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**Decay heat validation, FISPACT-II &
FENDL-3.0 and TENDL-2013,-2012
nuclear data libraries**

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Executive Summary

The calculation of activation inventories is a key input to virtually all aspects of the operation, safety and environmental assessment of nuclear plants. For the licensing of such devices, regulatory authorities will require proof that the calculations for structural materials and fuel inventories, and calculations to which these quantities are the inputs, are either correct or conservative. An important aspect of activation-transmutation is decay heat power.

In power plants decay power arises after shutdown from the energy released in the decay of the products of neutron interaction from α , γ and β emissions. Computation of the decay power is performed by sophisticated computer codes which solve the large number of coupled differential equations governing the generation and decay chains for the many nuclides involved. They rely on a large volume of nuclear data that includes both neutron activation-transmutation cross sections and radioactive decay data.

Validation of decay power computational predictions by means of direct comparison with integral data and measurement of sample structural materials under high energy relevant neutron spectra generates confidence in the values calculated. It also permits an assessment of the adequacy of the methods and nuclear data, and indicates any inaccuracy or omission that may have led to erroneous results.

No experimental data on decay power existed for most fission reactor materials other than reactor fuel, or for materials under high energy irradiation conditions typical of fusion, until a series of experiments were performed using the Fusion Neutron Source FNS facility at the Japan Atomic Energy Agency JAEA. Many elements and some alloy micro-samples were irradiated in a simulated D-T neutron field for times up to 7 hours and the resulting decay power generated was measured for cooling times of up to a year or more. Using the highly sensitive Whole Energy Absorption Spectrometer (WEAS) method, both β and γ emission decay energies were measured at selected cooling times as early as a few tens of seconds after the irradiation ended.

Overall the results of this particular validation exercise indicate that the calculational methods and nuclear databases, with some notable exceptions, generally allow predictions, with quantifiable margins, of the decay power of the tested materials against cooling time. It tests the specific production pathways and at the same time the decay data associated with the nuclides that dominate the decay heat. Note that the decay characteristic of the predominant isotopes is independent of the production route: be it fission, fusion or transmutation in general.

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1 Introduction

Safety and environmental (S&E) impact issues have acquired increasing importance for the development of power plants. As part of future programmes and especially in connection with engineering feasibility studies, S&E and R&D analyses require a sound and reliable database for the neutron-induced primary and secondary responses. The words primary and secondary define two very different types of response: the former relates to neutronic and gamma-ray time independent responses when the plant is in operation, while the latter refers to time dependent responses which are important after shutdown. In power plants, decay heat will arise after shutdown from the energy released in the decay of the products of particle interactions.

The calculation of activation inventories is an important input to virtually all aspects of S&E analysis. For licensing, the regulatory authorities will require proof of either the correctness or conservatism of the calculations of activation-transmutation and of calculations which use activation-transmutation as input. The radioactive inventory and residual decay power generation depend on the specific design of the plant and its components, its geometrical configuration and material choices, as well as the given irradiation conditions: power, operational scenario, and neutron source distribution. It is essential to include in the plant development properly performed activation inventory calculations that are consistent with the overall plant design. An important aspect of activation is residual decay power. The residual decay power, in the event of a postulated accident in which cooling is lost, might induce structural damage in certain plant components. Temperature transients may promote gas-generating chemical reactions and, in plants of high power density, may promote the mobilisation of activation, transmutation or fission products.

There is thus a strong motivation to limit accidental temperature transients and to ensure that the design and material-choices provide for removal of decay heat, preferably by passive means. Safety studies assess the efficiency of the design in this regard using computer models which require, as a starting point, an accurate assessment of the decay heat levels in the plant. Computation of the decay power is performed by sophisticated computer codes which solve the large number of coupled differential equations which govern the generation and decay chains for the many nuclides involved. They rely on a large volume of nuclear data, both neutron activation-transmutation cross sections and radioactive decay data.

Validation of decay power predictions from such codes by means of direct comparison with integral data measurements of sample structural materials under neutron spectra allow confidence to be given to the decay power values calculated. It also permits an assessment of the adequacy of the methods and nuclear data, and indicates any inaccuracy or omission that may have led to erroneous code predictions. Safety authorities world-wide tend to request experimental validation results that can be used to assess the adequacy of the safety features. It is clear that certain safety margins can be derived from such a validation exercise, if relevant to plant operation, materials and

design, and applied as bounding conditions in S&E analyses.

Little experimental data exists for structural material samples irradiated under relevant neutron spectra and even when data does exist the measured quantities are either specific activity and/or γ spectroscopy. In particular, no experimental data on decay power has previously existed for fission plant structural materials and for materials under high energy irradiation conditions (i.e. fusion). It was to fill this gap that a series of experiments were performed using the Fusion Neutron Source (FNS) facility at the Japan Atomic Energy Agency JAEA [1, 2, 3]. Material samples were irradiated in a simulated D-T neutron field and the resulting decay power was measured for cooling times of up to thirteen months. Using the highly sensitive Whole Energy Absorption Spectrometer (WEAS) method, both β and γ emission decay energies were measured at selected cooling times and, quite impressively, as soon as a few tens of seconds after the end of irradiation.

2 EXPERIMENTAL SET-UP

2.1 FNS assembly

14 MeV neutrons are generated by a 2 mA deuteron beam impinging on a stationary tritium-bearing titanium target. The total neutron flux at the sample location, for this experiment, is in the range of 1.0×10^{10} [$\text{n cm}^{-2} \text{s}^{-1}$], the same order of magnitude as in the first wall of the Joint European Torus (JET) fusion experiment when operating with D-T plasma. However, the irradiation time at the FNS were of 5 minutes and 7 hours in comparison with the few seconds flat burn achieved during the DTE1 JET fusion campaign. The DTE1 campaign culminated in a single 16MW fusion shot. As a point of reference the total flux in a power plant is typically in the region of 10^{13} or 10^{14} [$\text{n cm}^{-2} \text{s}^{-1}$], three to four orders of magnitude higher and also continuous.

Thin samples, $25 \times 25 \text{ mm}^2$ in area, and typically $10 \mu\text{m}$ thick, have been used, either as metallic foil or powder sandwiched between tape. Use of a thin sample minimises the self-absorption of β rays emitted in the sample itself and allows their measurement. A total of 74 different materials have been used across the different phases of the experiment.

The decay energy in each irradiated sample was measured in the Whole Energy Absorption Spectrometer (WEAS), which comprises two large bismuth-germanate BGO scintillators in a geometric arrangement, provides almost 100 % detection efficiency for both β and γ -rays (see Figure 1). Correction factors need to be applied for γ -ray efficiency and for β and electron energy loss in the sample itself (less than 15% generally), and for other effects such as the decay heat due to the plastic tape used for the powder samples. The overall experimental uncertainty totals between 6 to 10% in most cases, although it rises to higher levels at particular cooling time for certain samples. The WEAS provides high sensitivity, down to powers less than 1 pW, which is valuable for

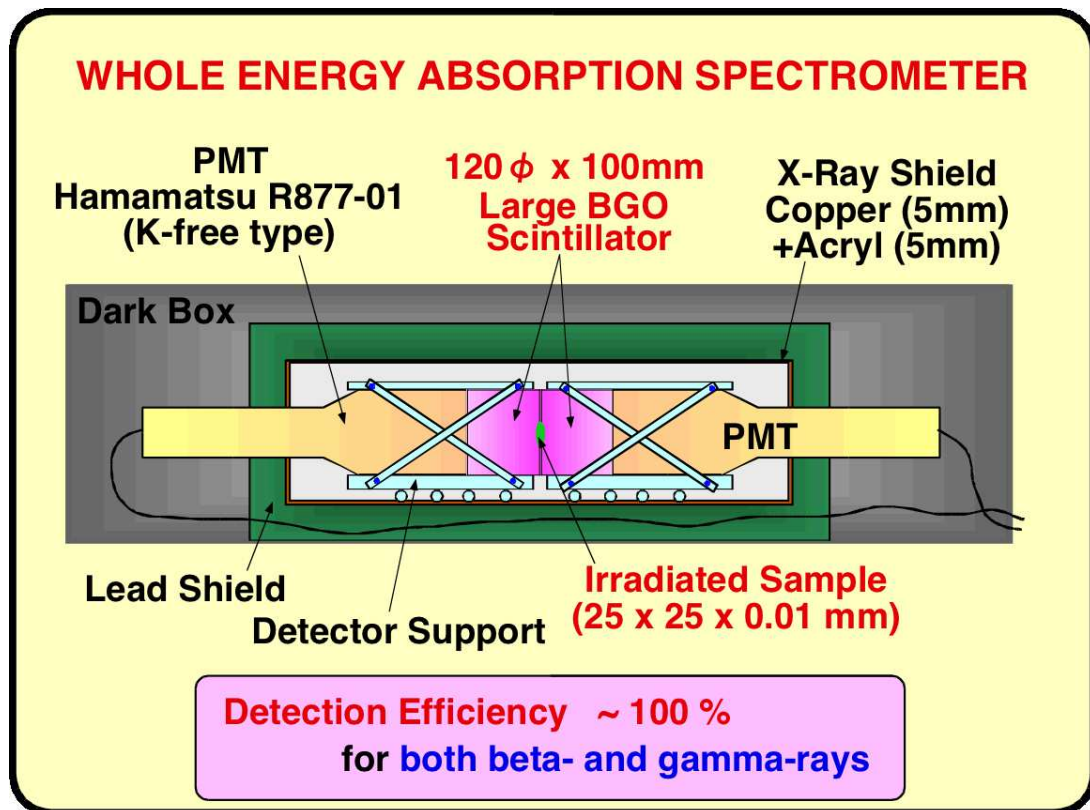


Figure 1: Whole Energy Absorption Spectrometer WEAS set-up

measurement of some nuclides with long half-lives. It also has a wide dynamic range: measurements of up to a few mW have been achieved in the experiments.

2.2 Irradiation conditions

Three types of irradiation have been performed in order to extract the maximum information possible from such experiments. First, a 5 minute irradiation rapidly followed by a time dependent series of decay power measurements from tens of seconds up to one hour of cooling was used. Such prompt measurements are made possible by the use of a small sample rapidly transported from the irradiation zone to the measurement areas by means of pneumatic tubes. This particular type of measurement allows very short half-life nuclides to be detected and measured. Second, a 7 hour irradiation was performed for some of the samples, followed by a more relaxed time-dependent series of decay power measurements spanning from half a day up to a year of cooling. And third, in order to broaden the scope of the study and enlarge the materials database, the number of studied materials was increased from 32 to 74, covering many more elements of interest, but with published results only on the 5 minute irradiation experiments.

In the 5 minute irradiation experiments, three different positions were used: positions 1, 2, 3; while only one sample position, 7, was used for the 7 hour irradiations. The experimental set-ups in for each position are depicted in Figure 2. Different neutron spectra, in the 175 Vitamin-J group structure, were calculated using the Monte Carlo code MCNP [3] with a geometrical configuration corresponding to the different assembly positions, and are plotted in Figure 3. Slight spectral differences exist between position 1, 2 and 3; however the neutron flux profiles indicate a marked 14 MeV fusion peak and very few neutrons at energies lower than one MeV. The flux profile corresponding to position 7 is sufficiently shifted from the others to be treated separately. It is clear from Figure 3 and the fact the calculated standard deviation is large (typically greater than 20% [3]) for the energy groups below 1 keV, that no reaction rates can be well characterised at these energies. This means that if the energies below 1 keV are important in the production pathways of a measured radionuclide, no clear conclusion should be drawn from the comparison. Note that a nominal 0.5 to 1% standard deviation convergence criteria for reaction rates in all the neutron energy bins was not achieved in the Monte Carlo simulation, although the standard deviation of the total fluxes was below a few percent. This highlights the fact that in Monte Carlo simulations the total-flux standard deviation is not a good indicator of the quality of the neutron flux spectra, particularly in their low energy tails.

Originally in 1996, 32 relevant materials were irradiated at JAEA/FNS, for 5 minutes and 7 hours, and decay heat values measured over a wide range of cooling times: from a few tens of seconds up to 400 days, and compared to predictions with previous activation databases [4, 5]. These results are referred to as FNS-96 in this report. Additionally in 1998-99, 74 samples - one for each of naturally occurring elements, but excluding very light element and noble gases - were prepared for a new measurement campaign in the same assembly. The experimental results are referred to in this report as FNS-00, having been released officially in 2000.

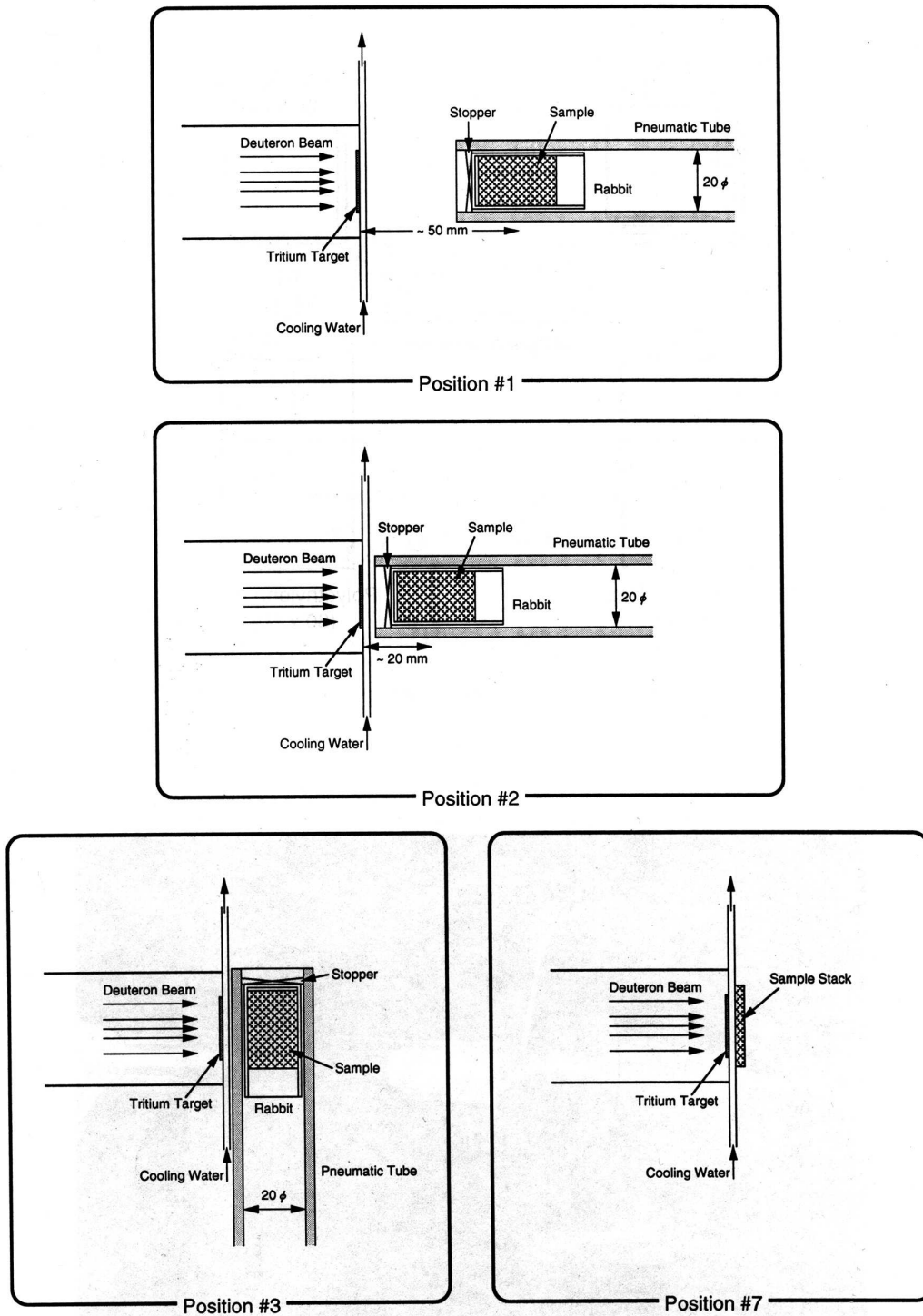


Figure 2: JAEA FNS four set up assemblies

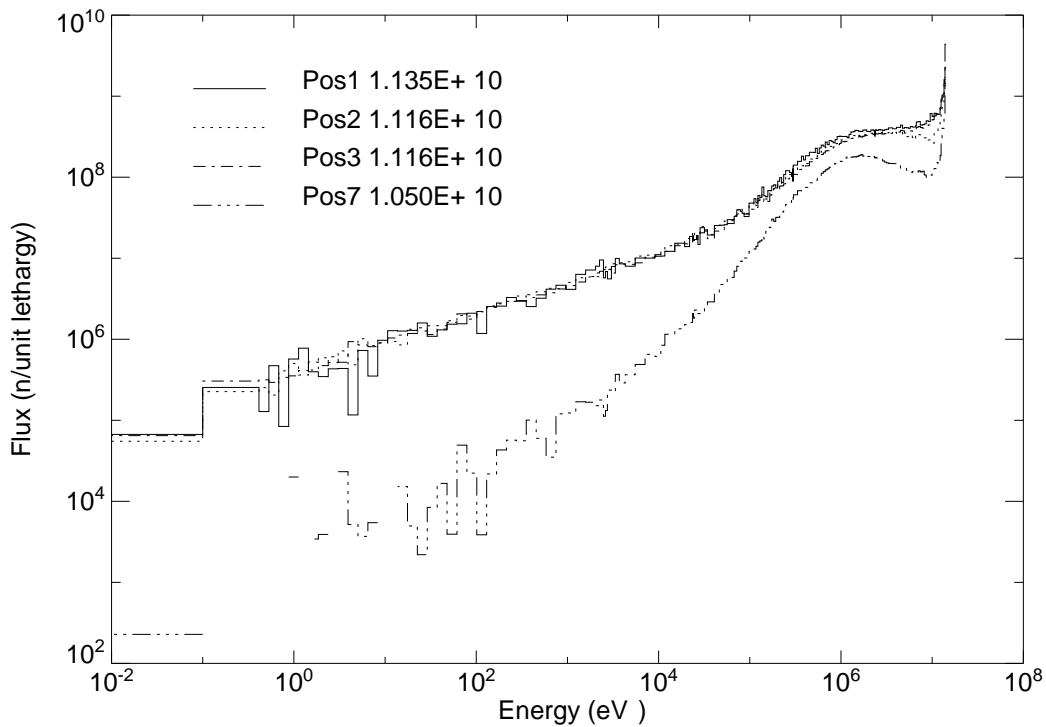


Figure 3: FNS Neutron spectra, neutron fluence monitored by $^{27}\text{Al}(n,\alpha)^{24}\text{Na}$

2.3 Material data

For each of the 74 material samples, the percentage elemental weight has been supplied by JAEA. These tend to correspond to the theoretical weight distribution calculated from the compound or material formulae for the major isotopes. No impurity levels have been given and thus no isotopes other than the major ones have been used in the input data of the calculation scheme. The lack of real chemical analysis of the irradiated samples, although not thought to be important at the preparatory stage of this validation exercise, will be shown to be a drawback for certain materials that seem to have contained a specified (by the manufacturer), but un-quantified, amount of impurities. If those levels of impurities are not known then the code predictions cannot be accurate, and so the comparison will be inconclusive at times when impurities are proven to be important. Table 1 gives a complete list of the irradiated samples and their experimental form.

| Z | Element | Form | Z | Element | Form |
|-------|---------------|---|----|--------------|-----------------------------------|
| 9 | Fluorine | CF ₂ | 46 | Palladium | Metallic Foil |
| 11 | Sodium | Na ₂ CO ₃ | 47 | Silver | Metallic Foil |
| 12 | Magnesium | MgO | 48 | Cadmium | Metallic Foil |
| 13 | Aluminium | Metallic Foil | 49 | Indium | Metallic Foil |
| 14 | Silicon | Metallic Powder | 50 | Tin | SnO ₂ |
| 15 | Phosphorus | P ₃ N ₅ | 51 | Antimony | Metallic Powder |
| 16 | Sulphur | Powder | 52 | Tellurium | TeO ₂ |
| 17 | Chlorine | C ₂ H ₂ Cl ₂ | 53 | Iodine | IC ₆ H ₄ OH |
| 19 | Potassium | K ₂ CO ₃ | 55 | Caesium | Cs ₂ O ₃ |
| 20 | Calcium | CaO | 56 | Barium | BaCO ₃ |
| 21 | Scandium | Sc ₂ O ₃ | 57 | Lanthanum | La ₂ O ₃ |
| 22 | Titanium | Metallic Foil | 58 | Cerium | CeO ₂ |
| 23 | Vanadium | Metallic Foil | 59 | Praseodymium | Pr ₆ O ₁₁ |
| 24 | Chromium | Metallic Powder | 60 | Neodymium | Nd ₂ O ₃ |
| 25 | Manganese | Metallic Powder | 62 | Samarium | Sm ₂ O ₃ |
| 26 | Iron | Metallic Foil | 63 | Europium | Eu ₂ O ₃ |
| Alloy | SS304 | Metallic Foil | 64 | Gadolinium | Gd ₂ O ₃ |
| Alloy | SS316 | Metallic Foil | 65 | Terbium | Tb ₄ O ₇ |
| 27 | Cobalt | Metallic Foil | 66 | Dysprosium | Dy ₂ O ₃ |
| Alloy | Inconel-600 | Metallic Foil | 67 | Holmium | Ho ₂ O ₃ |
| 28 | Nickel | Metallic Foil | 68 | Erbium | Er ₂ O ₃ |
| Alloy | Nickel-chrome | Metallic Foil | 69 | Thulium | Tm ₂ O ₃ |
| 29 | Copper | Metallic Foil | 70 | Ytterbium | Yb ₂ O ₃ |
| 30 | Zinc | Metallic Foil | 71 | Lutetium | Lu ₂ O ₃ |
| 31 | Gallium | Ga ₂ O ₃ | 72 | Hafnium | Metallic Powder |
| 32 | Germanium | GeO ₂ | 73 | Tantalum | Metallic Foil |
| 33 | Arsenic | As ₂ O ₃ | 74 | Tungsten | Metallic Foil |
| 34 | Selenium | Metallic Powder | 75 | Rhenium | Metallic Powder |
| 35 | Bromine | BrC ₆ H ₄ COOH | 76 | Osmium | Metallic Powder |
| 37 | Rubidium | Rb ₂ CO ₃ | 77 | Iridium | Metallic Powder |
| 38 | Strontium | SrCO ₃ | 78 | Platinum | Metallic Foil |
| 39 | Yttrium | Y ₂ O ₃ | 79 | Gold | Metallic Foil |
| 40 | Zirconium | Metallic Foil | 80 | Mercury | HgO |
| 41 | Niobium | Metallic Foil | 81 | Thallium | Tl ₂ O |
| 42 | Molybdenum | Metallic Foil | 82 | Lead | Metallic Foil |
| 44 | Ruthenium | Metallic Powder | 83 | Bismuth | Metallic Powder |
| 45 | Rhodium | Metallic Powder | | | |

Table 1: Irradiated sample materials

3 CODE AND LIBRARIES

The European Activation System, EASY-II [6], has been used to perform this validation exercise. Three, quite-different, cross section databases have been accessed using the FISPACT-II code [7]: FENDL-3.0/A [8], TENDL-2012 [9] and TENDL-2013 [10]. The decay data libraries used with the three cross sections libraries are different as well, although they have evolved to a lesser extent. In chronological and quality terms TENDL-2013 is the more up to date nuclear data library. In order not to bias the experimental spectral data, the groupwise libraries used in the calculation scheme all correspond to a 616 group structure collapsed using a flat micro flux weighting function.

These calculations required the collapse of the nuclear data libraries for each flux at positions 1, 2, 3 and 7. The well validated FISPACT-II features that allow a determination of the dominant radionuclides, and the pathways analysis of their formation, have been used and are reflected in the detailed comparison analysis.

Also the method used in FENDL libraries to assess the calculation uncertainties could be related to either the E/C results or the experimental uncertainties. This provides a unique opportunity to assess the adequacy of the uncertainty data.

4 COMPARISON OF THE RESULTS

For each material sample and irradiation condition, FISPACT-II, combined with the FENDL-3.0/A, TENDL-2012, or TENDL-2013, calculations have been performed. Tabular and graphical comparisons of the results are presented. On the graphs FNS experimental measurements are also plotted and include the uncertainties as vertical lines, while the grey shadow area corresponds to the calculation uncertainty for FENDL-3.0/A. The 5 minute irradiation results are presented first followed by those for the 7 hour irradiations. Care needs to be taken when interpreting the graphs, particularly in view of the log-linear scales. Such plots allow a direct visual interpretation of nuclide half-life at times when one isotope is clearly dominant. A departure from equivalence in the decay profile between experiment and calculation would indicate a mismatch in terms of half-life in one or more of the important nuclides. Graphs corresponding to the 5-minute irradiations of the year 2000 campaign are given first, followed by the results of the year 1996 experiments, where they exist. A table (for the 2000 5-minute or 1996 7-hour experiments only) give more information, such as the calculation uncertainties, and allows a more precise interpretation of the comparison. This is followed by, for each irradiation experiment, the list of the dominant radionuclides that contribute at a level of more than 0.5% to the total decay power at all cooling times. Their production pathways, extracted by FISPACT-II & TENDL-2013, are also here, including the percentage contribution of each route, if more than one exists. All these quantities allow a judgement to be made on whether the experimental

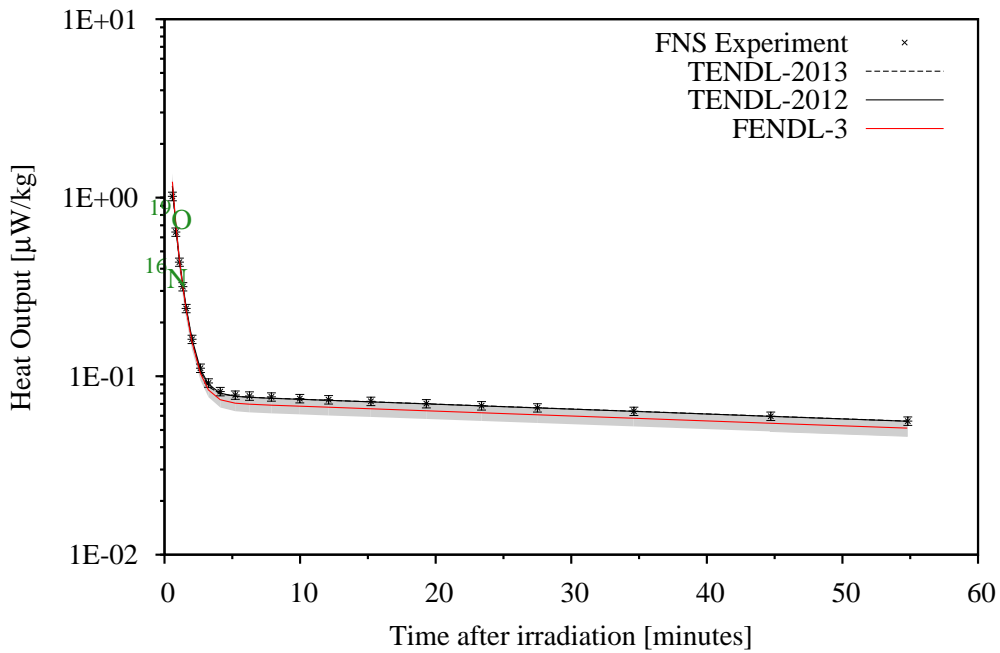
result is able to validate the calculational method for the production paths and decay data. The judgement is shown in the E/C column. The half-life of each dominant radionuclide, and thus the timescale at which they are predominant, is also presented. Following this, another graph is given (again, only for the 2000 5-minute or 1996 7-hour experiments), showing the calculated decay heat as a function of time with the predominant radionuclides, added on the graphs with their isotopic name at their heat output level at shutdown on the ordinate and half live on the abscissa. Such plotting, on a log-log scale allows one to immediately comprehend the relative contribution of different nuclides to the total heat output as a function of time.

Careful consideration needs to be given when analysing a experimental data such as that produced from FNS. The fact is that the measured quantities may, or may not, be directly related to the pathways of production of a particular radionuclide. There is only a strong possibility, not a certainty, that, firstly the major radionuclides measured are the one predicted by the code, and secondly that their amount has been properly calculated before their respective decay power is derived. Although improbable, one may envisage a 20% under prediction in terms of atomic amount of a nuclide, balanced by a 20% over prediction through the decay data scheme. This would lead to a perfect E/C value. Such possibilities of error compensation, though unlikely, may well exist at a certain level and so make the interpretation of the results more difficult. However, such scenarios, if difficult to detect are made less probable when the experimental results are analysed by different activation codes, cross section and decay data [3], and are used with other comparison methods such as C/E values for the cross sections themselves.

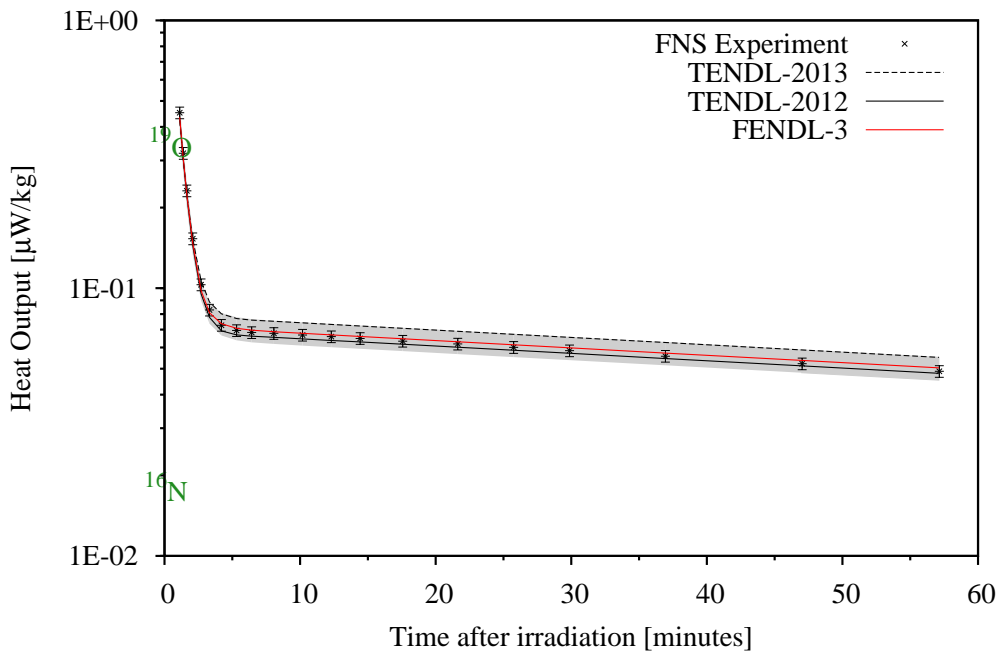
There follows in the rest of the report a presentation, as described above, of the analysis for each of the 74 materials samples that have been irradiated.

Fluorine

FNS-00 5 Min. Irradiation - CF₂



FNS-96 5 Min. Irradiation - CF₂

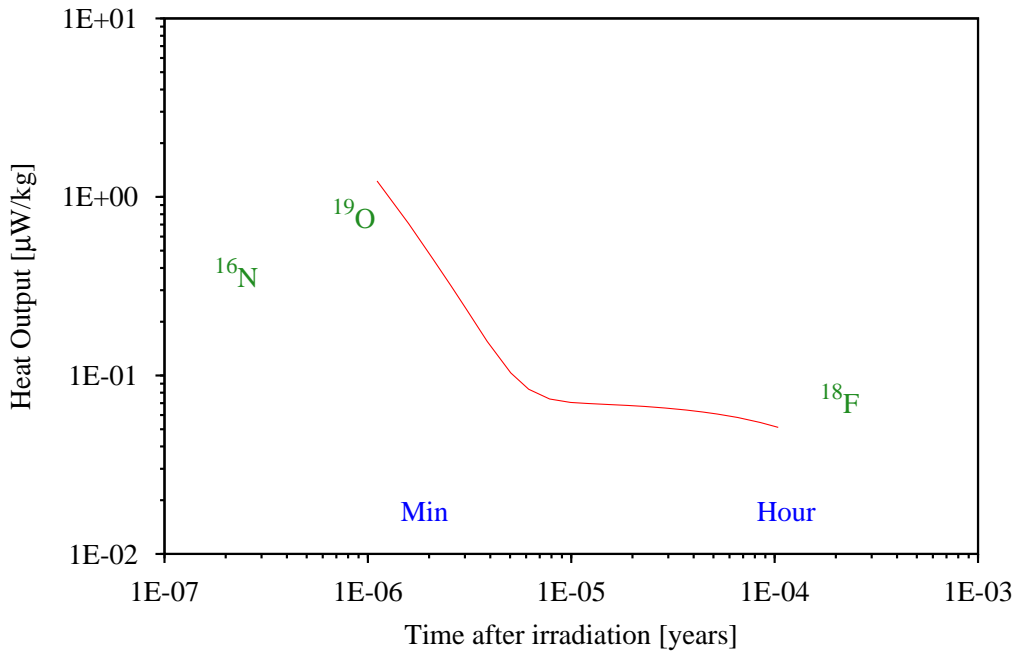


For Fluorine, the agreements look excellent for both samples and irradiation batches. This also clearly demonstrates that experiments do not always lead to the same measurements, even when carried out in the same assembly set-up. However, the F18 route of production uncertainty of 10% accounts for such experimental fluctuation.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | 1.02E+00 +/-5% | 1.23E+00 +/-11% | 0.83 | 1.16E+00 | 0.88 | 1.16E+00 | 0.87 |
| 0.83 | 6.42E-01 +/-5% | 7.10E-01 +/-12% | 0.90 | 7.01E-01 | 0.92 | 6.76E-01 | 0.95 |
| 1.10 | 4.36E-01 +/-5% | 4.48E-01 +/-12% | 0.97 | 4.50E-01 | 0.97 | 4.41E-01 | 0.99 |
| 1.35 | 3.17E-01 +/-5% | 3.17E-01 +/-12% | 1.00 | 3.23E-01 | 0.98 | 3.19E-01 | 1.00 |
| 1.60 | 2.40E-01 +/-5% | 2.36E-01 +/-11% | 1.02 | 2.42E-01 | 0.99 | 2.40E-01 | 1.00 |
| 2.03 | 1.61E-01 +/-5% | 1.55E-01 +/-9% | 1.04 | 1.61E-01 | 1.00 | 1.58E-01 | 1.02 |
| 2.65 | 1.11E-01 +/-5% | 1.03E-01 +/-8% | 1.07 | 1.09E-01 | 1.02 | 1.06E-01 | 1.05 |
| 3.25 | 9.17E-02 +/-5% | 8.36E-02 +/-9% | 1.10 | 9.00E-02 | 1.02 | 8.73E-02 | 1.05 |
| 4.12 | 8.21E-02 +/-5% | 7.39E-02 +/-10% | 1.11 | 8.03E-02 | 1.02 | 7.95E-02 | 1.03 |
| 5.22 | 7.84E-02 +/-5% | 7.06E-02 +/-10% | 1.11 | 7.71E-02 | 1.02 | 7.73E-02 | 1.01 |
| 6.27 | 7.74E-02 +/-5% | 6.96E-02 +/-10% | 1.11 | 7.61E-02 | 1.02 | 7.63E-02 | 1.01 |
| 7.88 | 7.66E-02 +/-5% | 6.88E-02 +/-10% | 1.11 | 7.52E-02 | 1.02 | 7.53E-02 | 1.02 |
| 9.98 | 7.50E-02 +/-5% | 6.79E-02 +/-10% | 1.10 | 7.42E-02 | 1.01 | 7.43E-02 | 1.01 |
| 12.10 | 7.38E-02 +/-5% | 6.70E-02 +/-10% | 1.10 | 7.32E-02 | 1.01 | 7.33E-02 | 1.01 |
| 15.22 | 7.23E-02 +/-5% | 6.57E-02 +/-10% | 1.10 | 7.18E-02 | 1.01 | 7.19E-02 | 1.01 |
| 19.32 | 7.02E-02 +/-5% | 6.40E-02 +/-10% | 1.10 | 7.00E-02 | 1.00 | 7.01E-02 | 1.00 |
| 23.38 | 6.83E-02 +/-5% | 6.24E-02 +/-10% | 1.09 | 6.82E-02 | 1.00 | 6.83E-02 | 1.00 |
| 27.50 | 6.65E-02 +/-5% | 6.08E-02 +/-10% | 1.09 | 6.64E-02 | 1.00 | 6.65E-02 | 1.00 |
| 34.62 | 6.36E-02 +/-5% | 5.81E-02 +/-10% | 1.09 | 6.35E-02 | 1.00 | 6.36E-02 | 1.00 |
| 44.72 | 5.97E-02 +/-5% | 5.45E-02 +/-10% | 1.10 | 5.96E-02 | 1.00 | 5.97E-02 | 1.00 |
| 54.82 | 5.60E-02 +/-5% | 5.11E-02 +/-10% | 1.10 | 5.59E-02 | 1.00 | 5.60E-02 | 1.00 |

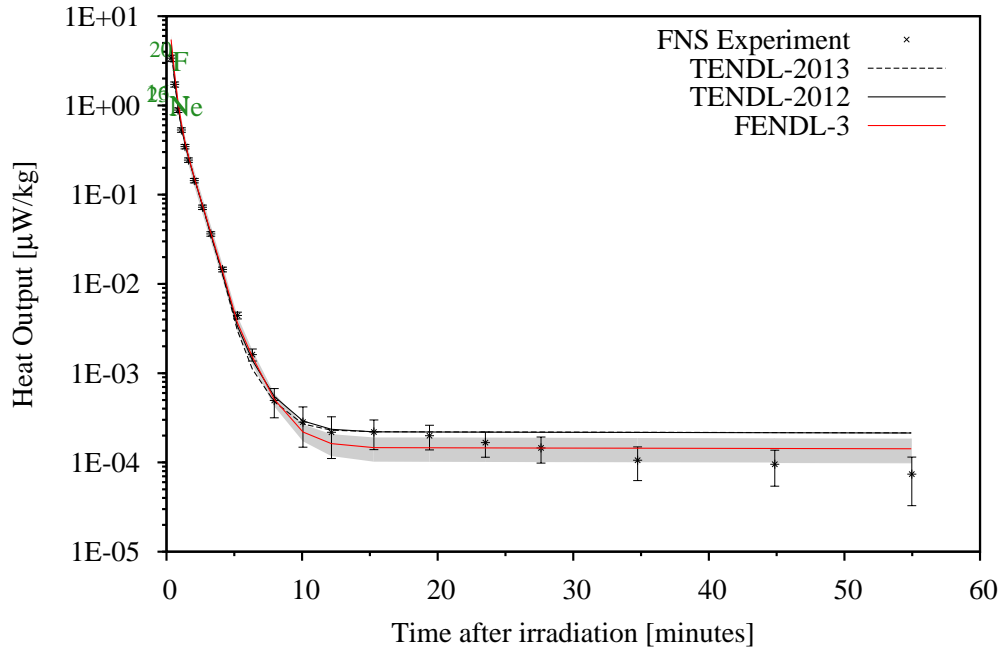
| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|--------------|------------------|--------|------|-----|
| O19 | F19(n,p)O19 | 26.9s | 100.0 | 0.99 | 5% |
| F18 | F19(n,2n)F18 | 1.82h | 100.0 | 1.00 | 5% |

