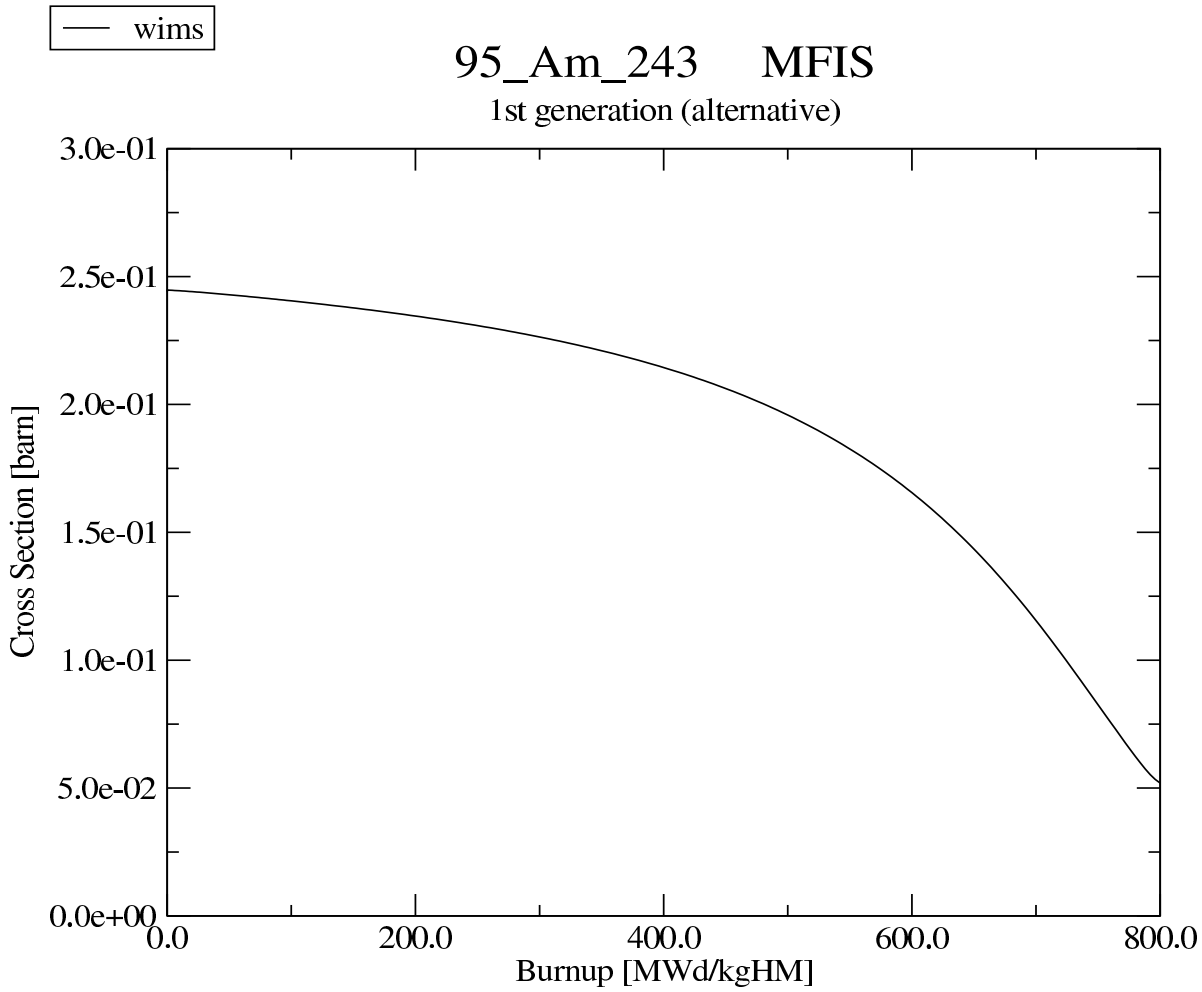


Figure 6.54 Fission Cross Section [$barn$] 95_Am_243 for case B1

Table 6.55 Fission Cross Section [$barn$] 96_Cm_242 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	8.2808e-01	–	–
100.00	8.5139e-01	–	–
400.00	1.0587e+00	–	–
600.00	1.4756e+00	–	–
800.00	2.4833e+00	–	–

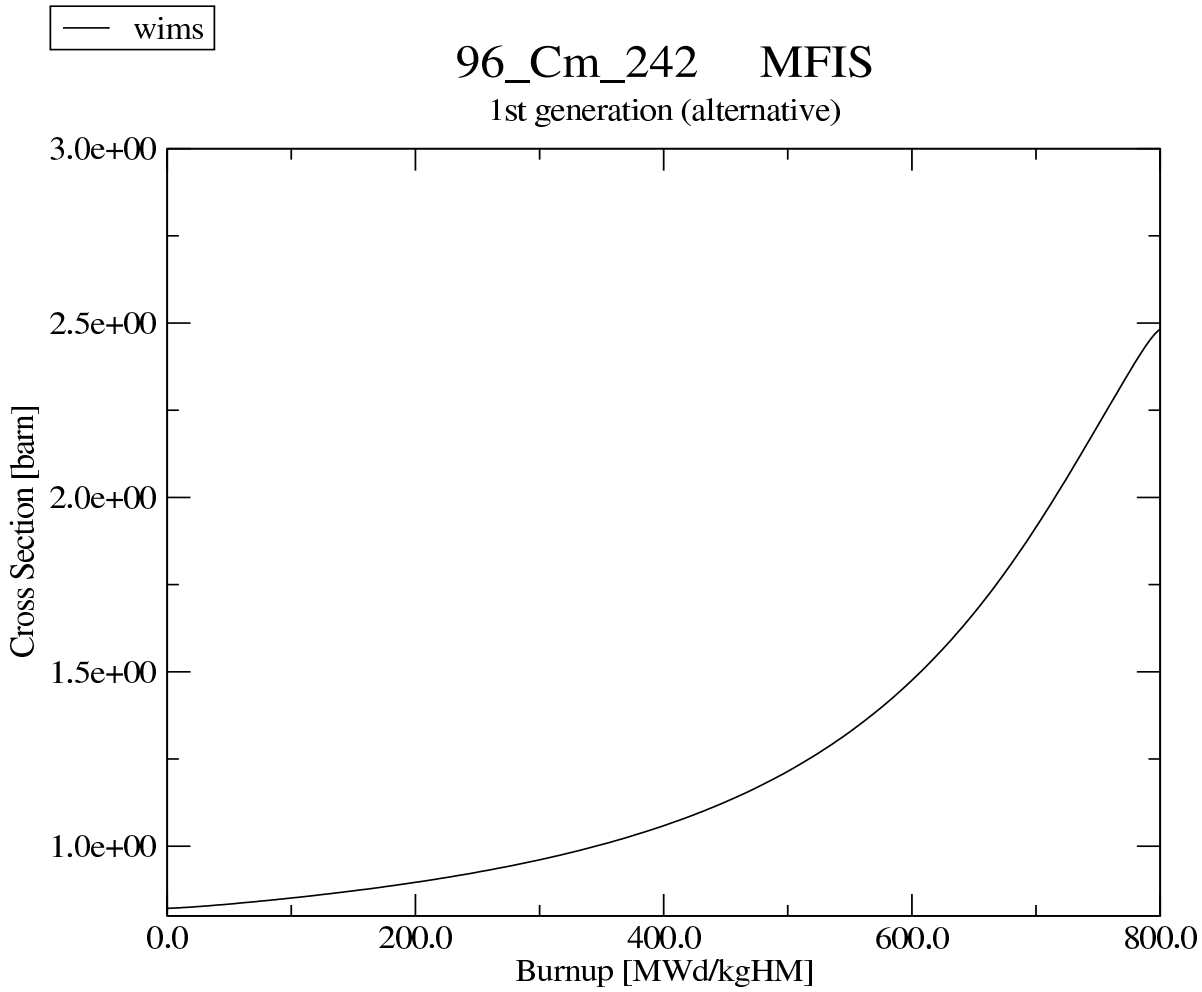


Figure 6.55 Fission Cross Section [$barn$] 96_Cm_242 for case B1

Table 6.56 Fission Cross Section [$barn$] 96_Cm_243 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1201e+02	–	–
100.00	1.1320e+02	–	–
400.00	1.2503e+02	–	–
600.00	1.5020e+02	–	–
800.00	2.1077e+02	–	–

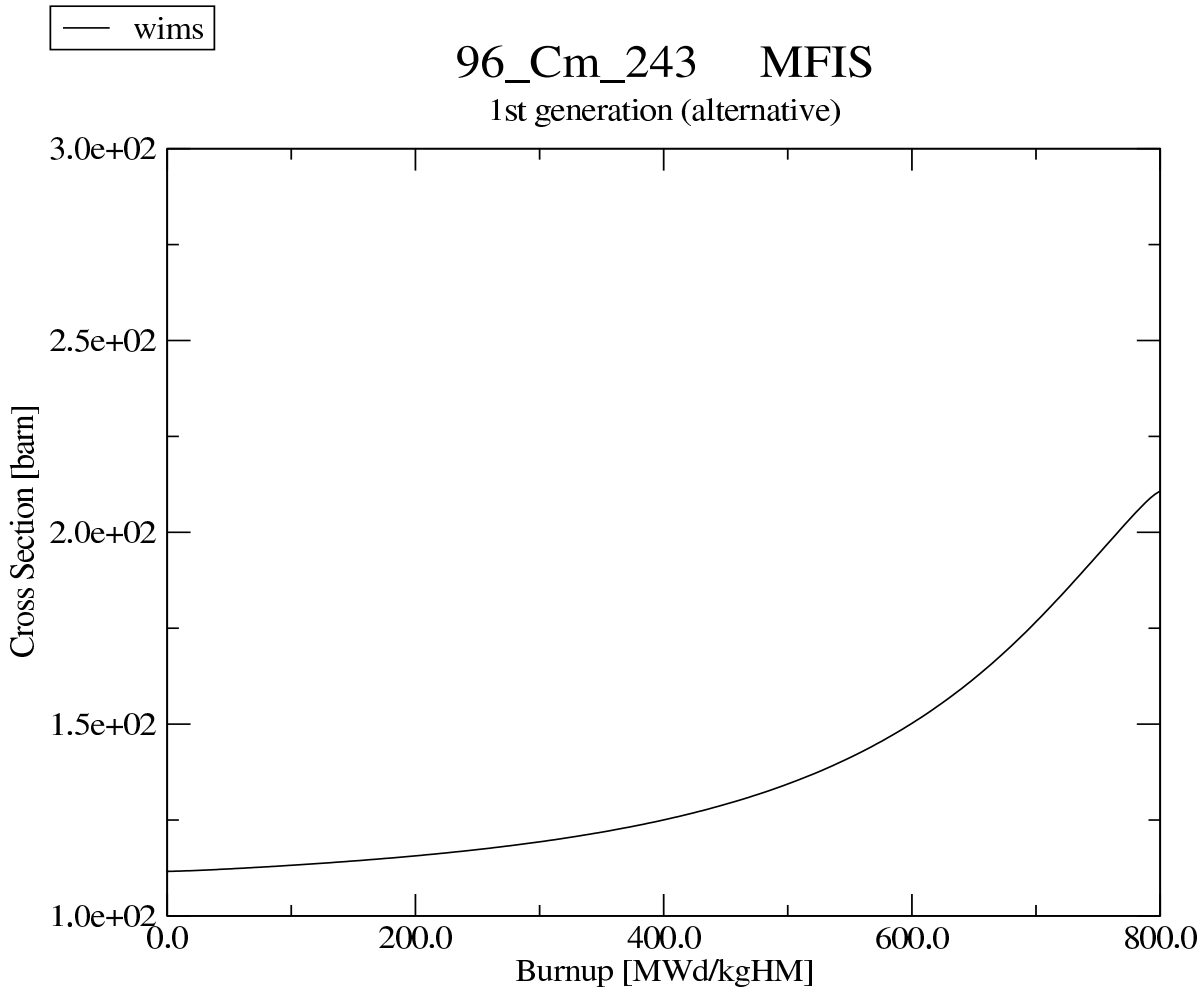


Figure 6.56 Fission Cross Section [$barn$] 96_Cm_243 for case B1

Table 6.57 Fission Cross Section [$barn$] 96_Cm_244 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.1218e-01	–	–
100.00	9.0829e-01	–	–
400.00	8.5454e-01	–	–
600.00	7.4979e-01	–	–
800.00	5.1270e-01	–	–

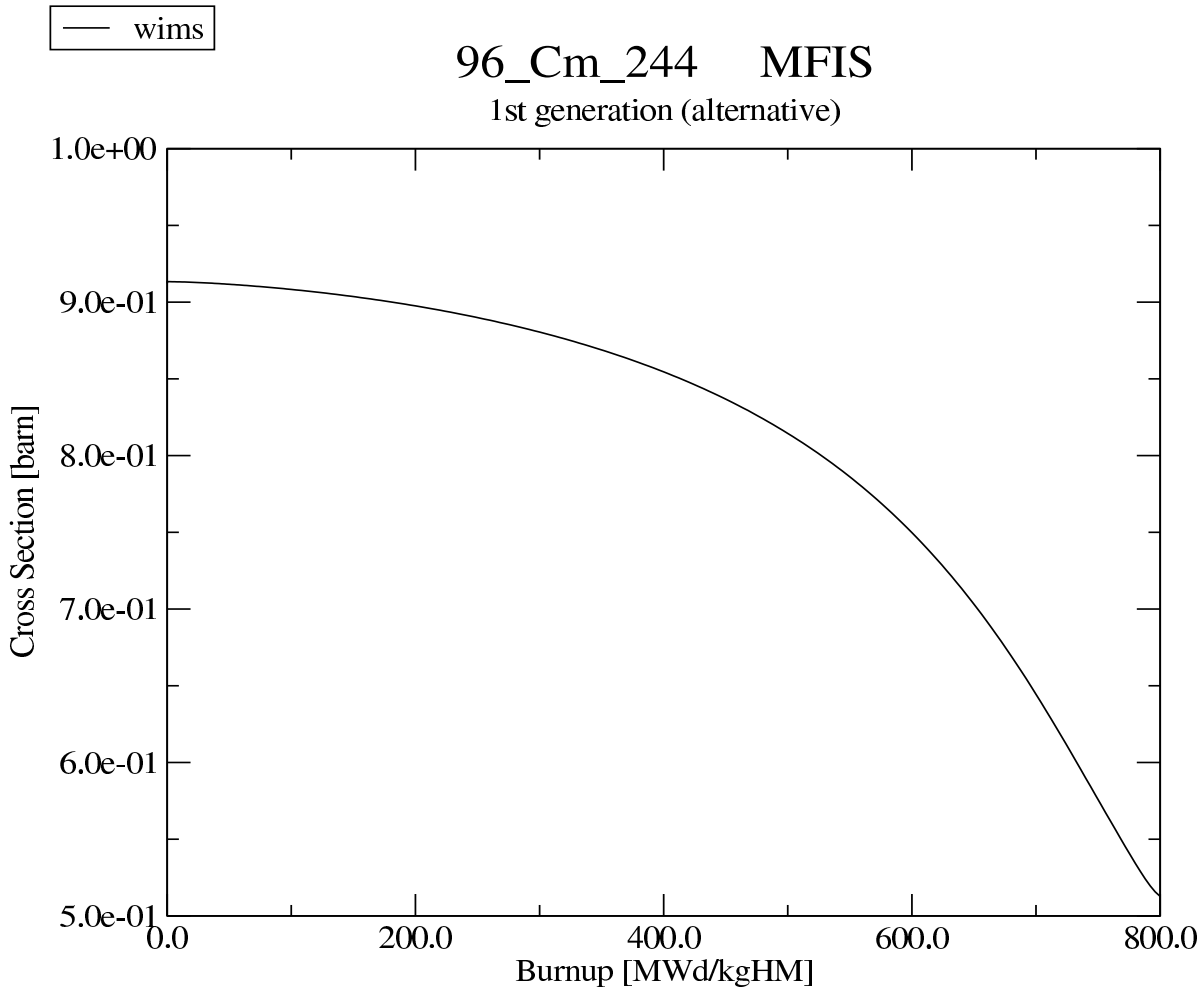


Figure 6.57 Fission Cross Section [$barn$] 96_Cm_244 for case B1

Table 6.58 Fission Cross Section [$barn$] 96_Cm_245 for case B1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0722e+02	–	–
100.00	1.1418e+02	–	–
400.00	1.7960e+02	–	–
600.00	3.1355e+02	–	–
800.00	6.4266e+02	–	–

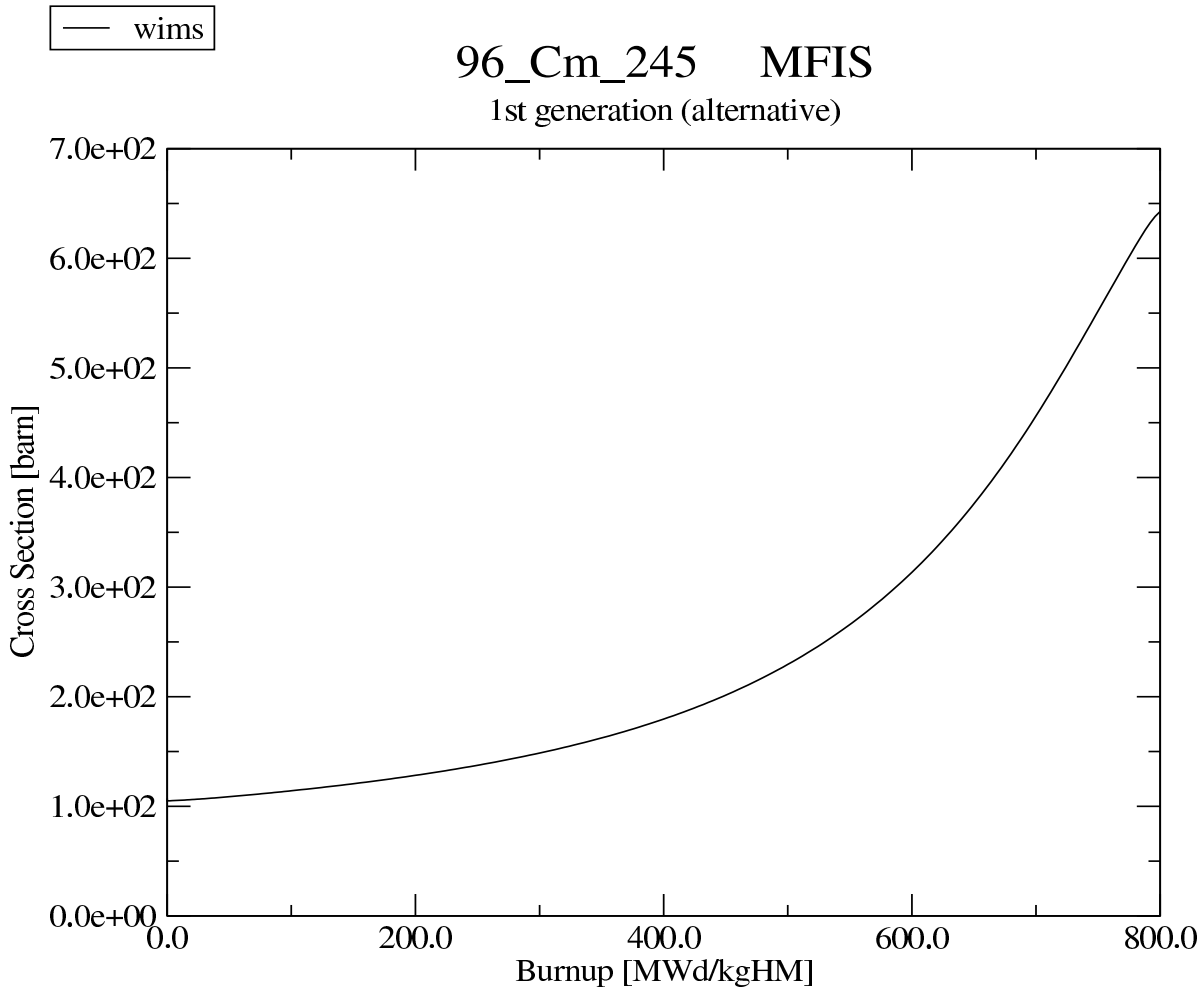


Figure 6.58 Fission Cross Section [$barn$] 96_Cm_245 for case B1

7. Case C1 results and discussion

Case C1 of this HTR Plutonium Cell Burnup Benchmark has 1.5 g plutonium per fuel element with the following 2nd generation composition for
^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu
in weight %: 4.9, 26.9, 34.3, 15.3, 18.3

7.1 Case C1 results

The figures at the end of this chapter show calculation results from all burnup steps. The corresponding tables give numerical values only for the burnup steps that are required by the benchmark specification [2].

Table 7.1 and figure 7.1 give the neutron flux collapsed to 1 group.

Table 7.2 and figure 7.2 give k_∞.

Table 7.3 and figure 7.3 give the fuel temperature coefficient.
In this table the OCTOPUS burnup values for which the FTC values are given differ slightly from those of WIMS.

Table 7.4 and figure 7.4 give the total fission rate.

Tables 7.5 - 7.30 and figures 7.5 - 7.30 give the nuclide densities.

Tables 7.31 - 7.56 and figures 7.31 - 7.56 give the 1-group microscopic absorption cross sections. Because WIMS does not count (n,2n) as absorption the figures show the OCTOPUS absorption cross sections with (n,2n) subtracted. The tables give the true OCTOPUS absorption cross sections. The WIMS absorption cross sections in the tables are also given with the (n,2n) OCTOPUS value (from OCTOPUS-MCNP-FISPACT) added to it.

Tables 7.57 - 7.69 and figures 7.57 - 7.69 give the 1-group microscopic fission cross sections.

7.2 Case C1 discussion

The calculations here are done with WIMS and OCTOPUS-MCNP-FISPACT. The results show a good agreement between the different calculation methods. It should be noted that the calculations of the FTC by MCNP are not reliable with the accuracies used here.

Table 7.1 one group neutron flux [$s^{-1}cm^{-2}$] for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.8677e+14	–	1.848854E+14
100.00	1.9514e+14	–	1.949202E+14
400.00	2.3596e+14	–	2.368059E+14
600.00	6.4770e+14	–	6.629206E+14
800.00	6.7119e+15	–	7.667896E+15

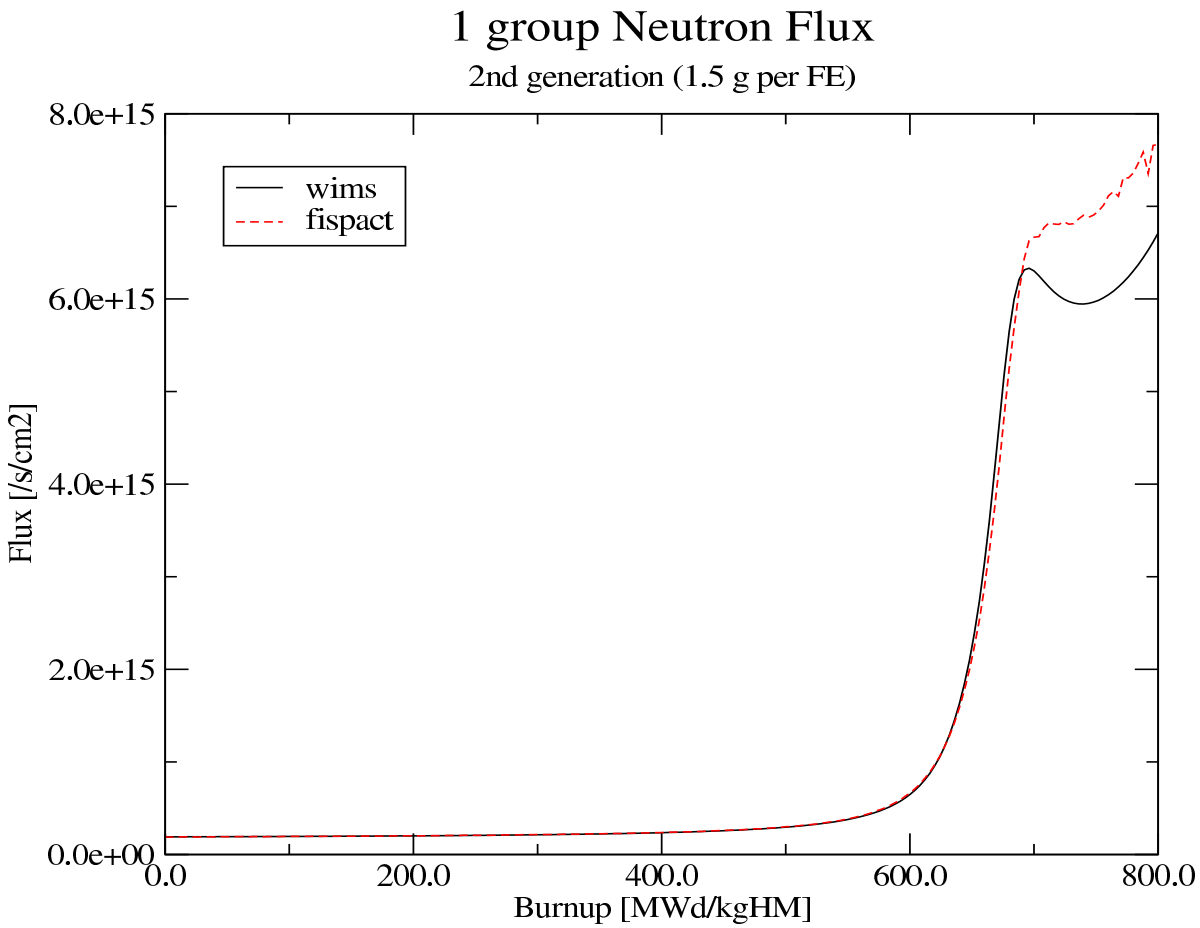


Figure 7.1 one group neutron flux [$s^{-1}cm^{-2}$] for case C1

Table 7.2 k_∞ for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1200	–	1.13547
100.00	1.0876	–	1.08755
400.00	1.0503	–	1.05404
600.00	0.7225	–	0.71012
800.00	0.3503	–	0.32857

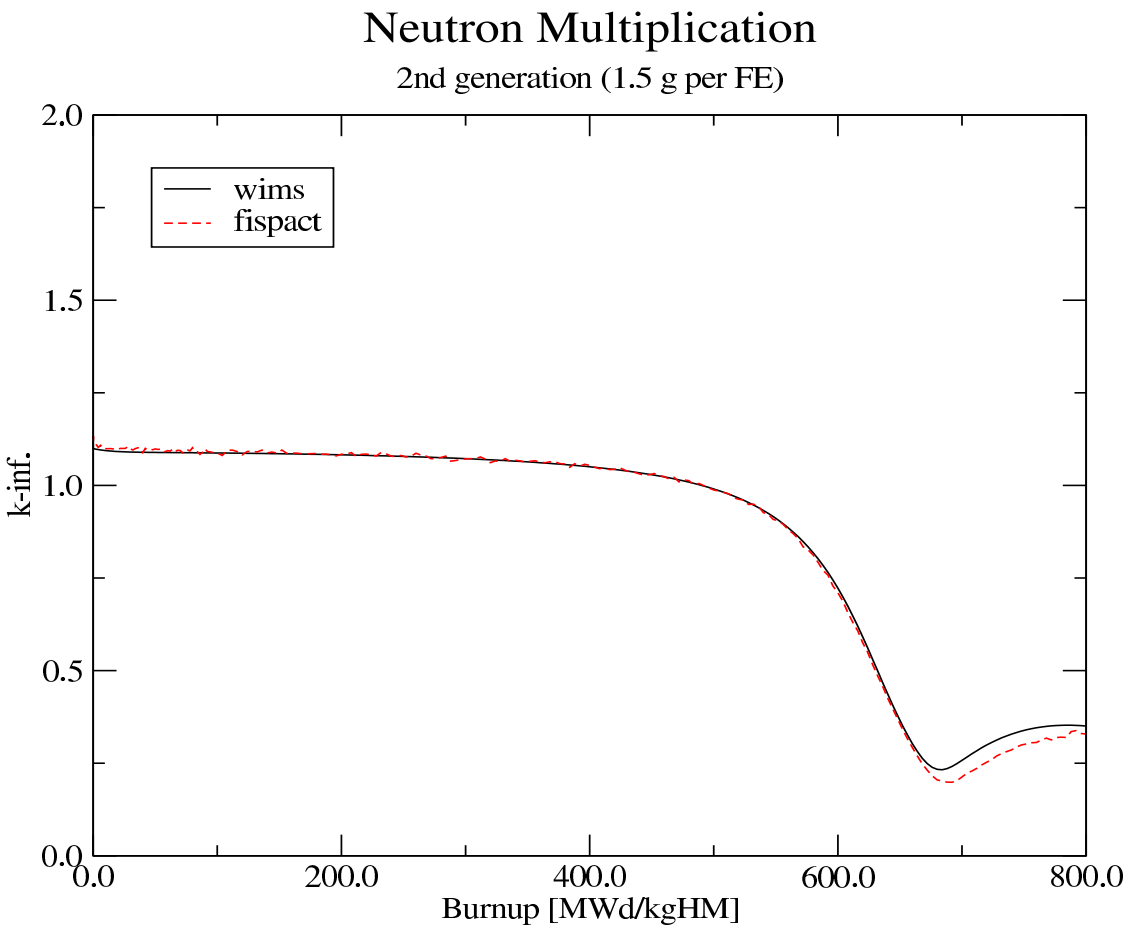


Figure 7.2 k_∞ for case C1

Table 7.3 FTC $[pcm/K]$ for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	-10.88	–	-23.55
98.00		–	5.15
100.00	-9.76		
396.00		–	-16.88
400.00	-8.87		
596.00		–	16.97
600.00	1.30		
796.00		–	-80.42
800.00	-59.31		

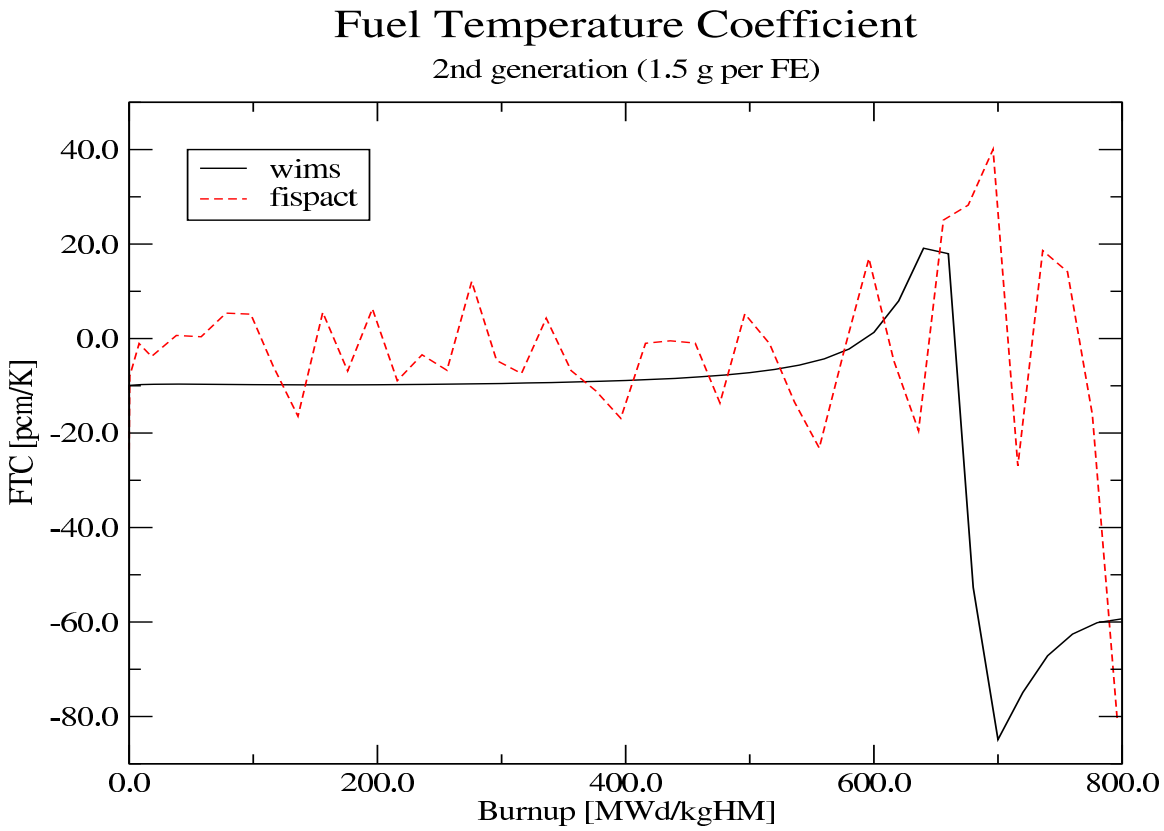


Figure 7.3 FTC $[pcm/K]$ for case C1

Table 7.4 Fission Rate $[s^{-1}]$ for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.9577e+13	–	–
100.00	2.9525e+13	–	–
400.00	2.9384e+13	–	–
600.00	2.9302e+13	–	–
800.00	2.8259e+13	–	–

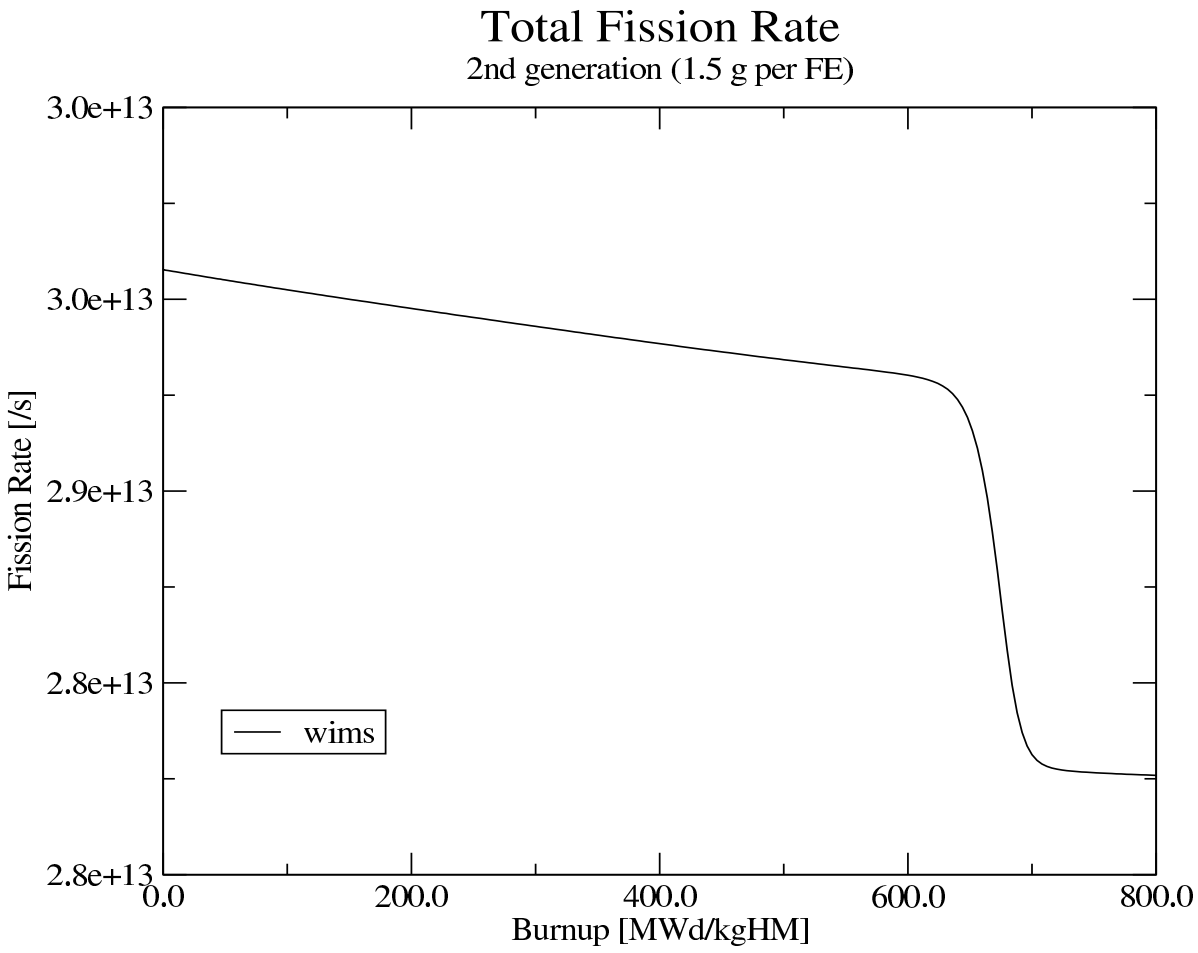


Figure 7.4 Fission Rate $[s^{-1}]$ for case C1

Table 7.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1377e-03	–	1.1377e-03
100.00	1.0698e-03	–	1.0703e-03
400.00	8.7253e-04	–	8.6746e-04
600.00	5.3704e-04	–	5.1426e-04
800.00	4.9861e-07	–	3.3320e-07

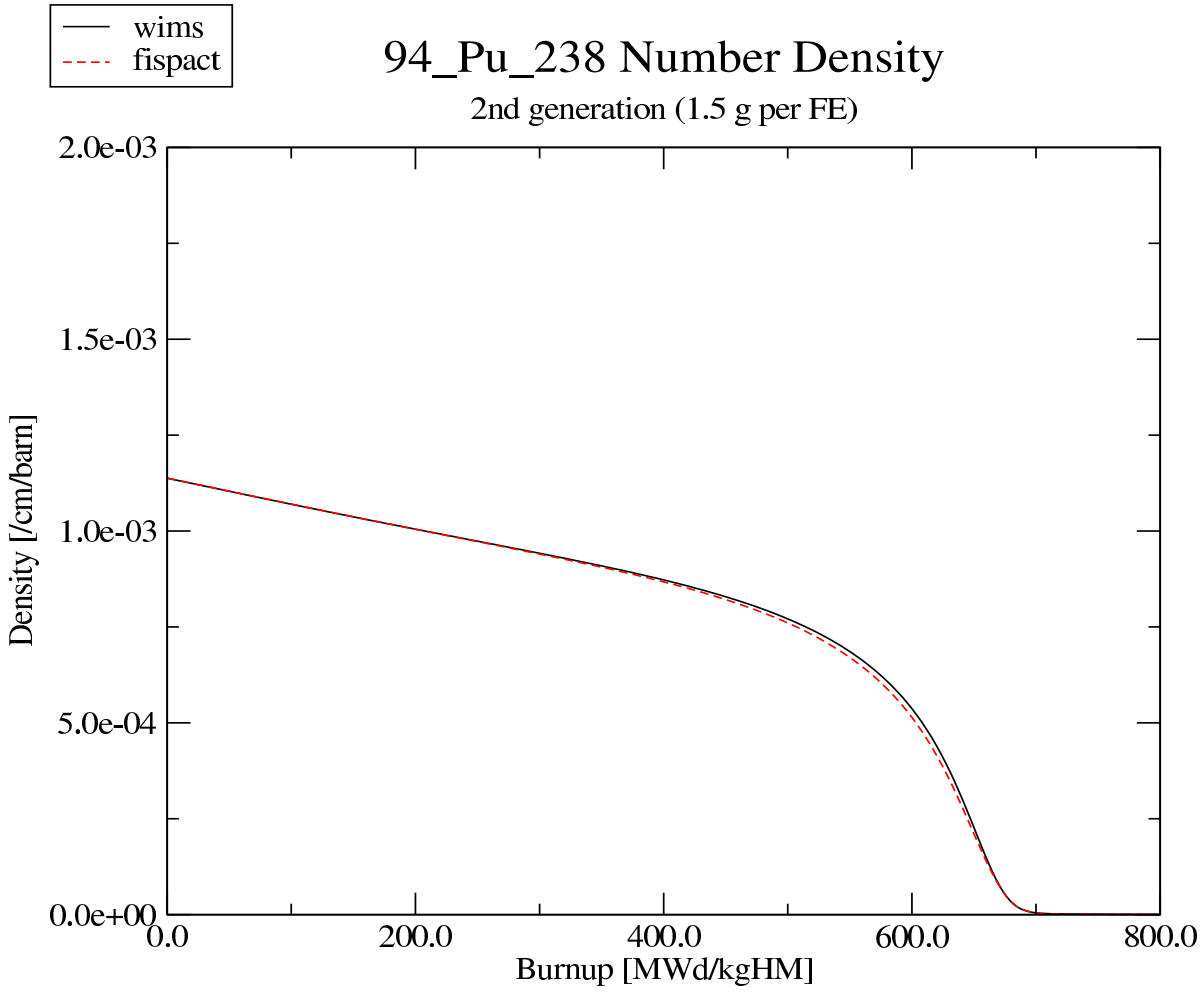


Figure 7.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case C1

Table 7.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.2196e-03	–	6.2195e-03
100.00	4.1567e-03	–	4.0950e-03
400.00	6.1805e-04	–	5.7226e-04
600.00	7.3907e-05	–	7.2353e-05
800.00	6.2941e-08	–	4.4175e-08

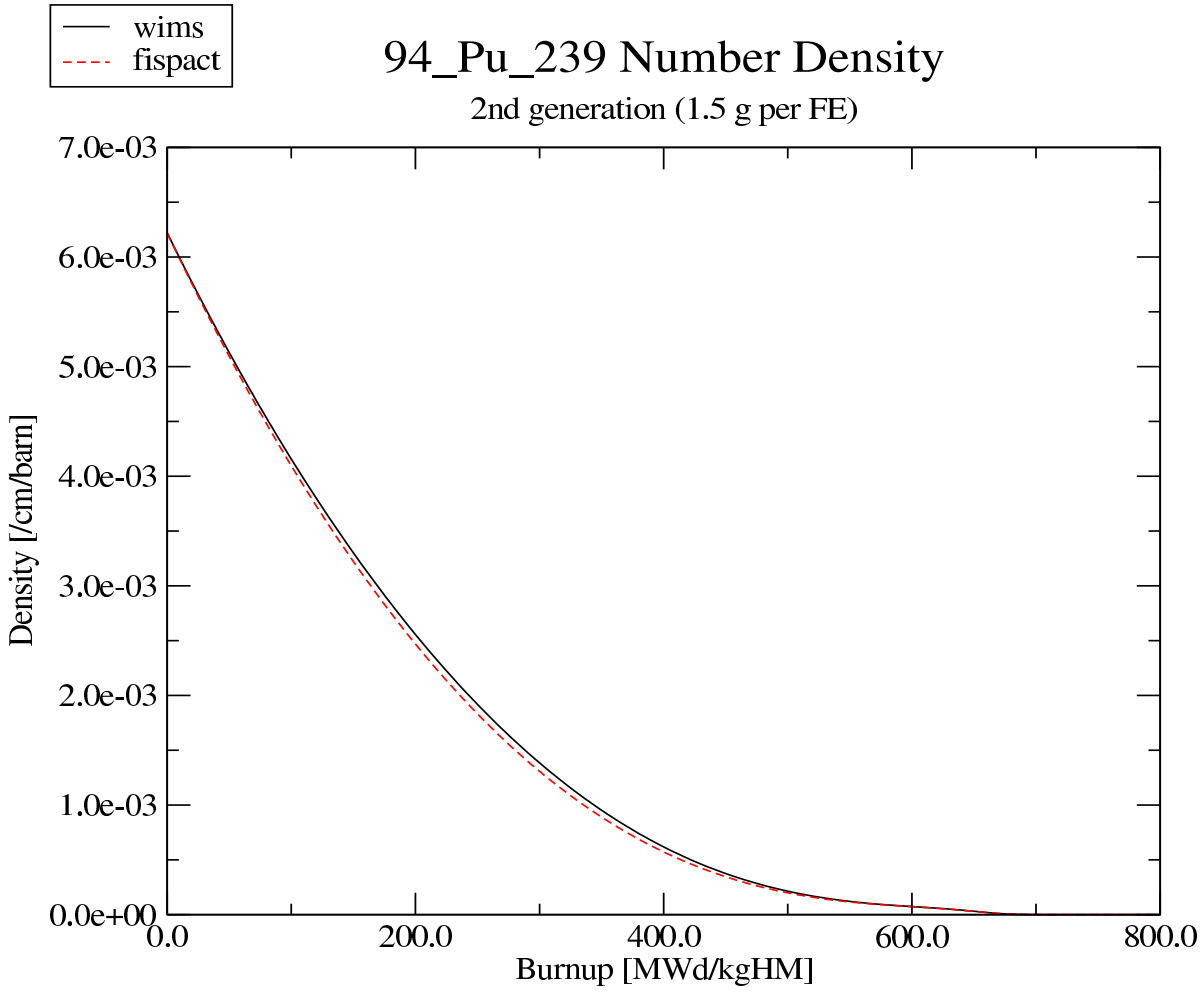


Figure 7.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case C1

Table 7.7 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_240 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.8975e-03	–	7.8974e-03
100.00	6.6566e-03	–	6.7298e-03
400.00	2.8669e-03	–	2.9077e-03
600.00	5.7682e-04	–	5.7272e-04
800.00	2.5042e-06	–	2.4594e-06

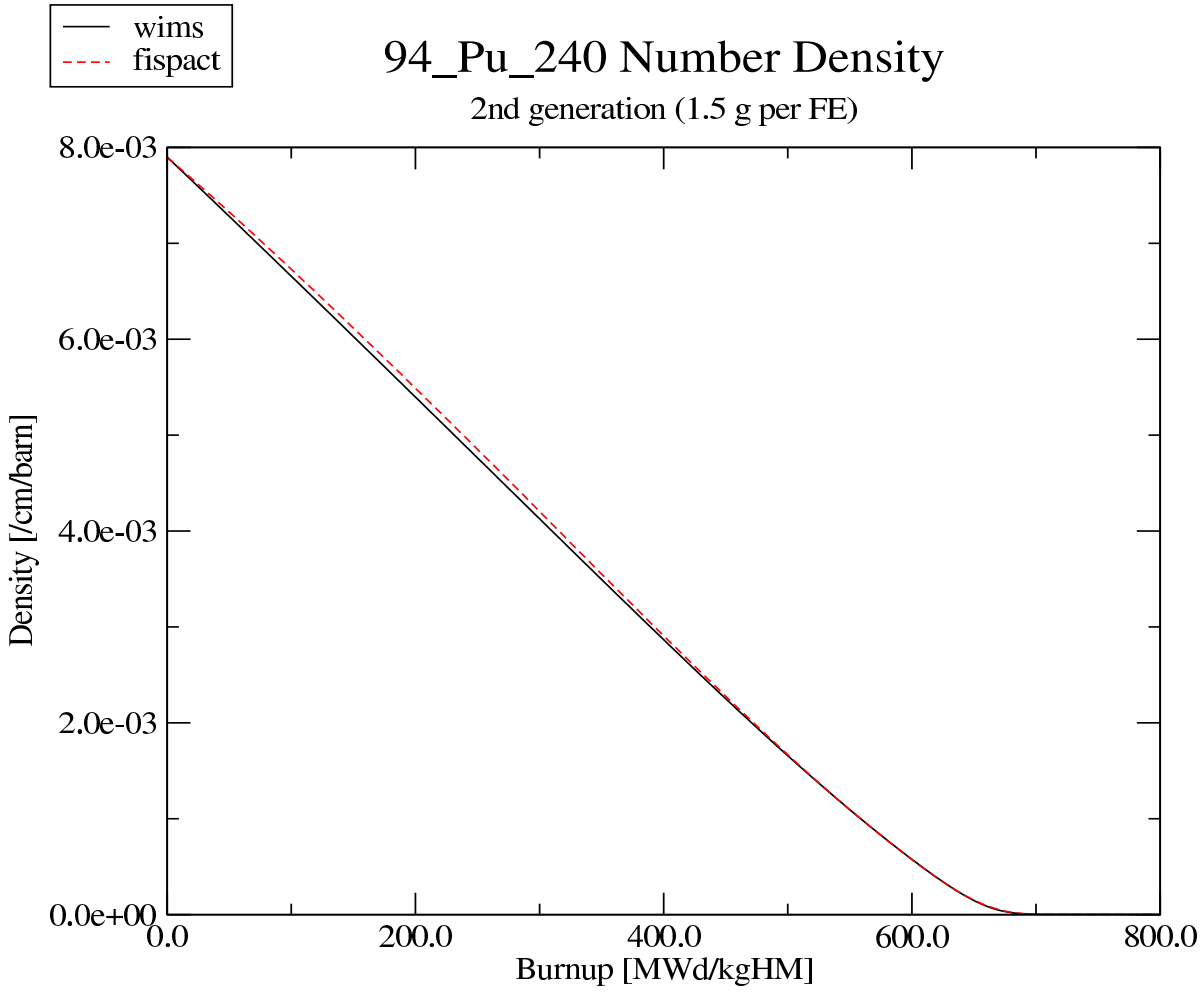


Figure 7.7 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_240 for case C1

Table 7.8 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_241 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.5081e-03	–	3.5081e-03
100.00	4.1227e-03	–	4.0994e-03
400.00	2.9758e-03	–	2.9173e-03
600.00	4.3656e-04	–	4.0004e-04
800.00	5.7838e-07	–	5.3570e-07

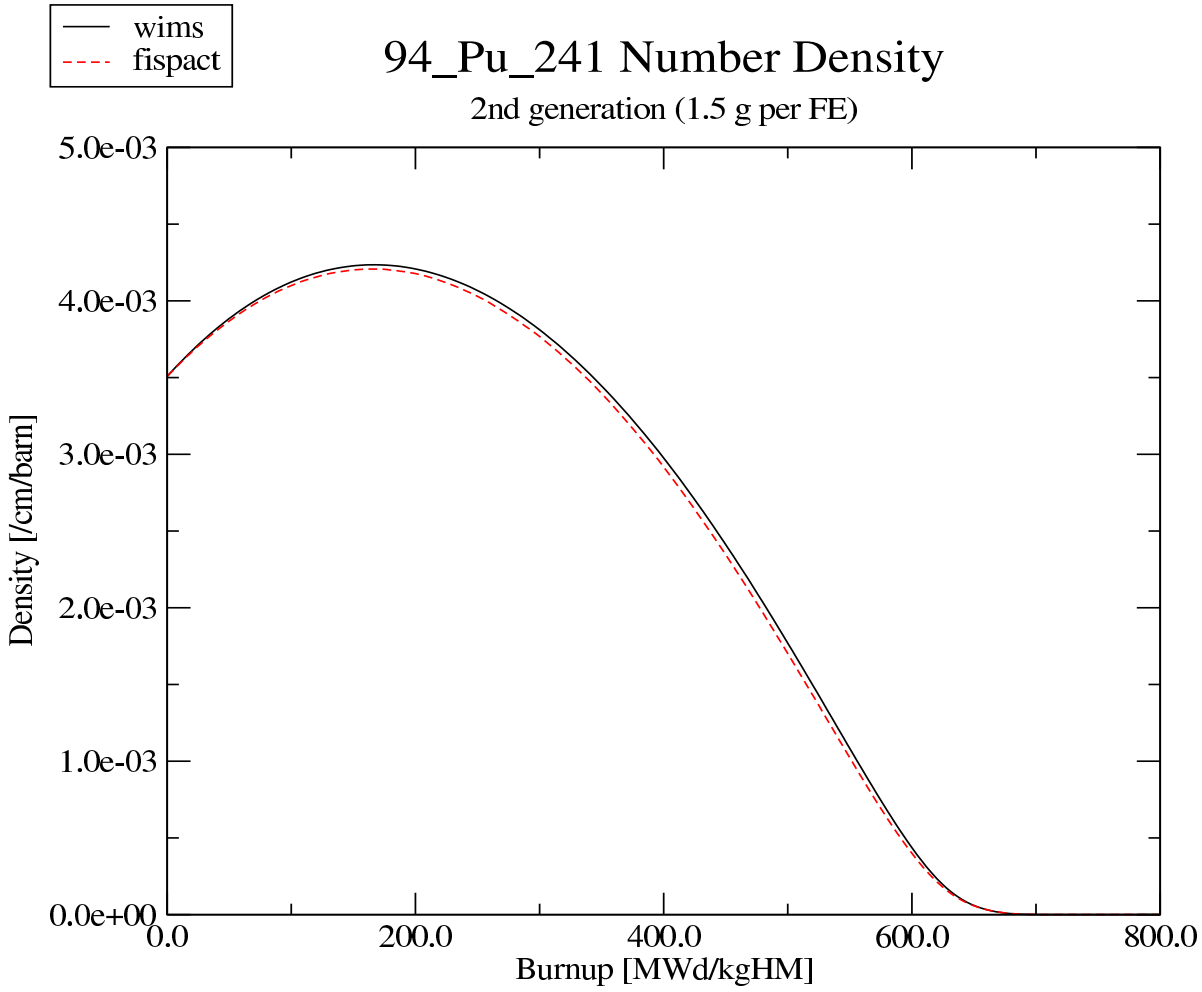


Figure 7.8 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_241 for case C1

Table 7.9 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_242 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.2471e-03	–	4.2471e-03
100.00	4.2176e-03	–	4.2146e-03
400.00	4.6543e-03	–	4.6488e-03
600.00	4.9465e-03	–	4.9191e-03
800.00	9.5017e-04	–	8.3150e-04

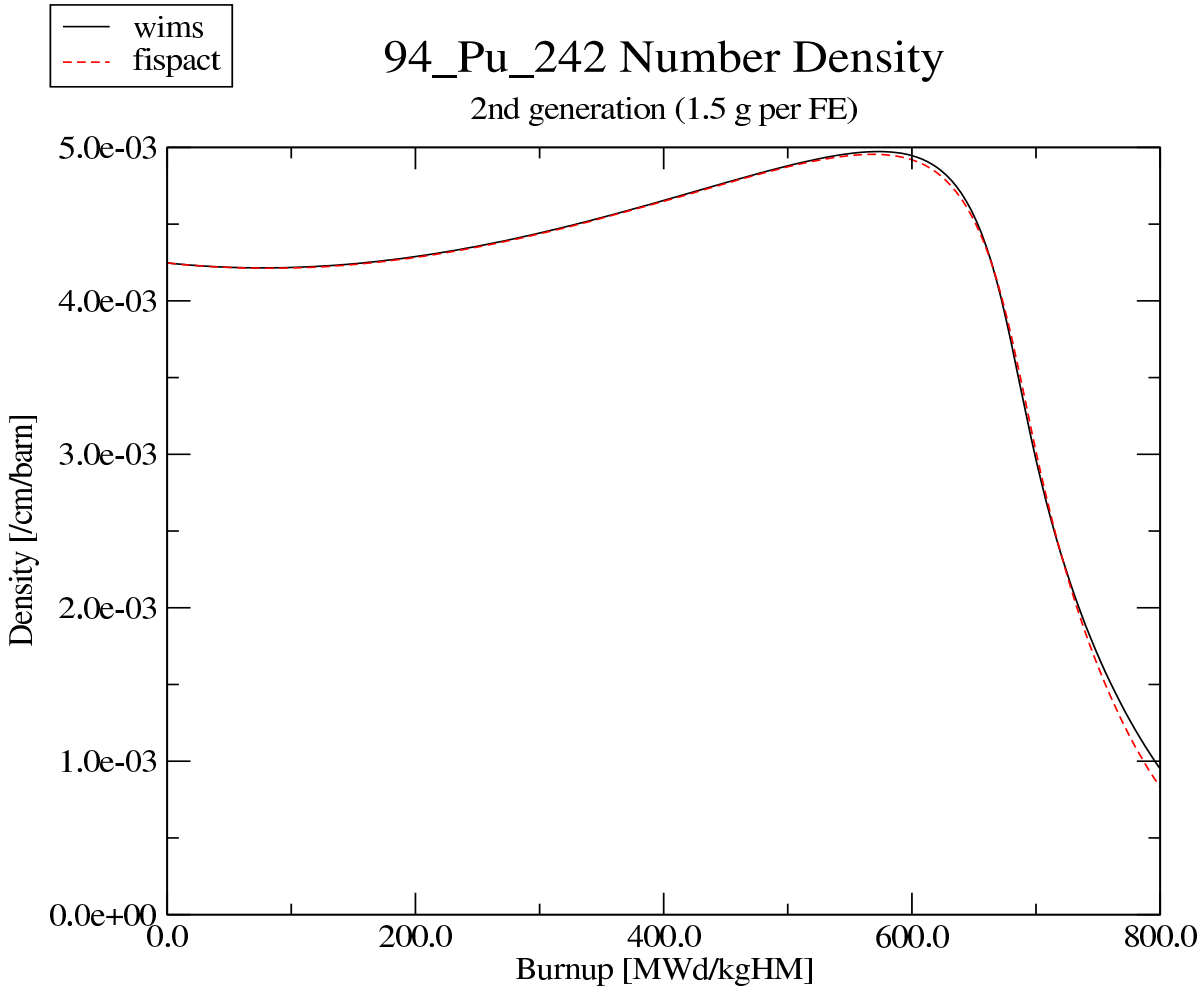


Figure 7.9 Number Density $[cm^{-1}barn^{-1}]$ 94_Pu_242 for case C1

Table 7.10 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_241 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	6.3863e-05	–	6.3821e-05
400.00	1.1608e-04	–	1.1444e-04
600.00	1.4781e-05	–	1.3630e-05
800.00	1.9224e-10	–	1.5644e-10

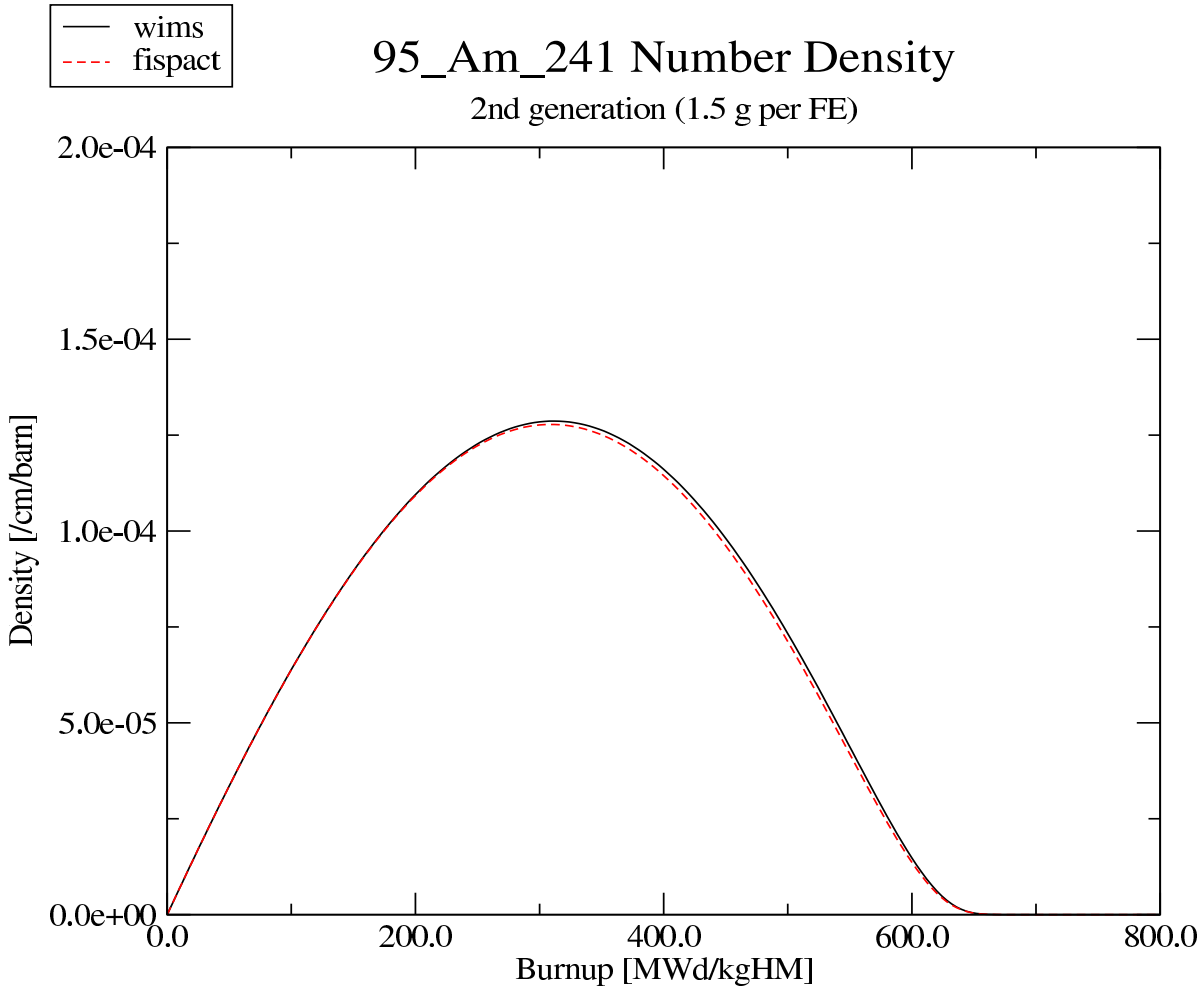


Figure 7.10 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_241 for case C1

Table 7.11 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_242 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	1.0000e-20
100.00	–	–	1.4275e-07
400.00	–	–	4.9613e-07
600.00	–	–	2.8833e-07
800.00	–	–	2.3128e-11

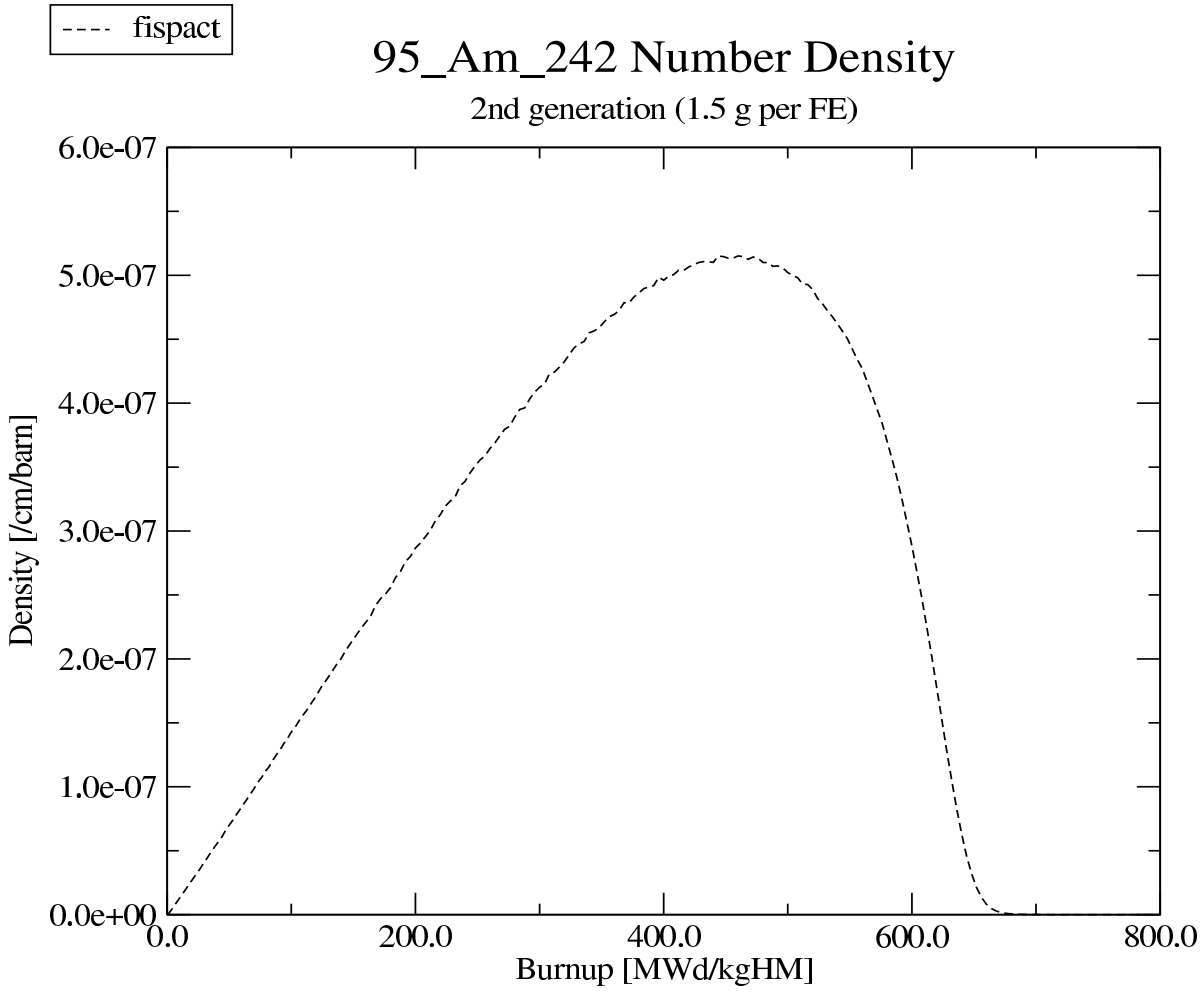


Figure 7.11 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_242 for case C1

Table 7.12 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	7.8658e-07	–	6.2245e-07
400.00	2.3723e-06	–	1.8344e-06
600.00	2.5229e-07	–	1.7915e-07
800.00	2.6116e-12	–	4.0502e-12

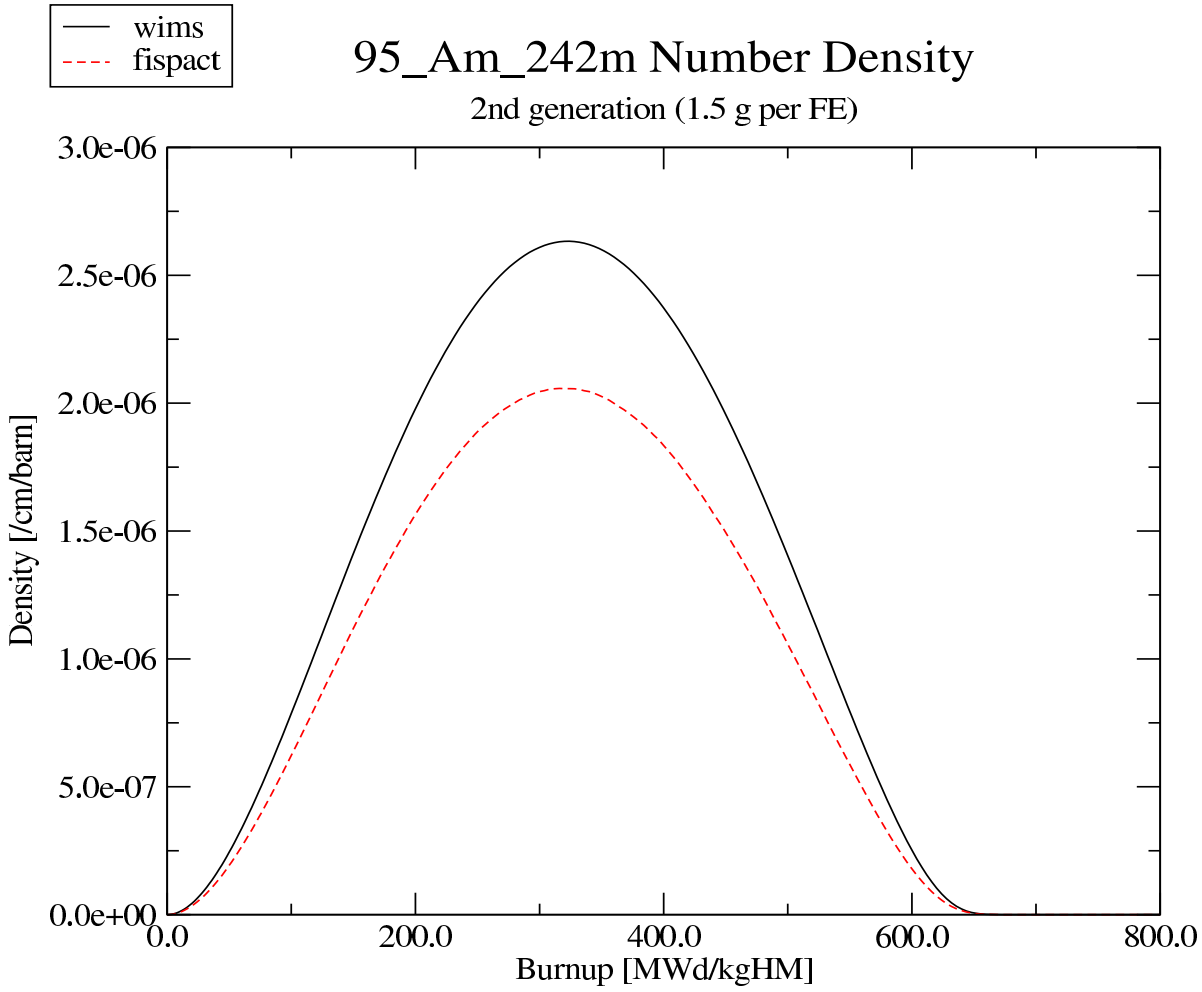


Figure 7.12 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case C1

Table 7.13 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_243 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	3.3287e-04	–	2.9803e-04
400.00	1.0231e-03	–	9.7061e-04
600.00	1.3520e-03	–	1.2885e-03
800.00	3.9166e-04	–	3.2926e-04