FNS-00 5 Min. Irradiation - CF₂

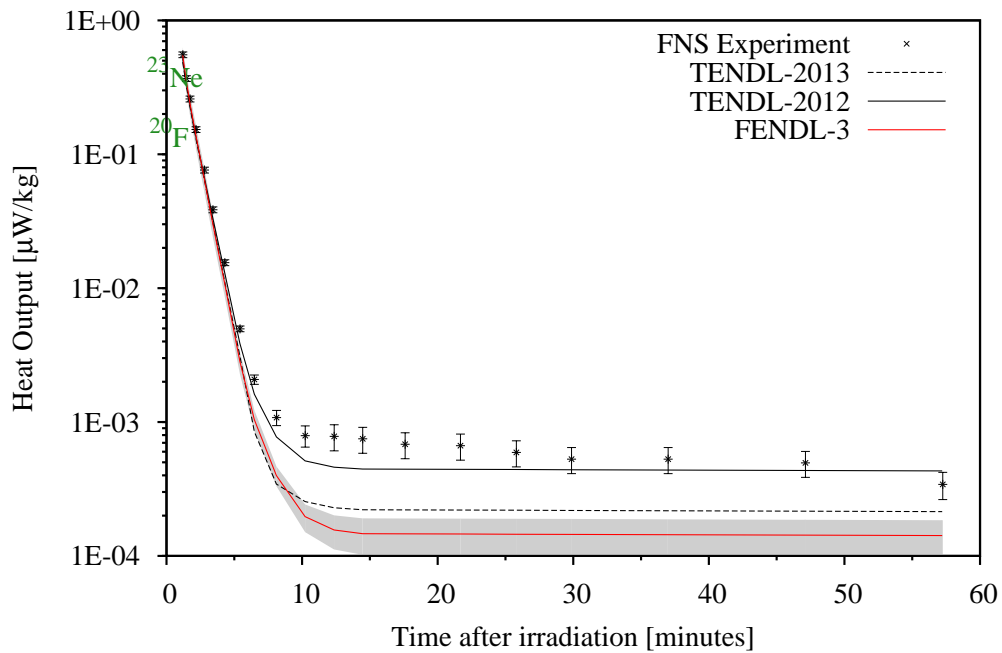


Sodium

FNS-00 5 Min. Irradiation - Na_2CO_3



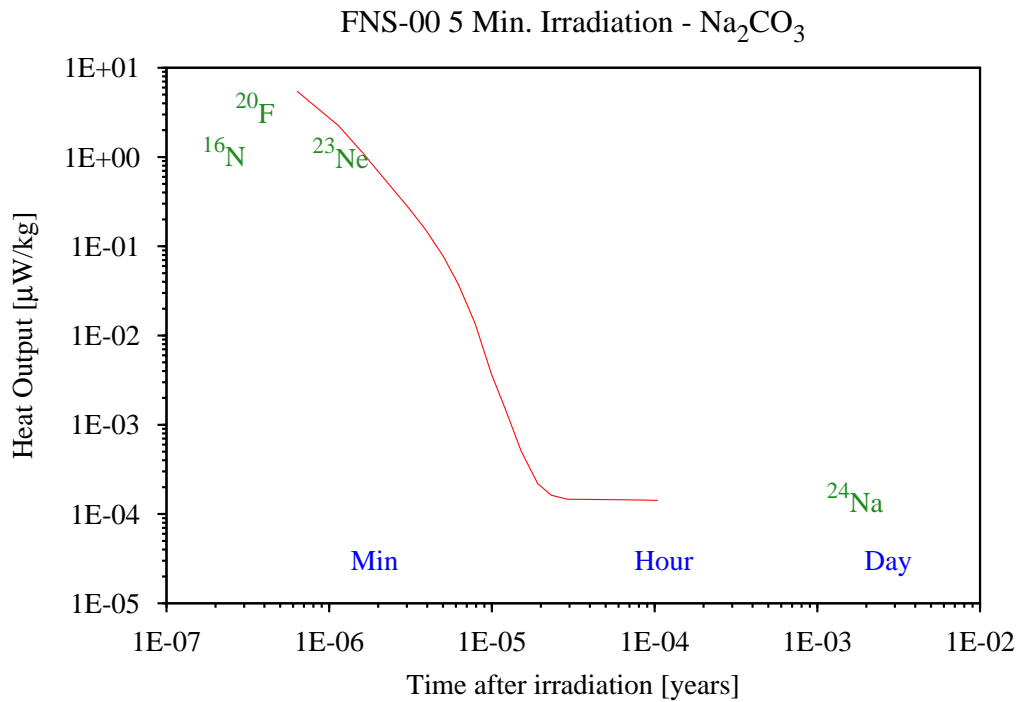
FNS-96 5 Min. Irradiation - Na_2CO_3

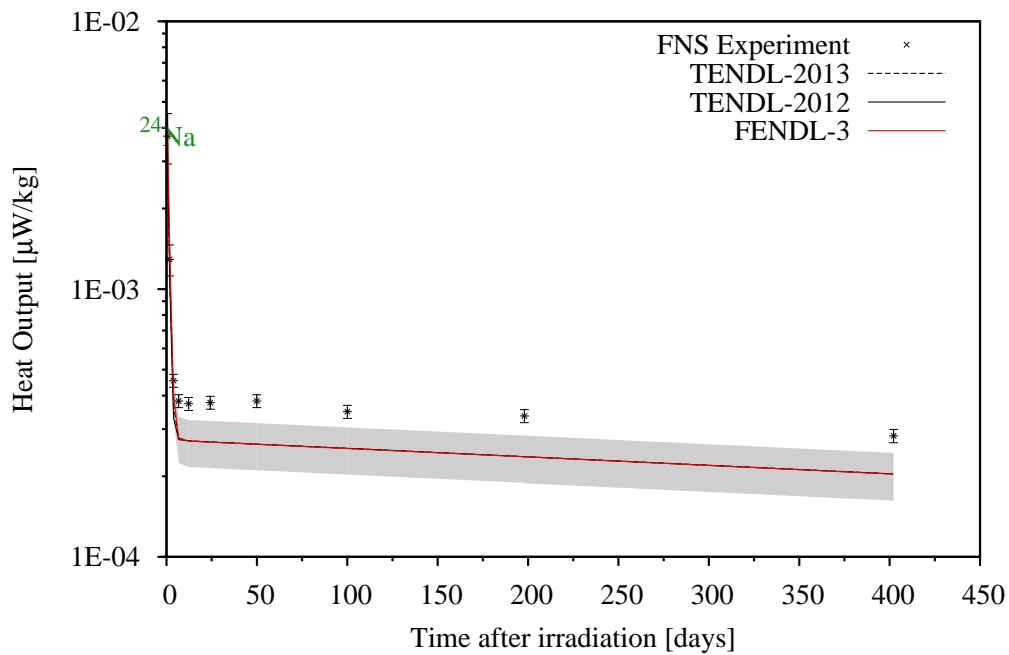


For Sodium, the two experimental measurements do not exhibit the same decay heat level, particularly in the plateau. Many factors could have influenced the experimental set-up and the presence of impurities in the sample is plausible. High experimental uncertainties accompany the latest 2000 experiment but the time dependence shape is definitely there. The FENDL-3.0 Na^{23} total capture cross section well represents the experiment and its associated uncertainty.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-------------------|-------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.33 | $3.38E+00$ +/-8% | $5.47E+00$ +/-10% | 0.62 | $4.78E+00$ | 0.71 | $4.40E+00$ | 0.77 |
| 0.60 | $1.72E+00$ +/-7% | $2.24E+00$ +/-11% | 0.77 | $1.89E+00$ | 0.91 | $1.86E+00$ | 0.92 |
| 0.85 | $8.86E-01$ +/-6% | $1.10E+00$ +/-12% | 0.81 | $9.66E-01$ | 0.92 | $9.41E-01$ | 0.94 |
| 1.10 | $5.30E-01$ +/-6% | $6.25E-01$ +/-15% | 0.85 | $5.76E-01$ | 0.92 | $5.66E-01$ | 0.94 |
| 1.37 | $3.45E-01$ +/-6% | $3.88E-01$ +/-17% | 0.89 | $3.70E-01$ | 0.93 | $3.79E-01$ | 0.91 |
| 1.62 | $2.44E-01$ +/-6% | $2.70E-01$ +/-18% | 0.90 | $2.62E-01$ | 0.93 | $2.66E-01$ | 0.92 |
| 2.05 | $1.44E-01$ +/-6% | $1.55E-01$ +/-20% | 0.93 | $1.53E-01$ | 0.94 | $1.54E-01$ | 0.94 |
| 2.65 | $7.22E-02$ +/-6% | $7.67E-02$ +/-20% | 0.94 | $7.56E-02$ | 0.96 | $7.53E-02$ | 0.96 |
| 3.27 | $3.63E-02$ +/-6% | $3.76E-02$ +/-20% | 0.97 | $3.62E-02$ | 1.00 | $3.57E-02$ | 1.02 |
| 4.13 | $1.45E-02$ +/-6% | $1.38E-02$ +/-20% | 1.05 | $1.31E-02$ | 1.11 | $1.28E-02$ | 1.14 |
| 5.23 | $4.44E-03$ +/-9% | $3.67E-03$ +/-19% | 1.21 | $3.37E-03$ | 1.32 | $3.00E-03$ | 1.48 |
| 6.33 | $1.61E-03$ +/-15% | $1.53E-03$ +/-18% | 1.06 | $1.40E-03$ | 1.15 | $1.11E-03$ | 1.45 |
| 7.95 | $4.94E-04$ +/-36% | $5.09E-04$ +/-17% | 0.97 | $5.49E-04$ | 0.90 | $4.79E-04$ | 1.03 |
| 10.07 | $2.83E-04$ +/-48% | $2.20E-04$ +/-21% | 1.29 | $2.91E-04$ | 0.97 | $2.70E-04$ | 1.05 |
| 12.17 | $2.18E-04$ +/-49% | $1.63E-04$ +/-27% | 1.34 | $2.36E-04$ | 0.92 | $2.30E-04$ | 0.95 |
| 15.30 | $2.19E-04$ +/-37% | $1.46E-04$ +/-30% | 1.50 | $2.20E-04$ | 1.00 | $2.21E-04$ | 0.99 |
| 19.40 | $1.99E-04$ +/-31% | $1.46E-04$ +/-30% | 1.37 | $2.19E-04$ | 0.91 | $2.20E-04$ | 0.90 |
| 23.52 | $1.67E-04$ +/-31% | $1.45E-04$ +/-30% | 1.15 | $2.19E-04$ | 0.76 | $2.20E-04$ | 0.76 |
| 27.62 | $1.46E-04$ +/-33% | $1.45E-04$ +/-30% | 1.00 | $2.18E-04$ | 0.67 | $2.19E-04$ | 0.66 |
| 34.75 | $1.06E-04$ +/-41% | $1.44E-04$ +/-30% | 0.73 | $2.17E-04$ | 0.49 | $2.18E-04$ | 0.49 |
| 44.87 | $9.55E-05$ +/-43% | $1.43E-04$ +/-30% | 0.67 | $2.15E-04$ | 0.44 | $2.16E-04$ | 0.44 |
| 54.97 | $7.39E-05$ +/-56% | $1.42E-04$ +/-30% | 0.52 | $2.13E-04$ | 0.35 | $2.14E-04$ | 0.34 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-------------------------|-----------|--------|------|--------------|
| Ne23 | Na23(n,p)Ne23 | 37.2s | 100.0 | 0.94 | 6% |
| Na24 | Na23(n, γ)Na24 | 14.9h | 100.0 | 0.90 | 31% |
| | Na23(n, γ)Na24m | | 0.0 | 0.00 | % |

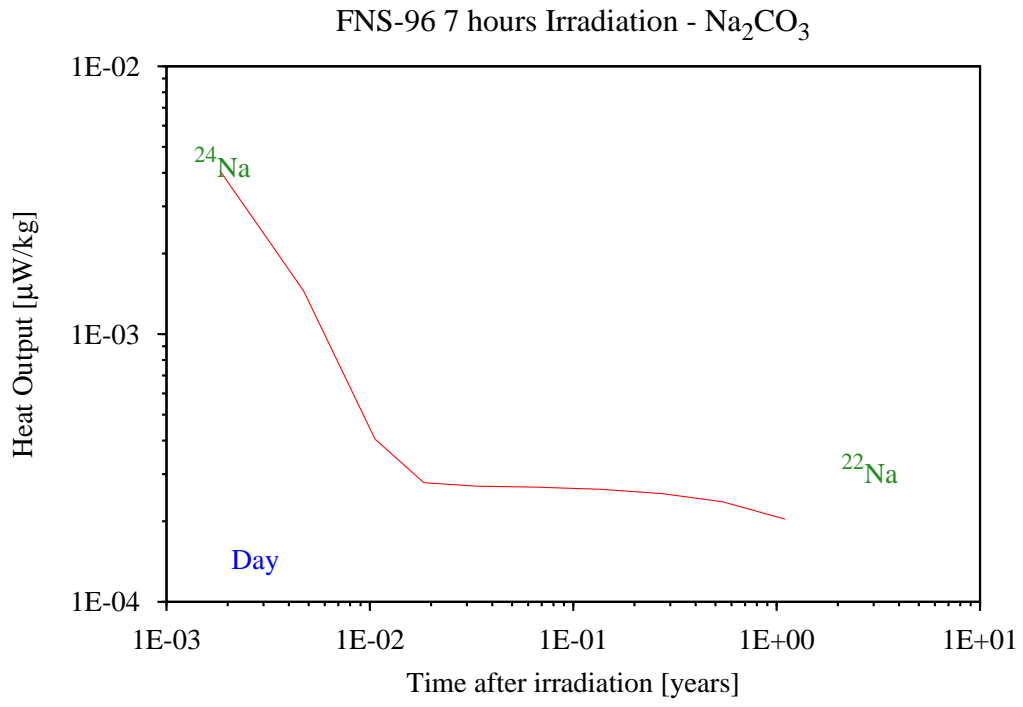


FNS-96 7 hours Irradiation - Na₂CO₃

In this case the heat arising from Na22 seems to be under predicted by around 40% for all libraries. Otherwise, there could be a contribution from unknown impurities that have not been taken into account in the simulation.

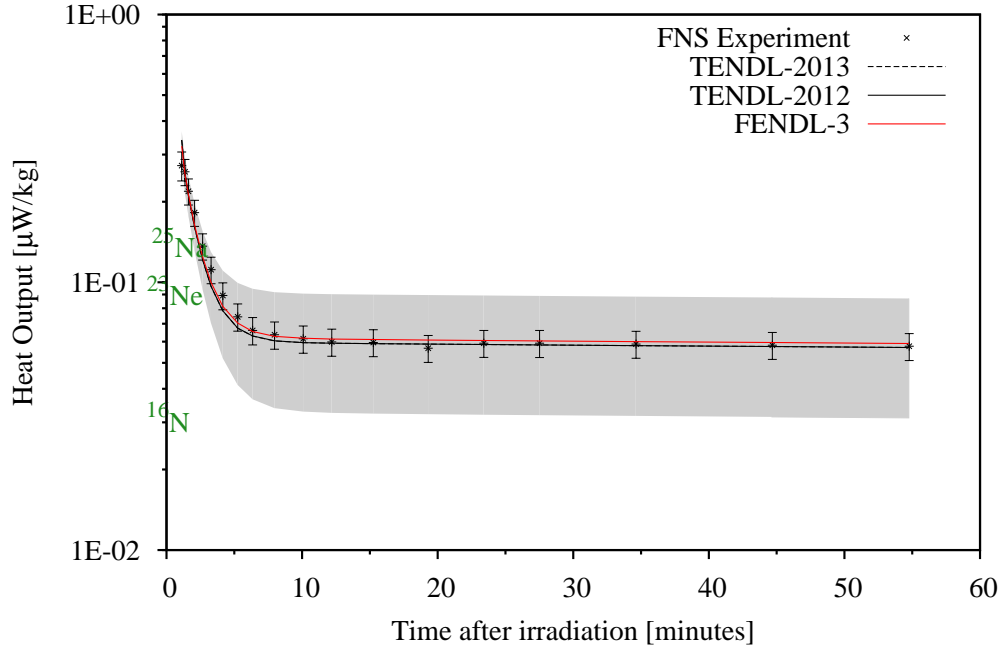
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C | |
|--------|-------------------|-------------------|------|------------|------|------------|------|--|
| Days | $\mu\text{W/g}$ | | | | | | | |
| 0.67 | $3.73E-03$ +/-21% | $4.09E-03$ +/-36% | 0.91 | $3.04E-03$ | 1.23 | $3.19E-03$ | 1.17 | |
| 1.72 | $1.29E-03$ +/-13% | $1.45E-03$ +/-32% | 0.89 | $1.08E-03$ | 1.20 | $1.19E-03$ | 1.08 | |
| 3.87 | $4.55E-04$ +/-6% | $4.05E-04$ +/-19% | 1.12 | $3.31E-04$ | 1.37 | $3.66E-04$ | 1.24 | |
| 6.74 | $3.82E-04$ +/-6% | $2.78E-04$ +/-20% | 1.37 | $2.74E-04$ | 1.39 | $2.78E-04$ | 1.38 | |
| 12.19 | $3.73E-04$ +/-6% | $2.70E-04$ +/-20% | 1.38 | $2.71E-04$ | 1.38 | $2.71E-04$ | 1.38 | |
| 24.20 | $3.77E-04$ +/-6% | $2.68E-04$ +/-20% | 1.41 | $2.69E-04$ | 1.40 | $2.69E-04$ | 1.40 | |
| 49.95 | $3.82E-04$ +/-6% | $2.63E-04$ +/-20% | 1.45 | $2.64E-04$ | 1.45 | $2.64E-04$ | 1.45 | |
| 100.08 | $3.49E-04$ +/-6% | $2.54E-04$ +/-20% | 1.37 | $2.54E-04$ | 1.37 | $2.54E-04$ | 1.37 | |
| 197.95 | $3.36E-04$ +/-6% | $2.36E-04$ +/-20% | 1.42 | $2.37E-04$ | 1.42 | $2.37E-04$ | 1.42 | |
| 402.16 | $2.83E-04$ +/-6% | $2.04E-04$ +/-20% | 1.39 | $2.04E-04$ | 1.39 | $2.04E-04$ | 1.39 | |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|----------------|------------------|--------|------|-----|
| Na24 | Na23(n,γ)Na24 | 14.9h | 99.9 | 1.08 | 13% |
| Na22 | Na23(n,2n)Na22 | 2.6y | 100.0 | 1.42 | 6% |



Magnesium

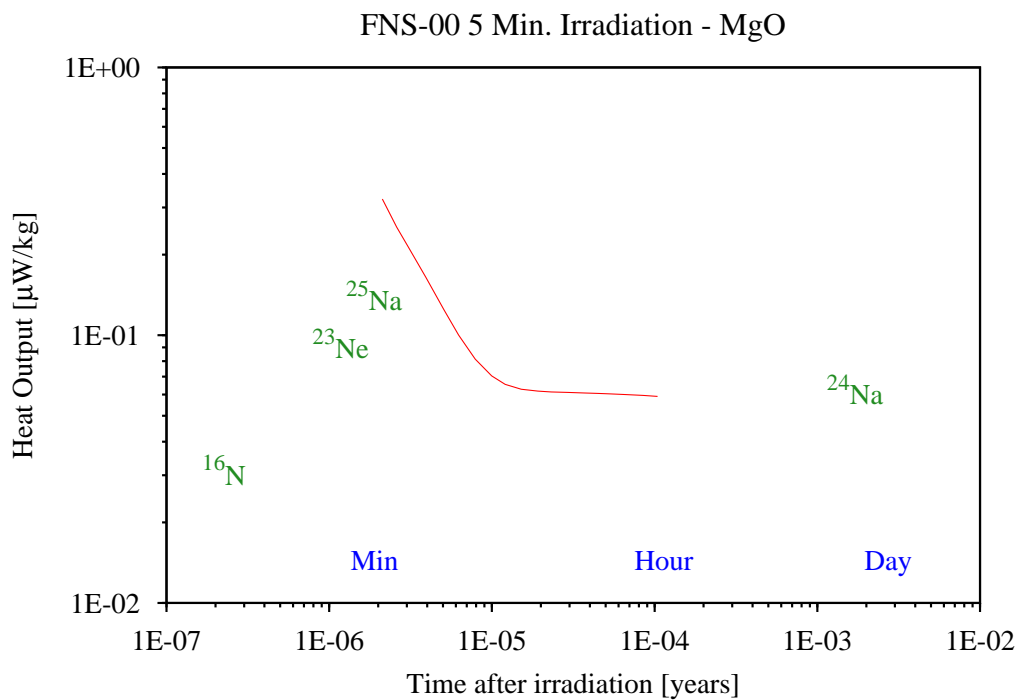
FNS-00 5 Min. Irradiation - MgO



For Magnesium, there is excellent agreement at all cooling times. Na24 production reaction-rates are perfectly predicted, although note that the Na24m isomer is not produced in the TENDL libraries.

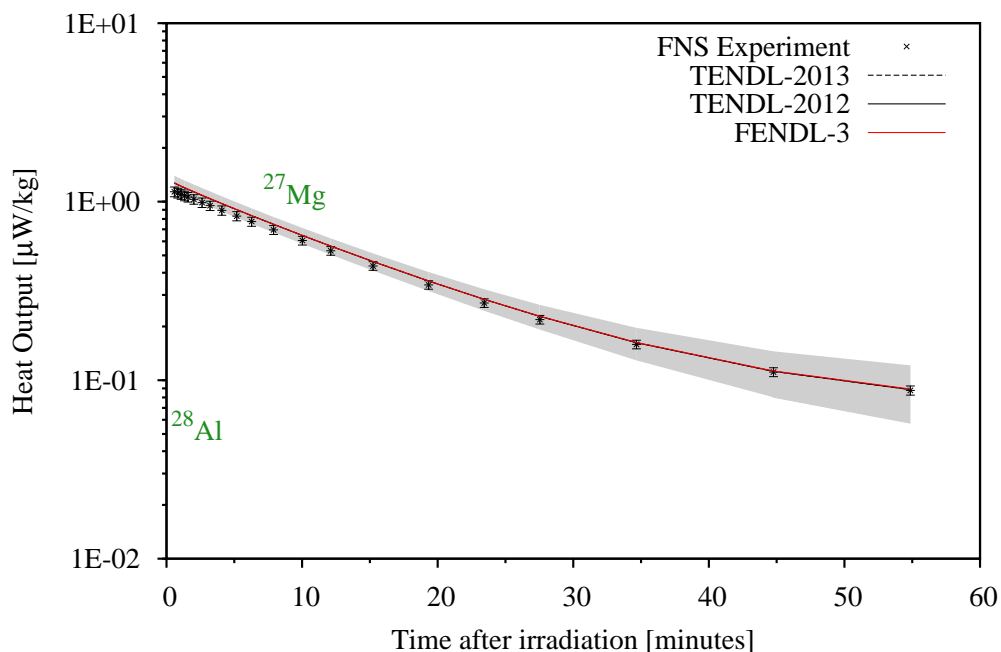
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 1.12 | 2.73E-01 +/-12% | 3.23E-01 +/-14% | 0.85 | 3.40E-01 | 0.80 | 3.40E-01 | 0.80 |
| 1.37 | 2.59E-01 +/-11% | 2.53E-01 +/-16% | 1.02 | 2.55E-01 | 1.01 | 2.55E-01 | 1.01 |
| 1.62 | 2.19E-01 +/-11% | 2.13E-01 +/-17% | 1.03 | 2.11E-01 | 1.04 | 2.11E-01 | 1.04 |
| 2.07 | 1.82E-01 +/-11% | 1.64E-01 +/-20% | 1.11 | 1.61E-01 | 1.13 | 1.61E-01 | 1.13 |
| 2.67 | 1.36E-01 +/-11% | 1.24E-01 +/-25% | 1.10 | 1.21E-01 | 1.12 | 1.21E-01 | 1.12 |
| 3.28 | 1.11E-01 +/-11% | 1.00E-01 +/-30% | 1.11 | 9.68E-02 | 1.15 | 9.67E-02 | 1.15 |
| 4.15 | 8.93E-02 +/-12% | 8.13E-02 +/-36% | 1.10 | 7.83E-02 | 1.14 | 7.83E-02 | 1.14 |
| 5.25 | 7.43E-02 +/-12% | 7.04E-02 +/-41% | 1.06 | 6.75E-02 | 1.10 | 6.74E-02 | 1.10 |
| 6.35 | 6.61E-02 +/-12% | 6.56E-02 +/-44% | 1.01 | 6.31E-02 | 1.05 | 6.30E-02 | 1.05 |
| 7.97 | 6.37E-02 +/-12% | 6.28E-02 +/-46% | 1.01 | 6.05E-02 | 1.05 | 6.04E-02 | 1.05 |
| 10.08 | 6.15E-02 +/-12% | 6.18E-02 +/-47% | 0.99 | 5.95E-02 | 1.03 | 5.95E-02 | 1.03 |
| 12.18 | 5.99E-02 +/-12% | 6.14E-02 +/-47% | 0.98 | 5.92E-02 | 1.01 | 5.92E-02 | 1.01 |
| 15.25 | 5.96E-02 +/-12% | 6.11E-02 +/-47% | 0.98 | 5.90E-02 | 1.01 | 5.90E-02 | 1.01 |
| 19.30 | 5.67E-02 +/-12% | 6.09E-02 +/-47% | 0.93 | 5.88E-02 | 0.97 | 5.88E-02 | 0.97 |
| 23.40 | 5.92E-02 +/-12% | 6.06E-02 +/-47% | 0.98 | 5.86E-02 | 1.01 | 5.86E-02 | 1.01 |
| 27.52 | 5.92E-02 +/-12% | 6.04E-02 +/-47% | 0.98 | 5.84E-02 | 1.01 | 5.84E-02 | 1.01 |
| 34.63 | 5.88E-02 +/-12% | 6.01E-02 +/-47% | 0.98 | 5.80E-02 | 1.01 | 5.80E-02 | 1.01 |
| 44.68 | 5.82E-02 +/-12% | 5.96E-02 +/-47% | 0.98 | 5.75E-02 | 1.01 | 5.76E-02 | 1.01 |
| 54.78 | 5.77E-02 +/-12% | 5.91E-02 +/-47% | 0.98 | 5.71E-02 | 1.01 | 5.71E-02 | 1.01 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------------|-----------|--------|------|--------------|
| Ne23 | Mg26(n, α)Ne23 | 37.2s | 100.0 | 1.01 | 11% |
| Na25 | Mg25(n,p)Na25 | 59.6s | 96.3 | 1.13 | 11% |
| | Mg26(n,d+np)Na25 | | 3.7 | | |
| Na24 | Mg24(n,p)Na24 | 14.9h | 98.7 | 1.01 | 12% |
| | Mg25(n,d+np)Na24 | | 1.3 | | |

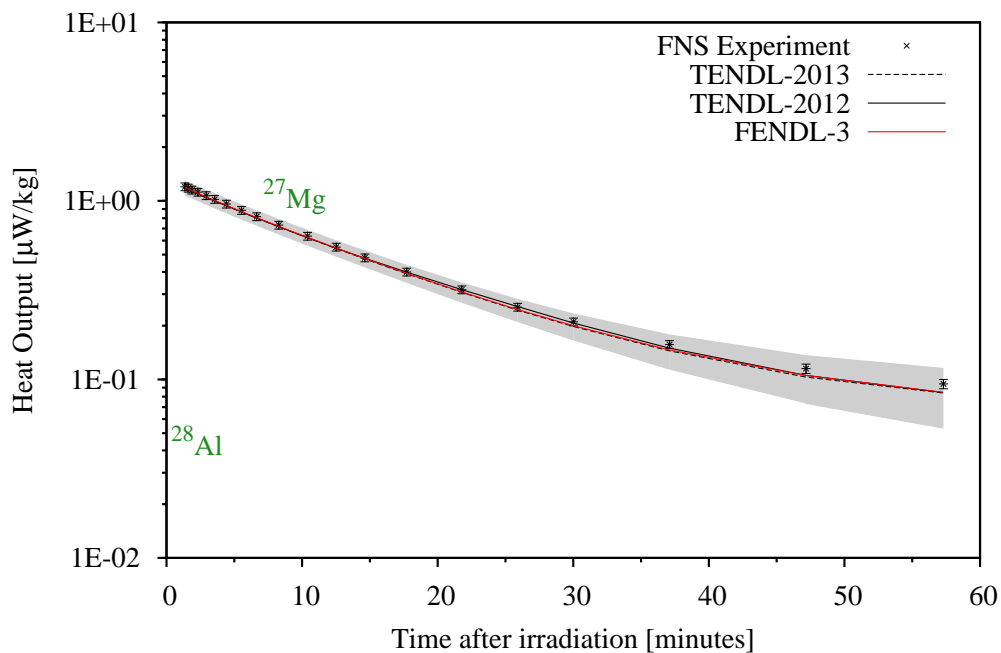


Aluminium

FNS-00 5 Min. Irradiation - Al



FNS-96 5 Min. Irradiation - Al

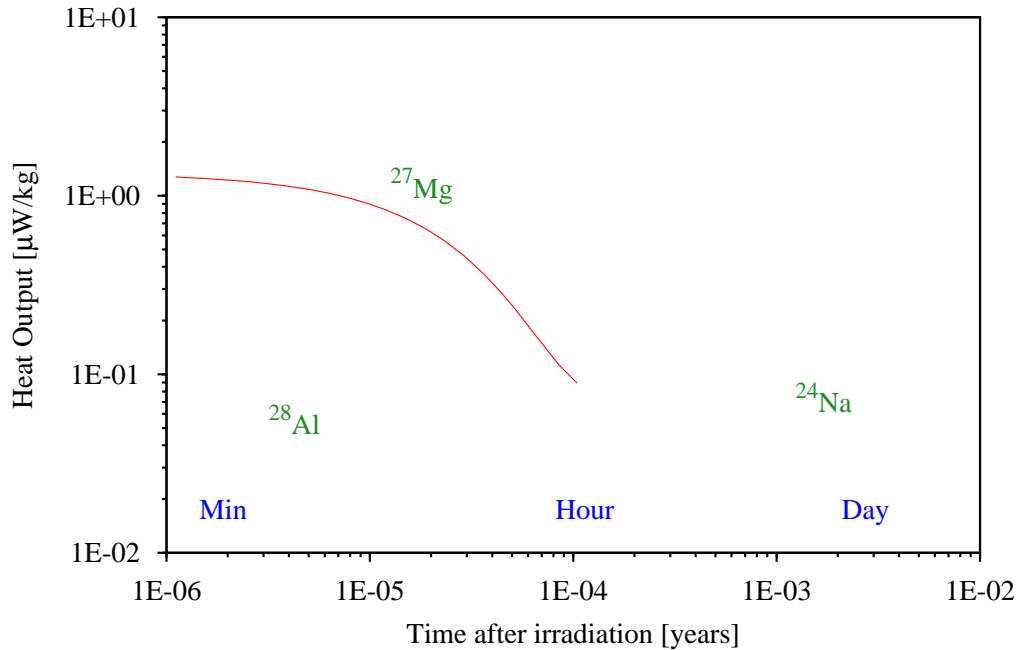


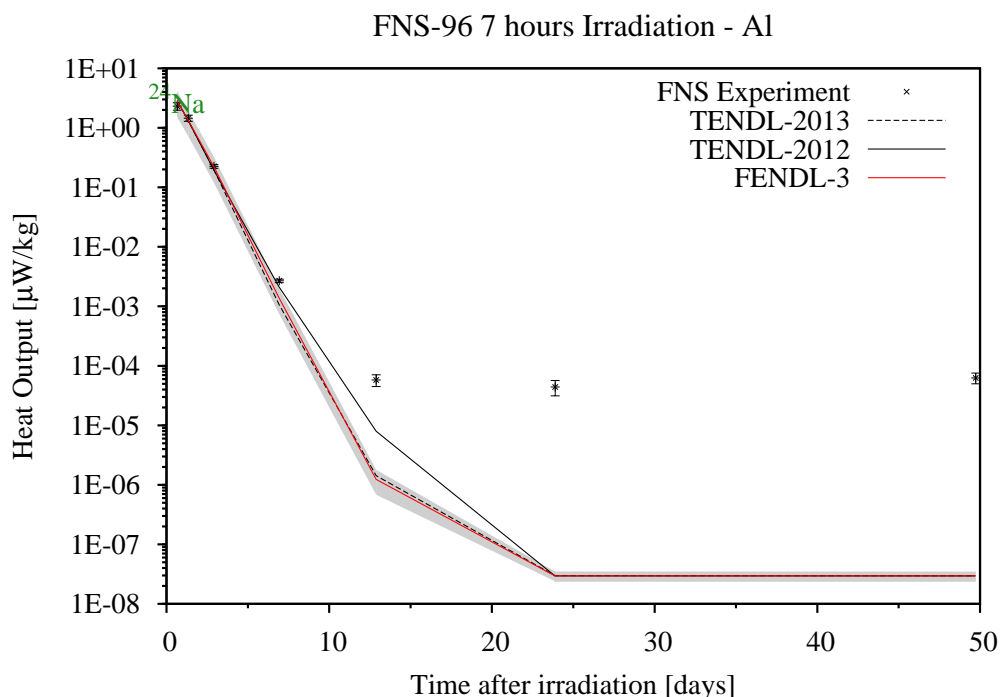
For Aluminium, an excellent agreement can be seen, for both batches, for the production route of the Mg27 radionuclide. The variance seems to be large and should benefit from experimental inputs.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C TENDL-2012 | E/C TENDL-2013 | E/C |
|-------|-----------------|-----------------|----------------|----------------|------|
| Min. | $\mu\text{W/g}$ | | | | |
| 0.58 | 1.14E+00 +/-6% | 1.28E+00 +/-10% | 0.89 | 1.27E+00 | 0.89 |
| 0.83 | 1.12E+00 +/-6% | 1.25E+00 +/-10% | 0.90 | 1.24E+00 | 0.90 |
| 1.08 | 1.10E+00 +/-6% | 1.22E+00 +/-10% | 0.90 | 1.22E+00 | 0.90 |
| 1.33 | 1.08E+00 +/-6% | 1.20E+00 +/-10% | 0.90 | 1.20E+00 | 0.90 |
| 1.58 | 1.06E+00 +/-6% | 1.18E+00 +/-10% | 0.90 | 1.17E+00 | 0.90 |
| 2.02 | 1.03E+00 +/-6% | 1.14E+00 +/-10% | 0.91 | 1.14E+00 | 0.91 |
| 2.62 | 9.88E-01 +/-6% | 1.09E+00 +/-10% | 0.91 | 1.09E+00 | 0.91 |
| 3.22 | 9.49E-01 +/-6% | 1.04E+00 +/-10% | 0.91 | 1.04E+00 | 0.91 |
| 4.08 | 8.93E-01 +/-6% | 9.76E-01 +/-10% | 0.91 | 9.75E-01 | 0.92 |
| 5.18 | 8.31E-01 +/-6% | 9.02E-01 +/-10% | 0.92 | 9.02E-01 | 0.92 |
| 6.28 | 7.73E-01 +/-6% | 8.35E-01 +/-10% | 0.93 | 8.35E-01 | 0.93 |
| 7.90 | 6.95E-01 +/-6% | 7.47E-01 +/-10% | 0.93 | 7.47E-01 | 0.93 |
| 10.02 | 6.06E-01 +/-6% | 6.48E-01 +/-10% | 0.94 | 6.47E-01 | 0.94 |
| 12.12 | 5.30E-01 +/-6% | 5.64E-01 +/-11% | 0.94 | 5.64E-01 | 0.94 |
| 15.23 | 4.37E-01 +/-6% | 4.63E-01 +/-11% | 0.94 | 4.62E-01 | 0.94 |
| 19.33 | 3.42E-01 +/-6% | 3.60E-01 +/-12% | 0.95 | 3.59E-01 | 0.95 |
| 23.43 | 2.71E-01 +/-6% | 2.84E-01 +/-14% | 0.95 | 2.84E-01 | 0.95 |
| 27.53 | 2.18E-01 +/-6% | 2.28E-01 +/-16% | 0.96 | 2.28E-01 | 0.96 |
| 34.67 | 1.59E-01 +/-6% | 1.63E-01 +/-21% | 0.97 | 1.62E-01 | 0.98 |
| 44.77 | 1.11E-01 +/-6% | 1.13E-01 +/-29% | 0.98 | 1.12E-01 | 0.99 |
| 54.87 | 8.76E-02 +/-6% | 8.94E-02 +/-36% | 0.98 | 8.86E-02 | 0.99 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C $\Delta E\%$ |
|---------|---------------|-----------|--------|------------------|
| Mg27 | Al27(n,p)Mg27 | 9.4m | 100.0 | 0.94 6% |

FNS-00 5 Min. Irradiation - Al

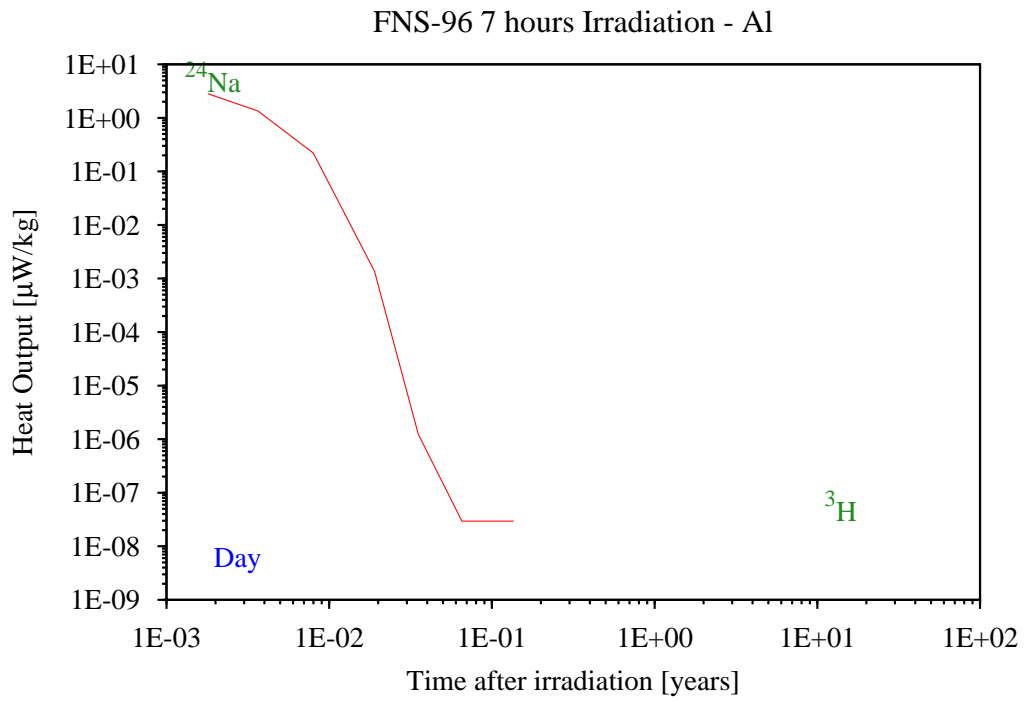




The rather good agreement, up to 3 days of cooling, does not persist at longer times. This may be due to unaccounted levels of impurities in the sample – indeed, thousands of ppm of Mn and Fe are enough to generate such levels of heat. It could also be due to a severe underestimation in the production of H3 or Al26.

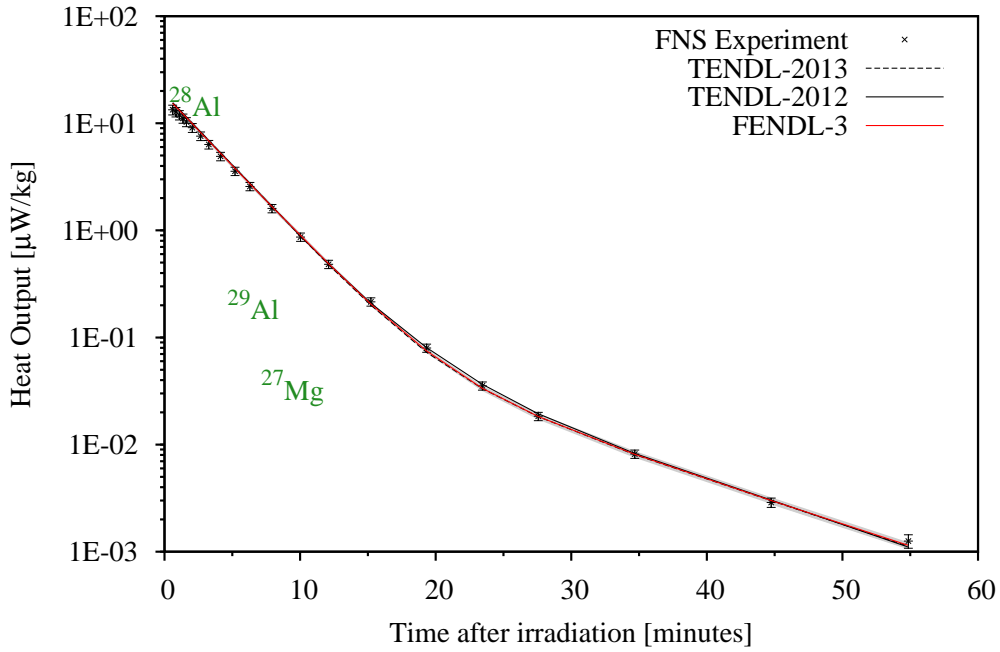
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|-----------------|---------|------------|---------|------------|---------|
| 0.66 | 2.31E+00 +/-14% | 2.82E+00 +/-46% | 0.82 | 2.86E+00 | 0.81 | 2.87E+00 | 0.81 |
| 1.34 | 1.46E+00 +/-12% | 1.34E+00 +/-46% | 1.09 | 1.31E+00 | 1.11 | 1.32E+00 | 1.10 |
| 2.92 | 2.25E-01 +/-7% | 2.21E-01 +/-46% | 1.02 | 1.94E-01 | 1.16 | 1.96E-01 | 1.15 |
| 6.93 | 2.68E-03 +/-7% | 1.37E-03 +/-46% | 1.96 | 2.11E-03 | 1.27 | 1.07E-03 | 2.52 |
| 12.89 | 5.78E-05 +/-22% | 1.24E-06 +/-45% | 46.80 | 7.96E-06 | 7.26 | 1.43E-06 | 40.51 |
| 23.89 | 4.40E-05 +/-29% | 2.96E-08 +/-19% | 1490.24 | 2.96E-08 | 1489.53 | 2.98E-08 | 1477.25 |
| 49.74 | 6.28E-05 +/-20% | 2.94E-08 +/-19% | 2131.88 | 2.95E-08 | 2130.87 | 2.97E-08 | 2113.23 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|----------------|------------------|--------|------|-----|
| Na24 | Al27(n,α)Na24 | 14.9h | 100.0 | 1.11 | 12% |
| | Al27(n,α)Na24m | 0.02s | 0.0 | 1.11 | 12% |



Silicon

FNS-00 5 Min. Irradiation - Si

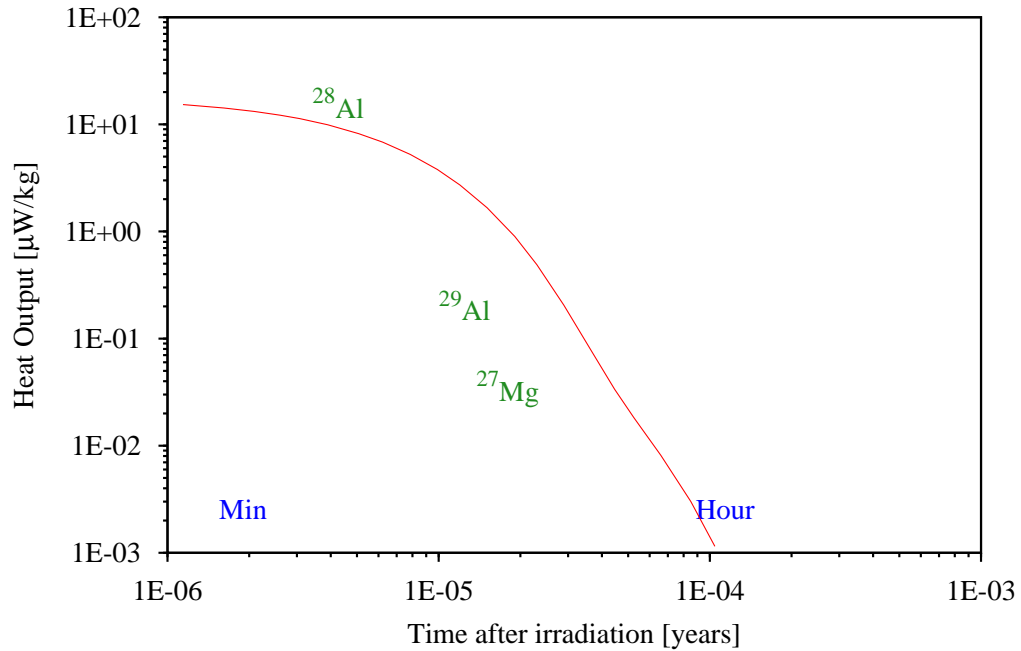


For Silicon, the first irradiated sample in 1996 (results not shown) was made of silicon oxide that certainly did contain some unaccounted level of impurities, causing an under prediction in the simulation. The second experiment contained solely pure silicon as powder and the decay heat is predicted with a much better agreement.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|----------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.60 | 1.33E+01 +/-10% | 1.53E+01 +/-5% | 0.87 | 1.55E + 01 | 0.86 | 1.55E+01 | 0.86 |
| 0.85 | 1.28E+01 +/-10% | 1.42E+01 +/-5% | 0.90 | 1.44E + 01 | 0.89 | 1.44E+01 | 0.89 |
| 1.10 | 1.19E+01 +/-10% | 1.32E+01 +/-5% | 0.90 | 1.33E + 01 | 0.89 | 1.33E+01 | 0.89 |
| 1.37 | 1.11E+01 +/-10% | 1.22E+01 +/-5% | 0.91 | 1.23E + 01 | 0.90 | 1.23E+01 | 0.90 |
| 1.62 | 1.03E+01 +/-10% | 1.13E+01 +/-5% | 0.91 | 1.14E + 01 | 0.90 | 1.14E+01 | 0.90 |
| 2.05 | 9.08E+00 +/-10% | 9.90E+00 +/-5% | 0.92 | 9.99E + 00 | 0.91 | 9.99E+00 | 0.91 |
| 2.67 | 7.59E+00 +/-9% | 8.20E+00 +/-5% | 0.93 | 8.28E + 00 | 0.92 | 8.27E+00 | 0.92 |
| 3.27 | 6.34E+00 +/-9% | 6.83E+00 +/-5% | 0.93 | 6.89E + 00 | 0.92 | 6.89E+00 | 0.92 |
| 4.13 | 4.91E+00 +/-9% | 5.24E+00 +/-5% | 0.94 | 5.29E + 00 | 0.93 | 5.29E+00 | 0.93 |
| 5.20 | 3.57E+00 +/-9% | 3.79E+00 +/-5% | 0.94 | 3.82E + 00 | 0.93 | 3.82E+00 | 0.93 |
| 6.30 | 2.57E+00 +/-9% | 2.72E+00 +/-5% | 0.94 | 2.74E + 00 | 0.94 | 2.74E+00 | 0.94 |
| 7.93 | 1.60E+00 +/-9% | 1.66E+00 +/-5% | 0.96 | 1.68E + 00 | 0.96 | 1.67E+00 | 0.96 |
| 10.03 | 8.67E-01 +/-9% | 8.98E-01 +/-5% | 0.97 | 8.86E - 01 | 0.98 | 8.84E-01 | 0.98 |
| 12.10 | 4.83E-01 +/-9% | 4.90E-01 +/-4% | 0.99 | 4.90E - 01 | 0.99 | 4.80E-01 | 1.01 |
| 15.22 | 2.15E-01 +/-9% | 2.06E-01 +/-4% | 1.05 | 2.09E - 01 | 1.03 | 2.01E-01 | 1.07 |
| 19.33 | 7.97E-02 +/-9% | 7.51E-02 +/-5% | 1.06 | 8.05E - 02 | 0.99 | 7.26E-02 | 1.10 |
| 23.45 | 3.53E-02 +/-9% | 3.36E-02 +/-6% | 1.05 | 3.66E - 02 | 0.97 | 3.33E-02 | 1.06 |
| 27.57 | 1.84E-02 +/-9% | 1.84E-02 +/-7% | 1.00 | 1.94E - 02 | 0.95 | 1.83E-02 | 1.01 |
| 34.68 | 8.16E-03 +/-9% | 8.13E-03 +/-7% | 1.00 | 8.29E - 03 | 0.98 | 8.08E-03 | 1.01 |
| 44.75 | 2.88E-03 +/-10% | 3.01E-03 +/-7% | 0.95 | 3.04E - 03 | 0.95 | 3.00E-03 | 0.96 |
| 54.87 | 1.26E-03 +/-14% | 1.15E-03 +/-7% | 1.09 | 1.11E - 03 | 1.14 | 1.13E-03 | 1.12 |

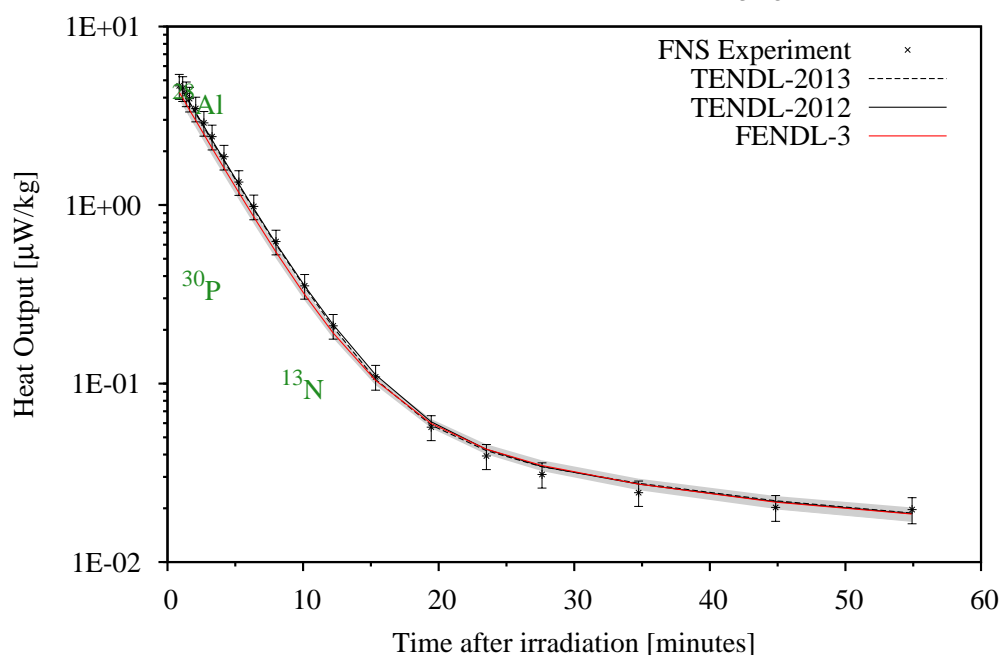
| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------------|-----------|--------|------|--------------|
| Al28 | Si28(n,p)Al28 | 2.2m | 100.0 | 0.91 | 10% |
| Al29 | Si29(n,p)Al29 | 6.5m | 95.8 | 0.96 | 9% |
| | Si30(n,d+np)Al29 | | 3.9 | | |
| Mg27 | Si30(n, α)Mg27 | 9.4m | 100.0 | 0.98 | 9% |

FNS-00 5 Min. Irradiation - Si



Phosphorus

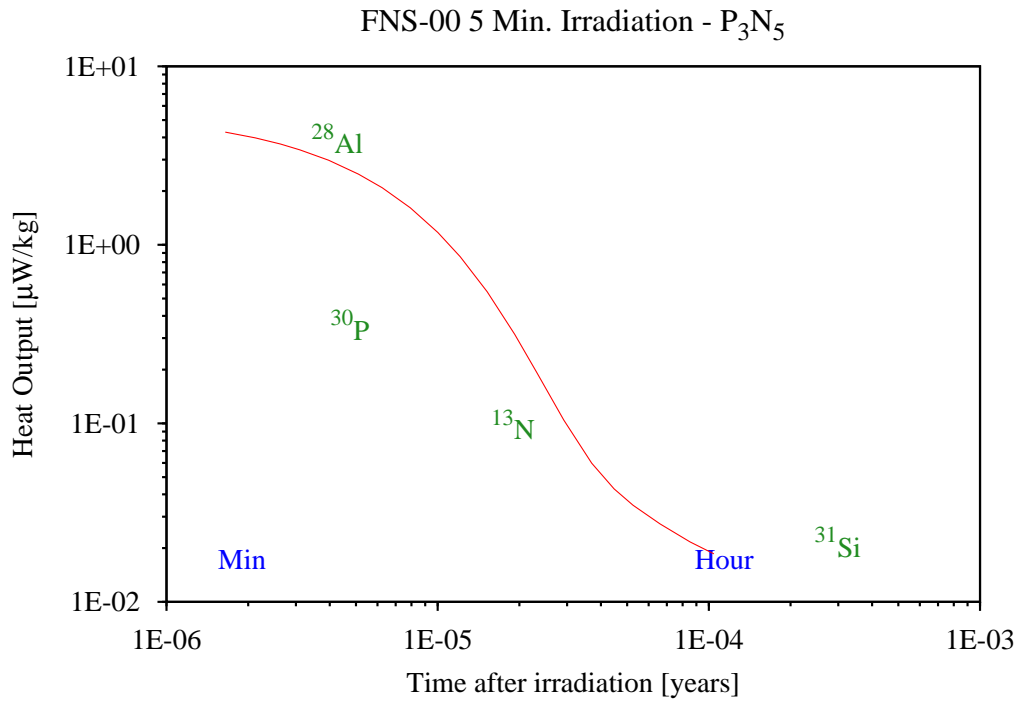
FNS-00 5 Min. Irradiation - P₃N₅



For Phosphorus, there is good agreement with the decay heat predictions for this nitrate sample, with the predictions well within a suspiciously uniform experimental uncertainty of 16%.

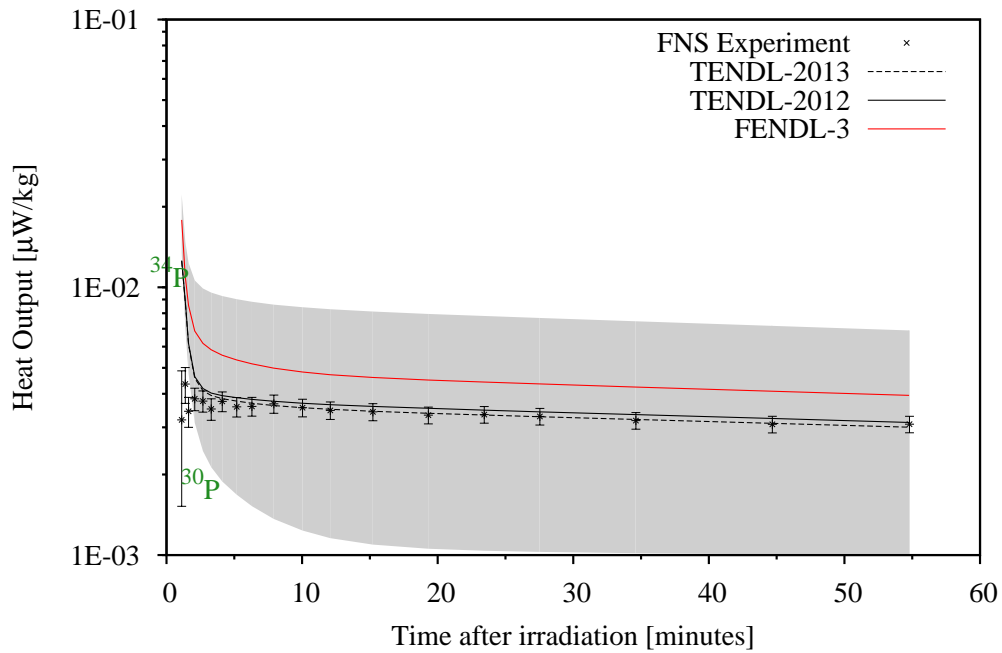
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|----------------|------|------------|------|------------|------|
| 0.87 | 4.65E+00 +/-16% | 4.28E+00 +/-9% | 1.09 | 4.72E+00 | 0.99 | 4.67E+00 | 1.00 |
| 1.12 | 4.52E+00 +/-16% | 3.97E+00 +/-9% | 1.14 | 4.39E+00 | 1.03 | 4.34E+00 | 1.04 |
| 1.38 | 4.22E+00 +/-16% | 3.67E+00 +/-9% | 1.15 | 4.06E+00 | 1.04 | 4.01E+00 | 1.05 |
| 1.63 | 3.94E+00 +/-16% | 3.40E+00 +/-9% | 1.16 | 3.77E+00 | 1.05 | 3.72E+00 | 1.06 |
| 2.08 | 3.47E+00 +/-16% | 2.98E+00 +/-9% | 1.17 | 3.30E+00 | 1.05 | 3.25E+00 | 1.07 |
| 2.68 | 2.88E+00 +/-16% | 2.49E+00 +/-9% | 1.16 | 2.77E+00 | 1.04 | 2.73E+00 | 1.06 |
| 3.28 | 2.42E+00 +/-16% | 2.09E+00 +/-9% | 1.16 | 2.32E+00 | 1.04 | 2.29E+00 | 1.06 |
| 4.17 | 1.87E+00 +/-16% | 1.61E+00 +/-9% | 1.16 | 1.79E+00 | 1.04 | 1.77E+00 | 1.06 |
| 5.27 | 1.34E+00 +/-16% | 1.17E+00 +/-9% | 1.15 | 1.31E+00 | 1.03 | 1.29E+00 | 1.04 |
| 6.37 | 9.82E-01 +/-16% | 8.58E-01 +/-8% | 1.14 | 9.58E-01 | 1.03 | 9.44E-01 | 1.04 |
| 8.00 | 6.25E-01 +/-16% | 5.47E-01 +/-8% | 1.14 | 6.11E-01 | 1.02 | 6.02E-01 | 1.04 |
| 10.12 | 3.53E-01 +/-16% | 3.16E-01 +/-7% | 1.12 | 3.53E-01 | 1.00 | 3.48E-01 | 1.01 |
| 12.22 | 2.10E-01 +/-16% | 1.92E-01 +/-7% | 1.09 | 2.14E-01 | 0.98 | 2.08E-01 | 1.01 |
| 15.35 | 1.09E-01 +/-16% | 1.04E-01 +/-6% | 1.05 | 1.12E-01 | 0.97 | 1.06E-01 | 1.03 |
| 19.45 | 5.70E-02 +/-16% | 5.98E-02 +/-6% | 0.95 | 6.11E-02 | 0.93 | 5.85E-02 | 0.97 |
| 23.52 | 3.93E-02 +/-16% | 4.29E-02 +/-6% | 0.91 | 4.28E-02 | 0.92 | 4.21E-02 | 0.93 |
| 27.62 | 3.10E-02 +/-16% | 3.48E-02 +/-7% | 0.89 | 3.43E-02 | 0.90 | 3.42E-02 | 0.91 |
| 34.75 | 2.45E-02 +/-16% | 2.73E-02 +/-7% | 0.90 | 2.73E-02 | 0.89 | 2.77E-02 | 0.88 |
| 44.85 | 2.02E-02 +/-17% | 2.17E-02 +/-8% | 0.93 | 2.18E-02 | 0.93 | 2.21E-02 | 0.92 |
| 54.92 | 1.97E-02 +/-17% | 1.86E-02 +/-9% | 1.06 | 1.87E-02 | 1.05 | 1.88E-02 | 1.04 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|--------------|------------------|--------|----------|
| Al28 | P31(n,α)Al28 | 2.2m | 100.0 | 1.05 16% |
| N13 | N14(n,2n)N13 | 9.9m | 100.0 | 1.00 16% |

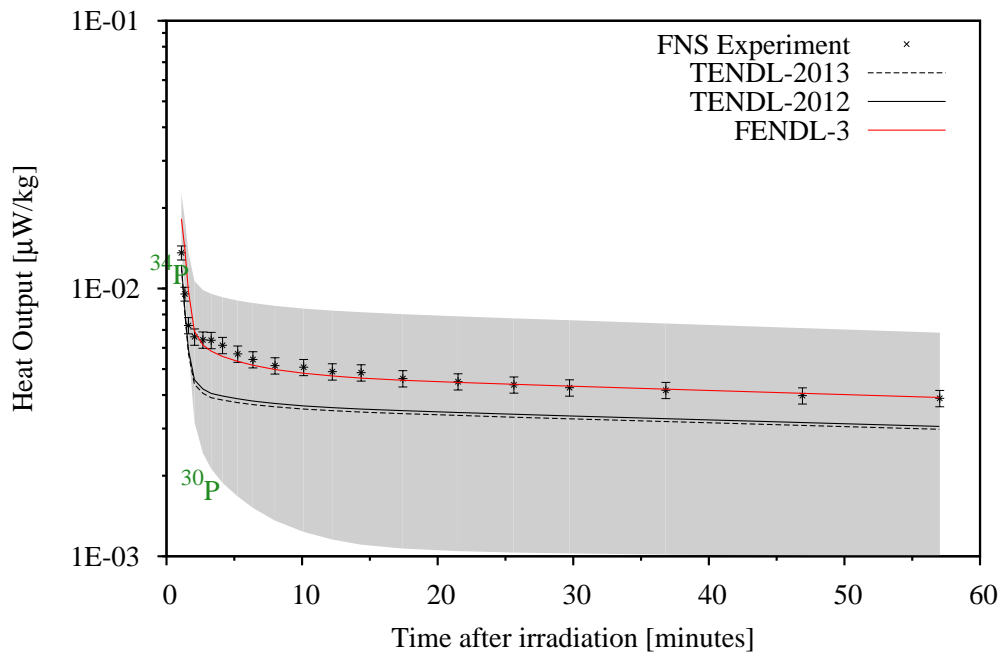


Sulphur

FNS-00 5 Min. Irradiation - S



FNS-96 5 Min. Irradiation - S

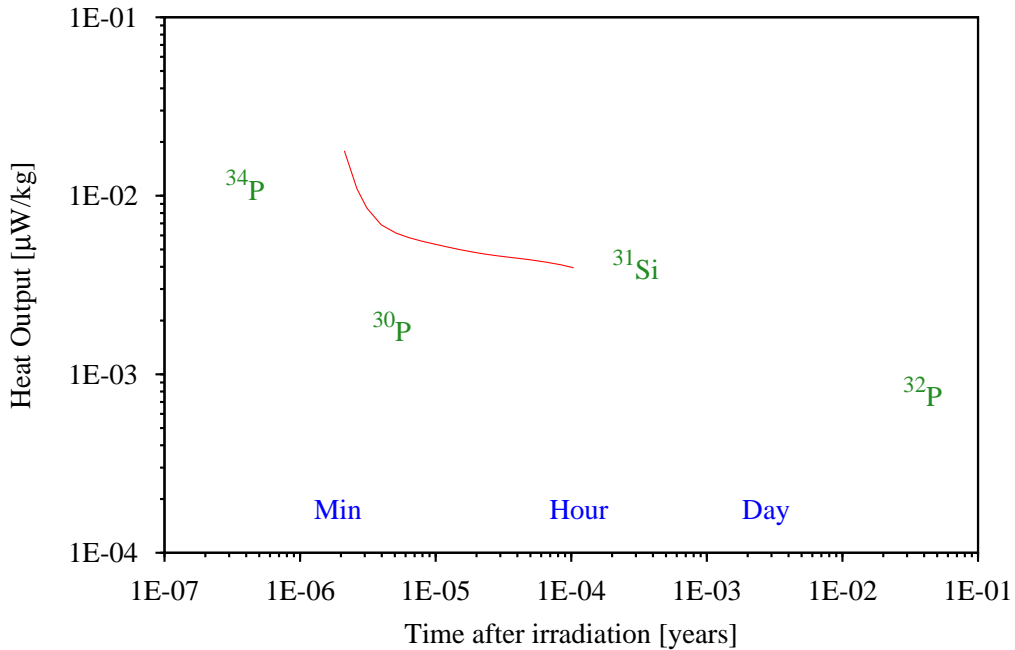


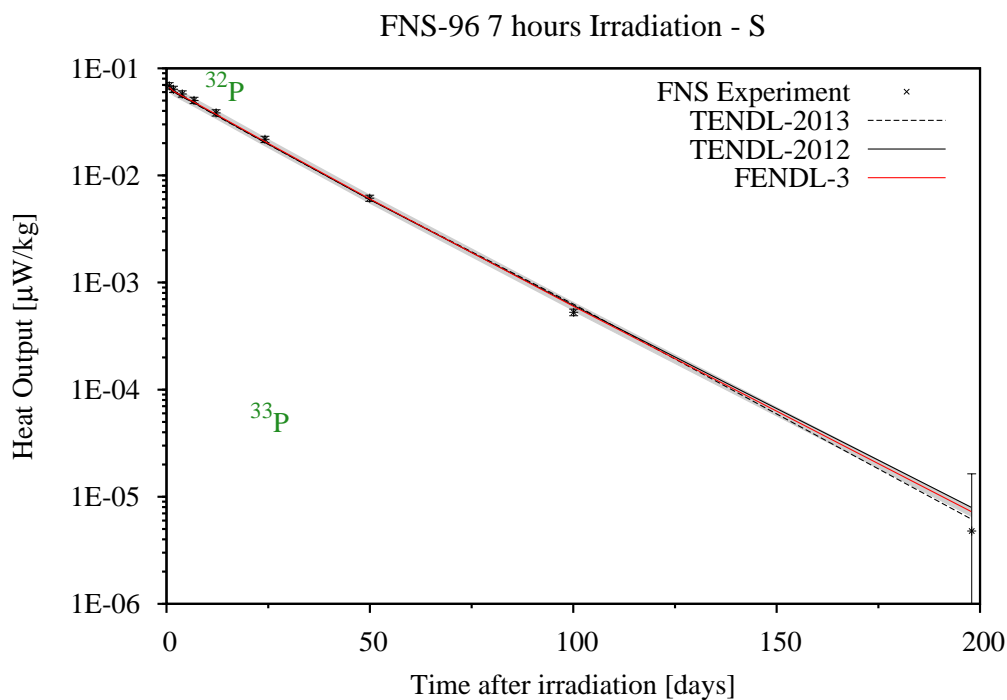
For Sulphur, it is clear that the two sets of experimental measurements do not agree, despite the fact that they should have been performed on identical sample materials. Nothing further can be extracted from such discrepant experimental results, other than an identification of the predominant isotopes.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|---------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 1.12 | $3.20E-03 \pm 52\%$ | $1.78E-02 \pm 25\%$ | 0.18 | $1.26E-02$ | 0.25 | $1.25E-02$ | 0.26 |
| 1.38 | $4.35E-03 \pm 15\%$ | $1.09E-02 \pm 35\%$ | 0.40 | $8.87E-03$ | 0.49 | $8.81E-03$ | 0.49 |
| 1.63 | $3.44E-03 \pm 13\%$ | $8.54E-03 \pm 44\%$ | 0.40 | $6.15E-03$ | 0.56 | $6.10E-03$ | 0.56 |
| 2.08 | $3.83E-03 \pm 10\%$ | $6.87E-03 \pm 55\%$ | 0.56 | $4.64E-03$ | 0.83 | $4.58E-03$ | 0.84 |
| 2.68 | $3.76E-03 \pm 9\%$ | $6.18E-03 \pm 60\%$ | 0.61 | $4.19E-03$ | 0.90 | $4.11E-03$ | 0.91 |
| 3.30 | $3.51E-03 \pm 9\%$ | $5.84E-03 \pm 64\%$ | 0.60 | $4.03E-03$ | 0.87 | $3.94E-03$ | 0.89 |
| 4.12 | $3.75E-03 \pm 8\%$ | $5.58E-03 \pm 66\%$ | 0.67 | $3.94E-03$ | 0.95 | $3.84E-03$ | 0.98 |
| 5.18 | $3.58E-03 \pm 8\%$ | $5.36E-03 \pm 69\%$ | 0.67 | $3.87E-03$ | 0.92 | $3.76E-03$ | 0.95 |
| 6.30 | $3.59E-03 \pm 8\%$ | $5.18E-03 \pm 71\%$ | 0.69 | $3.81E-03$ | 0.94 | $3.69E-03$ | 0.97 |
| 7.92 | $3.67E-03 \pm 8\%$ | $4.99E-03 \pm 73\%$ | 0.74 | $3.75E-03$ | 0.98 | $3.62E-03$ | 1.01 |
| 10.03 | $3.55E-03 \pm 8\%$ | $4.83E-03 \pm 74\%$ | 0.74 | $3.69E-03$ | 0.96 | $3.55E-03$ | 1.00 |
| 12.08 | $3.47E-03 \pm 7\%$ | $4.72E-03 \pm 75\%$ | 0.74 | $3.64E-03$ | 0.95 | $3.50E-03$ | 0.99 |
| 15.22 | $3.43E-03 \pm 7\%$ | $4.61E-03 \pm 76\%$ | 0.74 | $3.59E-03$ | 0.95 | $3.44E-03$ | 0.99 |
| 19.32 | $3.33E-03 \pm 7\%$ | $4.50E-03 \pm 77\%$ | 0.74 | $3.53E-03$ | 0.94 | $3.39E-03$ | 0.98 |
| 23.43 | $3.35E-03 \pm 7\%$ | $4.43E-03 \pm 77\%$ | 0.76 | $3.48E-03$ | 0.96 | $3.34E-03$ | 1.00 |
| 27.53 | $3.29E-03 \pm 7\%$ | $4.35E-03 \pm 76\%$ | 0.76 | $3.43E-03$ | 0.96 | $3.29E-03$ | 1.00 |
| 34.62 | $3.18E-03 \pm 7\%$ | $4.24E-03 \pm 76\%$ | 0.75 | $3.35E-03$ | 0.95 | $3.21E-03$ | 0.99 |
| 44.68 | $3.08E-03 \pm 7\%$ | $4.09E-03 \pm 75\%$ | 0.75 | $3.24E-03$ | 0.95 | $3.10E-03$ | 0.99 |
| 54.80 | $3.08E-03 \pm 7\%$ | $3.95E-03 \pm 75\%$ | 0.78 | $3.13E-03$ | 0.98 | $3.00E-03$ | 1.03 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------------|-----------|--------|------|--------------|
| P34 | S34(n,p)P34 | 12.4s | 100.0 | 0.26 | 52% |
| Si31 | S32(n,2p)Si31 | 2.62h | 27.7 | 0.99 | 7% |
| | S34(n, α)Si31 | | 72.3 | 0.99 | 7% |

FNS-00 5 Min. Irradiation - S

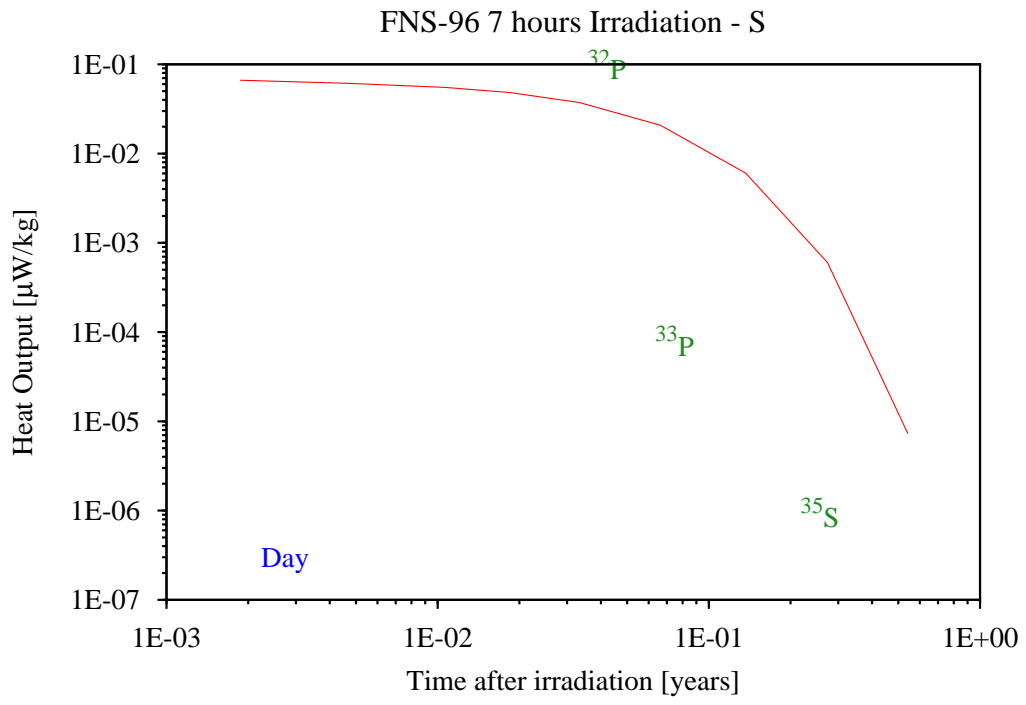




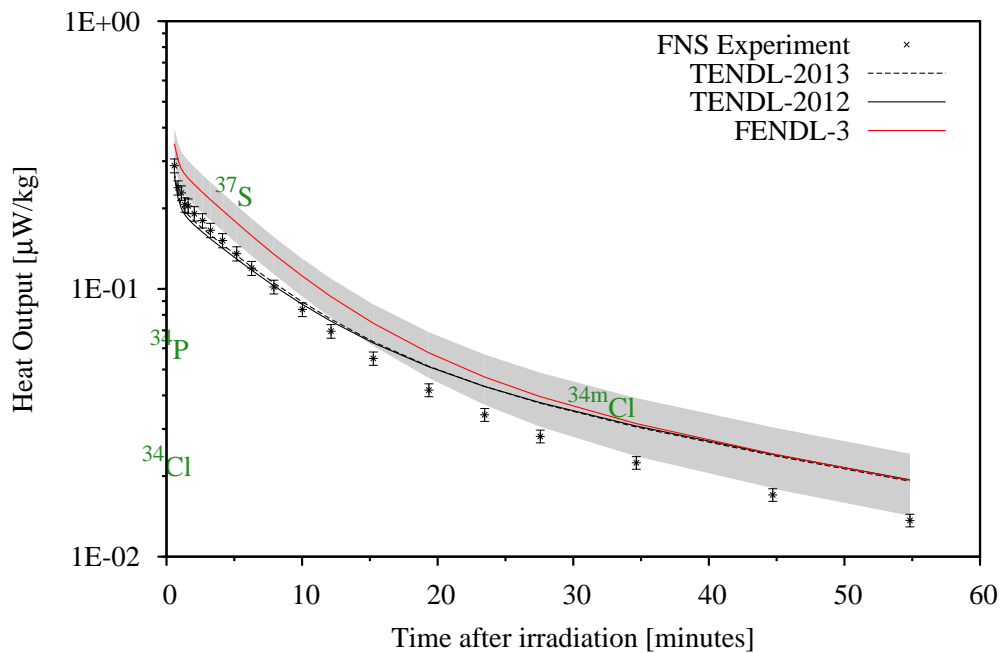
The only observation here is that cross section and uncertainty fit this text-book case.

| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|----------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.68 | $6.87E-02 \pm 7\%$ | $6.63E-02 \pm 10\%$ | 1.04 | $6.53E-02$ | 1.05 | $6.51E-02$ | 1.06 |
| 1.74 | $6.38E-02 \pm 7\%$ | $6.12E-02 \pm 10\%$ | 1.04 | $6.02E-02$ | 1.06 | $6.02E-02$ | 1.06 |
| 3.89 | $5.77E-02 \pm 7\%$ | $5.51E-02 \pm 10\%$ | 1.05 | $5.43E-02$ | 1.06 | $5.43E-02$ | 1.06 |
| 6.76 | $5.02E-02 \pm 7\%$ | $4.83E-02 \pm 10\%$ | 1.04 | $4.75E-02$ | 1.06 | $4.73E-02$ | 1.06 |
| 12.20 | $3.84E-02 \pm 7\%$ | $3.72E-02 \pm 10\%$ | 1.03 | $3.66E-02$ | 1.05 | $3.63E-02$ | 1.06 |
| 24.21 | $2.17E-02 \pm 7\%$ | $2.07E-02 \pm 10\%$ | 1.05 | $2.04E-02$ | 1.07 | $2.03E-02$ | 1.07 |
| 49.96 | $6.13E-03 \pm 7\%$ | $6.05E-03 \pm 10\%$ | 1.01 | $5.96E-03$ | 1.03 | $5.98E-03$ | 1.03 |
| 100.09 | $5.27E-04 \pm 7\%$ | $6.01E-04 \pm 10\%$ | 0.88 | $6.12E-04$ | 0.86 | $6.28E-04$ | 0.84 |
| 197.94 | $4.79E-06 \pm 242\%$ | $7.27E-06 \pm 10\%$ | 0.66 | $7.98E-06$ | 0.60 | $6.19E-06$ | 0.77 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|----------------|-----------|--------|------|--------------|
| P32 | S32(n,p)P32 | 14.2d | 99.3 | 1.06 | 7% |
| | S33(n,d+np)P32 | | 0.7 | 1.06 | 7% |



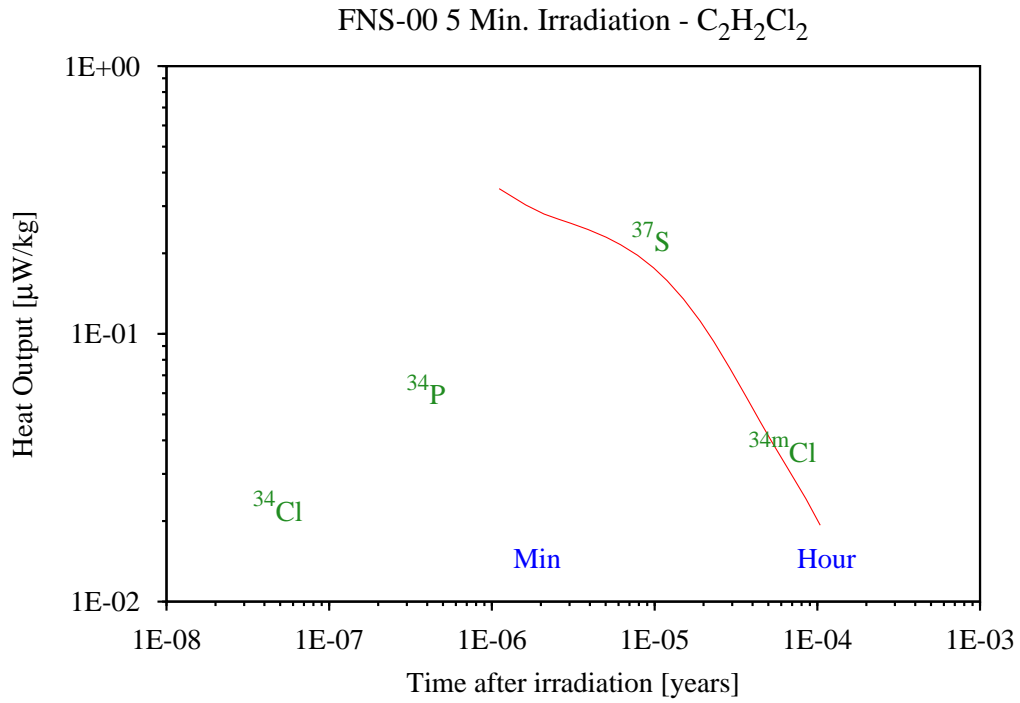
Chlorine

FNS-00 5 Min. Irradiation - C₂H₂Cl₂

For Chlorine, a good agreement for the TENDL libraries can be seen up to the point when Cl34m becomes predominant. The discrepancy beyond this may be due to an incorrect branching ratio or decay heat level allocated to this short-lived metastable.