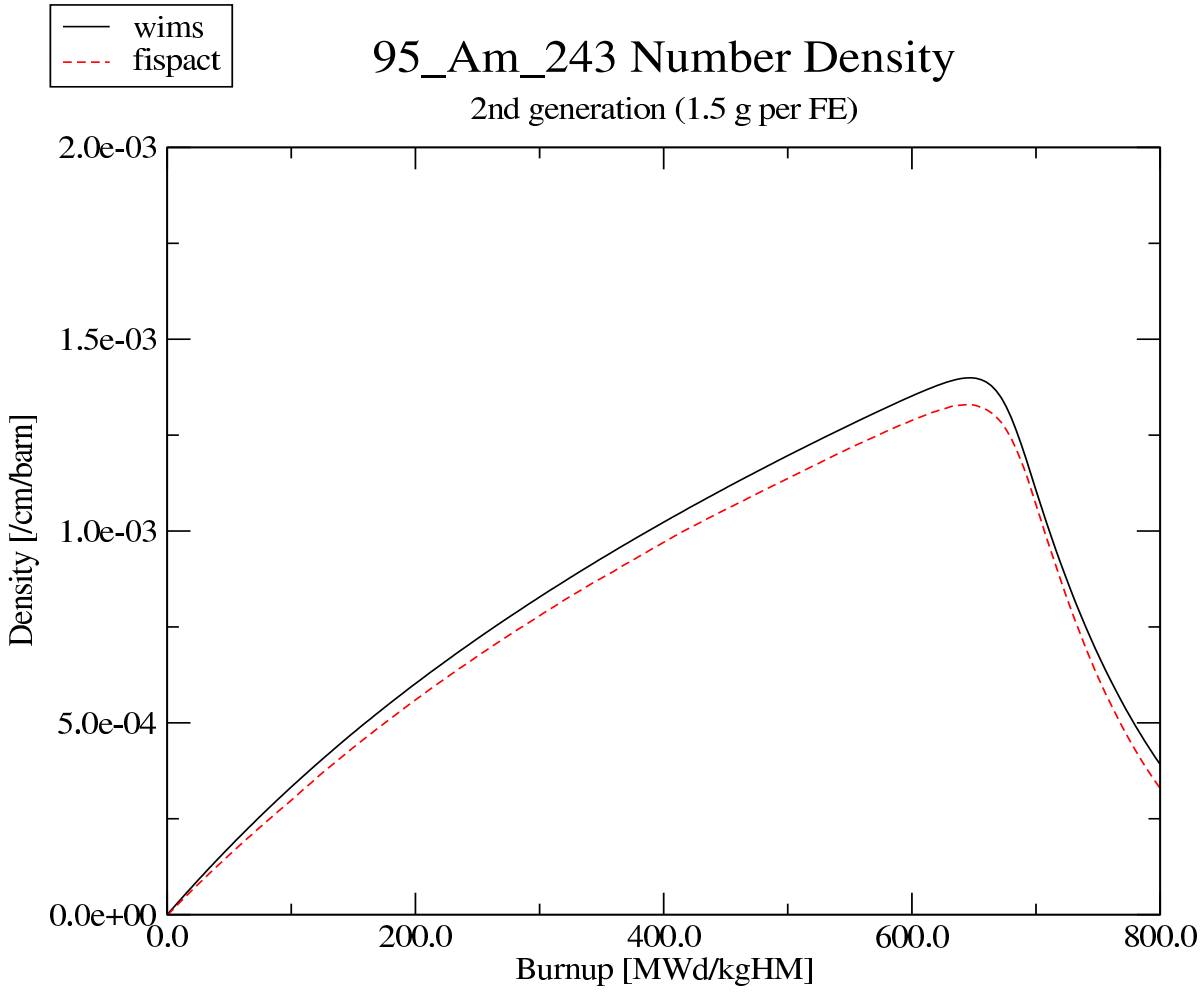


Figure 7.13 Number Density $[cm^{-1}barn^{-1}]$ 95_Am_243 for case C1

Table 7.14 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_242 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	7.4867e-06	–	7.3608e-06
400.00	6.7837e-05	–	6.8098e-05
600.00	8.4160e-05	–	8.1572e-05
800.00	9.1717e-06	–	7.6927e-06

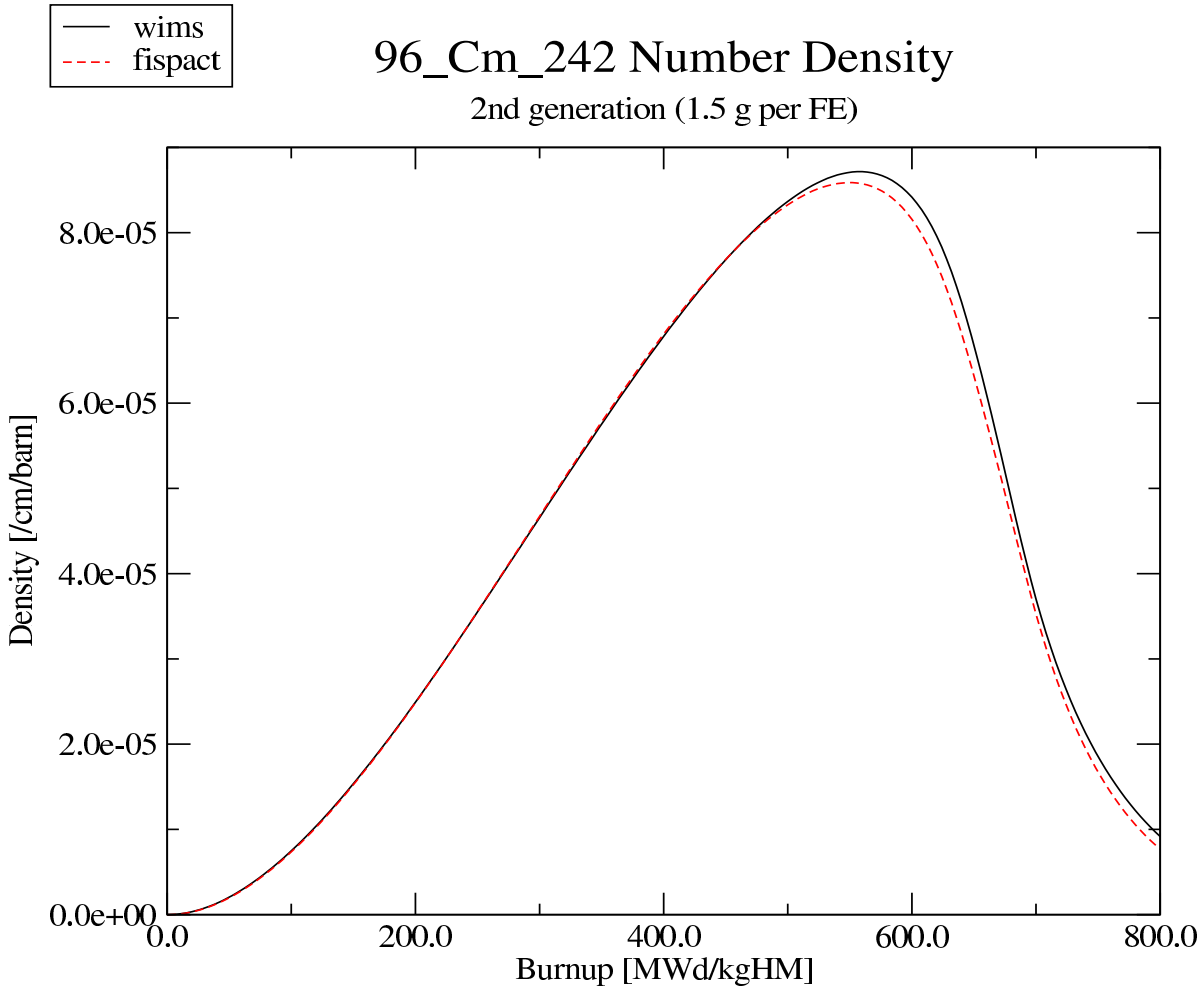


Figure 7.14 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_242 for case C1

Table 7.15 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	3.9836e-08	–	3.9150e-08
400.00	1.3906e-06	–	1.4151e-06
600.00	2.7699e-06	–	2.7611e-06
800.00	2.7700e-07	–	2.3246e-07

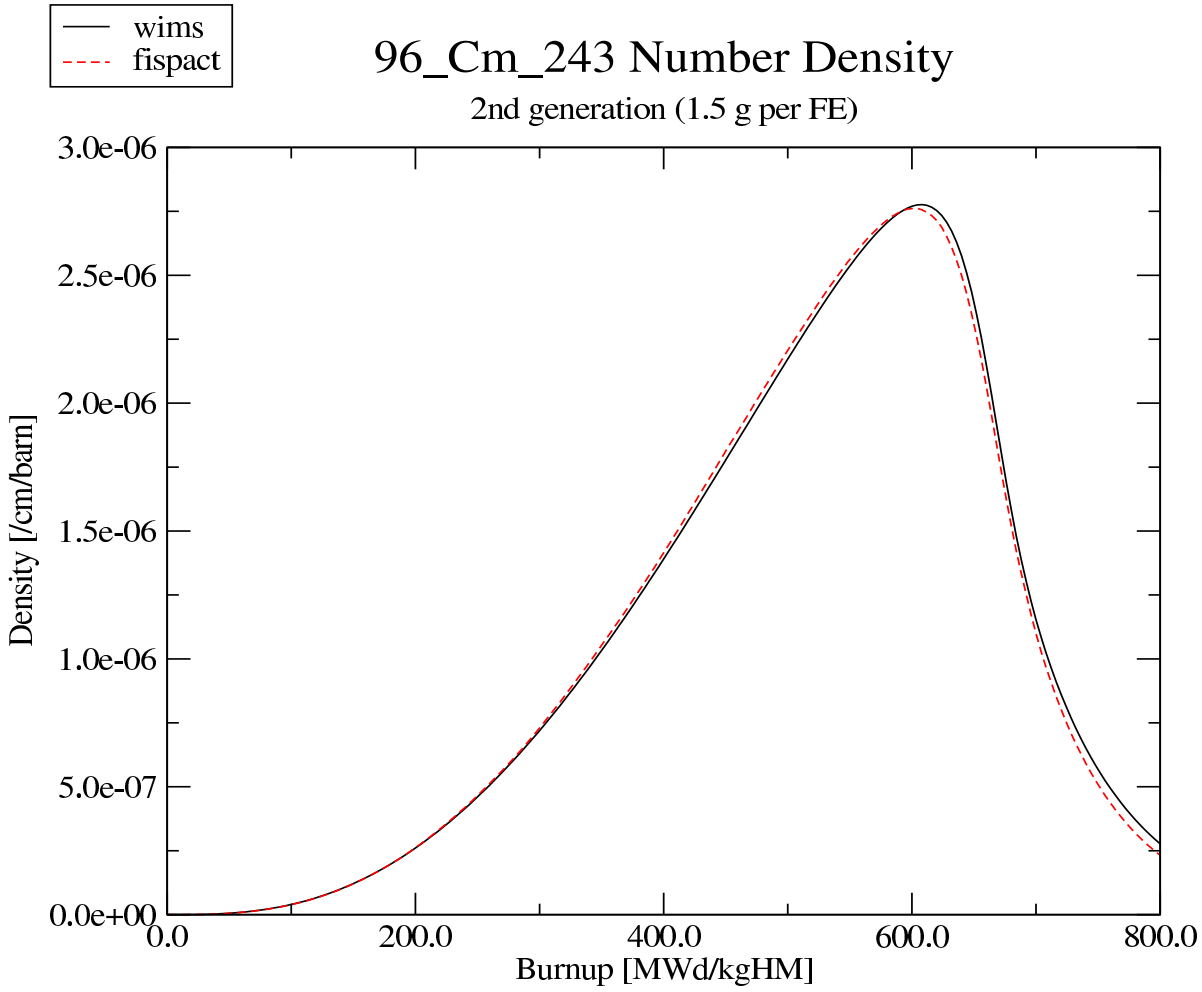


Figure 7.15 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case C1

Table 7.16 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_244 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	3.7035e-05	–	3.2752e-05
400.00	4.5430e-04	–	4.3312e-04
600.00	1.0293e-03	–	1.0018e-03
800.00	2.8902e-03	–	3.2113e-03

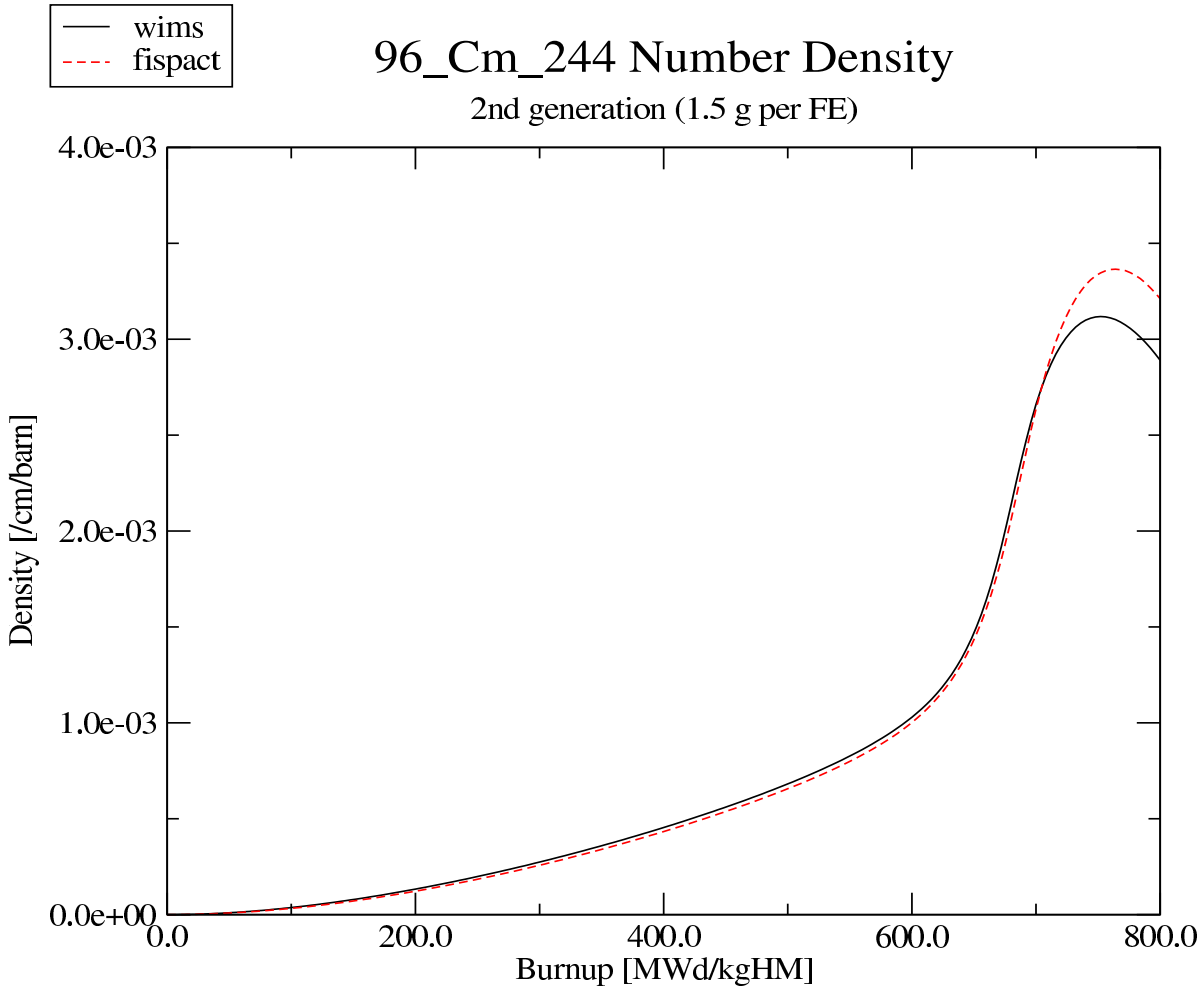


Figure 7.16 Number Density [$cm^{-1}barn^{-1}$] 96_Cm_244 for case C1

Table 7.17 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	9.4004e-07	–	7.7028e-07
400.00	3.3917e-05	–	2.9977e-05
600.00	4.4822e-05	–	3.6922e-05
800.00	3.6886e-05	–	2.9389e-05

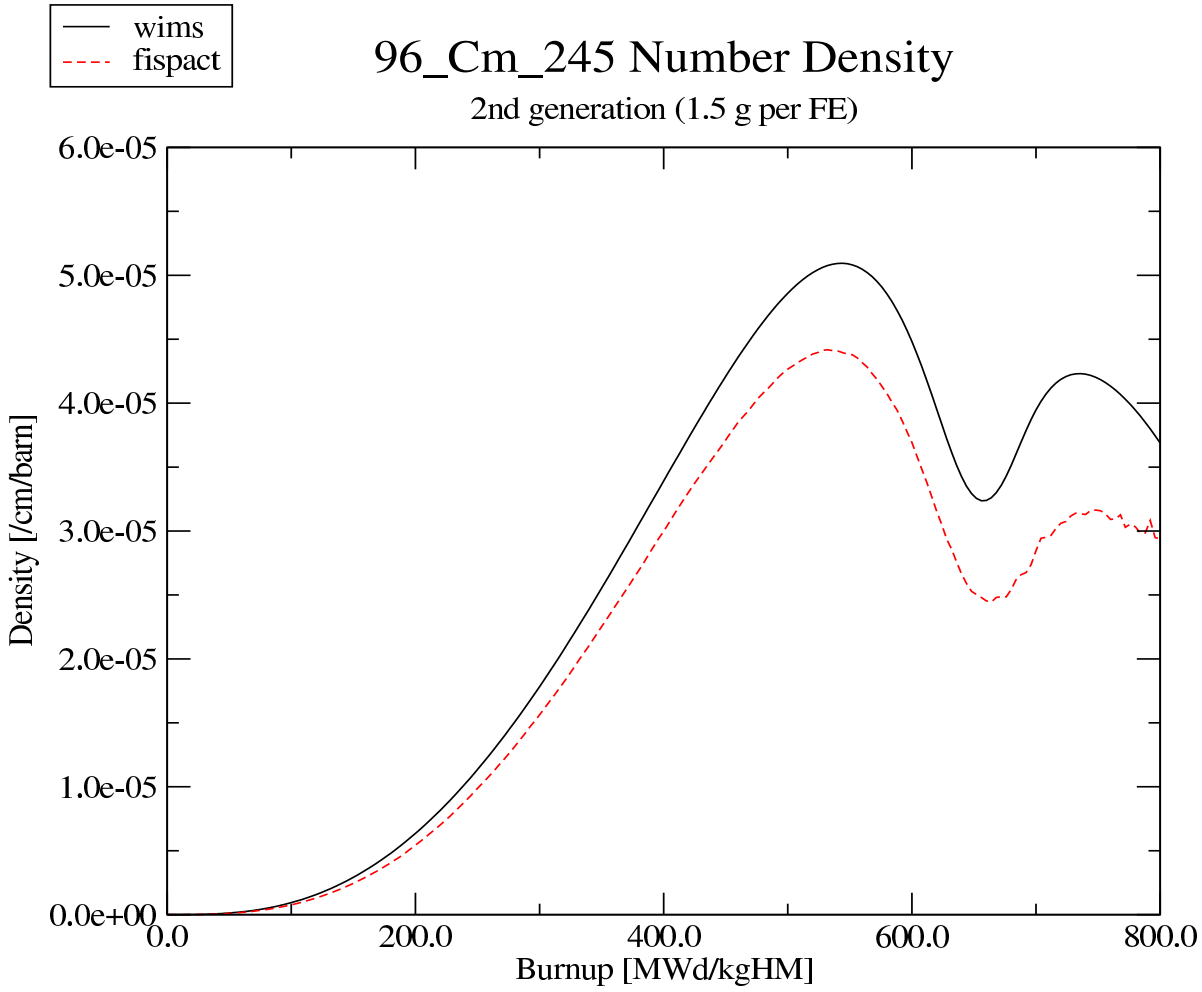


Figure 7.17 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case C1

Table 7.18 Number Density [$cm^{-1}barn^{-1}$] 38_Sr_90 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	1.0000e-20
100.00	–	–	4.2280e-05
400.00	–	–	1.6032e-04
600.00	–	–	2.3057e-04
800.00	–	–	2.6877e-04

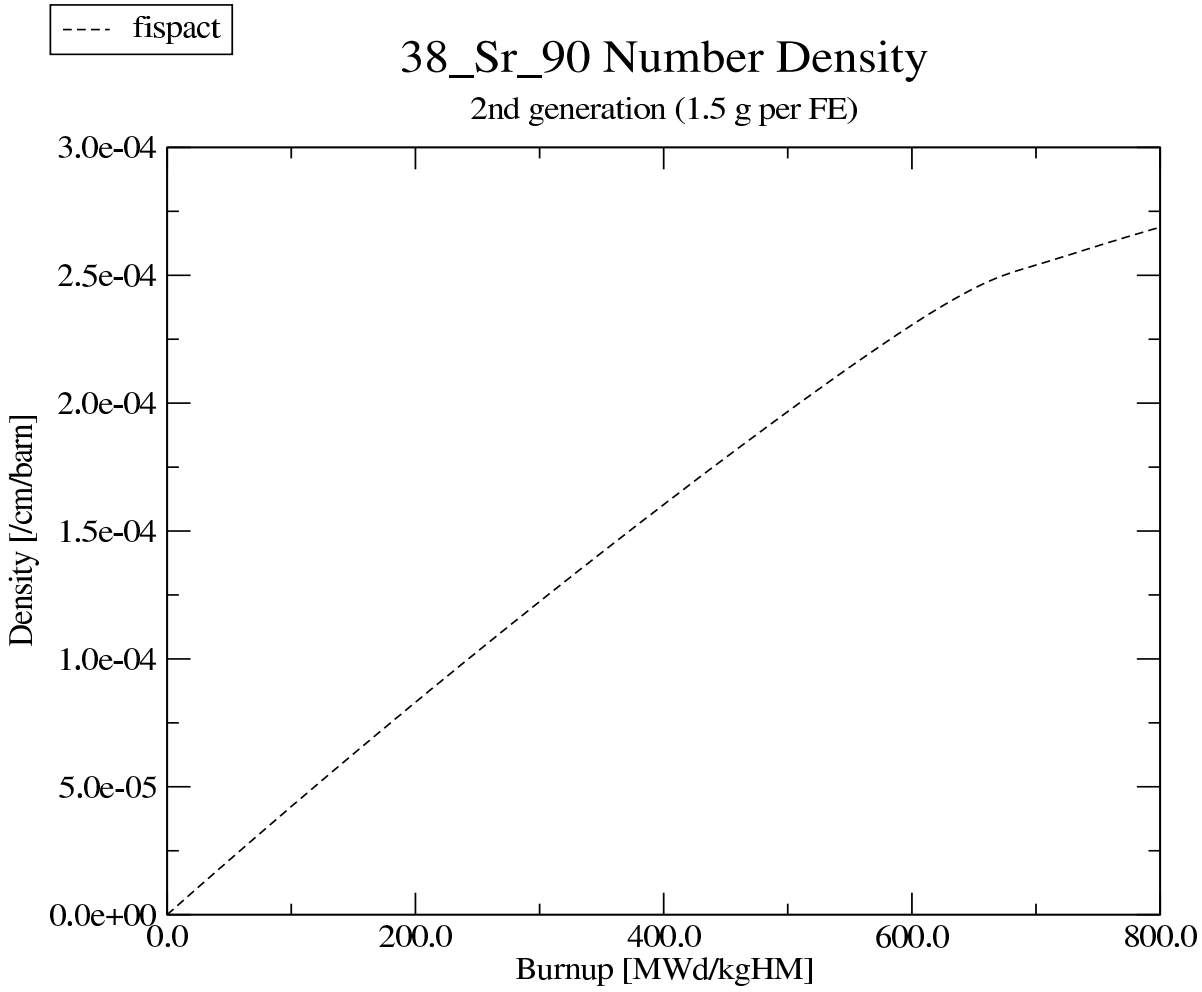


Figure 7.18 Number Density [$cm^{-1}barn^{-1}$] 38_Sr_90 for case C1

Table 7.19 Number Density $[cm^{-1}barn^{-1}]$ 40_Zr_93 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	8.1403e-05	–	6.1974e-05
400.00	3.0607e-04	–	2.5745e-04
600.00	4.4014e-04	–	3.7050e-04
800.00	4.8449e-04	–	4.0985e-04

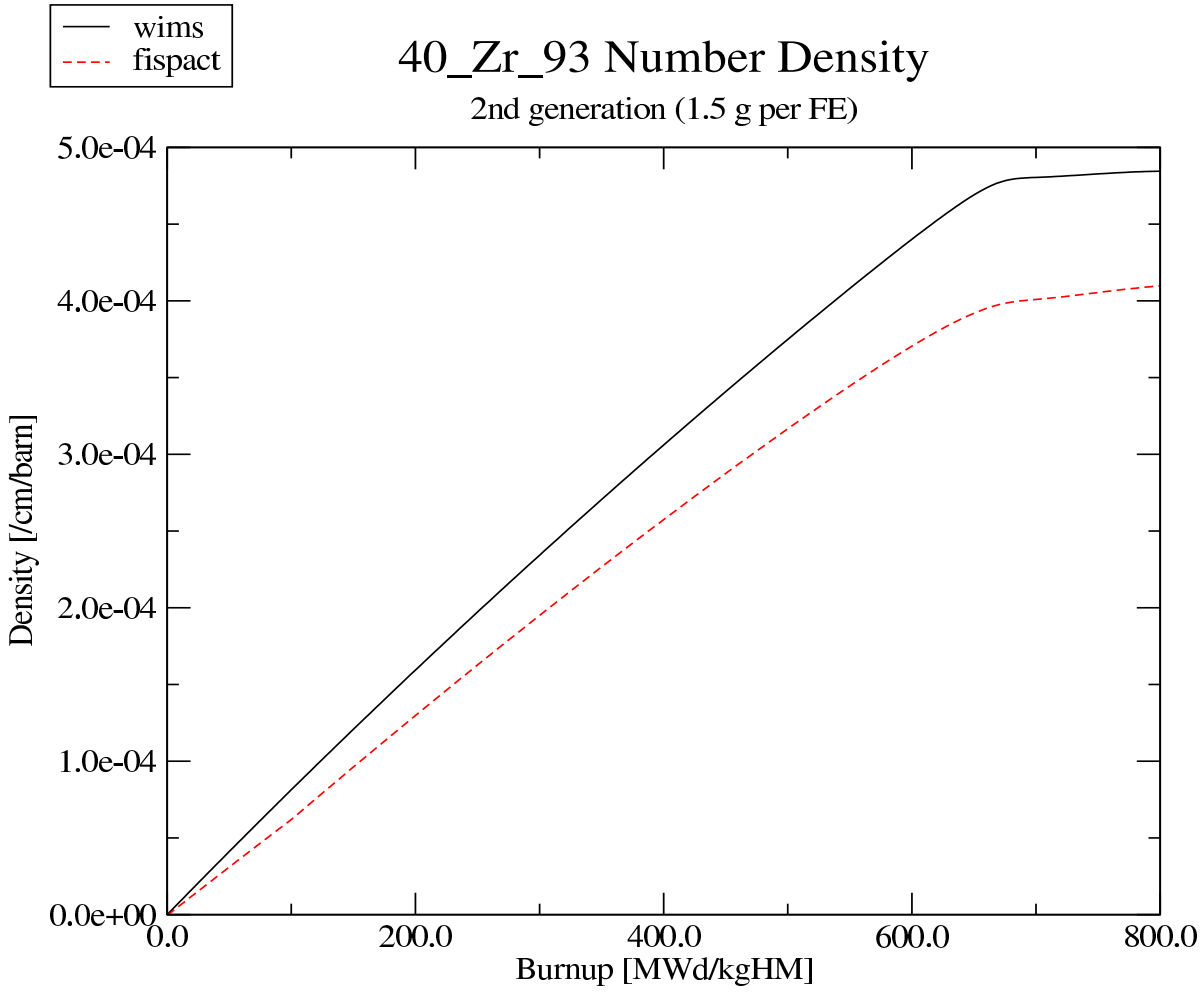


Figure 7.19 Number Density $[cm^{-1}barn^{-1}]$ 40_Zr_93 for case C1

Table 7.20 Number Density [$cm^{-1}barn^{-1}$] 43_Tc_99 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	1.3708e-04	–	1.1809e-04
400.00	5.0547e-04	–	4.6010e-04
600.00	6.9634e-04	–	6.2496e-04
800.00	3.1048e-04	–	2.4533e-04

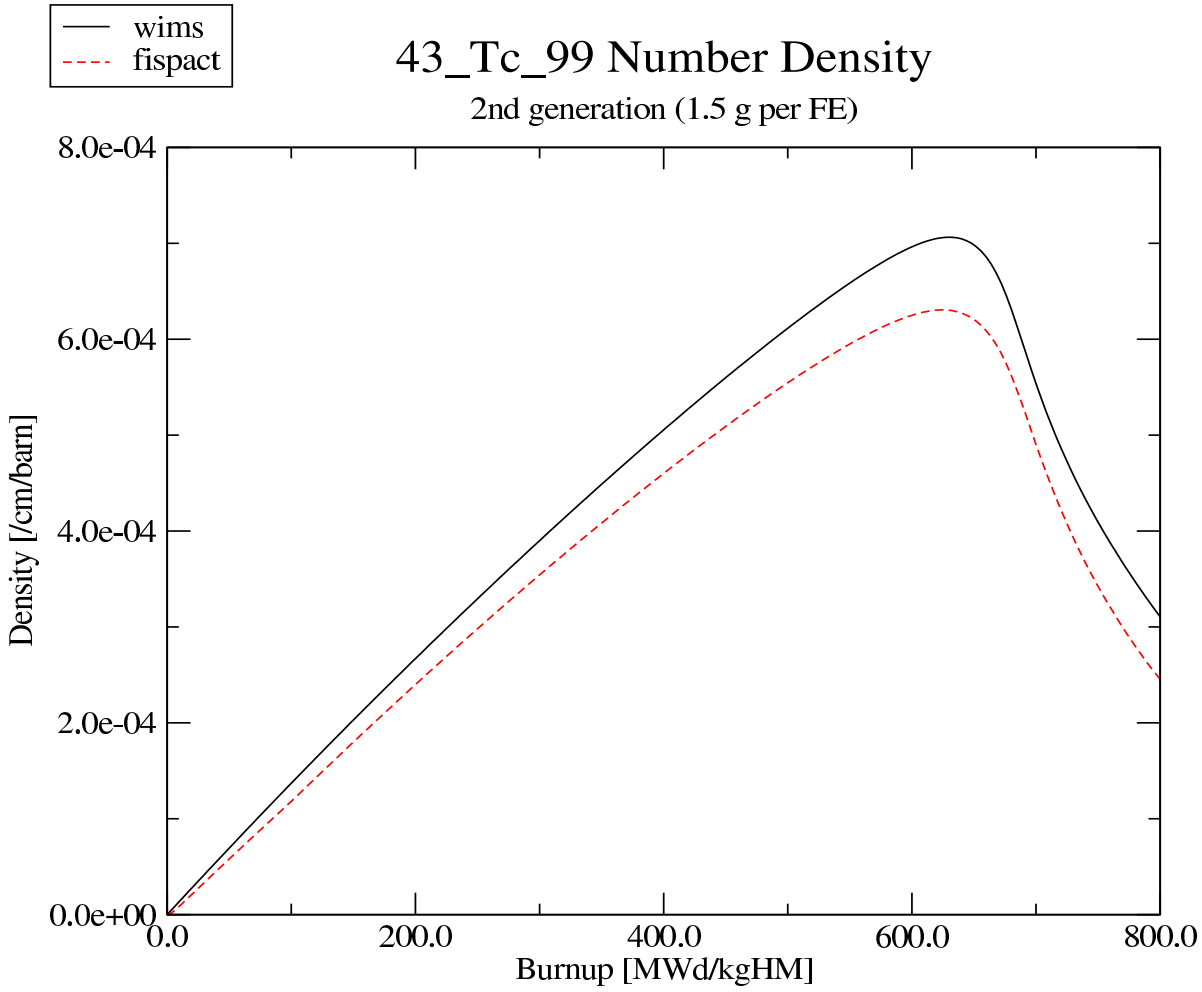


Figure 7.20 Number Density [$cm^{-1}barn^{-1}$] 43_Tc_99 for case C1

Table 7.21 Number Density $[cm^{-1}barn^{-1}]$ 46_Pd_107 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	9.2490e-05	–	9.6242e-05
400.00	3.9087e-04	–	4.1377e-04
600.00	5.9534e-04	–	6.5573e-04
800.00	7.2810e-04	–	7.9334e-04

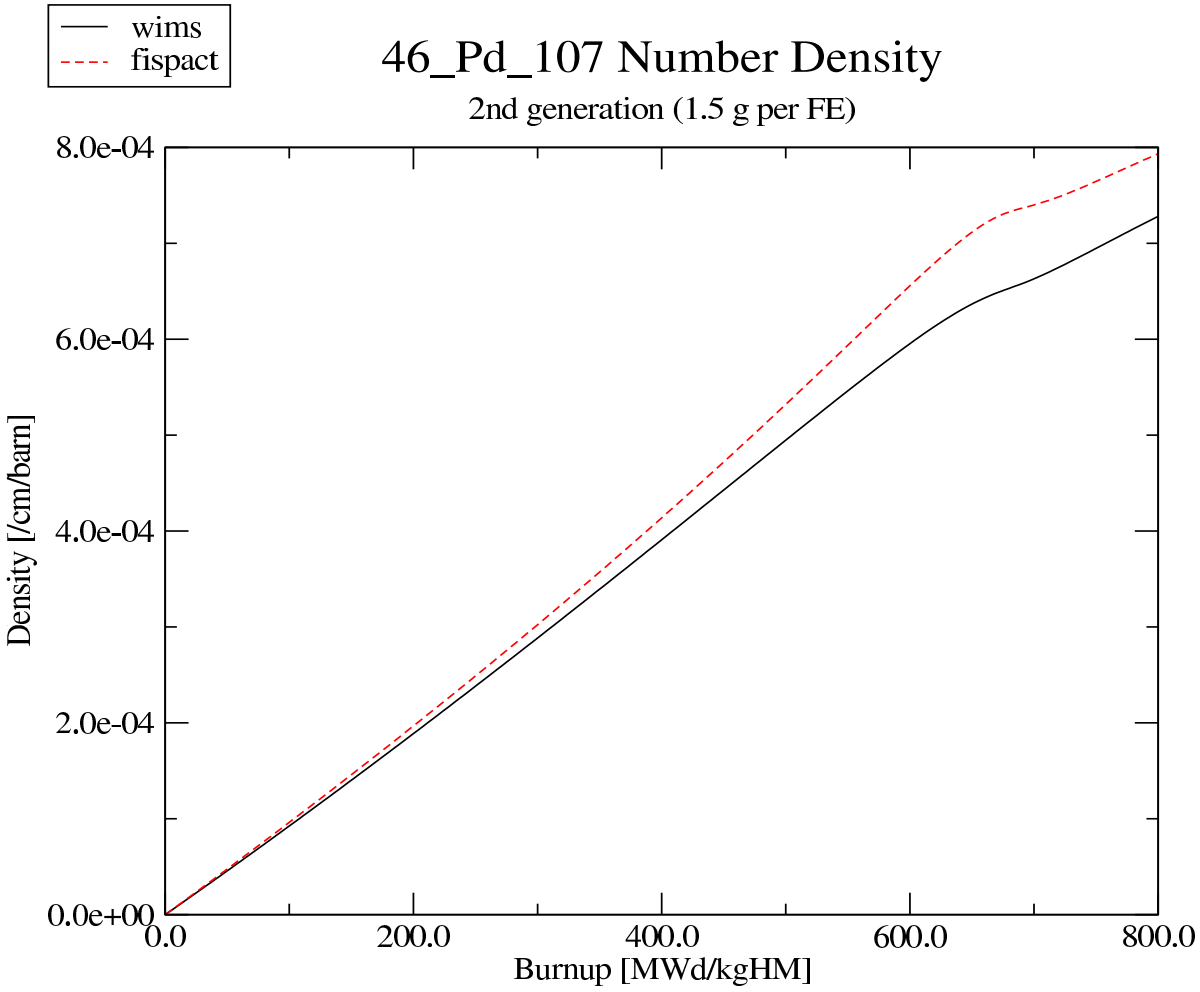


Figure 7.21 Number Density $[cm^{-1}barn^{-1}]$ 46_Pd_107 for case C1

Table 7.22 Number Density [$cm^{-1}barn^{-1}$] 50_Sn_126 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	1.0000e-20
100.00	–	–	5.9150e-06
400.00	–	–	2.3923e-05
600.00	–	–	3.5750e-05
800.00	–	–	4.7069e-05

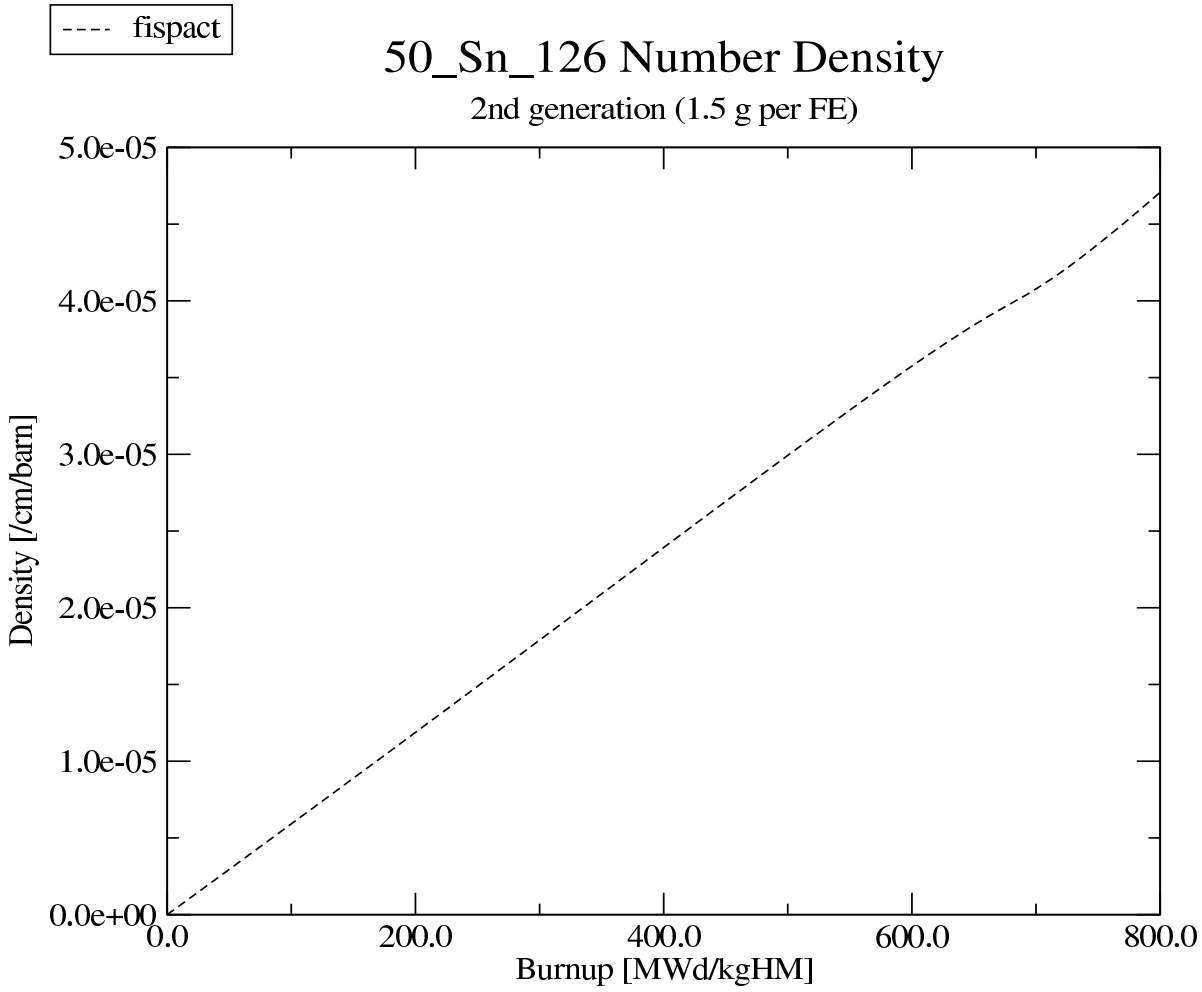


Figure 7.22 Number Density [$cm^{-1}barn^{-1}$] 50_Sn_126 for case C1

Table 7.23 Number Density $[cm^{-1}barn^{-1}]$ 53_I_129 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	3.2458e-05	–	–
400.00	1.2639e-04	–	–
600.00	1.7960e-04	–	–
800.00	5.9113e-05	–	–

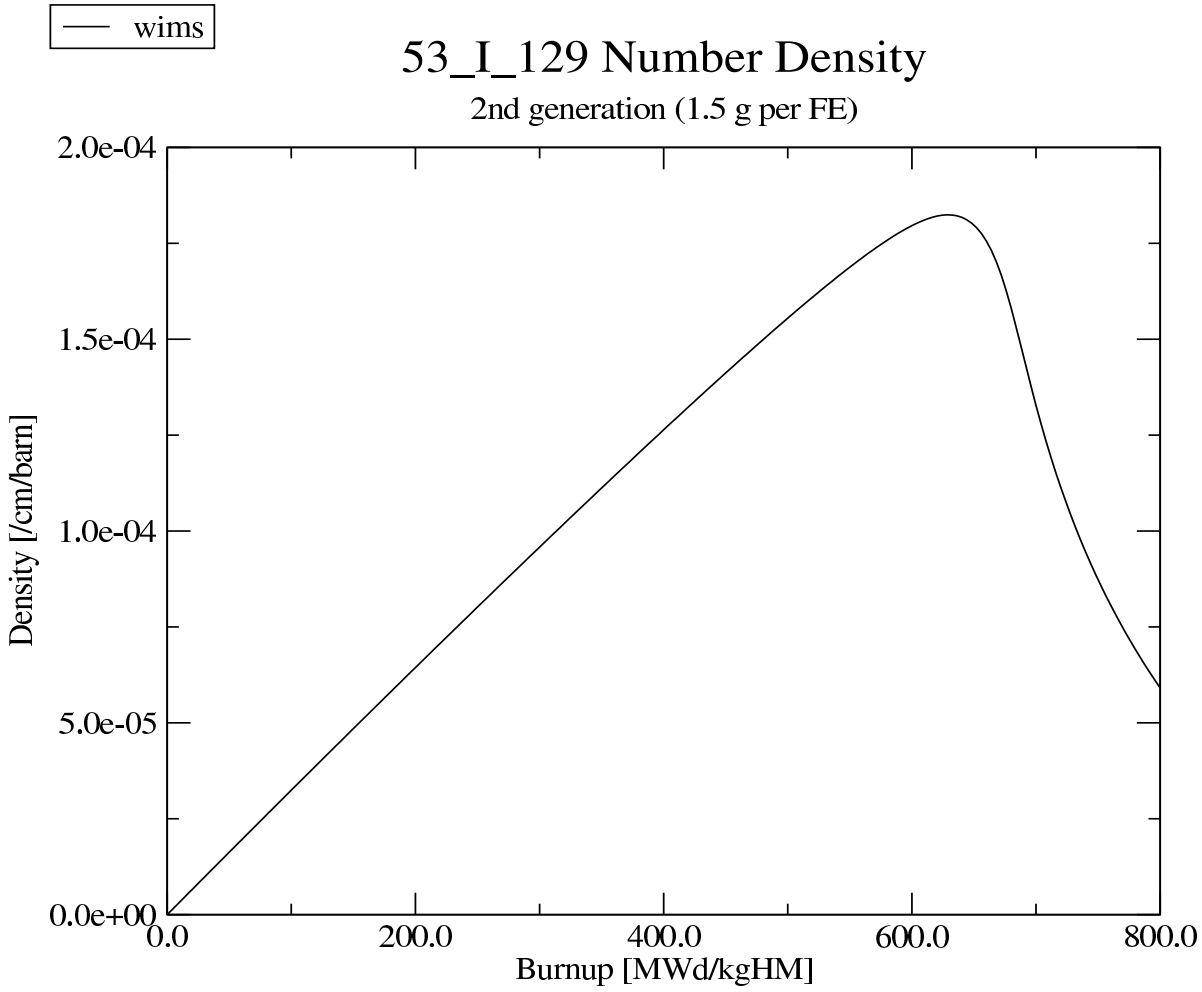


Figure 7.23 Number Density $[cm^{-1}barn^{-1}]$ 53_I_129 for case C1

Table 7.24 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_135 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	8.9181e-05	–	8.9742e-05
400.00	2.8736e-04	–	2.8455e-04
600.00	3.5062e-04	–	3.4604e-04
800.00	8.1990e-04	–	8.0460e-04

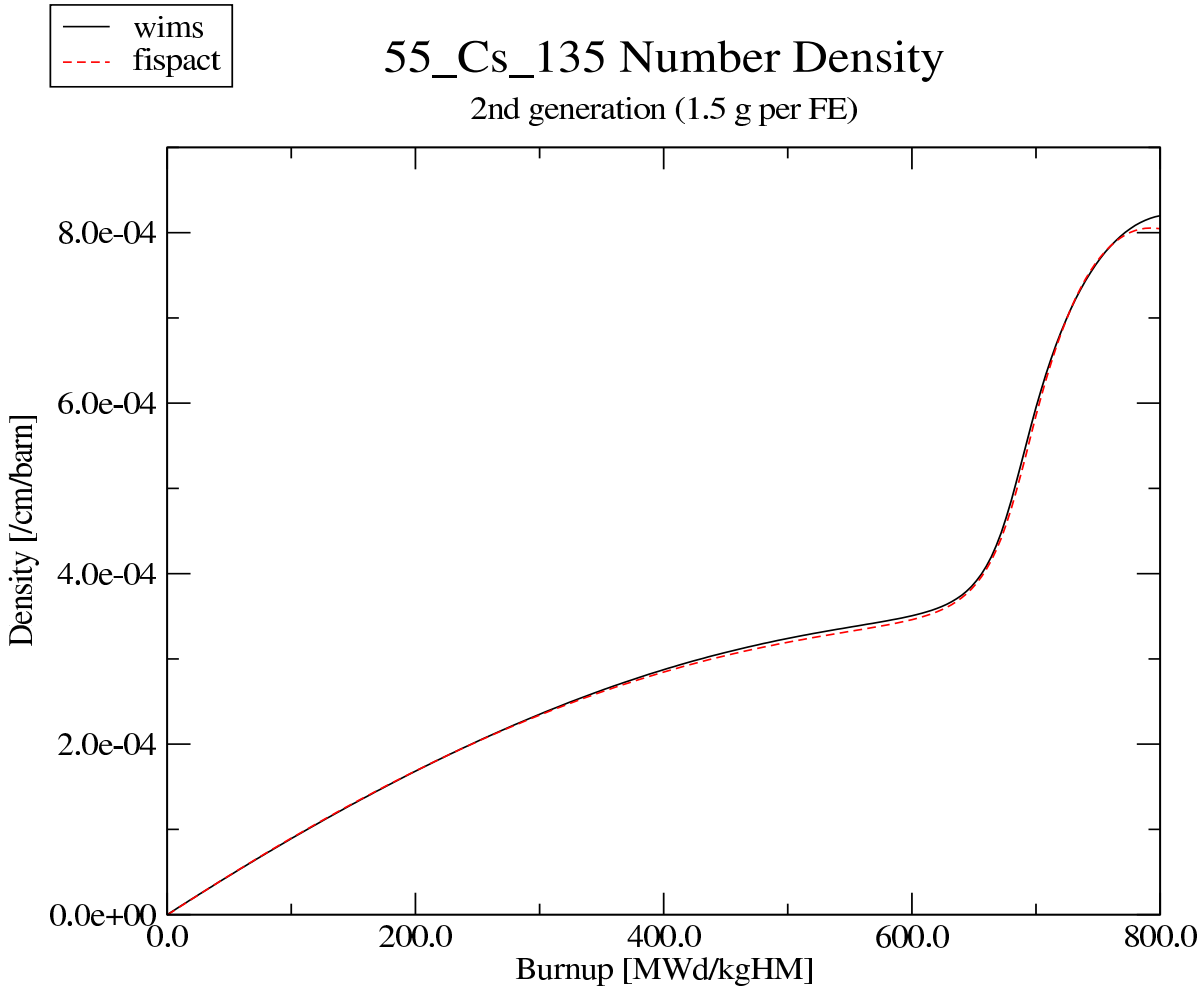


Figure 7.24 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_135 for case C1

Table 7.25 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_137 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	1.0000e-20
100.00	–	–	1.5316e-04
400.00	–	–	5.9969e-04
600.00	–	–	8.8226e-04
800.00	–	–	1.1301e-03

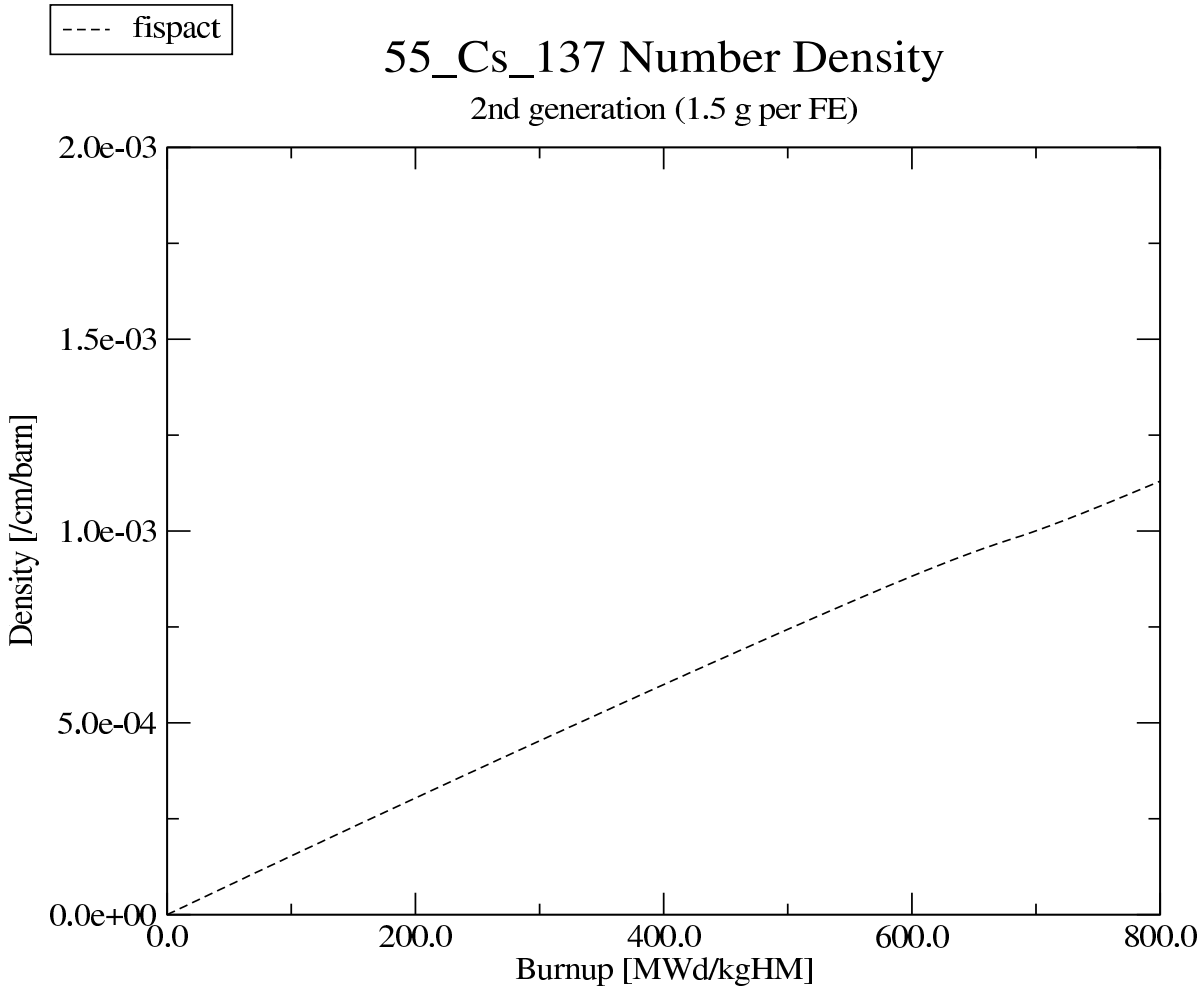


Figure 7.25 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_137 for case C1

Table 7.26 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_147 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	1.8856e-06	–	1.8980e-06
400.00	2.2258e-05	–	2.2223e-05
600.00	3.4271e-05	–	3.3933e-05
800.00	1.5095e-06	–	1.0910e-06

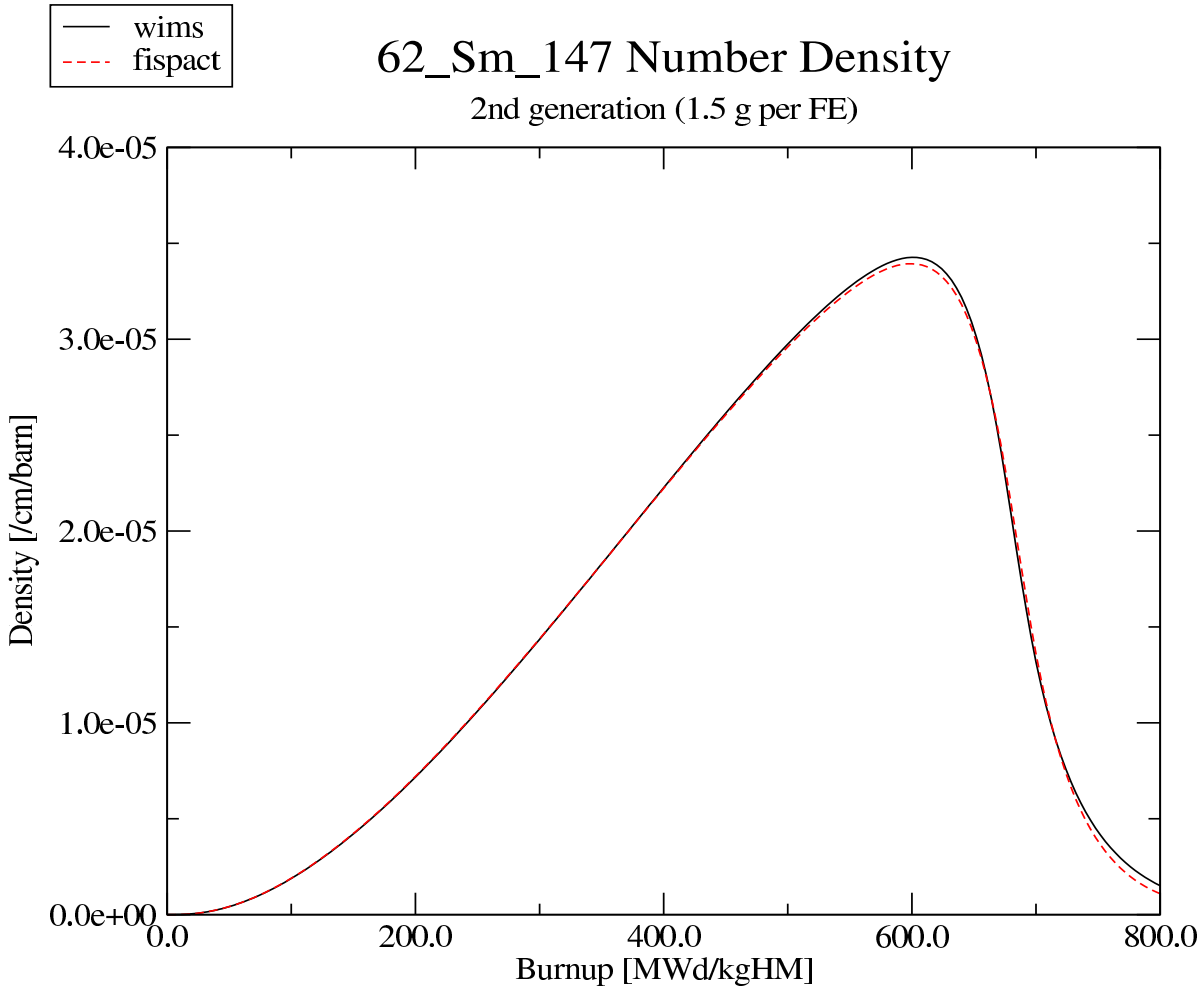


Figure 7.26 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_147 for case C1

Table 7.27 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_149 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	3.7219e-06	–	3.7964e-06
400.00	1.9366e-06	–	1.9305e-06
600.00	4.3477e-07	–	4.2389e-07
800.00	2.2696e-08	–	1.7830e-08

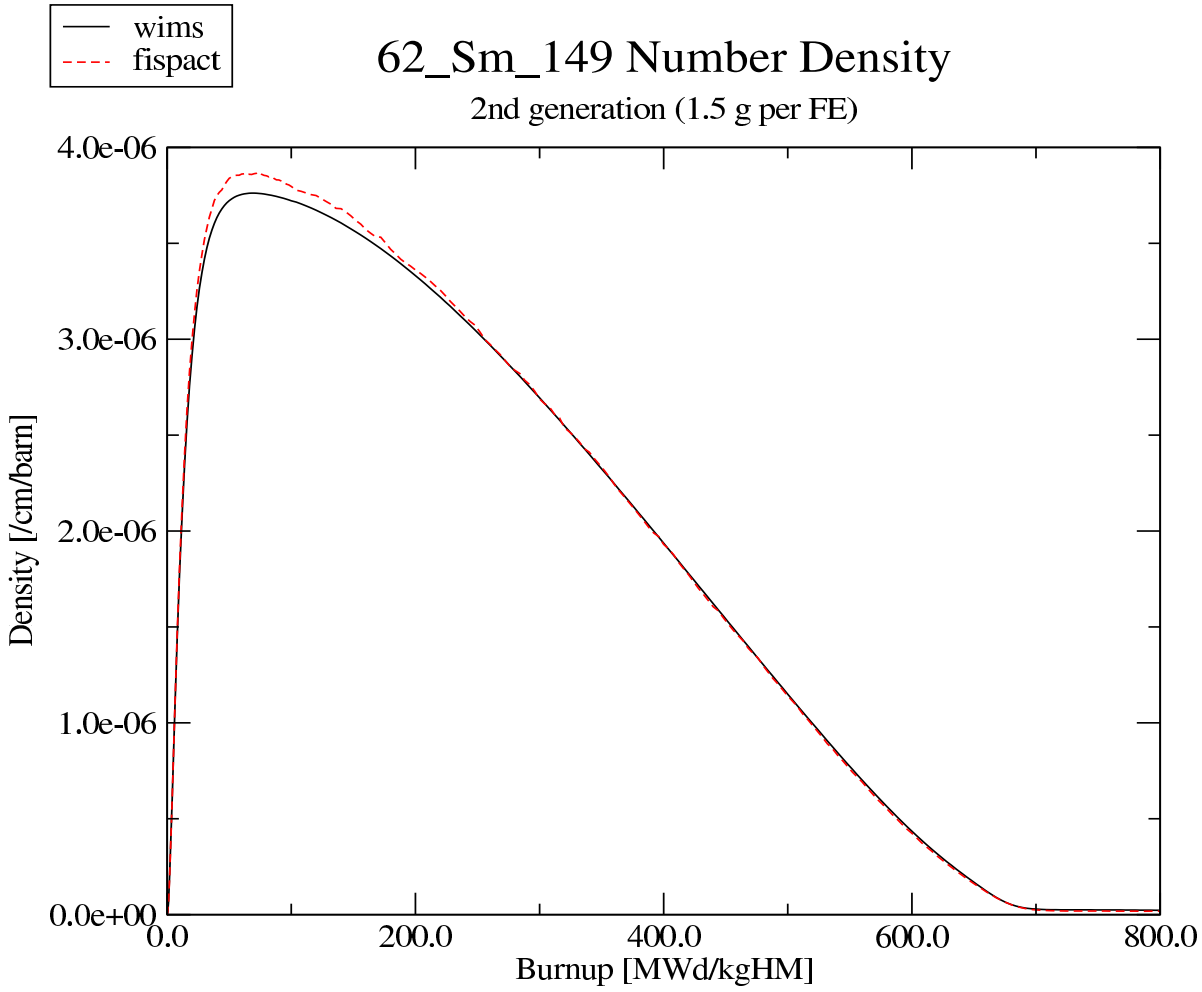


Figure 7.27 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_149 for case C1

Table 7.28 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_151 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	1.1861e-05	–	1.2319e-05
400.00	1.2972e-05	–	1.3056e-05
600.00	4.8815e-06	–	4.9215e-06
800.00	6.0164e-07	–	4.7657e-07

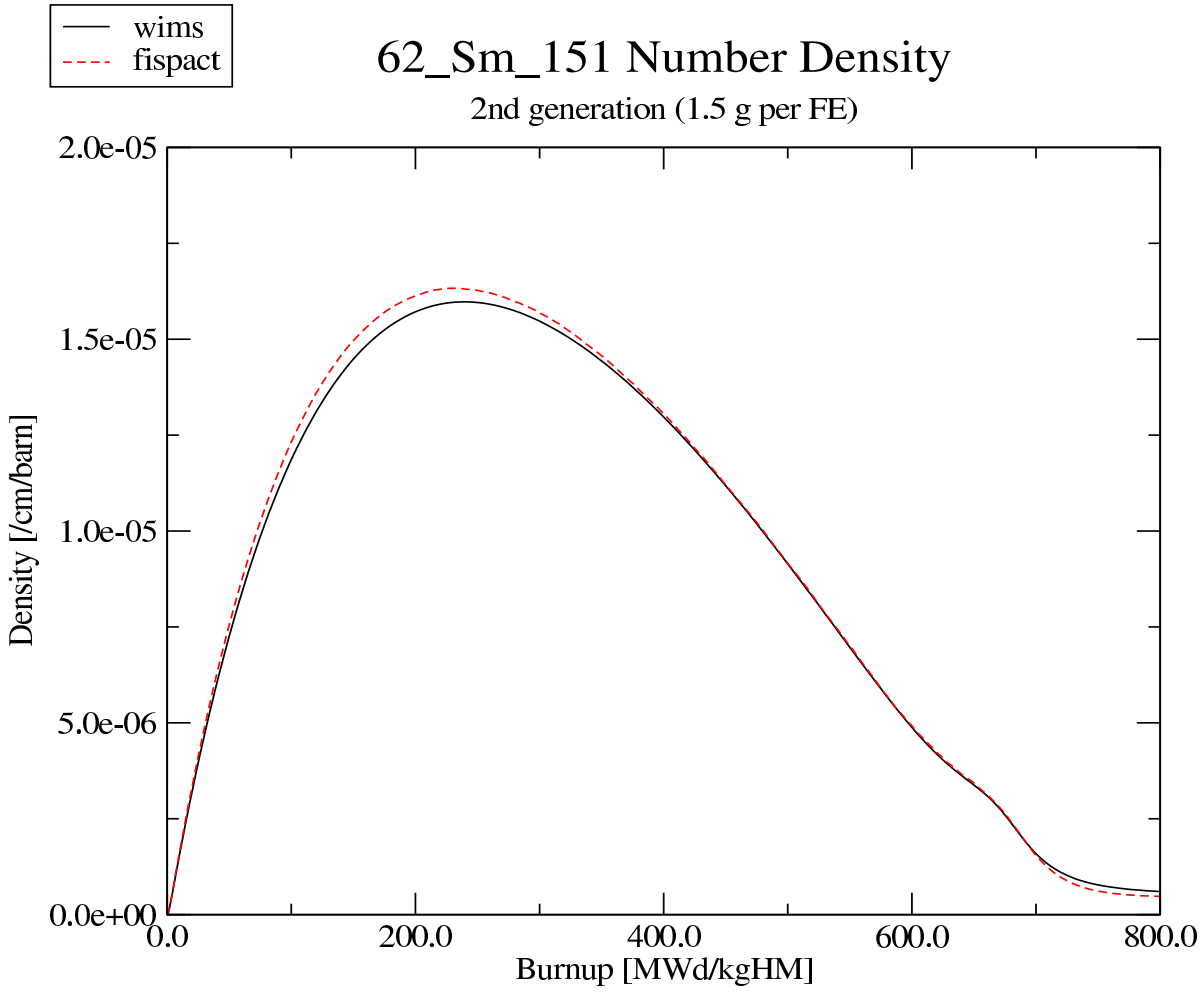


Figure 7.28 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_151 for case C1

Table 7.29 Number Density $[cm^{-1}barn^{-1}]$ 63_Eu_154 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	1.0481e-06	–	1.1047e-06
400.00	1.9244e-05	–	1.9978e-05
600.00	4.2337e-05	–	4.3358e-05
800.00	7.1061e-06	–	5.4807e-06

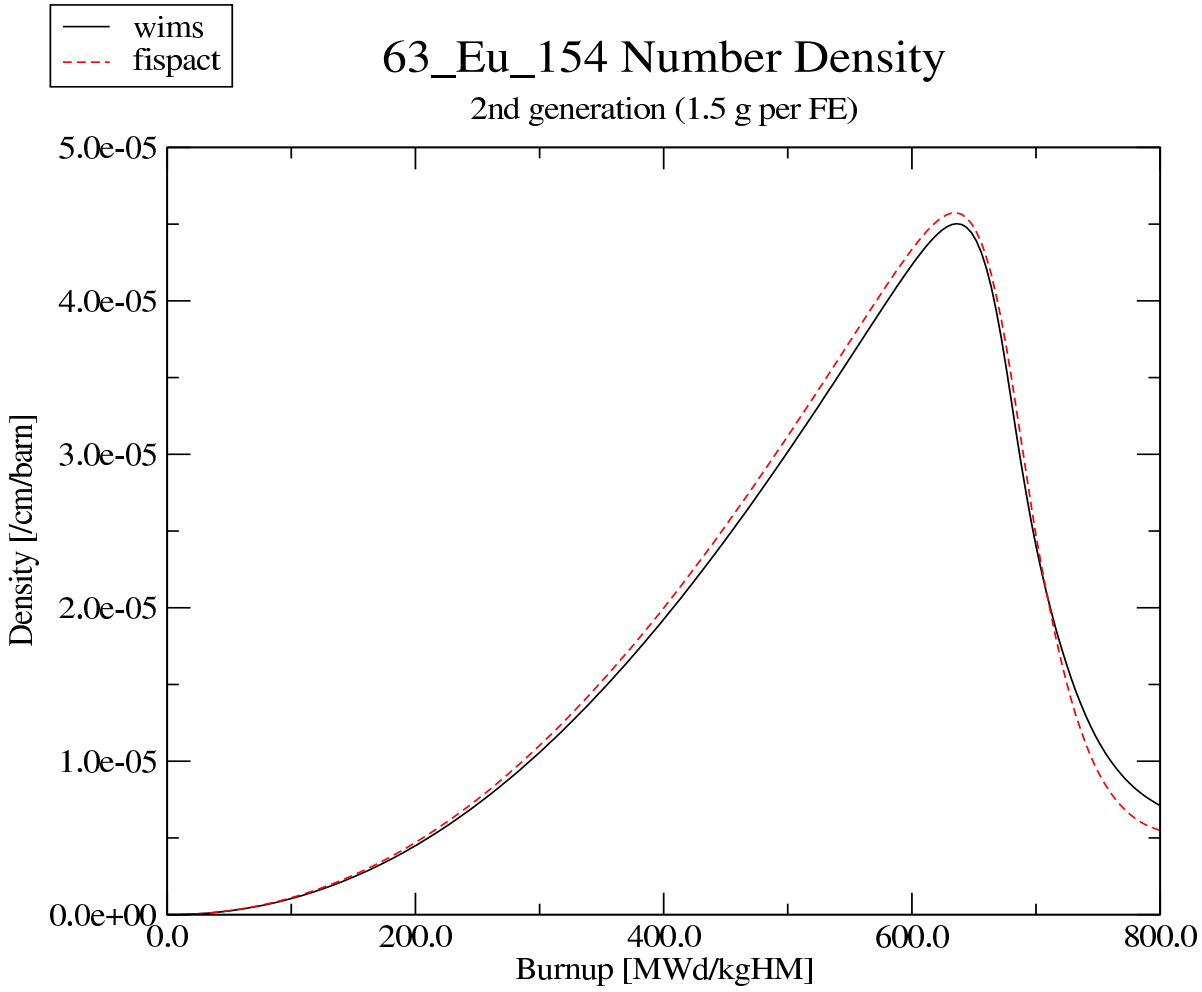


Figure 7.29 Number Density $[cm^{-1}barn^{-1}]$ 63_Eu_154 for case C1

Table 7.30 Number Density $[cm^{-1}barn^{-1}]$ 54_Xe_135 for case C1

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	1.0000e-20
100.00	3.1015e-07	–	3.1394e-07
400.00	1.6338e-07	–	1.5705e-07
600.00	2.7468e-08	–	2.4381e-08
800.00	1.4975e-09	–	1.3439e-09