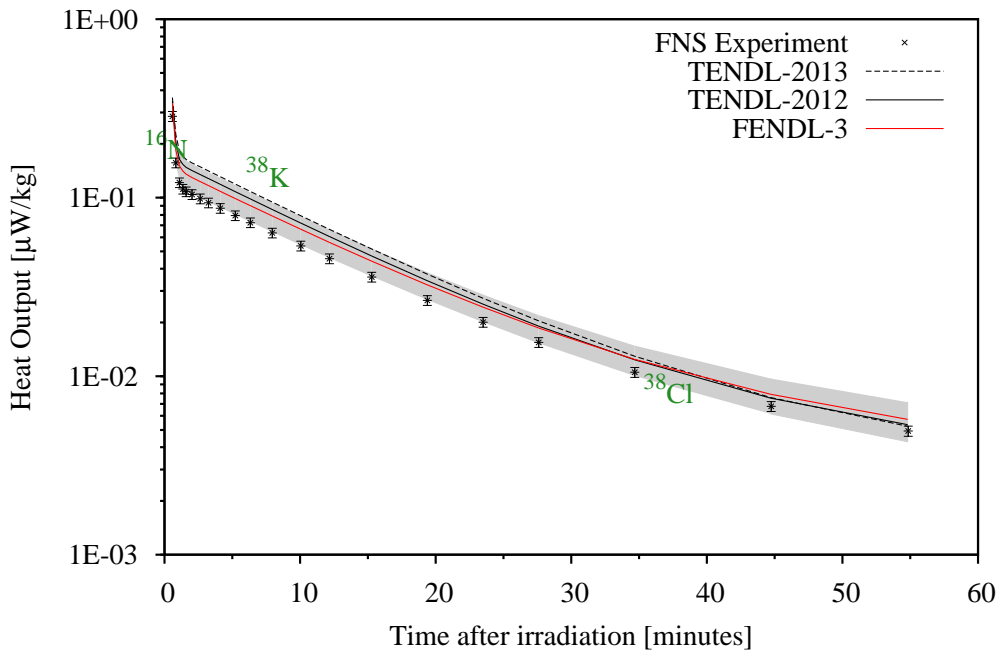
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.58 | 2.89E-01 +/-6% | 3.49E-01 +/-14% | 0.83 | 2.64E-01 | 1.09 | 2.72E-01 | 1.06 |
| 0.85 | 2.39E-01 +/-6% | 3.03E-01 +/-15% | 0.79 | 2.19E-01 | 1.09 | 2.26E-01 | 1.06 |
| 1.10 | 2.28E-01 +/-6% | 2.80E-01 +/-16% | 0.81 | 1.99E-01 | 1.15 | 2.06E-01 | 1.11 |
| 1.35 | 2.06E-01 +/-6% | 2.68E-01 +/-16% | 0.77 | 1.89E-01 | 1.09 | 1.96E-01 | 1.05 |
| 1.60 | 2.04E-01 +/-6% | 2.59E-01 +/-16% | 0.79 | 1.82E-01 | 1.12 | 1.89E-01 | 1.08 |
| 2.05 | 1.91E-01 +/-6% | 2.45E-01 +/-16% | 0.78 | 1.73E-01 | 1.10 | 1.79E-01 | 1.07 |
| 2.65 | 1.80E-01 +/-6% | 2.29E-01 +/-16% | 0.78 | 1.63E-01 | 1.11 | 1.68E-01 | 1.07 |
| 3.25 | 1.66E-01 +/-6% | 2.15E-01 +/-16% | 0.77 | 1.54E-01 | 1.08 | 1.59E-01 | 1.04 |
| 4.13 | 1.52E-01 +/-6% | 1.96E-01 +/-16% | 0.77 | 1.42E-01 | 1.07 | 1.46E-01 | 1.04 |
| 5.18 | 1.35E-01 +/-6% | 1.76E-01 +/-16% | 0.77 | 1.29E-01 | 1.05 | 1.33E-01 | 1.02 |
| 6.28 | 1.19E-01 +/-6% | 1.58E-01 +/-16% | 0.76 | 1.17E-01 | 1.02 | 1.21E-01 | 0.99 |
| 7.92 | 1.02E-01 +/-6% | 1.35E-01 +/-16% | 0.75 | 1.03E-01 | 0.99 | 1.05E-01 | 0.97 |
| 10.02 | 8.38E-02 +/-6% | 1.12E-01 +/-16% | 0.75 | 8.76E-02 | 0.96 | 8.95E-02 | 0.94 |
| 12.13 | 6.95E-02 +/-6% | 9.37E-02 +/-17% | 0.74 | 7.58E-02 | 0.92 | 7.71E-02 | 0.90 |
| 15.25 | 5.50E-02 +/-6% | 7.45E-02 +/-18% | 0.74 | 6.28E-02 | 0.88 | 6.36E-02 | 0.87 |
| 19.35 | 4.19E-02 +/-6% | 5.77E-02 +/-19% | 0.73 | 5.12E-02 | 0.82 | 5.15E-02 | 0.81 |
| 23.47 | 3.39E-02 +/-6% | 4.69E-02 +/-21% | 0.72 | 4.33E-02 | 0.78 | 4.33E-02 | 0.78 |
| 27.57 | 2.81E-02 +/-5% | 3.96E-02 +/-23% | 0.71 | 3.76E-02 | 0.75 | 3.74E-02 | 0.75 |
| 34.65 | 2.24E-02 +/-5% | 3.14E-02 +/-25% | 0.71 | 3.08E-02 | 0.73 | 3.05E-02 | 0.73 |
| 44.72 | 1.70E-02 +/-5% | 2.42E-02 +/-26% | 0.70 | 2.41E-02 | 0.71 | 2.39E-02 | 0.71 |
| 54.83 | 1.37E-02 +/-5% | 1.93E-02 +/-26% | 0.71 | 1.94E-02 | 0.70 | 1.91E-02 | 0.71 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-----------------|------------------|--------|------|-----|
| P34 | Cl37(n,α)P34 | 12.4s | 99.9 | 1.06 | 6% |
| S37 | Cl37(n,p)S37 | 4.9m | 100.0 | 1.02 | 6% |
| Cl34m | Cl35(n,2n)Cl34m | 32.1m | 100.0 | 0.73 | 5% |

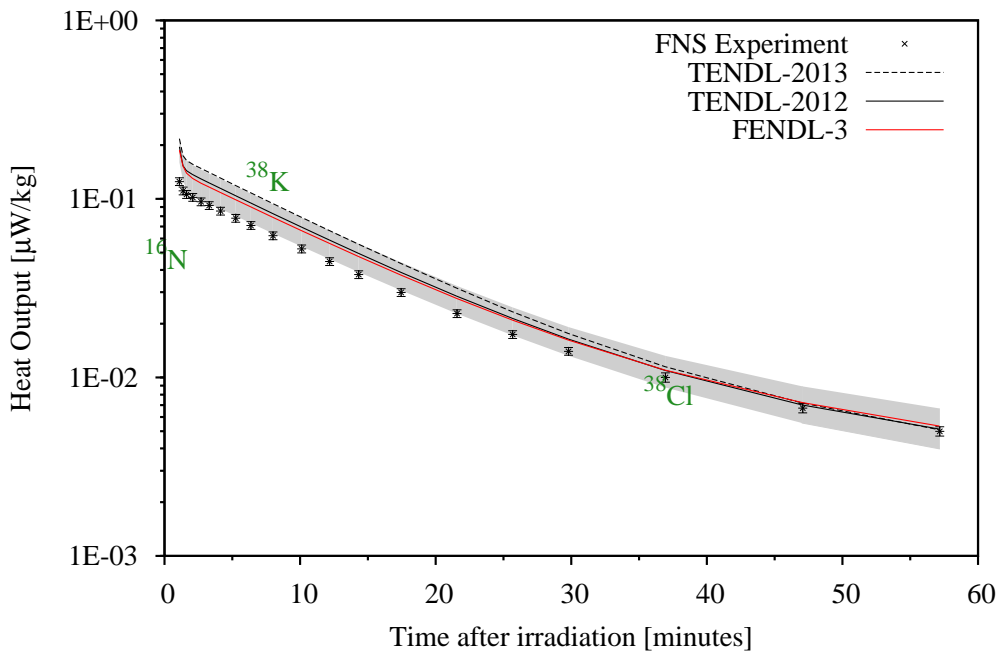


Potassium

FNS-00 5 Min. Irradiation - K_2CO_3



FNS-96 5 Min. Irradiation - K_2CO_3

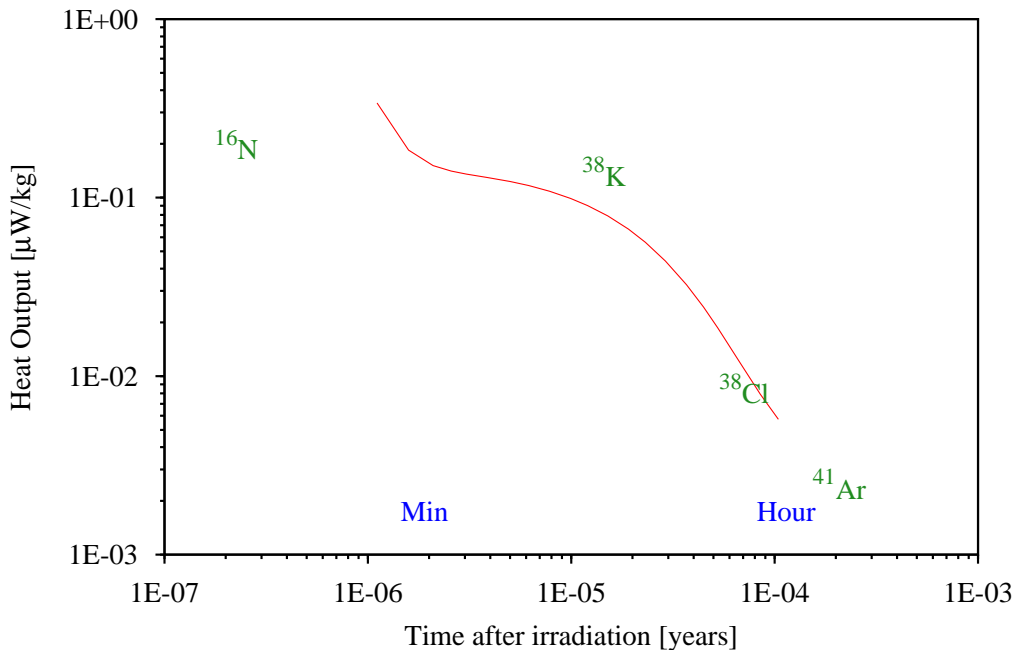


For Potassium, the extremely rapid measurements made barely 34 seconds after irradiation allow a glimpse of the N16 isotope heat prior to the appearance of K38, and then Cl38, both of which are slightly over-predicted.

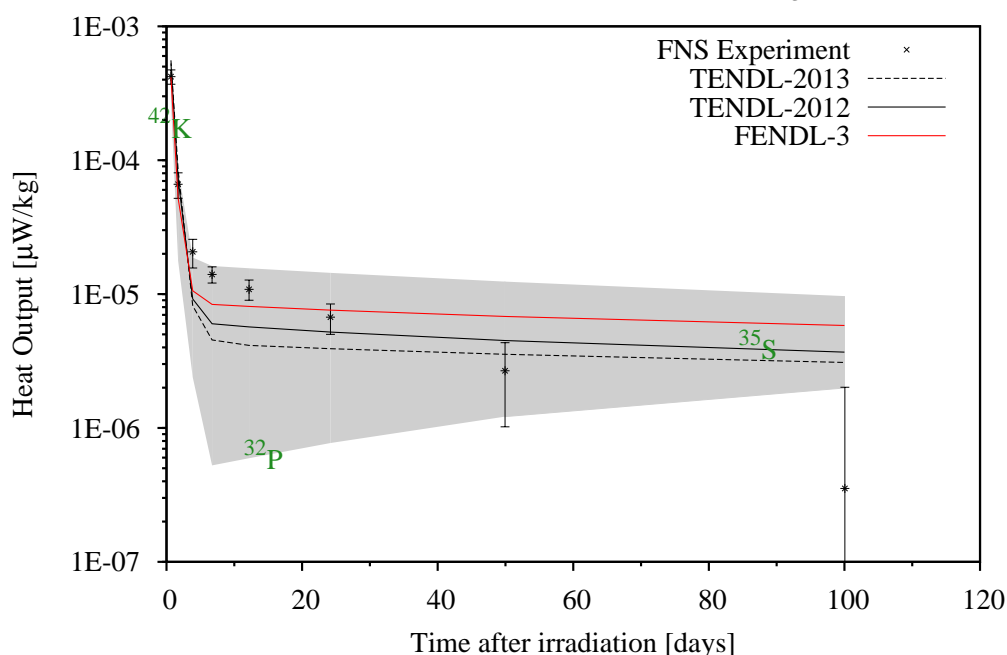
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $2.85E-01 \pm 7\%$ | $3.39E-01 \pm 10\%$ | 0.84 | $3.47E-01$ | 0.82 | $3.64E-01$ | 0.78 |
| 0.83 | $1.57E-01 \pm 6\%$ | $1.85E-01 \pm 15\%$ | 0.85 | $2.05E-01$ | 0.76 | $2.26E-01$ | 0.70 |
| 1.10 | $1.21E-01 \pm 6\%$ | $1.51E-01 \pm 18\%$ | 0.80 | $1.64E-01$ | 0.74 | $1.83E-01$ | 0.66 |
| 1.35 | $1.12E-01 \pm 6\%$ | $1.41E-01 \pm 19\%$ | 0.79 | $1.54E-01$ | 0.73 | $1.71E-01$ | 0.65 |
| 1.60 | $1.08E-01 \pm 6\%$ | $1.35E-01 \pm 19\%$ | 0.80 | $1.48E-01$ | 0.73 | $1.64E-01$ | 0.66 |
| 2.03 | $1.04E-01 \pm 6\%$ | $1.30E-01 \pm 19\%$ | 0.80 | $1.42E-01$ | 0.73 | $1.57E-01$ | 0.67 |
| 2.63 | $9.86E-02 \pm 6\%$ | $1.23E-01 \pm 19\%$ | 0.80 | $1.35E-01$ | 0.73 | $1.49E-01$ | 0.66 |
| 3.25 | $9.36E-02 \pm 6\%$ | $1.17E-01 \pm 19\%$ | 0.80 | $1.28E-01$ | 0.73 | $1.41E-01$ | 0.66 |
| 4.12 | $8.72E-02 \pm 6\%$ | $1.09E-01 \pm 19\%$ | 0.80 | $1.19E-01$ | 0.73 | $1.31E-01$ | 0.67 |
| 5.22 | $7.94E-02 \pm 6\%$ | $9.90E-02 \pm 19\%$ | 0.80 | $1.08E-01$ | 0.73 | $1.19E-01$ | 0.67 |
| 6.33 | $7.25E-02 \pm 6\%$ | $9.02E-02 \pm 19\%$ | 0.80 | $9.84E-02$ | 0.74 | $1.08E-01$ | 0.67 |
| 7.95 | $6.35E-02 \pm 6\%$ | $7.90E-02 \pm 19\%$ | 0.80 | $8.59E-02$ | 0.74 | $9.45E-02$ | 0.67 |
| 10.05 | $5.37E-02 \pm 6\%$ | $6.66E-02 \pm 18\%$ | 0.81 | $7.21E-02$ | 0.74 | $7.92E-02$ | 0.68 |
| 12.17 | $4.55E-02 \pm 6\%$ | $5.62E-02 \pm 18\%$ | 0.81 | $6.06E-02$ | 0.75 | $6.65E-02$ | 0.68 |
| 15.28 | $3.59E-02 \pm 6\%$ | $4.41E-02 \pm 18\%$ | 0.81 | $4.71E-02$ | 0.76 | $5.16E-02$ | 0.70 |
| 19.38 | $2.66E-02 \pm 6\%$ | $3.25E-02 \pm 18\%$ | 0.82 | $3.43E-02$ | 0.77 | $3.73E-02$ | 0.71 |
| 23.50 | $2.01E-02 \pm 6\%$ | $2.44E-02 \pm 18\%$ | 0.82 | $2.53E-02$ | 0.79 | $2.73E-02$ | 0.73 |
| 27.60 | $1.55E-02 \pm 6\%$ | $1.86E-02 \pm 18\%$ | 0.83 | $1.91E-02$ | 0.81 | $2.05E-02$ | 0.76 |
| 34.68 | $1.05E-02 \pm 6\%$ | $1.24E-02 \pm 19\%$ | 0.85 | $1.24E-02$ | 0.85 | $1.29E-02$ | 0.81 |
| 44.75 | $6.77E-03 \pm 6\%$ | $7.92E-03 \pm 22\%$ | 0.86 | $7.54E-03$ | 0.90 | $7.58E-03$ | 0.89 |
| 54.85 | $4.93E-03 \pm 6\%$ | $5.73E-03 \pm 25\%$ | 0.86 | $5.35E-03$ | 0.92 | $5.24E-03$ | 0.94 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------------|-----------|--------|------|--------------|
| N16 | O16(n,p)N16 | 7.1s | 100.0 | 0.78 | 7% |
| K38 | K39(n,2n)K38 | 7.6m | 100.0 | 0.67 | 6% |
| Cl38 | K39(n,2p)Cl38 | 0.7s | 2.9 | 0.81 | 6% |
| | K41(n, α)Cl38 | | 70.3 | 0.81 | 6% |
| | K39(n,2p)Cl38m | | 1.5 | 0.81 | 6% |
| | K41(n, α)Cl38m | | 25.7 | 0.81 | 6% |

FNS-00 5 Min. Irradiation - K_2CO_3



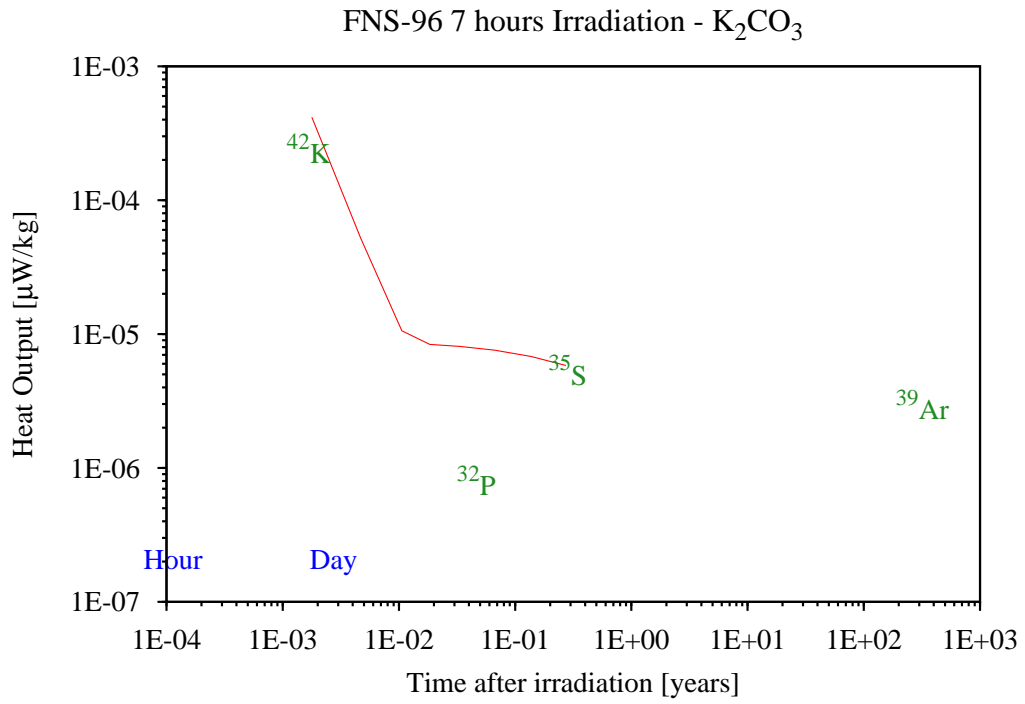
FNS-96 7 hours Irradiation - K₂CO₃



The rather high uncertainty bands on the experimental results do not allow an in-depth analysis to be undertaken. However, the decay heat profile is properly shaped.

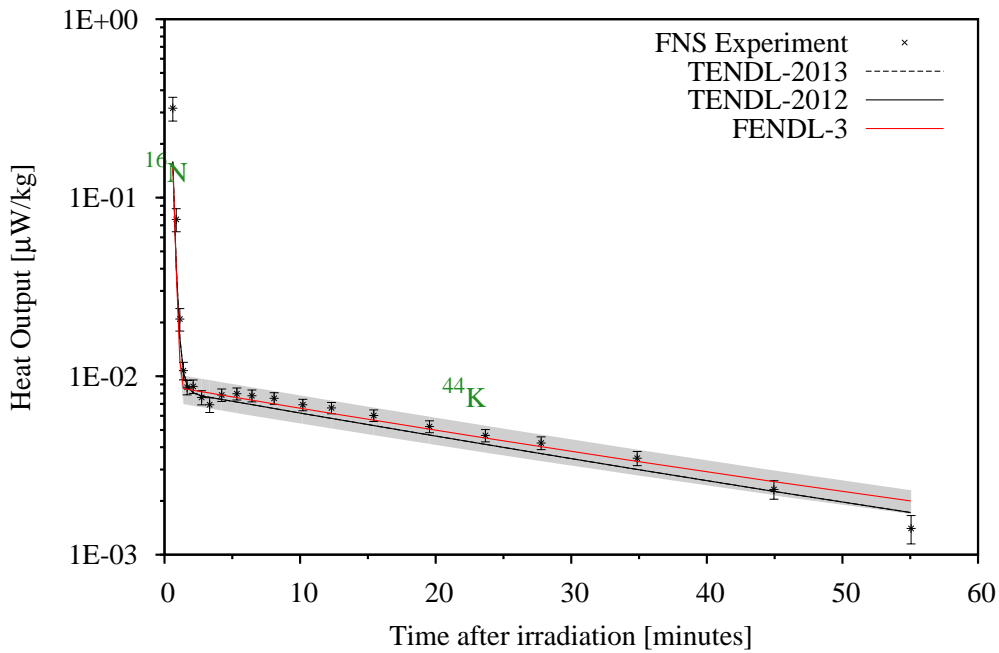
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|------------------|-----------------|------|------------|------|------------|------|
| Days | μW/g | | | | | | |
| 0.65 | 4.21E-04 +/-12% | 4.17E-04 +/-34% | 1.01 | 5.28E-04 | 0.80 | 5.58E-04 | 0.75 |
| 1.71 | 6.62E-05 +/-22% | 5.20E-05 +/-66% | 1.27 | 7.25E-05 | 0.91 | 8.49E-05 | 0.78 |
| 3.87 | 2.07E-05 +/-24% | 1.06E-05 +/-77% | 1.95 | 9.19E-06 | 2.25 | 8.17E-06 | 2.53 |
| 6.73 | 1.40E-05 +/-14% | 8.37E-06 +/-94% | 1.68 | 6.00E-06 | 2.34 | 4.55E-06 | 3.09 |
| 12.18 | 1.09E-05 +/-17% | 8.10E-06 +/-93% | 1.34 | 5.69E-06 | 1.91 | 4.14E-06 | 2.62 |
| 24.19 | 6.72E-06 +/-26% | 7.59E-06 +/-90% | 0.89 | 5.20E-06 | 1.29 | 3.91E-06 | 1.72 |
| 49.94 | 2.68E-06 +/-62% | 6.80E-06 +/-82% | 0.39 | 4.49E-06 | 0.60 | 3.55E-06 | 0.75 |
| 100.07 | 3.53E-07 +/-469% | 5.83E-06 +/-66% | 0.06 | 3.68E-06 | 0.10 | 3.08E-06 | 0.11 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|--------------|------------------|--------|------|-----|
| K42 | K41(n,γ)K42 | 12.3h | 99.9 | 0.80 | 12% |
| S35 | K39(n,pα)S35 | 87.3d | 100.0 | 0.60 | 62% |

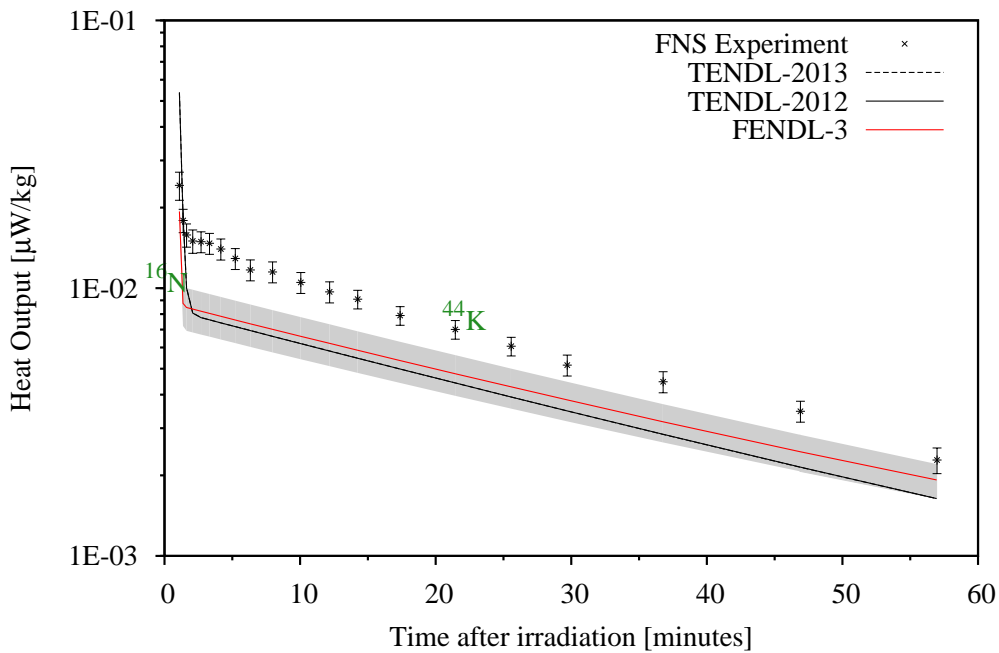


Calcium

FNS-00 5 Min. Irradiation - CaO



FNS-96 5 Min. Irradiation - CaO

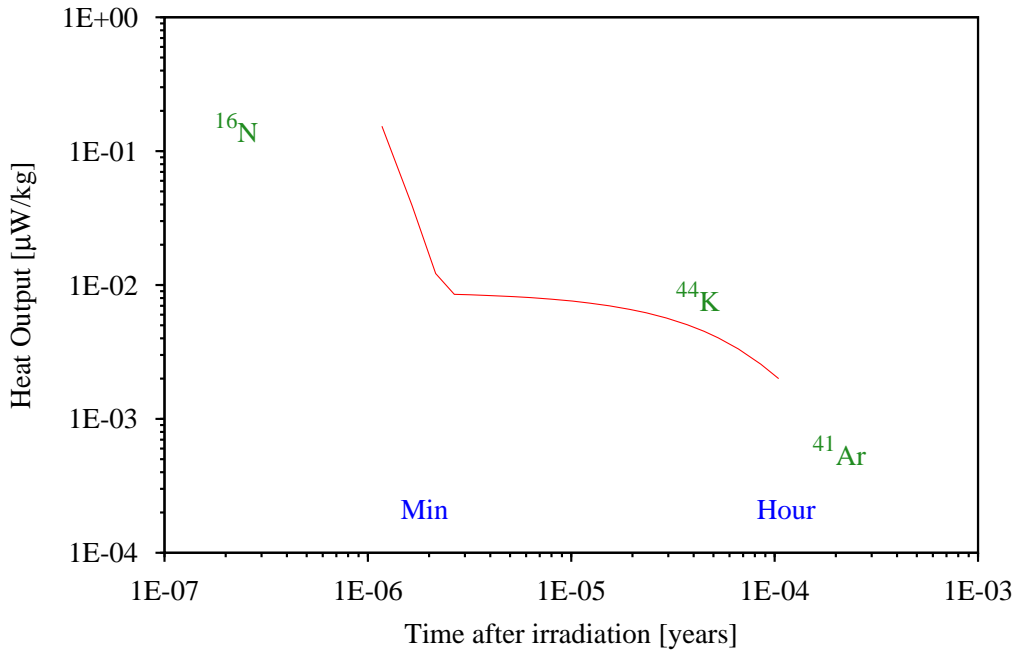


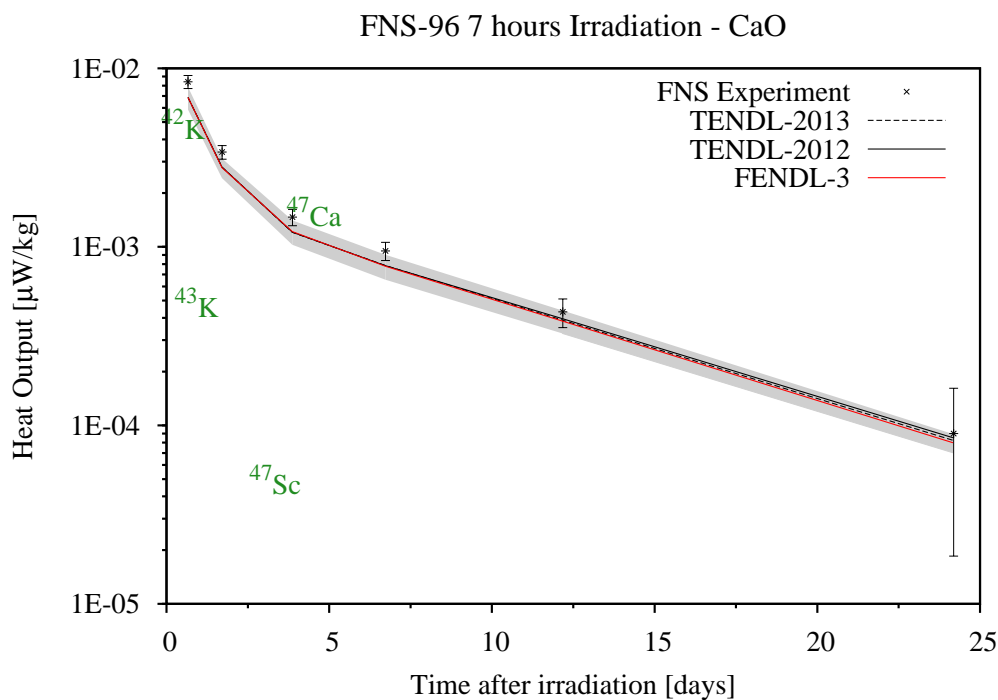
For Calcium, the latest experiment, when analysed with the latest libraries seems to lead to a much better agreement, even at rather short cooling times. Discrepancies seem to exist between this and the original experiment. One explanation for this is that the CaO powder, being extremely fine, was used in extremely small amounts. Because the sample was sandwiched in-between plastic tape, its contribution needed to be subtracted from the raw measured data. In other words, the signal to noise ratio was high. Such a situation should have been better reflected in the otherwise low experimental uncertainties. This situation also occurs for the SrCO₃, Y₂O₃, and SnO₂ samples.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C TENDL-2012 | E/C TENDL-2013 | E/C |
|-------|---------------------|---------------------|----------------|----------------|------|
| Min. | $\mu\text{W/g}$ | | | | |
| 0.62 | $3.17E-01 \pm 15\%$ | $1.53E-01 \pm 9\%$ | 2.07 | $1.59E-01$ | 1.99 |
| 0.87 | $7.56E-02 \pm 15\%$ | $3.93E-02 \pm 9\%$ | 1.92 | $4.12E-02$ | 1.83 |
| 1.13 | $2.09E-02 \pm 14\%$ | $1.22E-02 \pm 13\%$ | 1.72 | $1.64E-02$ | 1.27 |
| 1.40 | $1.07E-02 \pm 11\%$ | $8.53E-03 \pm 18\%$ | 1.26 | $1.07E-02$ | 1.01 |
| 1.67 | $8.67E-03 \pm 9\%$ | $8.46E-03 \pm 18\%$ | 1.02 | $8.81E-03$ | 0.98 |
| 2.12 | $8.77E-03 \pm 9\%$ | $8.34E-03 \pm 18\%$ | 1.05 | $8.06E-03$ | 1.09 |
| 2.73 | $7.60E-03 \pm 9\%$ | $8.19E-03 \pm 18\%$ | 0.93 | $7.76E-03$ | 0.98 |
| 3.33 | $6.92E-03 \pm 9\%$ | $8.04E-03 \pm 18\%$ | 0.86 | $7.61E-03$ | 0.91 |
| 4.22 | $7.85E-03 \pm 8\%$ | $7.84E-03 \pm 18\%$ | 1.00 | $7.41E-03$ | 1.06 |
| 5.33 | $7.97E-03 \pm 8\%$ | $7.58E-03 \pm 18\%$ | 1.05 | $7.16E-03$ | 1.11 |
| 6.45 | $7.77E-03 \pm 8\%$ | $7.33E-03 \pm 18\%$ | 1.06 | $6.92E-03$ | 1.12 |
| 8.08 | $7.51E-03 \pm 7\%$ | $7.00E-03 \pm 18\%$ | 1.07 | $6.59E-03$ | 1.14 |
| 10.20 | $6.91E-03 \pm 7\%$ | $6.58E-03 \pm 18\%$ | 1.05 | $6.18E-03$ | 1.12 |
| 12.32 | $6.64E-03 \pm 7\%$ | $6.20E-03 \pm 18\%$ | 1.07 | $5.80E-03$ | 1.14 |
| 15.43 | $6.02E-03 \pm 7\%$ | $5.67E-03 \pm 18\%$ | 1.06 | $5.29E-03$ | 1.14 |
| 19.55 | $5.22E-03 \pm 8\%$ | $5.05E-03 \pm 17\%$ | 1.03 | $4.68E-03$ | 1.12 |
| 23.67 | $4.65E-03 \pm 8\%$ | $4.51E-03 \pm 17\%$ | 1.03 | $4.15E-03$ | 1.12 |
| 27.78 | $4.22E-03 \pm 8\%$ | $4.03E-03 \pm 17\%$ | 1.05 | $3.68E-03$ | 1.15 |
| 34.87 | $3.47E-03 \pm 9\%$ | $3.33E-03 \pm 16\%$ | 1.04 | $3.00E-03$ | 1.15 |
| 44.95 | $2.32E-03 \pm 12\%$ | $2.57E-03 \pm 16\%$ | 0.90 | $2.26E-03$ | 1.03 |
| 55.07 | $1.40E-03 \pm 18\%$ | $2.00E-03 \pm 15\%$ | 0.70 | $1.72E-03$ | 0.81 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C $\Delta E\%$ |
|---------|--------------|-----------|--------|------------------|
| K44 | Ca44(n,p)K44 | 22.1m | 100.0 | 1.12 8% |

FNS-00 5 Min. Irradiation - CaO

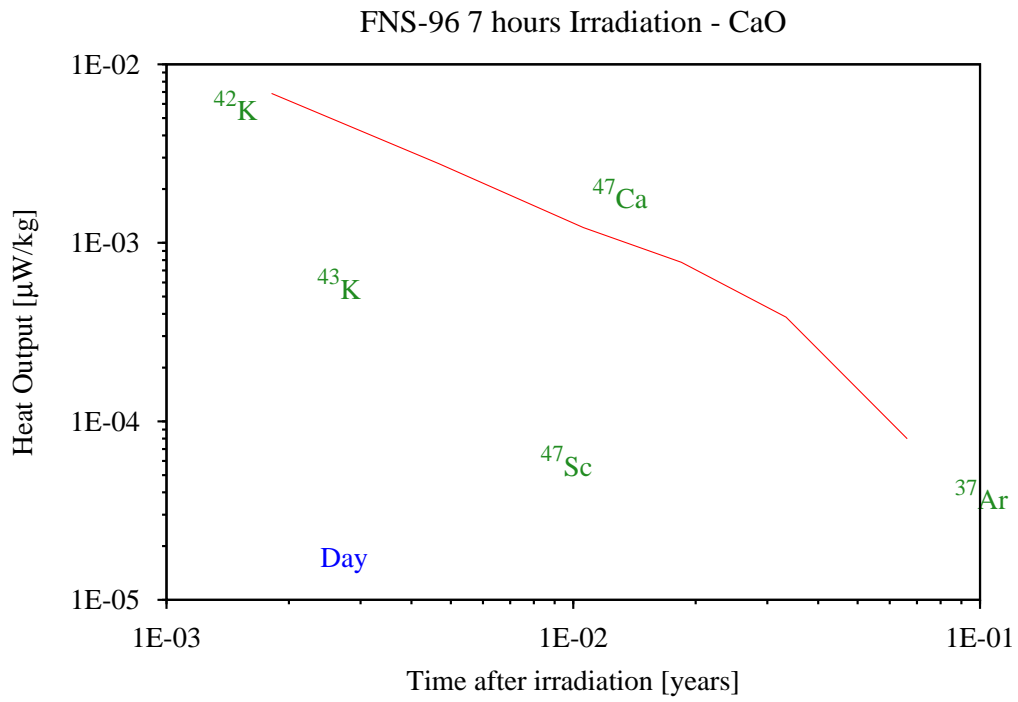




A rather good agreement exists for this element with multiple production pathways.

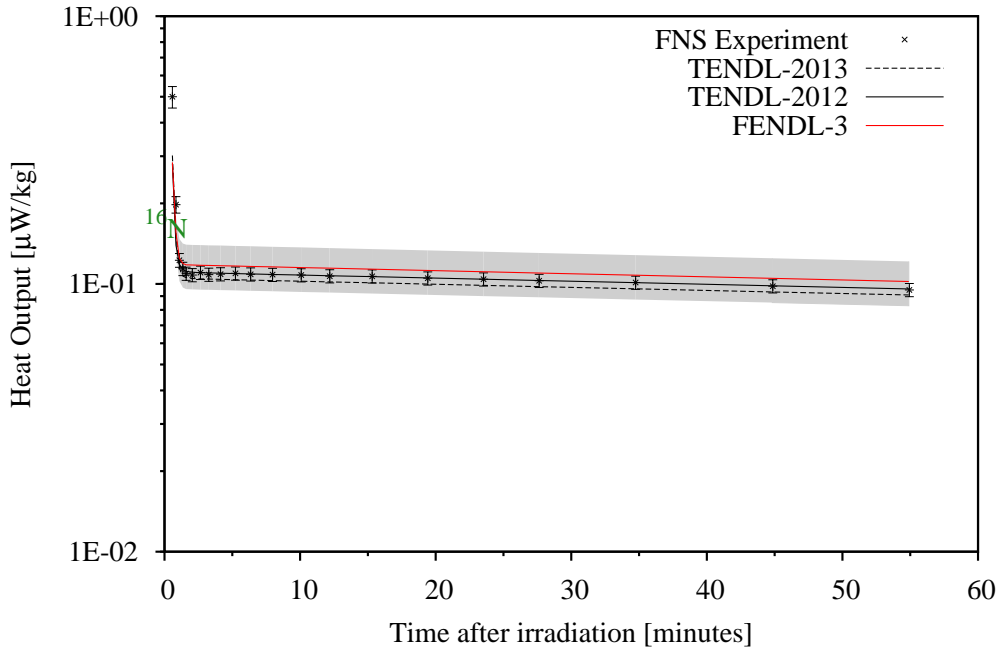
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------------|---------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.66 | $8.41E-03 \pm 8\%$ | $6.87E-03 \pm 14\%$ | 1.22 | $6.88E-03$ | 1.22 | $6.88E-03$ | 1.22 |
| 1.71 | $3.40E-03 \pm 9\%$ | $2.77E-03 \pm 13\%$ | 1.22 | $2.80E-03$ | 1.21 | $2.80E-03$ | 1.21 |
| 3.87 | $1.47E-03 \pm 10\%$ | $1.22E-03 \pm 16\%$ | 1.21 | $1.21E-03$ | 1.22 | $1.21E-03$ | 1.22 |
| 6.73 | $9.49E-04 \pm 12\%$ | $7.78E-04 \pm 16\%$ | 1.22 | $7.84E-04$ | 1.21 | $7.85E-04$ | 1.21 |
| 12.18 | $4.32E-04 \pm 18\%$ | $3.83E-04 \pm 15\%$ | 1.13 | $3.96E-04$ | 1.09 | $3.88E-04$ | 1.11 |
| 24.19 | $9.00E-05 \pm 79\%$ | $7.99E-05 \pm 12\%$ | 1.13 | $8.52E-05$ | 1.06 | $8.24E-05$ | 1.09 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| K42 | Ca42(n,p)K42 | 12.3h | 96.7 | 1.22 | 8% |
| | Ca43(n,d+np)K42 | | 3.3 | 1.22 | 8% |
| Ca47 | Ca48(n,2n)Ca47 | 4.5d | 99.9 | 1.22 | 10% |



Scandium

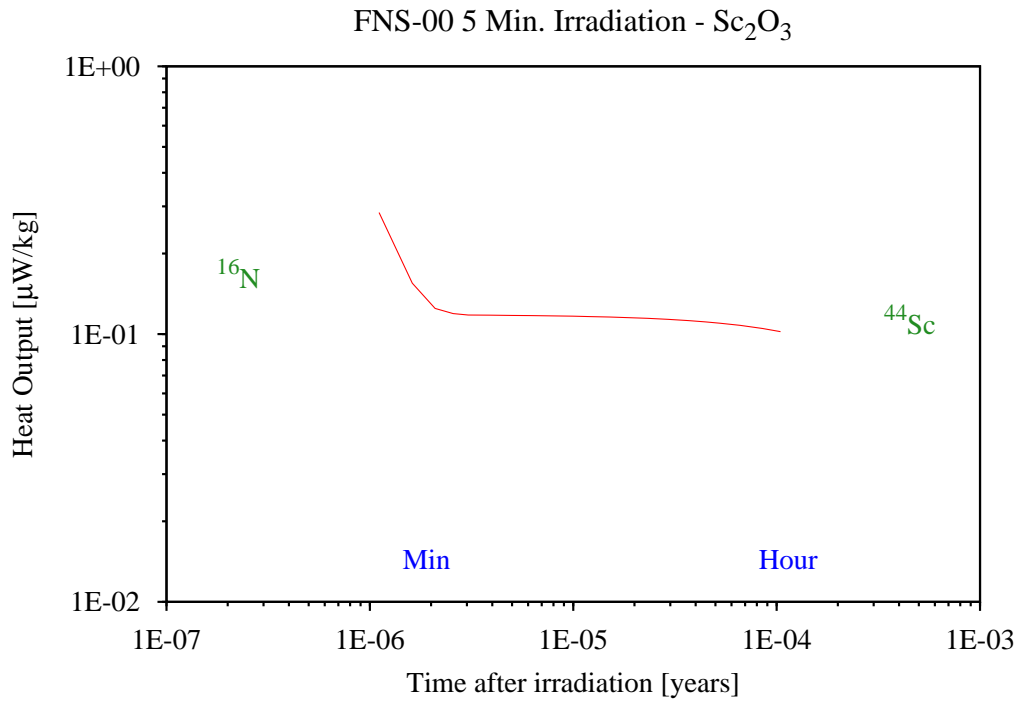
FNS-00 5 Min. Irradiation - Sc₂O₃



For Scandium, the above plot demonstrates an excellent agreement for the production of Sc44, where all results are always within the experimental uncertainty. FENDL-3.0 variance could be reduced to reflect this experiment.

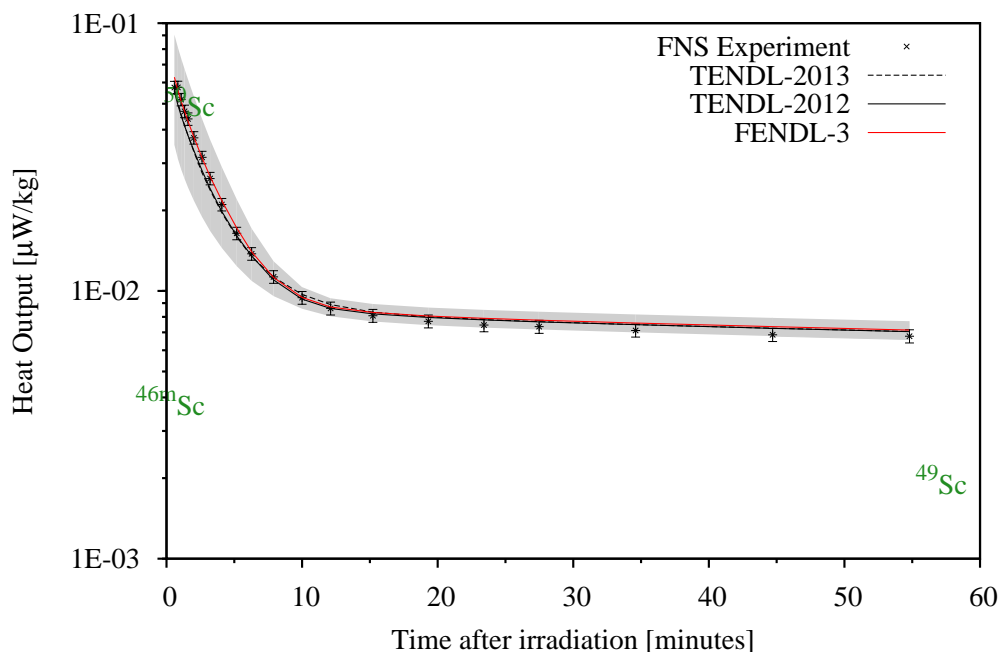
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.58 | 5.00E-01 +/-9% | 2.85E-01 +/-10% | 1.76 | 2.81E-01 | 1.78 | 3.02E-01 | 1.66 |
| 0.85 | 1.98E-01 +/-7% | 1.55E-01 +/-15% | 1.28 | 1.40E-01 | 1.42 | 1.52E-01 | 1.30 |
| 1.10 | 1.23E-01 +/-6% | 1.25E-01 +/-18% | 0.98 | 1.18E-01 | 1.04 | 1.14E-01 | 1.07 |
| 1.35 | 1.14E-01 +/-6% | 1.19E-01 +/-19% | 0.95 | 1.13E-01 | 1.00 | 1.07E-01 | 1.06 |
| 1.60 | 1.09E-01 +/-6% | 1.18E-01 +/-19% | 0.93 | 1.12E-01 | 0.98 | 1.06E-01 | 1.04 |
| 2.05 | 1.08E-01 +/-6% | 1.18E-01 +/-19% | 0.92 | 1.11E-01 | 0.98 | 1.05E-01 | 1.03 |
| 2.65 | 1.10E-01 +/-6% | 1.17E-01 +/-19% | 0.94 | 1.10E-01 | 1.00 | 1.04E-01 | 1.06 |
| 3.27 | 1.08E-01 +/-6% | 1.17E-01 +/-19% | 0.92 | 1.10E-01 | 0.99 | 1.04E-01 | 1.04 |
| 4.13 | 1.09E-01 +/-6% | 1.17E-01 +/-19% | 0.93 | 1.10E-01 | 0.99 | 1.04E-01 | 1.05 |
| 5.23 | 1.10E-01 +/-6% | 1.17E-01 +/-19% | 0.94 | 1.09E-01 | 1.00 | 1.04E-01 | 1.06 |
| 6.35 | 1.09E-01 +/-6% | 1.16E-01 +/-19% | 0.93 | 1.09E-01 | 1.00 | 1.03E-01 | 1.05 |
| 7.97 | 1.08E-01 +/-6% | 1.16E-01 +/-19% | 0.94 | 1.09E-01 | 1.00 | 1.03E-01 | 1.05 |
| 10.08 | 1.08E-01 +/-6% | 1.15E-01 +/-19% | 0.94 | 1.08E-01 | 1.00 | 1.02E-01 | 1.05 |
| 12.18 | 1.07E-01 +/-6% | 1.14E-01 +/-19% | 0.93 | 1.07E-01 | 1.00 | 1.02E-01 | 1.05 |
| 15.32 | 1.07E-01 +/-6% | 1.14E-01 +/-19% | 0.94 | 1.06E-01 | 1.00 | 1.01E-01 | 1.06 |
| 19.42 | 1.05E-01 +/-6% | 1.12E-01 +/-19% | 0.94 | 1.05E-01 | 1.00 | 9.99E-02 | 1.05 |
| 23.53 | 1.04E-01 +/-6% | 1.11E-01 +/-19% | 0.94 | 1.04E-01 | 1.00 | 9.88E-02 | 1.05 |
| 27.63 | 1.03E-01 +/-6% | 1.10E-01 +/-19% | 0.94 | 1.03E-01 | 1.00 | 9.77E-02 | 1.05 |
| 34.75 | 1.01E-01 +/-6% | 1.08E-01 +/-19% | 0.94 | 1.01E-01 | 1.00 | 9.59E-02 | 1.06 |
| 44.87 | 9.81E-02 +/-6% | 1.05E-01 +/-19% | 0.93 | 9.84E-02 | 1.00 | 9.34E-02 | 1.05 |
| 54.93 | 9.50E-02 +/-6% | 1.02E-01 +/-19% | 0.93 | 9.58E-02 | 0.99 | 9.09E-02 | 1.04 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|----------------|------------------|--------|---------|
| Sc44 | Sc45(n,2n)Sc44 | 3.9h | 100.0 | 1.04 6% |

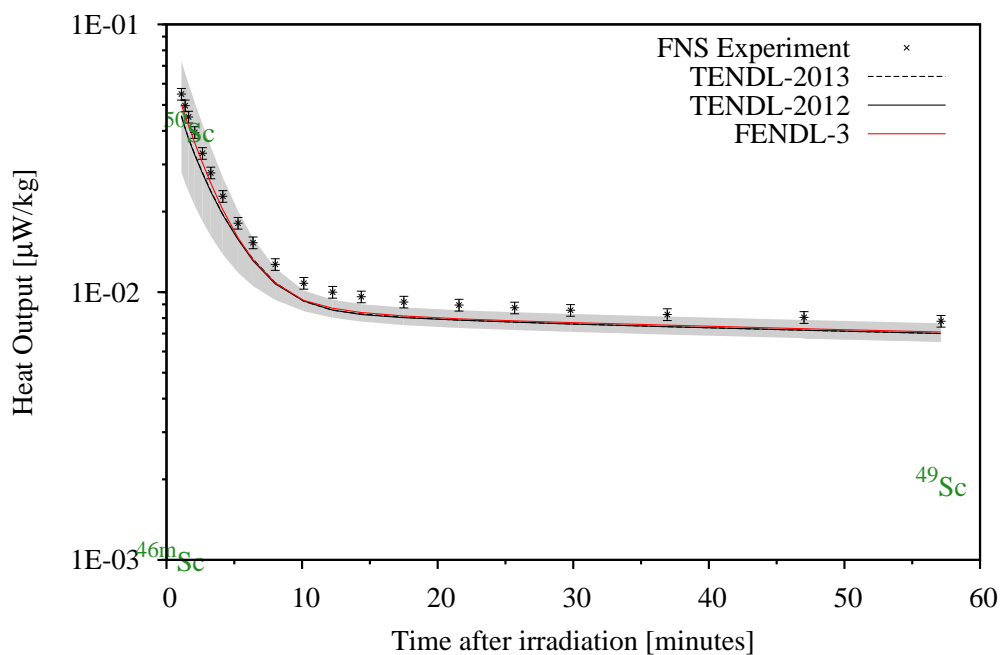


Titanium

FNS-00 5 Min. Irradiation - Ti



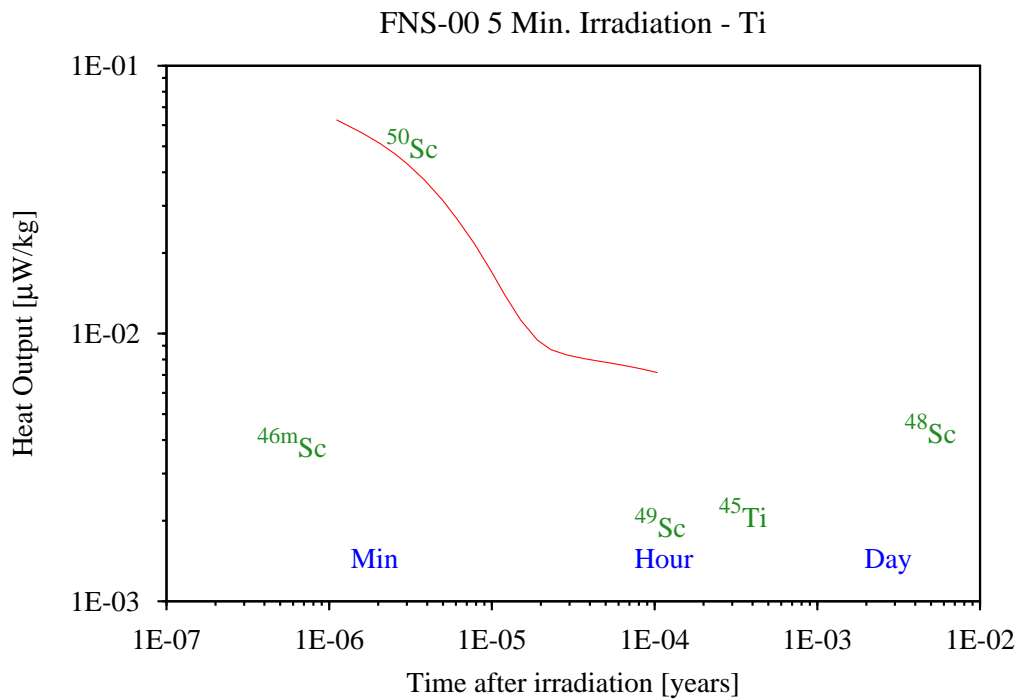
FNS-96 5 Min. Irradiation - Ti

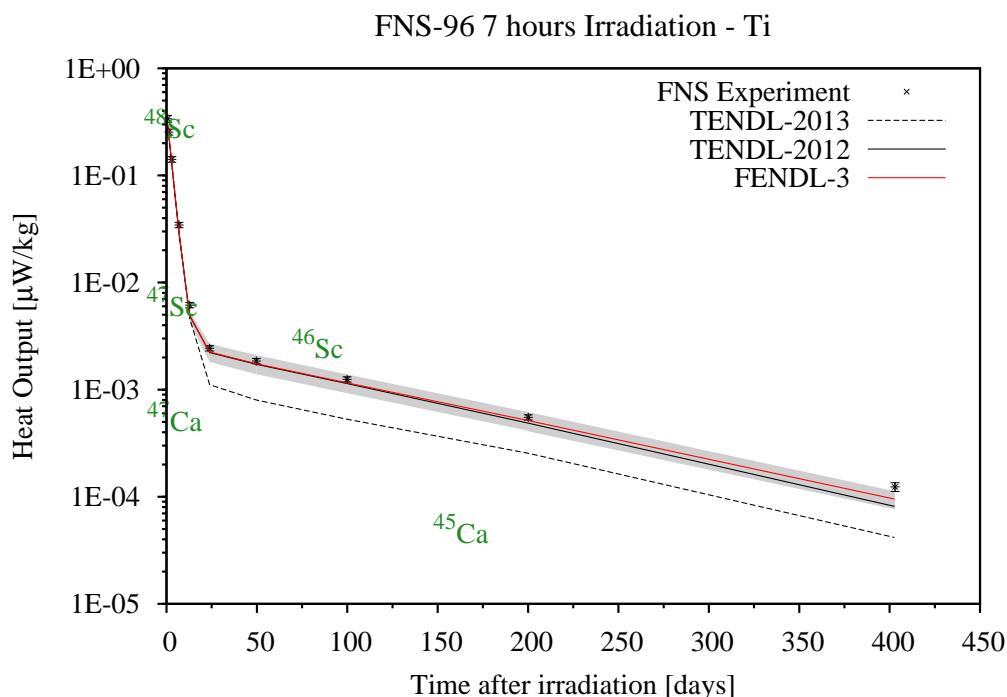


For titanium, the two 5-minute graphs exhibit some unexplained differences between the two experimental batches. The routes of production of the many isotopes involved are complex and prohibit further in-depth analyses.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $5.75E-02 \pm 5\%$ | $6.29E-02 \pm 44\%$ | 0.91 | $5.55E-02$ | 1.04 | $5.70E-02$ | 1.01 |
| 0.83 | $5.76E-02 \pm 5\%$ | $5.63E-02 \pm 45\%$ | 1.02 | $4.96E-02$ | 1.16 | $5.07E-02$ | 1.14 |
| 1.08 | $5.19E-02 \pm 5\%$ | $5.12E-02 \pm 44\%$ | 1.01 | $4.51E-02$ | 1.15 | $4.57E-02$ | 1.14 |
| 1.33 | $4.69E-02 \pm 5\%$ | $4.68E-02 \pm 44\%$ | 1.00 | $4.13E-02$ | 1.13 | $4.16E-02$ | 1.13 |
| 1.58 | $4.39E-02 \pm 5\%$ | $4.30E-02 \pm 43\%$ | 1.02 | $3.81E-02$ | 1.15 | $3.81E-02$ | 1.15 |
| 2.02 | $3.73E-02 \pm 5\%$ | $3.75E-02 \pm 42\%$ | 0.99 | $3.34E-02$ | 1.12 | $3.31E-02$ | 1.13 |
| 2.62 | $3.15E-02 \pm 5\%$ | $3.15E-02 \pm 40\%$ | 1.00 | $2.82E-02$ | 1.12 | $2.77E-02$ | 1.14 |
| 3.22 | $2.63E-02 \pm 5\%$ | $2.68E-02 \pm 37\%$ | 0.98 | $2.42E-02$ | 1.09 | $2.38E-02$ | 1.10 |
| 4.08 | $2.10E-02 \pm 5\%$ | $2.17E-02 \pm 33\%$ | 0.97 | $1.98E-02$ | 1.06 | $1.96E-02$ | 1.07 |
| 5.18 | $1.64E-02 \pm 5\%$ | $1.72E-02 \pm 28\%$ | 0.95 | $1.60E-02$ | 1.02 | $1.59E-02$ | 1.03 |
| 6.28 | $1.38E-02 \pm 5\%$ | $1.40E-02 \pm 22\%$ | 0.98 | $1.35E-02$ | 1.02 | $1.34E-02$ | 1.02 |
| 7.90 | $1.13E-02 \pm 5\%$ | $1.12E-02 \pm 15\%$ | 1.00 | $1.10E-02$ | 1.03 | $1.13E-02$ | 1.00 |
| 10.00 | $9.43E-03 \pm 5\%$ | $9.46E-03 \pm 9\%$ | 1.00 | $9.33E-03$ | 1.01 | $9.71E-03$ | 0.97 |
| 12.10 | $8.60E-03 \pm 6\%$ | $8.71E-03 \pm 8\%$ | 0.99 | $8.60E-03$ | 1.00 | $8.89E-03$ | 0.97 |
| 15.22 | $8.08E-03 \pm 6\%$ | $8.31E-03 \pm 7\%$ | 0.97 | $8.21E-03$ | 0.98 | $8.33E-03$ | 0.97 |
| 19.32 | $7.71E-03 \pm 6\%$ | $8.06E-03 \pm 8\%$ | 0.96 | $7.96E-03$ | 0.97 | $8.01E-03$ | 0.96 |
| 23.42 | $7.45E-03 \pm 6\%$ | $7.90E-03 \pm 8\%$ | 0.94 | $7.80E-03$ | 0.96 | $7.82E-03$ | 0.95 |
| 27.48 | $7.36E-03 \pm 6\%$ | $7.77E-03 \pm 8\%$ | 0.95 | $7.66E-03$ | 0.96 | $7.68E-03$ | 0.96 |
| 34.60 | $7.12E-03 \pm 6\%$ | $7.58E-03 \pm 8\%$ | 0.94 | $7.48E-03$ | 0.95 | $7.49E-03$ | 0.95 |
| 44.70 | $6.86E-03 \pm 6\%$ | $7.36E-03 \pm 8\%$ | 0.93 | $7.25E-03$ | 0.95 | $7.26E-03$ | 0.94 |
| 54.80 | $6.77E-03 \pm 6\%$ | $7.15E-03 \pm 8\%$ | 0.95 | $7.05E-03$ | 0.96 | $7.05E-03$ | 0.96 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------|-----------|--------|------|--------------|
| Sc50 | Ti50(n,p)Sc50 | 1.7m | 61.3 | 1.15 | 5% |
| | Ti50(n,p)Sc50m | 0.3s | 40.5 | 1.15 | 5% |
| Sc48 | Ti48(n,p)Sc48 | 1.8d | 99.5 | 0.96 | 6% |
| | Ti49(n,d+np)Sc48 | | 0.4 | 0.96 | 6% |

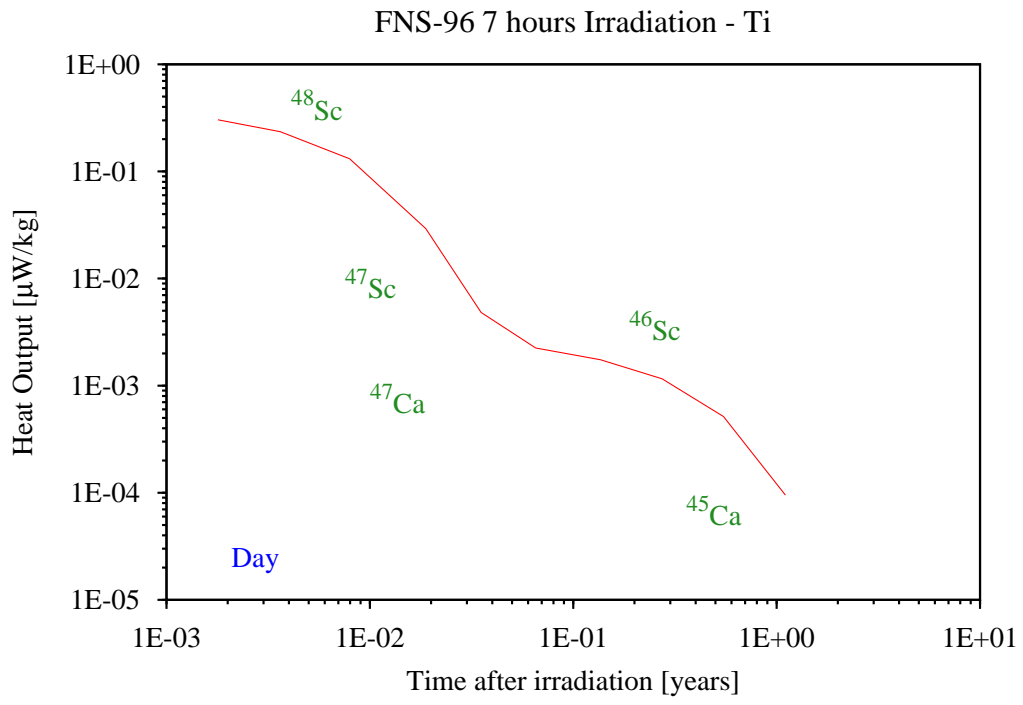




An excellent agreement exists at all cooling times, even with such complex production routes for FENDL-3.0 and TENDL-2012, however TENDL-2013 underpredicts the Sc46 production routes by about a factor 2.

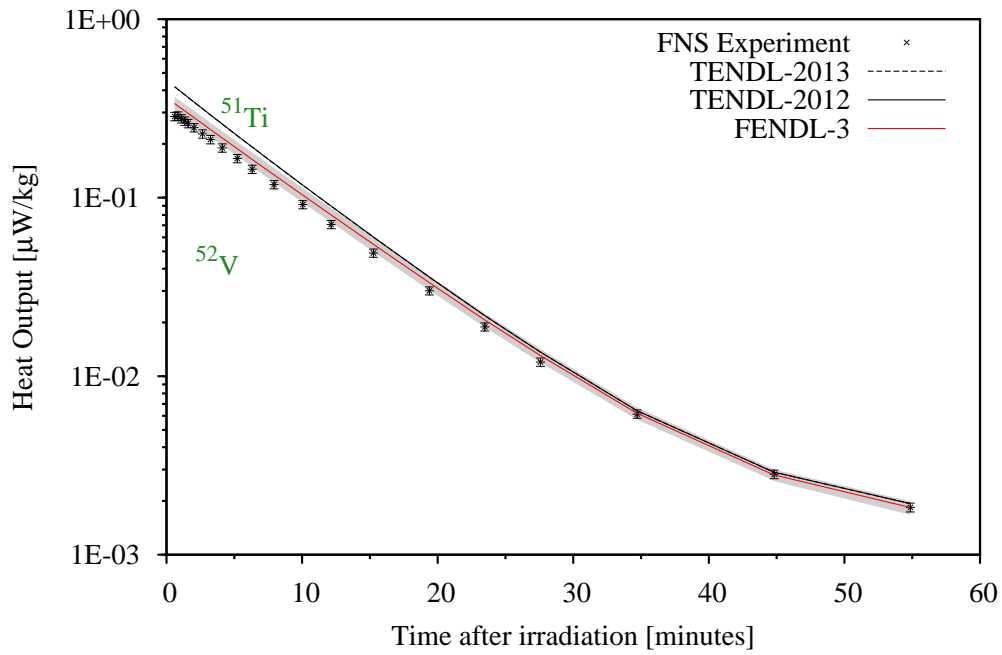
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|--------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.65 | $3.38E-01 \pm 7\%$ | $3.03E-01 \pm 10\%$ | 1.12 | $2.94E-01$ | 1.15 | $2.93E-01$ | 1.16 |
| 1.32 | $2.54E-01 \pm 6\%$ | $2.35E-01 \pm 10\%$ | 1.08 | $2.27E-01$ | 1.12 | $2.26E-01$ | 1.12 |
| 2.90 | $1.41E-01 \pm 6\%$ | $1.31E-01 \pm 10\%$ | 1.08 | $1.26E-01$ | 1.12 | $1.26E-01$ | 1.12 |
| 6.87 | $3.45E-02 \pm 6\%$ | $2.92E-02 \pm 9\%$ | 1.18 | $2.87E-02$ | 1.20 | $3.04E-02$ | 1.13 |
| 12.87 | $6.16E-03 \pm 6\%$ | $4.82E-03 \pm 11\%$ | 1.28 | $4.93E-03$ | 1.25 | $4.62E-03$ | 1.33 |
| 23.86 | $2.43E-03 \pm 6\%$ | $2.24E-03 \pm 19\%$ | 1.09 | $2.22E-03$ | 1.10 | $1.11E-03$ | 2.19 |
| 49.71 | $1.85E-03 \pm 6\%$ | $1.75E-03 \pm 20\%$ | 1.06 | $1.72E-03$ | 1.07 | $8.01E-04$ | 2.31 |
| 99.90 | $1.25E-03 \pm 6\%$ | $1.16E-03 \pm 20\%$ | 1.08 | $1.14E-03$ | 1.10 | $5.30E-04$ | 2.36 |
| 200.12 | $5.51E-04 \pm 6\%$ | $5.15E-04 \pm 20\%$ | 1.07 | $4.87E-04$ | 1.13 | $2.55E-04$ | 2.16 |
| 402.96 | $1.23E-04 \pm 9\%$ | $9.51E-05 \pm 19\%$ | 1.30 | $8.14E-05$ | 1.52 | $4.17E-05$ | 2.96 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-------------------|-----------|--------|------|--------------|
| Sc48 | Ti48(n,p)Sc48 | 1.8d | 99.7 | 1.12 | 6% |
| Sc46 | Ti46(n,p)Sc46 | 83.7d | 67.3 | 2.36 | 6% |
| | Ti47(n,d+np)Sc46 | | 13.2 | 2.36 | 6% |
| | Ti46(n,p)Sc46m | 18.7s | 17.5 | 2.36 | 6% |
| | Ti47(n,d+np)Sc46m | | 1.9 | 2.36 | 6% |

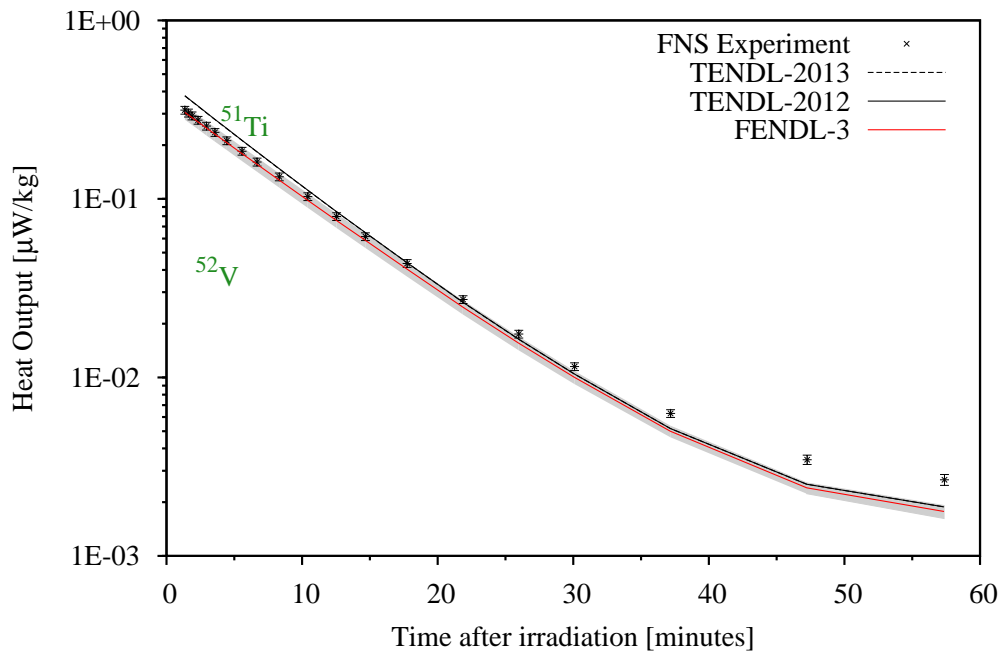


Vanadium

FNS-00 5 Min. Irradiation - V



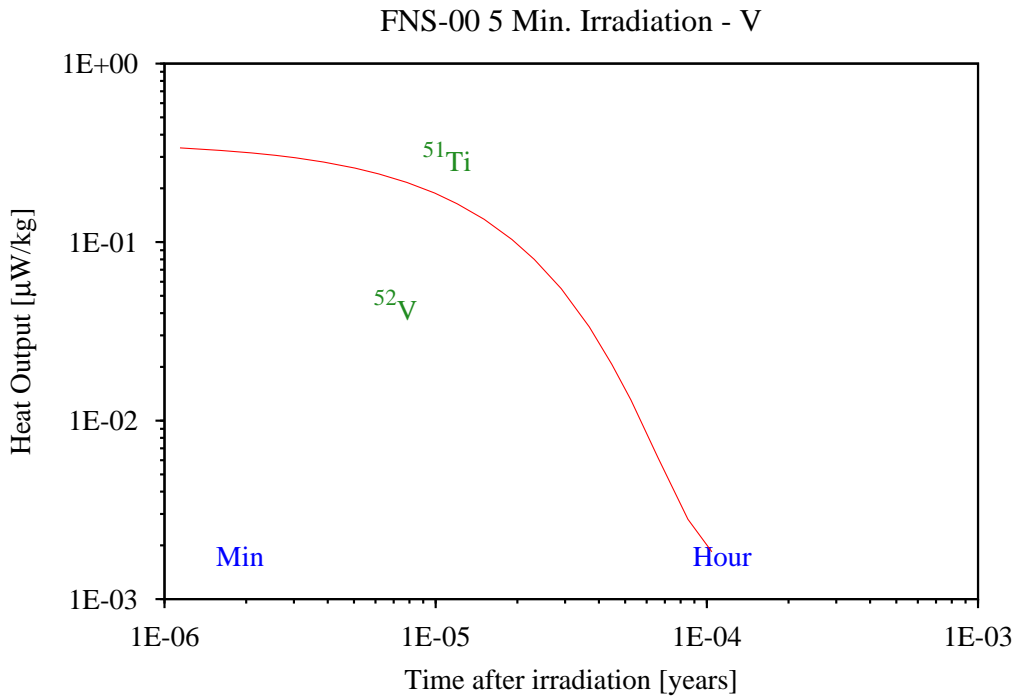
FNS-96 5 Min. Irradiation - V

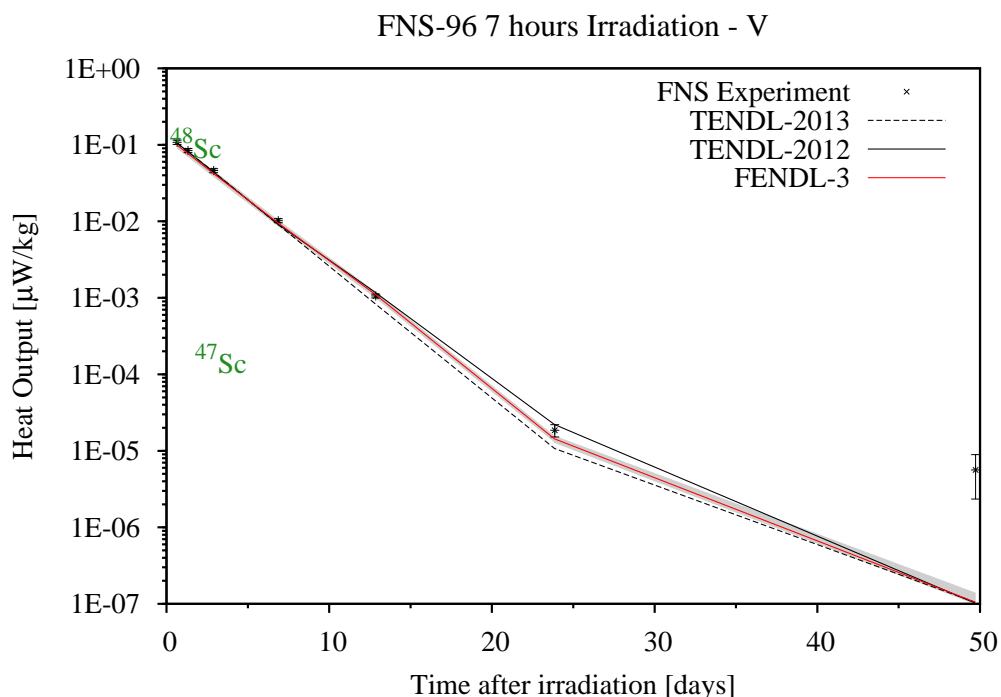


For Vanadium, the clear underestimation after 30 minutes cooling in the 1996 sample does not seem to persist in the results of the second batch. The two measured data-sets do not corroborate one another. However, Ti^{51} is better predicted with FENDL-3.0.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|--------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.60 | $2.85E-01 \pm 5\%$ | $3.37E-01 \pm 9\%$ | 0.85 | $4.19E-01$ | 0.68 | $4.18E-01$ | 0.68 |
| 0.85 | $2.87E-01 \pm 5\%$ | $3.26E-01 \pm 9\%$ | 0.88 | $4.04E-01$ | 0.71 | $4.03E-01$ | 0.71 |
| 1.10 | $2.77E-01 \pm 5\%$ | $3.16E-01 \pm 9\%$ | 0.88 | $3.91E-01$ | 0.71 | $3.90E-01$ | 0.71 |
| 1.35 | $2.69E-01 \pm 5\%$ | $3.06E-01 \pm 9\%$ | 0.88 | $3.77E-01$ | 0.71 | $3.76E-01$ | 0.71 |
| 1.60 | $2.61E-01 \pm 5\%$ | $2.97E-01 \pm 9\%$ | 0.88 | $3.65E-01$ | 0.71 | $3.64E-01$ | 0.72 |
| 2.03 | $2.47E-01 \pm 5\%$ | $2.81E-01 \pm 9\%$ | 0.88 | $3.44E-01$ | 0.72 | $3.43E-01$ | 0.72 |
| 2.65 | $2.28E-01 \pm 5\%$ | $2.60E-01 \pm 9\%$ | 0.88 | $3.16E-01$ | 0.72 | $3.15E-01$ | 0.72 |
| 3.25 | $2.12E-01 \pm 5\%$ | $2.41E-01 \pm 9\%$ | 0.88 | $2.91E-01$ | 0.73 | $2.90E-01$ | 0.73 |
| 4.12 | $1.90E-01 \pm 5\%$ | $2.16E-01 \pm 9\%$ | 0.88 | $2.59E-01$ | 0.73 | $2.58E-01$ | 0.74 |
| 5.22 | $1.66E-01 \pm 5\%$ | $1.88E-01 \pm 9\%$ | 0.88 | $2.23E-01$ | 0.74 | $2.22E-01$ | 0.75 |
| 6.32 | $1.44E-01 \pm 5\%$ | $1.64E-01 \pm 9\%$ | 0.88 | $1.92E-01$ | 0.75 | $1.92E-01$ | 0.75 |
| 7.93 | $1.18E-01 \pm 5\%$ | $1.34E-01 \pm 9\%$ | 0.88 | $1.55E-01$ | 0.76 | $1.55E-01$ | 0.76 |
| 10.05 | $9.15E-02 \pm 5\%$ | $1.03E-01 \pm 9\%$ | 0.88 | $1.18E-01$ | 0.78 | $1.18E-01$ | 0.78 |
| 12.15 | $7.07E-02 \pm 5\%$ | $8.01E-02 \pm 9\%$ | 0.88 | $8.98E-02$ | 0.79 | $8.96E-02$ | 0.79 |
| 15.27 | $4.89E-02 \pm 5\%$ | $5.48E-02 \pm 9\%$ | 0.89 | $6.03E-02$ | 0.81 | $6.02E-02$ | 0.81 |
| 19.38 | $3.01E-02 \pm 5\%$ | $3.35E-02 \pm 9\%$ | 0.90 | $3.60E-02$ | 0.84 | $3.60E-02$ | 0.84 |
| 23.48 | $1.89E-02 \pm 5\%$ | $2.07E-02 \pm 9\%$ | 0.91 | $2.18E-02$ | 0.86 | $2.18E-02$ | 0.86 |
| 27.58 | $1.20E-02 \pm 5\%$ | $1.31E-02 \pm 9\%$ | 0.92 | $1.37E-02$ | 0.88 | $1.37E-02$ | 0.88 |
| 34.72 | $6.14E-03 \pm 5\%$ | $6.21E-03 \pm 8\%$ | 0.99 | $6.41E-03$ | 0.96 | $6.41E-03$ | 0.96 |
| 44.82 | $2.82E-03 \pm 6\%$ | $2.80E-03 \pm 7\%$ | 1.01 | $2.90E-03$ | 0.97 | $2.90E-03$ | 0.97 |
| 54.87 | $1.84E-03 \pm 6\%$ | $1.84E-03 \pm 8\%$ | 1.00 | $1.93E-03$ | 0.95 | $1.93E-03$ | 0.95 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------------|-----------|--------|------|--------------|
| Ti51 | V51(n,p)Ti51 | 5.8m | 99.9 | 0.75 | 5% |
| V52 | V51(n, γ)V52 | 3.7m | 99.9 | 0.73 | 5% |
| Sc48 | v51(n, α)Sc48 | 1.8d | 100.0 | 0.95 | 6% |

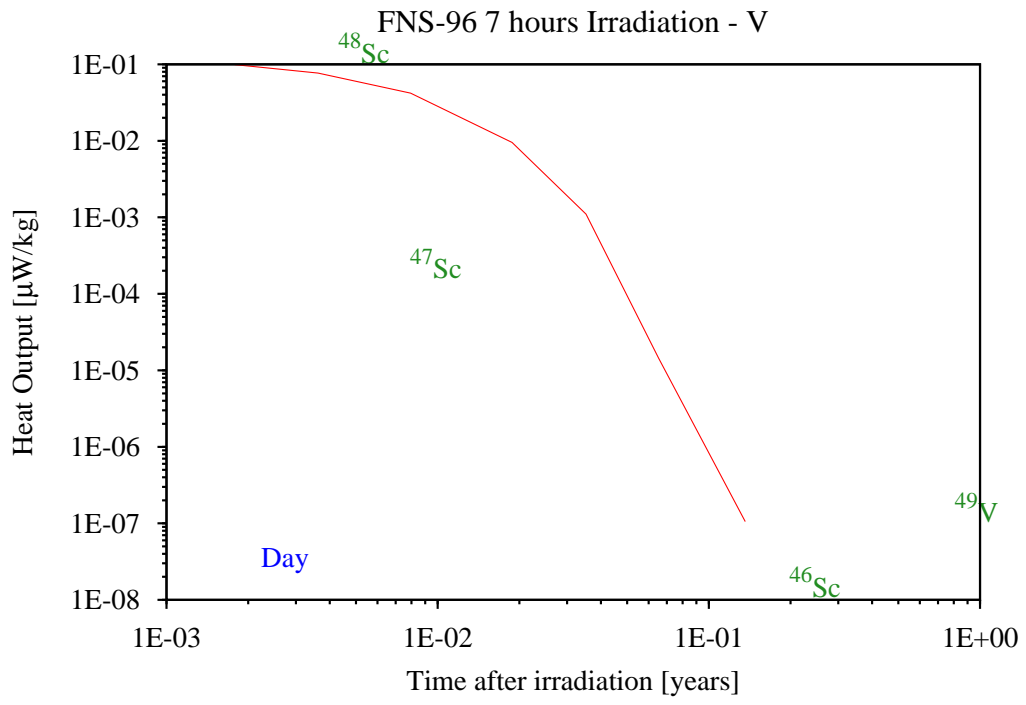




An excellent agreement can be seen, at all but the last 50-day cooling step, where the experimental uncertainty is quoted as 58%.