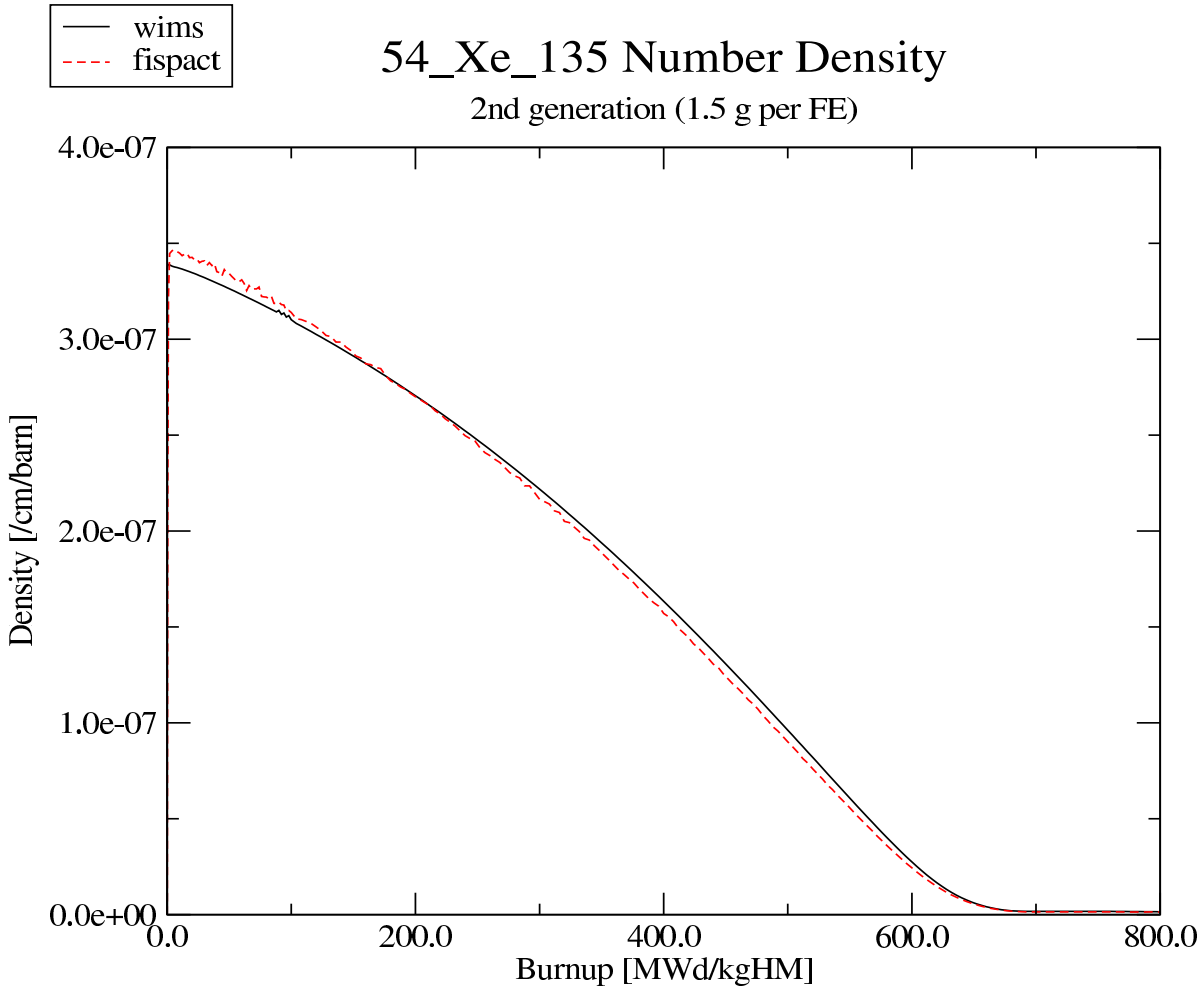


Figure 7.30 Number Density $[cm^{-1}barn^{-1}]$ 54_Xe_135 for case C1

Table 7.31 Absorption Cross Section [$barn$] 94_Pu_238 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.3452e+01	2.3452e+01	–	2.3281e+01
100.00	2.5243e+01	2.5243e+01	–	2.5421e+01
400.00	4.5094e+01	4.5094e+01	–	4.6812e+01
600.00	1.0790e+02	1.0790e+02	–	1.1316e+02
800.00	1.6694e+02	1.6694e+02	–	1.7341e+02

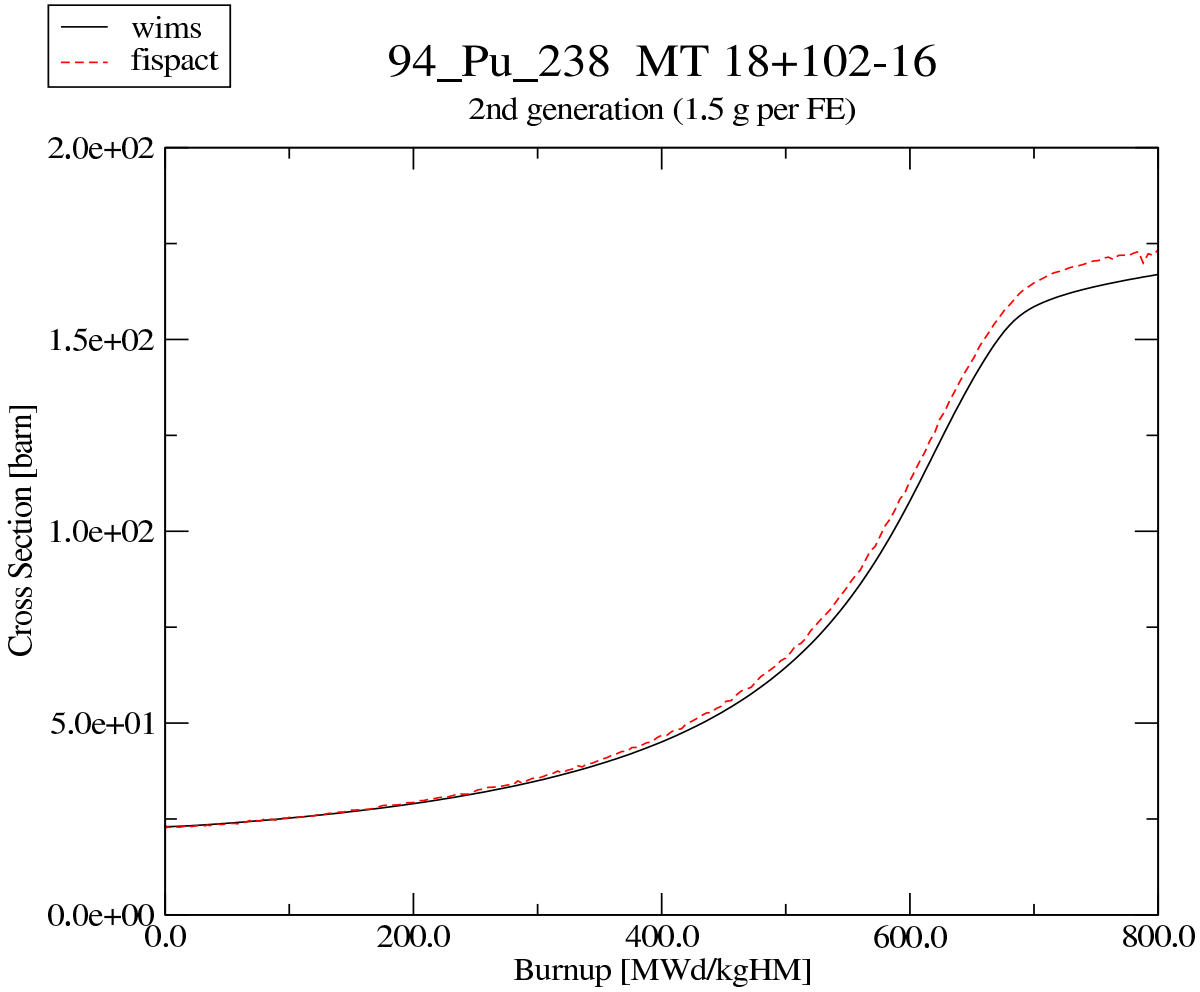


Figure 7.31 Absorption Cross Section [$barn$] 94_Pu_238 for case C1

Table 7.32 Absorption Cross Section [$barn$] 94_Pu_239 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5729e+02	1.5729e+02	–	1.6400e+02
100.00	1.8006e+02	1.8006e+02	–	1.8700e+02
400.00	3.6707e+02	3.6707e+02	–	3.7765e+02
600.00	8.7444e+02	8.7444e+02	–	8.8971e+02
800.00	1.3217e+03	1.3217e+03	–	1.3290e+03

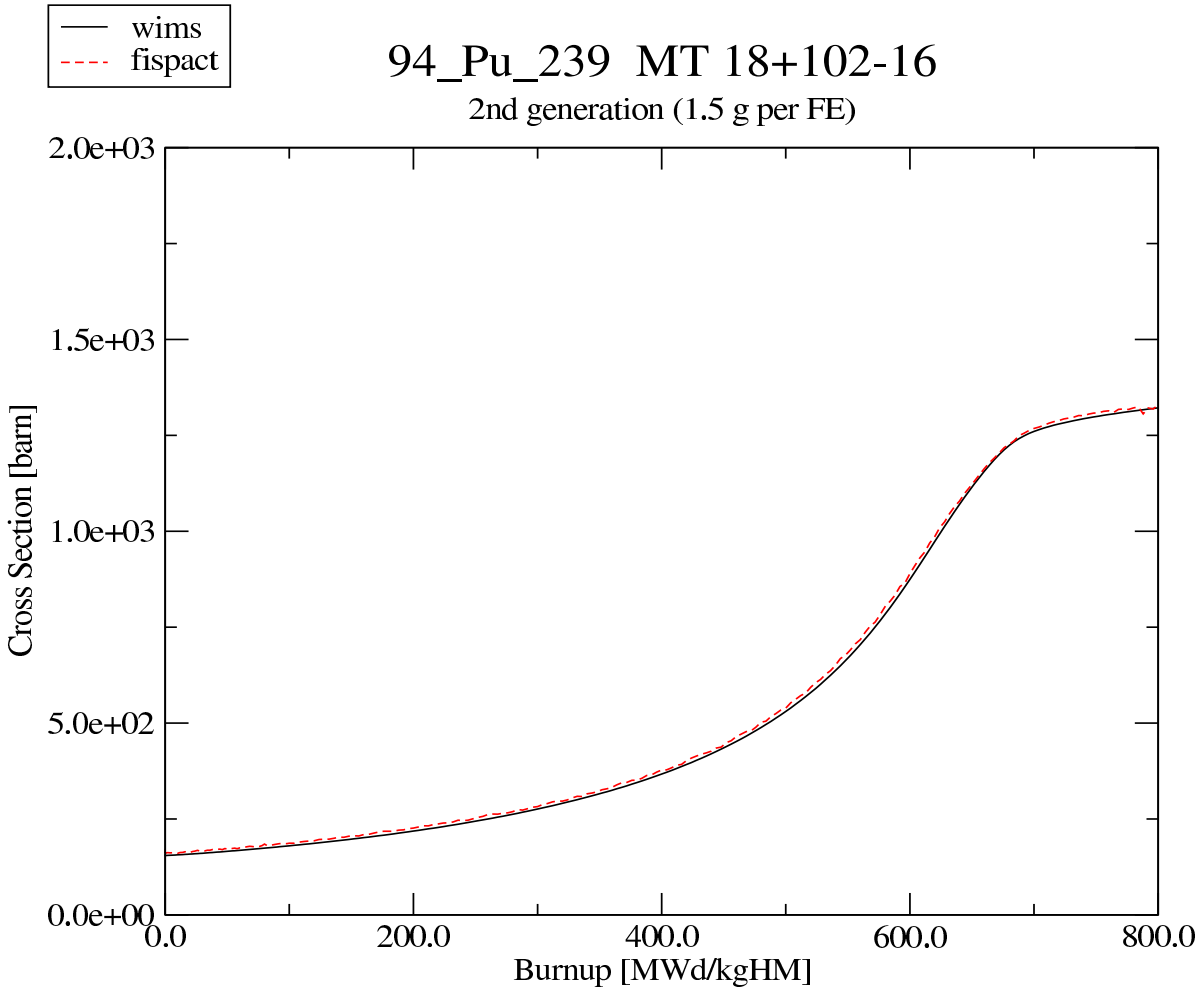


Figure 7.32 Absorption Cross Section [$barn$] 94_Pu_239 for case C1

Table 7.33 Absorption Cross Section [$barn$] 94_Pu_240 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0820e+02	1.0820e+02	–	1.0694e+02
100.00	1.1659e+02	1.1659e+02	–	1.1458e+02
400.00	1.7361e+02	1.7361e+02	–	1.7371e+02
600.00	2.5417e+02	2.5417e+02	–	2.4982e+02
800.00	2.3008e+02	2.3008e+02	–	2.2049e+02

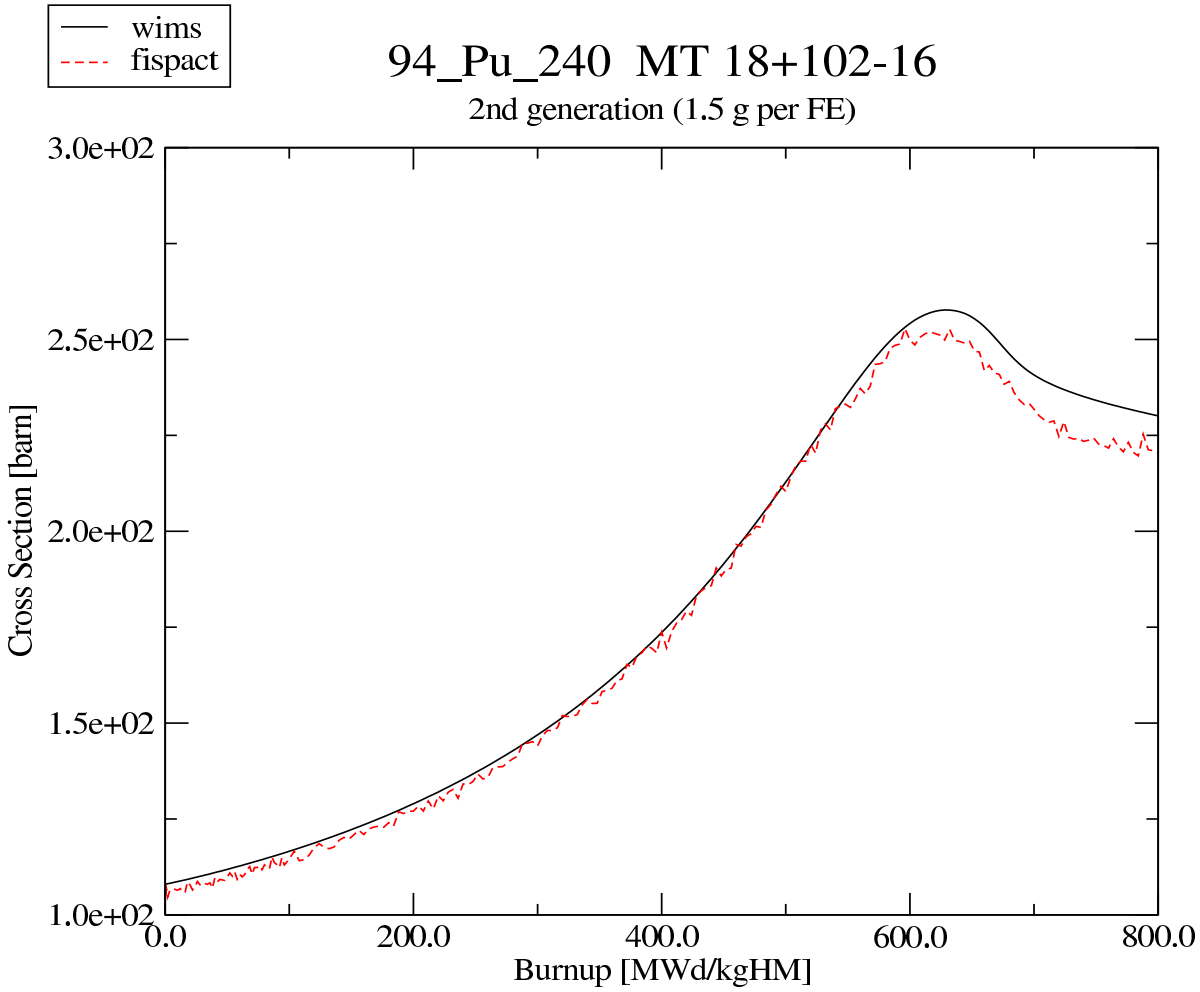


Figure 7.33 Absorption Cross Section [$barn$] 94_Pu_240 for case C1

Table 7.34 Absorption Cross Section [$barn$] 94_Pu_241 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3344e+02	1.3344e+02	–	1.3338e+02
100.00	1.4717e+02	1.4717e+02	–	1.4803e+02
400.00	2.7588e+02	2.7588e+02	–	2.8504e+02
600.00	6.5837e+02	6.5837e+02	–	6.8034e+02
800.00	1.0050e+03	1.0050e+03	–	1.0279e+03

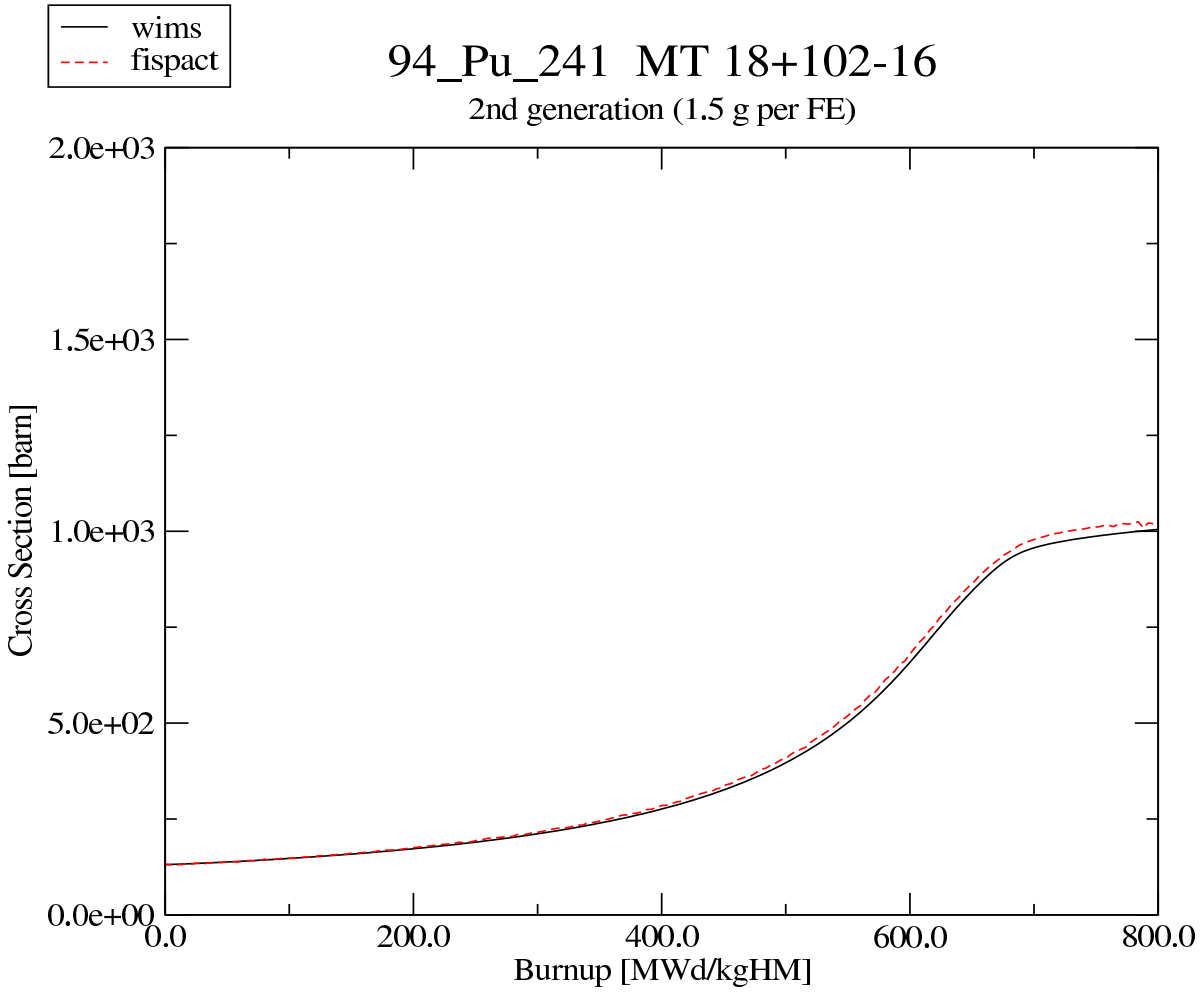


Figure 7.34 Absorption Cross Section [$barn$] 94_Pu_241 for case C1

Table 7.35 Absorption Cross Section [*barn*] 94_Pu_242 for case C1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.5665e+01	3.5666e+01	–	3.5184e+01
100.00	3.4996e+01	3.4997e+01	–	3.5382e+01
400.00	3.0376e+01	3.0377e+01	–	3.1041e+01
600.00	2.0726e+01	2.0726e+01	–	2.0619e+01
800.00	1.4280e+01	1.4280e+01	–	1.4215e+01

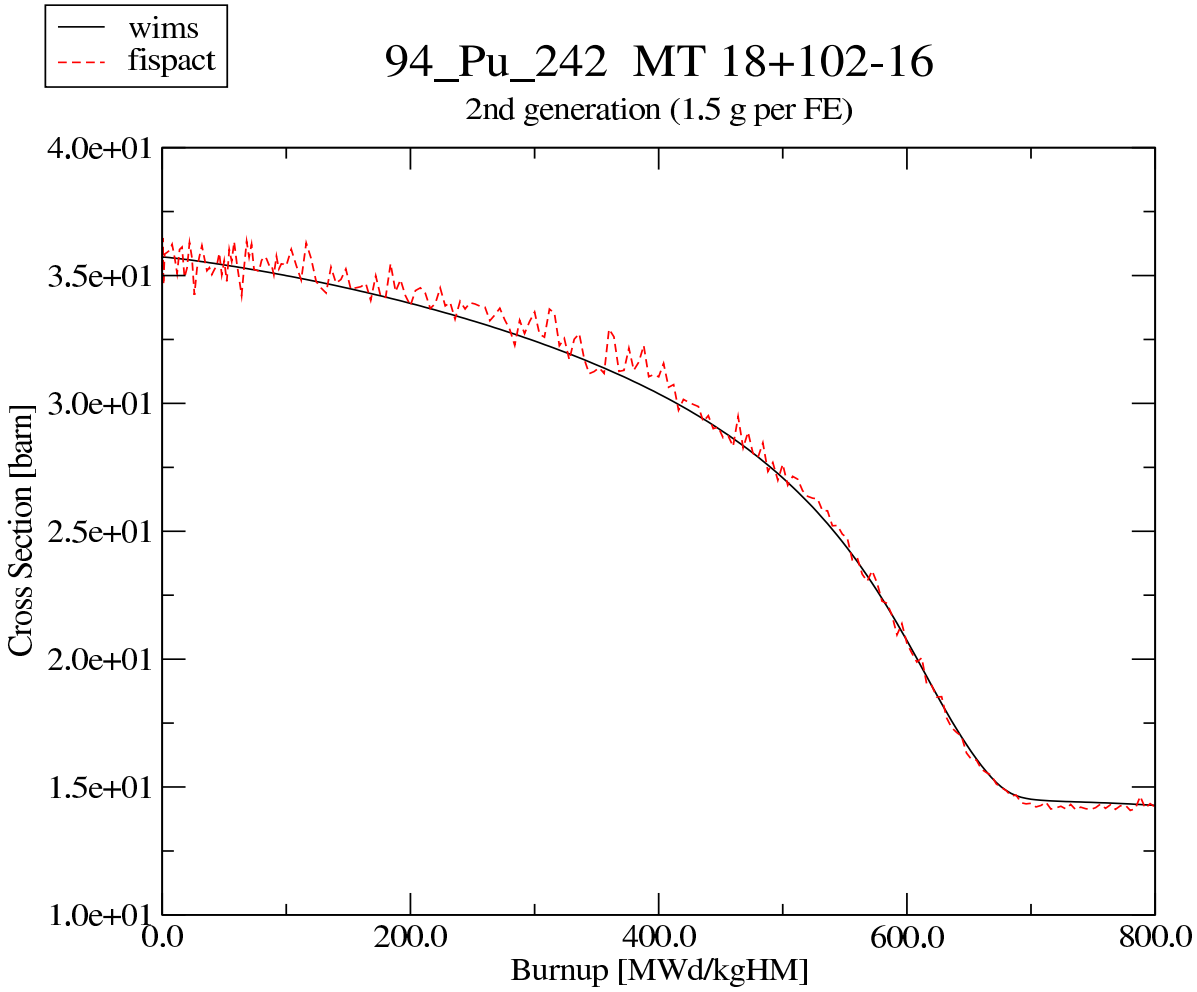


Figure 7.35 Absorption Cross Section [*barn*] 94_Pu_242 for case C1

Table 7.36 Absorption Cross Section [$barn$] 95_Am_241 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.4397e+02	1.4397e+02	–	1.4130e+02
100.00	1.5552e+02	1.5552e+02	–	1.5323e+02
400.00	2.4749e+02	2.4749e+02	–	2.4859e+02
600.00	4.9183e+02	4.9183e+02	–	4.9124e+02
800.00	7.0327e+02	7.0327e+02	–	6.9413e+02

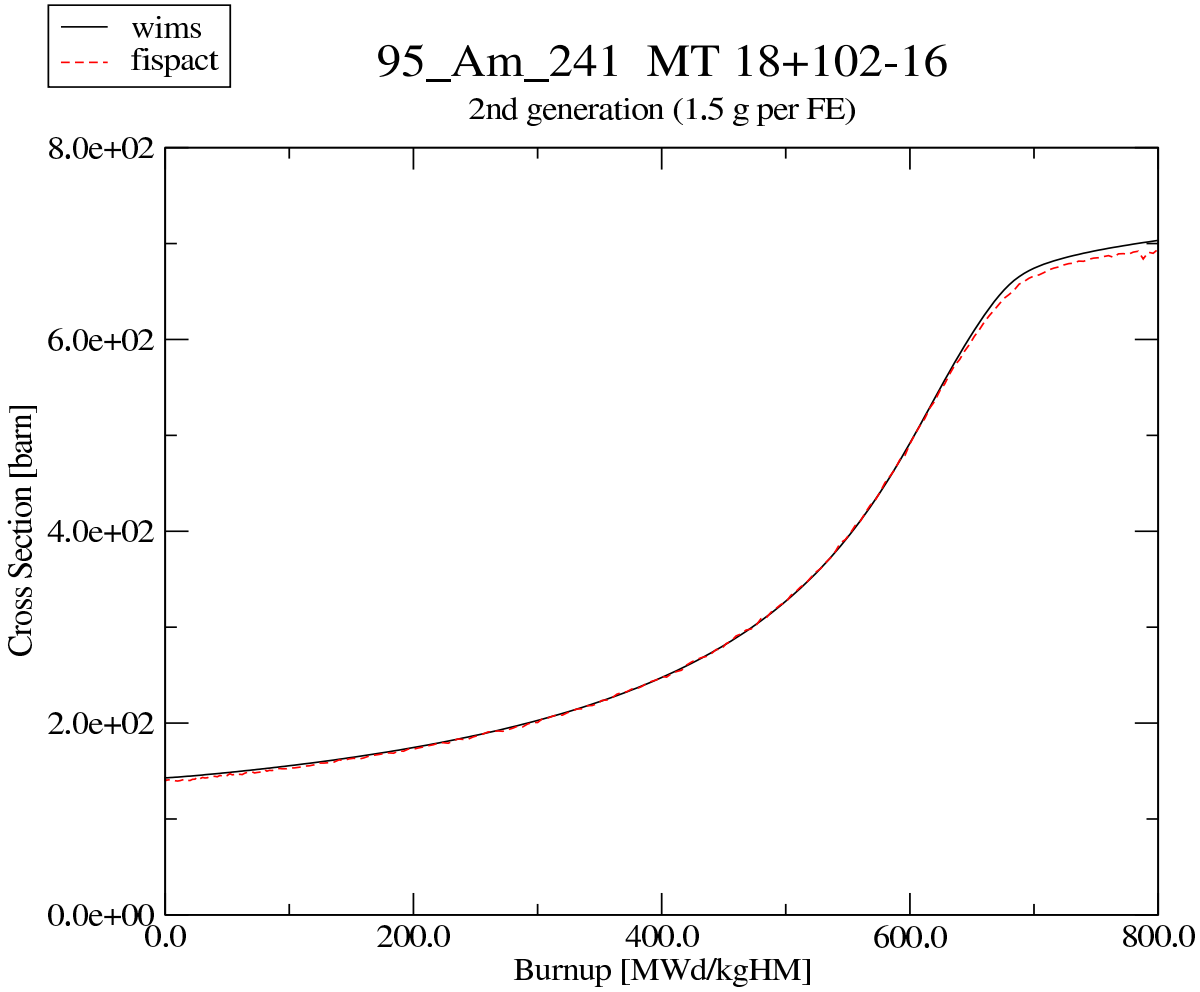


Figure 7.36 Absorption Cross Section [$barn$] 95_Am_241 for case C1

Table 7.37 Absorption Cross Section [$barn$] 95_Am_242 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	–	3.4285e+02
100.00	–	–	–	3.8233e+02
400.00	–	–	–	7.7688e+02
600.00	–	–	–	1.9799e+03
800.00	–	–	–	3.0587e+03

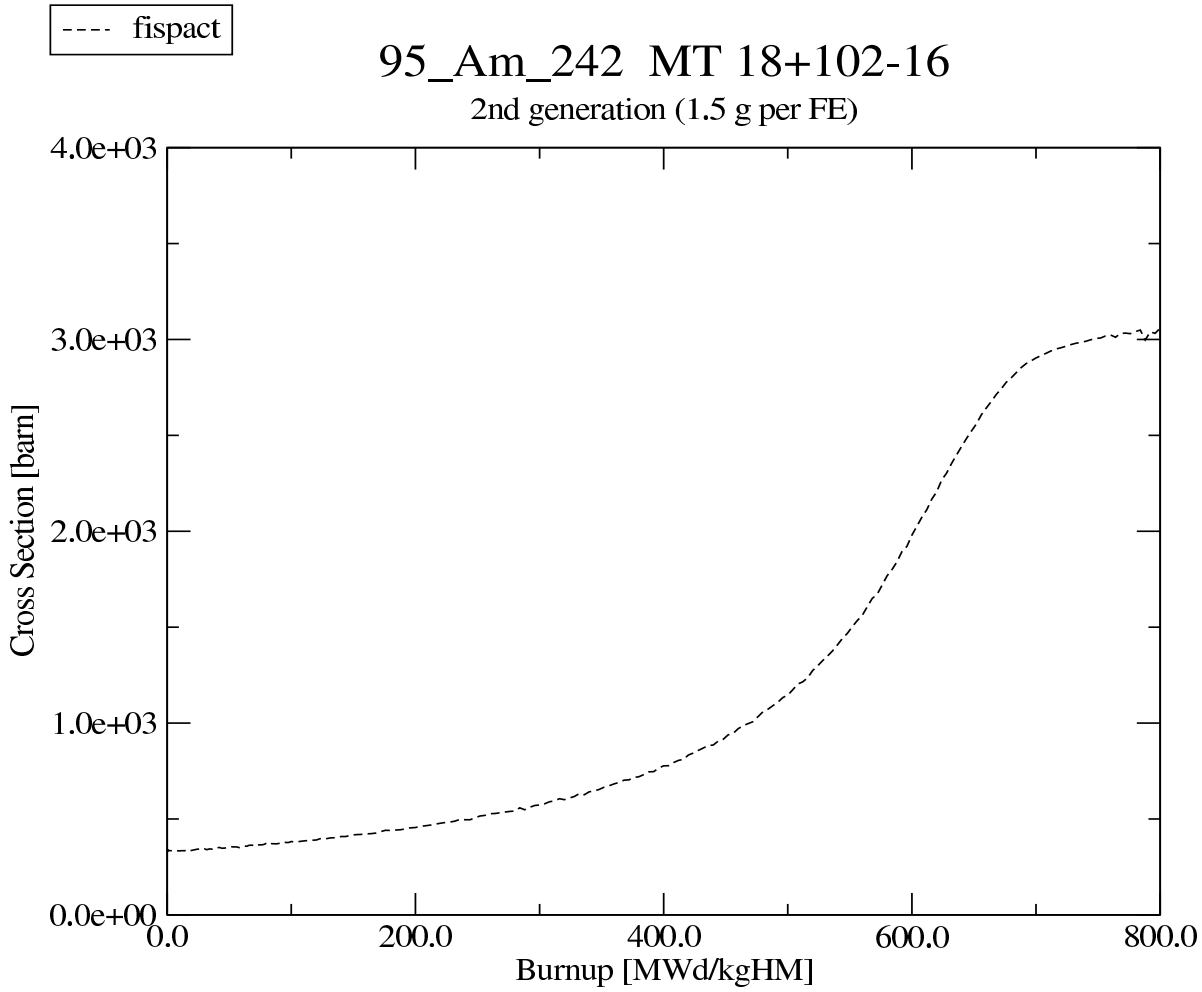


Figure 7.37 Absorption Cross Section [$barn$] 95_Am_242 for case C1

Table 7.38 Absorption Cross Section [$barn$] 95_Am_242m for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.7058e+02	5.7058e+02	–	5.6769e+02
100.00	6.3616e+02	6.3616e+02	–	6.3997e+02
400.00	1.2958e+03	1.2958e+03	–	1.3411e+03
600.00	3.3048e+03	3.3048e+03	–	3.4396e+03
800.00	5.1507e+03	5.1507e+03	–	5.3039e+03

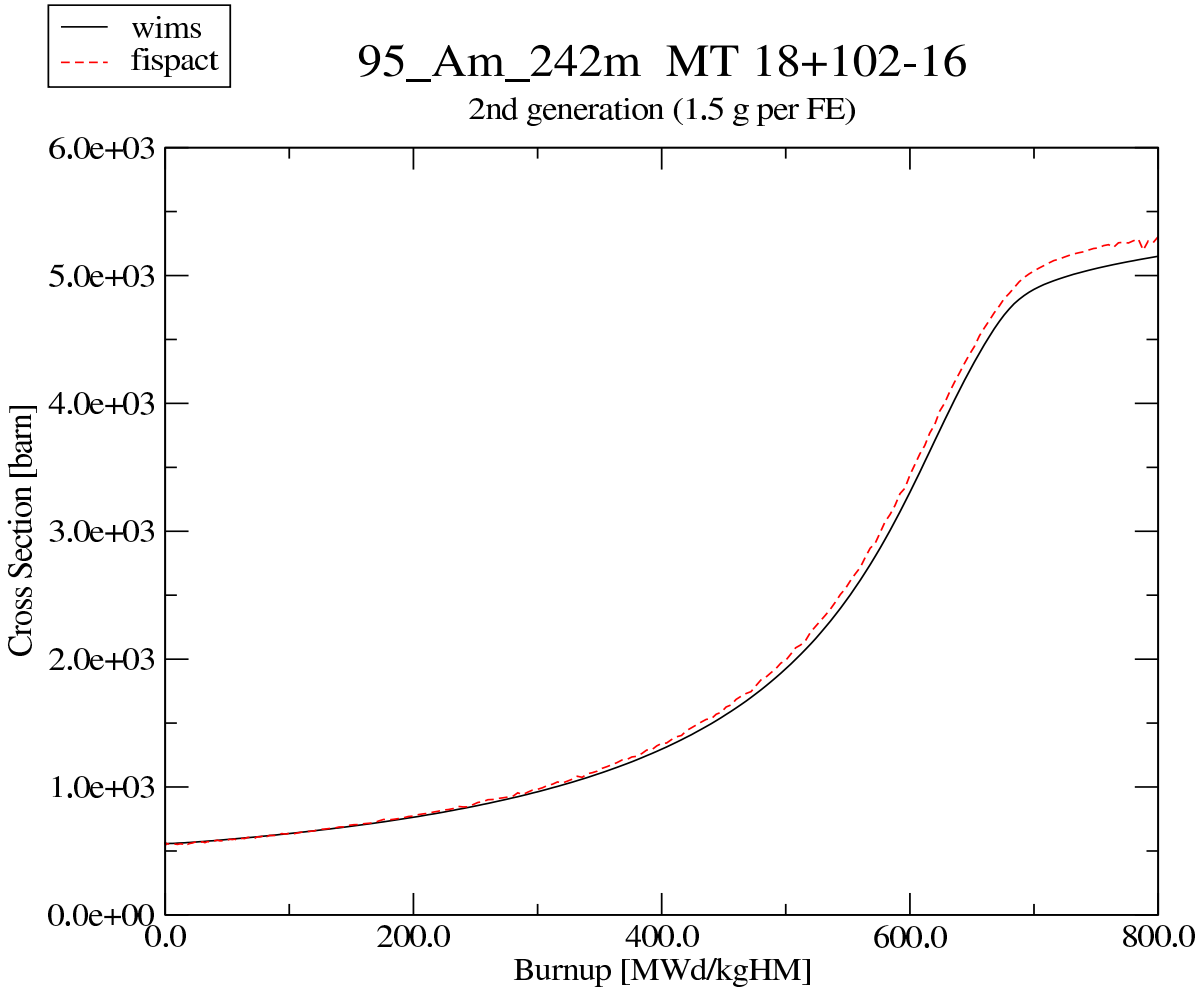


Figure 7.38 Absorption Cross Section [$barn$] 95_Am_242m for case C1

Table 7.39 Absorption Cross Section [$barn$] 95_Am_243 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.0583e+01	9.0583e+01	–	8.9999e+01
100.00	8.7538e+01	8.7538e+01	–	8.8528e+01
400.00	7.9261e+01	7.9261e+01	–	8.0177e+01
600.00	6.2894e+01	6.2894e+01	–	6.3033e+01
800.00	4.8358e+01	4.8358e+01	–	4.7802e+01

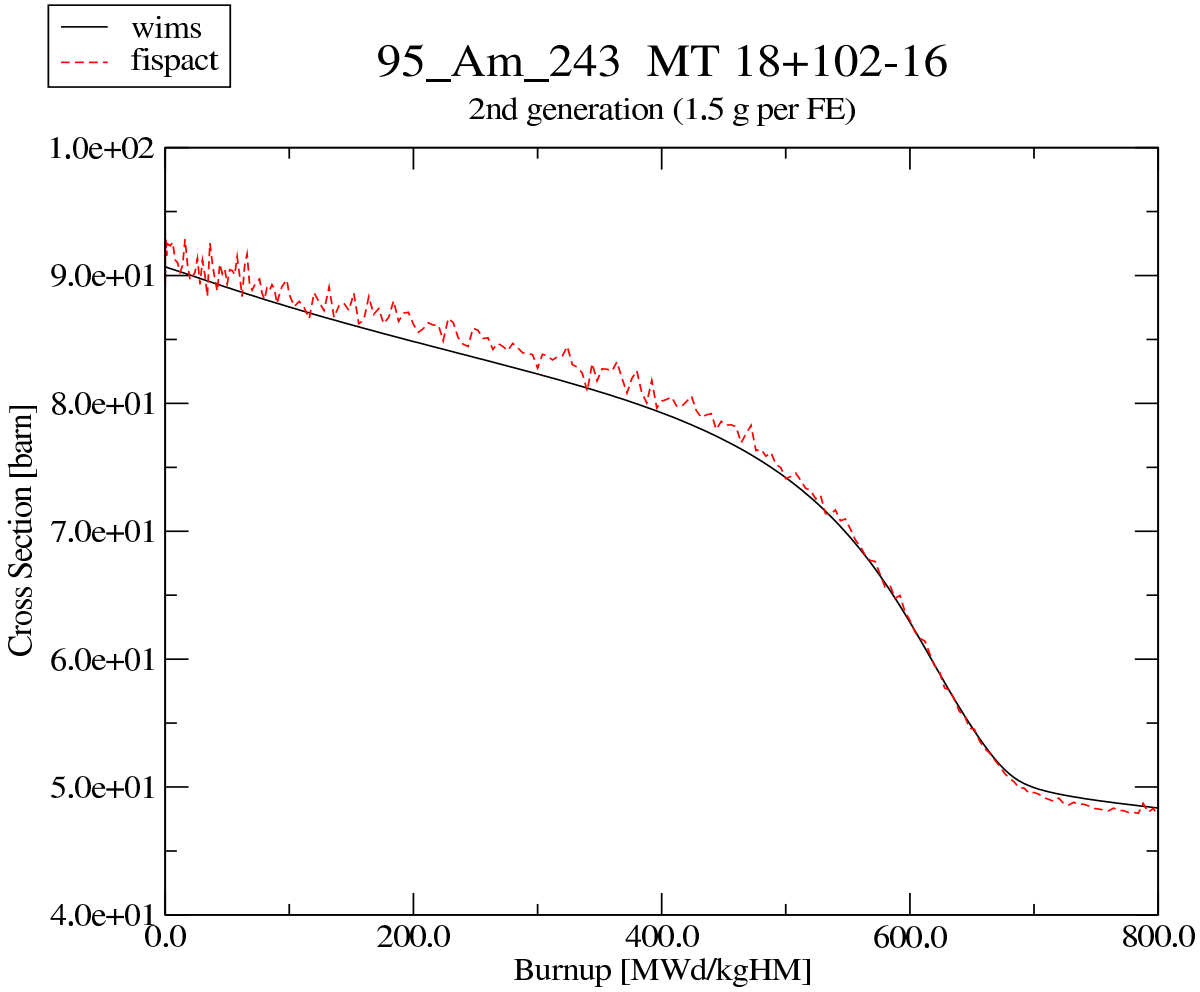


Figure 7.39 Absorption Cross Section [$barn$] 95_Am_243 for case C1

Table 7.40 Absorption Cross Section [$barn$] 96_Cm_242 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.3499e+00	7.3500e+00	–	7.5456e+00
100.00	7.3705e+00	7.3706e+00	–	7.3821e+00
400.00	7.6728e+00	7.6729e+00	–	7.7427e+00
600.00	8.6413e+00	8.6413e+00	–	8.8863e+00
800.00	9.5743e+00	9.5743e+00	–	9.7409e+00

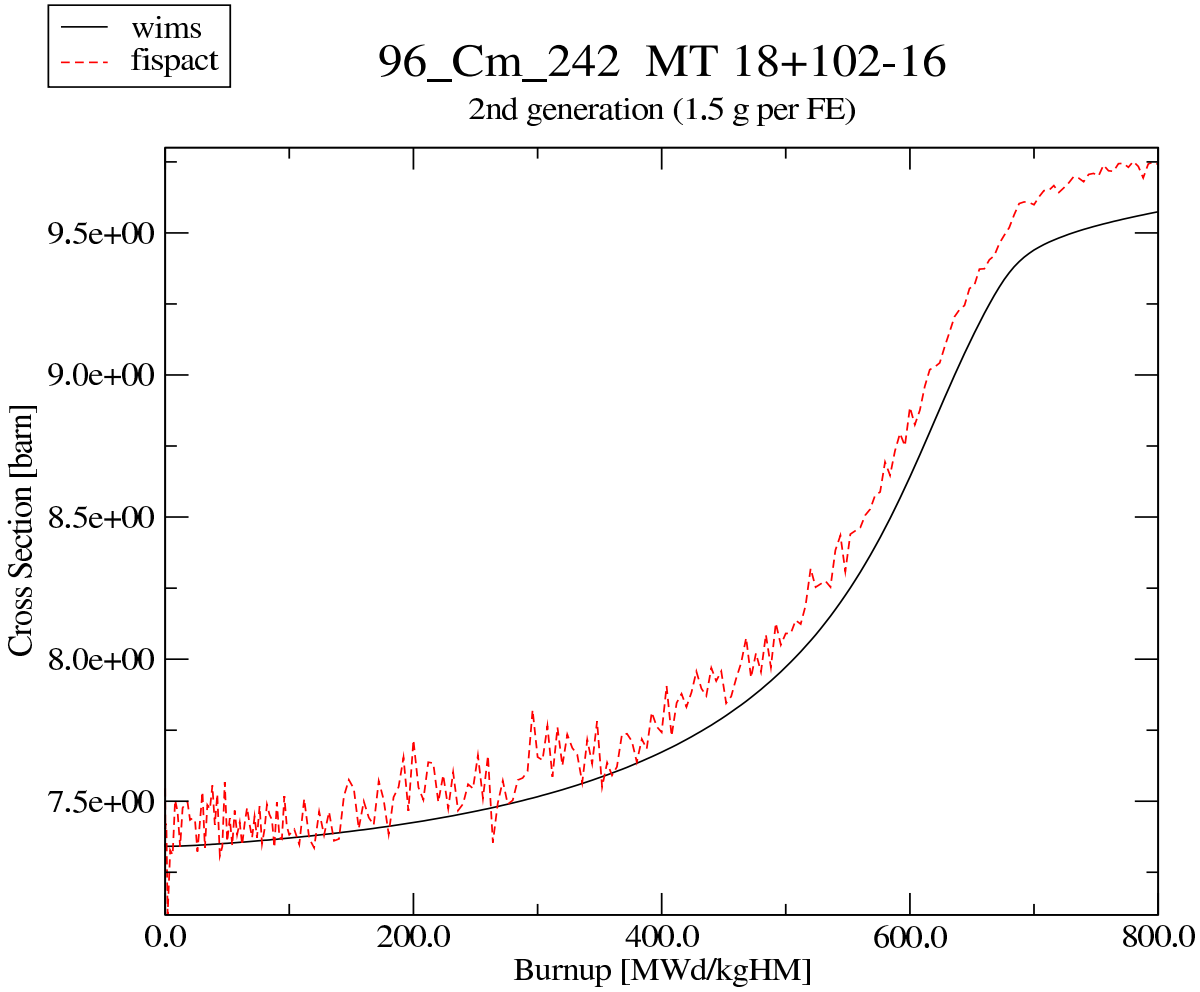


Figure 7.40 Absorption Cross Section [$barn$] 96_Cm_242 for case C1

Table 7.41 Absorption Cross Section [$barn$] 96_Cm_243 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.2469e+02	1.2469e+02	–	1.2292e+02
100.00	1.2552e+02	1.2552e+02	–	1.2439e+02
400.00	1.4366e+02	1.4366e+02	–	1.4571e+02
600.00	2.0076e+02	2.0076e+02	–	2.0485e+02
800.00	2.5270e+02	2.5270e+02	–	2.5719e+02

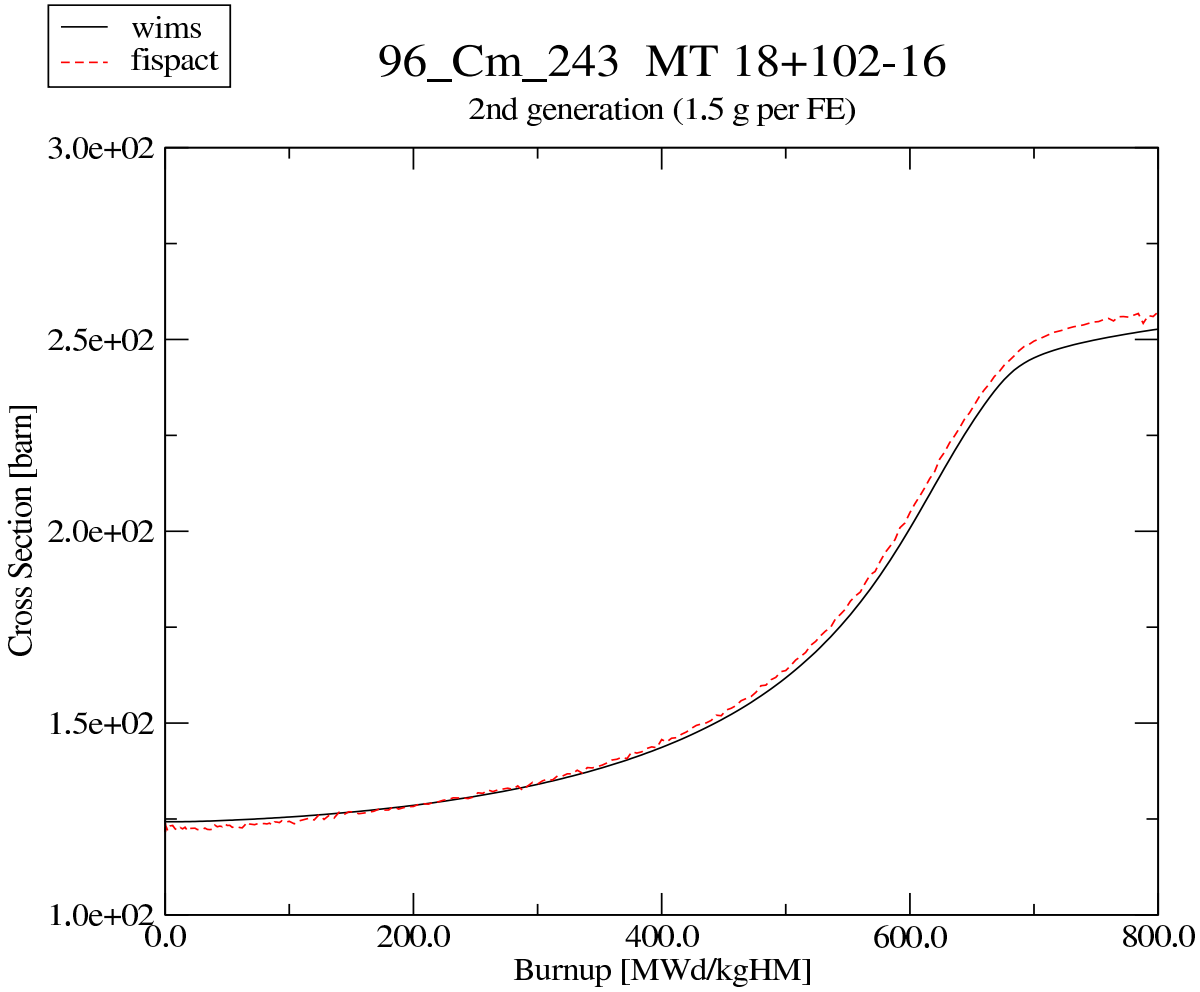


Figure 7.41 Absorption Cross Section [$barn$] 96_Cm_243 for case C1

Table 7.42 Absorption Cross Section [$barn$] 96_Cm_244 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.2890e+01	3.2890e+01	–	2.9881e+01
100.00	3.2336e+01	3.2336e+01	–	3.0013e+01
400.00	2.8187e+01	2.8187e+01	–	2.6941e+01
600.00	1.8396e+01	1.8396e+01	–	1.5581e+01
800.00	9.8511e+00	9.8511e+00	–	7.0444e+00

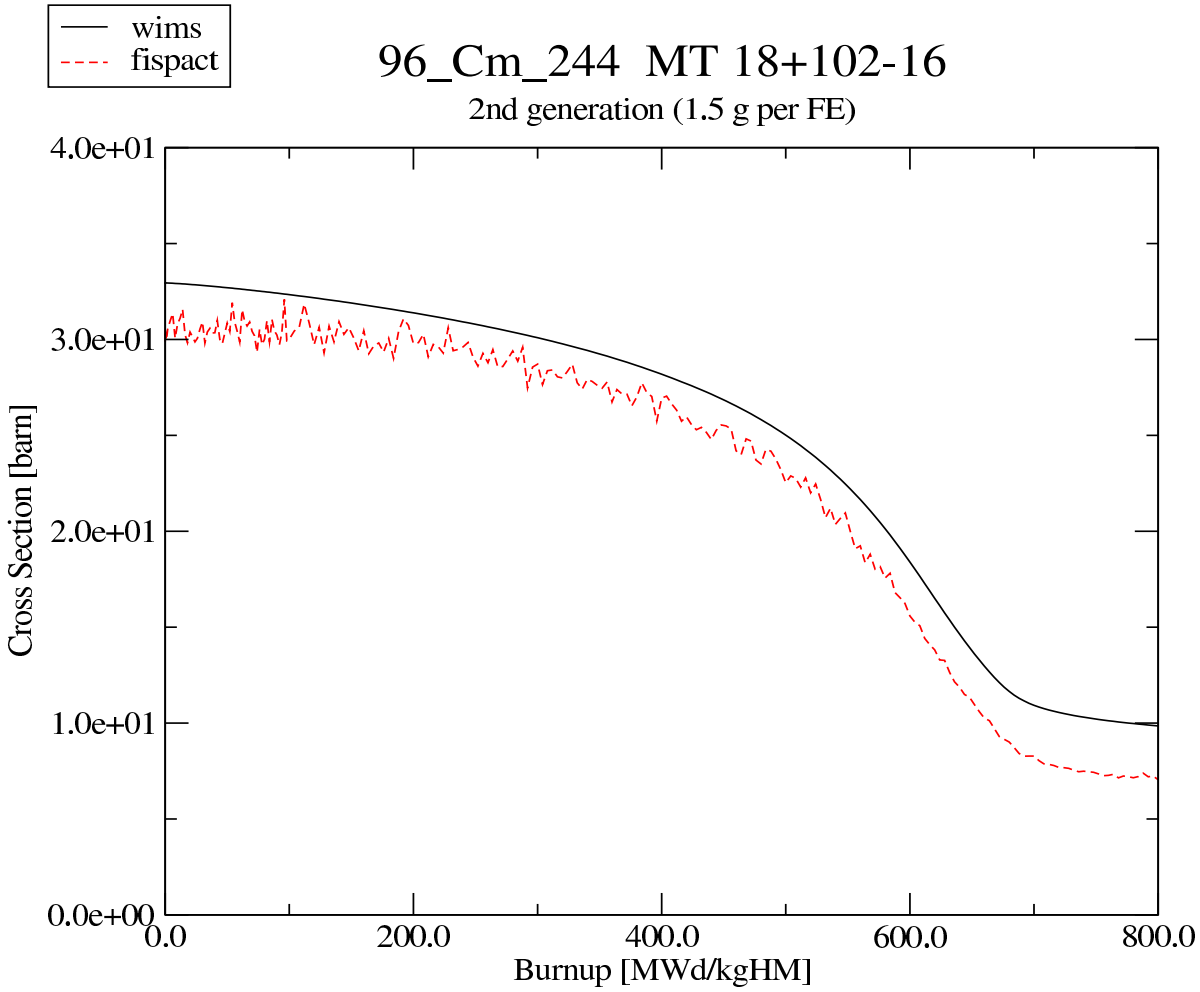


Figure 7.42 Absorption Cross Section [$barn$] 96_Cm_244 for case C1

Table 7.43 Absorption Cross Section [$barn$] 96_Cm_245 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0832e+02	1.0832e+02	–	1.0839e+02
100.00	1.1627e+02	1.1627e+02	–	1.1742e+02
400.00	2.0433e+02	2.0433e+02	–	2.1227e+02
600.00	4.8030e+02	4.8030e+02	–	5.0294e+02
800.00	7.3834e+02	7.3834e+02	–	7.6537e+02

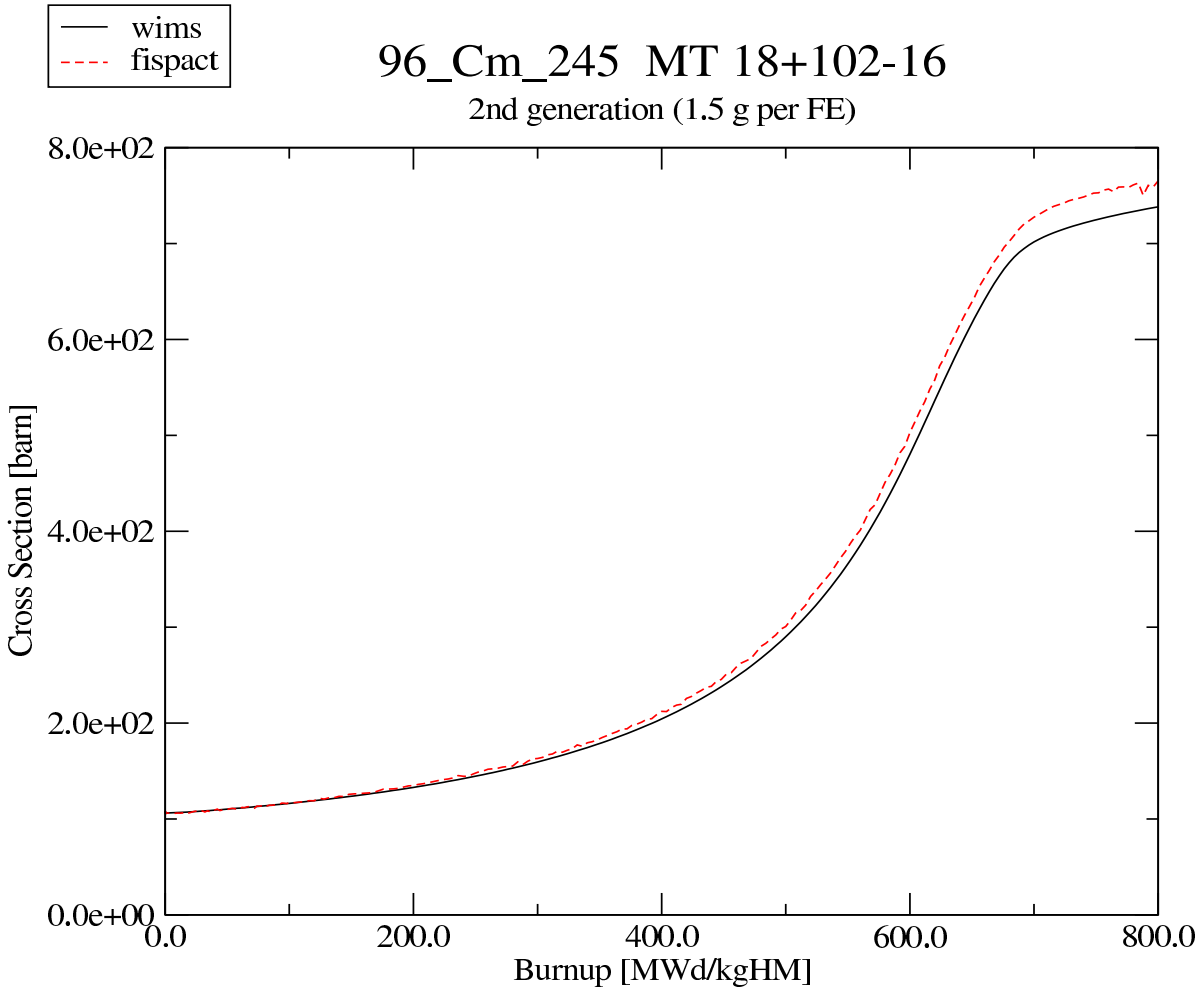


Figure 7.43 Absorption Cross Section [$barn$] 96_Cm_245 for case C1

Table 7.44 Absorption Cross Section [*barn*] 38_Sr_90 for case C1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	–	6.0346e-02
100.00	–	–	–	6.5362e-02
400.00	–	–	–	1.1456e-01
600.00	–	–	–	2.6115e-01
800.00	–	–	–	3.9150e-01

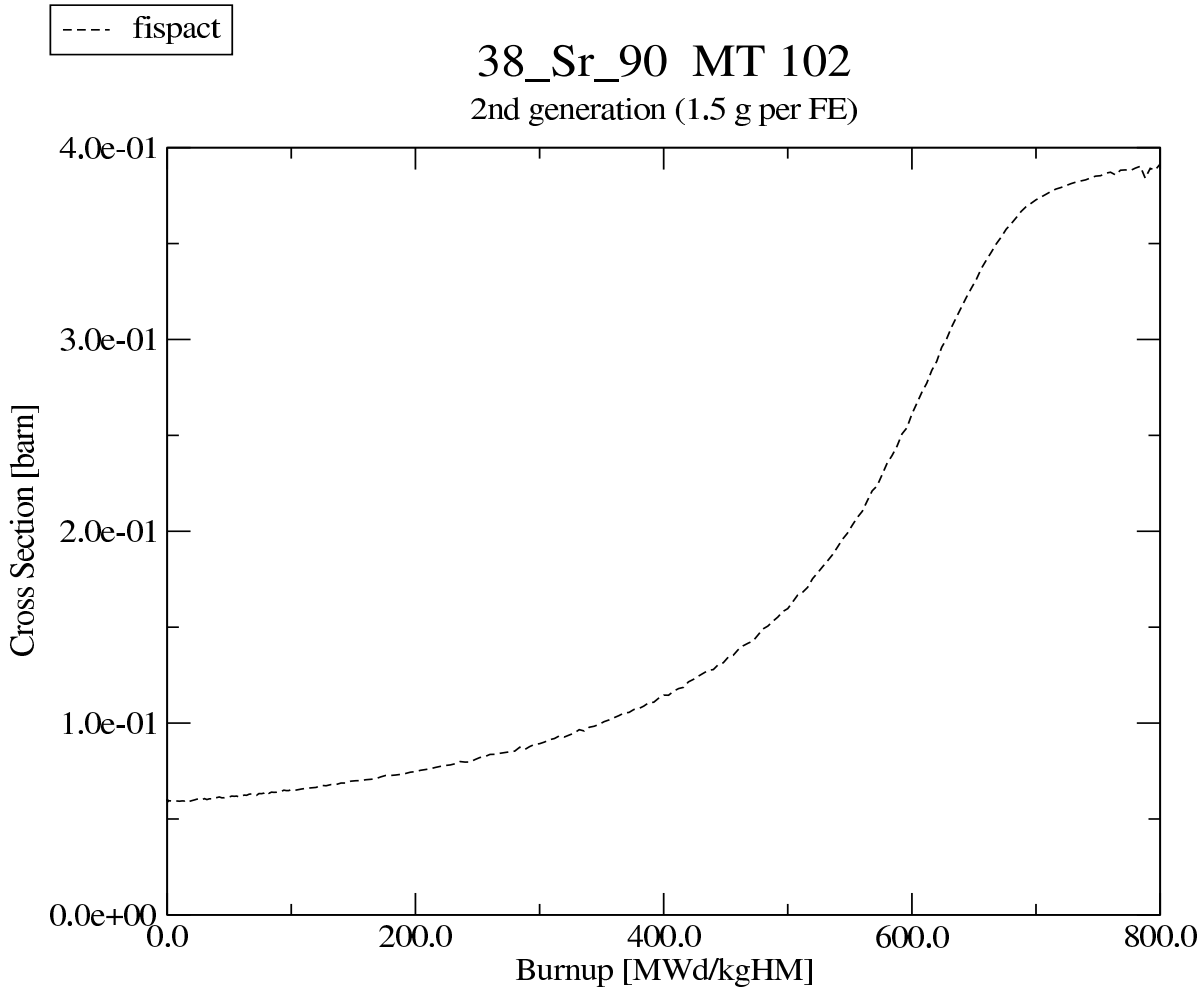


Figure 7.44 Absorption Cross Section [*barn*] 38_Sr_90 for case C1

Table 7.45 Absorption Cross Section [$barn$] 40_Zr_93 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.8329e+00	1.8335e+00	–	1.8281e+00
100.00	1.8189e+00	1.8195e+00	–	1.8544e+00
400.00	1.6814e+00	1.6819e+00	–	1.6363e+00
600.00	1.2897e+00	1.2899e+00	–	1.2669e+00
800.00	9.4757e-01	9.4764e-01	–	9.4691e-01

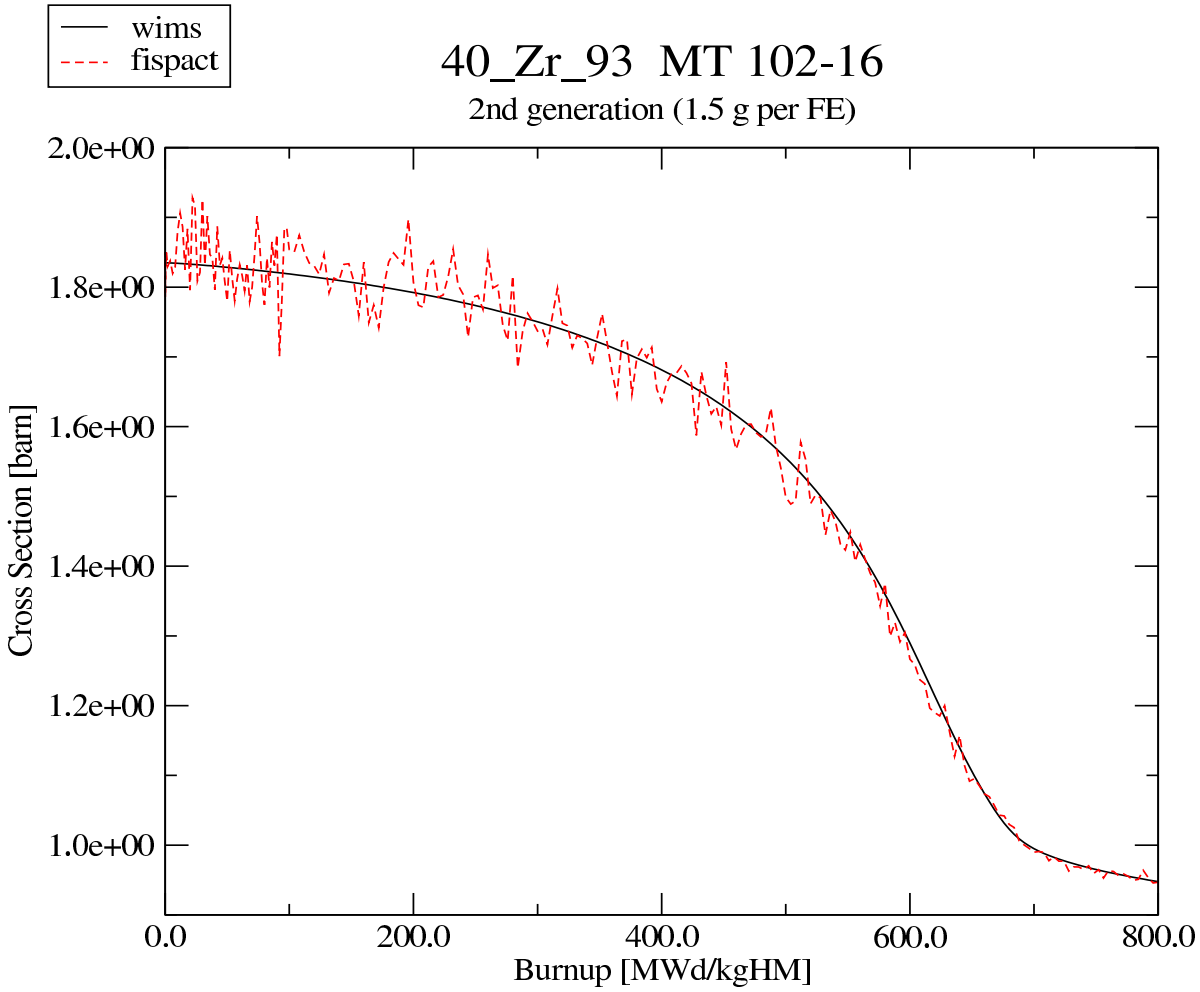


Figure 7.45 Absorption Cross Section [$barn$] 40_Zr_93 for case C1

Table 7.46 Absorption Cross Section [*barn*] 43_Tc_99 for case C1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5941e+01	1.5941e+01	–	1.5809e+01
100.00	1.5650e+01	1.5650e+01	–	1.5603e+01
400.00	1.4602e+01	1.4602e+01	–	1.4855e+01
600.00	1.2227e+01	1.2227e+01	–	1.2400e+01
800.00	1.0086e+01	1.0086e+01	–	1.0463e+01