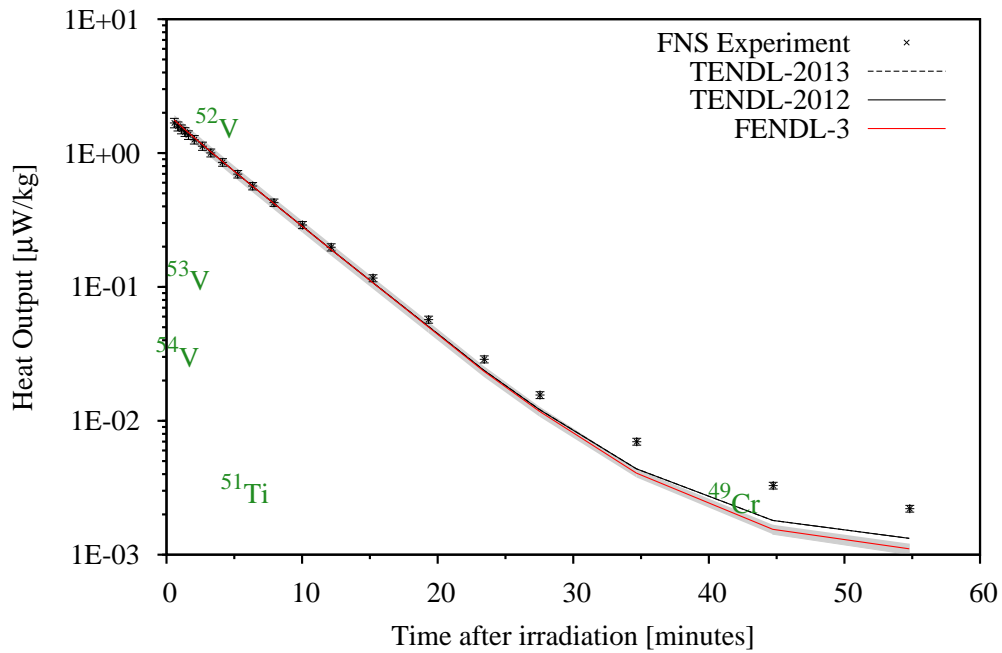
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-------------------|-------------------|-------|------------|-------|------------|-------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.65 | $1.08E-01$ +/-6% | $9.91E-02$ +/-10% | 1.09 | $1.05E-01$ | 1.03 | $1.05E-01$ | 1.03 |
| 1.32 | $8.42E-02$ +/-6% | $7.69E-02$ +/-10% | 1.10 | $8.12E-02$ | 1.04 | $8.13E-02$ | 1.04 |
| 2.90 | $4.61E-02$ +/-6% | $4.20E-02$ +/-10% | 1.10 | $4.37E-02$ | 1.05 | $4.44E-02$ | 1.04 |
| 6.87 | $1.02E-02$ +/-6% | $9.51E-03$ +/-10% | 1.07 | $9.14E-03$ | 1.12 | $9.08E-03$ | 1.12 |
| 12.86 | $1.06E-03$ +/-6% | $1.10E-03$ +/-10% | 0.96 | $1.17E-03$ | 0.90 | $8.26E-04$ | 1.28 |
| 23.86 | $1.86E-05$ +/-18% | $1.44E-05$ +/-10% | 1.29 | $2.21E-05$ | 0.84 | $1.07E-05$ | 1.73 |
| 49.73 | $5.62E-06$ +/-58% | $1.05E-07$ +/-33% | 53.30 | $1.02E-07$ | 55.13 | $1.05E-07$ | 53.72 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------------|-----------|--------|------|--------------|
| Sc48 | V51(n, α)Sc48 | 1.8d | 100.0 | 1.03 | 6% |

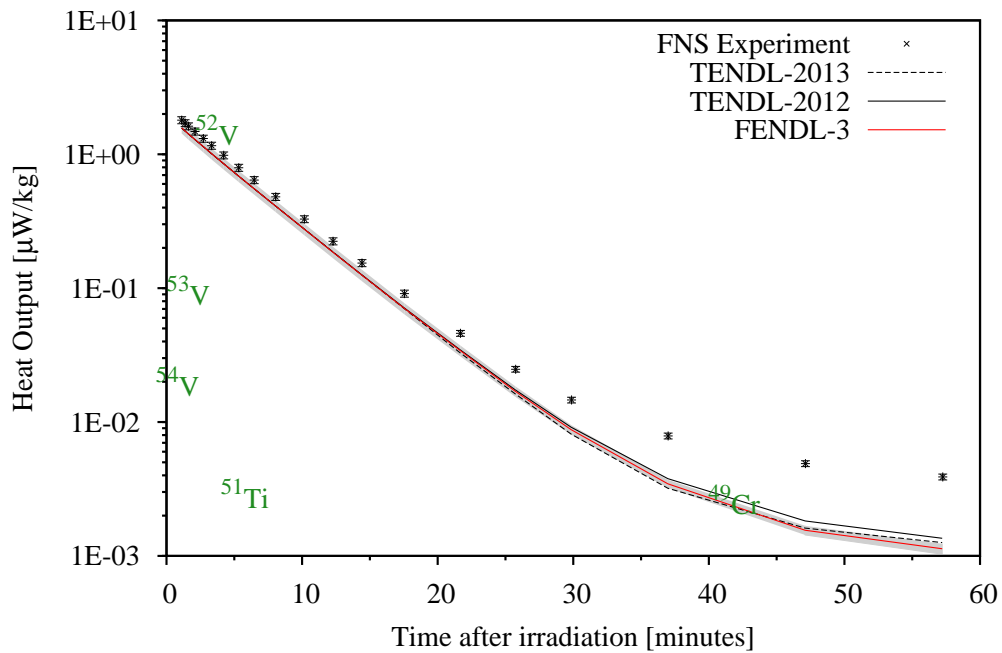


Chromium

FNS-00 5 Min. Irradiation - Cr



FNS-96 5 Min. Irradiation - Cr

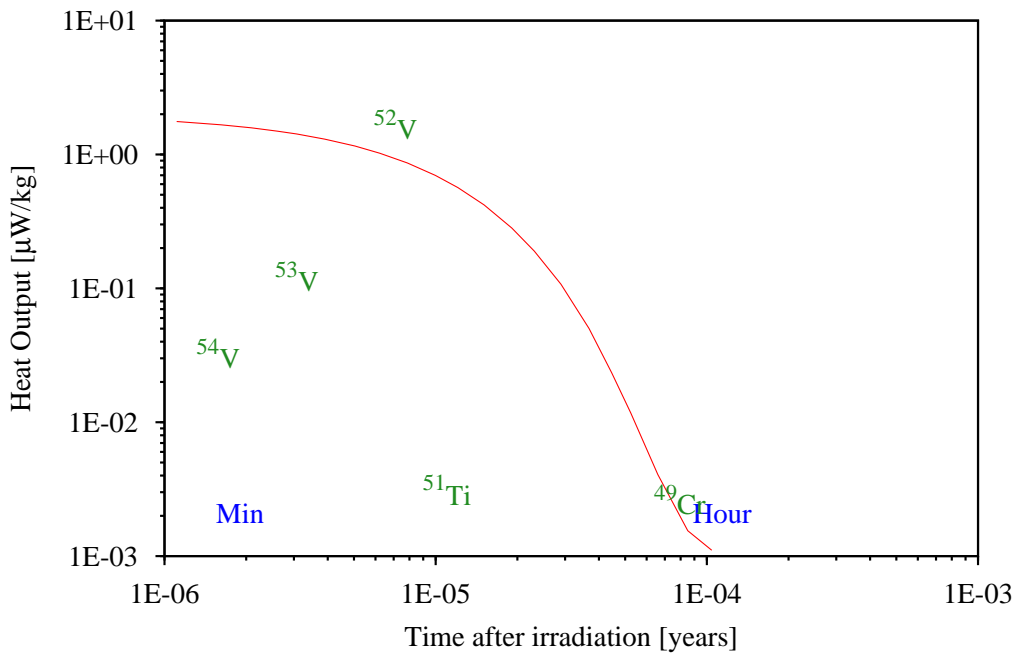


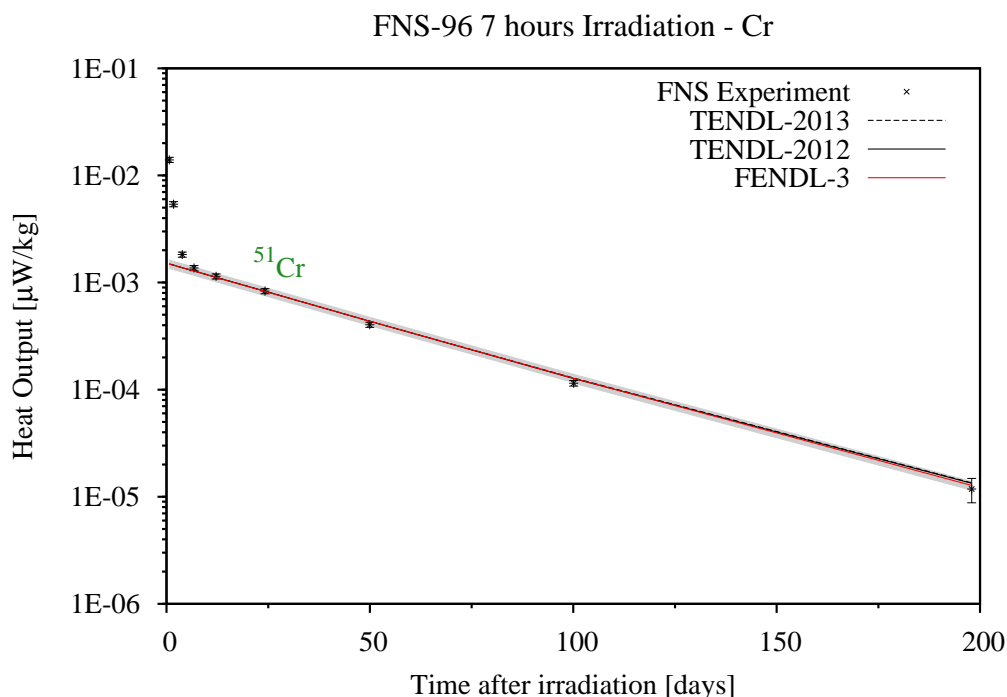
For Chromium, there is a good agreement if one allows for the fact that Al and Fe impurities could have been present in the sample at levels up to 2000 and 6000 ppm, respectively. Such levels of impurities have been measured in the similar samples.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $1.68E+00 \pm 8\%$ | $1.76E+00 \pm 9\%$ | 0.95 | $1.76E+00$ | 0.96 | $1.76E+00$ | 0.96 |
| 0.85 | $1.58E+00 \pm 8\%$ | $1.67E+00 \pm 9\%$ | 0.95 | $1.66E+00$ | 0.95 | $1.66E+00$ | 0.95 |
| 1.10 | $1.51E+00 \pm 8\%$ | $1.58E+00 \pm 9\%$ | 0.95 | $1.58E+00$ | 0.96 | $1.58E+00$ | 0.96 |
| 1.37 | $1.44E+00 \pm 8\%$ | $1.50E+00 \pm 9\%$ | 0.96 | $1.49E+00$ | 0.96 | $1.49E+00$ | 0.96 |
| 1.62 | $1.37E+00 \pm 7\%$ | $1.42E+00 \pm 9\%$ | 0.96 | $1.42E+00$ | 0.96 | $1.42E+00$ | 0.96 |
| 2.05 | $1.26E+00 \pm 7\%$ | $1.30E+00 \pm 9\%$ | 0.97 | $1.30E+00$ | 0.97 | $1.30E+00$ | 0.97 |
| 2.65 | $1.13E+00 \pm 7\%$ | $1.16E+00 \pm 9\%$ | 0.98 | $1.15E+00$ | 0.98 | $1.15E+00$ | 0.98 |
| 3.27 | $1.00E+00 \pm 7\%$ | $1.02E+00 \pm 10\%$ | 0.98 | $1.02E+00$ | 0.98 | $1.02E+00$ | 0.98 |
| 4.13 | $8.53E-01 \pm 7\%$ | $8.64E-01 \pm 10\%$ | 0.99 | $8.64E-01$ | 0.99 | $8.64E-01$ | 0.99 |
| 5.25 | $6.95E-01 \pm 6\%$ | $6.97E-01 \pm 10\%$ | 1.00 | $6.97E-01$ | 1.00 | $6.97E-01$ | 1.00 |
| 6.35 | $5.67E-01 \pm 6\%$ | $5.66E-01 \pm 10\%$ | 1.00 | $5.66E-01$ | 1.00 | $5.66E-01$ | 1.00 |
| 7.93 | $4.26E-01 \pm 6\%$ | $4.20E-01 \pm 10\%$ | 1.02 | $4.20E-01$ | 1.02 | $4.20E-01$ | 1.02 |
| 10.03 | $2.90E-01 \pm 6\%$ | $2.82E-01 \pm 10\%$ | 1.03 | $2.83E-01$ | 1.03 | $2.83E-01$ | 1.03 |
| 12.15 | $1.98E-01 \pm 6\%$ | $1.90E-01 \pm 10\%$ | 1.04 | $1.90E-01$ | 1.04 | $1.90E-01$ | 1.04 |
| 15.23 | $1.16E-01 \pm 6\%$ | $1.07E-01 \pm 10\%$ | 1.08 | $1.08E-01$ | 1.08 | $1.08E-01$ | 1.08 |
| 19.33 | $5.70E-02 \pm 6\%$ | $5.02E-02 \pm 10\%$ | 1.14 | $5.06E-02$ | 1.13 | $5.06E-02$ | 1.13 |
| 23.43 | $2.88E-02 \pm 6\%$ | $2.34E-02 \pm 9\%$ | 1.23 | $2.38E-02$ | 1.21 | $2.38E-02$ | 1.21 |
| 27.55 | $1.56E-02 \pm 6\%$ | $1.17E-02 \pm 9\%$ | 1.33 | $1.21E-02$ | 1.29 | $1.21E-02$ | 1.29 |
| 34.68 | $6.98E-03 \pm 6\%$ | $4.07E-03 \pm 7\%$ | 1.72 | $4.37E-03$ | 1.60 | $4.37E-03$ | 1.60 |
| 44.75 | $3.28E-03 \pm 6\%$ | $1.55E-03 \pm 8\%$ | 2.12 | $1.80E-03$ | 1.82 | $1.80E-03$ | 1.82 |
| 54.82 | $2.21E-03 \pm 6\%$ | $1.11E-03 \pm 9\%$ | 2.00 | $1.32E-03$ | 1.67 | $1.32E-03$ | 1.67 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| V52 | Cr52(n,p)V52 | 3.7m | 98.1 | 0.99 | 7% |
| | Cr53(n,d+np)V52 | | 1.9 | 0.99 | 7% |
| Cr49 | Cr50(n,2n)Cr49 | 41.9m | 100.0 | 1.82 | 6% |

FNS-00 5 Min. Irradiation - Cr

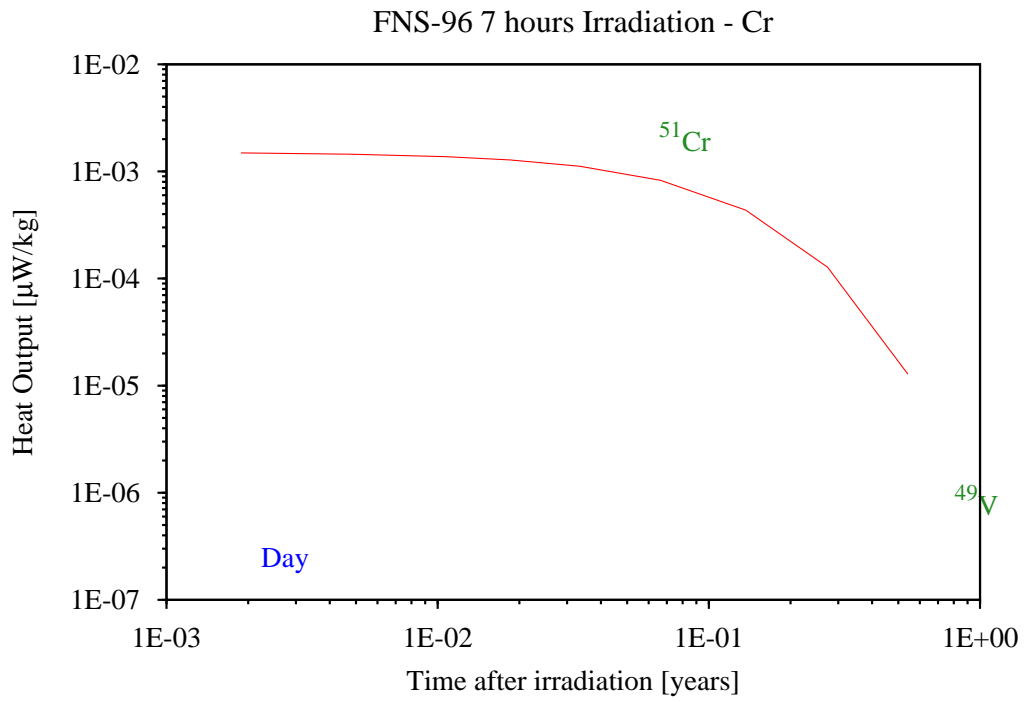




Some short-lived isotopes seem to be missing in the simulation, almost certainly produced from impurities within the sample, but the overall agreement remains excellent.

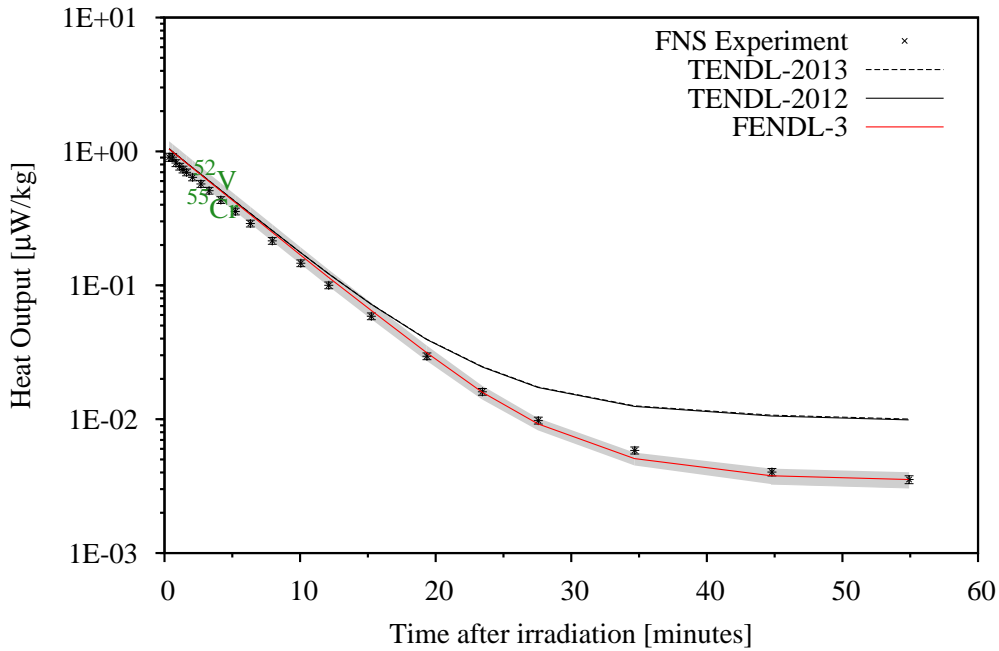
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------|-------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.69 | $1.40E-02$ +/-6% | $1.49E-03$ +/-10% | 9.39 | $1.49E-03$ | 9.38 | $1.49E-03$ | 9.37 |
| 1.74 | $5.39E-03$ +/-6% | $1.45E-03$ +/-10% | 3.72 | $1.45E-03$ | 3.71 | $1.45E-03$ | 3.71 |
| 3.89 | $1.83E-03$ +/-6% | $1.37E-03$ +/-10% | 1.33 | $1.38E-03$ | 1.33 | $1.38E-03$ | 1.33 |
| 6.75 | $1.37E-03$ +/-6% | $1.28E-03$ +/-10% | 1.07 | $1.28E-03$ | 1.06 | $1.28E-03$ | 1.06 |
| 12.20 | $1.14E-03$ +/-6% | $1.12E-03$ +/-10% | 1.02 | $1.12E-03$ | 1.02 | $1.12E-03$ | 1.02 |
| 24.21 | $8.31E-04$ +/-6% | $8.27E-04$ +/-10% | 1.00 | $8.29E-04$ | 1.00 | $8.29E-04$ | 1.00 |
| 49.96 | $4.03E-04$ +/-6% | $4.35E-04$ +/-10% | 0.93 | $4.36E-04$ | 0.92 | $4.36E-04$ | 0.93 |
| 100.09 | $1.15E-04$ +/-6% | $1.28E-04$ +/-10% | 0.90 | $1.27E-04$ | 0.90 | $1.29E-04$ | 0.89 |
| 197.96 | $1.18E-05$ +/-26% | $1.28E-05$ +/-10% | 0.92 | $1.34E-05$ | 0.88 | $1.35E-05$ | 0.87 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|----------------|-----------|--------|------|--------------|
| Cr51 | Cr52(n,2n)Cr51 | 27.7d | 100.0 | 1.00 | 6% |

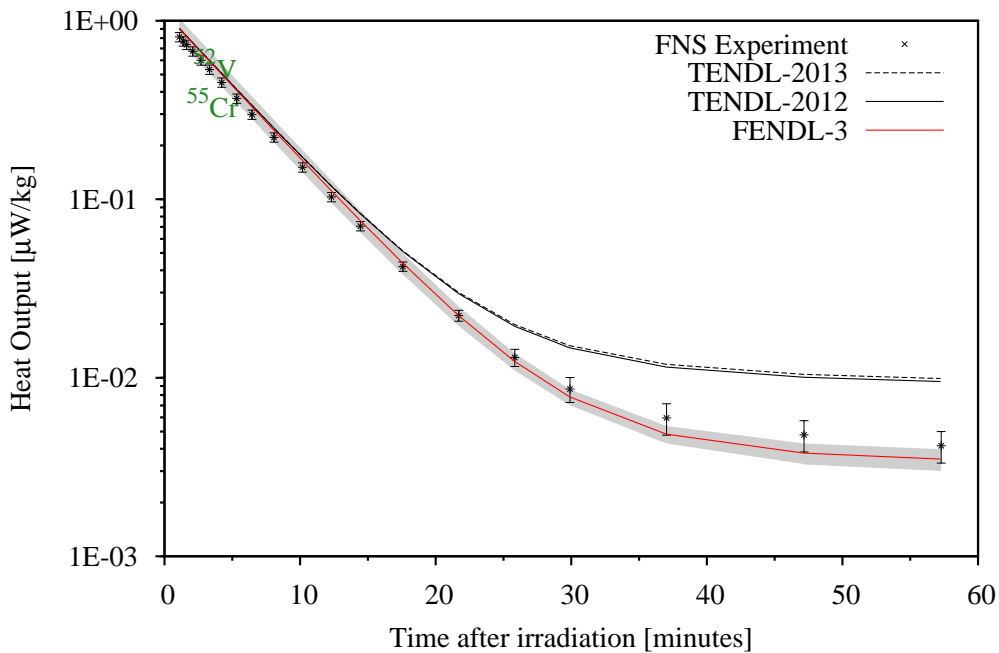


Manganese

FNS-00 5 Min. Irradiation - Mn



FNS-96 5 Min. Irradiation - Mn

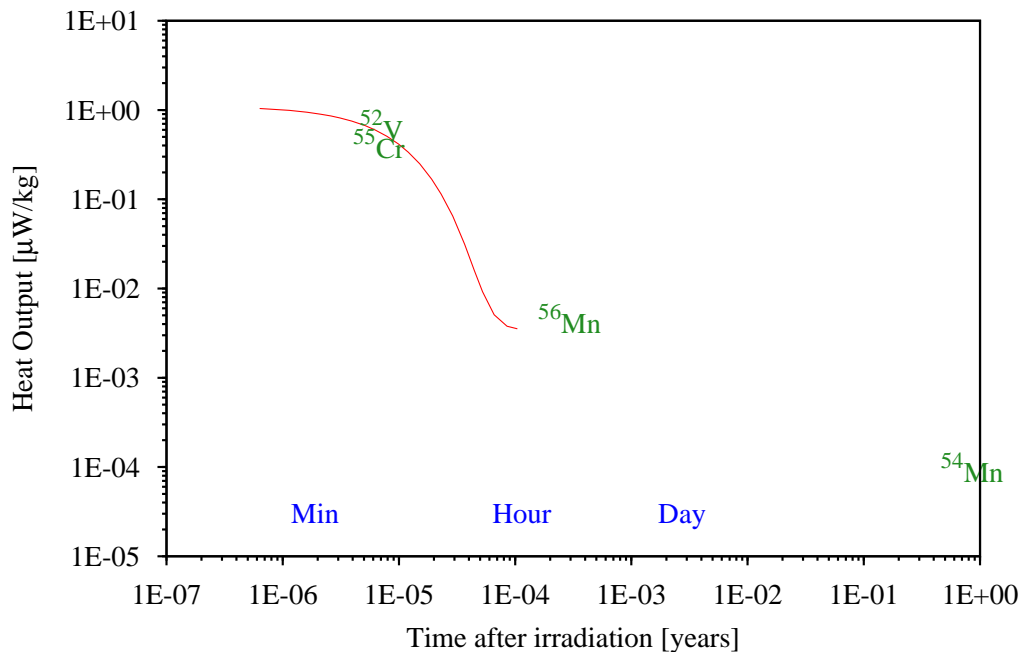


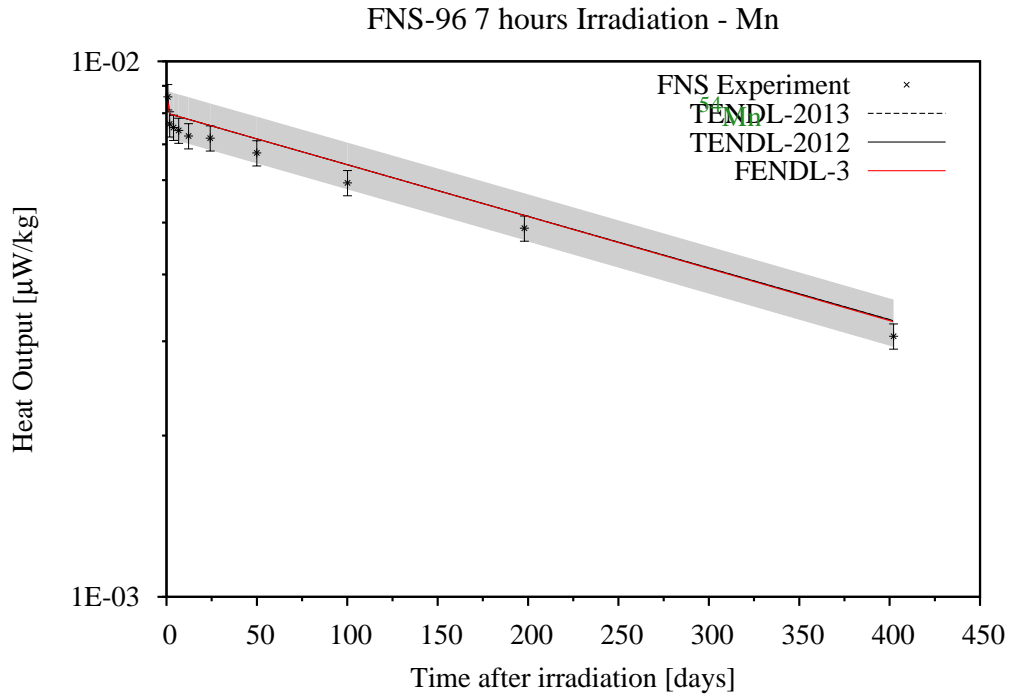
For Manganese, there is a good agreement at short cooling times for both batches with all libraries. At longer cooling times the TENDL libraries appear to over-predict the Mn56 reaction rate by a factor of 2.8. However, examining the capture cross section profile reveals that the TENDL libraries accurately reproduce the most recent IRDFF, while FENDL-3.0 appears to follow an earlier version of the International Reference Dosimetry File. It is not clear from the plots whether the agreement between FENDL and the experiment is the result of a coincidence or an adjustment in the previous IRDF file.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C TENDL-2012 | E/C TENDL-2013 | E/C |
|-------|--------------------|---------------------|----------------|----------------|------|
| Min. | $\mu\text{W/g}$ | | | | |
| 0.33 | $9.06E-01 \pm 7\%$ | $1.04E+00 \pm 14\%$ | 0.87 | $1.05E+00$ | 0.87 |
| 0.60 | $9.06E-01 \pm 6\%$ | $9.91E-01 \pm 14\%$ | 0.91 | $9.96E-01$ | 0.91 |
| 0.85 | $8.18E-01 \pm 6\%$ | $9.45E-01 \pm 14\%$ | 0.87 | $9.50E-01$ | 0.86 |
| 1.12 | $7.70E-01 \pm 6\%$ | $8.99E-01 \pm 14\%$ | 0.86 | $9.04E-01$ | 0.85 |
| 1.37 | $7.34E-01 \pm 6\%$ | $8.57E-01 \pm 14\%$ | 0.86 | $8.63E-01$ | 0.85 |
| 1.63 | $6.98E-01 \pm 6\%$ | $8.15E-01 \pm 14\%$ | 0.86 | $8.21E-01$ | 0.85 |
| 2.07 | $6.41E-01 \pm 6\%$ | $7.52E-01 \pm 14\%$ | 0.85 | $7.57E-01$ | 0.85 |
| 2.68 | $5.71E-01 \pm 6\%$ | $6.69E-01 \pm 14\%$ | 0.85 | $6.75E-01$ | 0.85 |
| 3.28 | $5.09E-01 \pm 6\%$ | $5.98E-01 \pm 14\%$ | 0.85 | $6.04E-01$ | 0.84 |
| 4.15 | $4.33E-01 \pm 6\%$ | $5.08E-01 \pm 14\%$ | 0.85 | $5.14E-01$ | 0.84 |
| 5.22 | $3.56E-01 \pm 6\%$ | $4.16E-01 \pm 14\%$ | 0.86 | $4.22E-01$ | 0.84 |
| 6.33 | $2.89E-01 \pm 6\%$ | $3.37E-01 \pm 14\%$ | 0.86 | $3.44E-01$ | 0.84 |
| 7.95 | $2.15E-01 \pm 6\%$ | $2.49E-01 \pm 14\%$ | 0.86 | $2.56E-01$ | 0.84 |
| 10.05 | $1.46E-01 \pm 6\%$ | $1.68E-01 \pm 14\%$ | 0.87 | $1.75E-01$ | 0.83 |
| 12.12 | $1.00E-01 \pm 6\%$ | $1.15E-01 \pm 14\%$ | 0.87 | $1.22E-01$ | 0.82 |
| 15.25 | $5.88E-02 \pm 6\%$ | $6.50E-02 \pm 14\%$ | 0.90 | $7.23E-02$ | 0.81 |
| 19.35 | $2.95E-02 \pm 6\%$ | $3.14E-02 \pm 13\%$ | 0.94 | $3.94E-02$ | 0.75 |
| 23.45 | $1.60E-02 \pm 6\%$ | $1.59E-02 \pm 12\%$ | 1.01 | $2.45E-02$ | 0.65 |
| 27.57 | $9.76E-03 \pm 6\%$ | $9.21E-03 \pm 10\%$ | 1.06 | $1.72E-02$ | 0.57 |
| 34.68 | $5.85E-03 \pm 6\%$ | $5.07E-03 \pm 11\%$ | 1.15 | $1.24E-02$ | 0.47 |
| 44.80 | $4.02E-03 \pm 7\%$ | $3.77E-03 \pm 13\%$ | 1.07 | $1.06E-02$ | 0.38 |
| 54.92 | $3.54E-03 \pm 7\%$ | $3.54E-03 \pm 14\%$ | 1.00 | $9.89E-03$ | 0.36 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C $\Delta E\%$ |
|---------|------------------------|-----------|--------|------------------|
| V52 | Mn55(n, α)V52 | 3.7m | 100.0 | 0.84 6% |
| Cr55 | Mn55(n,p)Cr55 | 3.5m | 100.0 | 0.84 6% |
| Mn56 | Mn55(n, γ)Mn56 | 2.5h | 100.0 | 0.36 7% |

FNS-00 5 Min. Irradiation - Mn

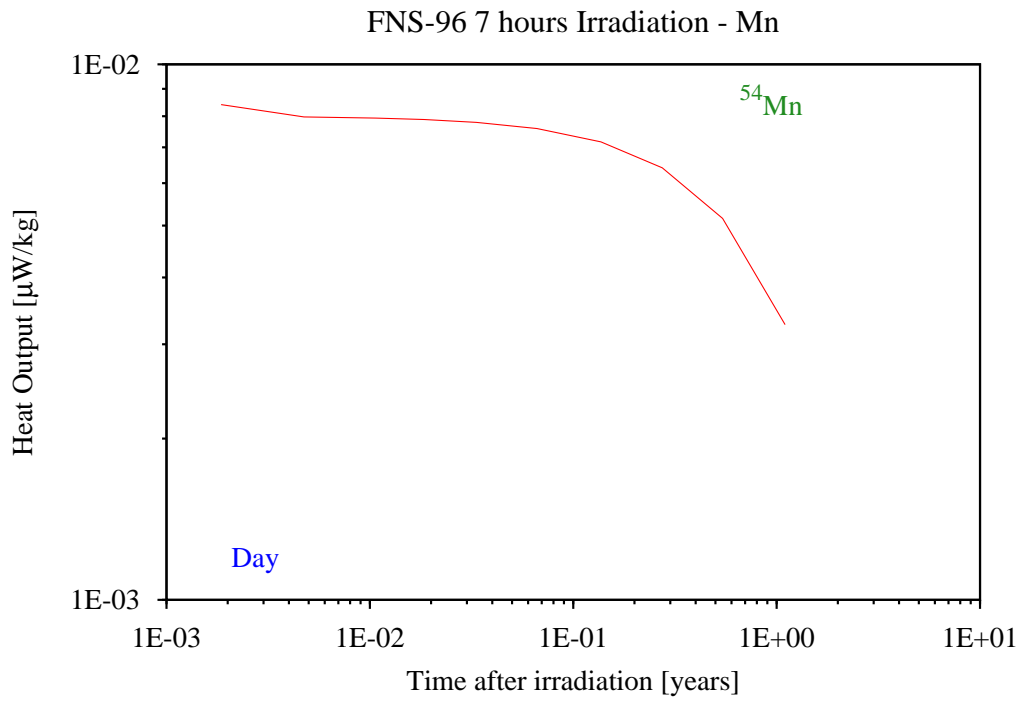




The production path of Mn54 seems to better agree with the measurement. The calculation uncertainty needs to be reviewed to reflect the C/E agreement.