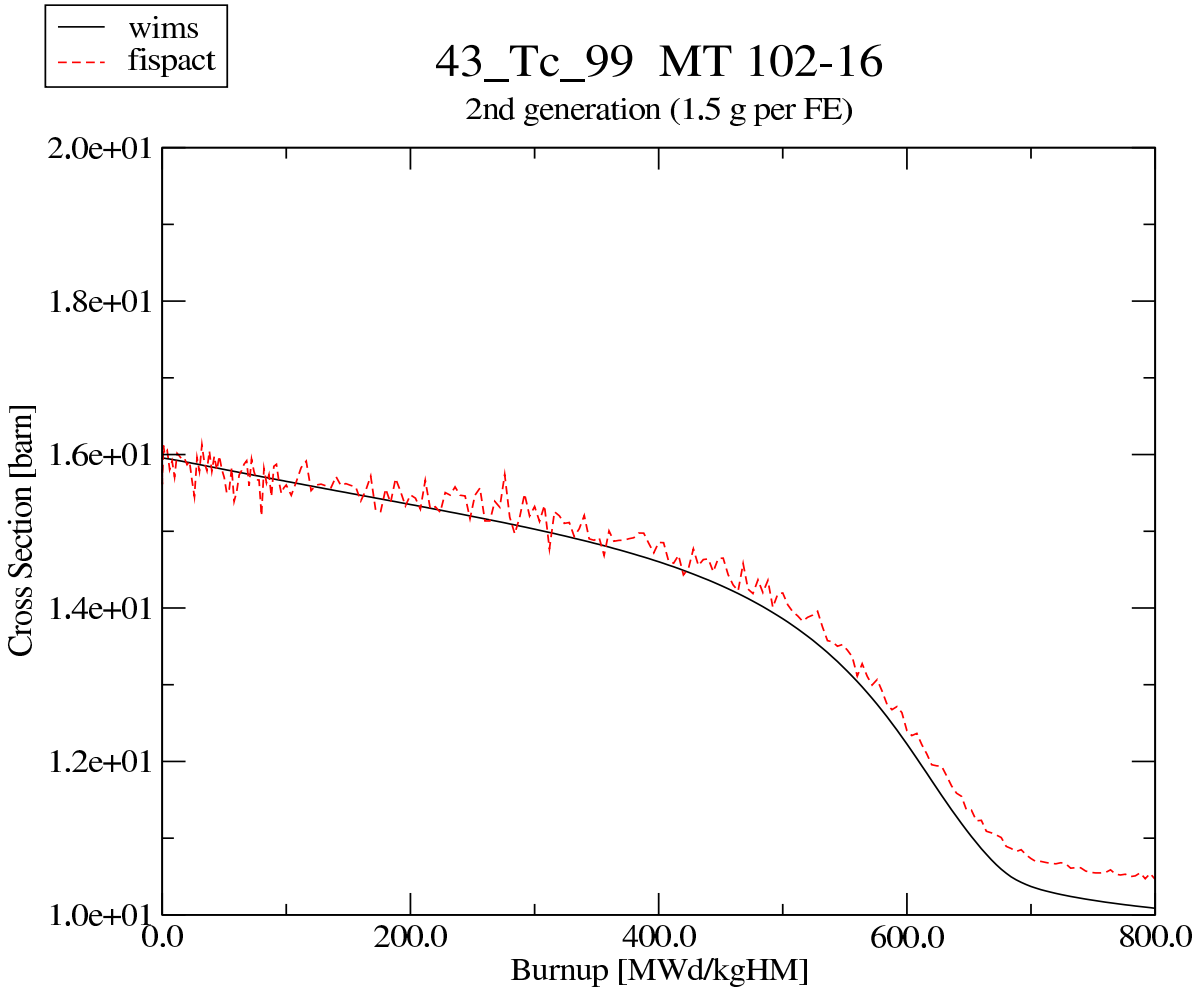


Figure 7.46 Absorption Cross Section [*barn*] 43_Tc_99 for case C1

Table 7.47 Absorption Cross Section [*barn*] 46_Pd_107 for case C1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.6544e+00	5.6562e+00	–	5.6919e+00
100.00	5.5925e+00	5.5942e+00	–	5.5830e+00
400.00	4.9593e+00	4.9607e+00	–	4.9526e+00
600.00	3.0808e+00	3.0815e+00	–	3.0292e+00
800.00	1.3999e+00	1.4001e+00	–	1.3566e+00

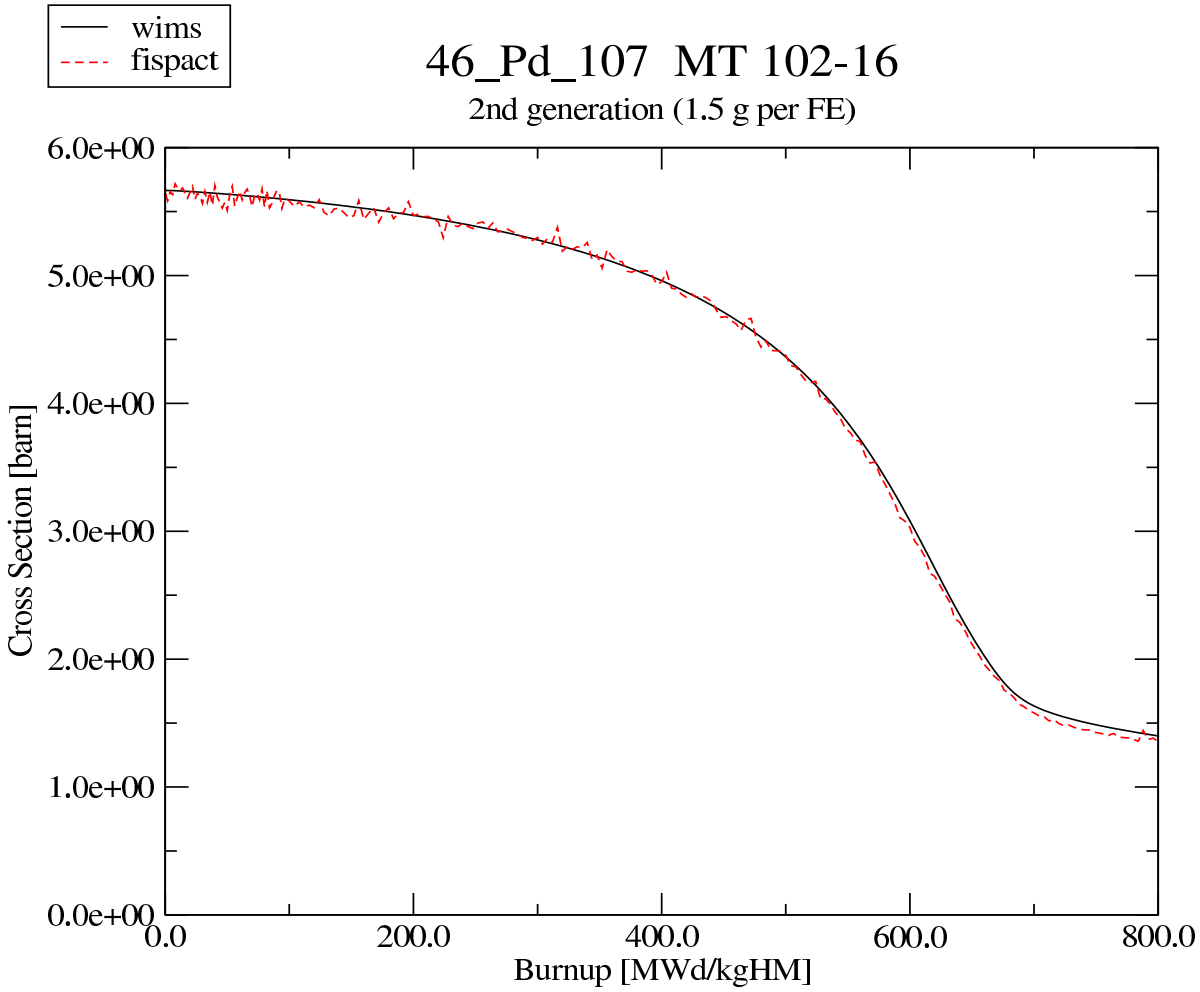


Figure 7.47 Absorption Cross Section [*barn*] 46_Pd_107 for case C1

Table 7.48 Absorption Cross Section [$barn$] 50_Sn_126 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	–	2.1061e-02
100.00	–	–	–	2.2715e-02
400.00	–	–	–	3.8968e-02
600.00	–	–	–	8.7461e-02
800.00	–	–	–	1.3059e-01

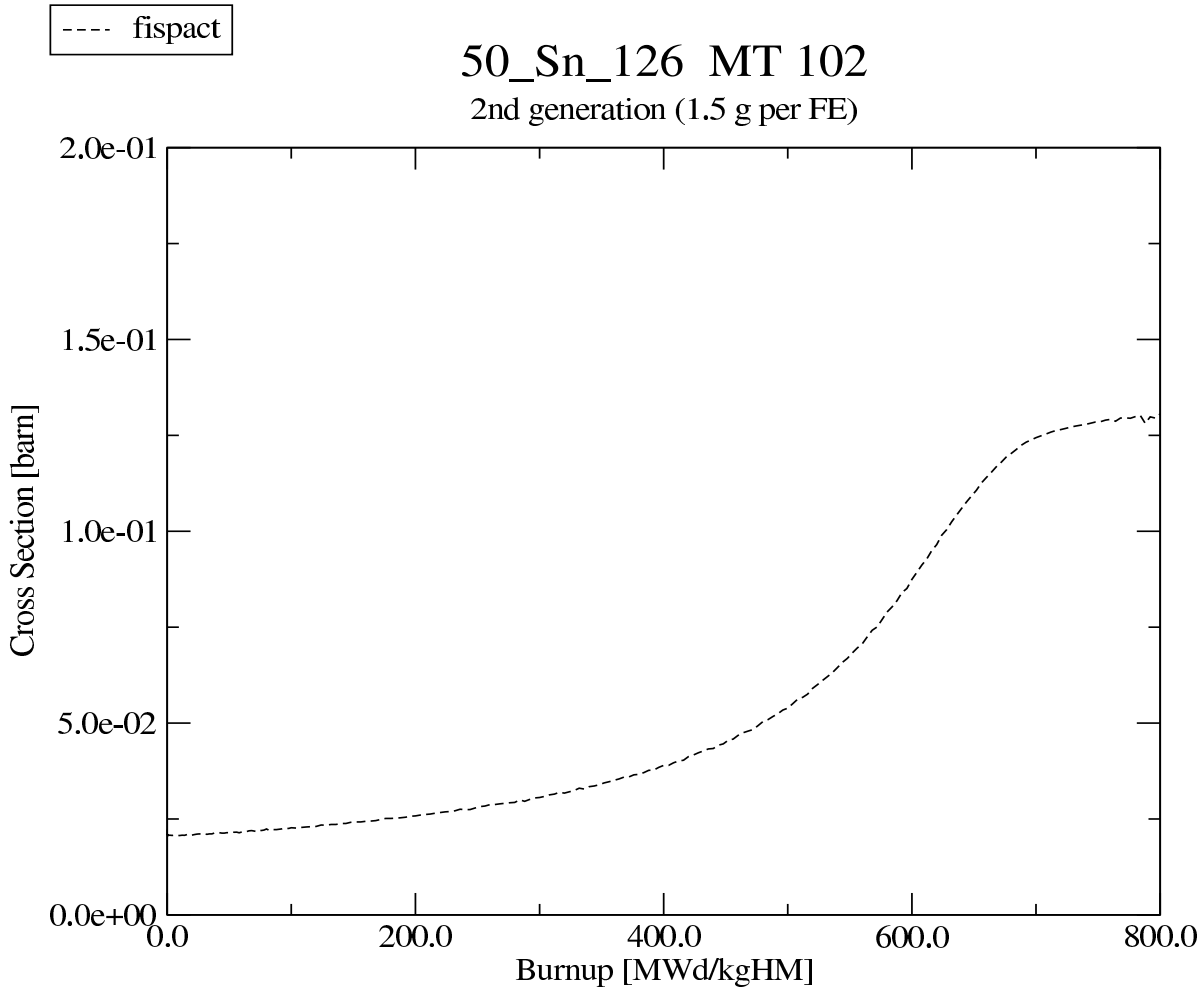


Figure 7.48 Absorption Cross Section [$barn$] 50_Sn_126 for case C1

Table 7.49 Absorption Cross Section [$barn$] 53_I_129 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.8735e+00	–	–	–
100.00	3.0311e+00	–	–	–
400.00	4.6402e+00	–	–	–
600.00	9.5614e+00	–	–	–
800.00	1.4109e+01	–	–	–

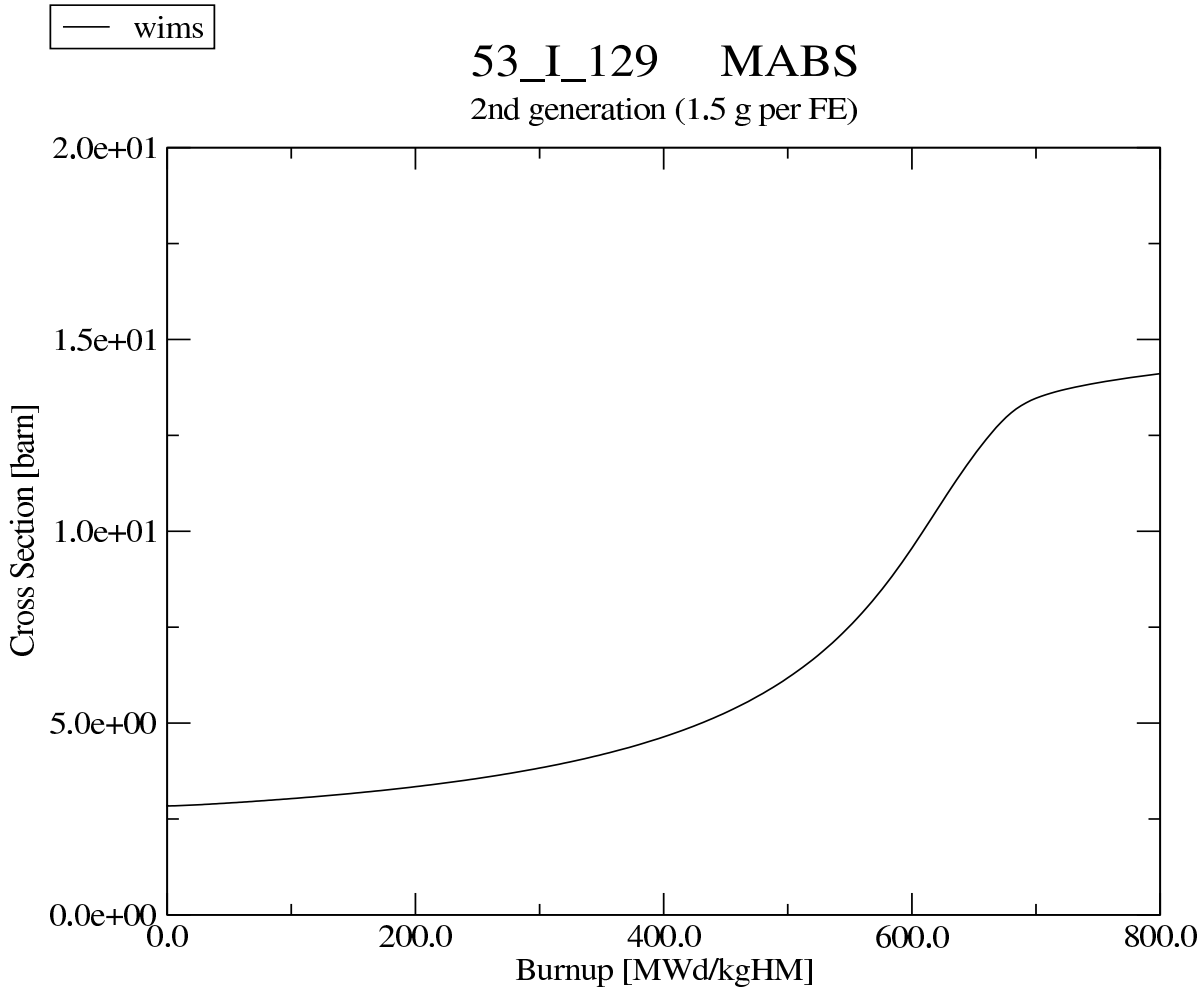


Figure 7.49 Absorption Cross Section [$barn$] 53_I_129 for case C1

Table 7.50 Absorption Cross Section [*barn*] 55_Cs_135 for case C1

burnup [*MWd/kgHM*]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.5719e+00	3.5721e+00	–	3.5311e+00
100.00	3.5760e+00	3.5761e+00	–	3.4709e+00
400.00	3.6377e+00	3.6378e+00	–	3.7350e+00
600.00	3.8689e+00	3.8690e+00	–	3.9004e+00
800.00	4.1108e+00	4.1108e+00	–	4.1685e+00

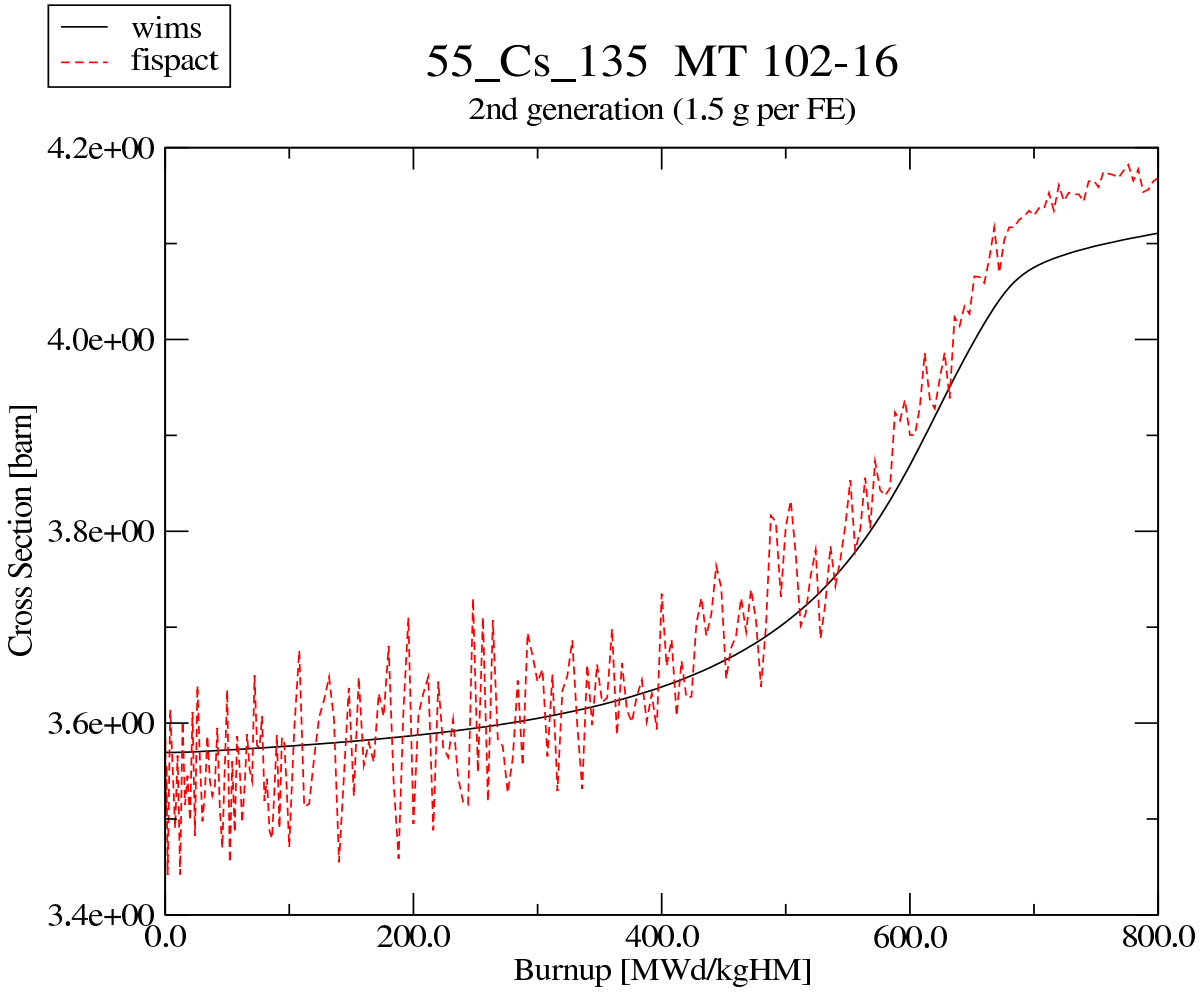


Figure 7.50 Absorption Cross Section [*barn*] 55_Cs_135 for case C1

Table 7.51 Absorption Cross Section [$barn$] 55_Cs_137 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	–	3.9354e-02
100.00	–	–	–	4.0209e-02
400.00	–	–	–	4.2605e-02
600.00	–	–	–	5.4316e-02
800.00	–	–	–	6.4469e-02

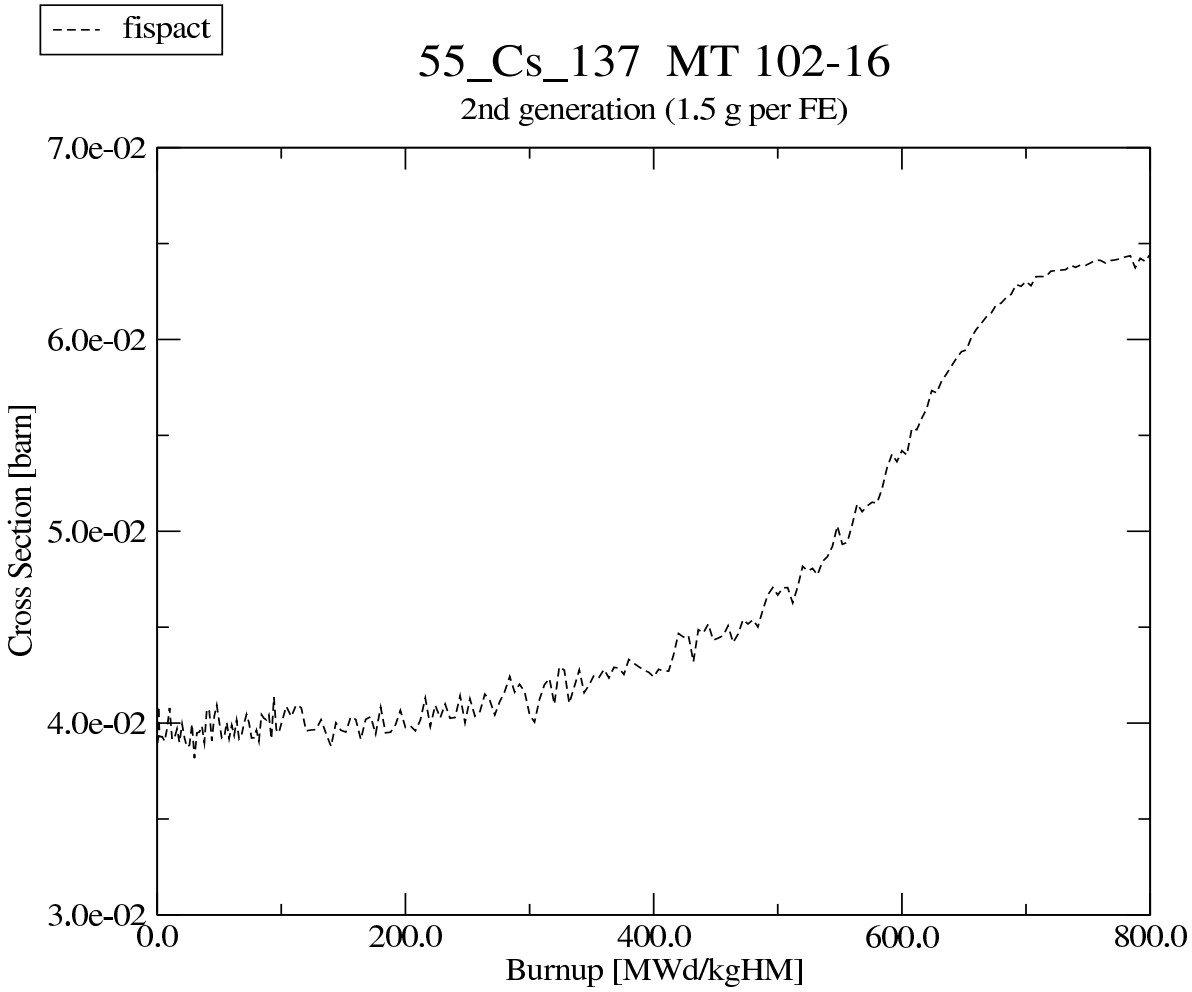


Figure 7.51 Absorption Cross Section [$barn$] 55_Cs_137 for case C1

Table 7.52 Absorption Cross Section [$barn$] 62_Sm_147 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.4213e+01	4.4215e+01	–	4.3506e+01
100.00	4.3801e+01	4.3803e+01	–	4.2960e+01
400.00	4.1474e+01	4.1476e+01	–	4.1291e+01
600.00	3.4944e+01	3.4945e+01	–	3.4692e+01
800.00	2.9057e+01	2.9057e+01	–	2.9126e+01

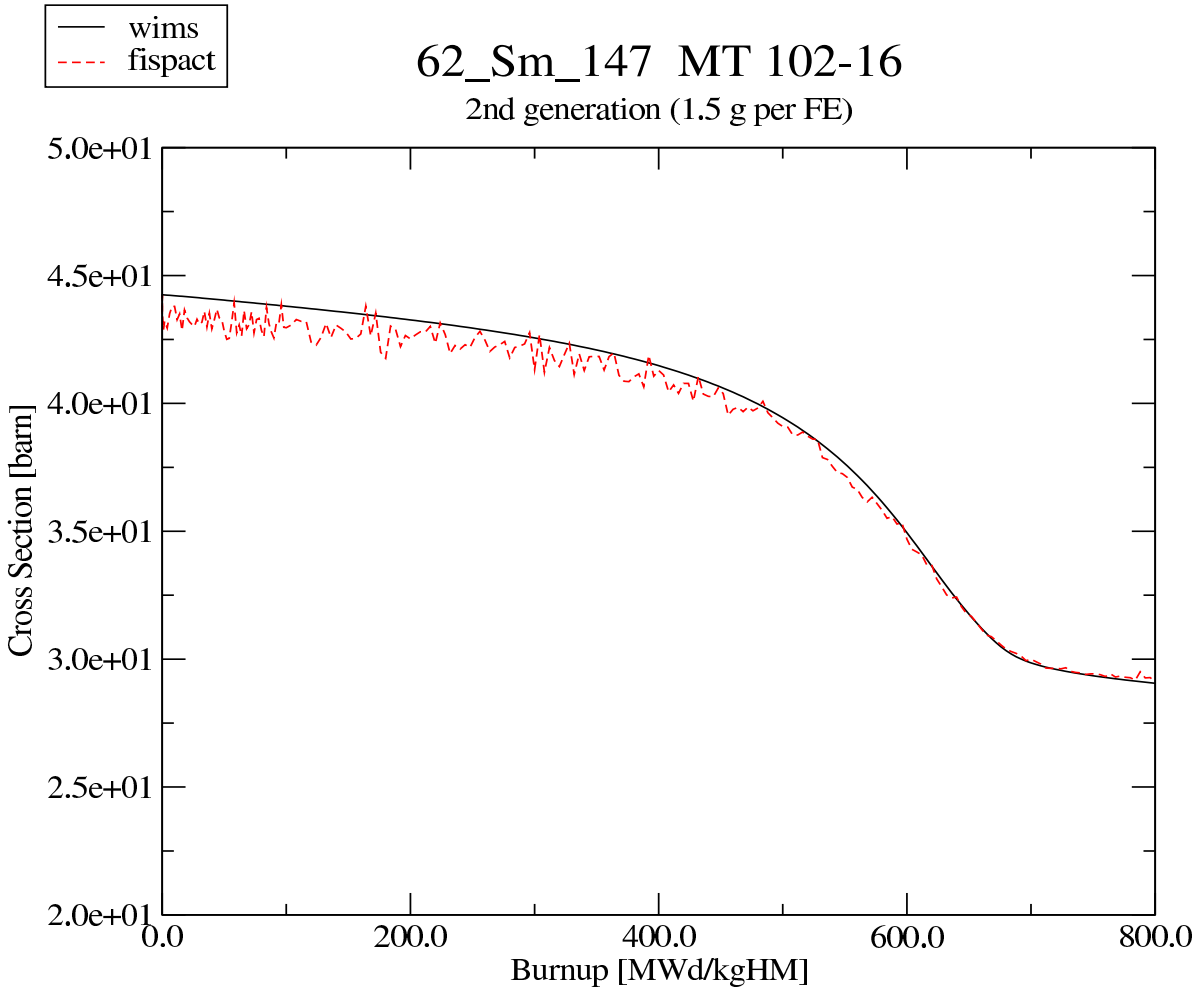


Figure 7.52 Absorption Cross Section [$barn$] 62_Sm_147 for case C1

Table 7.53 Absorption Cross Section [$barn$] 62_Sm_149 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.3696e+03	3.3696e+03	–	3.3797e+03
100.00	3.7768e+03	3.7768e+03	–	3.8478e+03
400.00	8.4460e+03	8.4460e+03	–	8.7988e+03
600.00	2.3200e+04	2.3200e+04	–	2.4455e+04
800.00	3.6990e+04	3.6990e+04	–	3.8581e+04

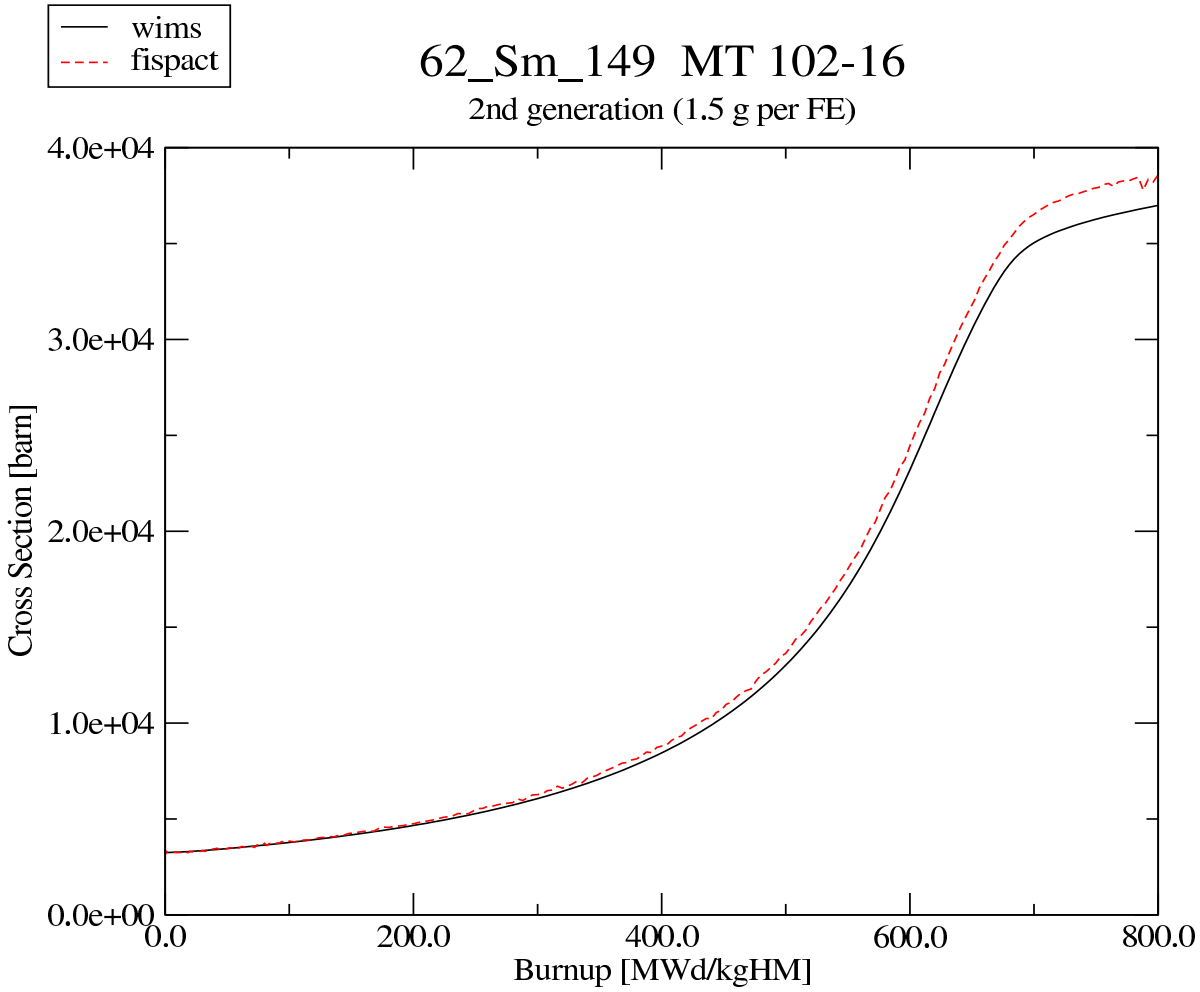


Figure 7.53 Absorption Cross Section [$barn$] 62_Sm_149 for case C1

Table 7.54 Absorption Cross Section [$barn$] 62_Sm_151 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.0989e+02	4.0989e+02	–	4.1002e+02
100.00	4.4522e+02	4.4522e+02	–	4.5178e+02
400.00	8.5056e+02	8.5056e+02	–	8.9092e+02
600.00	2.1388e+03	2.1388e+03	–	2.2534e+03
800.00	3.3497e+03	3.3497e+03	–	3.4900e+03

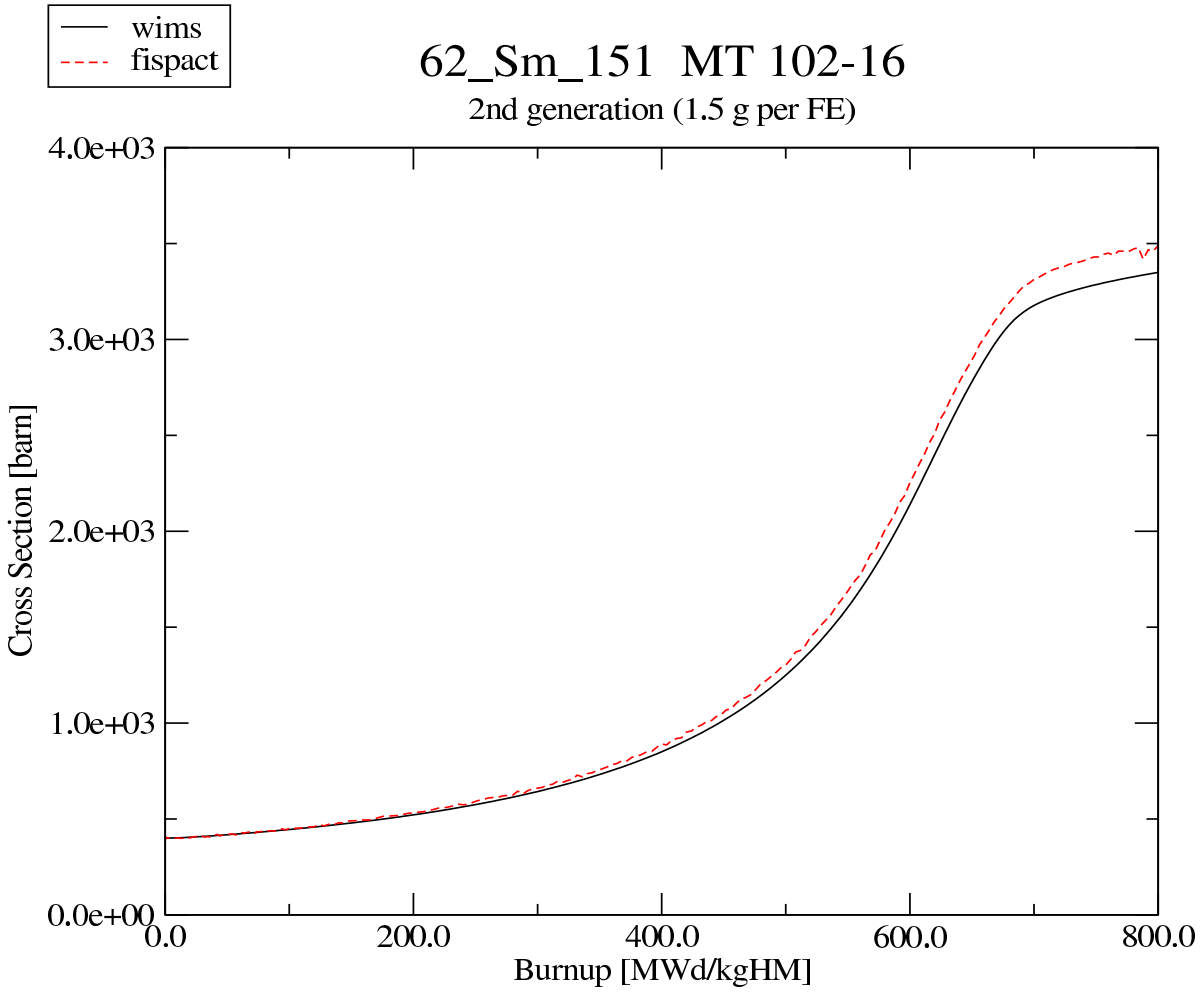


Figure 7.54 Absorption Cross Section [$barn$] 62_Sm_151 for case C1

Table 7.55 Absorption Cross Section [$barn$] 63_Eu_154 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3248e+02	1.3248e+02	–	1.3054e+02
100.00	1.3459e+02	1.3459e+02	–	1.3360e+02
400.00	1.6287e+02	1.6287e+02	–	1.6551e+02
600.00	2.4392e+02	2.4392e+02	–	2.5107e+02
800.00	3.1515e+02	3.1515e+02	–	3.2345e+02

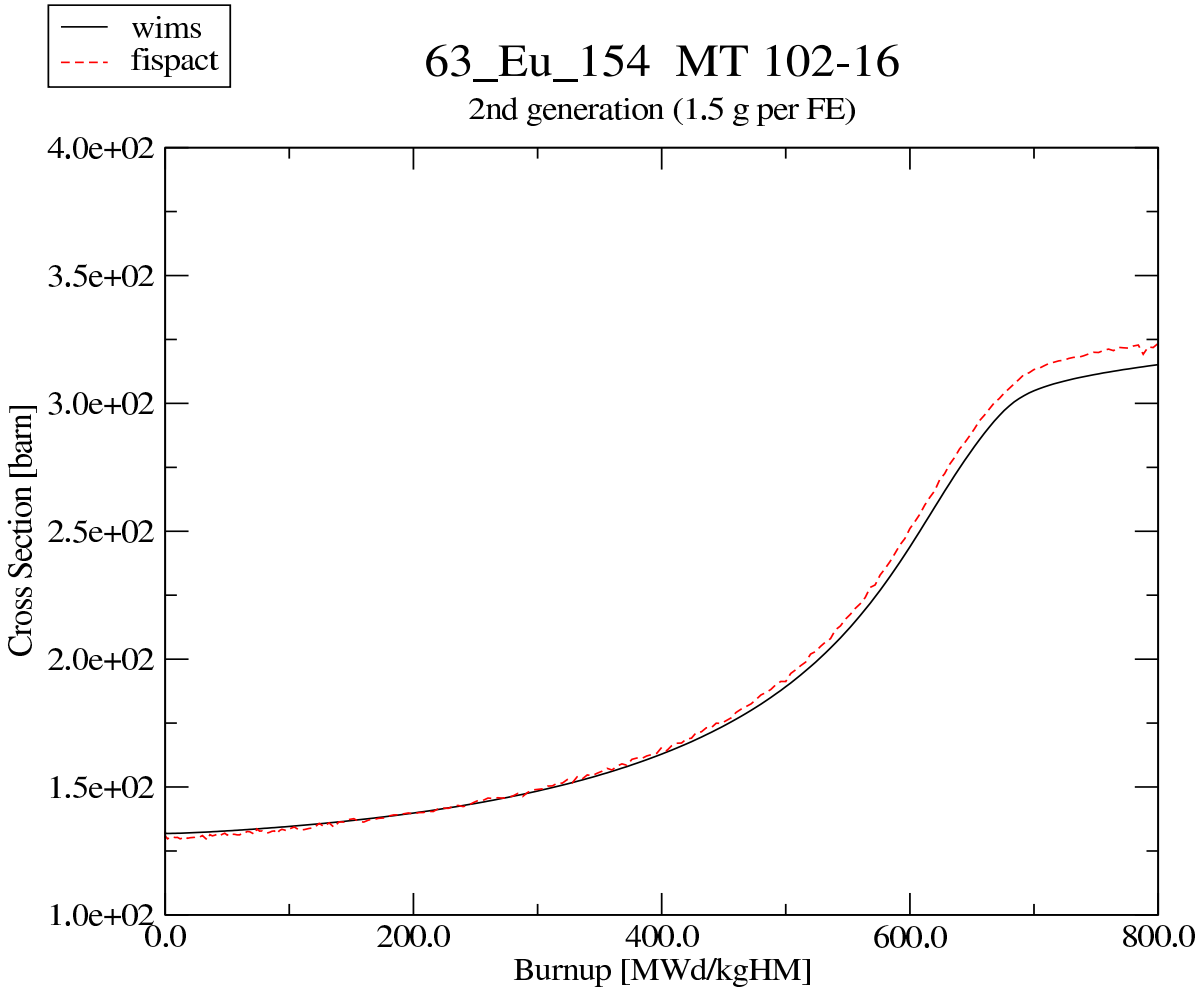


Figure 7.55 Absorption Cross Section [$barn$] 63_Eu_154 for case C1

Table 7.56 Absorption Cross Section [$barn$] 54_Xe_135 for case C1

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	–	9.6191e+04
100.00	–	–	–	1.1034e+05
400.00	–	–	–	2.6054e+05
600.00	–	–	–	7.3874e+05
800.00	–	–	–	1.1722e+06

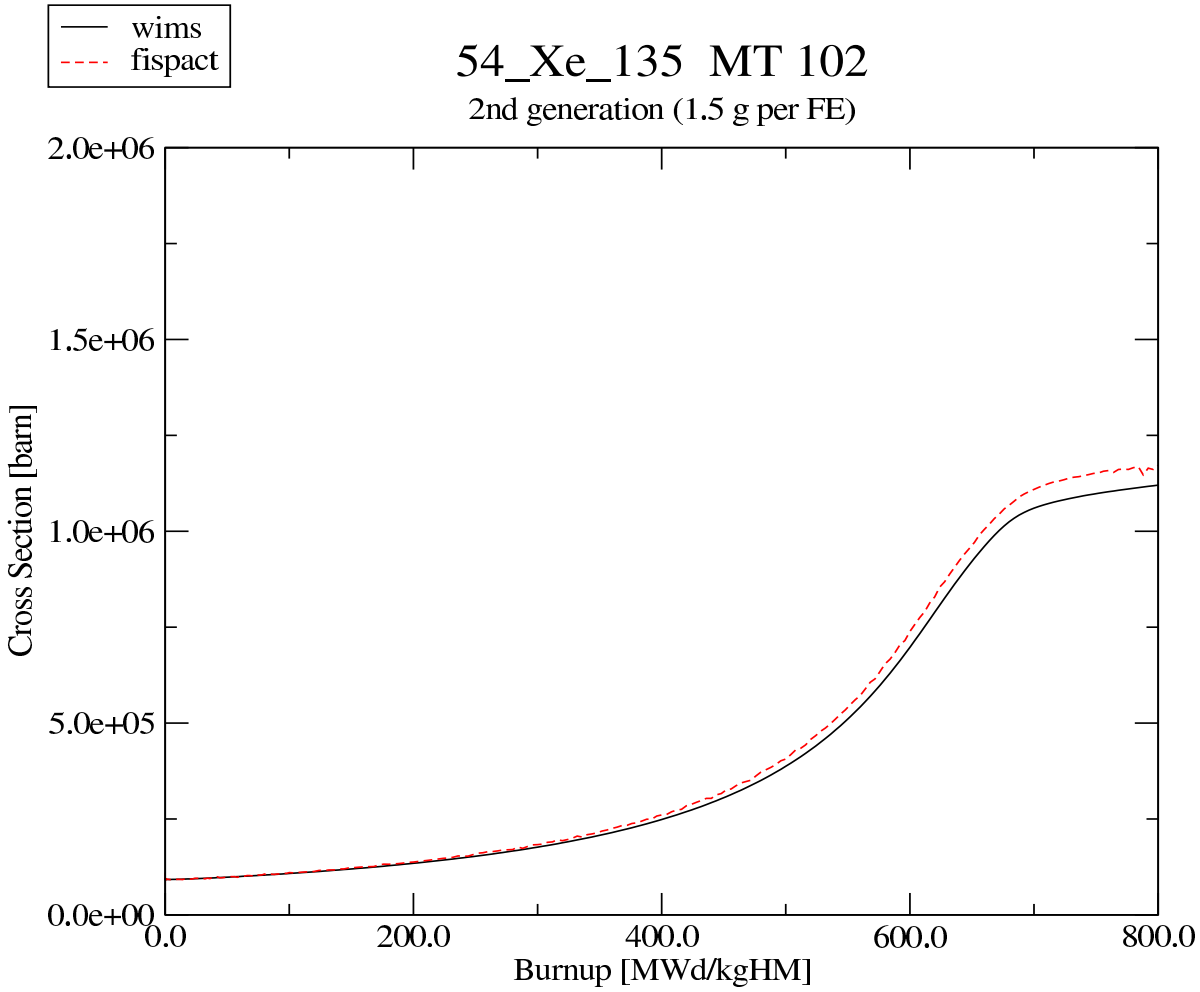


Figure 7.56 Absorption Cross Section [$barn$] 54_Xe_135 for case C1

Table 7.57 Fission Cross Section [$barn$] 94_Pu_238 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.1000e+00	–	2.0911e+00
100.00	2.1406e+00	–	2.1470e+00
400.00	2.5985e+00	–	2.6426e+00
600.00	4.0814e+00	–	4.2193e+00
800.00	5.4962e+00	–	5.6780e+00

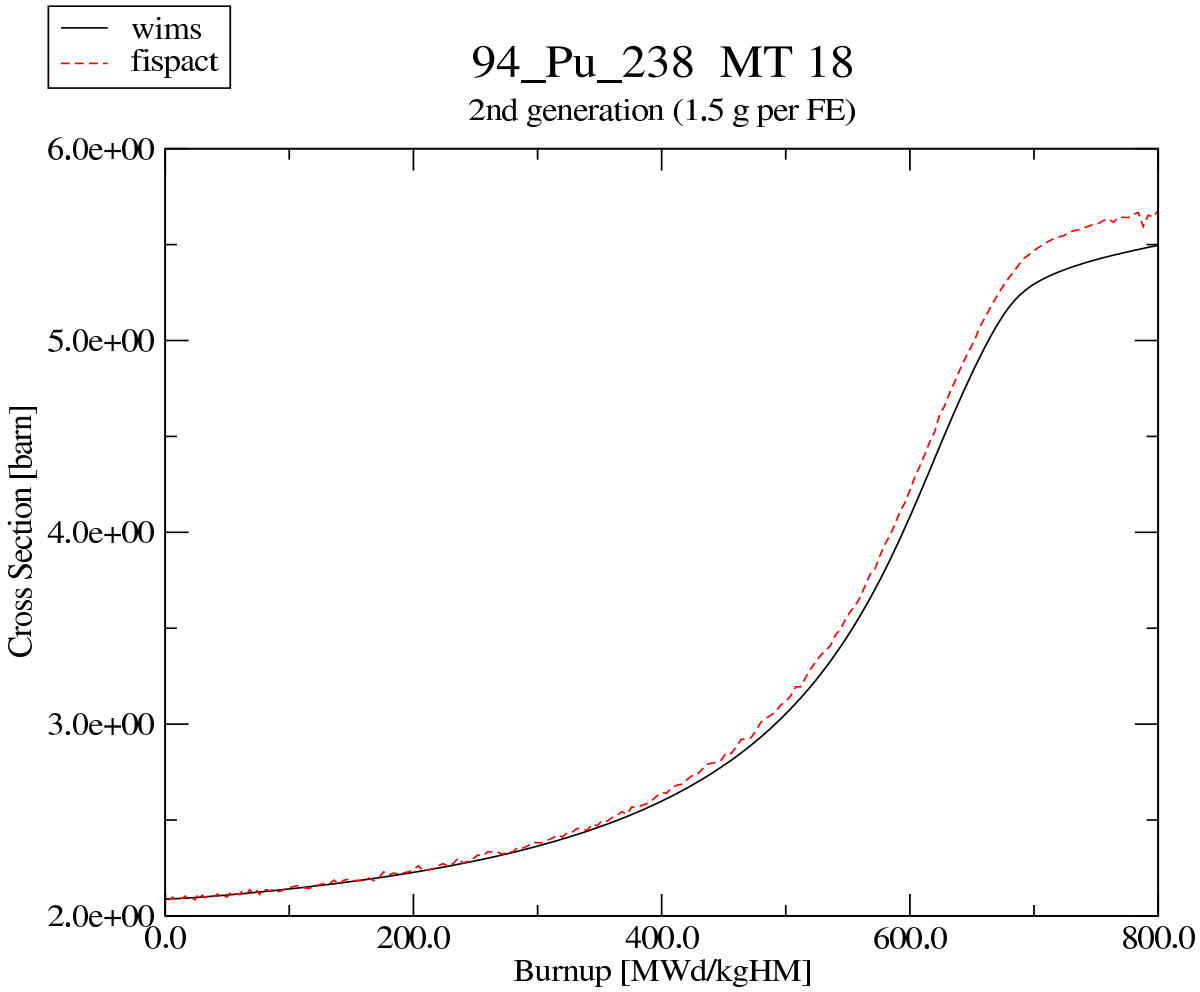


Figure 7.57 Fission Cross Section [$barn$] 94_Pu_238 for case C1

Table 7.58 Fission Cross Section [$barn$] 94_Pu_239 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.8724e+01	–	1.0172e+02
100.00	1.1269e+02	–	1.1601e+02
400.00	2.2841e+02	–	2.3480e+02
600.00	5.4580e+02	–	5.5603e+02
800.00	8.2658e+02	–	8.3232e+02

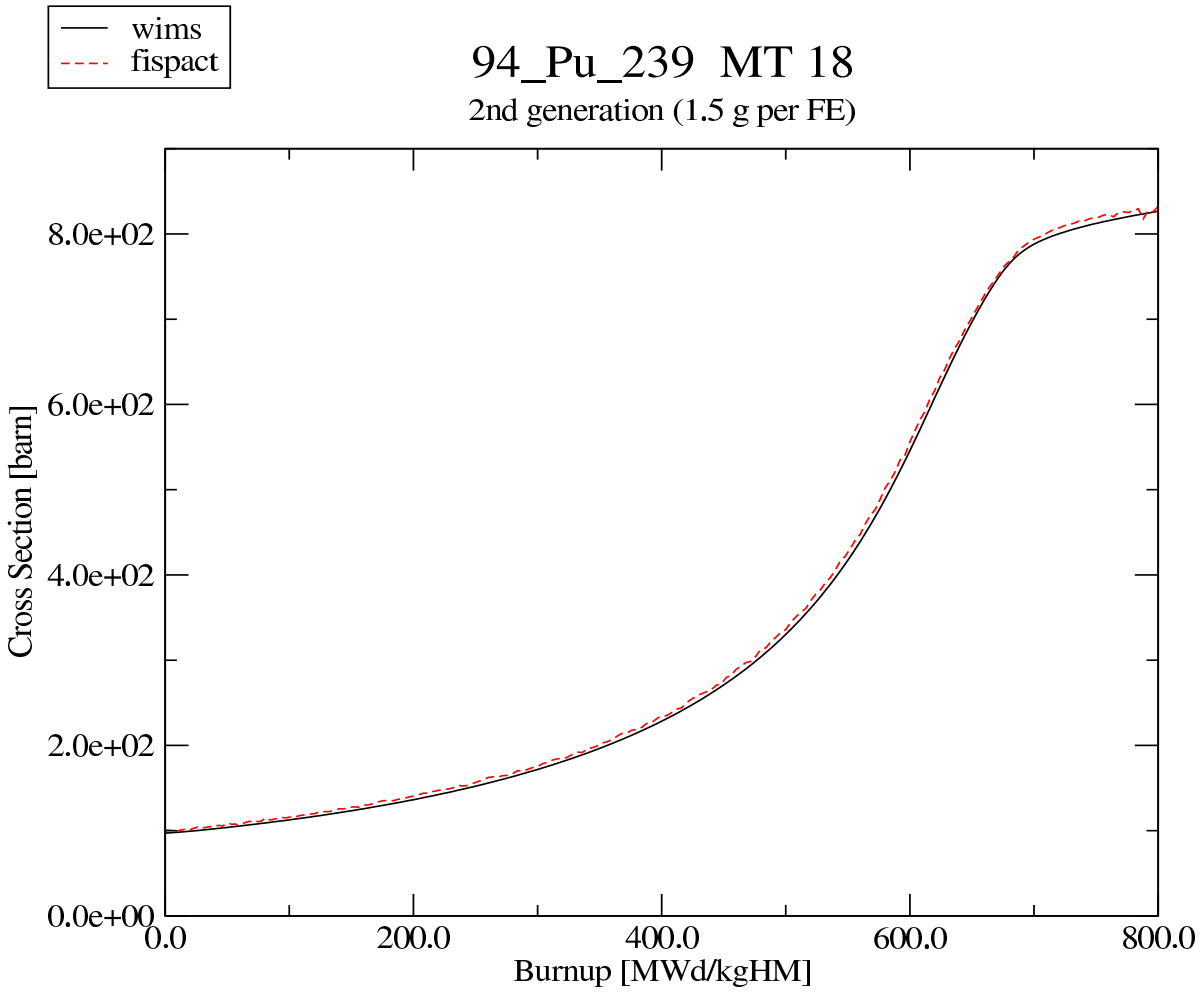


Figure 7.58 Fission Cross Section [$barn$] 94_Pu_239 for case C1

Table 7.59 Fission Cross Section [*barn*] 94_Pu_240 for case C1

burnup [*MWd/kgHM*]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.7433e-01	–	3.7560e-01
100.00	3.7231e-01	–	3.7206e-01
400.00	3.3854e-01	–	3.3301e-01
600.00	2.1707e-01	–	2.0780e-01
800.00	8.9473e-02	–	8.2762e-02

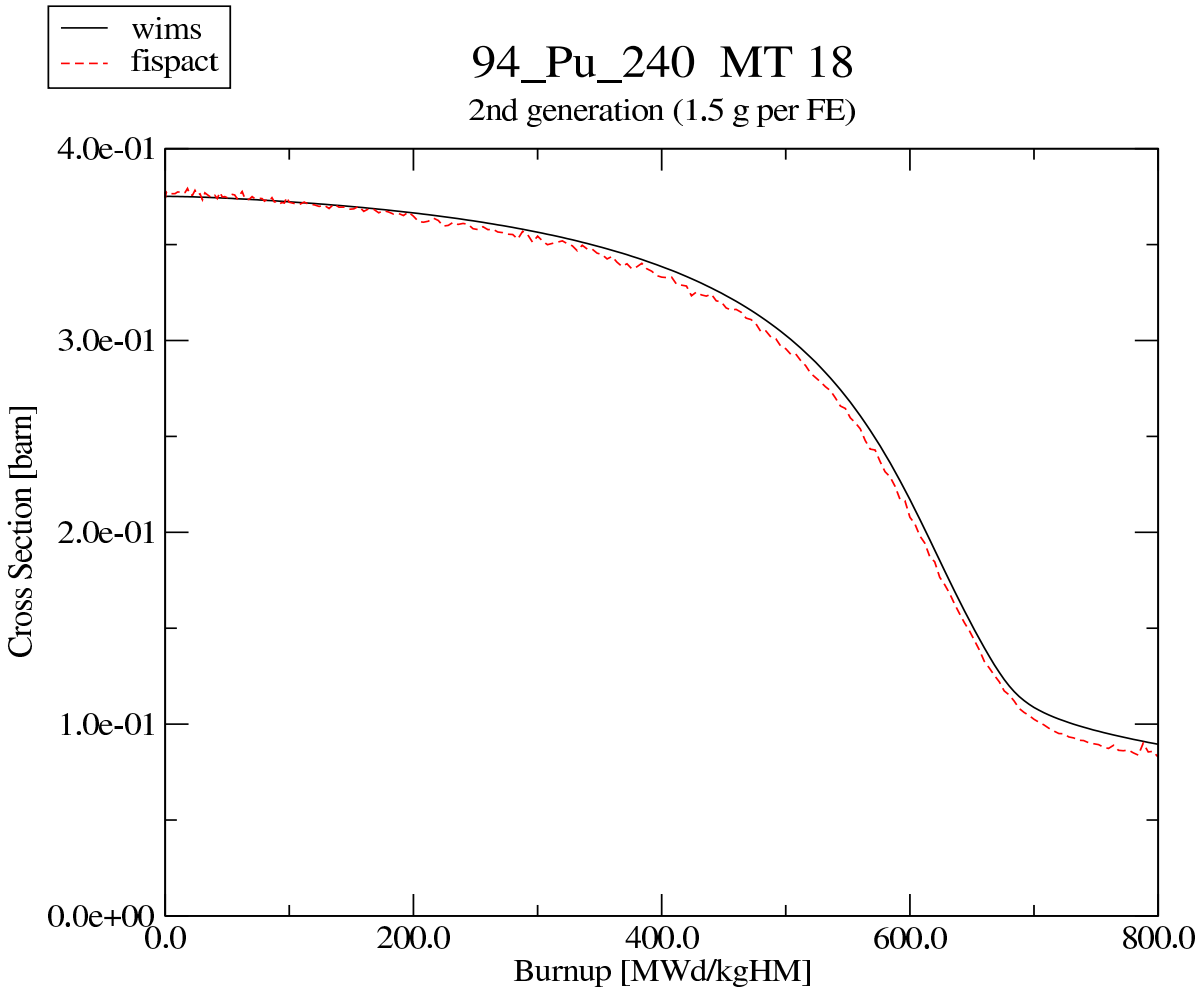


Figure 7.59 Fission Cross Section [*barn*] 94_Pu_240 for case C1

Table 7.60 Fission Cross Section [*barn*] 94_Pu_241 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.9364e+01	–	9.9318e+01
100.00	1.0936e+02	–	1.1003e+02
400.00	2.0395e+02	–	2.1080e+02
600.00	4.8623e+02	–	5.0295e+02
800.00	7.4240e+02	–	7.6018e+02

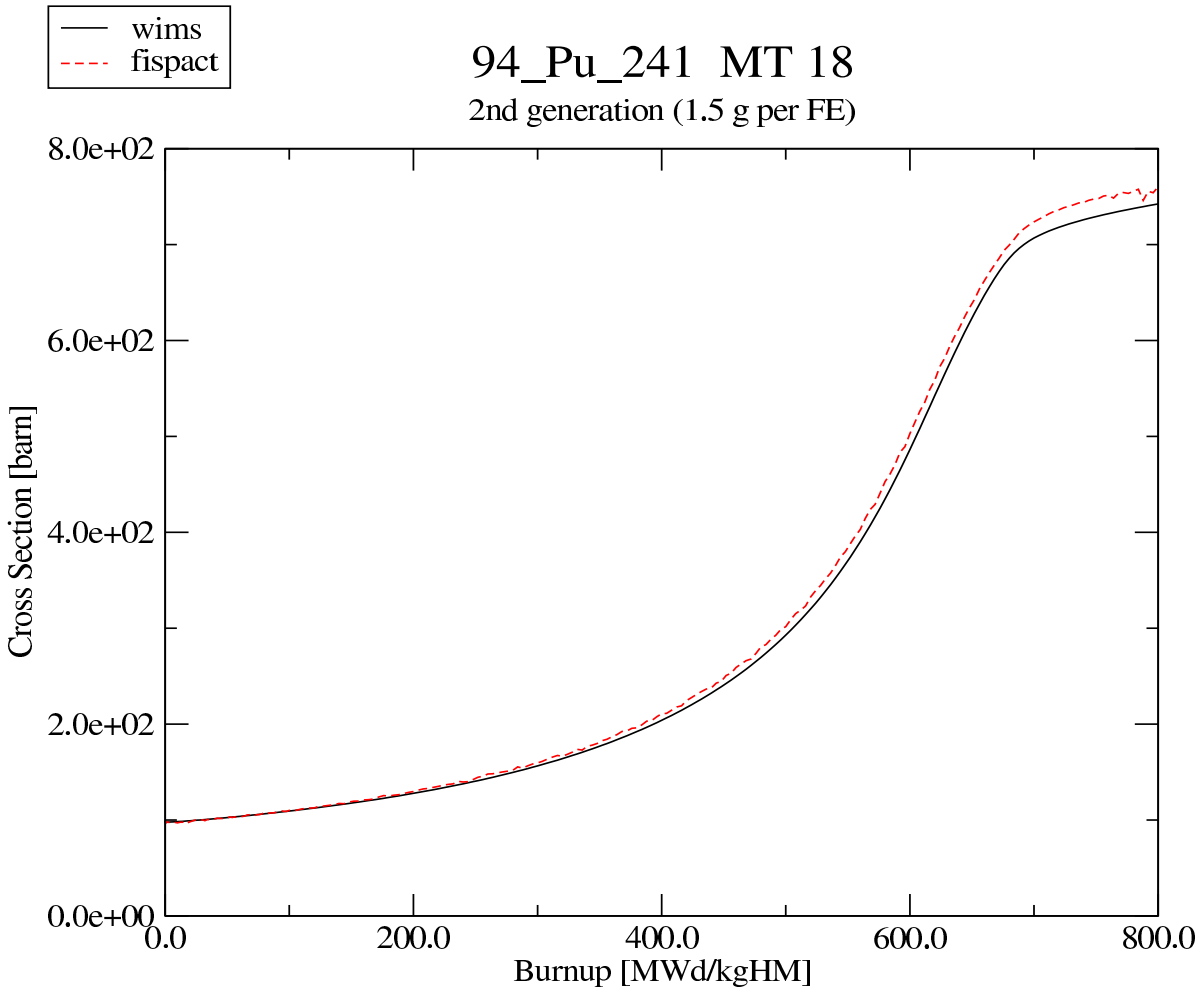


Figure 7.60 Fission Cross Section [*barn*] 94_Pu_241 for case C1

Table 7.61 Fission Cross Section [*barn*] 94_Pu_242 for case C1

burnup [*MWd/kgHM*]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.3471e-01	–	2.3619e-01
100.00	2.3152e-01	–	2.3234e-01
400.00	1.9966e-01	–	1.9596e-01
600.00	1.1085e-01	–	1.0570e-01
800.00	3.3830e-02	–	3.0875e-02

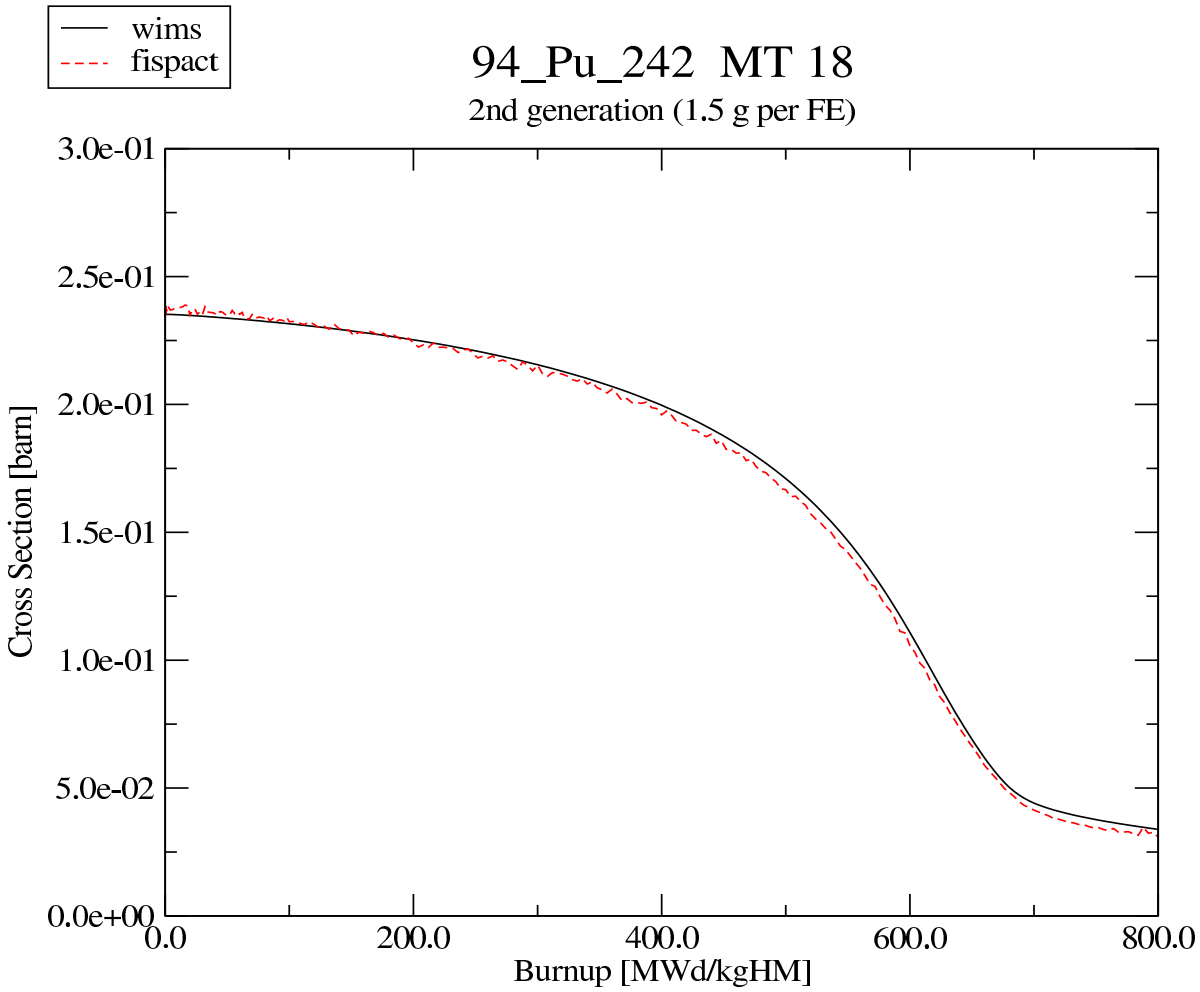


Figure 7.61 Fission Cross Section [*barn*] 94_Pu_242 for case C1

Table 7.62 Fission Cross Section [$barn$] 95_Am_241 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.2226e+00	–	1.2053e+00
100.00	1.3051e+00	–	1.2897e+00
400.00	1.9392e+00	–	1.9411e+00
600.00	3.5958e+00	–	3.5772e+00
800.00	5.0181e+00	–	4.9356e+00

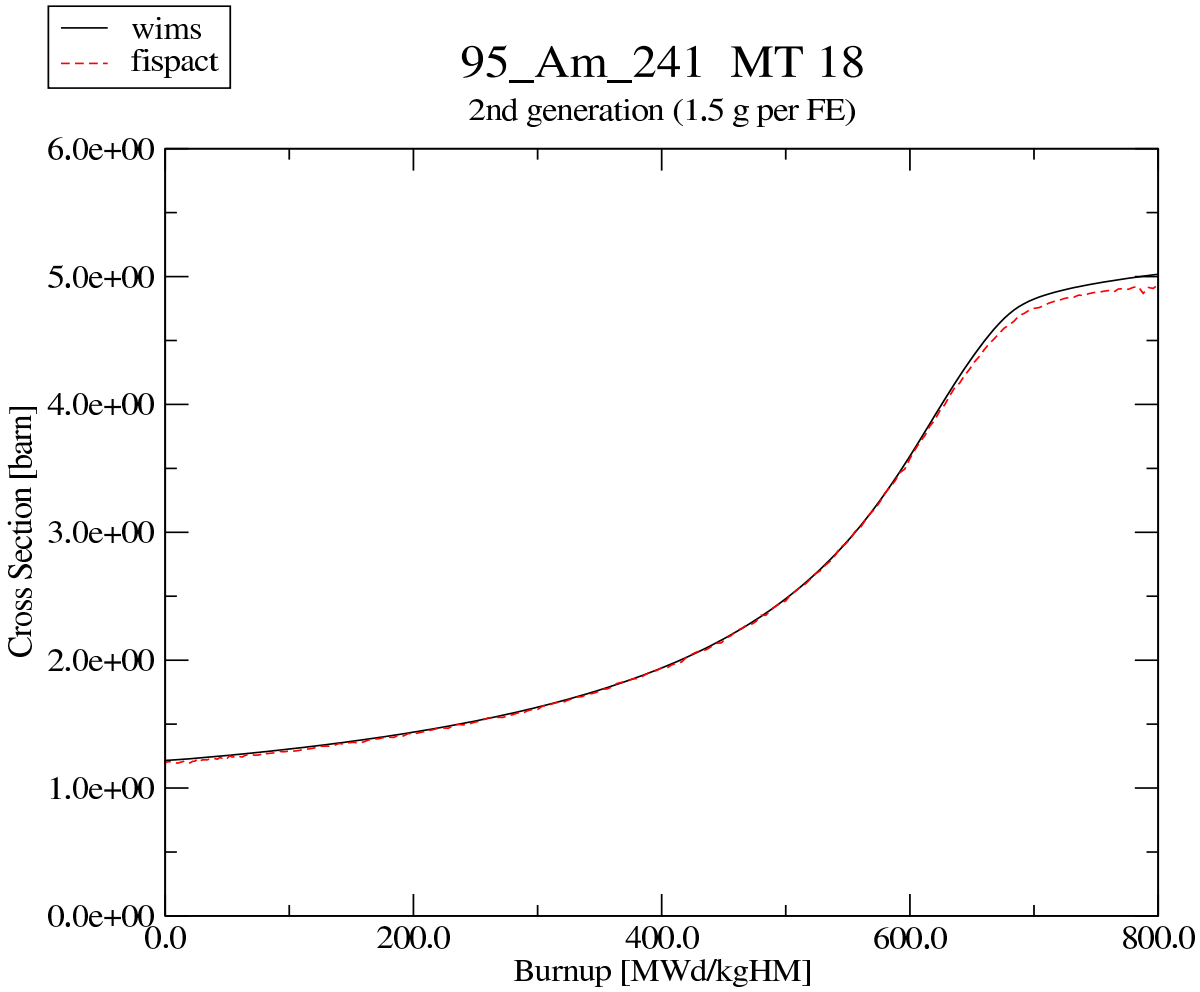


Figure 7.62 Fission Cross Section [$barn$] 95_Am_241 for case C1

Table 7.63 Fission Cross Section [$barn$] 95_Am_242 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	–	–	1.4738e+02
100.00	–	–	1.6001e+02
400.00	–	–	2.8294e+02
600.00	–	–	6.4309e+02
800.00	–	–	9.6123e+02