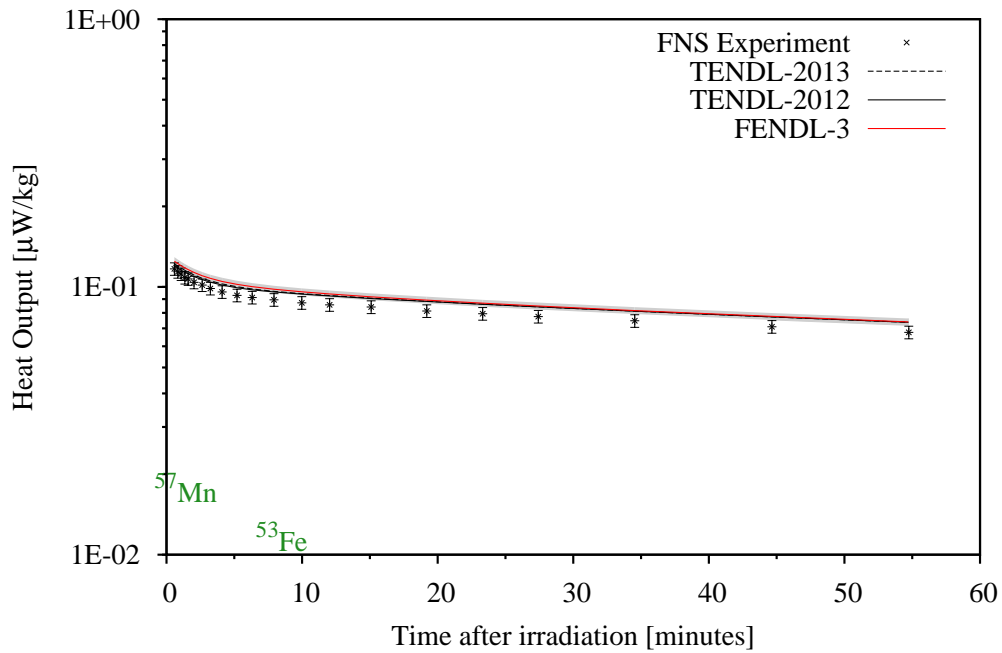
| Times Days | FNS EXP. 7 hrs $\mu\text{W/g}$ | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-----------------------------------|---------------------|------|------------|------|------------|------|
| 0.68 | $8.58E-03 \pm 5\%$ | $8.41E-03 \pm 10\%$ | 1.02 | $8.57E-03$ | 1.00 | $8.43E-03$ | 1.02 |
| 1.73 | $7.64E-03 \pm 5\%$ | $7.97E-03 \pm 10\%$ | 0.96 | $7.98E-03$ | 0.96 | $7.98E-03$ | 0.96 |
| 3.89 | $7.52E-03 \pm 5\%$ | $7.94E-03 \pm 10\%$ | 0.95 | $7.94E-03$ | 0.95 | $7.94E-03$ | 0.95 |
| 6.75 | $7.43E-03 \pm 5\%$ | $7.89E-03 \pm 10\%$ | 0.94 | $7.89E-03$ | 0.94 | $7.89E-03$ | 0.94 |
| 12.20 | $7.25E-03 \pm 5\%$ | $7.79E-03 \pm 10\%$ | 0.93 | $7.79E-03$ | 0.93 | $7.79E-03$ | 0.93 |
| 24.21 | $7.19E-03 \pm 5\%$ | $7.59E-03 \pm 10\%$ | 0.95 | $7.59E-03$ | 0.95 | $7.59E-03$ | 0.95 |
| 49.96 | $6.74E-03 \pm 5\%$ | $7.16E-03 \pm 10\%$ | 0.94 | $7.17E-03$ | 0.94 | $7.17E-03$ | 0.94 |
| 100.10 | $5.93E-03 \pm 5\%$ | $6.41E-03 \pm 10\%$ | 0.93 | $6.41E-03$ | 0.92 | $6.41E-03$ | 0.92 |
| 197.97 | $4.88E-03 \pm 5\%$ | $5.16E-03 \pm 10\%$ | 0.95 | $5.16E-03$ | 0.95 | $5.16E-03$ | 0.95 |
| 402.18 | $3.07E-03 \pm 5\%$ | $3.27E-03 \pm 10\%$ | 0.94 | $3.28E-03$ | 0.94 | $3.28E-03$ | 0.94 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|----------------|-----------|--------|------|--------------|
| Mn54 | Mn55(n,2n)Mn54 | 312d | 100.0 | 0.94 | 5% |

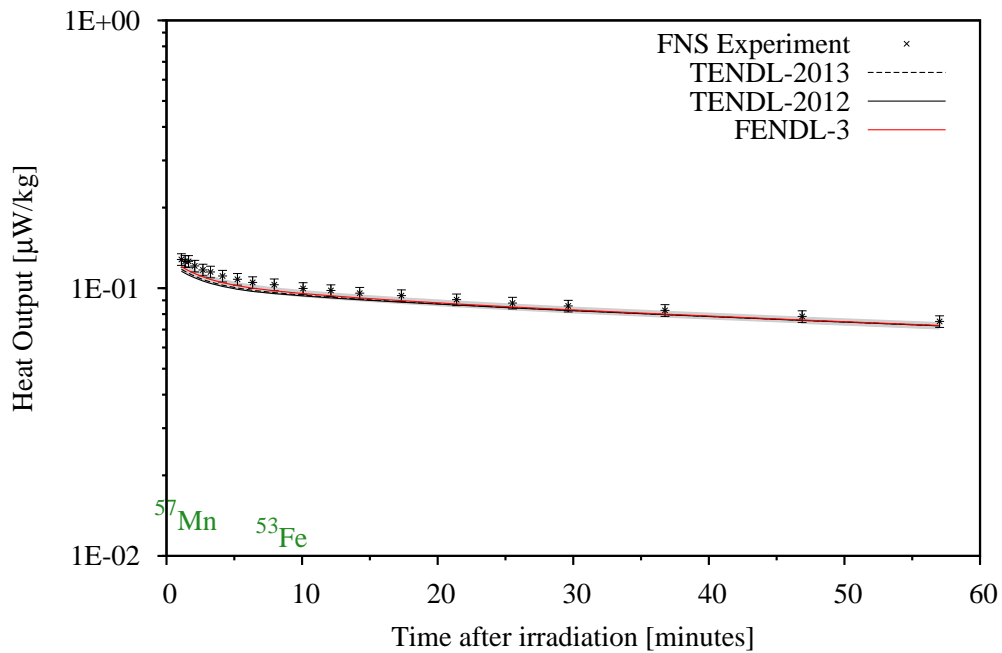


Iron

FNS-00 5 Min. Irradiation - Fe



FNS-96 5 Min. Irradiation - Fe

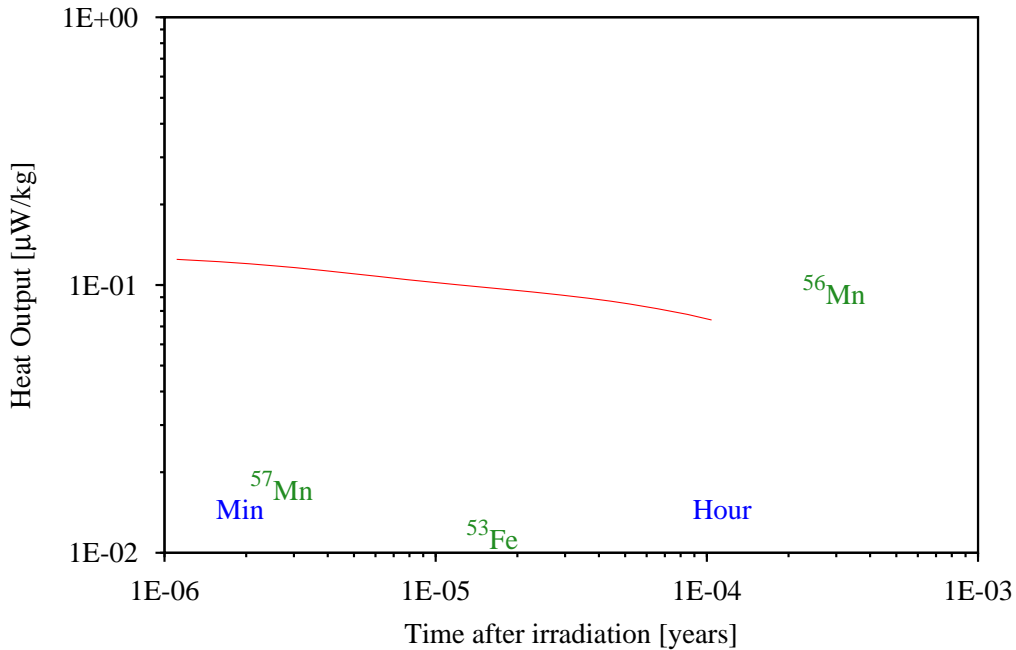


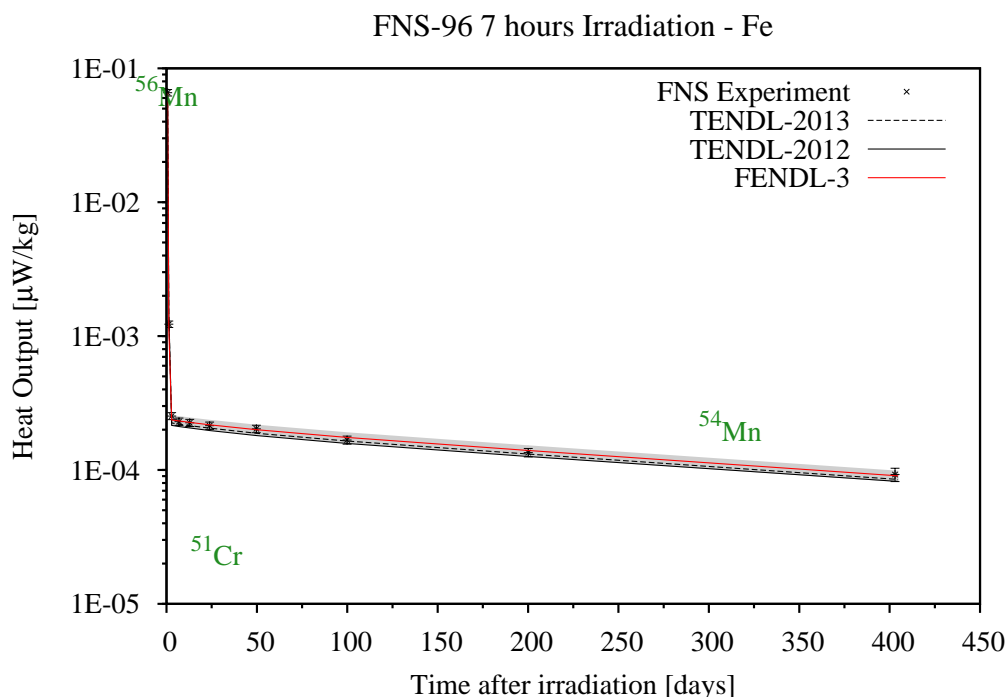
For Iron, the experimental decay results differ in the two batches and are positioned just above and below the code predictions that remain unchanged in all but the distribution of cooling time steps. However, the experimental errors are given as a range of one standard deviation, not a limit of the error. If the error bars for the two batches of experimental data do not overlap each other, it does not directly mean that the experimental data are incorrect.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|----------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | 1.17E-01 +/-5% | 1.25E-01 +/-4% | 0.94 | 1.20E-01 | 0.97 | 1.22E-01 | 0.96 |
| 0.83 | 1.14E-01 +/-5% | 1.22E-01 +/-4% | 0.93 | 1.18E-01 | 0.97 | 1.20E-01 | 0.95 |
| 1.08 | 1.12E-01 +/-5% | 1.20E-01 +/-3% | 0.93 | 1.16E-01 | 0.97 | 1.17E-01 | 0.95 |
| 1.35 | 1.08E-01 +/-5% | 1.18E-01 +/-3% | 0.92 | 1.14E-01 | 0.95 | 1.15E-01 | 0.94 |
| 1.60 | 1.07E-01 +/-5% | 1.16E-01 +/-3% | 0.92 | 1.12E-01 | 0.96 | 1.14E-01 | 0.94 |
| 2.03 | 1.04E-01 +/-5% | 1.13E-01 +/-3% | 0.92 | 1.09E-01 | 0.95 | 1.11E-01 | 0.94 |
| 2.63 | 1.02E-01 +/-5% | 1.10E-01 +/-3% | 0.92 | 1.06E-01 | 0.95 | 1.08E-01 | 0.94 |
| 3.23 | 9.87E-02 +/-5% | 1.08E-01 +/-3% | 0.92 | 1.04E-01 | 0.95 | 1.05E-01 | 0.94 |
| 4.10 | 9.58E-02 +/-5% | 1.05E-01 +/-3% | 0.91 | 1.02E-01 | 0.94 | 1.03E-01 | 0.93 |
| 5.20 | 9.30E-02 +/-5% | 1.02E-01 +/-3% | 0.91 | 9.93E-02 | 0.94 | 1.00E-01 | 0.93 |
| 6.32 | 9.13E-02 +/-5% | 1.00E-01 +/-3% | 0.91 | 9.76E-02 | 0.94 | 9.83E-02 | 0.93 |
| 7.93 | 8.96E-02 +/-5% | 9.80E-02 +/-3% | 0.91 | 9.57E-02 | 0.94 | 9.63E-02 | 0.93 |
| 9.98 | 8.73E-02 +/-5% | 9.59E-02 +/-3% | 0.91 | 9.40E-02 | 0.93 | 9.44E-02 | 0.92 |
| 12.03 | 8.58E-02 +/-5% | 9.41E-02 +/-3% | 0.91 | 9.25E-02 | 0.93 | 9.28E-02 | 0.92 |
| 15.10 | 8.41E-02 +/-5% | 9.19E-02 +/-3% | 0.92 | 9.05E-02 | 0.93 | 9.08E-02 | 0.93 |
| 19.20 | 8.13E-02 +/-5% | 8.93E-02 +/-3% | 0.91 | 8.82E-02 | 0.92 | 8.84E-02 | 0.92 |
| 23.32 | 7.94E-02 +/-5% | 8.69E-02 +/-3% | 0.91 | 8.62E-02 | 0.92 | 8.62E-02 | 0.92 |
| 27.42 | 7.75E-02 +/-5% | 8.49E-02 +/-3% | 0.91 | 8.42E-02 | 0.92 | 8.42E-02 | 0.92 |
| 34.53 | 7.47E-02 +/-5% | 8.16E-02 +/-3% | 0.92 | 8.12E-02 | 0.92 | 8.12E-02 | 0.92 |
| 44.65 | 7.10E-02 +/-5% | 7.76E-02 +/-3% | 0.91 | 7.73E-02 | 0.92 | 7.73E-02 | 0.92 |
| 54.75 | 6.77E-02 +/-5% | 7.40E-02 +/-3% | 0.91 | 7.38E-02 | 0.92 | 7.37E-02 | 0.92 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|---------------|-----------|--------|------|--------------|
| Mn56 | Fe56(n,p)Mn56 | 2.5h | 99.6 | 0.92 | 5% |

FNS-00 5 Min. Irradiation - Fe

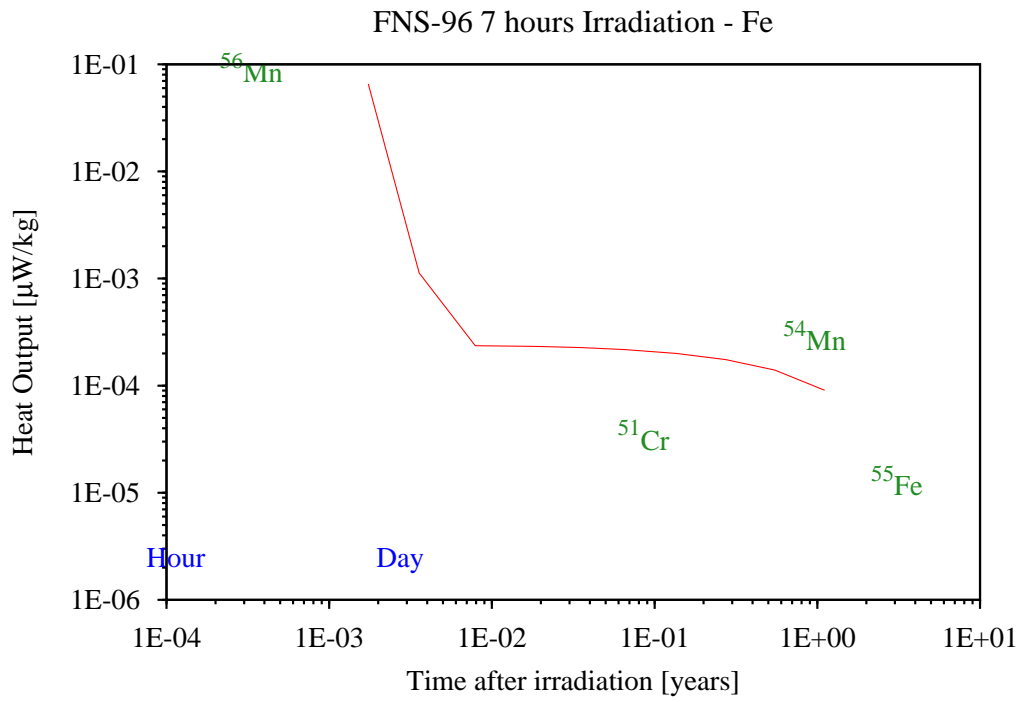




The above picture shows an excellent agreement, well within the experimental uncertainty bands.

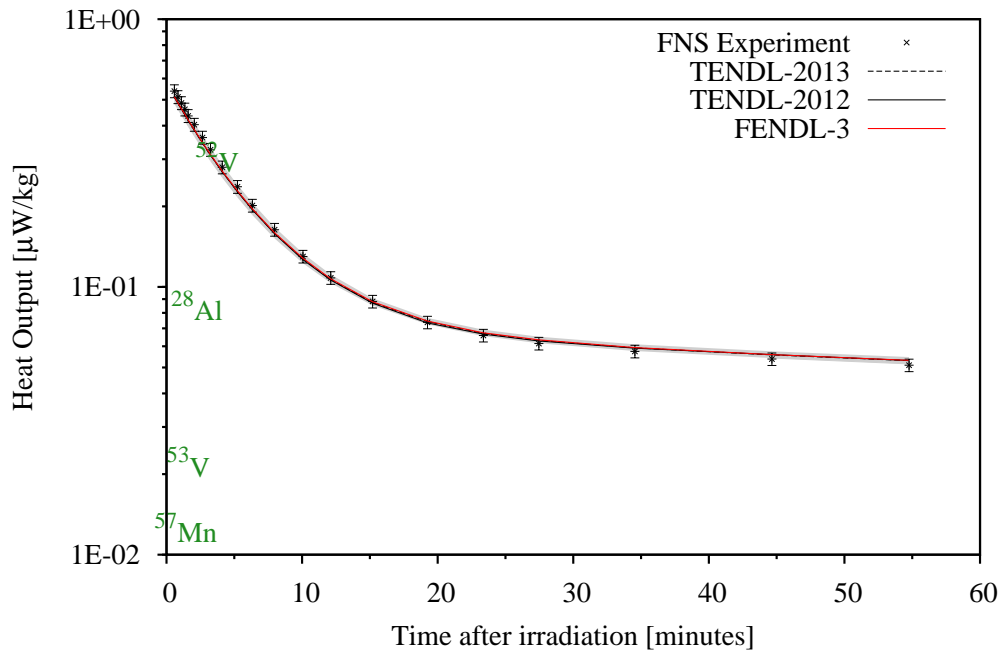
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|----------------|------|------------|------|------------|------|
| 0.63 | 6.58E-02 +/-5% | 6.56E-02 +/-3% | 1.00 | 6.44E-02 | 1.02 | 6.49E-02 | 1.01 |
| 1.30 | 1.23E-03 +/-5% | 1.13E-03 +/-3% | 1.09 | 1.51E-03 | 0.81 | 1.49E-03 | 0.83 |
| 2.88 | 2.53E-04 +/-6% | 2.36E-04 +/-9% | 1.07 | 2.15E-04 | 1.18 | 2.24E-04 | 1.13 |
| 6.89 | 2.30E-04 +/-6% | 2.32E-04 +/-9% | 0.99 | 2.11E-04 | 1.09 | 2.20E-04 | 1.05 |
| 12.88 | 2.25E-04 +/-6% | 2.27E-04 +/-9% | 0.99 | 2.06E-04 | 1.09 | 2.14E-04 | 1.05 |
| 23.89 | 2.14E-04 +/-6% | 2.17E-04 +/-9% | 0.99 | 1.97E-04 | 1.09 | 2.05E-04 | 1.04 |
| 49.72 | 2.03E-04 +/-6% | 2.00E-04 +/-9% | 1.02 | 1.81E-04 | 1.12 | 1.88E-04 | 1.08 |
| 99.91 | 1.67E-04 +/-7% | 1.75E-04 +/-9% | 0.96 | 1.58E-04 | 1.06 | 1.64E-04 | 1.02 |
| 200.13 | 1.35E-04 +/-7% | 1.40E-04 +/-9% | 0.97 | 1.26E-04 | 1.07 | 1.31E-04 | 1.03 |
| 402.95 | 9.24E-05 +/-11% | 9.04E-05 +/-9% | 1.02 | 8.22E-05 | 1.12 | 8.51E-05 | 1.09 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|---------------|------------------|--------|------|-----|
| Mn56 | Fe56(n,p)Mn56 | 2.5d | 98.8 | 1.13 | 5% |
| Mn54 | Fe54(n,p)Mn54 | 312d | 99.9 | 1.09 | 11% |

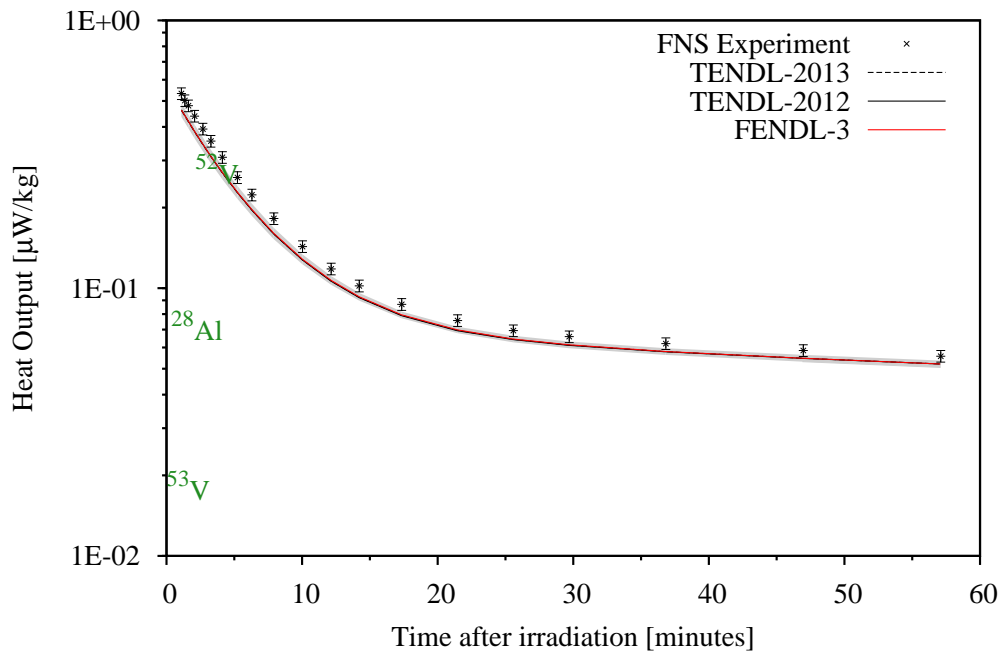


SS304

FNS-00 5 Min. Irradiation - SS304



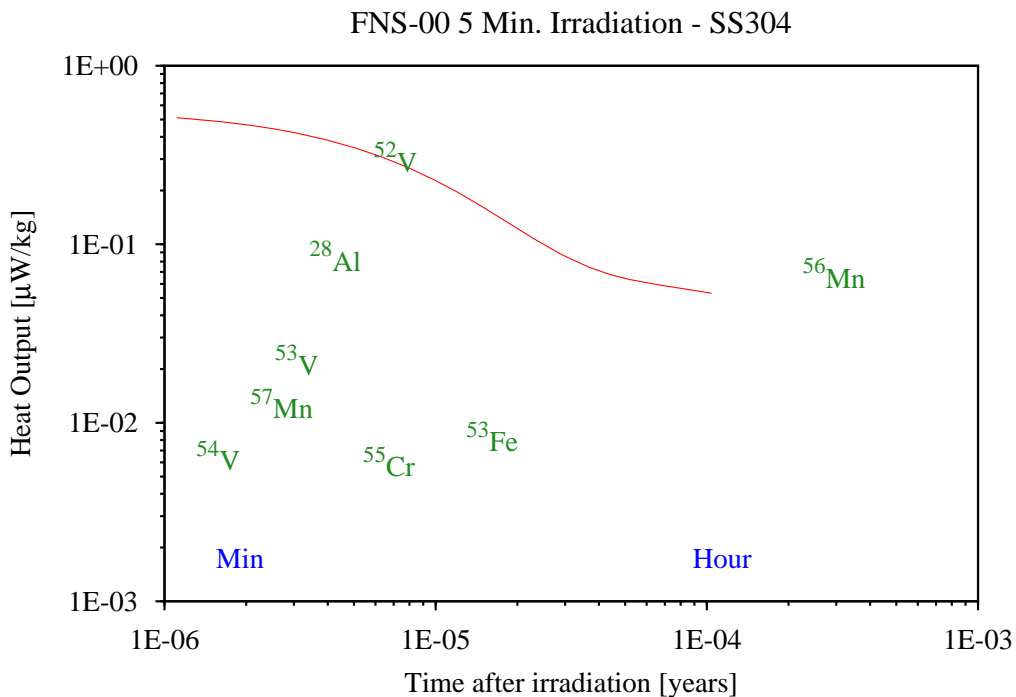
FNS-96 5 Min. Irradiation - SS304

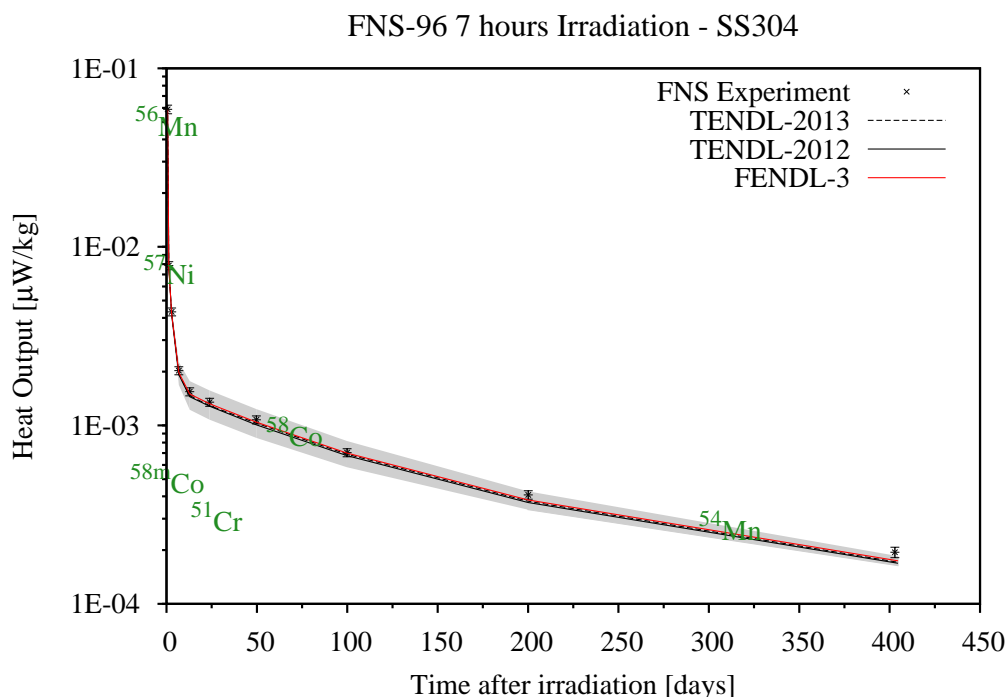


For SS-304, a remarkable agreement between experiment and prediction exists for this steel for cooling times up to 1 hour.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|----------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | 5.39E-01 +/-6% | 5.12E-01 +/-6% | 1.05 | 5.13E-01 | 1.05 | 5.10E-01 | 1.06 |
| 0.85 | 5.12E-01 +/-6% | 4.86E-01 +/-6% | 1.05 | 4.86E-01 | 1.05 | 4.84E-01 | 1.06 |
| 1.10 | 4.86E-01 +/-6% | 4.63E-01 +/-6% | 1.05 | 4.62E-01 | 1.05 | 4.61E-01 | 1.06 |
| 1.35 | 4.60E-01 +/-6% | 4.41E-01 +/-6% | 1.04 | 4.40E-01 | 1.05 | 4.40E-01 | 1.05 |
| 1.60 | 4.35E-01 +/-6% | 4.21E-01 +/-6% | 1.03 | 4.19E-01 | 1.04 | 4.19E-01 | 1.04 |
| 2.05 | 4.04E-01 +/-6% | 3.86E-01 +/-6% | 1.04 | 3.85E-01 | 1.05 | 3.85E-01 | 1.05 |
| 2.65 | 3.61E-01 +/-6% | 3.47E-01 +/-6% | 1.04 | 3.45E-01 | 1.05 | 3.45E-01 | 1.05 |
| 3.25 | 3.25E-01 +/-6% | 3.12E-01 +/-6% | 1.04 | 3.11E-01 | 1.05 | 3.11E-01 | 1.05 |
| 4.12 | 2.80E-01 +/-6% | 2.71E-01 +/-6% | 1.03 | 2.69E-01 | 1.04 | 2.69E-01 | 1.04 |
| 5.23 | 2.37E-01 +/-5% | 2.28E-01 +/-6% | 1.04 | 2.27E-01 | 1.04 | 2.27E-01 | 1.04 |
| 6.33 | 2.01E-01 +/-5% | 1.96E-01 +/-5% | 1.03 | 1.94E-01 | 1.04 | 1.95E-01 | 1.03 |
| 7.97 | 1.64E-01 +/-5% | 1.60E-01 +/-5% | 1.03 | 1.58E-01 | 1.03 | 1.59E-01 | 1.03 |
| 10.07 | 1.30E-01 +/-5% | 1.28E-01 +/-4% | 1.02 | 1.26E-01 | 1.03 | 1.27E-01 | 1.02 |
| 12.12 | 1.08E-01 +/-5% | 1.07E-01 +/-4% | 1.01 | 1.06E-01 | 1.02 | 1.07E-01 | 1.01 |
| 15.20 | 8.82E-02 +/-5% | 8.80E-02 +/-3% | 1.00 | 8.69E-02 | 1.02 | 8.75E-02 | 1.01 |
| 19.25 | 7.37E-02 +/-5% | 7.46E-02 +/-3% | 0.99 | 7.34E-02 | 1.00 | 7.42E-02 | 0.99 |
| 23.37 | 6.59E-02 +/-5% | 6.74E-02 +/-3% | 0.98 | 6.67E-02 | 0.99 | 6.71E-02 | 0.98 |
| 27.47 | 6.15E-02 +/-5% | 6.34E-02 +/-3% | 0.97 | 6.29E-02 | 0.98 | 6.32E-02 | 0.97 |
| 34.55 | 5.74E-02 +/-5% | 5.94E-02 +/-3% | 0.97 | 5.91E-02 | 0.97 | 5.92E-02 | 0.97 |
| 44.65 | 5.38E-02 +/-5% | 5.59E-02 +/-3% | 0.96 | 5.59E-02 | 0.96 | 5.58E-02 | 0.96 |
| 54.77 | 5.10E-02 +/-5% | 5.32E-02 +/-3% | 0.96 | 5.32E-02 | 0.96 | 5.31E-02 | 0.96 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-----------------|------------------|--------|------|-----|
| V52 | Cr52(n,p)V52 | 3.7m | 94.5 | 1.05 | 6% |
| | Cr53(n,d+np)V52 | | 1.9 | 1.05 | 6% |
| | Mn55(n,α)V52 | | 2.9 | 1.05 | 6% |
| Mn56 | Fe56(n,p)Mn56 | 2.5h | 99.3 | 0.96 | 5% |

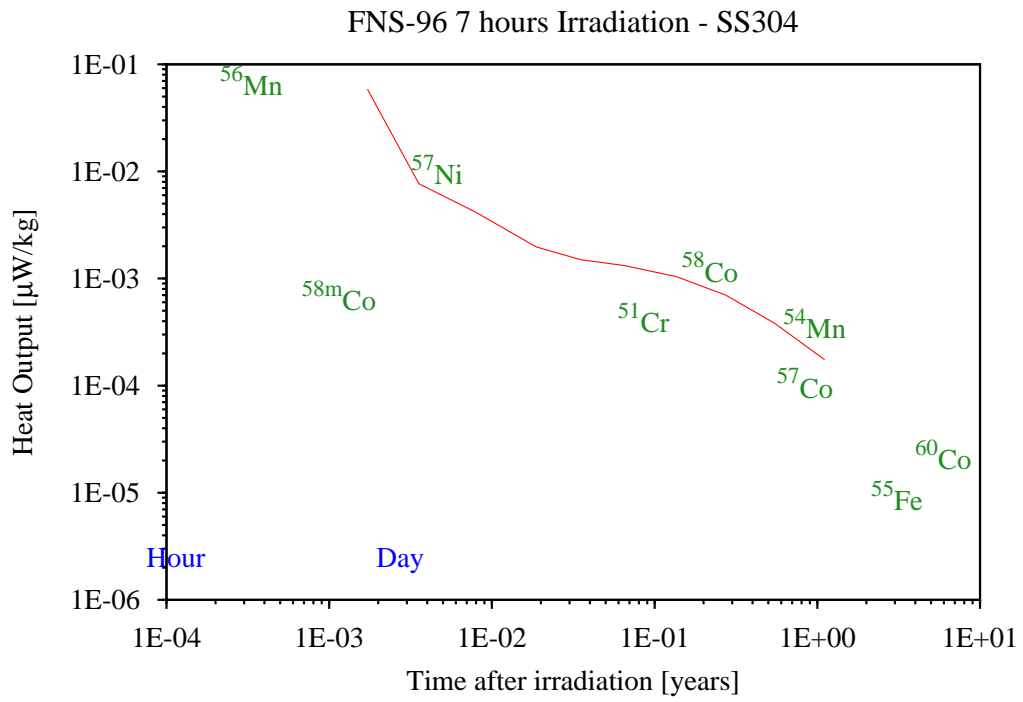




From the above graph one sees a very clean and well defined agreement.