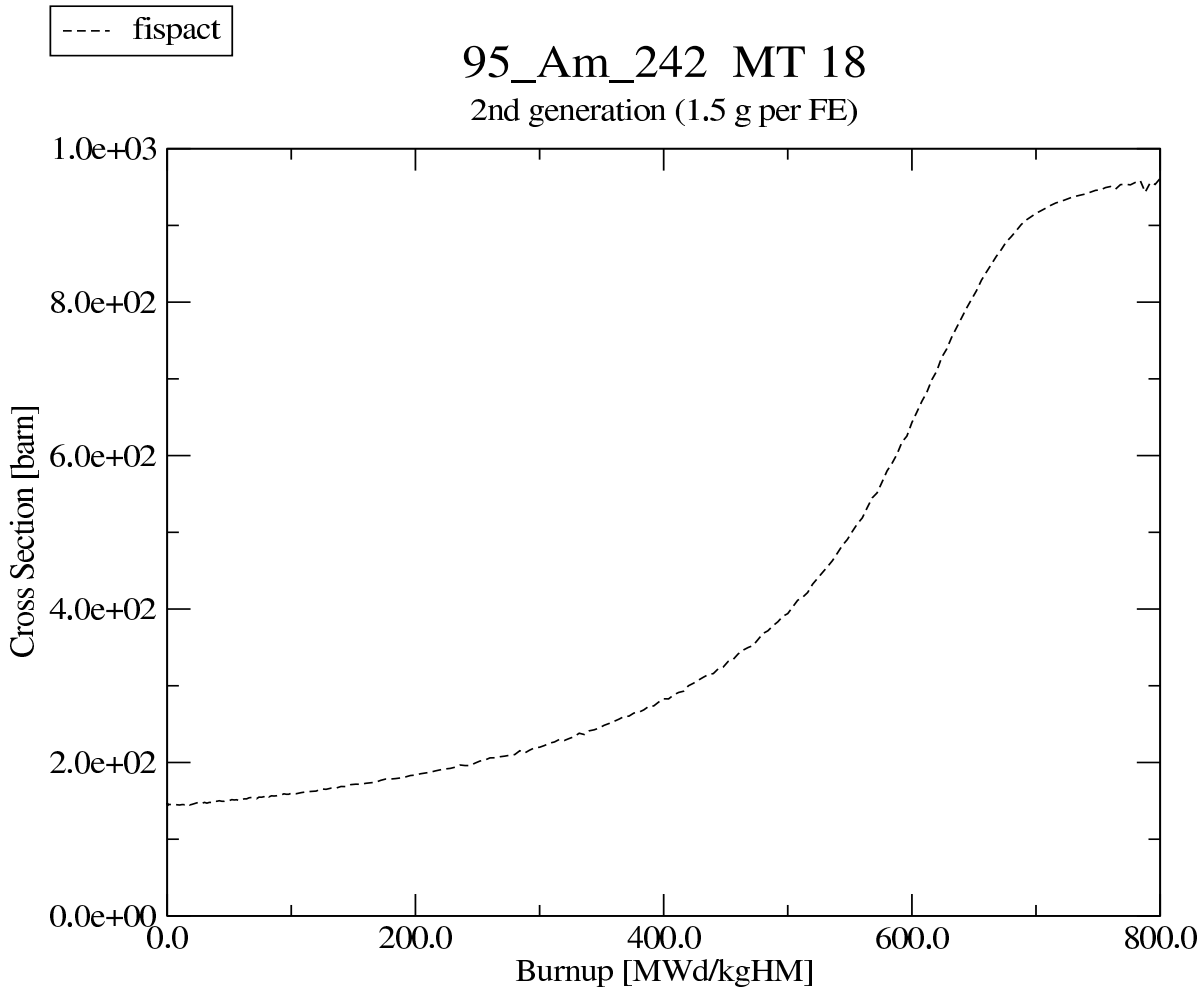


Figure 7.63 Fission Cross Section [$barn$] 95_Am_242 for case C1

Table 7.64 Fission Cross Section [$barn$] 95_Am_242m for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.6806e+02	–	4.6562e+02
100.00	5.2137e+02	–	5.2434e+02
400.00	1.0567e+03	–	1.0933e+03
600.00	2.6856e+03	–	2.7941e+03
800.00	4.1810e+03	–	4.3041e+03

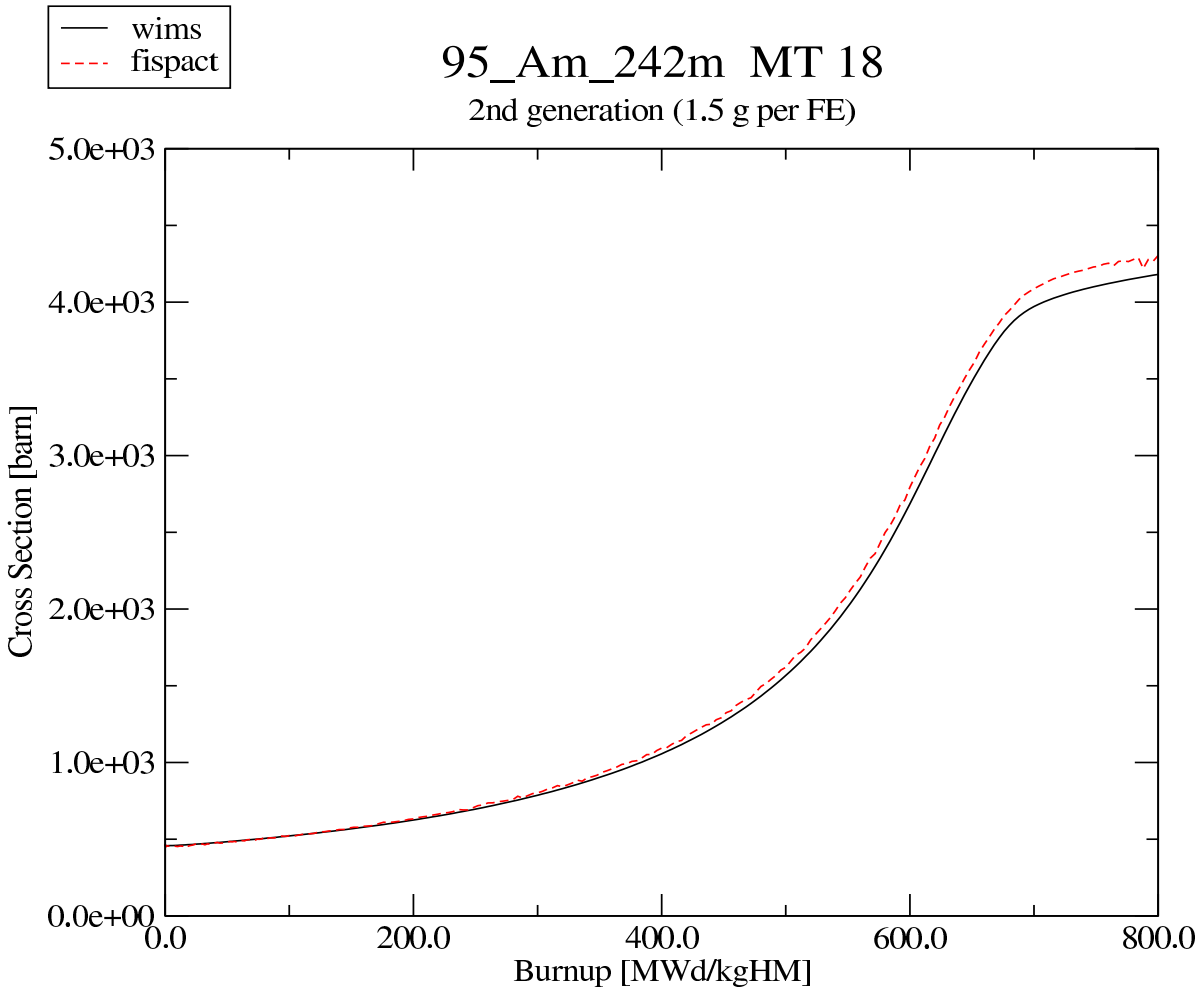


Figure 7.64 Fission Cross Section [$barn$] 95_Am_242m for case C1

Table 7.65 Fission Cross Section [$barn$] 95_Am_243 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.3836e-01	–	2.3966e-01
100.00	2.3407e-01	–	2.3530e-01
400.00	2.0411e-01	–	2.0143e-01
600.00	1.2301e-01	–	1.1867e-01
800.00	5.1306e-02	–	4.8488e-02

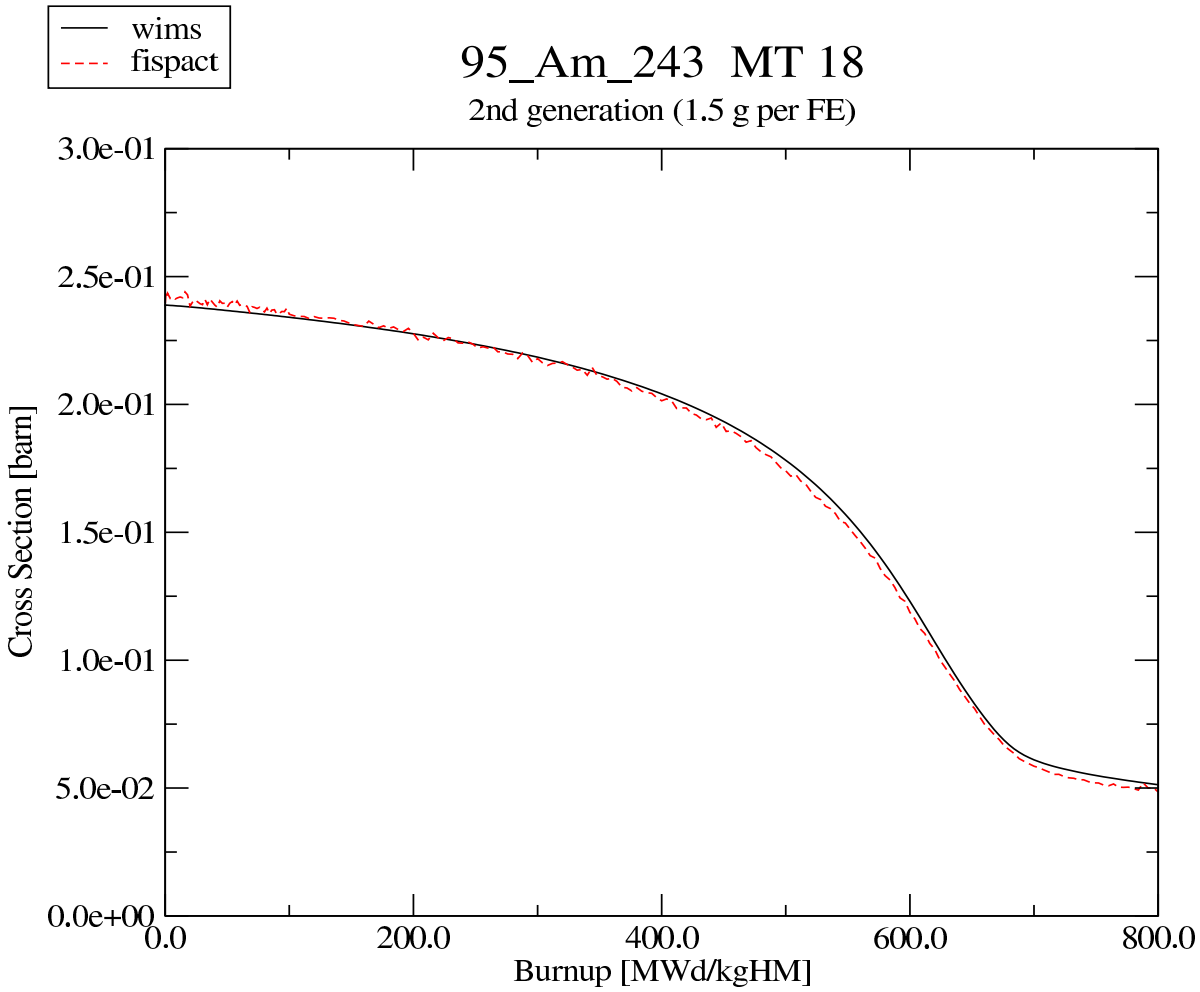


Figure 7.65 Fission Cross Section [$barn$] 95_Am_243 for case C1

Table 7.66 Fission Cross Section [$barn$] 96_Cm_242 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.7387e-01	–	7.7398e-01
100.00	7.9820e-01	–	7.9959e-01
400.00	1.0436e+00	–	1.0574e+00
600.00	1.7904e+00	–	1.8385e+00
800.00	2.4782e+00	–	2.5336e+00

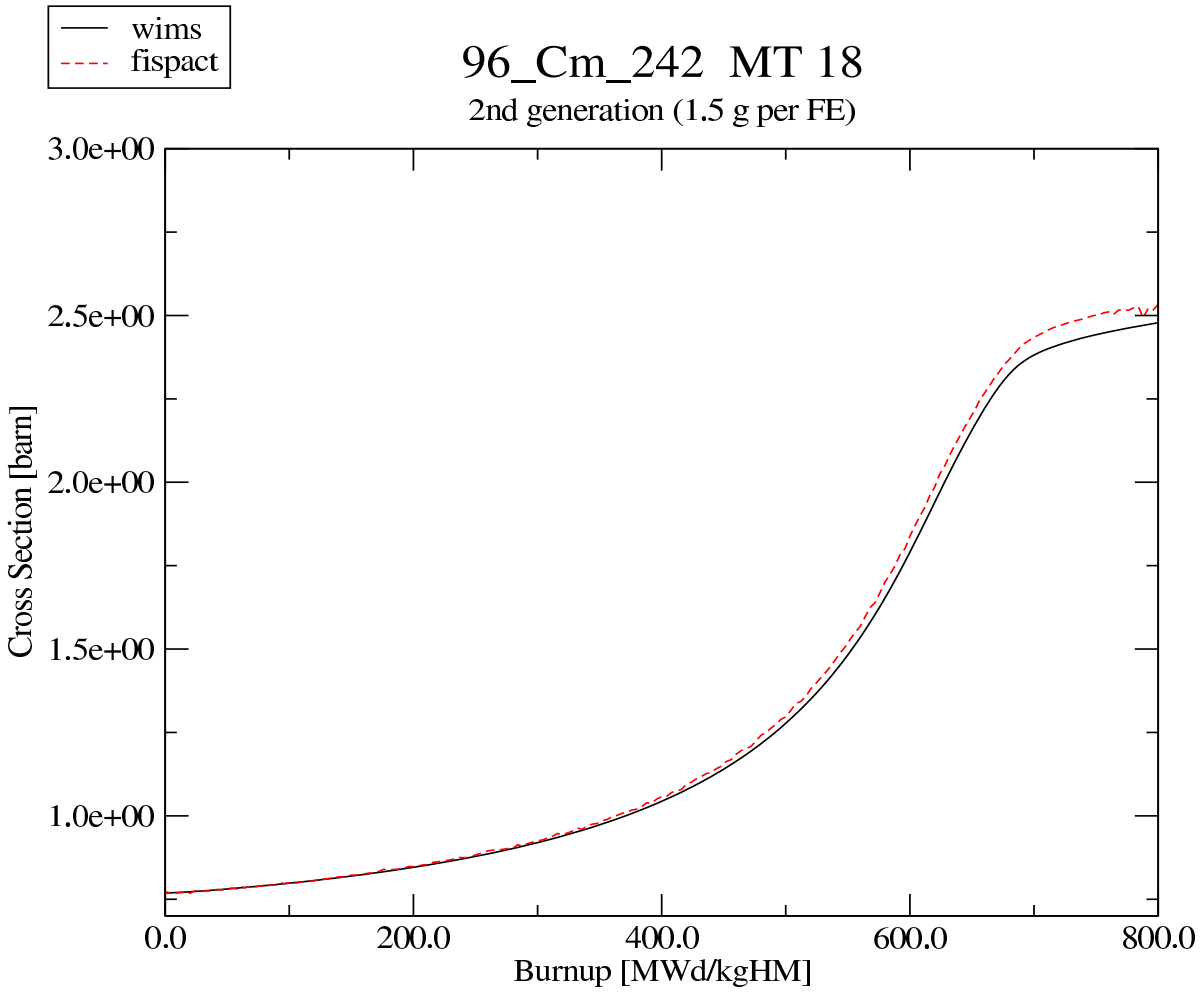


Figure 7.66 Fission Cross Section [$barn$] 96_Cm_242 for case C1

Table 7.67 Fission Cross Section [$barn$] 96_Cm_243 for case C1

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0664e+02	–	1.0523e+02
100.00	1.0730e+02	–	1.0643e+02
400.00	1.2214e+02	–	1.2387e+02
600.00	1.6858e+02	–	1.7181e+02
800.00	2.1063e+02	–	2.1404e+02

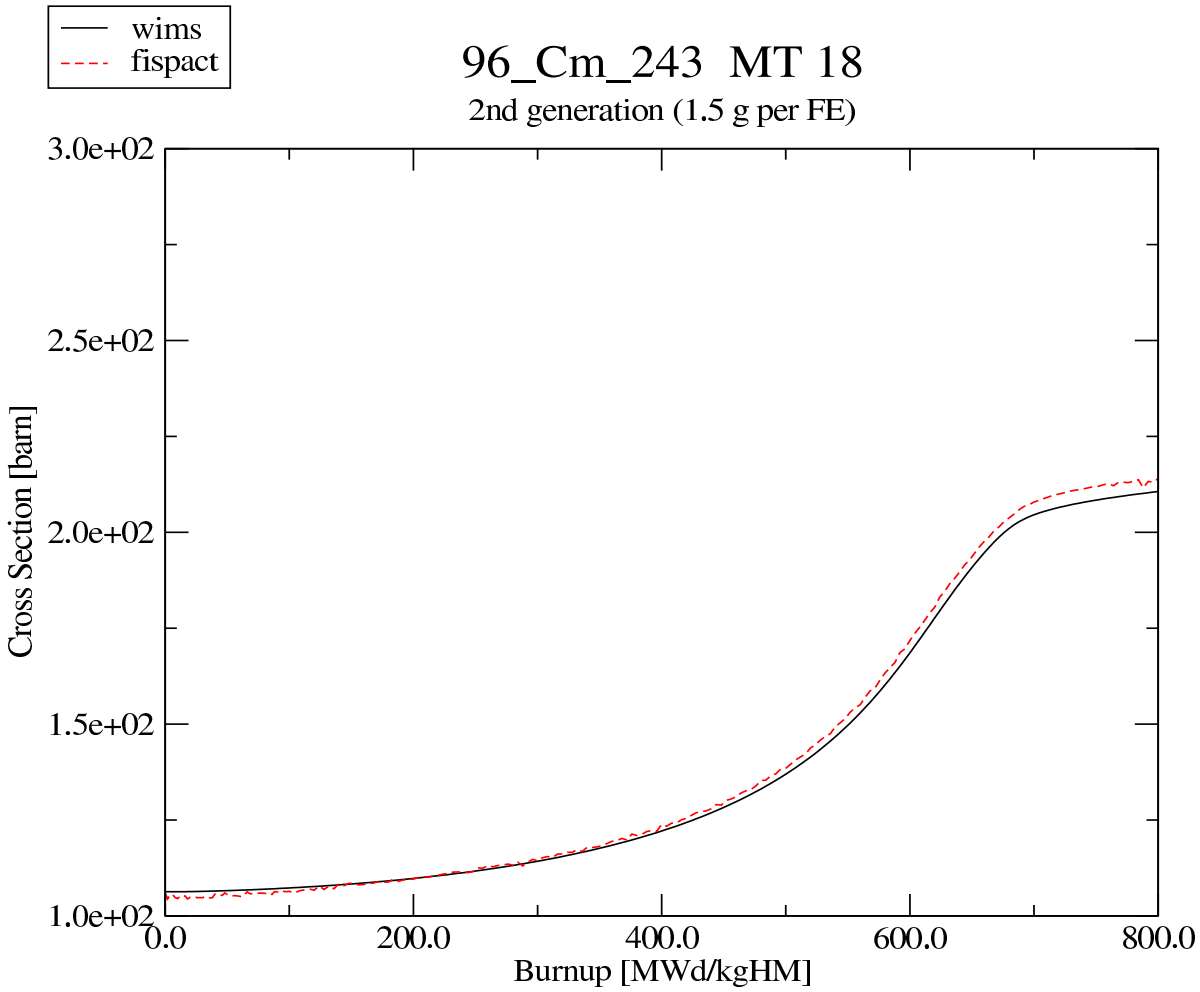


Figure 7.67 Fission Cross Section [$barn$] 96_Cm_243 for case C1

Table 7.68 Fission Cross Section [*barn*] 96_Cm_244 for case C1

burnup [*MWd/kgHM*]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.2644e-01	–	8.4547e-01
100.00	9.1690e-01	–	8.4397e-01
400.00	8.4158e-01	–	7.6132e-01
600.00	6.6237e-01	–	5.0835e-01
800.00	5.0975e-01	–	3.1115e-01

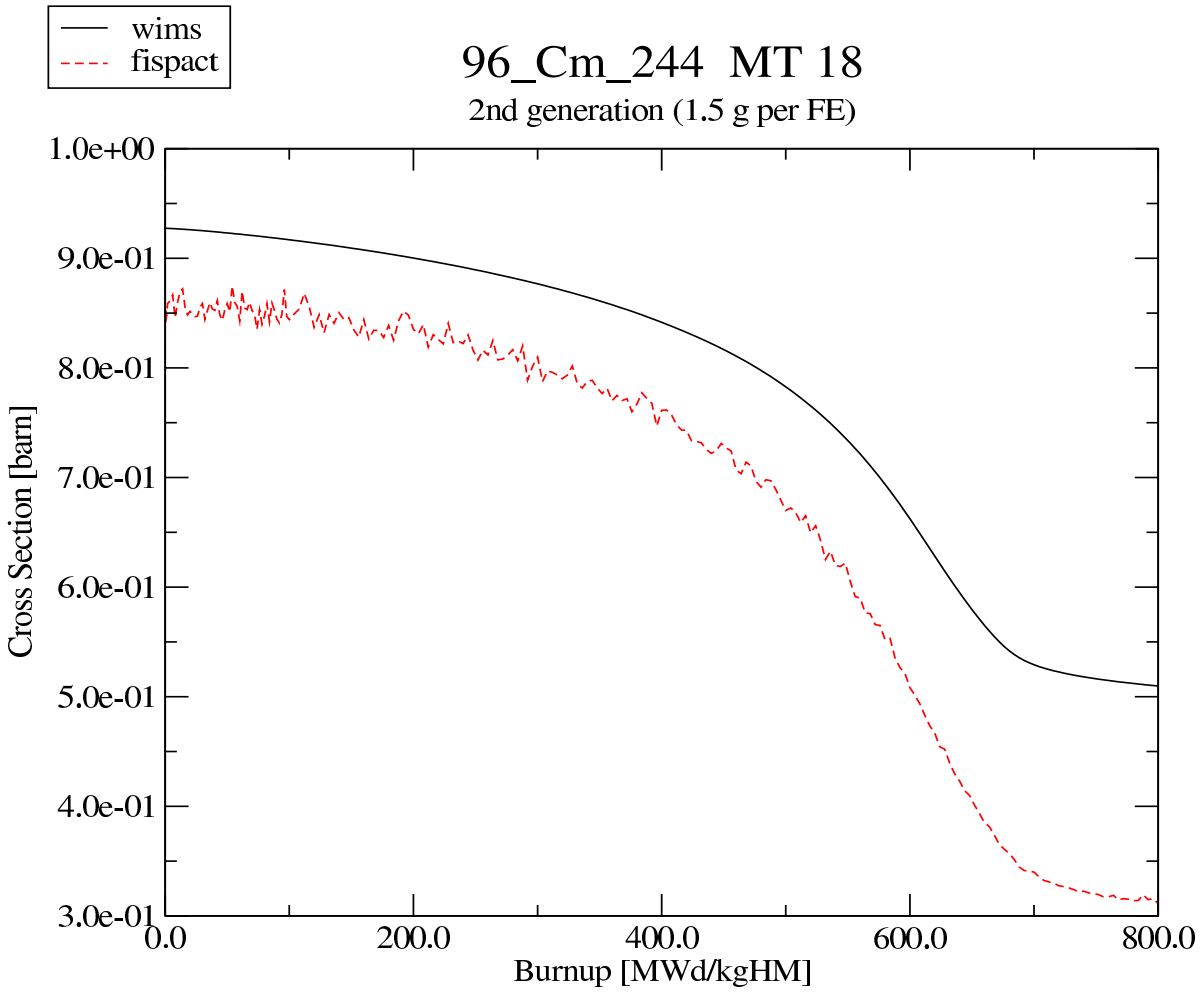


Figure 7.68 Fission Cross Section [*barn*] 96_Cm_244 for case C1

Table 7.69 Fission Cross Section [*barn*] 96_Cm_245 for case C1

burnup [*MWd/kgHM*]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.3923e+01	–	9.3975e+01
100.00	1.0089e+02	–	1.0187e+02
400.00	1.7763e+02	–	1.8445e+02
600.00	4.1752e+02	–	4.3692e+02
800.00	6.4160e+02	–	6.6462e+02

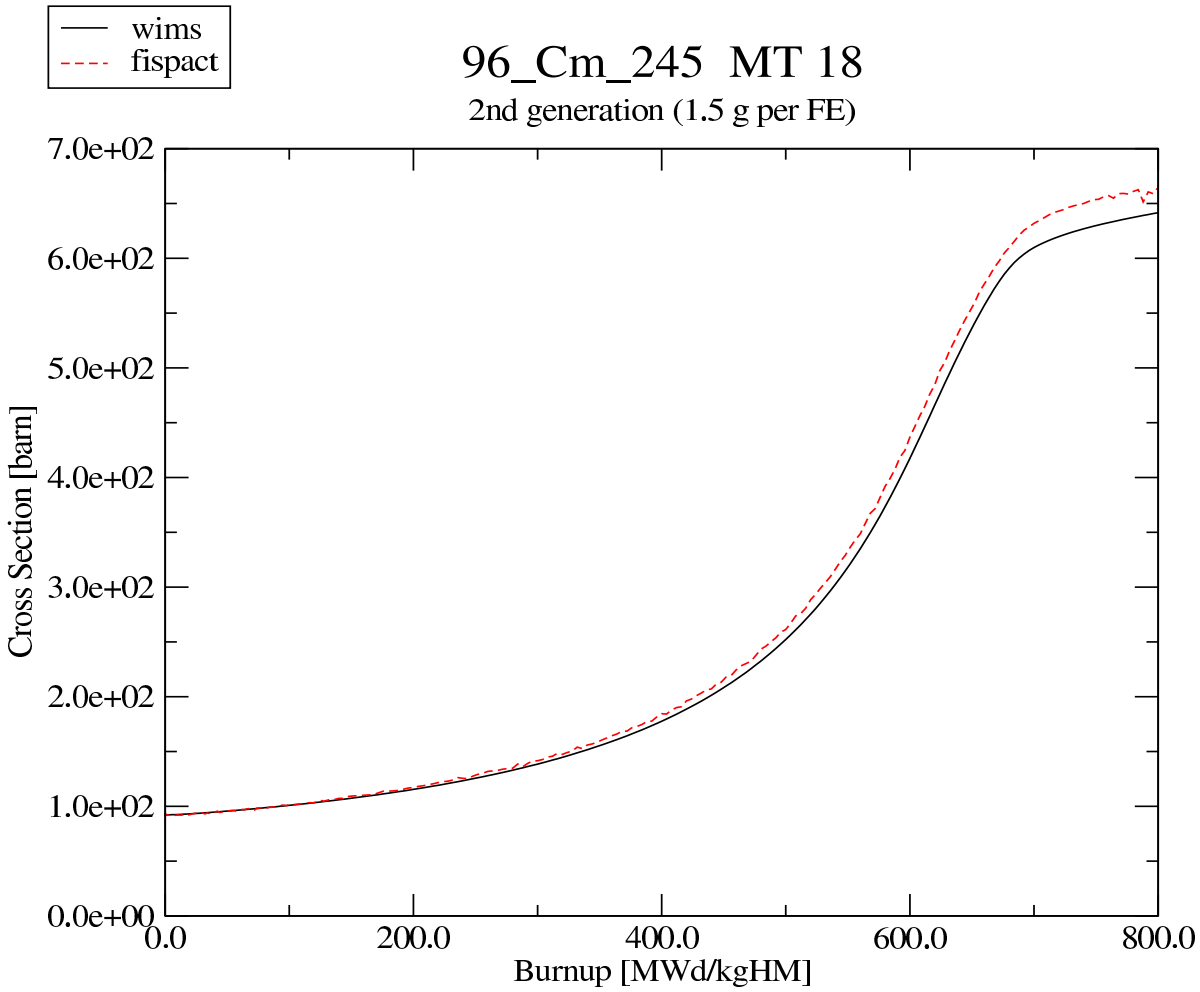


Figure 7.69 Fission Cross Section [*barn*] 96_Cm_245 for case C1

8. Case C2 results and discussion

Case C2 of this Plutonium Cell Burnup Benchmark has 3.0 g plutonium per fuel element (this is the only difference with case C1) with the following 2nd generation composition for
^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu
in weight %: 4.9, 26.9, 34.3, 15.3, 18.3

8.1 Case C2 results

The figures at the end of this chapter show calculation results from all burnup steps. The corresponding tables give numerical values only for the burnup steps that are required by the benchmark specification [2].

Table 8.1 and figure 8.1 give the neutron flux collapsed to 1 group.

Table 8.2 and figure 8.2 give k_∞.

Table 8.3 and figure 8.3 give the fuel temperature coefficient.

Table 8.4 and figure 8.4 give the total fission rate.

Tables 8.5 - 8.25 and figures 8.5 - 8.25 give the nuclide densities.

Tables 8.26 - 8.46 and figures 8.26 - 8.46 give the 1-group microscopic absorption cross sections. Because WIMS does not count (n,2n) as absorption the figures show the OCTOPUS absorption cross sections with (n,2n) subtracted. The tables give the true OCTOPUS absorption cross sections. The WIMS absorption cross sections in the tables are also given with the (n,2n) OCTOPUS average (from OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT) added to it.

Tables 8.47 - 8.58 and figures 8.47 - 8.58 give the 1-group microscopic fission cross sections.

8.2 Case C2 discussion

Only WIMS calculations were done here, so no comparison can be done with OCTOPUS-MCNP-ORIGEN and OCTOPUS-MCNP-FISPACT.

Table 8.1 one group neutron flux $[s^{-1}cm^{-2}]$ for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.9985e+14	–	–
100.00	1.9646e+14	–	–
400.00	2.0381e+14	–	–
600.00	3.1726e+14	–	–
800.00	2.8390e+15	–	–

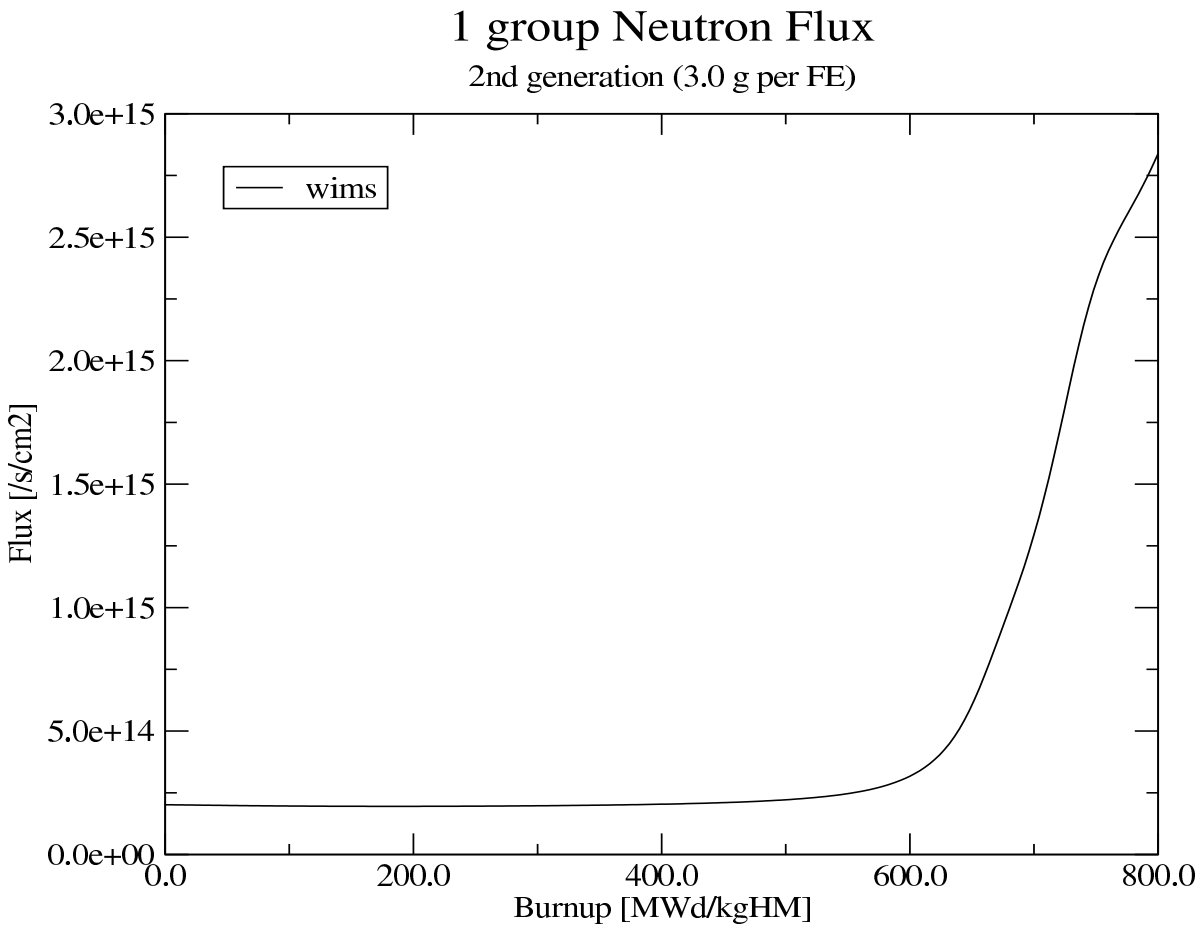


Figure 8.1 one group neutron flux $[s^{-1}cm^{-2}]$ for case C2

Table 8.2 k_∞ for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	0.9330	–	–
100.00	0.9504	–	–
400.00	0.9813	–	–
600.00	0.8623	–	–
800.00	0.4157	–	–

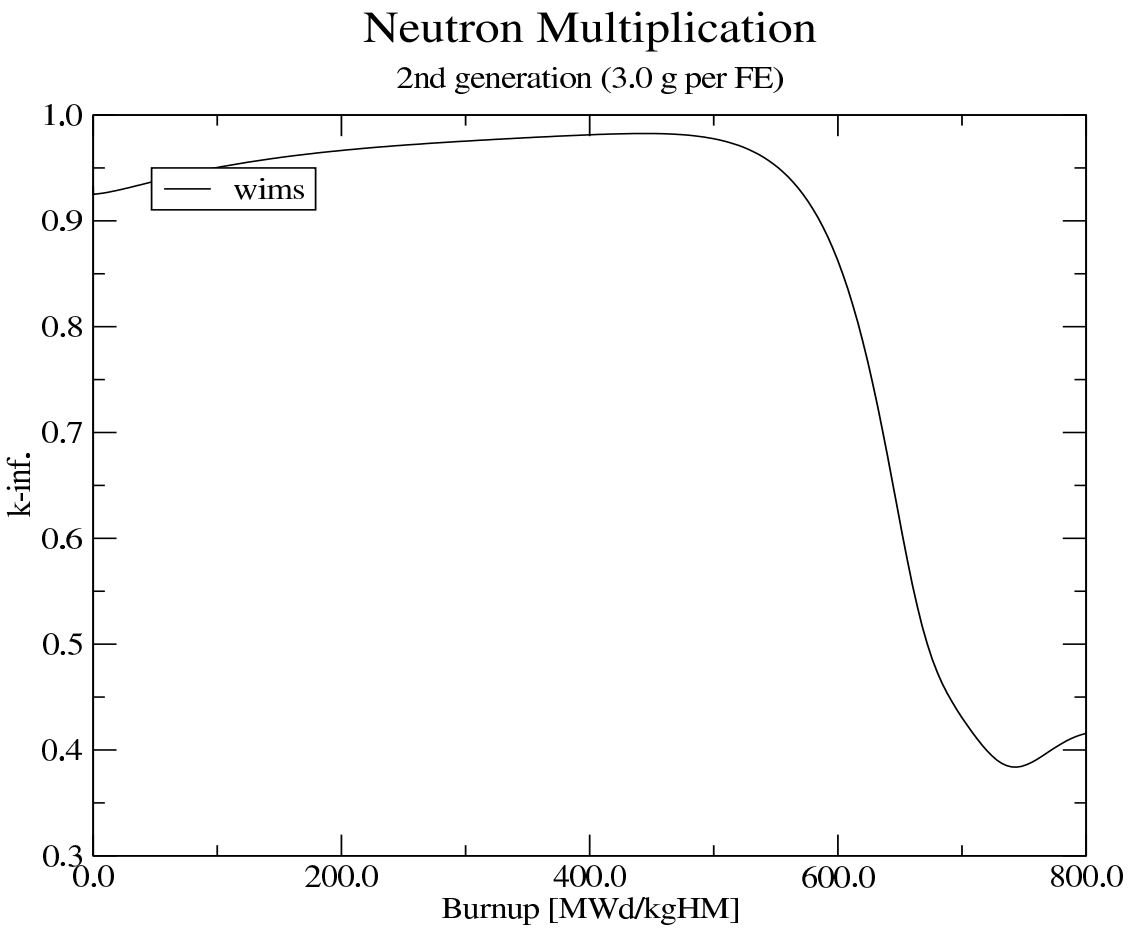


Figure 8.2 k_∞ for case C2

Table 8.3 FTC $[pcm/K]$ for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	-14.90	–	–
100.00	-13.66	–	–
400.00	-11.03	–	–
600.00	-4.64	–	–
800.00	-46.43	–	–

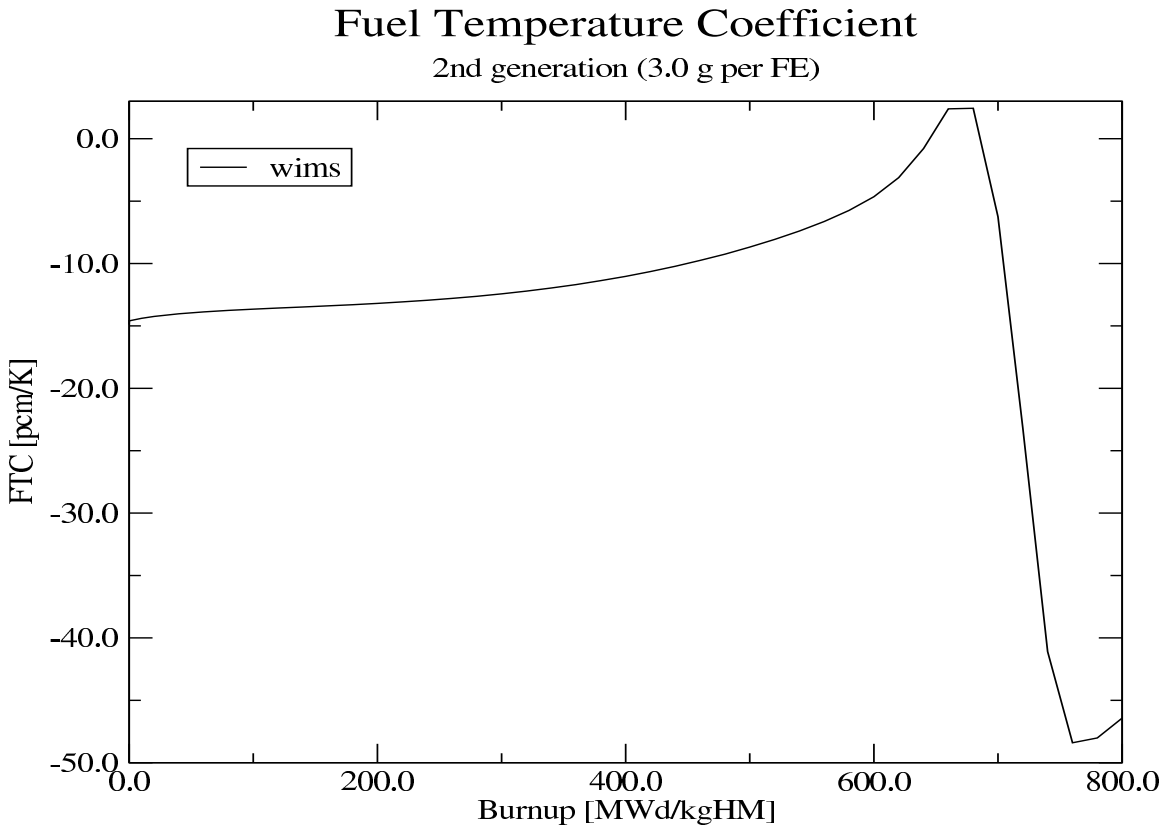


Figure 8.3 FTC $[pcm/K]$ for case C2

Table 8.4 Fission Rate $[s^{-1}]$ for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.9558e+13	–	–
100.00	2.9499e+13	–	–
400.00	2.9373e+13	–	–
600.00	2.9203e+13	–	–
800.00	2.8285e+13	–	–

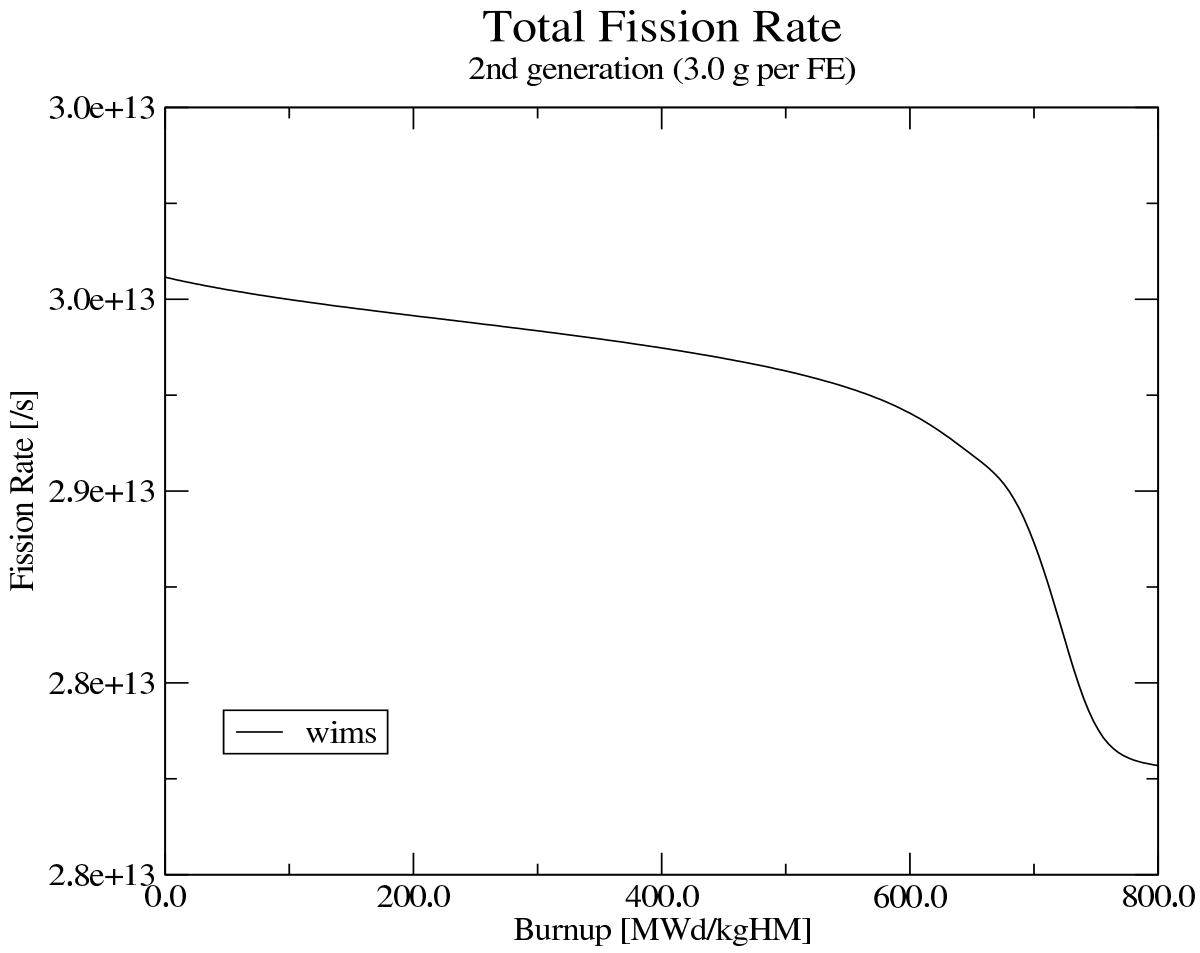


Figure 8.4 Fission Rate $[s^{-1}]$ for case C2

Table 8.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.1377e-03	–	–
100.00	1.0607e-03	–	–
400.00	1.0003e-03	–	–
600.00	8.7139e-04	–	–
800.00	1.5090e-06	–	–

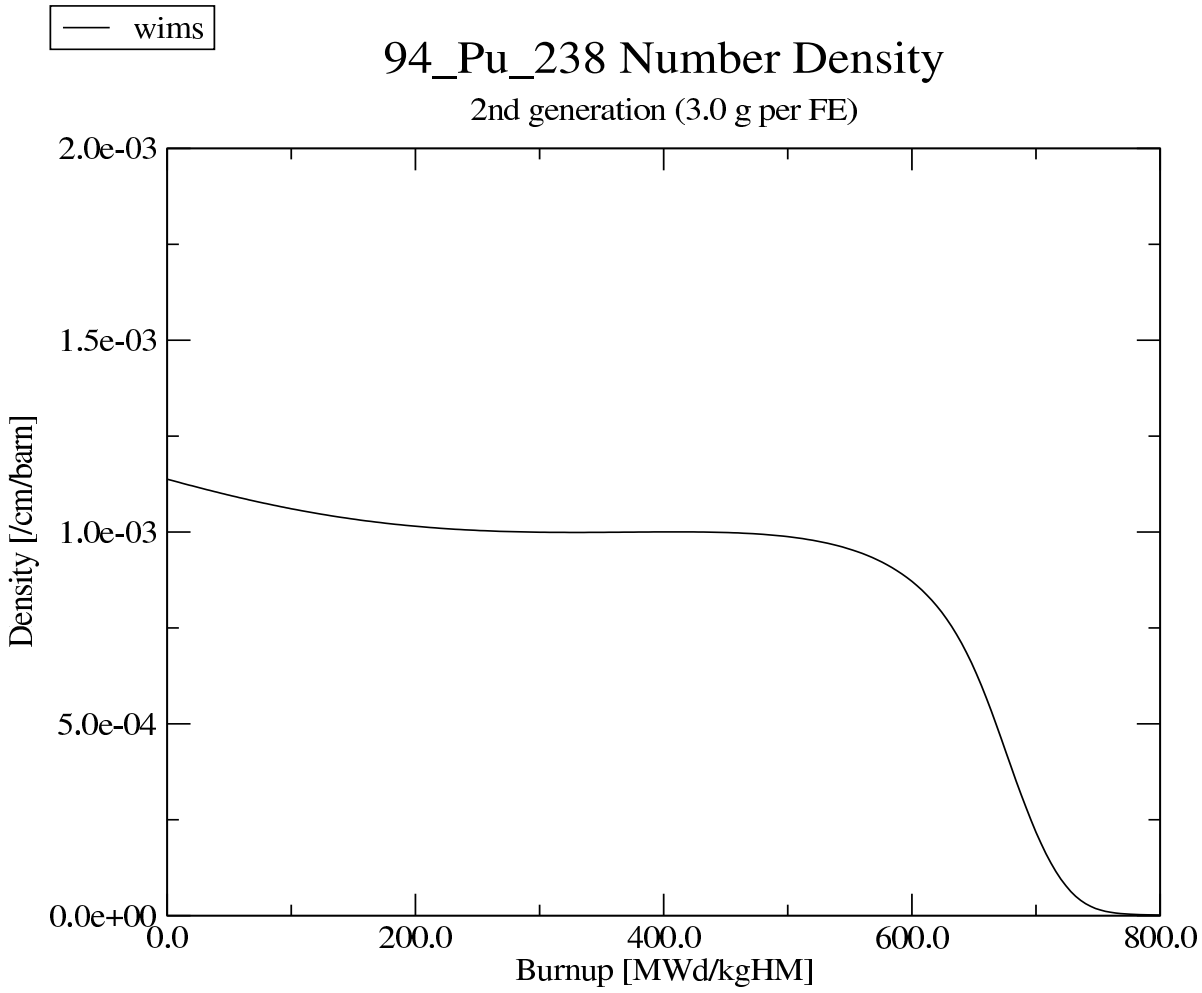


Figure 8.5 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_238 for case C2

Table 8.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.2195e-03	–	–
100.00	4.4149e-03	–	–
400.00	1.0496e-03	–	–
600.00	1.4537e-04	–	–
800.00	1.9055e-07	–	–

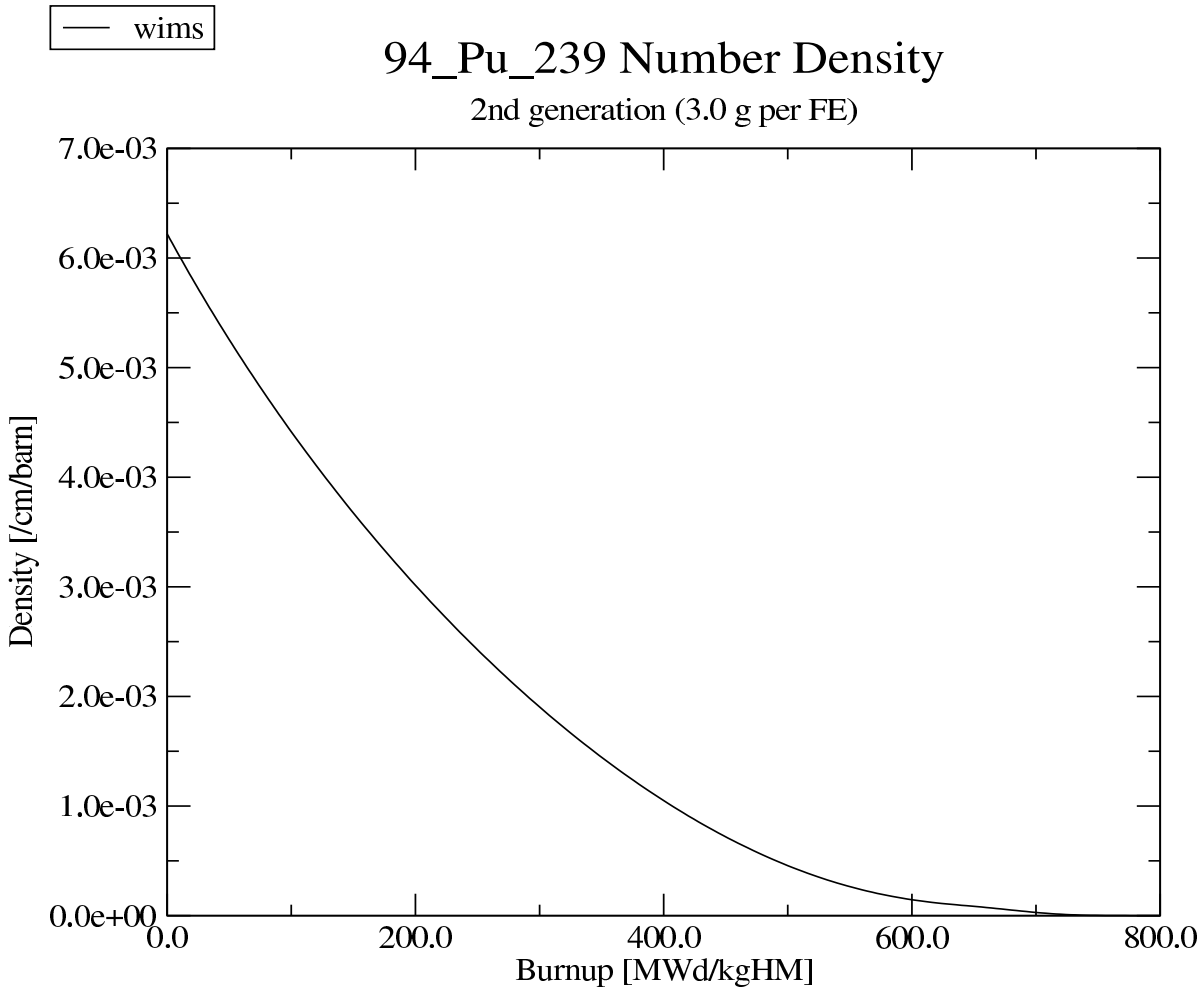


Figure 8.6 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_239 for case C2

Table 8.7 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_240 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.8974e-03	–	–
100.00	5.8354e-03	–	–
400.00	1.5613e-03	–	–
600.00	2.3890e-04	–	–
800.00	5.1245e-06	–	–

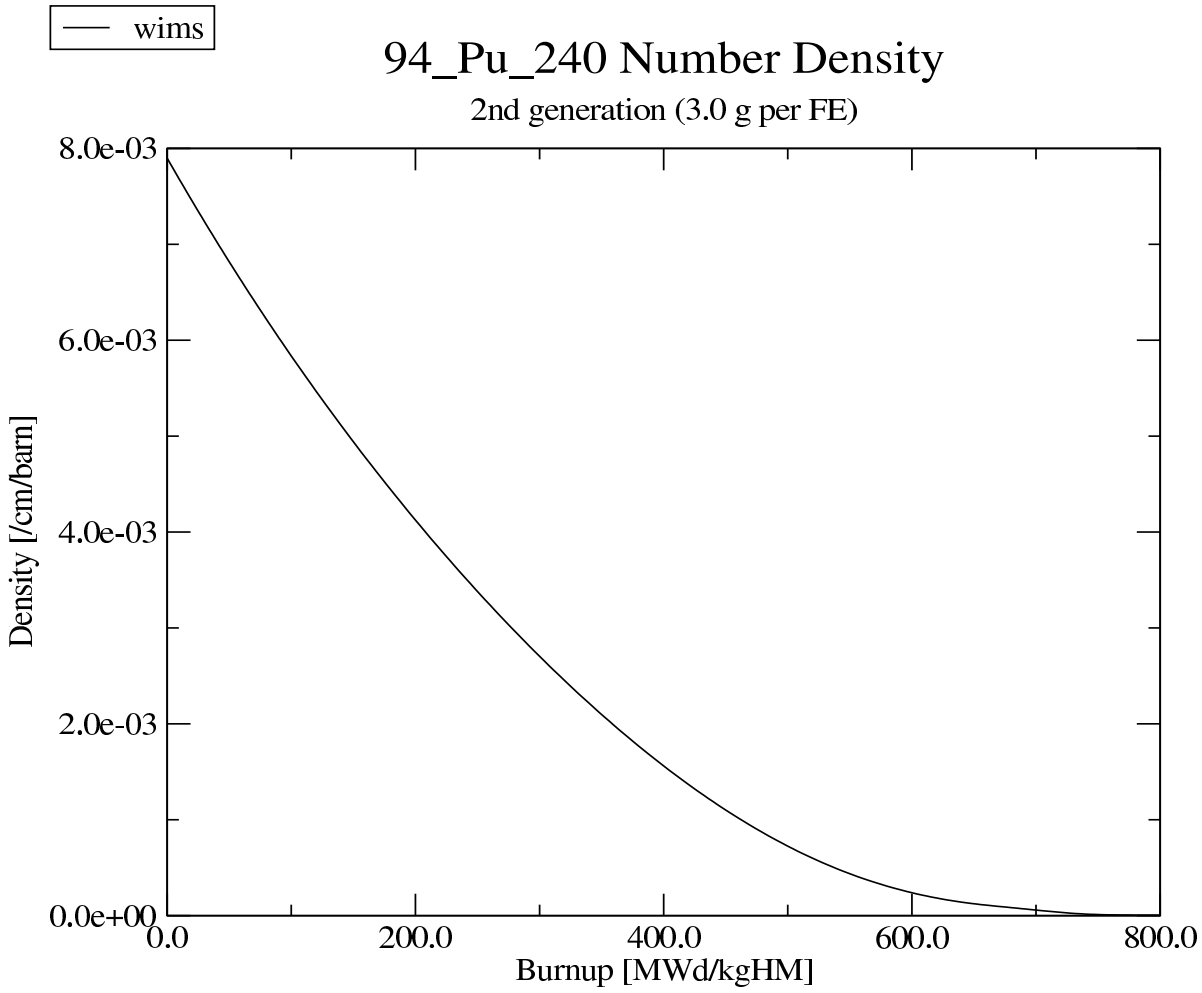


Figure 8.7 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_240 for case C2

Table 8.8 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_241 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.5081e-03	–	–
100.00	4.5850e-03	–	–
400.00	3.6069e-03	–	–
600.00	7.4040e-04	–	–
800.00	1.4820e-06	–	–

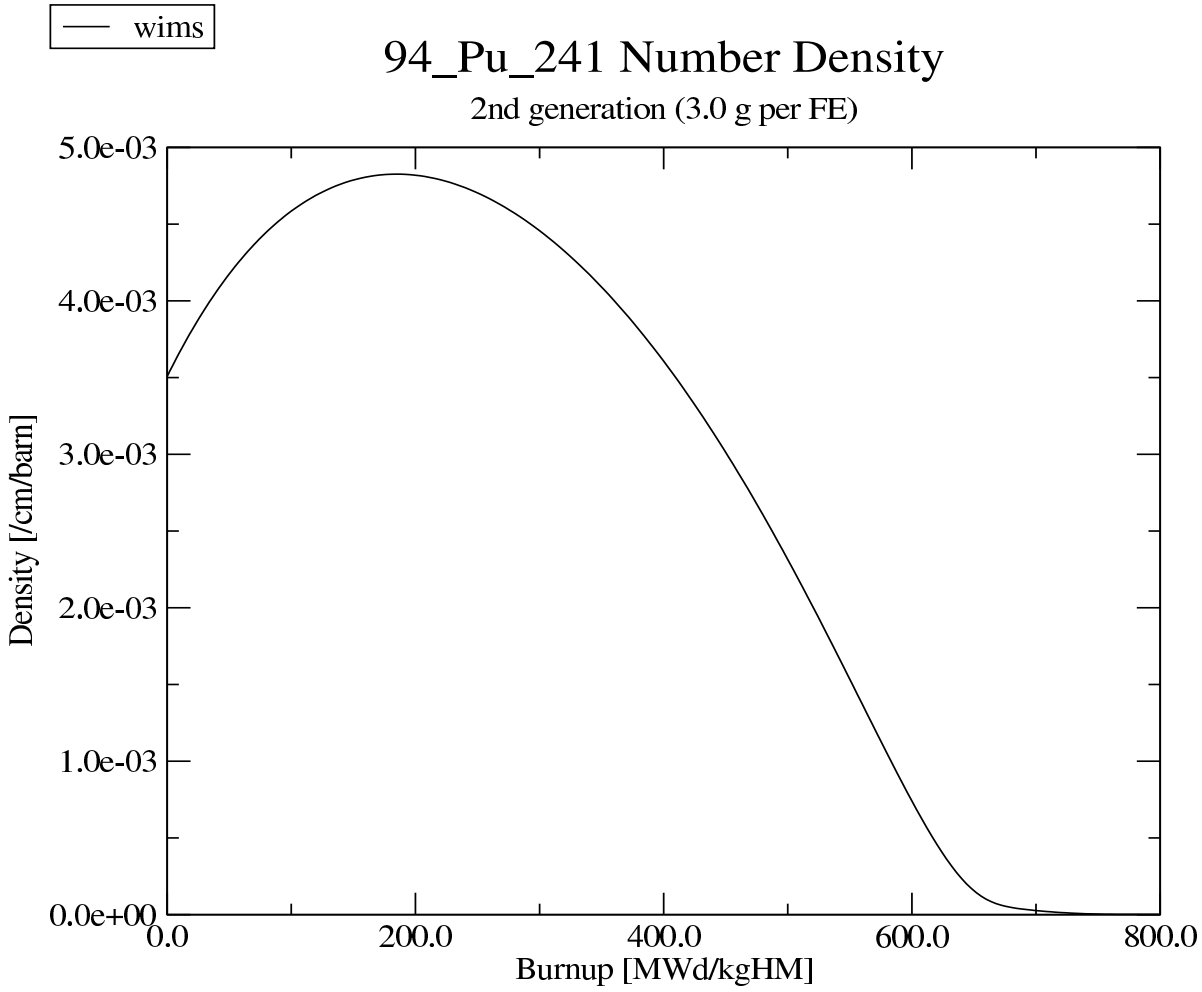


Figure 8.8 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_241 for case C2

Table 8.9 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_242 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.2471e-03	–	–
100.00	3.9537e-03	–	–
400.00	3.7329e-03	–	–
600.00	3.6573e-03	–	–
800.00	9.9285e-04	–	–

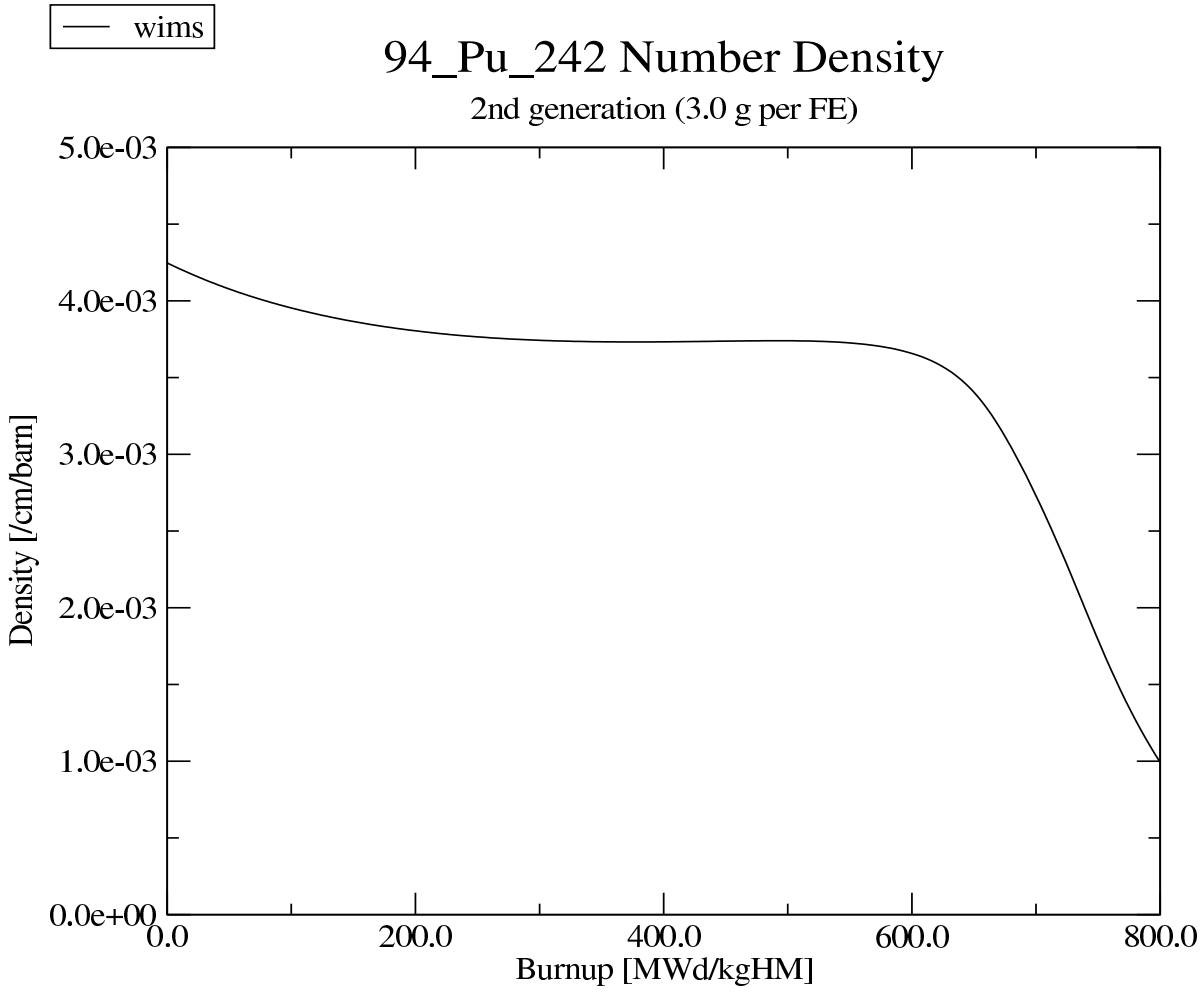


Figure 8.9 Number Density [$cm^{-1}barn^{-1}$] 94_Pu_242 for case C2

Table 8.10 Number Density [$cm^{-1}barn^{-1}$] 95_Am_241 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.3280e-04	–	–
400.00	2.7021e-04	–	–
600.00	7.0502e-05	–	–
800.00	1.2998e-09	–	–

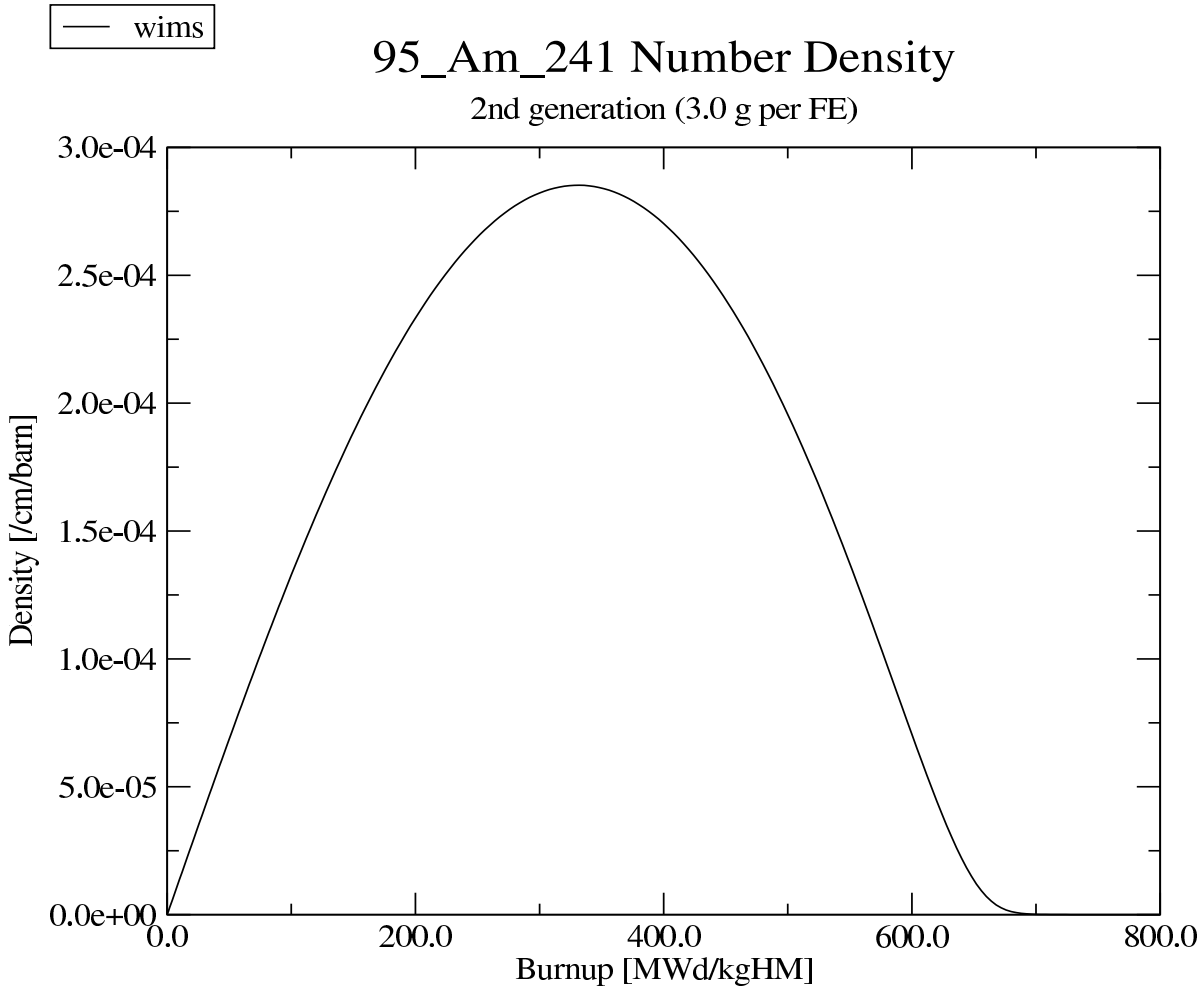


Figure 8.10 Number Density [$cm^{-1}barn^{-1}$] 95_Am_241 for case C2

Table 8.11 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	2.0935e-06	–	–
400.00	7.8654e-06	–	–
600.00	1.4967e-06	–	–
800.00	1.8089e-11	–	–

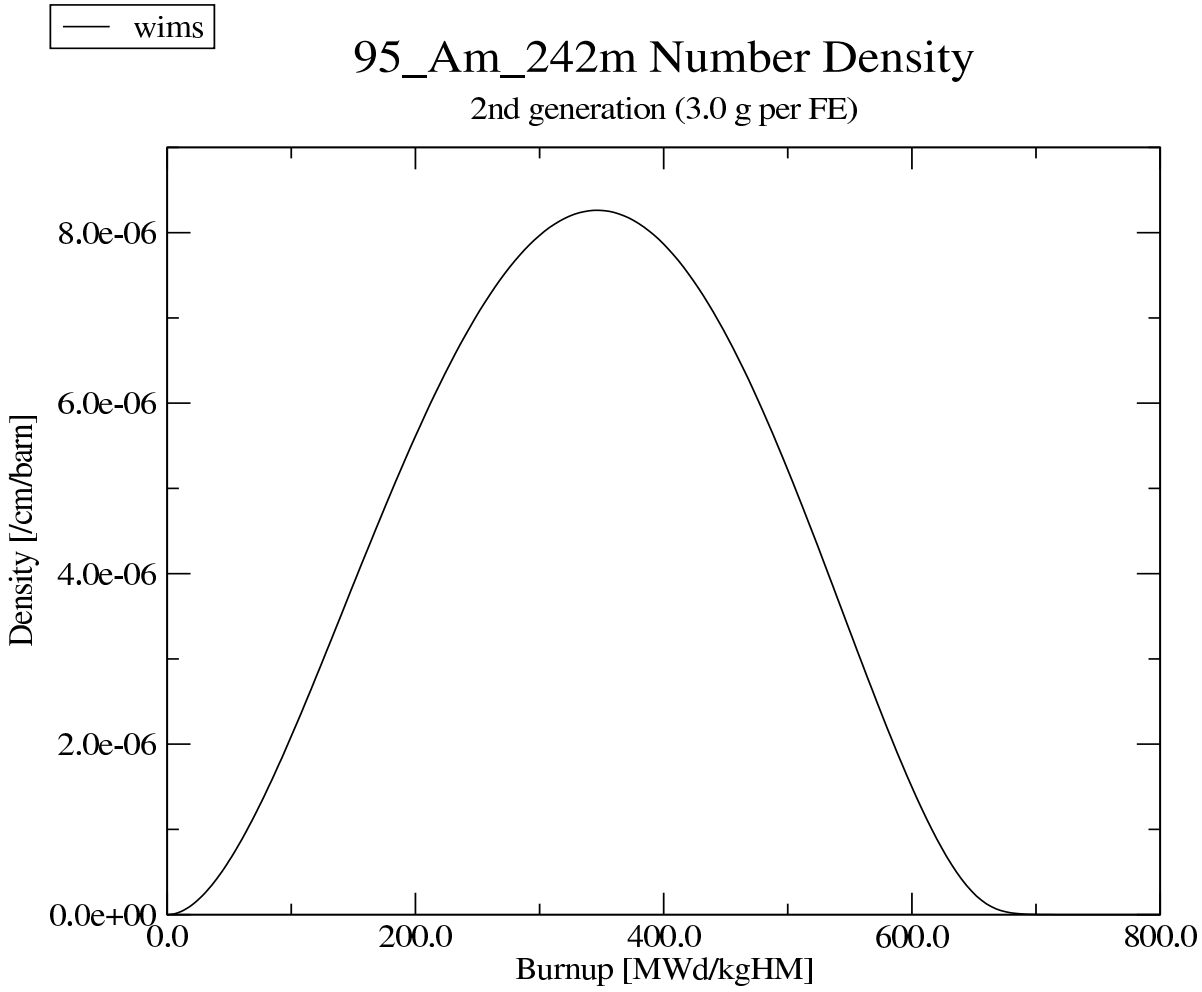


Figure 8.11 Number Density [$cm^{-1}barn^{-1}$] 95_Am_242m for case C2

Table 8.12 Number Density [$cm^{-1}barn^{-1}$] 95_Am_243 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	5.4372e-04	–	–
400.00	1.2447e-03	–	–
600.00	1.3930e-03	–	–
800.00	4.9028e-04	–	–

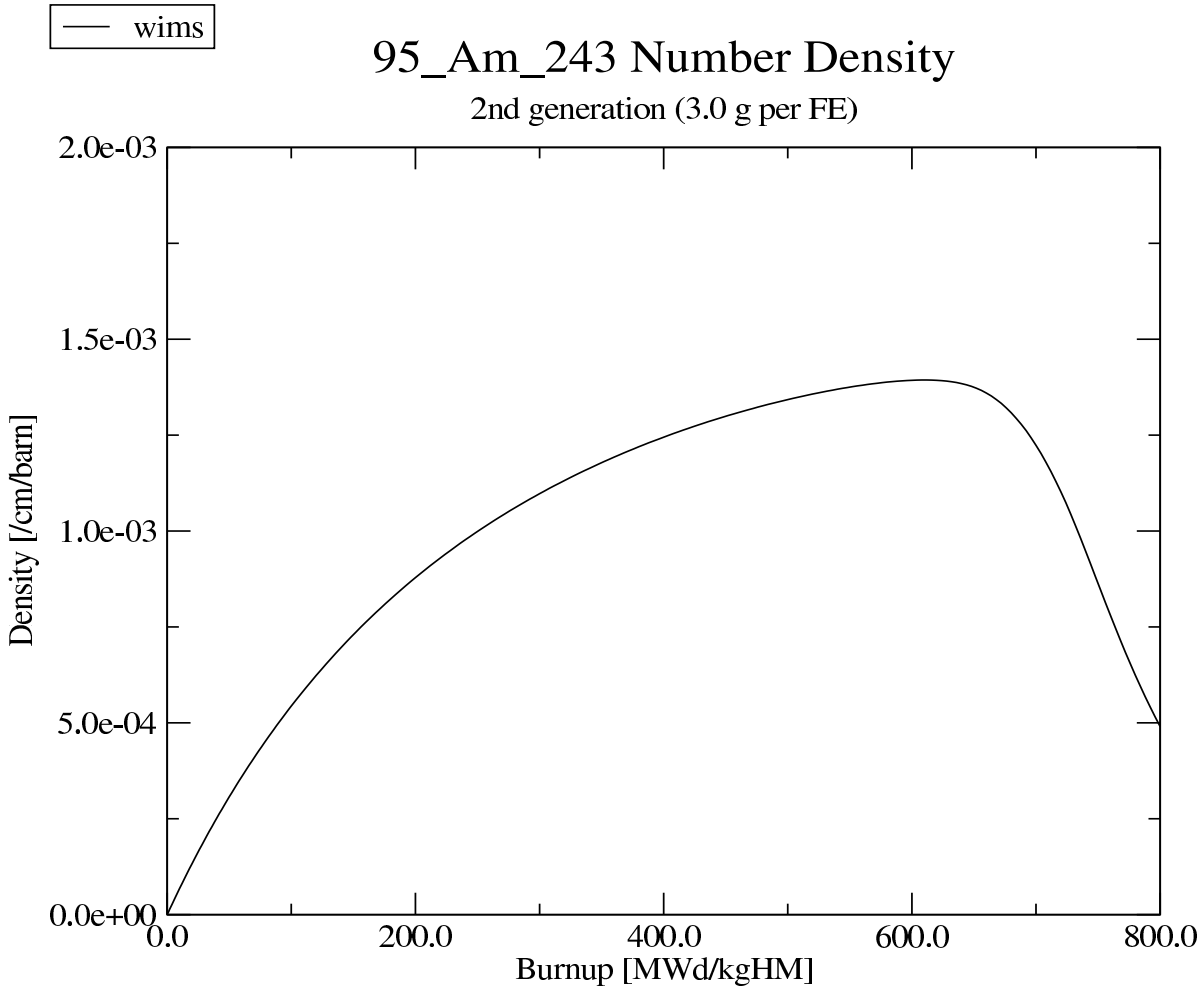


Figure 8.12 Number Density [$cm^{-1}barn^{-1}$] 95_Am_243 for case C2

Table 8.13 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_242 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.5182e-05	–	–
400.00	9.0846e-05	–	–
600.00	1.0197e-04	–	–
800.00	7.9542e-06	–	–

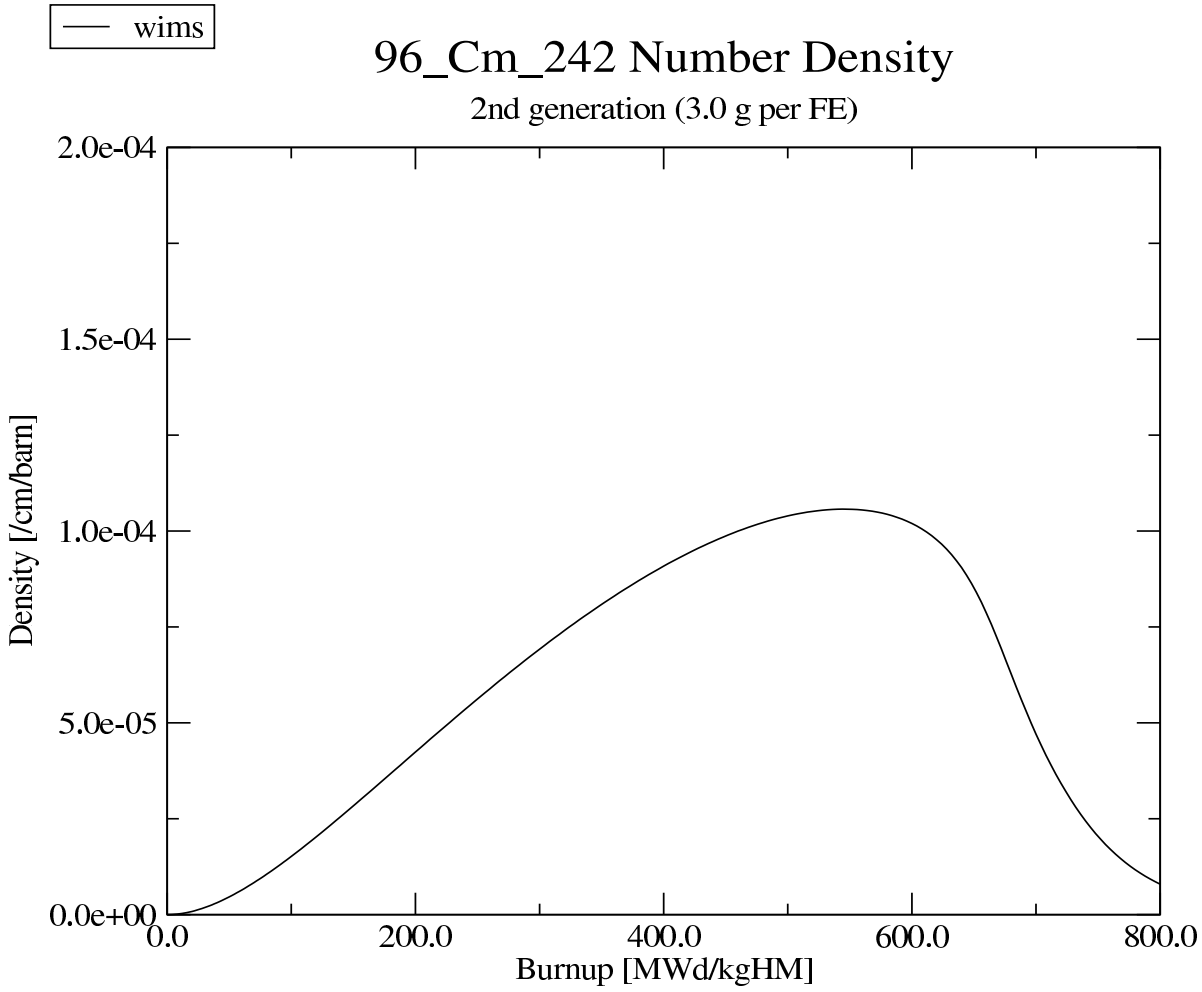


Figure 8.13 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_242 for case C2

Table 8.14 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.6426e-07	–	–
400.00	3.2144e-06	–	–
600.00	4.7355e-06	–	–
800.00	2.6935e-07	–	–

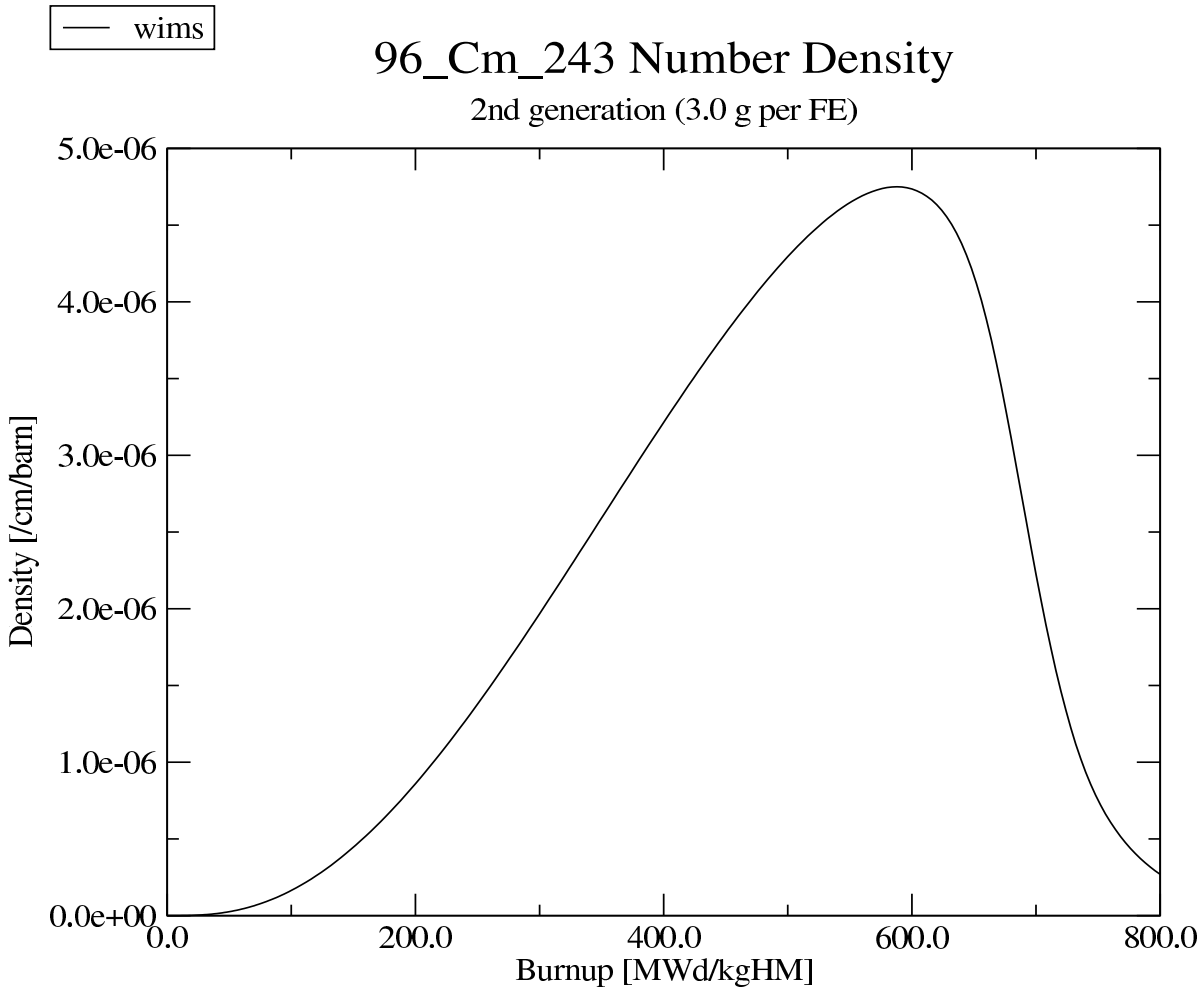


Figure 8.14 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_243 for case C2

Table 8.15 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_244 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.1200e-04	–	–
400.00	9.3204e-04	–	–
600.00	1.5949e-03	–	–
800.00	2.7261e-03	–	–

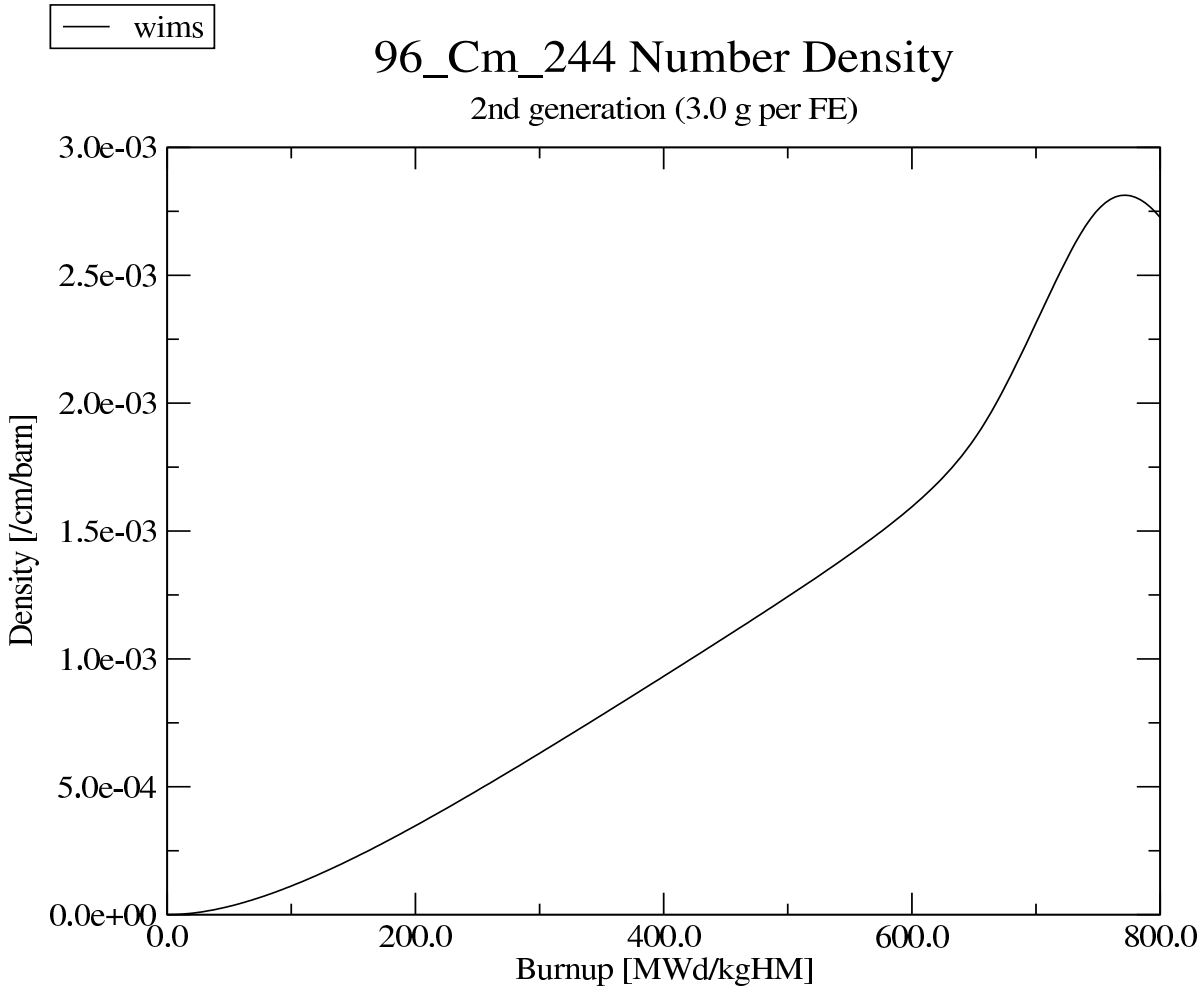


Figure 8.15 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_244 for case C2

Table 8.16 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	6.0935e-06	–	–
400.00	1.5575e-04	–	–
600.00	2.0029e-04	–	–
800.00	4.8324e-05	–	–

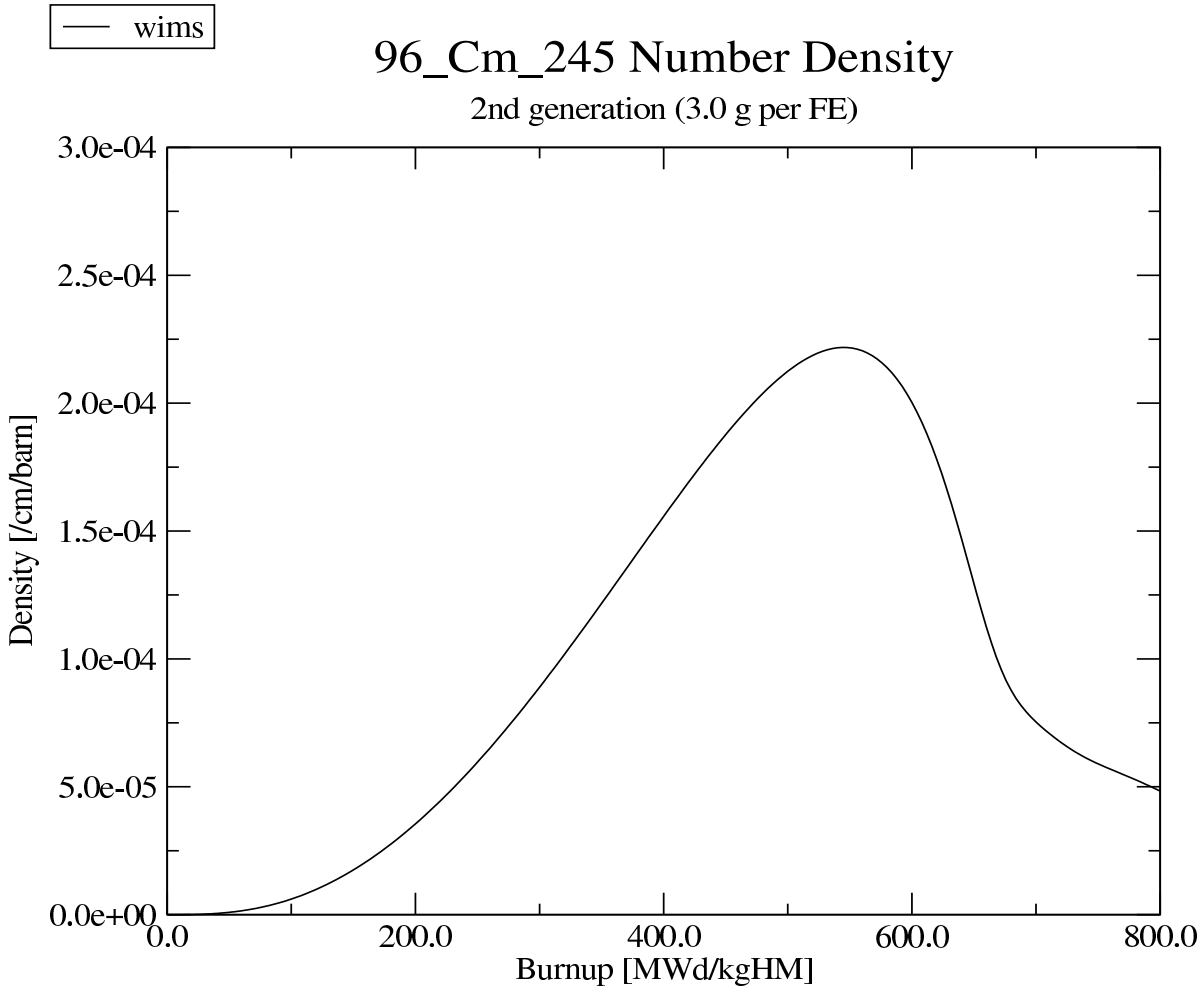


Figure 8.16 Number Density $[cm^{-1}barn^{-1}]$ 96_Cm_245 for case C2

Table 8.17 Number Density $[cm^{-1}barn^{-1}]$ 40_Zr_93 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	7.9858e-05	–	–
400.00	3.0028e-04	–	–
600.00	4.3095e-04	–	–
800.00	4.9766e-04	–	–

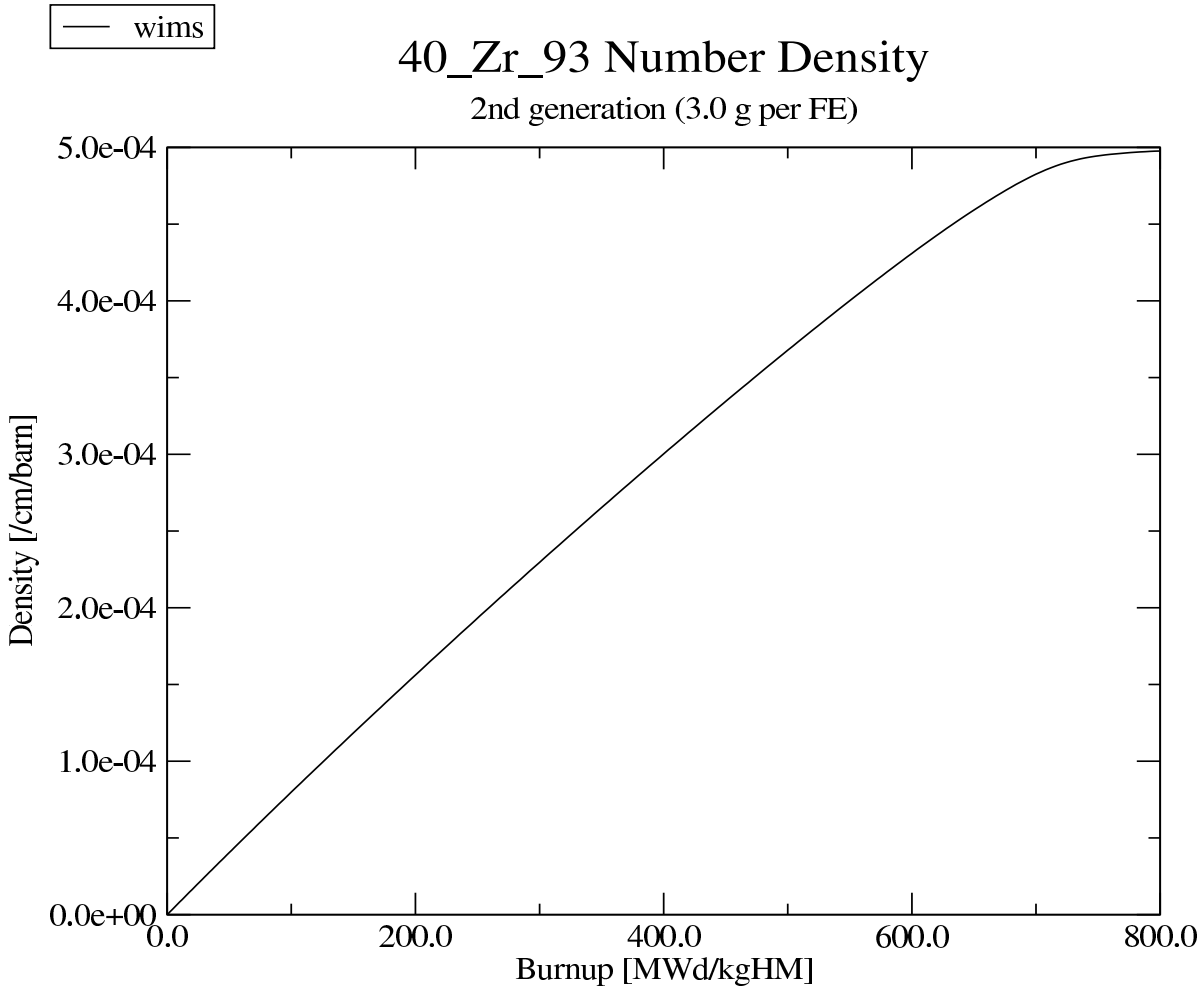


Figure 8.17 Number Density $[cm^{-1}barn^{-1}]$ 40_Zr_93 for case C2

Table 8.18 Number Density [$cm^{-1}barn^{-1}$] 43_Tc_99 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.3382e-04	–	–
400.00	4.7114e-04	–	–
600.00	6.3462e-04	–	–
800.00	4.0384e-04	–	–

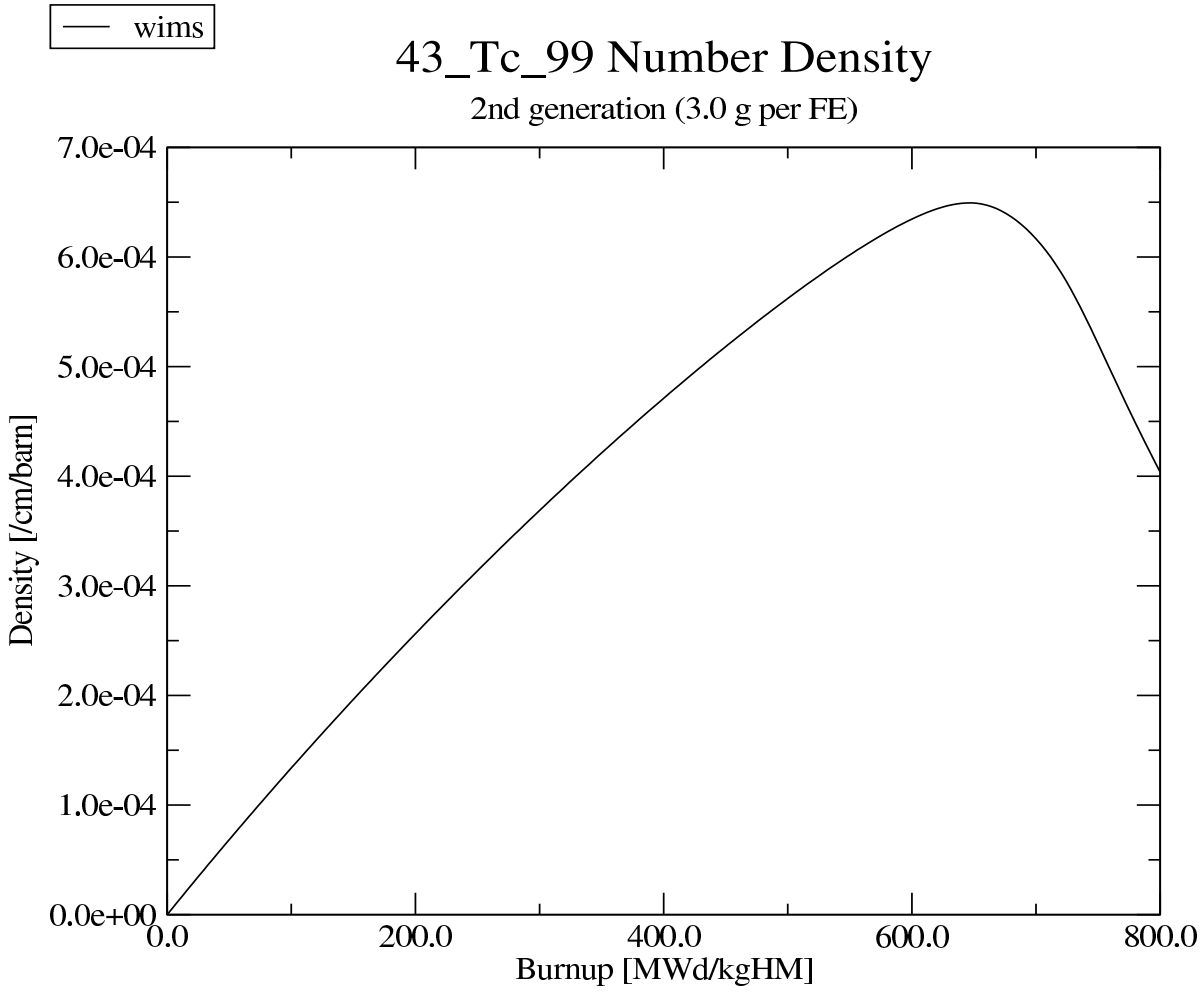


Figure 8.18 Number Density [$cm^{-1}barn^{-1}$] 43_Tc_99 for case C2

Table 8.19 Number Density [$cm^{-1}barn^{-1}$] 46_Pd_107 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	9.4399e-05	–	–
400.00	3.8481e-04	–	–
600.00	5.7510e-04	–	–
800.00	6.9570e-04	–	–

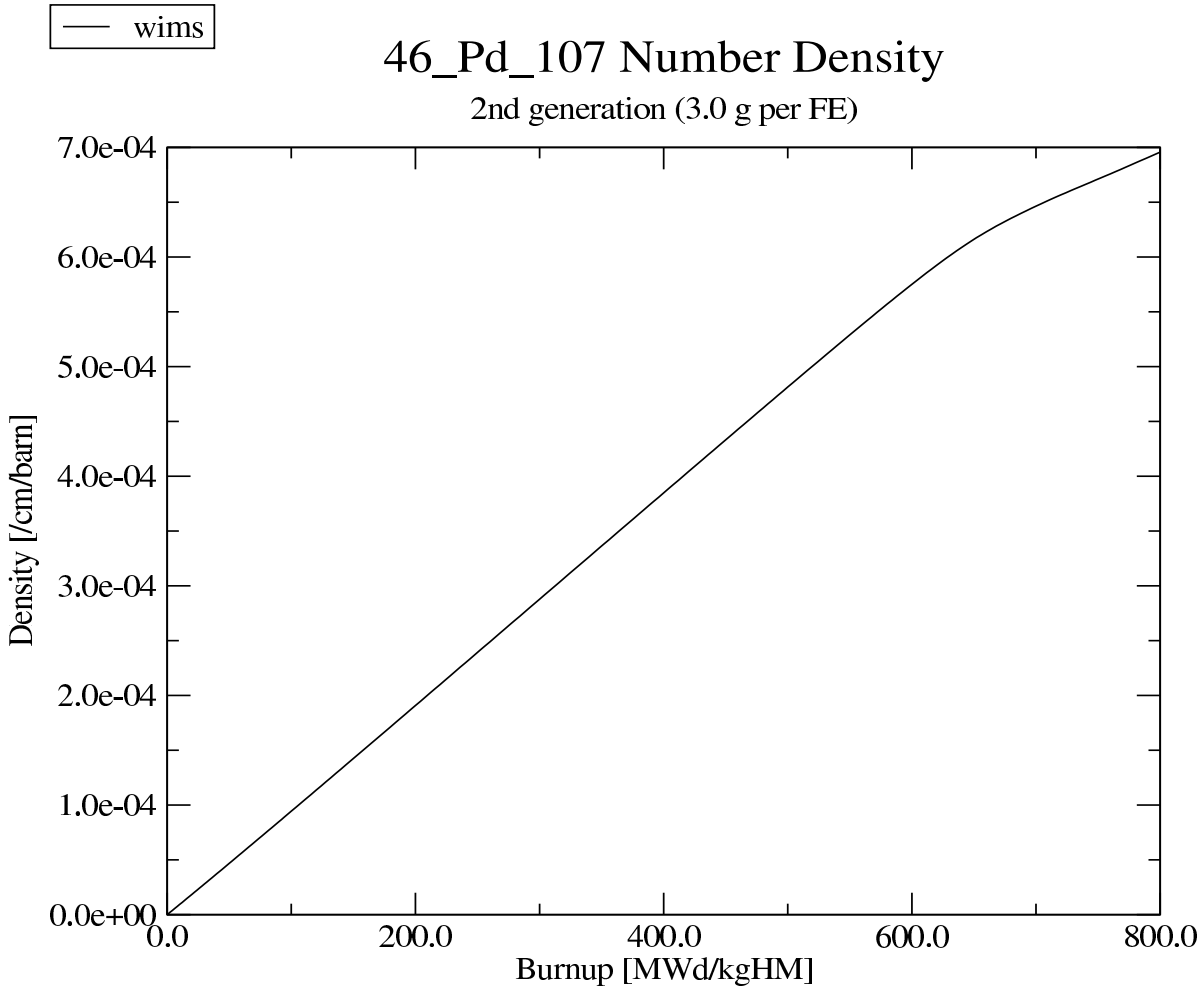


Figure 8.19 Number Density [$cm^{-1}barn^{-1}$] 46_Pd_107 for case C2

Table 8.20 Number Density [$cm^{-1}barn^{-1}$] 53_I_129 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	3.2406e-05	–	–
400.00	1.2590e-04	–	–
600.00	1.8108e-04	–	–
800.00	1.1202e-04	–	–

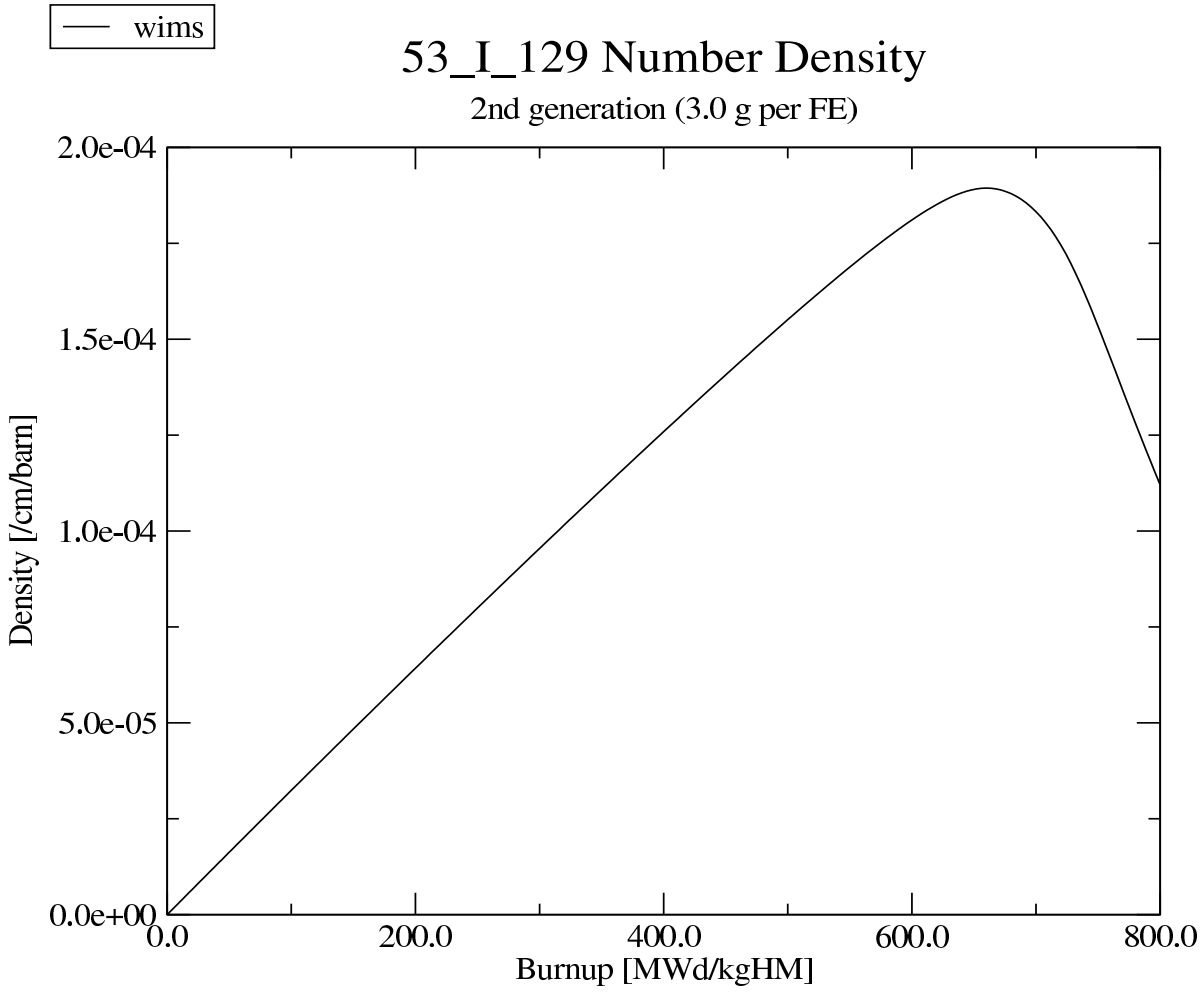


Figure 8.20 Number Density [$cm^{-1}barn^{-1}$] 53_I_129 for case C2

Table 8.21 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_135 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.3393e-04	–	–
400.00	4.7941e-04	–	–
600.00	6.0706e-04	–	–
800.00	9.3053e-04	–	–

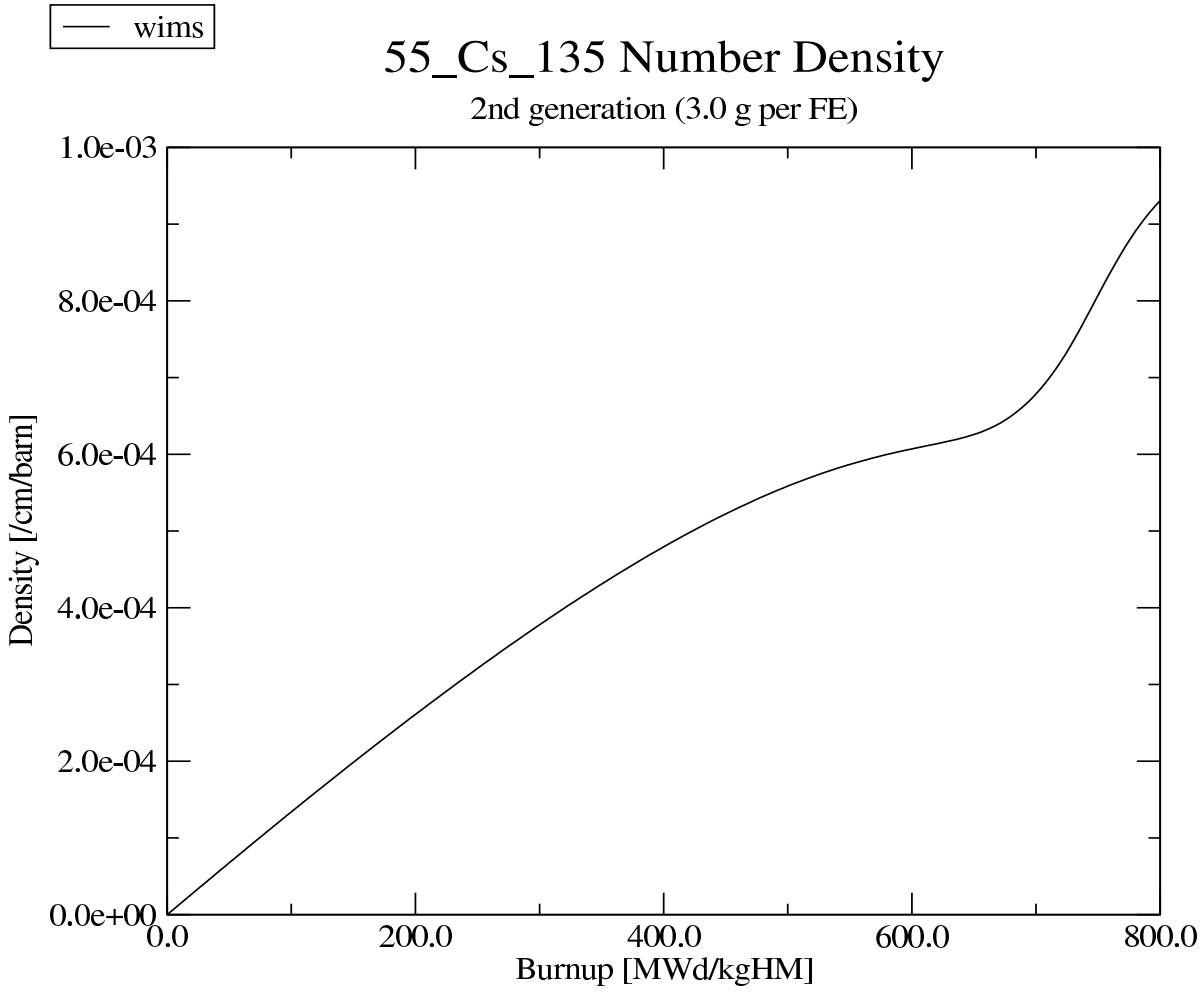


Figure 8.21 Number Density $[cm^{-1}barn^{-1}]$ 55_Cs_135 for case C2

Table 8.22 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_147 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	3.6027e-06	–	–
400.00	2.8302e-05	–	–
600.00	3.8710e-05	–	–
800.00	5.7627e-06	–	–

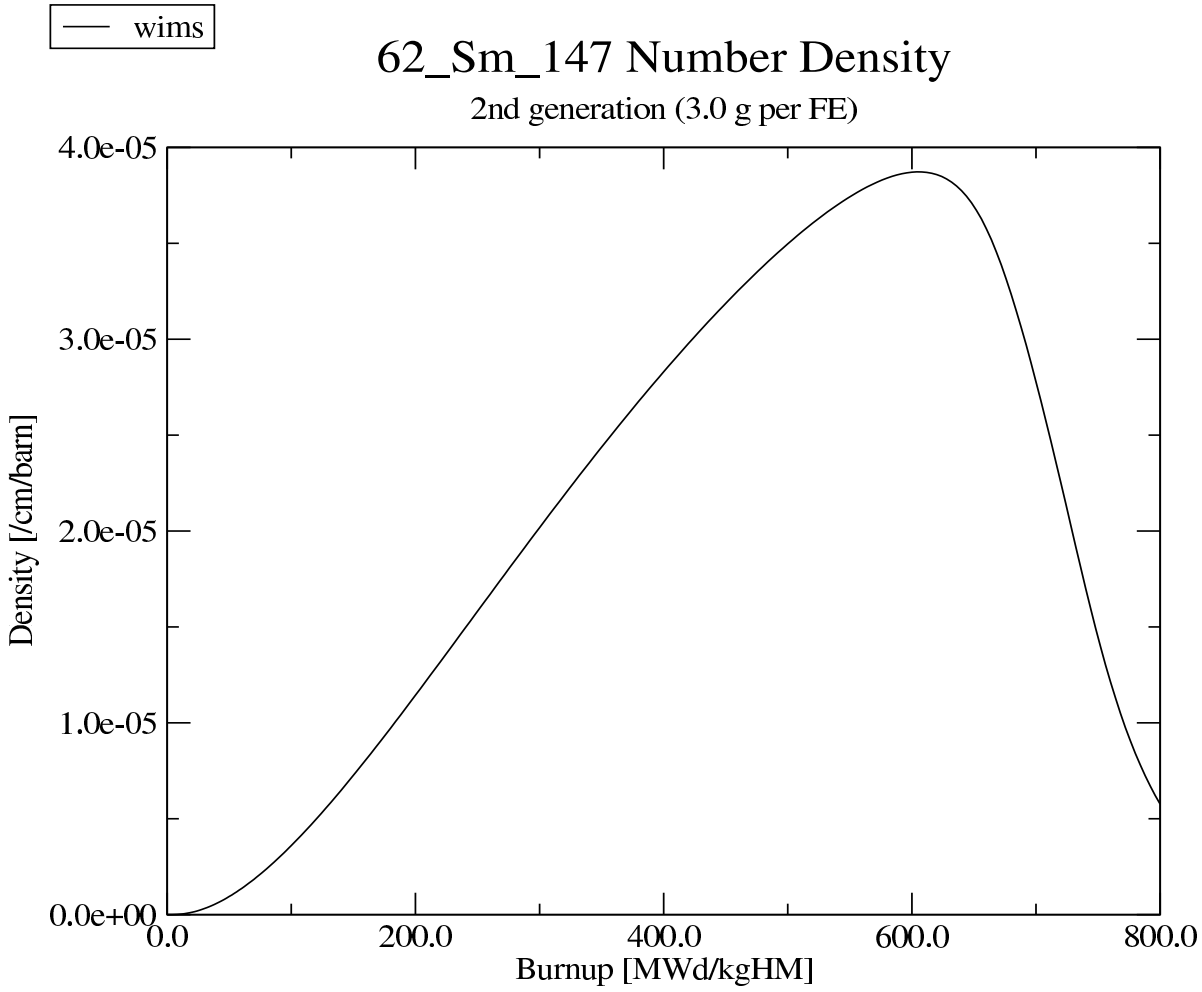


Figure 8.22 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_147 for case C2

Table 8.23 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_149 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	6.3701e-06	–	–
400.00	3.4719e-06	–	–
600.00	7.5567e-07	–	–
800.00	4.4778e-08	–	–

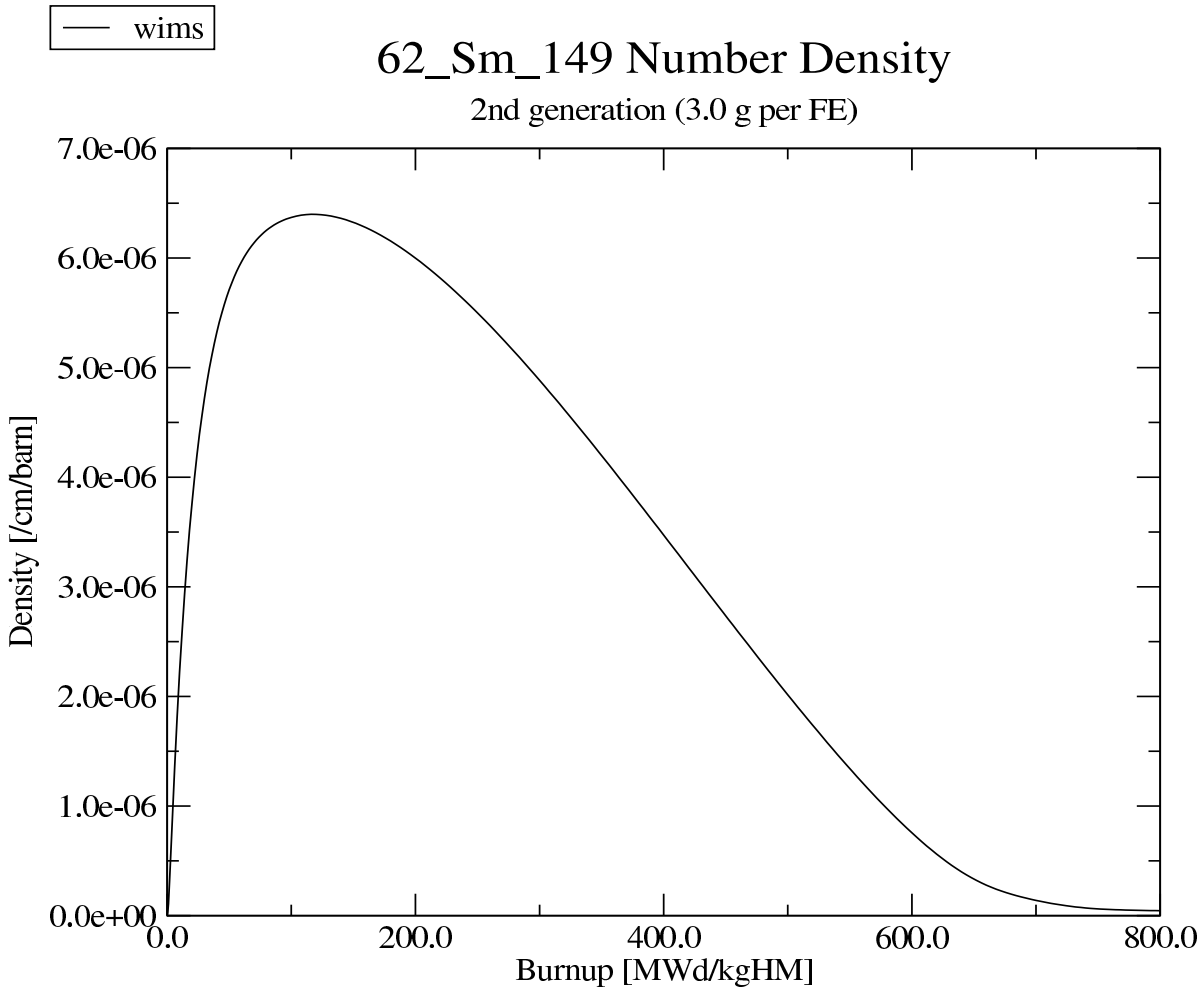


Figure 8.23 Number Density $[cm^{-1}barn^{-1}]$ 62_Sm_149 for case C2

Table 8.24 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_151 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	1.2375e-05	–	–
400.00	1.9679e-05	–	–
600.00	8.2715e-06	–	–
800.00	1.0890e-06	–	–

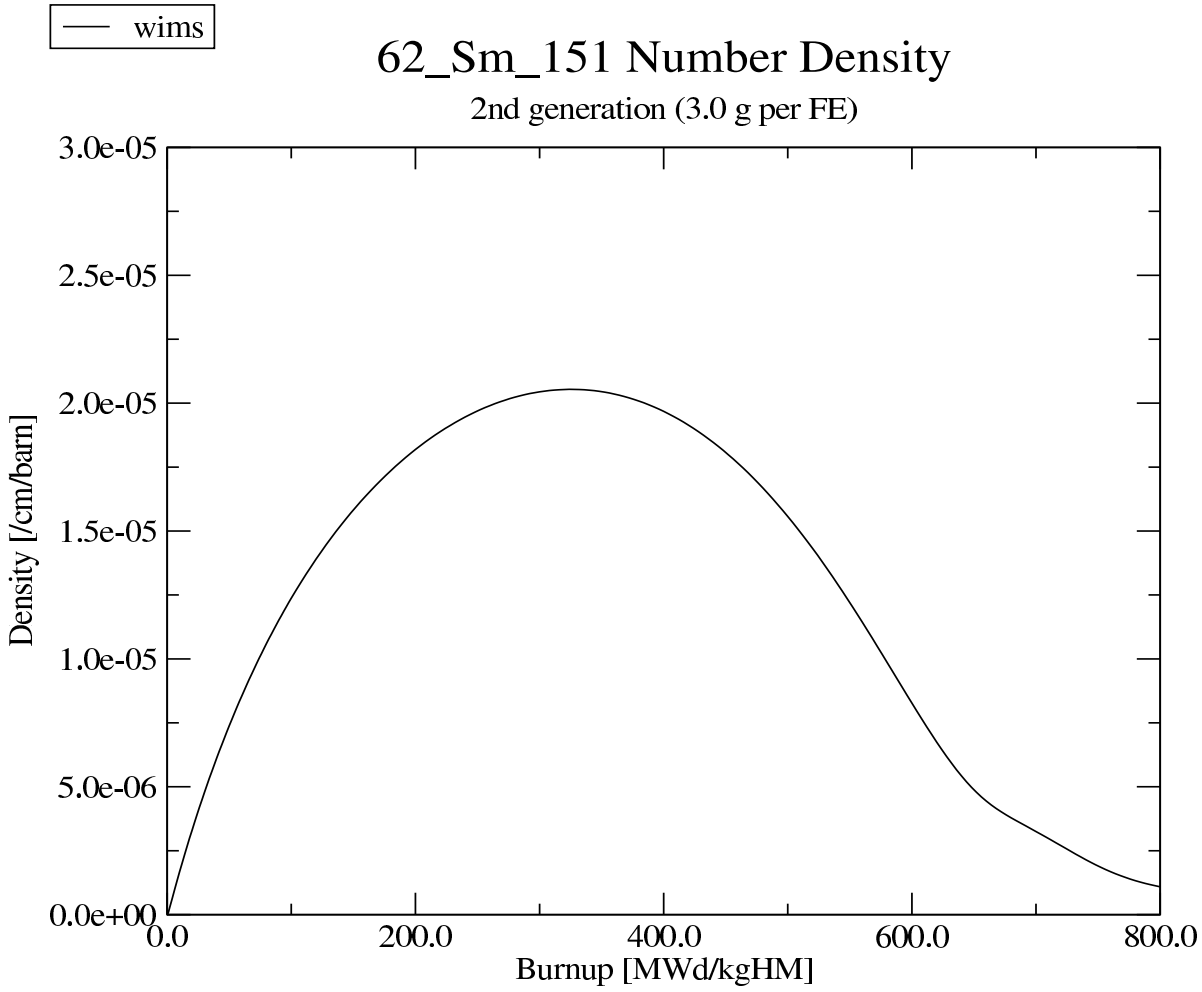


Figure 8.24 Number Density [$cm^{-1}barn^{-1}$] 62_Sm_151 for case C2

Table 8.25 Number Density $[cm^{-1}barn^{-1}]$ 63_Eu_154 for case C2

burnup $[MWd/kgHM]$	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0000e-19	–	–
100.00	2.1029e-06	–	–
400.00	2.8563e-05	–	–
600.00	4.8959e-05	–	–
800.00	1.5719e-05	–	–

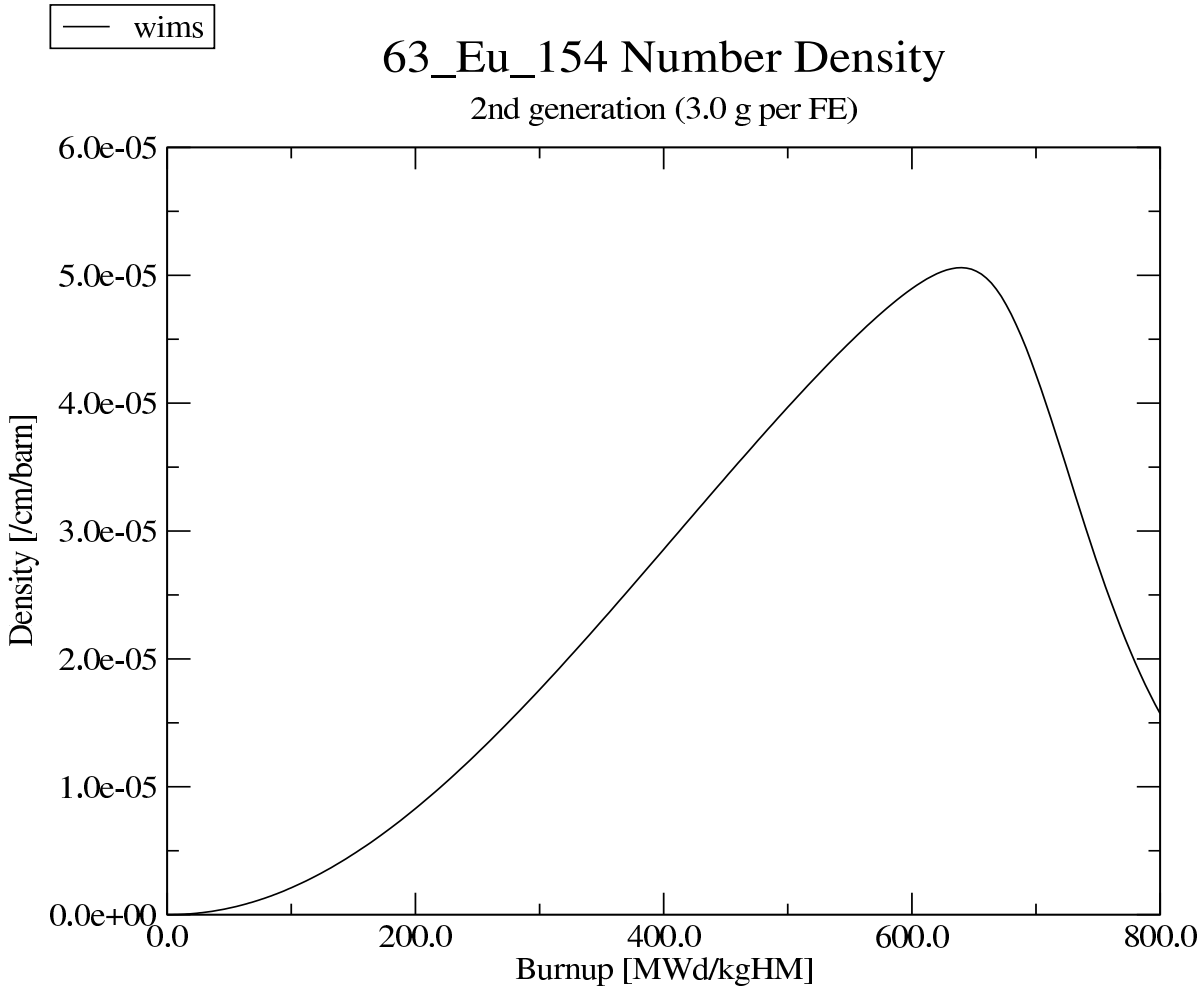


Figure 8.25 Number Density $[cm^{-1}barn^{-1}]$ 63_Eu_154 for case C2

Table 8.26 Absorption Cross Section [$barn$] 94_Pu_238 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.3604e+01	–	–	–
100.00	1.3908e+01	–	–	–
400.00	2.0621e+01	–	–	–
600.00	5.5516e+01	–	–	–
800.00	1.4851e+02	–	–	–

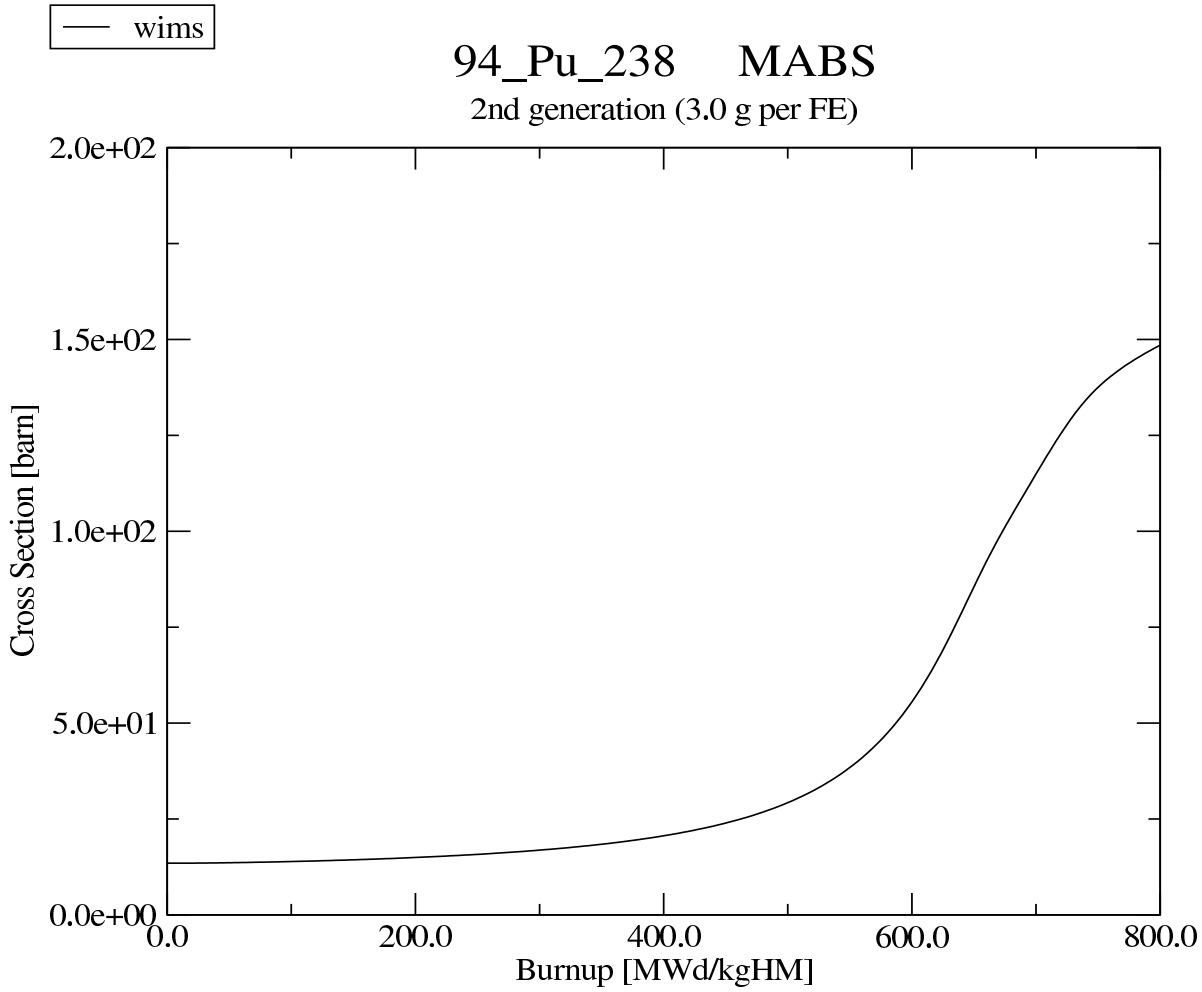


Figure 8.26 Absorption Cross Section [$barn$] 94_Pu_238 for case C2

Table 8.27 Absorption Cross Section [$barn$] 94_Pu_239 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.6752e+01	–	–	–
100.00	7.3017e+01	–	–	–
400.00	1.4994e+02	–	–	–
600.00	4.6189e+02	–	–	–
800.00	1.1855e+03	–	–	–

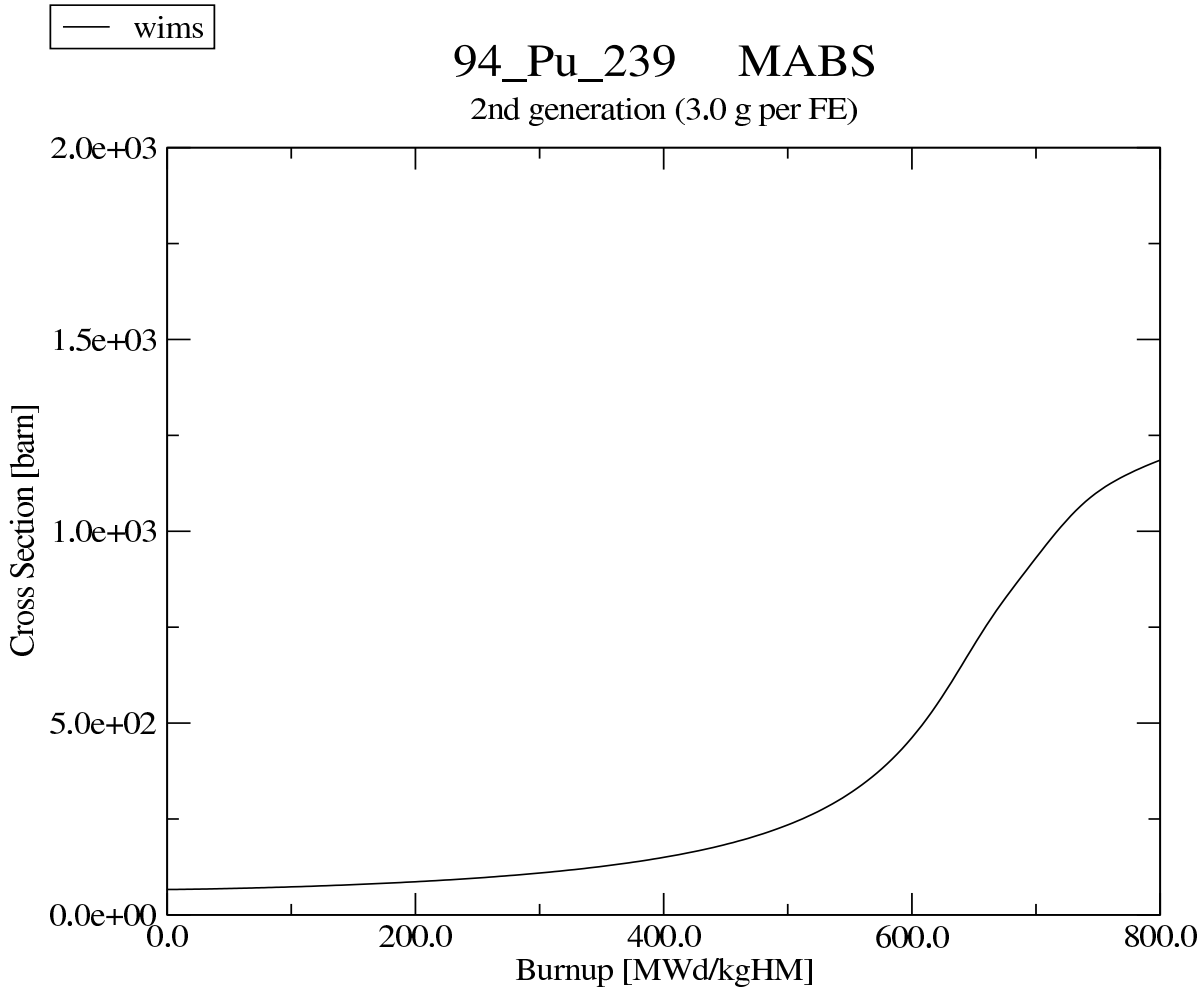


Figure 8.27 Absorption Cross Section [$barn$] 94_Pu_239 for case C2

Table 8.28 Absorption Cross Section [$barn$] 94_Pu_240 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.4185e+01	–	–	–
100.00	8.3695e+01	–	–	–
400.00	1.6357e+02	–	–	–
600.00	2.9147e+02	–	–	–
800.00	2.5540e+02	–	–	–

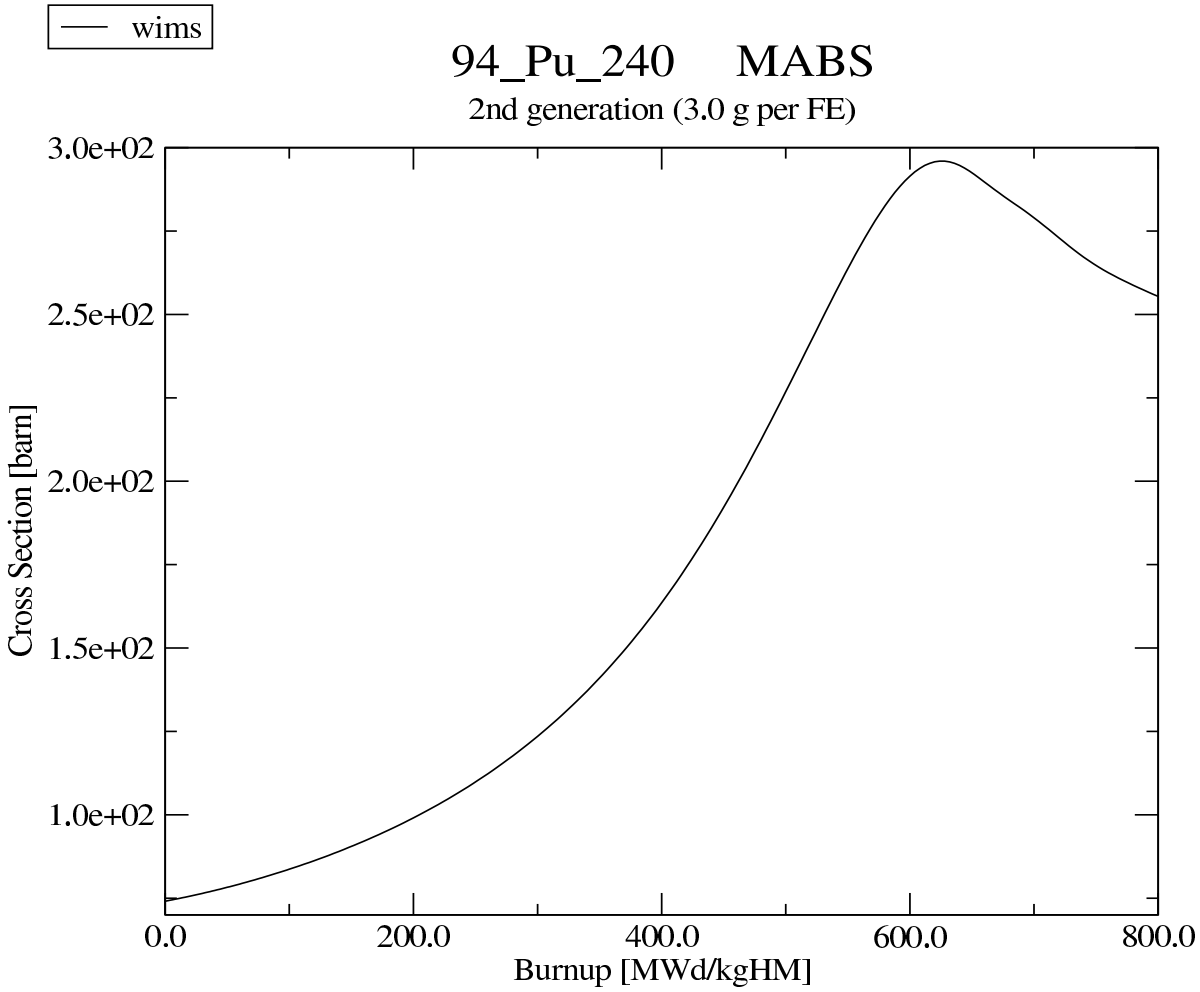


Figure 8.28 Absorption Cross Section [$barn$] 94_Pu_240 for case C2

Table 8.29 Absorption Cross Section [$barn$] 94_Pu_241 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.9679e+01	–	–	–
100.00	7.2522e+01	–	–	–
400.00	1.2007e+02	–	–	–
600.00	3.4406e+02	–	–	–
800.00	8.9840e+02	–	–	–

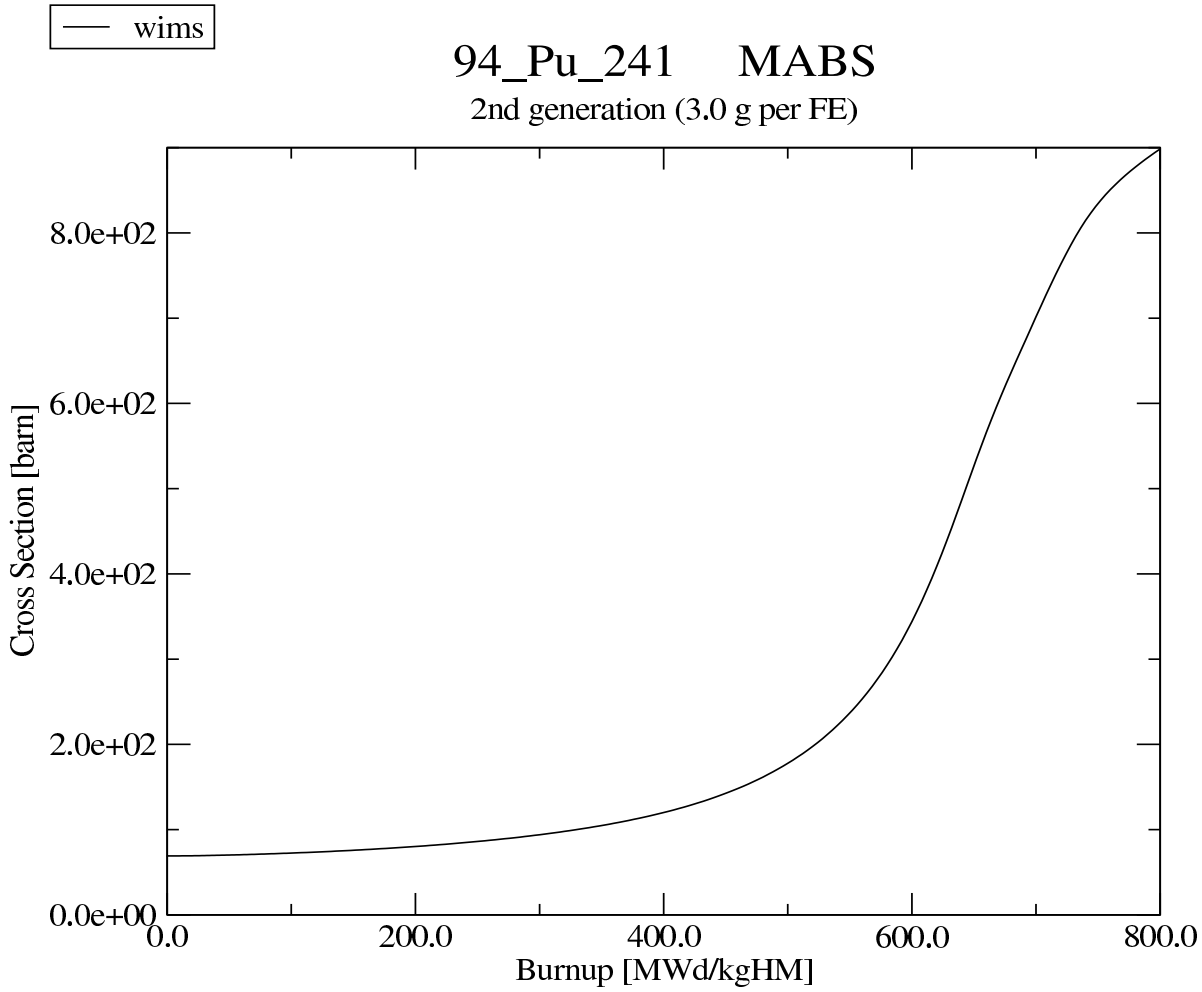


Figure 8.29 Absorption Cross Section [$barn$] 94_Pu_241 for case C2

Table 8.30 Absorption Cross Section [$barn$] 94_Pu_242 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.1852e+01	–	–	–
100.00	3.1659e+01	–	–	–
400.00	3.0751e+01	–	–	–
600.00	2.6998e+01	–	–	–
800.00	1.7734e+01	–	–	–

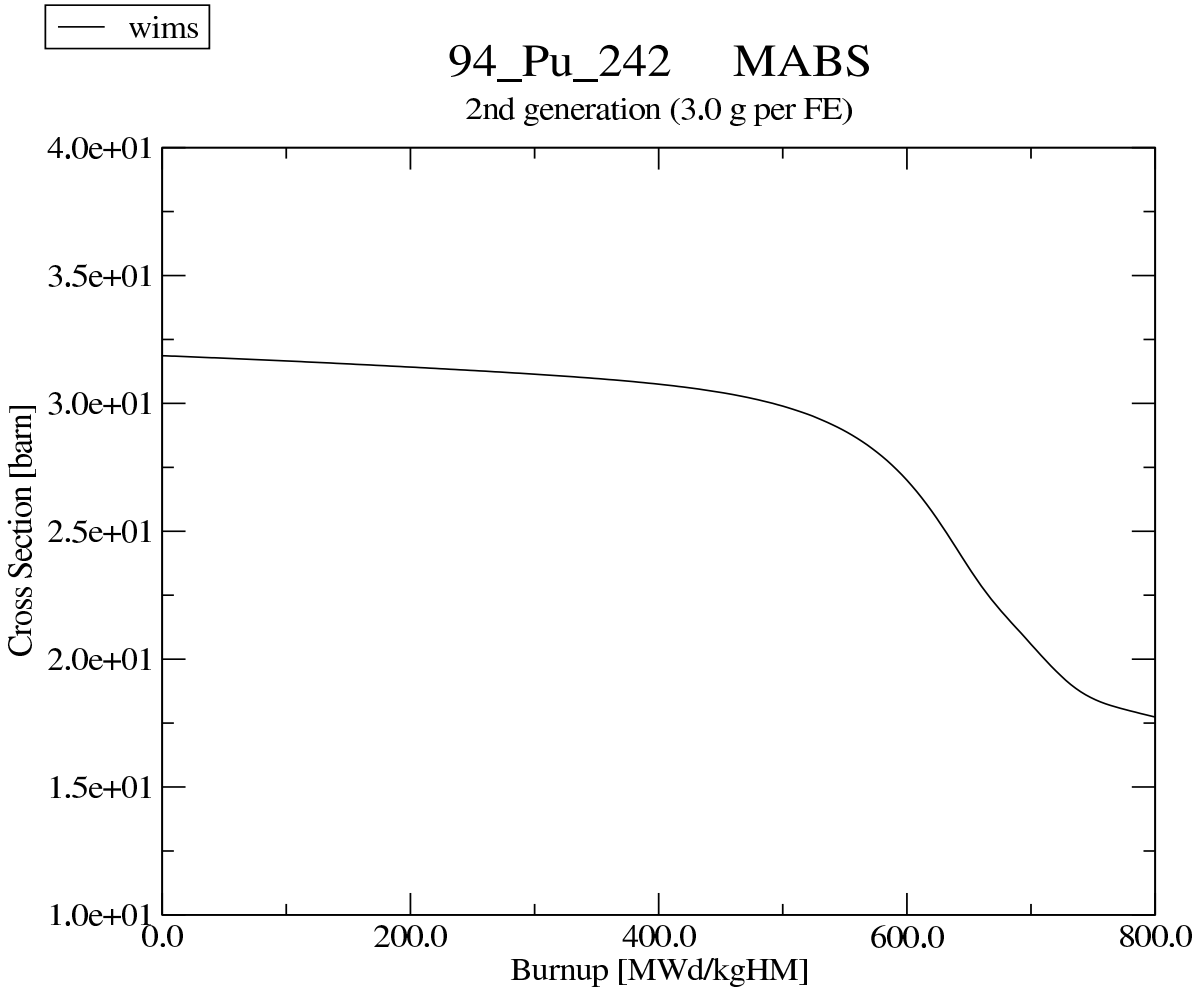


Figure 8.30 Absorption Cross Section [$barn$] 94_Pu_242 for case C2

Table 8.31 Absorption Cross Section [$barn$] 95_Am_241 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	8.6285e+01	–	–	–
100.00	8.9214e+01	–	–	–
400.00	1.3122e+02	–	–	–
600.00	2.9015e+02	–	–	–
800.00	6.3927e+02	–	–	–

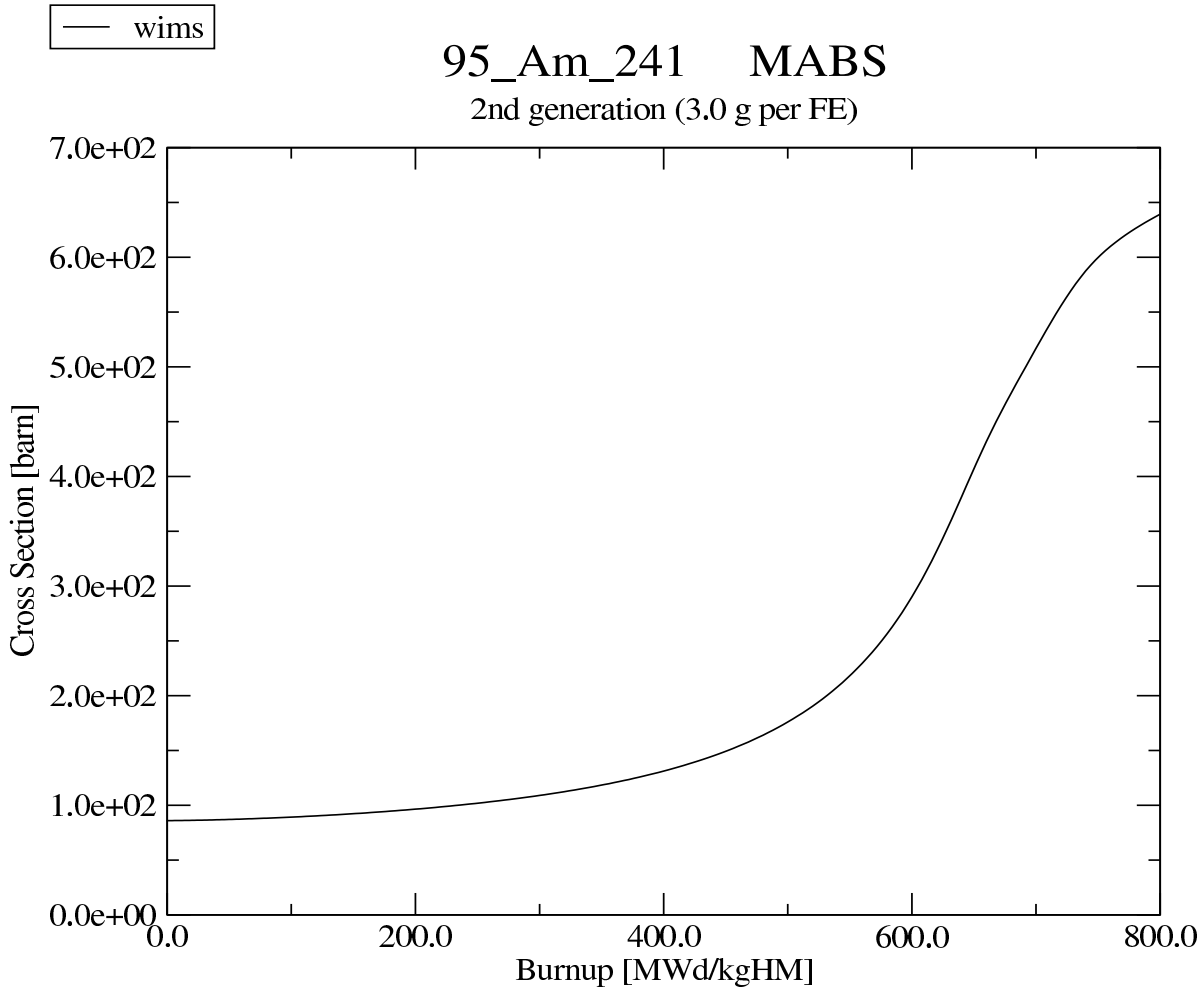


Figure 8.31 Absorption Cross Section [$barn$] 95_Am_241 for case C2

Table 8.32 Absorption Cross Section [$barn$] 95_Am_242m for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.2936e+02	–	–	–
100.00	2.4377e+02	–	–	–
400.00	4.8411e+02	–	–	–
600.00	1.6406e+03	–	–	–
800.00	4.5794e+03	–	–	–

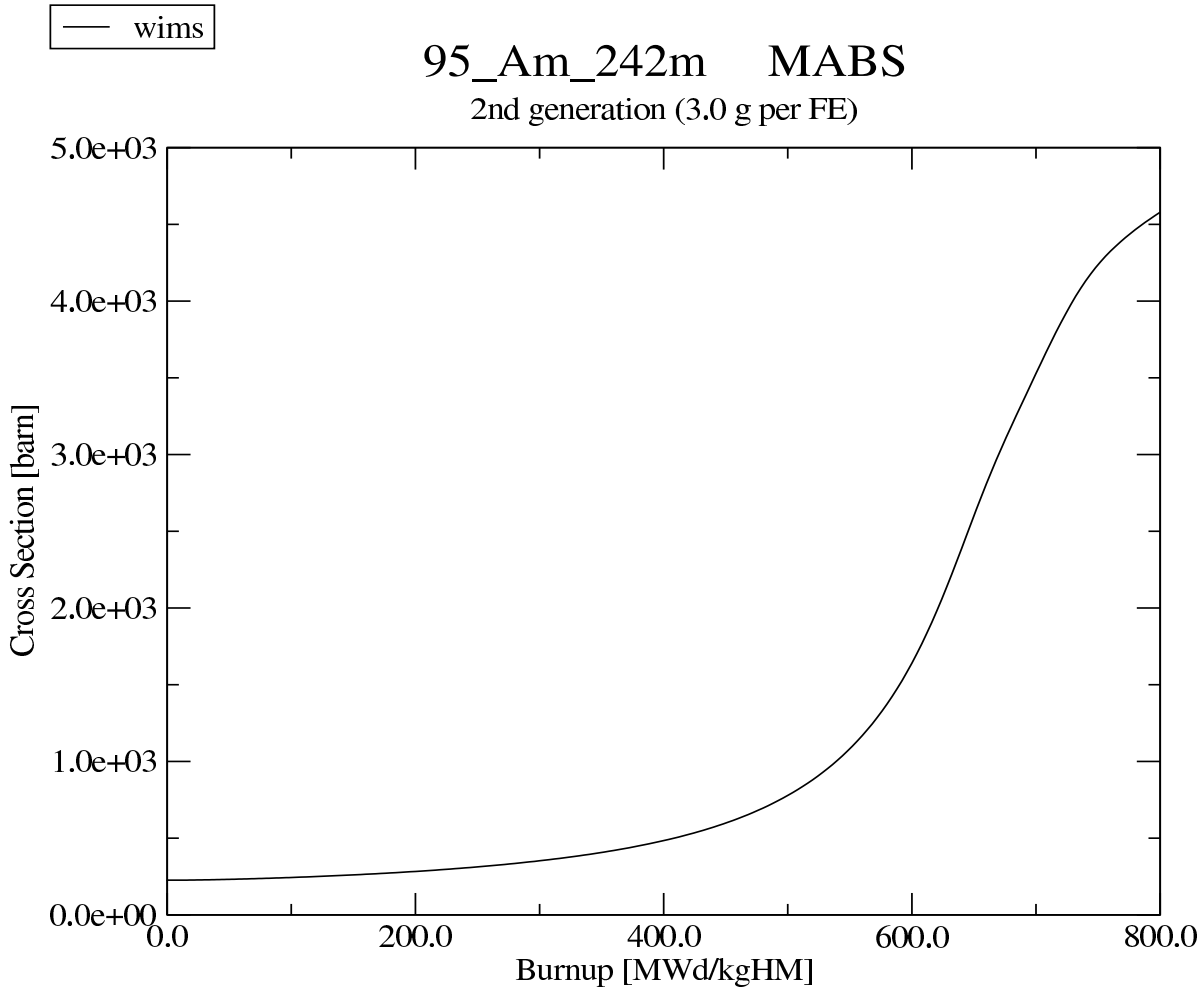


Figure 8.32 Absorption Cross Section [$barn$] 95_Am_242m for case C2

Table 8.33 Absorption Cross Section [$barn$] 95_Am_243 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	8.2989e+01	–	–	–
100.00	7.7868e+01	–	–	–
400.00	7.3778e+01	–	–	–
600.00	6.9643e+01	–	–	–
800.00	5.3012e+01	–	–	–

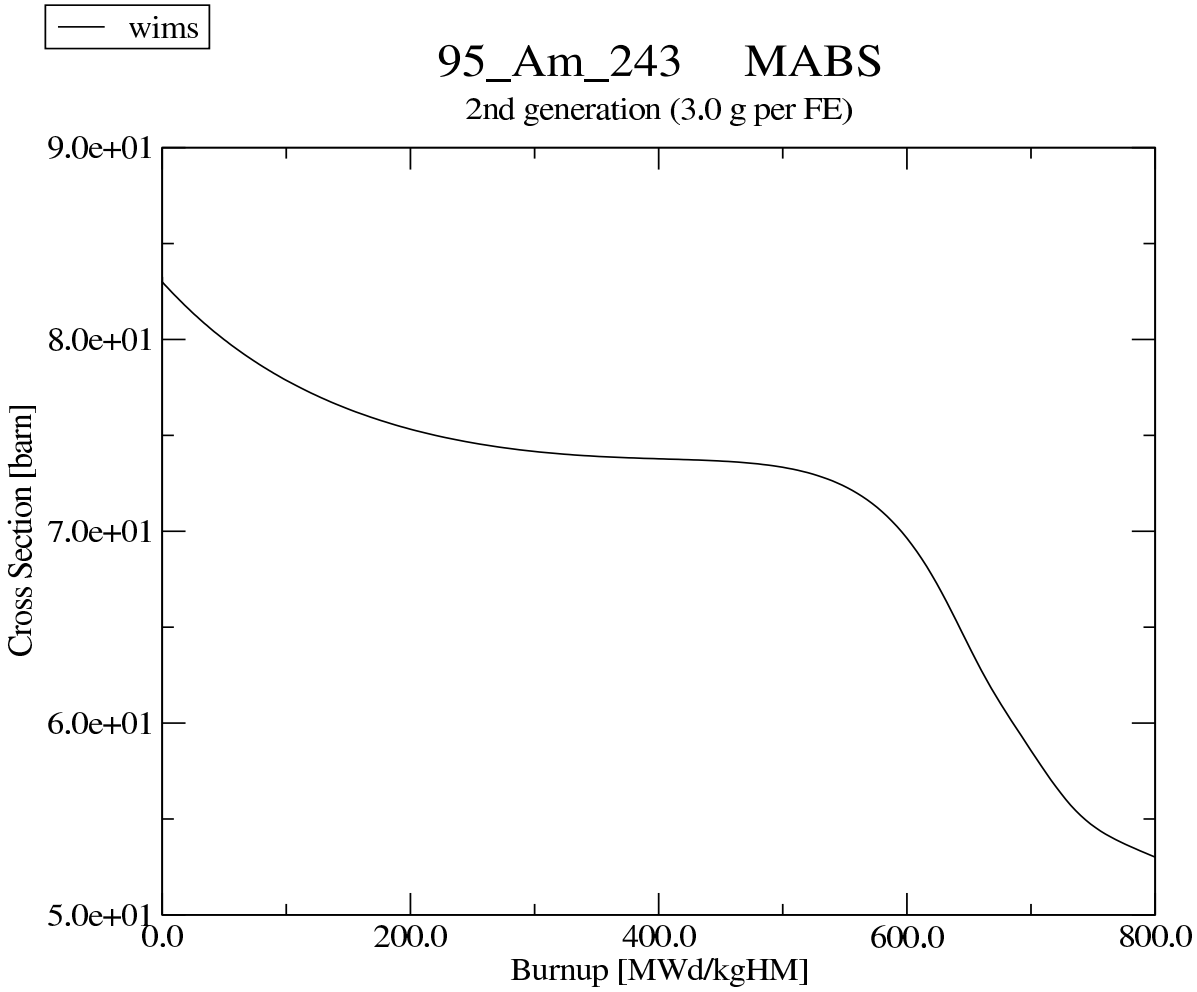


Figure 8.33 Absorption Cross Section [$barn$] 95_Am_243 for case C2

Table 8.34 Absorption Cross Section [$barn$] 96_Cm_242 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	7.2239e+00	–	–	–
100.00	7.2254e+00	–	–	–
400.00	7.3428e+00	–	–	–
600.00	7.8634e+00	–	–	–
800.00	9.2856e+00	–	–	–

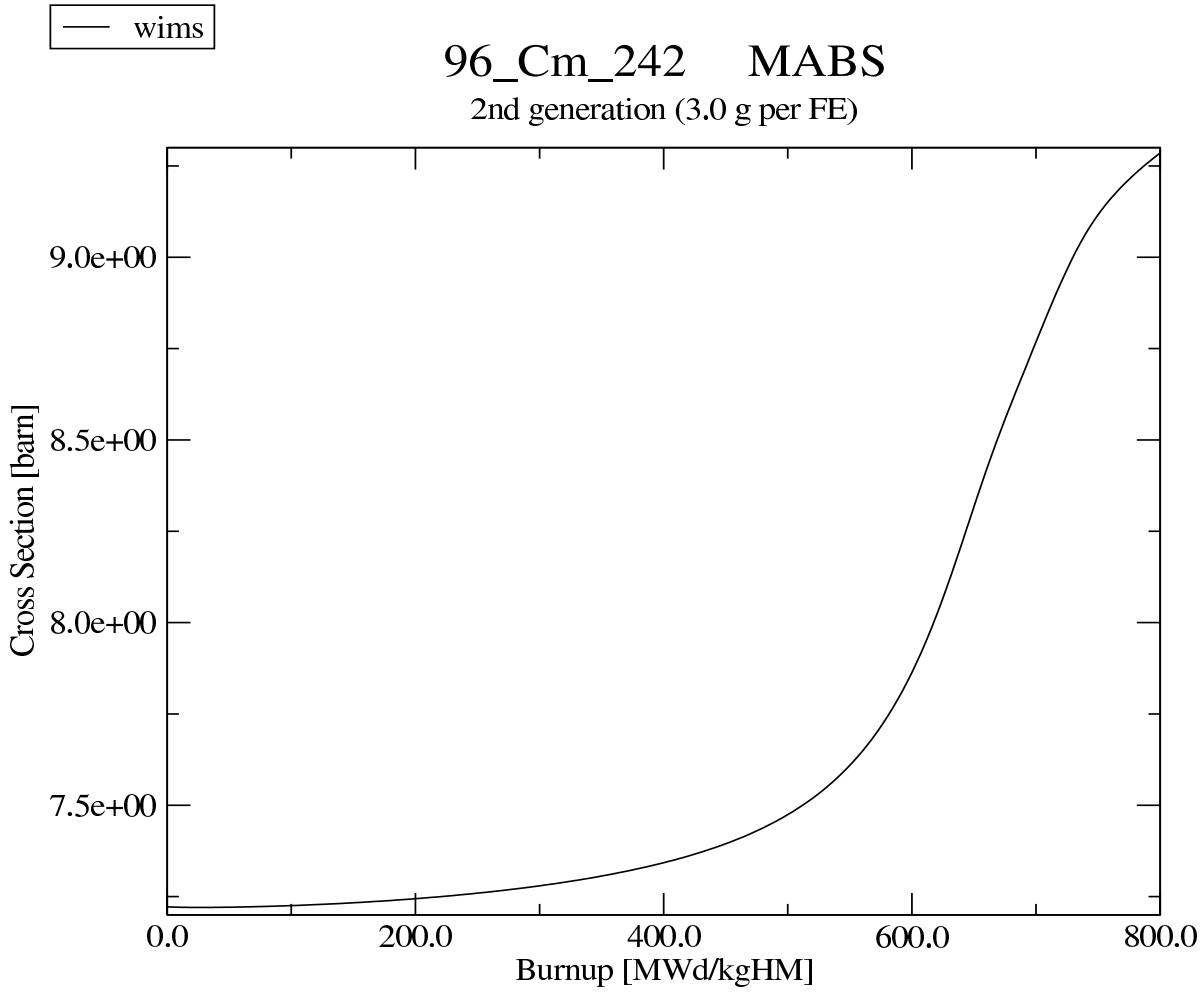


Figure 8.34 Absorption Cross Section [$barn$] 96_Cm_242 for case C2

Table 8.35 Absorption Cross Section [$barn$] 96_Cm_243 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0658e+02	–	–	–
100.00	1.0464e+02	–	–	–
400.00	1.1174e+02	–	–	–
600.00	1.4938e+02	–	–	–
800.00	2.3639e+02	–	–	–

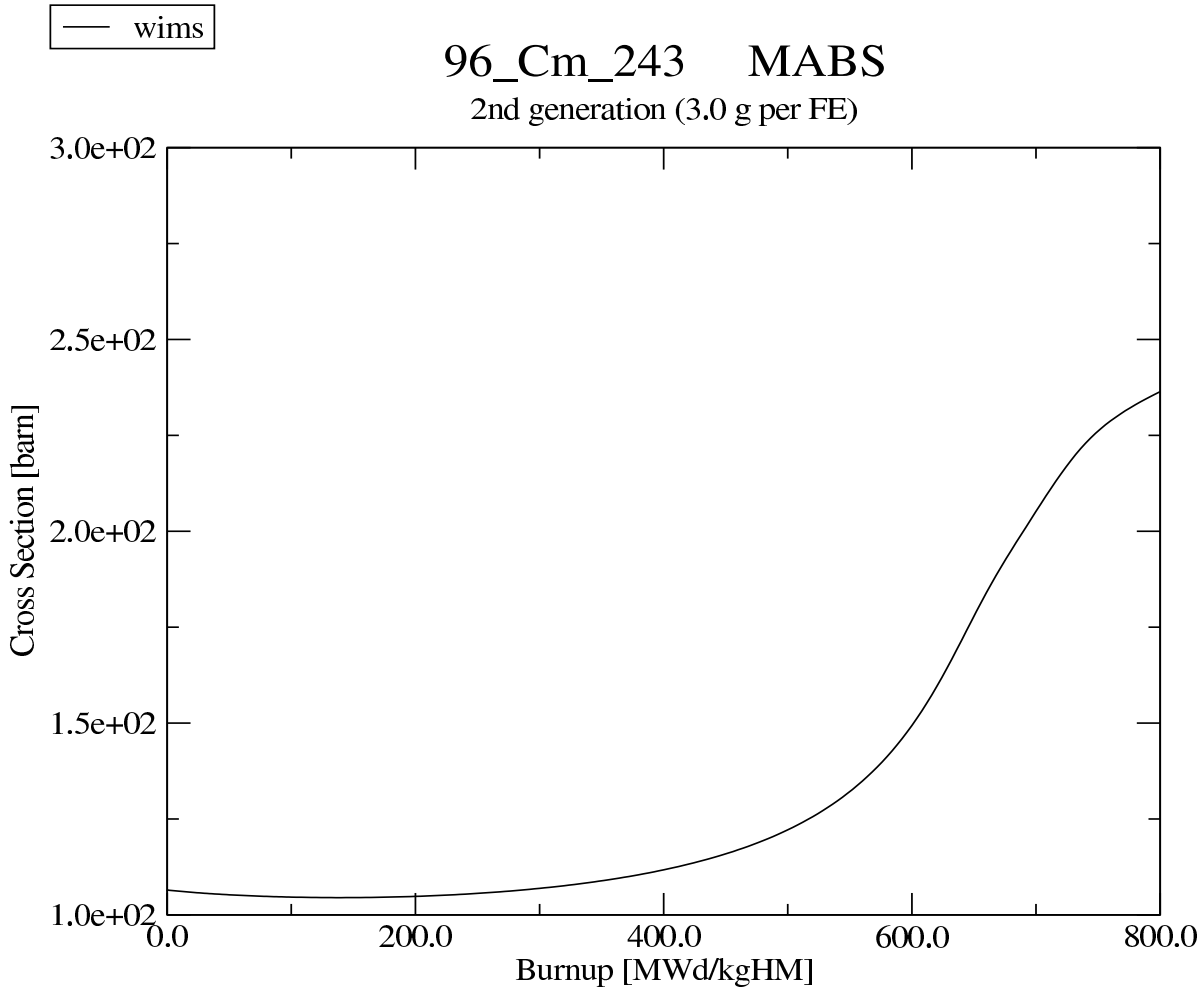


Figure 8.35 Absorption Cross Section [$barn$] 96_Cm_243 for case C2

Table 8.36 Absorption Cross Section [$barn$] 96_Cm_244 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.3524e+01	–	–	–
100.00	3.2820e+01	–	–	–
400.00	3.0112e+01	–	–	–
600.00	2.4621e+01	–	–	–
800.00	1.2007e+01	–	–	–

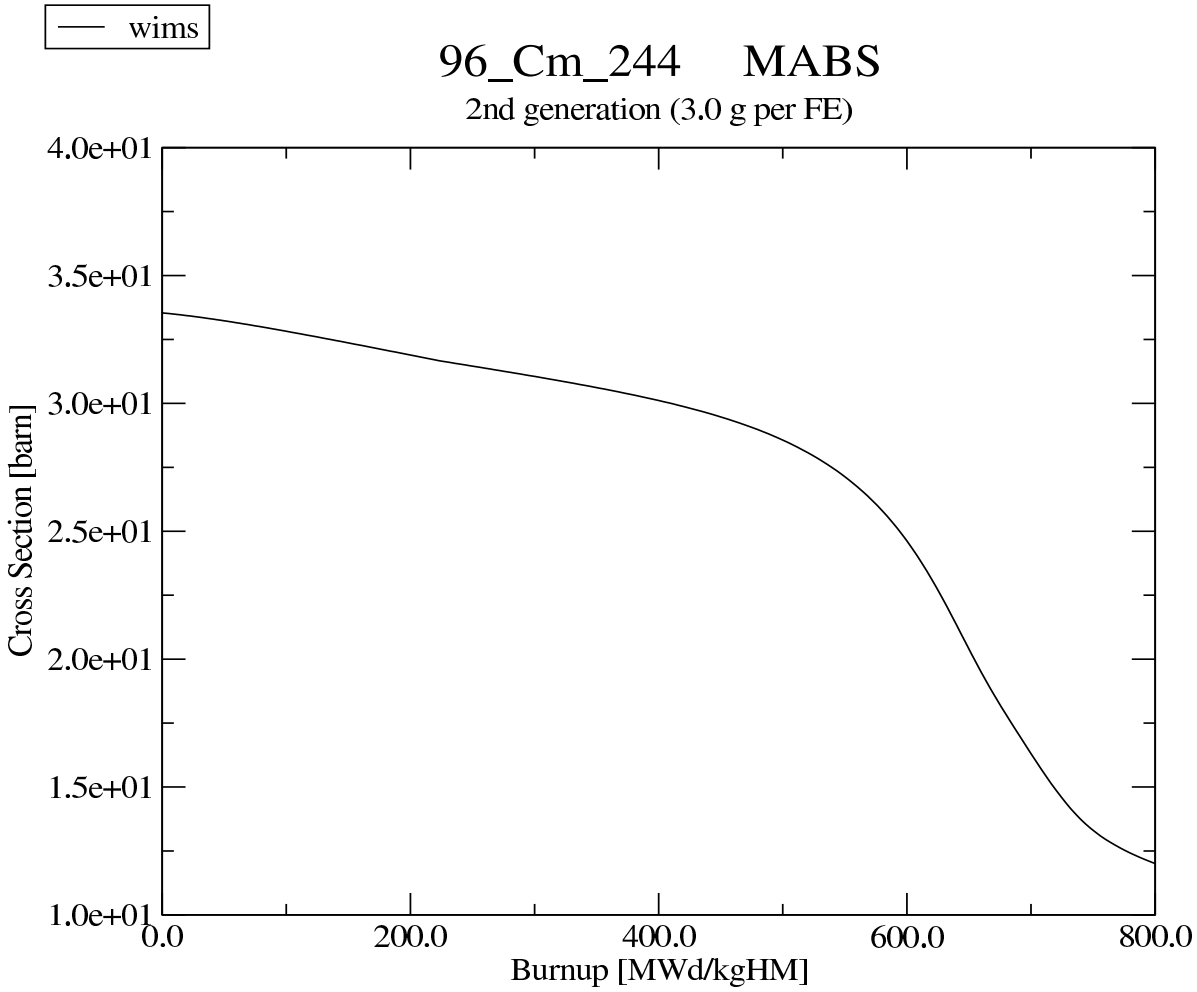


Figure 8.36 Absorption Cross Section [$barn$] 96_Cm_244 for case C2

Table 8.37 Absorption Cross Section [$barn$] 96_Cm_245 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.1620e+01	–	–	–
100.00	6.2743e+01	–	–	–
400.00	9.3647e+01	–	–	–
600.00	2.4953e+02	–	–	–
800.00	6.5780e+02	–	–	–

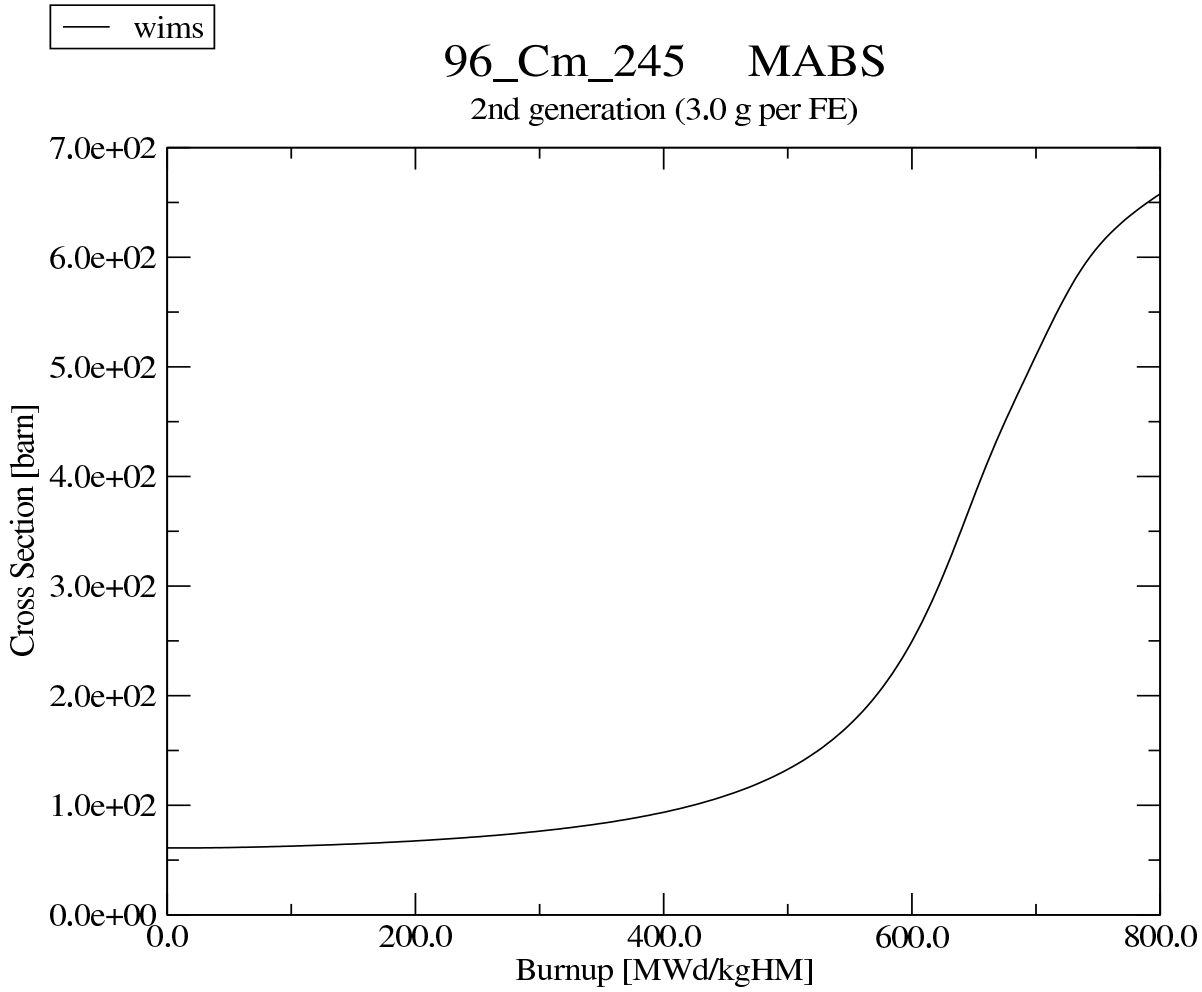


Figure 8.37 Absorption Cross Section [$barn$] 96_Cm_245 for case C2

Table 8.38 Absorption Cross Section [$barn$] 40_Zr_93 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.9582e+00	–	–	–
100.00	1.9571e+00	–	–	–
400.00	1.8942e+00	–	–	–
600.00	1.6349e+00	–	–	–
800.00	1.0563e+00	–	–	–

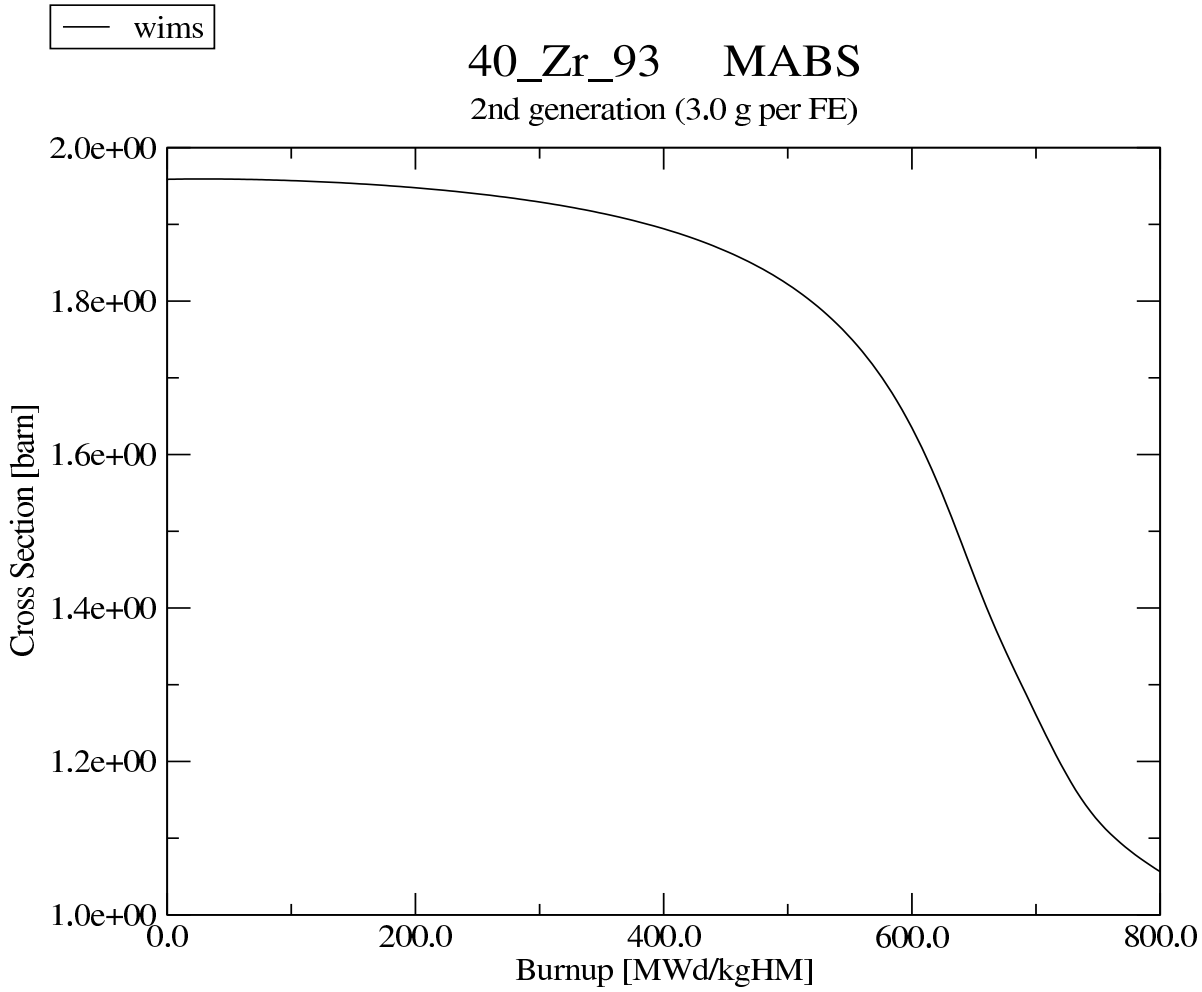


Figure 8.38 Absorption Cross Section [$barn$] 40_Zr_93 for case C2

Table 8.39 Absorption Cross Section [$barn$] 43_Tc_99 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.5856e+01	–	–	–
100.00	1.5434e+01	–	–	–
400.00	1.4840e+01	–	–	–
600.00	1.3787e+01	–	–	–
800.00	1.0676e+01	–	–	–

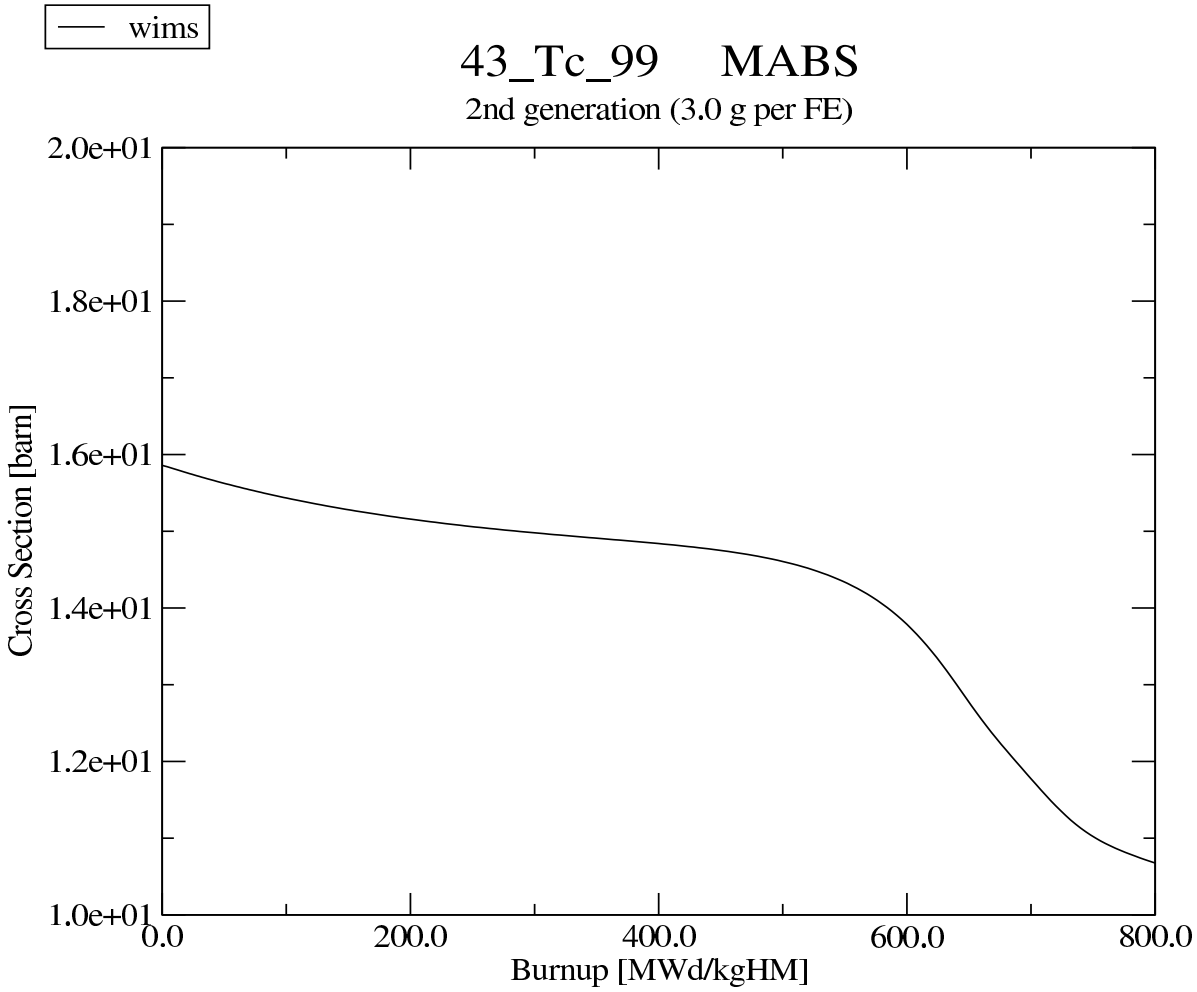


Figure 8.39 Absorption Cross Section [$barn$] 43_Tc_99 for case C2

Table 8.40 Absorption Cross Section [$barn$] 46_Pd_107 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.1024e+00	–	–	–
100.00	6.1019e+00	–	–	–
400.00	5.8548e+00	–	–	–
600.00	4.6894e+00	–	–	–
800.00	1.9257e+00	–	–	–

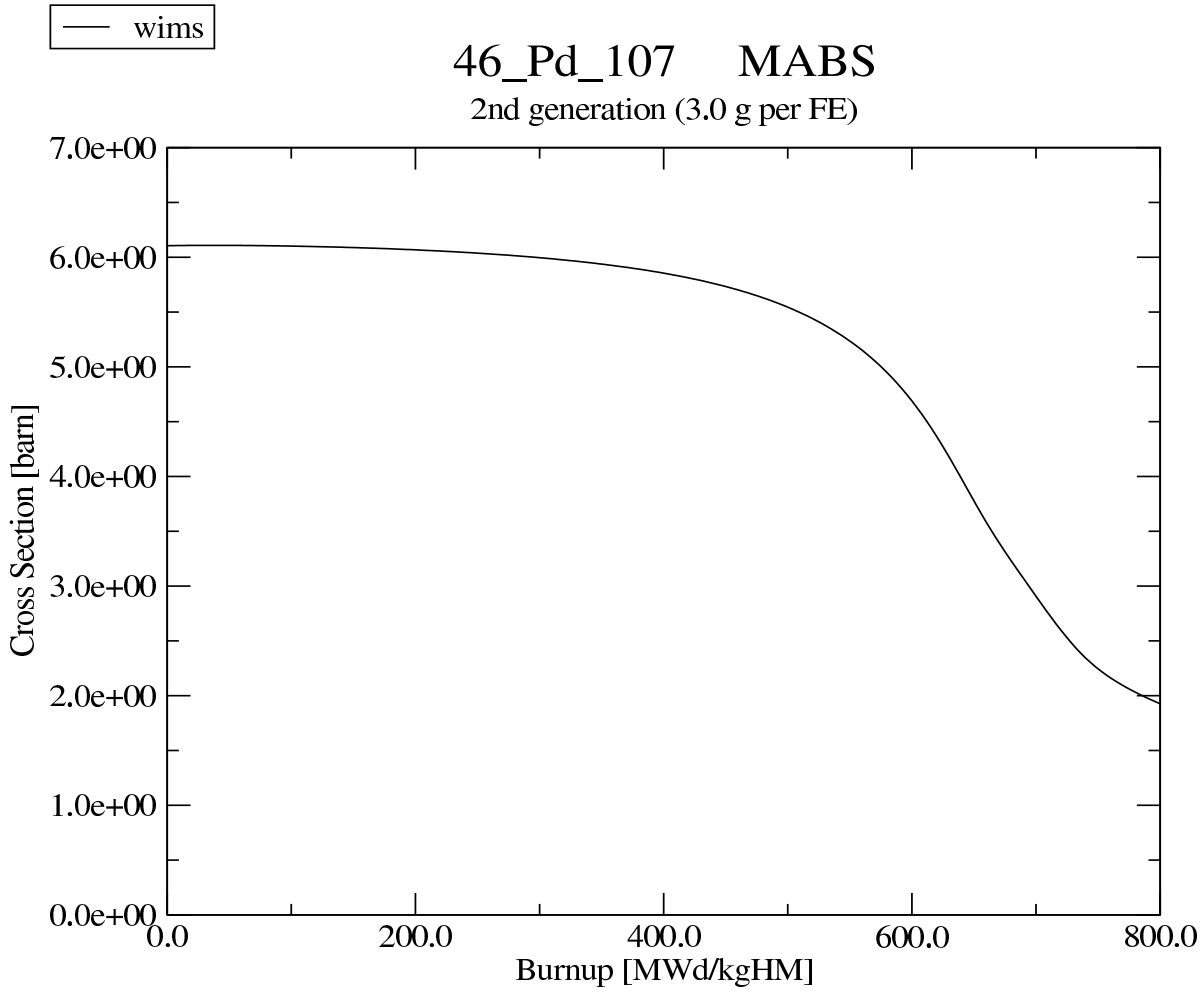


Figure 8.40 Absorption Cross Section [$barn$] 46_Pd_107 for case C2

Table 8.41 Absorption Cross Section [$barn$] 53_I_129 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.0440e+00	–	–	–
100.00	2.0799e+00	–	–	–
400.00	2.6713e+00	–	–	–
600.00	5.4874e+00	–	–	–
800.00	1.2701e+01	–	–	–

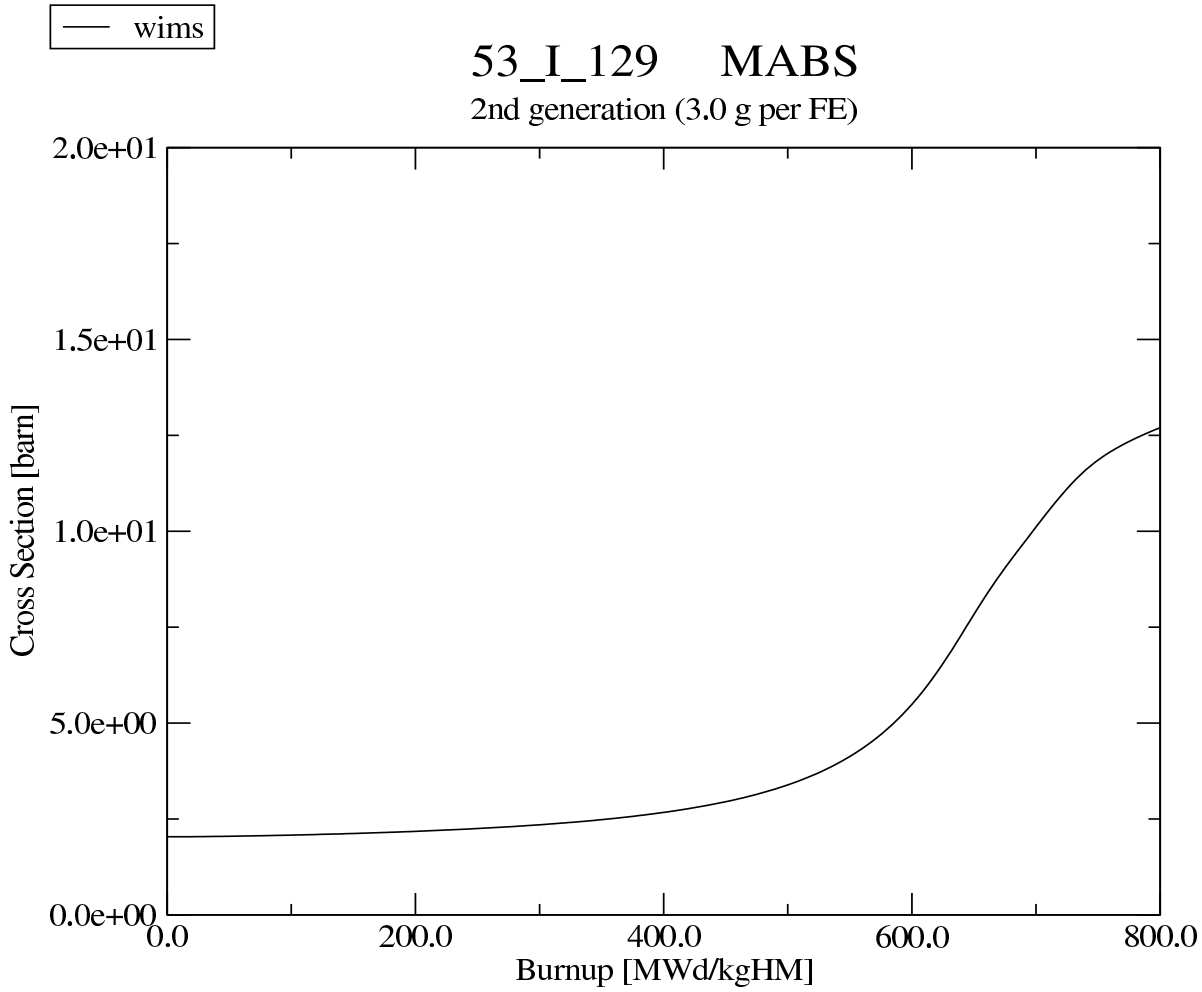


Figure 8.41 Absorption Cross Section [$barn$] 53_I_129 for case C2

Table 8.42 Absorption Cross Section [$barn$] 55_Cs_135 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.5982e+00	–	–	–
100.00	3.6020e+00	–	–	–
400.00	3.6101e+00	–	–	–
600.00	3.6995e+00	–	–	–
800.00	4.0373e+00	–	–	–

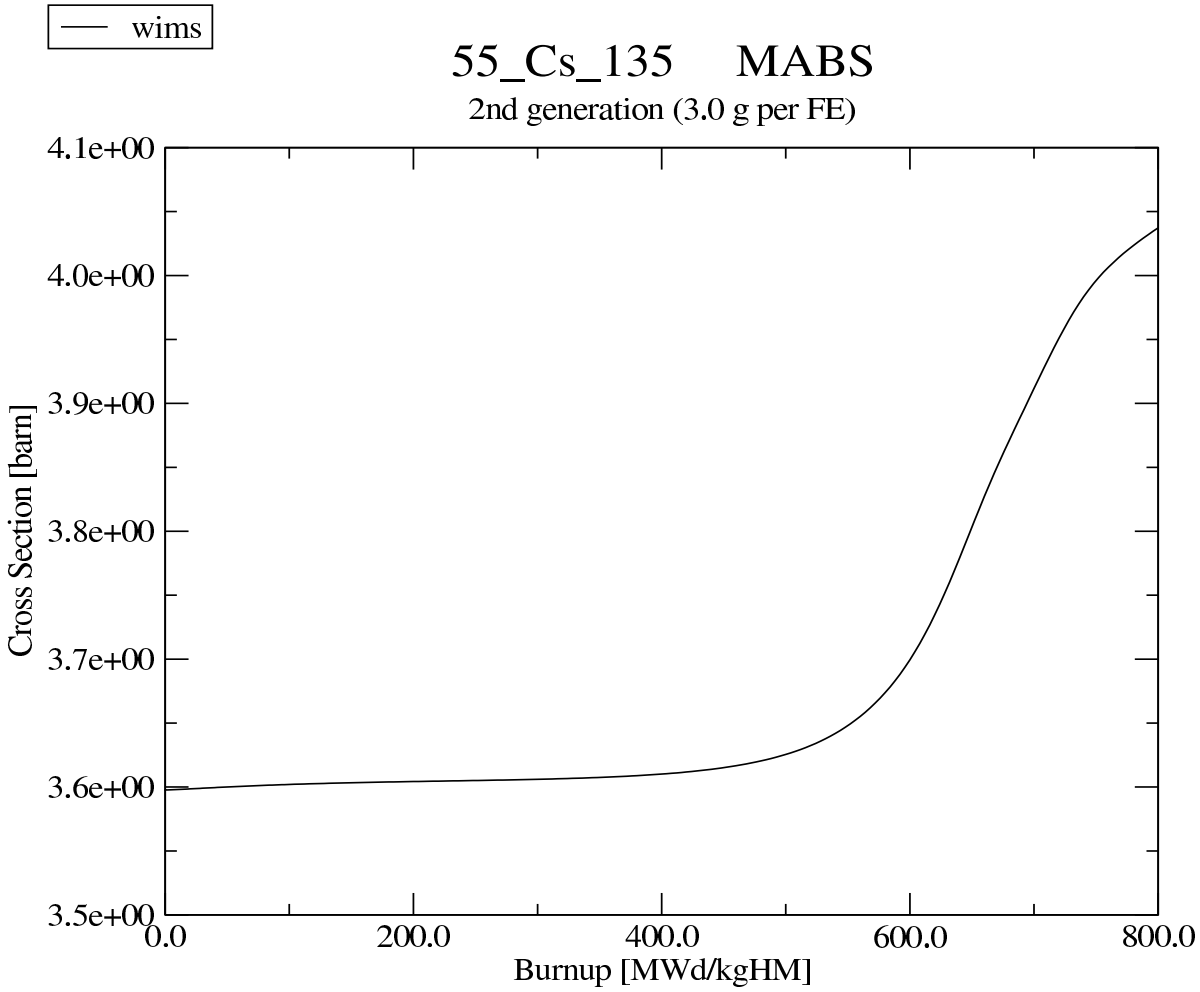


Figure 8.42 Absorption Cross Section [$barn$] 55_Cs_135 for case C2

Table 8.43 Absorption Cross Section [$barn$] 62_Sm_147 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.4773e+01	–	–	–
100.00	4.4316e+01	–	–	–
400.00	4.3370e+01	–	–	–
600.00	3.9946e+01	–	–	–
800.00	3.0787e+01	–	–	–

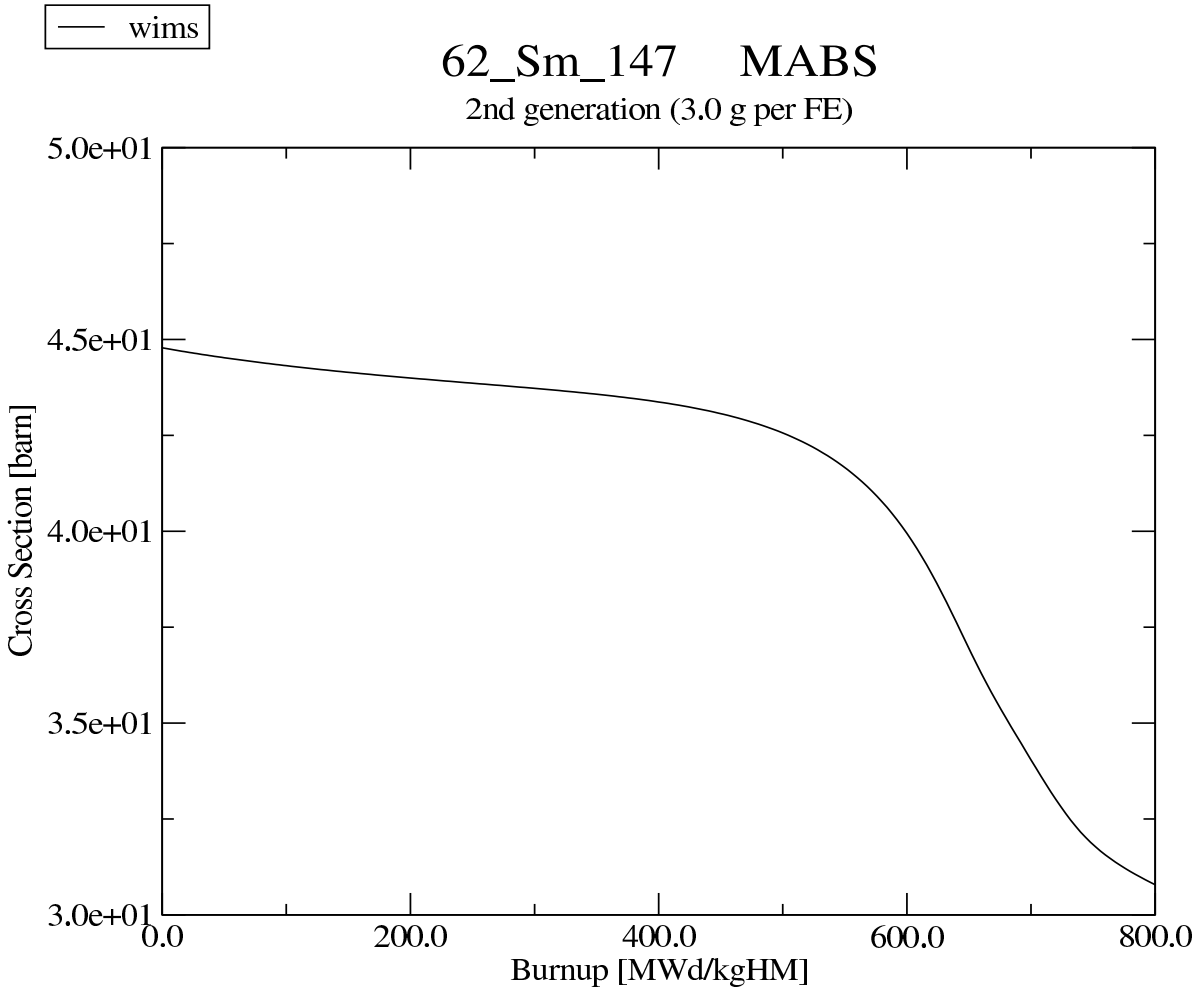


Figure 8.43 Absorption Cross Section [$barn$] 62_Sm_147 for case C2

Table 8.44 Absorption Cross Section [$barn$] 62_Sm_149 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0537e+03	–	–	–
100.00	1.1251e+03	–	–	–
400.00	2.6909e+03	–	–	–
600.00	1.0902e+04	–	–	–
800.00	3.2691e+04	–	–	–

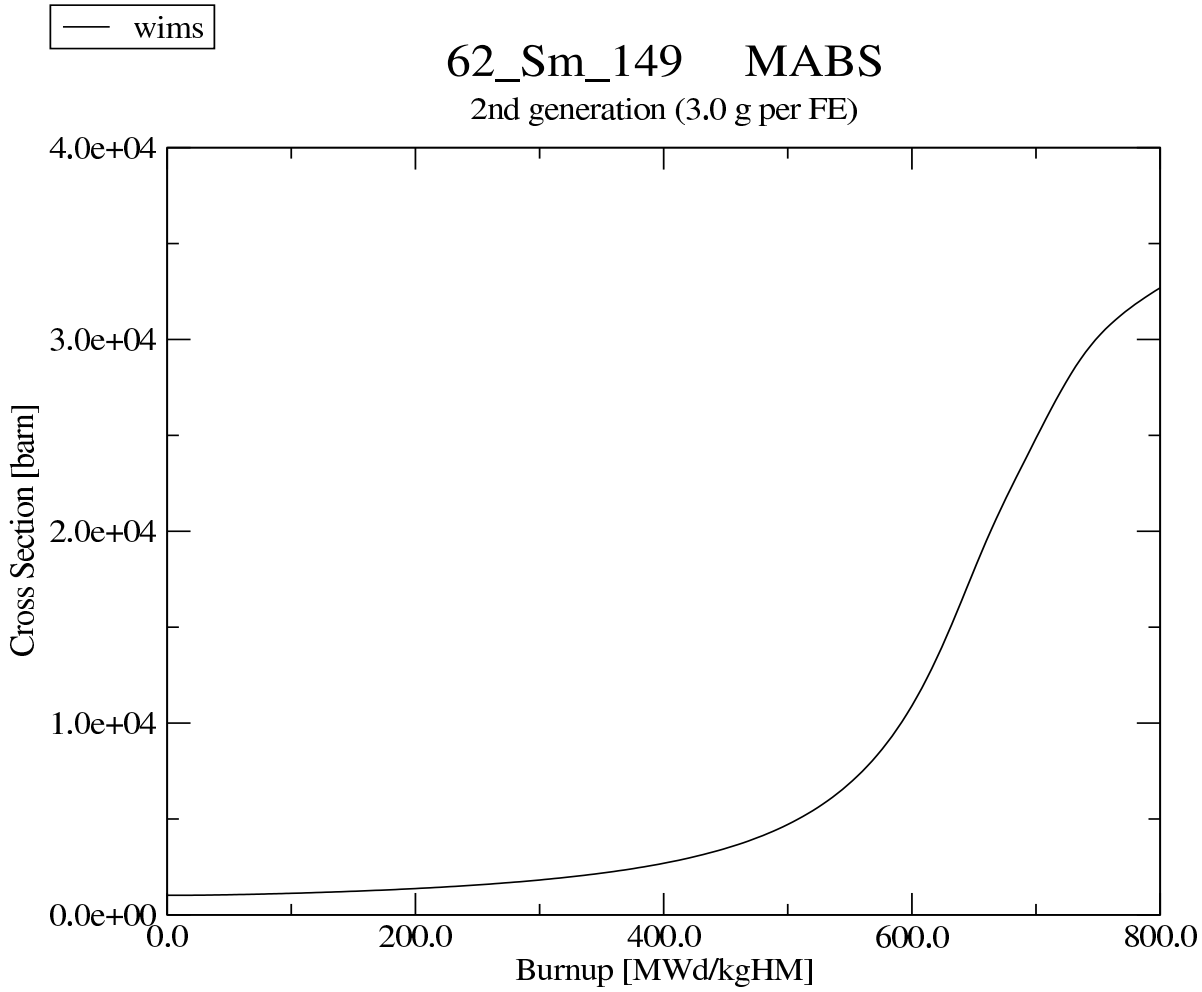


Figure 8.44 Absorption Cross Section [$barn$] 62_Sm_149 for case C2

Table 8.45 Absorption Cross Section [$barn$] 62_Sm_151 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.0534e+02	–	–	–
100.00	2.1170e+02	–	–	–
400.00	3.5471e+02	–	–	–
600.00	1.0717e+03	–	–	–
800.00	2.9722e+03	–	–	–

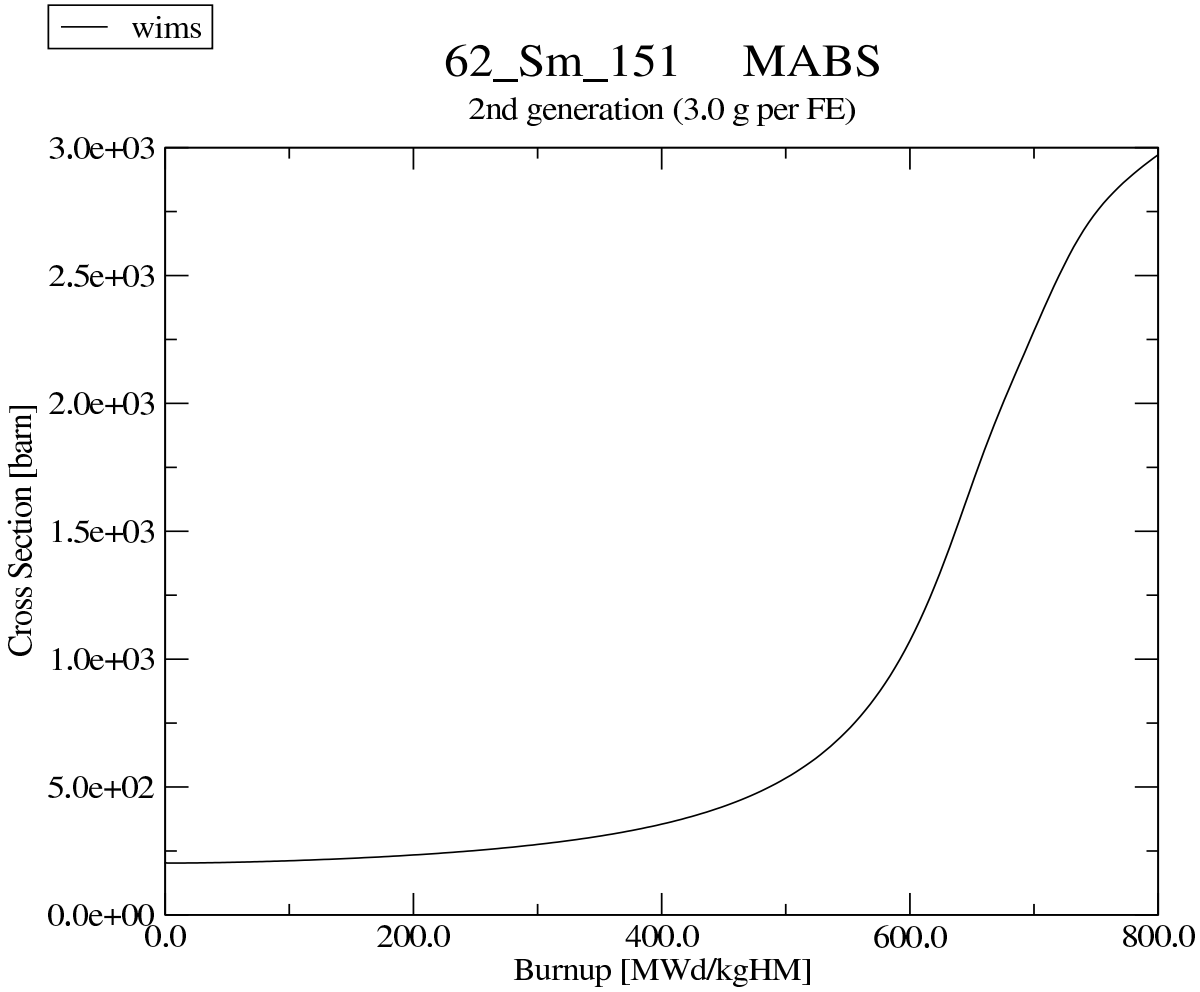


Figure 8.45 Absorption Cross Section [$barn$] 62_Sm_151 for case C2

Table 8.46 Absorption Cross Section [$barn$] 63_Eu_154 for case C2

burnup [$MWd/kgHM$]	WIMS	WIMS plus (n,2n)	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.0875e+02	–	–	–
100.00	1.0861e+02	–	–	–
400.00	1.2408e+02	–	–	–
600.00	1.7687e+02	–	–	–
800.00	2.9332e+02	–	–	–

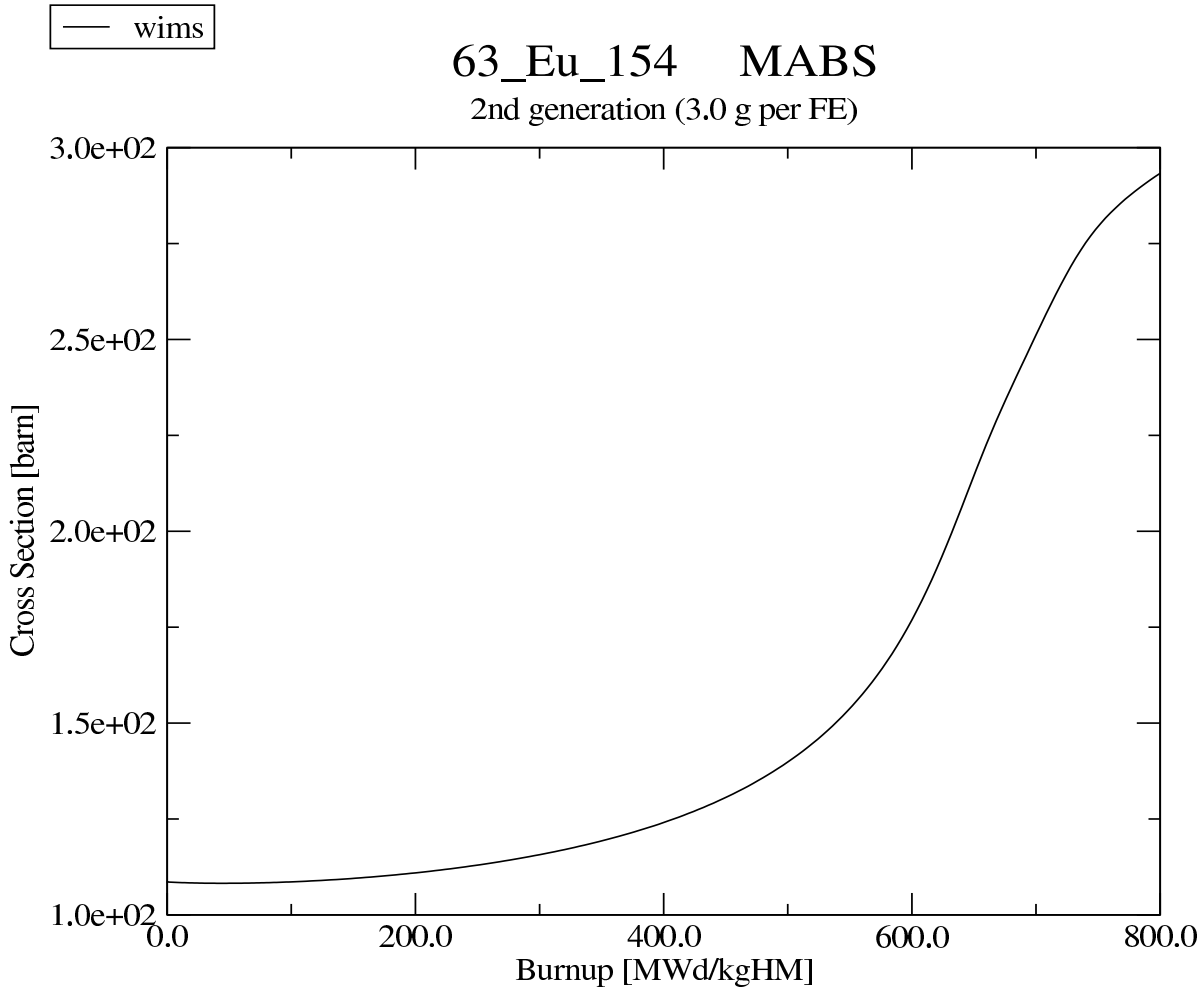


Figure 8.46 Absorption Cross Section [$barn$] 63_Eu_154 for case C2

Table 8.47 Fission Cross Section [$barn$] 94_Pu_238 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.9008e+00	–	–
100.00	1.9097e+00	–	–
400.00	2.0520e+00	–	–
600.00	2.8453e+00	–	–
800.00	5.0519e+00	–	–

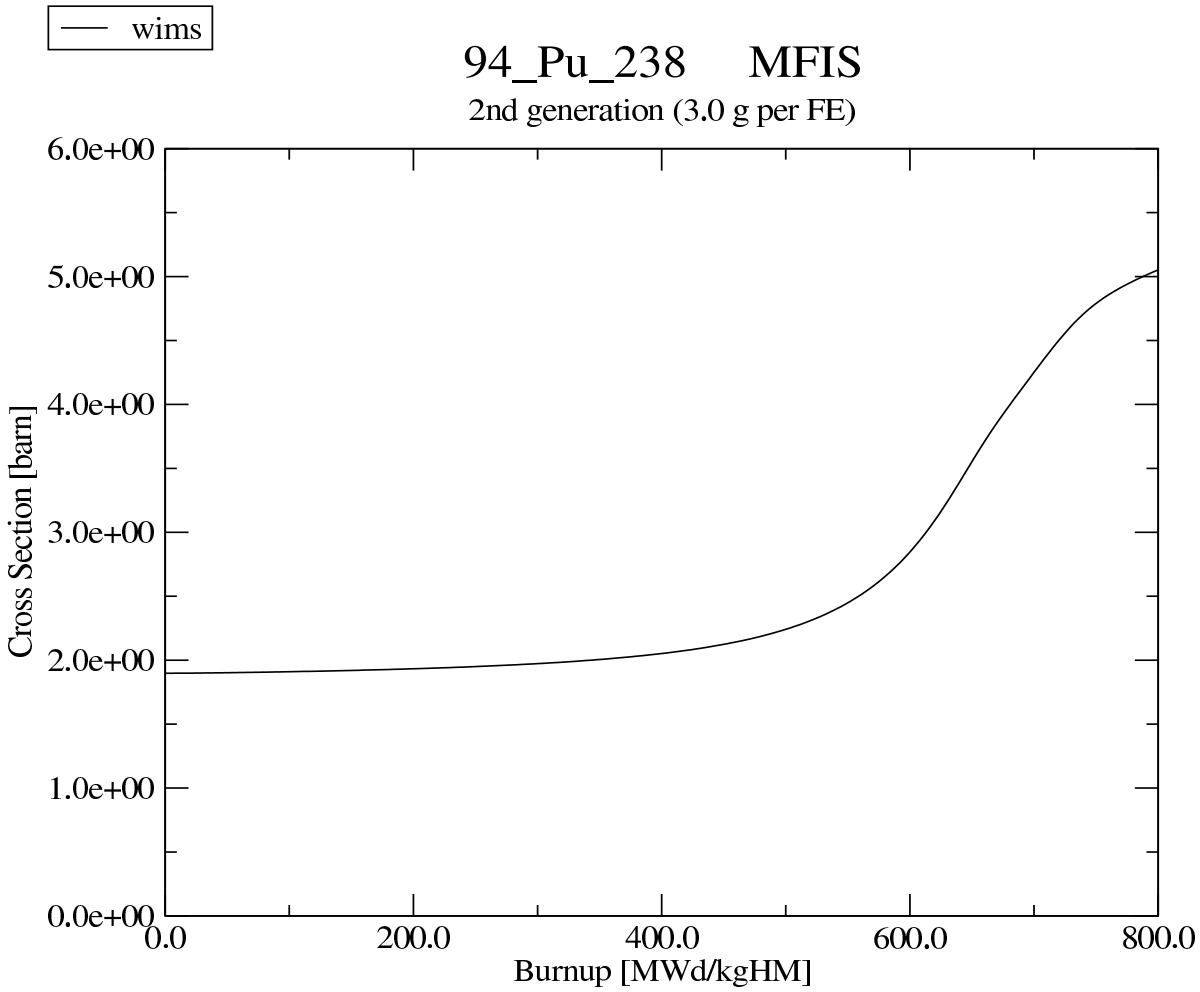


Figure 8.47 Fission Cross Section [$barn$] 94_Pu_238 for case C2

Table 8.48 Fission Cross Section [$barn$] 94_Pu_239 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	4.2131e+01	–	–
100.00	4.5976e+01	–	–
400.00	9.3151e+01	–	–
600.00	2.8724e+02	–	–
800.00	7.4097e+02	–	–

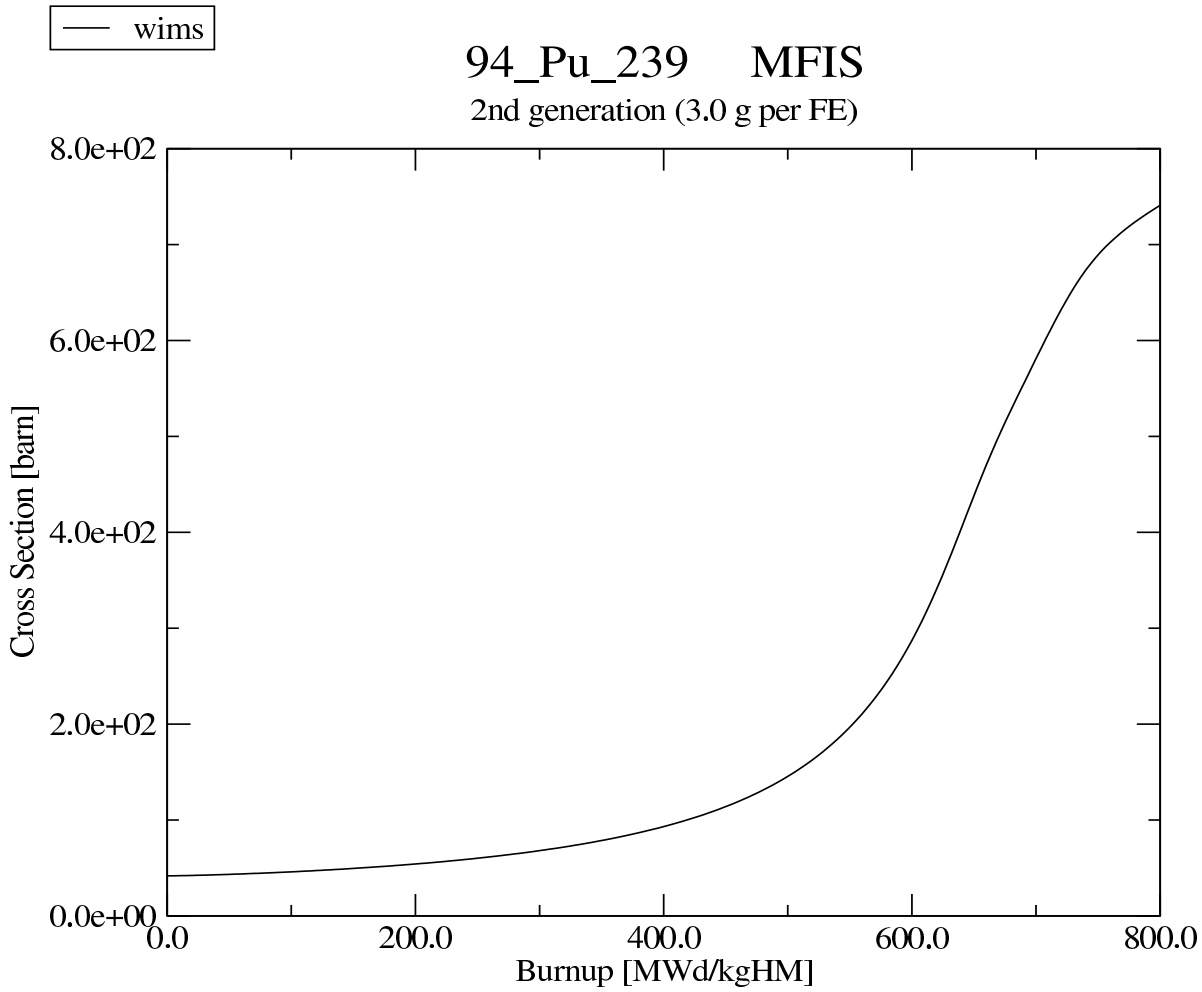


Figure 8.48 Fission Cross Section [$barn$] 94_Pu_239 for case C2

Table 8.49 Fission Cross Section [$barn$] 94_Pu_240 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	3.8964e-01	–	–
100.00	3.9346e-01	–	–
400.00	3.9321e-01	–	–
600.00	3.3316e-01	–	–
800.00	1.2981e-01	–	–

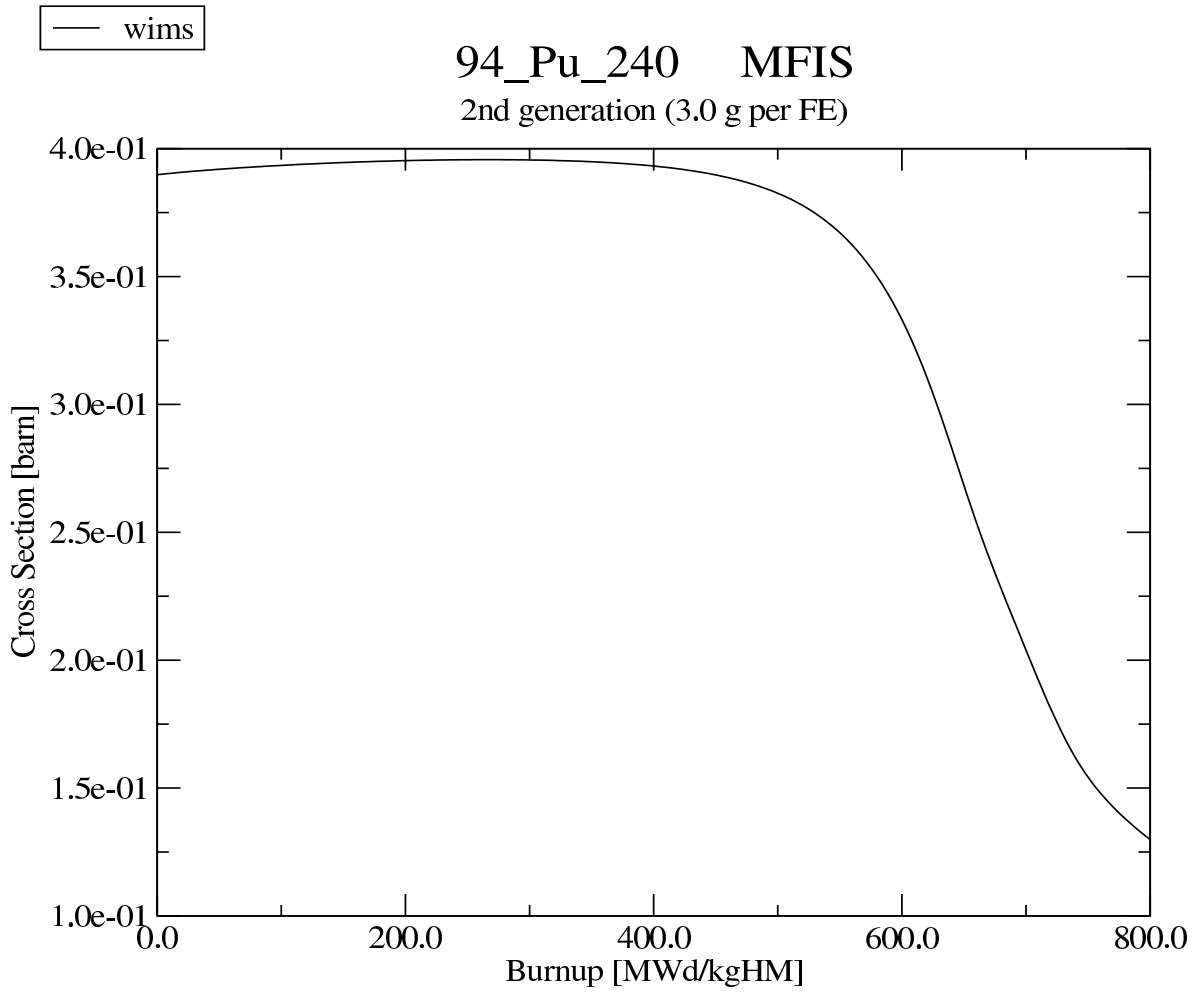


Figure 8.49 Fission Cross Section [$barn$] 94_Pu_240 for case C2

Table 8.50 Fission Cross Section [$barn$] 94_Pu_241 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.2495e+01	–	–
100.00	5.4522e+01	–	–
400.00	8.9237e+01	–	–
600.00	2.5409e+02	–	–
800.00	6.6360e+02	–	–

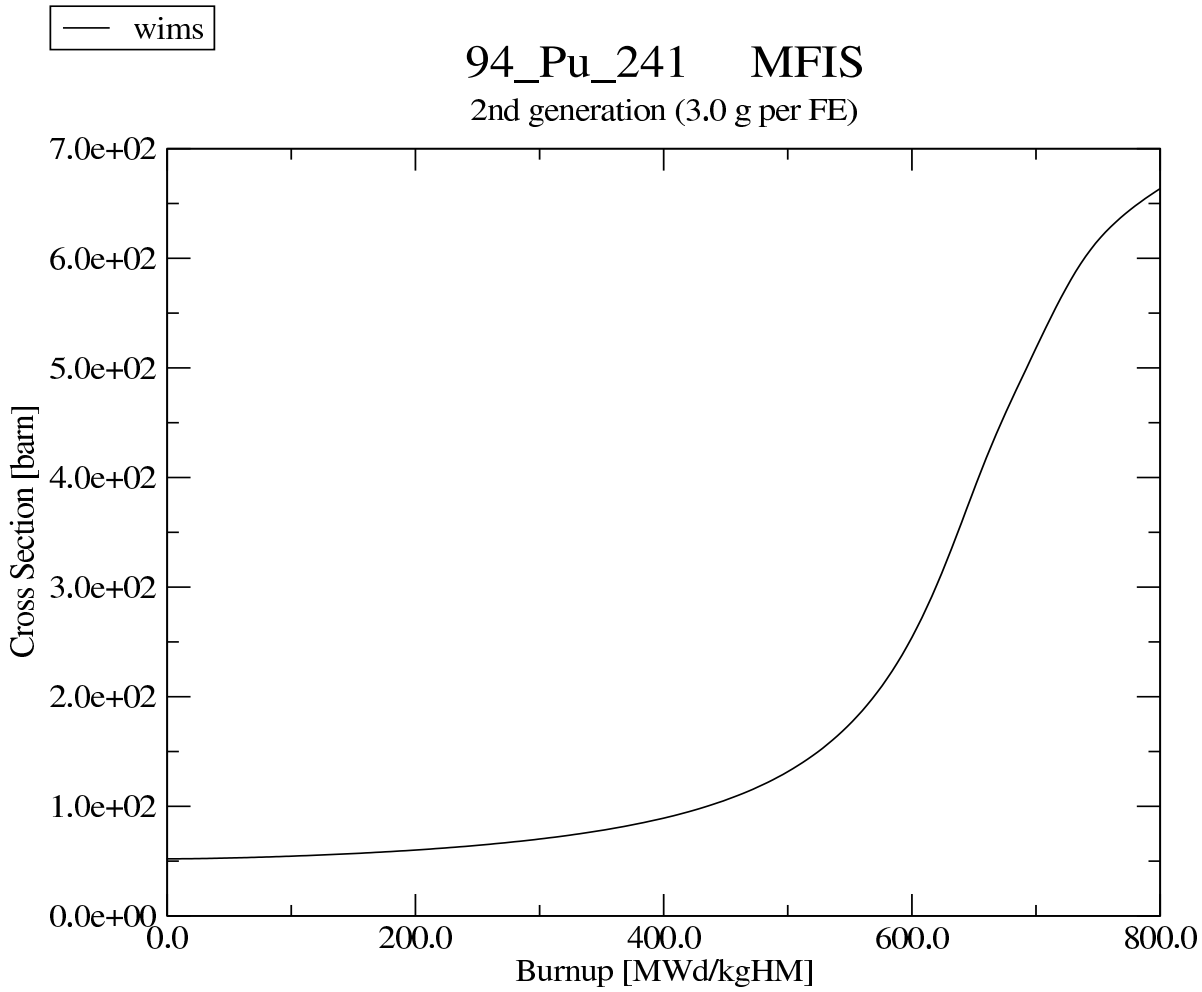


Figure 8.50 Fission Cross Section [$barn$] 94_Pu_241 for case C2

Table 8.51 Fission Cross Section [$barn$] 94_Pu_242 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.4329e-01	–	–
100.00	2.4325e-01	–	–
400.00	2.3012e-01	–	–
600.00	1.7671e-01	–	–
800.00	5.6276e-02	–	–

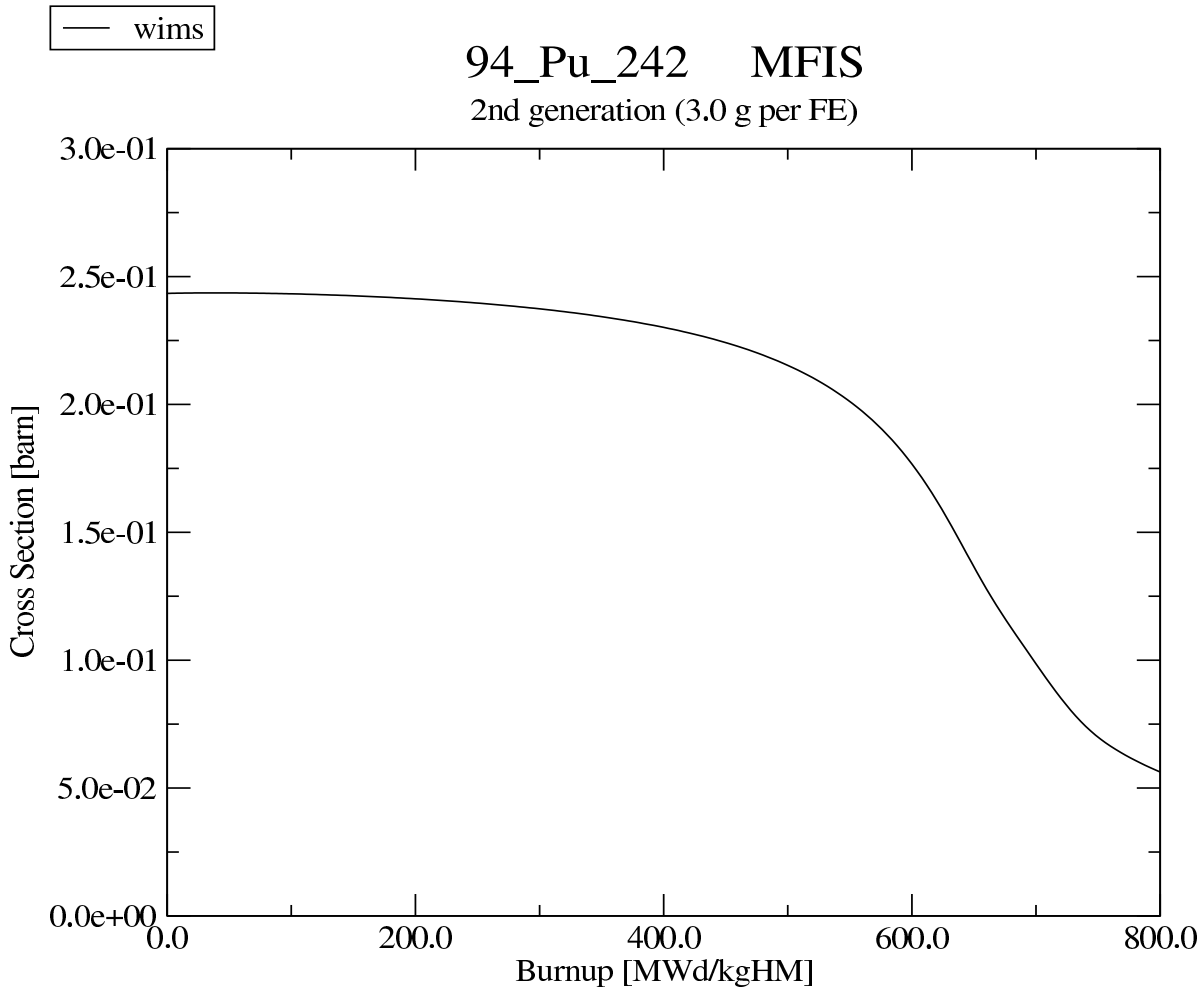


Figure 8.51 Fission Cross Section [$barn$] 94_Pu_242 for case C2

Table 8.52 Fission Cross Section [$barn$] 95_Am_241 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	8.2418e-01	–	–
100.00	8.4580e-01	–	–
400.00	1.1368e+00	–	–
600.00	2.2247e+00	–	–
800.00	4.5865e+00	–	–

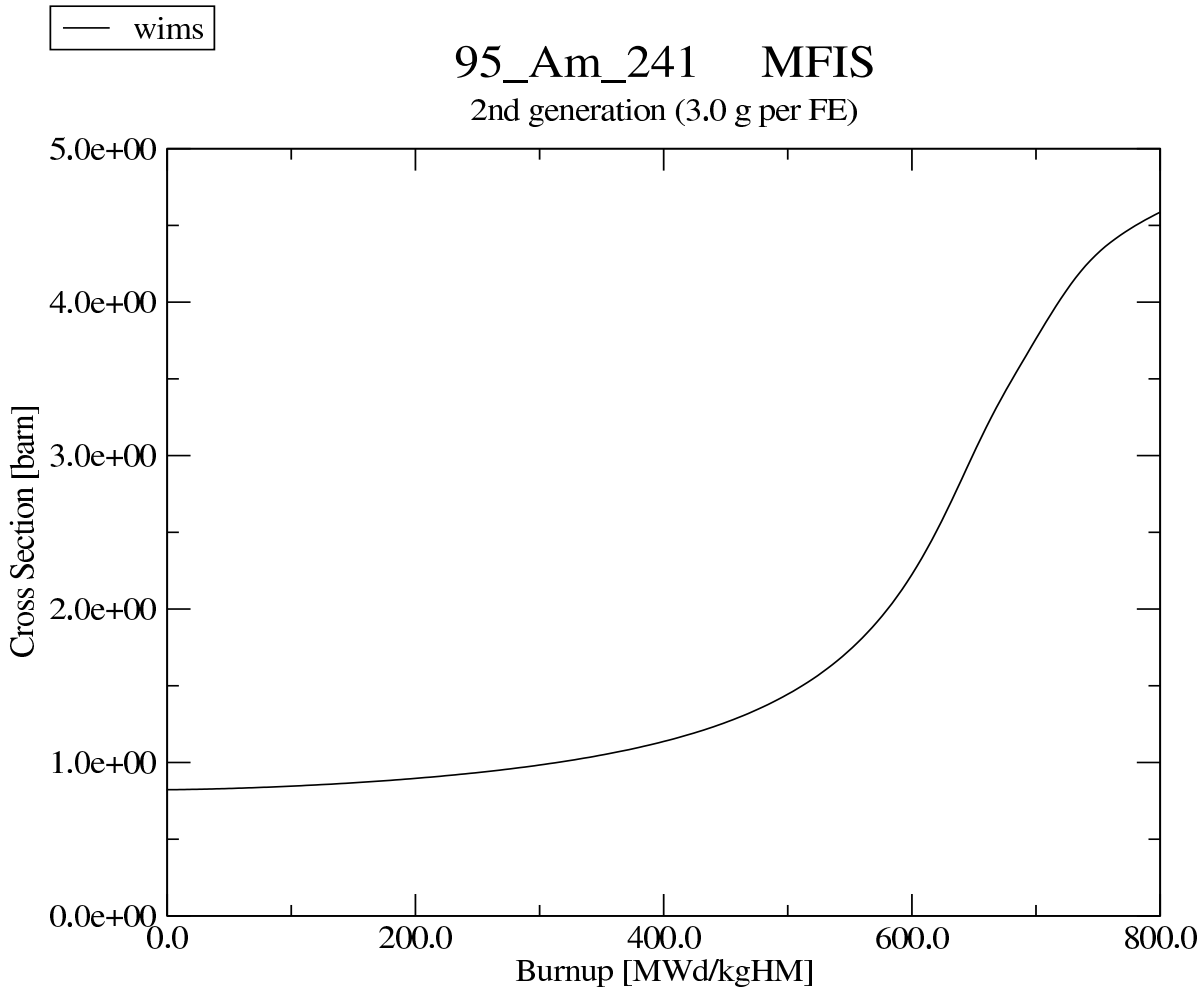


Figure 8.52 Fission Cross Section [$barn$] 95_Am_241 for case C2

Table 8.53 Fission Cross Section [$barn$] 95_Am_242m for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	1.9046e+02	–	–
100.00	2.0218e+02	–	–
400.00	3.9774e+02	–	–
600.00	1.3365e+03	–	–
800.00	3.7183e+03	–	–

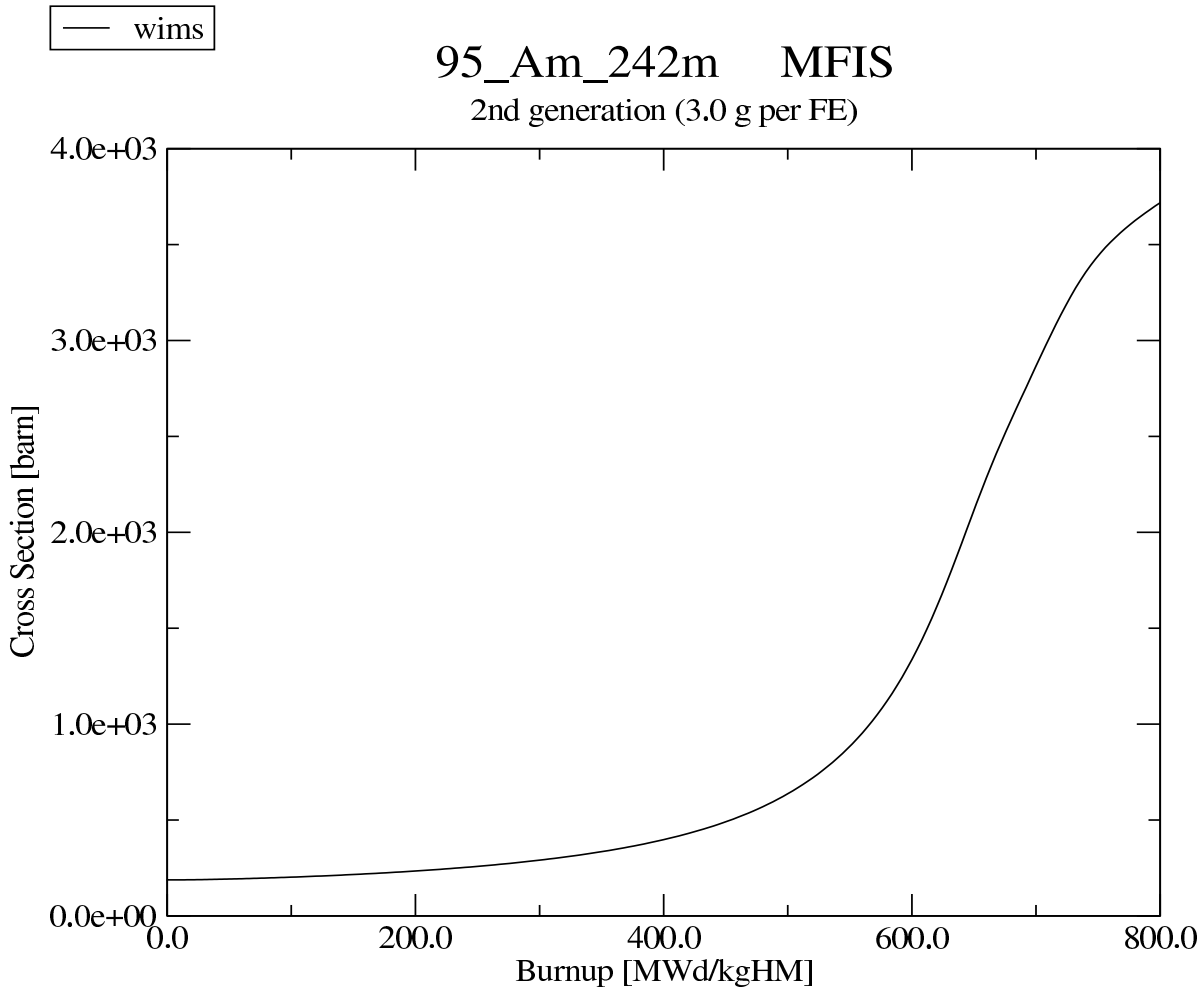


Figure 8.53 Fission Cross Section [$barn$] 95_Am_242m for case C2

Table 8.54 Fission Cross Section [$barn$] 95_Am_243 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	2.4131e-01	–	–
100.00	2.3810e-01	–	–
400.00	2.2481e-01	–	–
600.00	1.7890e-01	–	–
800.00	7.1160e-02	–	–

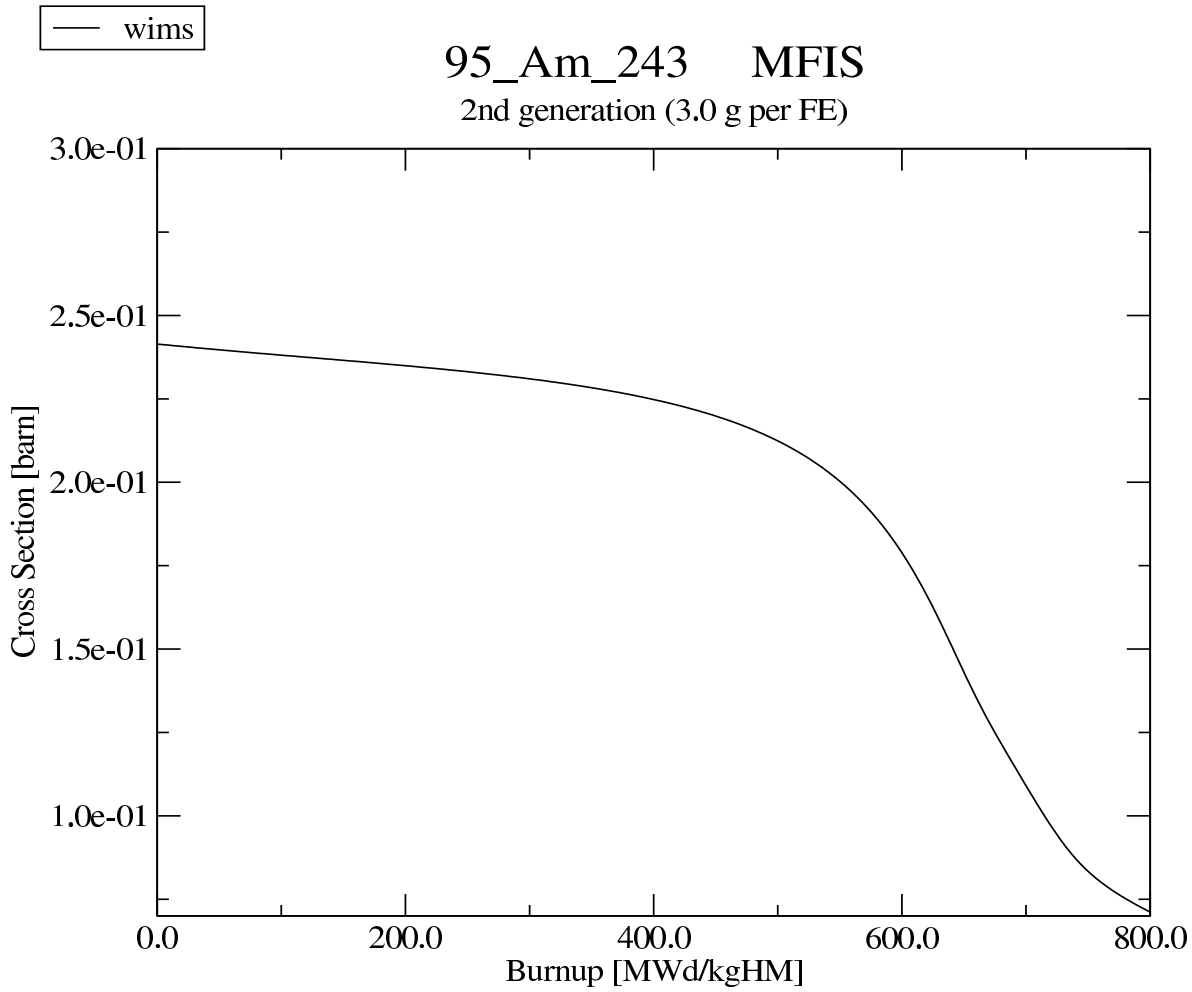


Figure 8.54 Fission Cross Section [$barn$] 95_Am_243 for case C2

Table 8.55 Fission Cross Section [$barn$] 96_Cm_242 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	6.3041e-01	–	–
100.00	6.3601e-01	–	–
400.00	7.2760e-01	–	–
600.00	1.1607e+00	–	–
800.00	2.2620e+00	–	–

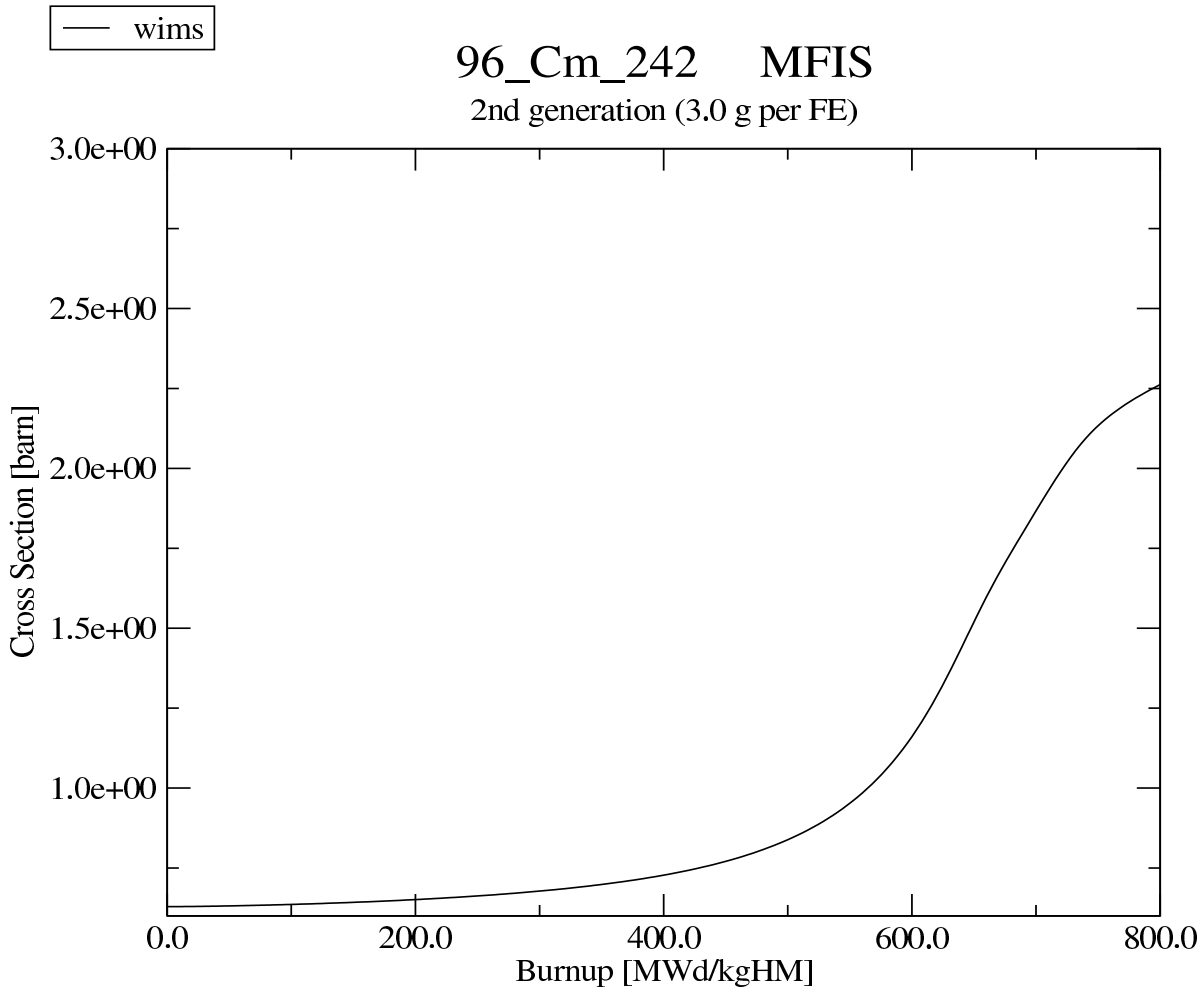


Figure 8.55 Fission Cross Section [$barn$] 96_Cm_242 for case C2

Table 8.56 Fission Cross Section [$barn$] 96_Cm_243 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.1206e+01	–	–
100.00	8.9548e+01	–	–
400.00	9.5513e+01	–	–
600.00	1.2658e+02	–	–
800.00	1.9745e+02	–	–

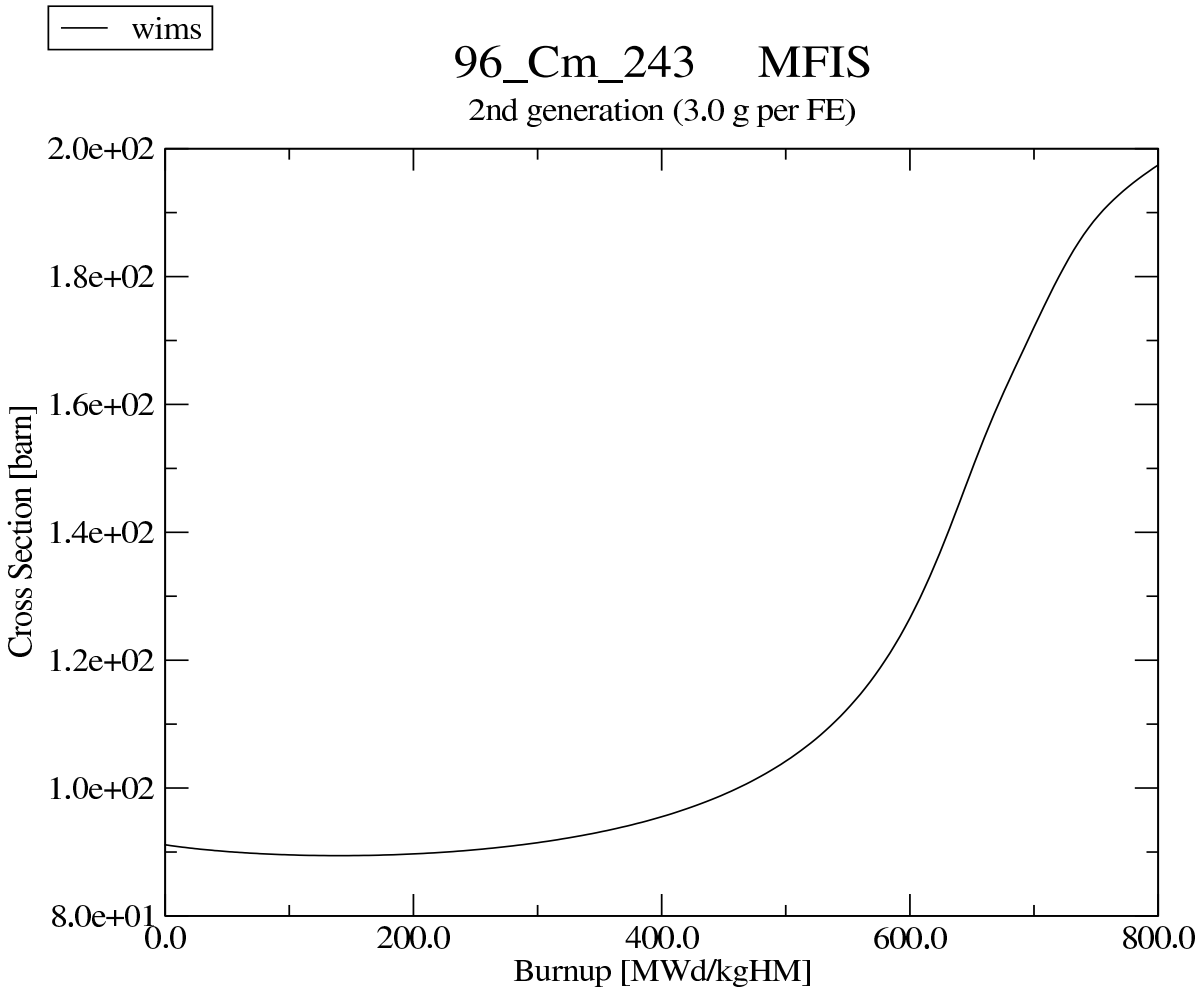


Figure 8.56 Fission Cross Section [$barn$] 96_Cm_243 for case C2

Table 8.57 Fission Cross Section [$barn$] 96_Cm_244 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	9.3977e-01	–	–
100.00	9.3029e-01	–	–
400.00	8.8254e-01	–	–
600.00	7.7499e-01	–	–
800.00	5.4654e-01	–	–

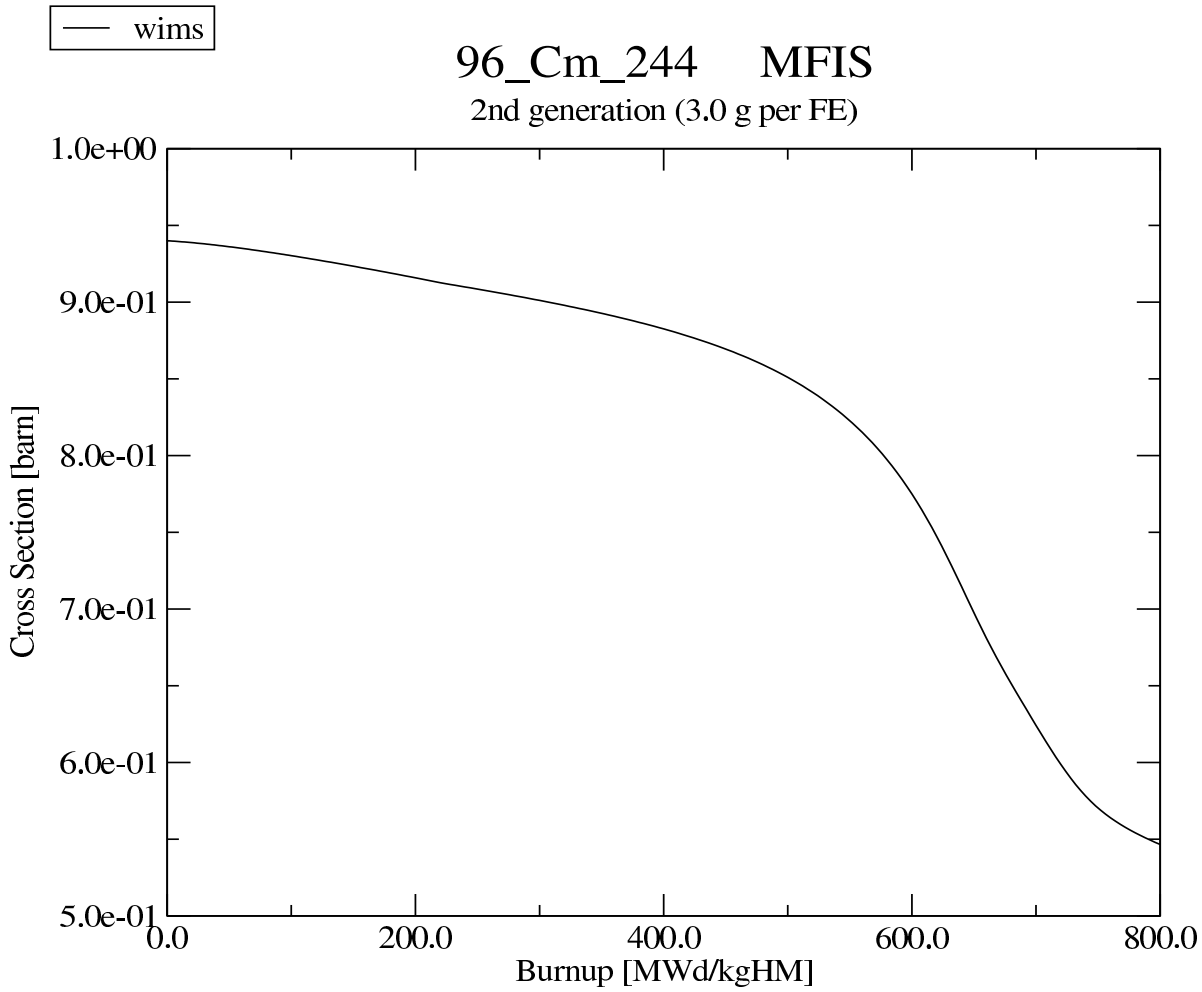


Figure 8.57 Fission Cross Section [$barn$] 96_Cm_244 for case C2

Table 8.58 Fission Cross Section [$barn$] 96_Cm_245 for case C2

burnup [$MWd/kgHM$]	WIMS	OCTOPUS ORIGEN	OCTOPUS FISPACT
0.00	5.3095e+01	–	–
100.00	5.4126e+01	–	–
400.00	8.1227e+01	–	–
600.00	2.1700e+02	–	–
800.00	5.7168e+02	–	–

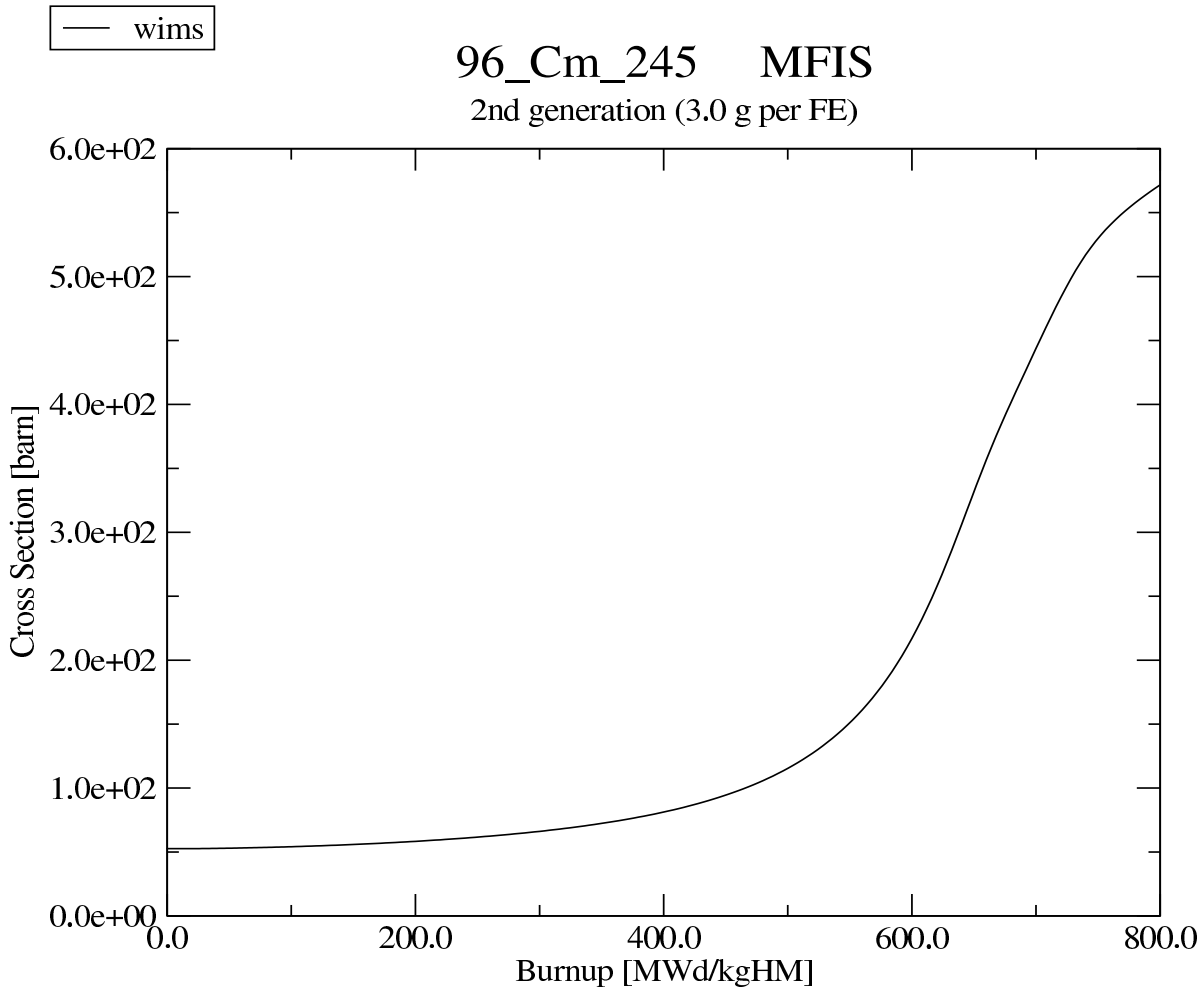


Figure 8.58 Fission Cross Section [$barn$] 96_Cm_245 for case C2

9. Conclusions

Generally, before extremely high burnup is reached, a good correspondence is observed between the results obtained by different code systems.

For example the case A1 (table 5.2) difference in reactivity between OCTOPUS-MCNP-FISPACT and WIMS lies between -278 and +231 pcm until a burnup of 400 MWd/kgHM. This is within the 95% confidence interval (2σ) for the MCNP-calculated k_∞ (standard deviations at 0, 100 and 400 MWd/kgHM are 0.0031, 0.0033 and 0.0027 respectively) in the OCTOPUS-MCNP-FISPACT route. For a burnup of 600 MWd/kgHM the WIMS result is at the border of the 99% confidence interval (3σ) for the MCNP-calculated k_∞ (standard deviation is 0.0005) in the OCTOPUS-MCNP-FISPACT route. Between OCTOPUS-MCNP-ORIGEN and WIMS the reactivity difference lies between -330 and +460 pcm until a burnup of 400 MWd/kgHM. This is within the 95% confidence interval (2σ) for the MCNP k_∞ standard deviation in the OCTOPUS-MCNP-FISPACT route. For a burnup of 600 MWd/kgHM the WIMS result is also within the 95% confidence interval.

The case A1 one-group flux difference (table 5.1) between OCTOPUS-MCNP-FISPACT and WIMS is 1 to 2% until a burnup of 400 MWd/kgHM, and 4% at 600 MWd/kgHM. Between OCTOPUS-MCNP-ORIGEN and WIMS this difference is 1 to 2% until 600 MWd/kgHM.

For density differences we take ^{242}Pu as example. Case A1 (table 5.9) has a difference between OCTOPUS-MCNP-ORIGEN and WIMS below 0.2% (only at 800 MWd/kgHM it becomes 2.5%), and between OCTOPUS-MCNP-FISPACT and WIMS below 1% (only at 800 MWd/kgHM it becomes 3%). Case C1 (table 7.9) has a difference between OCTOPUS-MCNP-FISPACT and WIMS below 0.5% (only at 800 MWd/kgHM it becomes 1.2%).

Only ^{244}Cm and ^{245}Cm (and as a consequence the nuclides descending from them) show large differences in density between OCTOPUS-MCNP-ORIGEN and WIMS. For cases A1 (tables 5.21 and 5.22) as well as C1 (tables 7.16 and 7.17) the WIMS calculated densities of both ^{244}Cm and ^{245}Cm are already at 100 MWd/kgHM burnup 4 times higher than the corresponding OCTOPUS-MCNP-ORIGEN calculated densities, and at 400 MWd/kgHM burnup even 5 times higher These differences can be explained by the differences in the implementation of the ^{243}Am reaction pathways between WIMS8a and ORIGEN. Further investigation of the OCTOPUS-MCNP-FISPACT route is required, as well as intercomparison with the results from other benchmark participants.

References

[1] European Fifth Framework Program Contract no. FIKI-CT-2001-00169 "HTR-N1", signed 20. September 2001.

[2] H.J. Ruetten and J.C. Kuijper,
Plutonium (1st and 2nd generation) cell burnup benchmark specification,
Report HTR-N1-02/06-S-3.1.1 (2003).

[3] AEA Technology
WIMS
Original Issue, July 1999
A Modular Scheme for Neutronics Calculations
User Guide for Version 8, ANSWERS/WIMS(99)9

[4] J.Oppe,
WIMS datagram library uitbreiding,
NRG Report 20780/02.48983 FAI/JO/AB (28 aug. 2002)

[5] J.Oppe,
OCTOPUS_TNG Reference Guide,
NRG Report 20748/03.54103/C (August 2003)

[6] NRG FAI verification number 20030516ver1

[7] J.F. Briesmeister,
MCNP - A General Monte Carlo N-Particle Transport Code, Version 4C,
Technical Report LA-13709-M, Los Alamos National Laboratory, USA (2000)
J.S. Hendricks,
MCNP4C3, Report X-5:RN(U)-JSH-01-17, Los Alamos National Laboratory, USA (2001)

[8] O.W. Hermann, R.M. Westfall,
ORIGEN-S
SCALE SYSTEM module to calculate fuel depletion, actinide transmutation, fission product buildup and decay, and associated radiation source terms,
Oak Ridge National Laboratory, USA (February 1989)

[9] R.A. Forrest and J.-Ch. Sublet,
FISPACT 4 User Manual,
EASY Documentation Series UKAEA FUS 287 (1995)

[10] E.E. Bende,
Plutonium Burning in a Pebble-Bed Type High Temperature Nuclear Reactor,
Ph.D.Thesis, Delft University of Technology, 1999.

[11] K.M. Case, F. de Hoffmann, G. Placzek,
Introduction to the theory of neutron diffusion,
Vol.1, U.S. A.E.C. report, Los Alamos National Laboratory, Los Alamos, New Mexico, USA (1953)

[12] H.Th. Klippel, A. Hogenbirk, R.C.L. van der Stad, A.J. Janssen, J.C. Kuijper, P. Levin,
Reactor physics calculations on HTR type configurations,
in *Proceedings of the ECN workshop on the role of modular HTRs in the Netherlands*,
ECN-R–95-027 (June 1995)

APPENDIX A. Timesteps

Given as burnup values [MWd/kgHM] the time steps are the same for each case. For cases A1 and B1 each burnup increment of 1.0 MWd/kgHM corresponds to 1.0 full power days. For case C1 each burnup increment of 1.0 MWd/kgHM corresponds to 1.5 full power days. For case C2 each burnup increment of 1.0 MWd/kgHM corresponds to 3.0 full power days.

The following burnup values [MWd/kgHM] were used to define 230 time steps for WIMS (chapter 2) and for OCTOPUS (chapters 3 and 4).

cycle number	burnup $[MWd/kgHM]$
0	0.00
1	0.05
2	0.10
3	0.50
4	1.00
5	2.00
6	4.00
7	6.00
8	8.00
9	10.00
10	12.00
11	14.00
12	16.00
13	18.00
14	20.00
15	22.00
16	24.00
17	26.00
18	28.00
19	30.00
20	32.00
21	34.00
22	36.00
23	38.00
24	40.00
25	42.00
26	44.00
27	46.00
28	48.00
29	50.00
30	52.00

cycle number	burnup $[MWd/kgHM]$
31	54.00
32	56.00
33	58.00
34	60.00
35	62.00
36	64.00
37	66.00
38	68.00
39	70.00
40	72.00
41	74.00
42	76.00
43	78.00
44	80.00
45	82.00
46	84.00
47	86.00
48	88.00
49	90.00
50	92.00
51	94.00
52	96.00
53	98.00
54	100.00
55	104.00
56	108.00
57	112.00
58	116.00
59	120.00
60	124.00
61	128.00
62	132.00
63	136.00
64	140.00
65	144.00
66	148.00
67	152.00
68	156.00
69	160.00
70	164.00

cycle number	burnup $[MWd/kgHM]$
71	168.00
72	172.00
73	176.00
74	180.00
75	184.00
76	188.00
77	192.00
78	196.00
79	200.00
80	204.00
81	208.00
82	212.00
83	216.00
84	220.00
85	224.00
86	228.00
87	232.00
88	236.00
89	240.00
90	244.00
91	248.00
92	252.00
93	256.00
94	260.00
95	264.00
96	268.00
97	272.00
98	276.00
99	280.00
100	284.00
101	288.00
102	292.00
103	296.00
104	300.00
105	304.00
106	308.00
107	312.00
108	316.00
109	320.00
110	324.00

cycle number	burnup $[MWd/kgHM]$
111	328.00
112	332.00
113	336.00
114	340.00
115	344.00
116	348.00
117	352.00
118	356.00
119	360.00
120	364.00
121	368.00
122	372.00
123	376.00
124	380.00
125	384.00
126	388.00
127	392.00
128	396.00
129	400.00
130	404.00
131	408.00
132	412.00
133	416.00
134	420.00
135	424.00
136	428.00
137	432.00
138	436.00
139	440.00
140	444.00
141	448.00
142	452.00
143	456.00
144	460.00
145	464.00
146	468.00
147	472.00
148	476.00
149	480.00
150	484.00

cycle number	burnup $[MWd/kgHM]$
151	488.00
152	492.00
153	496.00
154	500.00
155	504.00
156	508.00
157	512.00
158	516.00
159	520.00
160	524.00
161	528.00
162	532.00
163	536.00
164	540.00
165	544.00
166	548.00
167	552.00
168	556.00
169	560.00
170	564.00
171	568.00
172	572.00
173	576.00
174	580.00
175	584.00
176	588.00
177	592.00
178	596.00
179	600.00
180	604.00
181	608.00
182	612.00
183	616.00
184	620.00
185	624.00
186	628.00
187	632.00
188	636.00
189	640.00
190	644.00

cycle number	burnup $[MWd/kgHM]$
191	648.00
192	652.00
193	656.00
194	660.00
195	664.00
196	668.00
197	672.00
198	676.00
199	680.00
200	684.00
201	688.00
202	692.00
203	696.00
204	700.00
205	704.00
206	708.00
207	712.00
208	716.00
209	720.00
210	724.00
211	728.00
212	732.00
213	736.00
214	740.00
215	744.00
216	748.00
217	752.00
218	756.00
219	760.00
220	764.00
221	768.00
222	772.00
223	776.00
224	780.00
225	784.00
226	788.00
227	792.00
228	796.00
229	800.00
230	800.10

APPENDIX B. Benchmark specification

This appendix is a copy of [2].