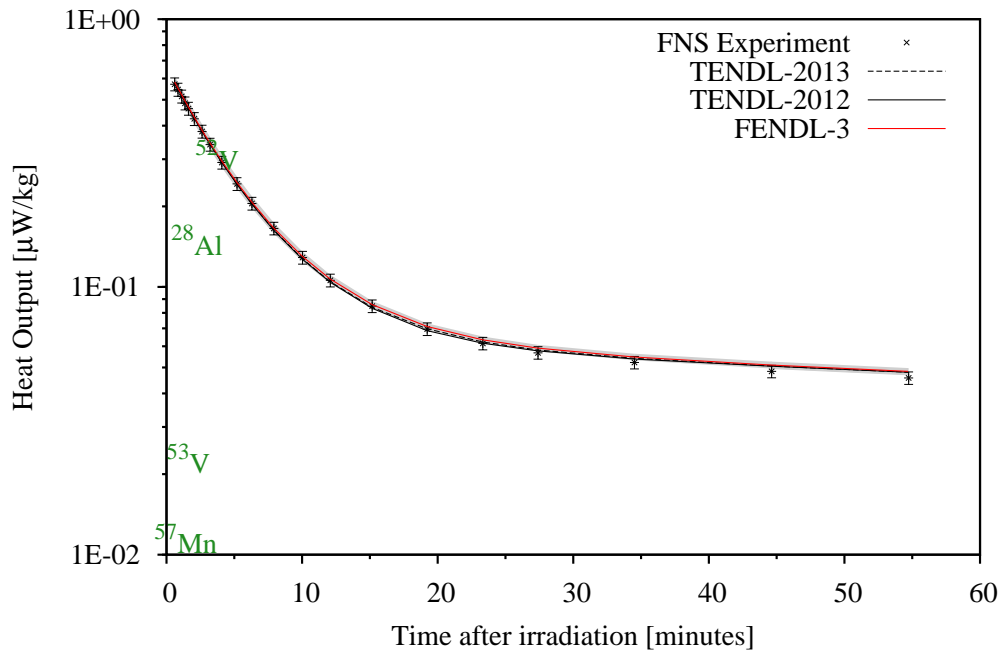
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|--------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.63 | $5.90E-02 \pm 6\%$ | $5.86E-02 \pm 3\%$ | 1.01 | $5.47E-02$ | 1.08 | $5.47E-02$ | 1.08 |
| 1.30 | $7.85E-03 \pm 5\%$ | $7.67E-03 \pm 5\%$ | 1.02 | $7.79E-03$ | 1.01 | $7.78E-03$ | 1.01 |
| 2.88 | $4.32E-03 \pm 5\%$ | $4.20E-03 \pm 8\%$ | 1.03 | $4.16E-03$ | 1.04 | $4.18E-03$ | 1.03 |
| 6.85 | $2.02E-03 \pm 5\%$ | $1.97E-03 \pm 15\%$ | 1.03 | $1.92E-03$ | 1.05 | $1.94E-03$ | 1.04 |
| 12.84 | $1.54E-03 \pm 5\%$ | $1.50E-03 \pm 18\%$ | 1.03 | $1.45E-03$ | 1.07 | $1.46E-03$ | 1.05 |
| 23.84 | $1.35E-03 \pm 5\%$ | $1.32E-03 \pm 19\%$ | 1.02 | $1.28E-03$ | 1.05 | $1.29E-03$ | 1.04 |
| 49.69 | $1.07E-03 \pm 5\%$ | $1.04E-03 \pm 18\%$ | 1.03 | $1.01E-03$ | 1.07 | $1.03E-03$ | 1.04 |
| 99.88 | $7.03E-04 \pm 5\%$ | $7.00E-04 \pm 17\%$ | 1.00 | $6.77E-04$ | 1.04 | $6.89E-04$ | 1.02 |
| 200.10 | $4.08E-04 \pm 5\%$ | $3.82E-04 \pm 12\%$ | 1.07 | $3.69E-04$ | 1.10 | $3.76E-04$ | 1.08 |
| 402.93 | $1.94E-04 \pm 7\%$ | $1.74E-04 \pm 6\%$ | 1.12 | $1.69E-04$ | 1.15 | $1.71E-04$ | 1.14 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|----------------|-----------|--------|------|--------------|
| Ni57 | Ni58(n,2n)Ni57 | 1.4d | 100.0 | 1.01 | 5% |
| Co58 | Ni58(n,p)Co58 | 70.8d | 91.6 | 1.04 | 5% |
| | Ni58(n,p)Co58m | | 8.4 | 1.04 | 5% |
| Mn54 | Mn55(n,2n)Mn54 | 312d | 48.5 | 1.14 | 7% |
| | Fe54(n,p)Mn54 | | 51.4 | 1.14 | 7% |

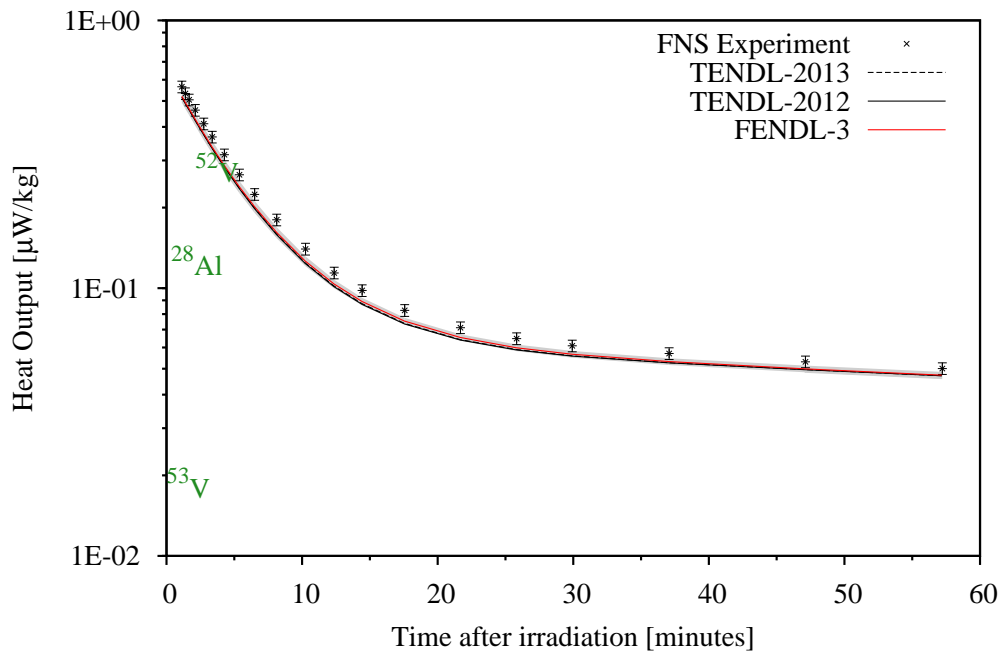


SS316

FNS-00 5 Min. Irradiation - SS316



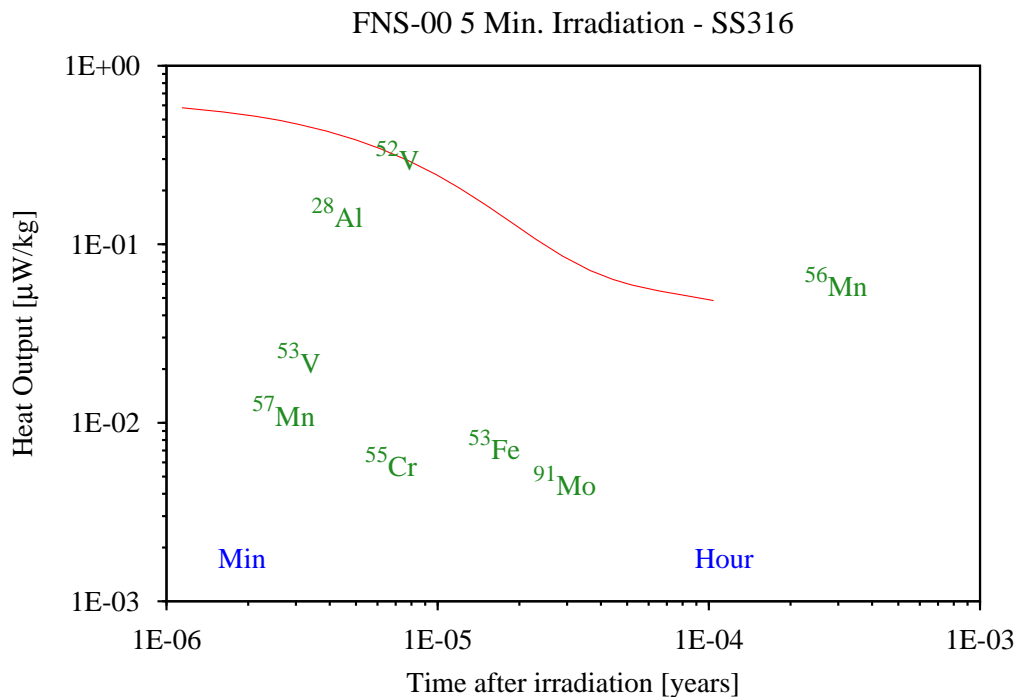
FNS-96 5 Min. Irradiation - SS316

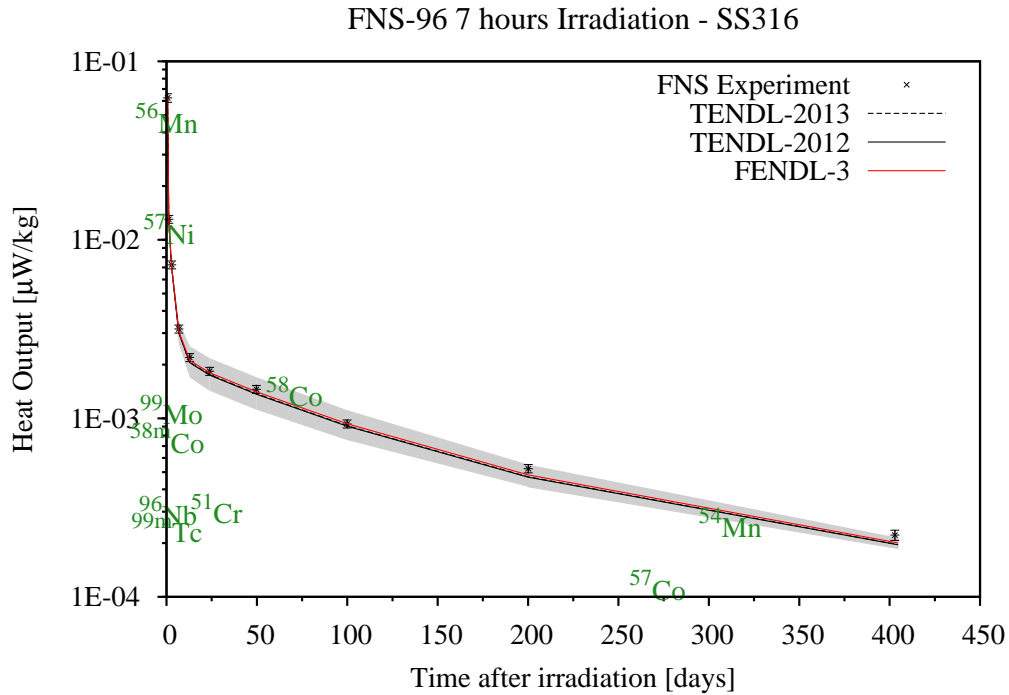


For SS-316, a remarkable agreement between experiment and prediction exists for this type of stainless steel for cooling times up to 1 hour.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|----------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.60 | 5.72E-01 +/-6% | 5.82E-01 +/-5% | 0.98 | 5.76E-01 | 0.99 | 5.79E-01 | 0.99 |
| 0.85 | 5.46E-01 +/-6% | 5.52E-01 +/-5% | 0.99 | 5.46E-01 | 1.00 | 5.49E-01 | 0.99 |
| 1.12 | 5.15E-01 +/-6% | 5.22E-01 +/-5% | 0.99 | 5.17E-01 | 1.00 | 5.19E-01 | 0.99 |
| 1.37 | 4.85E-01 +/-6% | 4.95E-01 +/-5% | 0.98 | 4.90E-01 | 0.99 | 4.92E-01 | 0.99 |
| 1.62 | 4.64E-01 +/-6% | 4.70E-01 +/-5% | 0.99 | 4.65E-01 | 1.00 | 4.67E-01 | 0.99 |
| 2.05 | 4.24E-01 +/-6% | 4.30E-01 +/-5% | 0.99 | 4.26E-01 | 1.00 | 4.28E-01 | 0.99 |
| 2.62 | 3.80E-01 +/-6% | 3.85E-01 +/-5% | 0.99 | 3.81E-01 | 1.00 | 3.83E-01 | 0.99 |
| 3.22 | 3.40E-01 +/-6% | 3.44E-01 +/-5% | 0.99 | 3.40E-01 | 1.00 | 3.42E-01 | 0.99 |
| 4.08 | 2.91E-01 +/-6% | 2.95E-01 +/-5% | 0.99 | 2.91E-01 | 1.00 | 2.93E-01 | 1.00 |
| 5.20 | 2.43E-01 +/-5% | 2.45E-01 +/-5% | 0.99 | 2.41E-01 | 1.01 | 2.43E-01 | 1.00 |
| 6.30 | 2.05E-01 +/-5% | 2.07E-01 +/-5% | 0.99 | 2.04E-01 | 1.01 | 2.05E-01 | 1.00 |
| 7.92 | 1.65E-01 +/-5% | 1.66E-01 +/-5% | 1.00 | 1.63E-01 | 1.02 | 1.63E-01 | 1.01 |
| 10.03 | 1.29E-01 +/-5% | 1.30E-01 +/-4% | 0.99 | 1.27E-01 | 1.02 | 1.27E-01 | 1.01 |
| 12.08 | 1.06E-01 +/-5% | 1.07E-01 +/-4% | 0.99 | 1.04E-01 | 1.02 | 1.05E-01 | 1.01 |
| 15.17 | 8.48E-02 +/-5% | 8.59E-02 +/-3% | 0.99 | 8.32E-02 | 1.02 | 8.40E-02 | 1.01 |
| 19.23 | 6.96E-02 +/-5% | 7.11E-02 +/-3% | 0.98 | 6.87E-02 | 1.01 | 6.98E-02 | 1.00 |
| 23.33 | 6.15E-02 +/-5% | 6.35E-02 +/-3% | 0.97 | 6.16E-02 | 1.00 | 6.23E-02 | 0.99 |
| 27.40 | 5.68E-02 +/-5% | 5.91E-02 +/-3% | 0.96 | 5.77E-02 | 0.98 | 5.81E-02 | 0.98 |
| 34.52 | 5.22E-02 +/-5% | 5.47E-02 +/-3% | 0.95 | 5.38E-02 | 0.97 | 5.41E-02 | 0.97 |
| 44.63 | 4.84E-02 +/-5% | 5.11E-02 +/-3% | 0.95 | 5.06E-02 | 0.96 | 5.06E-02 | 0.96 |
| 54.73 | 4.57E-02 +/-5% | 4.84E-02 +/-3% | 0.95 | 4.81E-02 | 0.95 | 4.80E-02 | 0.95 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|---------------|------------------|--------|------|-----|
| V52 | Cr52(n,p)V52 | 3.7m | 94.5 | 0.99 | 6% |
| | Cr53(n,d)V52 | | 1.9 | 0.99 | 6% |
| | Mn55(n,α)V52 | | 2.9 | 0.99 | 6% |
| Mn56 | Fe56(n,p)Mn56 | 2.5h | 99.2 | 0.95 | 5% |

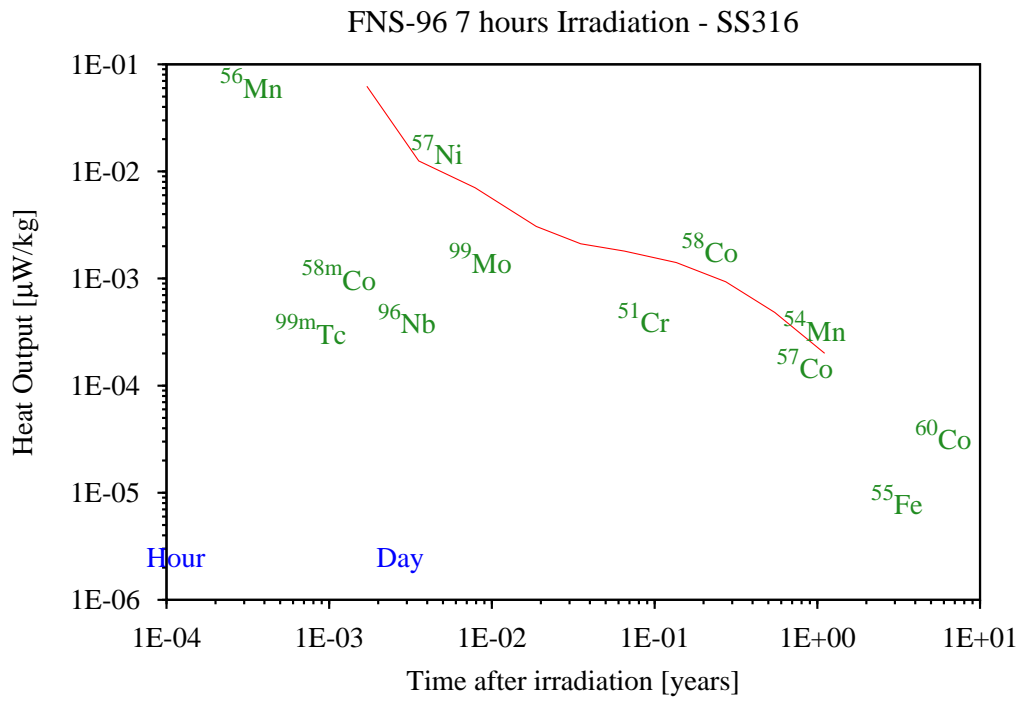




Although numerous radionuclides are present, a well characterized agreement exists, nearly within the uncertainties, up to 400 days cooling.

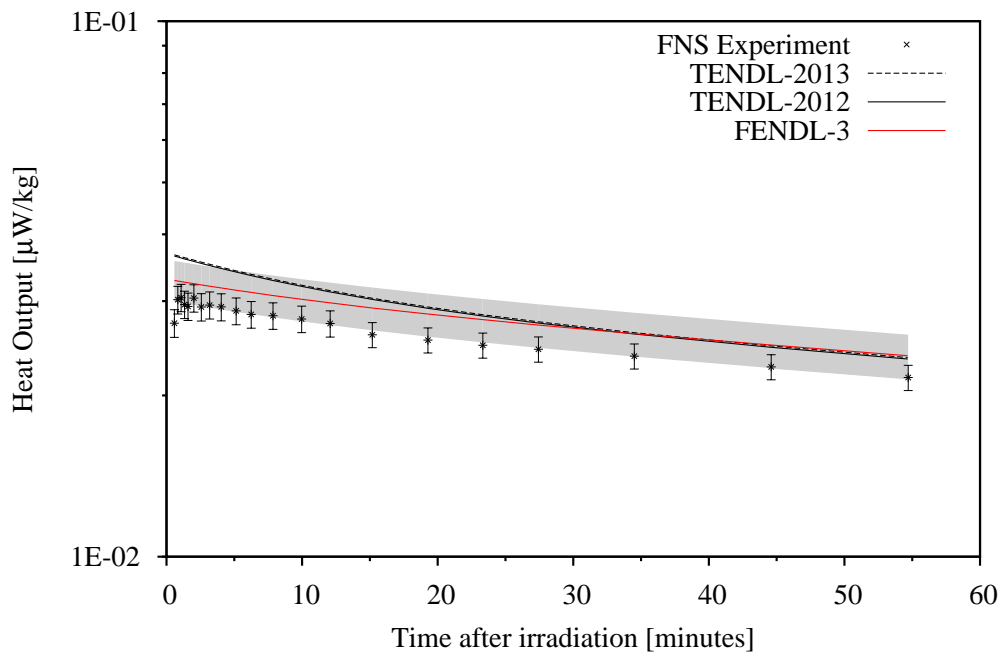
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|-----------------|------|------------|------|------------|------|
| 0.62 | 6.24E-02 +/-6% | 6.25E-02 +/-3% | 1.00 | 6.06E-02 | 1.03 | 6.09E-02 | 1.03 |
| 1.30 | 1.30E-02 +/-5% | 1.25E-02 +/-5% | 1.04 | 1.24E-02 | 1.05 | 1.25E-02 | 1.05 |
| 2.88 | 7.24E-03 +/-5% | 7.05E-03 +/-7% | 1.03 | 7.00E-03 | 1.03 | 7.01E-03 | 1.03 |
| 6.85 | 3.17E-03 +/-5% | 3.06E-03 +/-14% | 1.03 | 3.00E-03 | 1.05 | 3.02E-03 | 1.05 |
| 12.84 | 2.19E-03 +/-5% | 2.11E-03 +/-20% | 1.04 | 2.05E-03 | 1.07 | 2.06E-03 | 1.06 |
| 23.83 | 1.84E-03 +/-5% | 1.80E-03 +/-21% | 1.02 | 1.75E-03 | 1.05 | 1.76E-03 | 1.04 |
| 49.69 | 1.45E-03 +/-5% | 1.41E-03 +/-21% | 1.03 | 1.37E-03 | 1.06 | 1.38E-03 | 1.06 |
| 99.88 | 9.31E-04 +/-5% | 9.34E-04 +/-19% | 1.00 | 9.05E-04 | 1.03 | 9.10E-04 | 1.02 |
| 200.10 | 5.23E-04 +/-5% | 4.82E-04 +/-14% | 1.08 | 4.68E-04 | 1.12 | 4.71E-04 | 1.11 |
| 402.93 | 2.22E-04 +/-7% | 2.00E-04 +/-7% | 1.11 | 1.96E-04 | 1.13 | 1.96E-04 | 1.13 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|----------------|------------------|--------|------|-----|
| Ni57 | Ni58(n,2n)Ni57 | 1.4d | 100.0 | 1.05 | 5% |
| Co58 | Ni58(n,p)Co58 | 70.8d | 91.6 | 1.03 | 5% |
| | Ni58(n,p)Co58m | | 8.4 | | |
| Mn54 | Mn55(n,2n)Mn54 | 312d | 48.5 | 1.13 | 7% |
| | Fe54(n,p)Mn54 | | 51.4 | | |

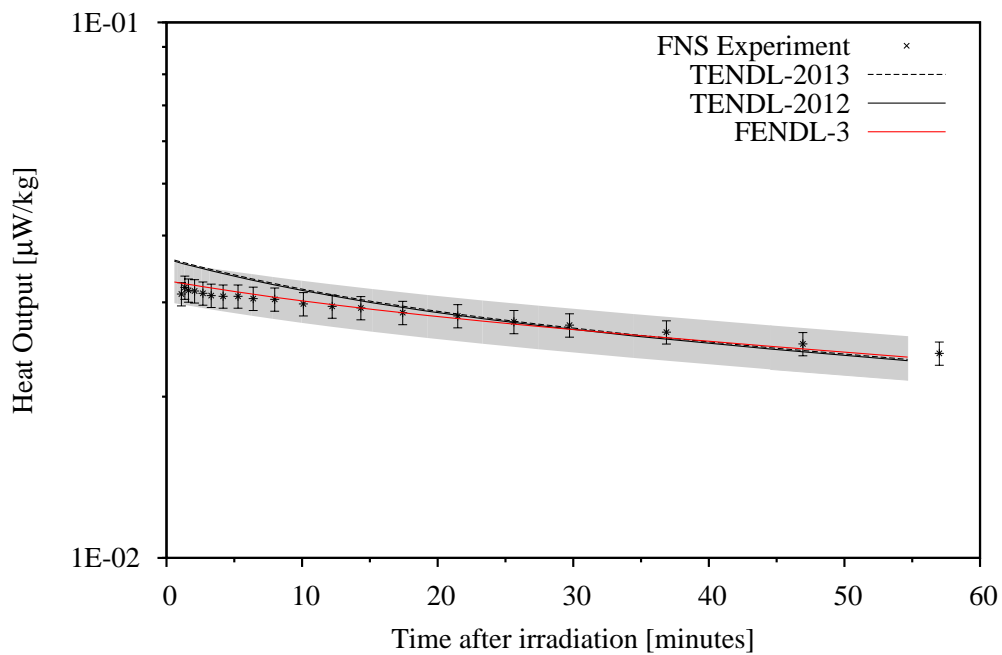


Cobalt

FNS-00 5 Min. Irradiation - Co



FNS-96 5 Min. Irradiation - Co

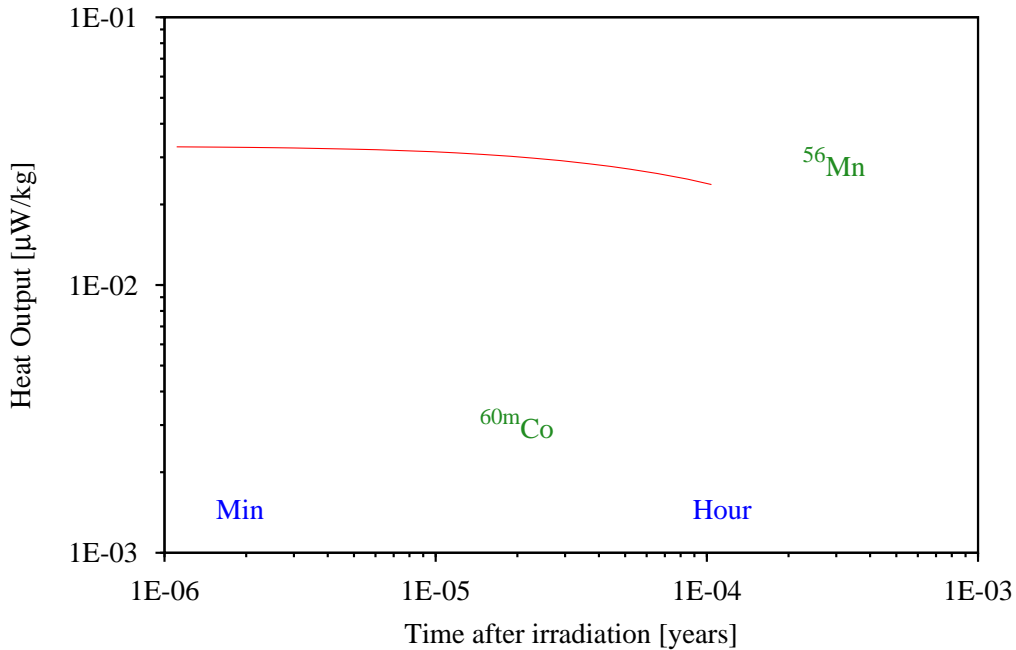


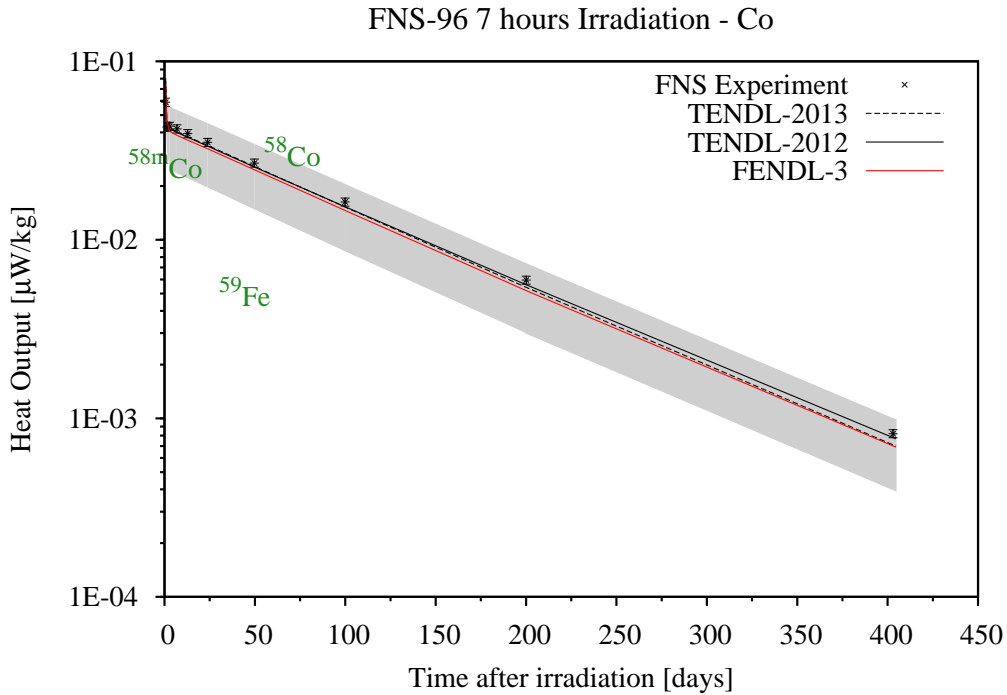
For Cobalt, the two batches of measured experimental data sets are different. The differences lie outside of the quoted experimental uncertainty. However, the code predictions stay, for both batches, within the quoted calculational uncertainties.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|--------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $2.73E-02 \pm 6\%$ | $3.28E-02 \pm 9\%$ | 0.83 | $3.64E-02$ | 0.75 | $3.66E-02$ | 0.75 |
| 0.83 | $3.02E-02 \pm 6\%$ | $3.27E-02 \pm 9\%$ | 0.92 | $3.63E-02$ | 0.83 | $3.65E-02$ | 0.83 |
| 1.08 | $3.05E-02 \pm 6\%$ | $3.26E-02 \pm 9\%$ | 0.93 | $3.61E-02$ | 0.84 | $3.63E-02$ | 0.84 |
| 1.33 | $2.96E-02 \pm 6\%$ | $3.26E-02 \pm 9\%$ | 0.91 | $3.60E-02$ | 0.82 | $3.62E-02$ | 0.82 |
| 1.58 | $2.93E-02 \pm 6\%$ | $3.25E-02 \pm 9\%$ | 0.90 | $3.58E-02$ | 0.82 | $3.60E-02$ | 0.81 |
| 2.02 | $3.04E-02 \pm 6\%$ | $3.23E-02 \pm 9\%$ | 0.94 | $3.56E-02$ | 0.85 | $3.58E-02$ | 0.85 |
| 2.57 | $2.93E-02 \pm 6\%$ | $3.22E-02 \pm 9\%$ | 0.91 | $3.53E-02$ | 0.83 | $3.55E-02$ | 0.82 |
| 3.18 | $2.95E-02 \pm 6\%$ | $3.20E-02 \pm 9\%$ | 0.92 | $3.50E-02$ | 0.84 | $3.52E-02$ | 0.84 |
| 4.03 | $2.93E-02 \pm 6\%$ | $3.18E-02 \pm 9\%$ | 0.92 | $3.45E-02$ | 0.85 | $3.47E-02$ | 0.84 |
| 5.13 | $2.88E-02 \pm 6\%$ | $3.14E-02 \pm 9\%$ | 0.91 | $3.40E-02$ | 0.85 | $3.42E-02$ | 0.84 |
| 6.25 | $2.83E-02 \pm 6\%$ | $3.12E-02 \pm 9\%$ | 0.91 | $3.35E-02$ | 0.85 | $3.37E-02$ | 0.84 |
| 7.85 | $2.82E-02 \pm 6\%$ | $3.07E-02 \pm 9\%$ | 0.92 | $3.28E-02$ | 0.86 | $3.30E-02$ | 0.85 |
| 9.97 | $2.78E-02 \pm 6\%$ | $3.02E-02 \pm 9\%$ | 0.92 | $3.20E-02$ | 0.87 | $3.21E-02$ | 0.86 |
| 12.07 | $2.72E-02 \pm 6\%$ | $2.98E-02 \pm 9\%$ | 0.92 | $3.12E-02$ | 0.87 | $3.14E-02$ | 0.87 |
| 15.18 | $2.60E-02 \pm 5\%$ | $2.91E-02 \pm 9\%$ | 0.89 | $3.02E-02$ | 0.86 | $3.04E-02$ | 0.85 |
| 19.28 | $2.54E-02 \pm 5\%$ | $2.84E-02 \pm 9\%$ | 0.89 | $2.91E-02$ | 0.87 | $2.93E-02$ | 0.87 |
| 23.33 | $2.48E-02 \pm 5\%$ | $2.77E-02 \pm 9\%$ | 0.90 | $2.81E-02$ | 0.88 | $2.83E-02$ | 0.88 |
| 27.43 | $2.44E-02 \pm 5\%$ | $2.71E-02 \pm 9\%$ | 0.90 | $2.73E-02$ | 0.89 | $2.75E-02$ | 0.89 |
| 34.50 | $2.37E-02 \pm 5\%$ | $2.61E-02 \pm 9\%$ | 0.91 | $2.61E-02$ | 0.91 | $2.62E-02$ | 0.90 |
| 44.60 | $2.26E-02 \pm 5\%$ | $2.49E-02 \pm 9\%$ | 0.91 | $2.46E-02$ | 0.92 | $2.48E-02$ | 0.91 |
| 54.70 | $2.16E-02 \pm 5\%$ | $2.37E-02 \pm 9\%$ | 0.91 | $2.34E-02$ | 0.92 | $2.35E-02$ | 0.92 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C $\Delta E\%$ |
|---------|------------------------|-----------|--------|------------------|
| Mn56 | Co59(n, α)Mn56 | 2.5h | 100.0 | 0.92 5% |

FNS-00 5 Min. Irradiation - Co

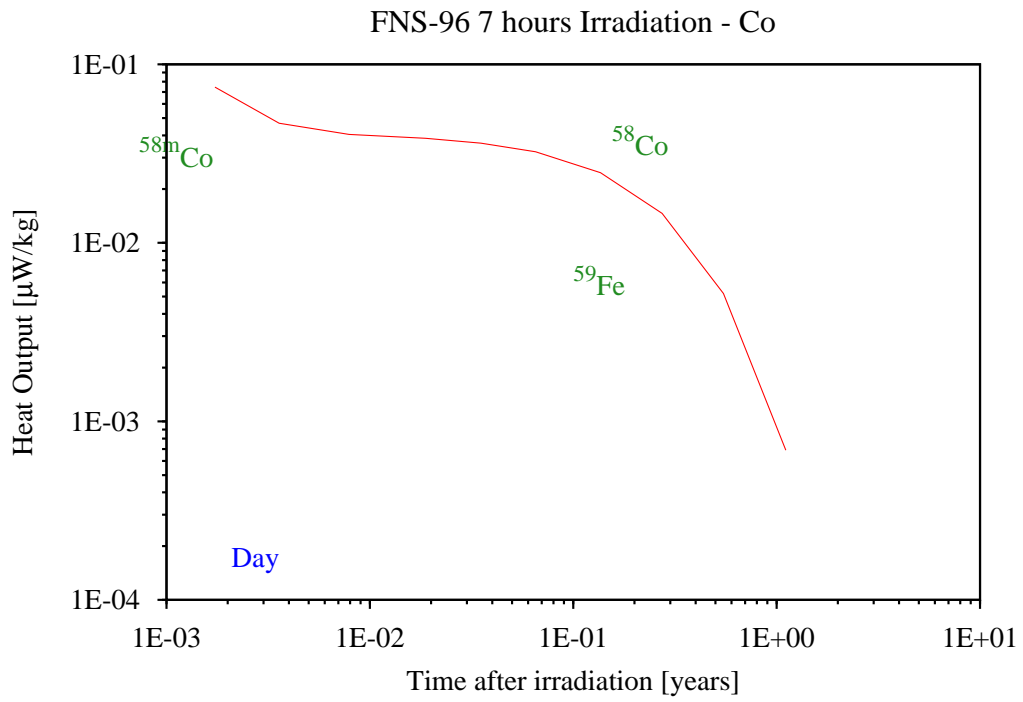




Good agreement, within the experimental uncertainty bands.

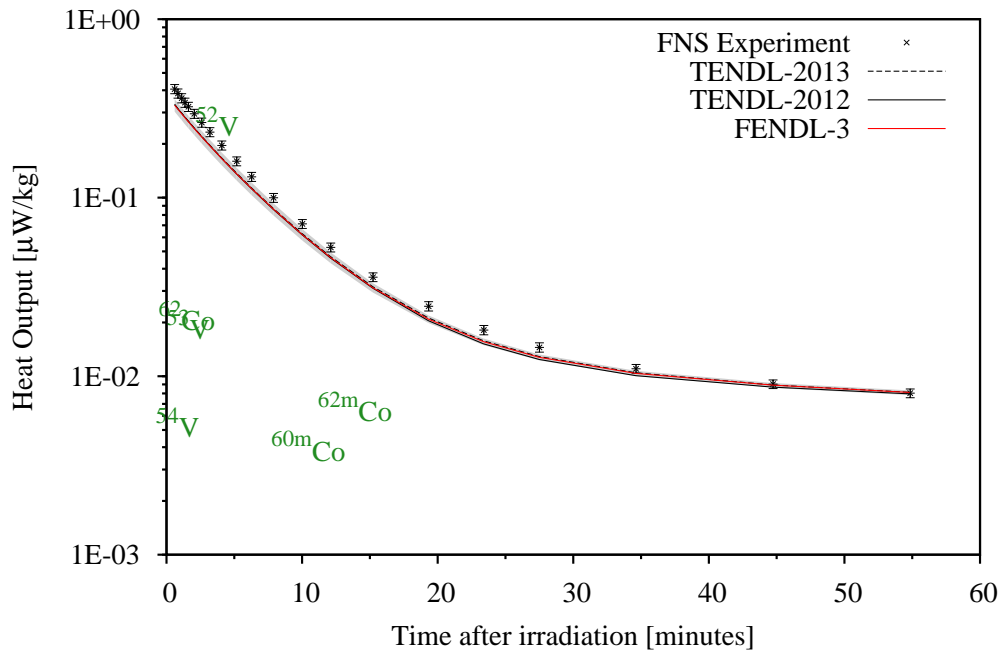
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|--------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.63 | $5.90E-02 \pm 5\%$ | $7.46E-02 \pm 19\%$ | 0.79 | $7.72E-02$ | 0.76 | $8.05E-02$ | 0.73 |
| 1.31 | $4.28E-02 \pm 5\%$ | $4.67E-02 \pm 32\%$ | 0.92 | $4.62E-02$ | 0.93 | $4.74E-02$ | 0.90 |
| 2.89 | $4.33E-02 \pm 5\%$ | $4.05E-02 \pm 38\%$ | 1.07 | $4.18E-02$ | 1.04 | $4.22E-02$ | 1.03 |
| 6.86 | $4.19E-02 \pm 5\%$ | $3.85E-02 \pm 39\%$ | 1.09 | $3.99E-02$ | 1.05 | $4.03E-02$ | 1.04 |
| 12.85 | $3.94E-02 \pm 5\%$ | $3.62E-02 \pm 39\%$ | 1.09 | $3.75E-02$ | 1.05 | $3.78E-02$ | 1.04 |
| 23.84 | $3.52E-02 \pm 5\%$ | $3.23E-02 \pm 39\%$ | 1.09 | $3.35E-02$ | 1.05 | $3.38E-02$ | 1.04 |
| 49.70 | $2.69E-02 \pm 5\%$ | $2.47E-02 \pm 40\%$ | 1.09 | $2.56E-02$ | 1.05 | $2.58E-02$ | 1.04 |
| 99.89 | $1.63E-02 \pm 5\%$ | $1.46E-02 \pm 41\%$ | 1.11 | $1.53E-02$ | 1.06 | $1.53E-02$ | 1.07 |
| 200.11 | $5.95E-03 \pm 5\%$ | $5.20E-03 \pm 42\%$ | 1.14 | $5.61E-03$ | 1.06 | $5.43E-03$ | 1.10 |
| 402.95 | $8.21E-04 \pm 5\%$ | $6.89E-04 \pm 43\%$ | 1.19 | $7.67E-04$ | 1.07 | $6.98E-04$ | 1.18 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| Co58m | Co59(n,2n)Co58m | 8.9h | 99.7 | 0.73 | 5% |
| Co58 | Co59(n,2n)Co58 | 70.8d | 86.2 | 1.07 | 5% |
| | Co59(n,2n)Co58m | 8.9h | 13.8 | 1.07 | 5% |

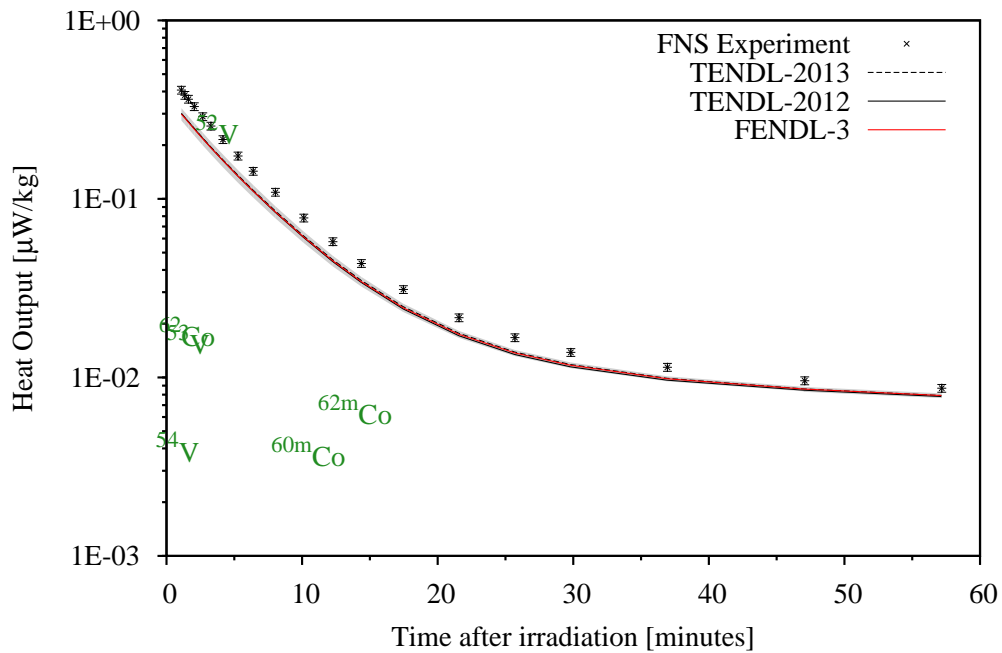


Inconel-600

FNS-00 5 Min. Irradiation - Inc600



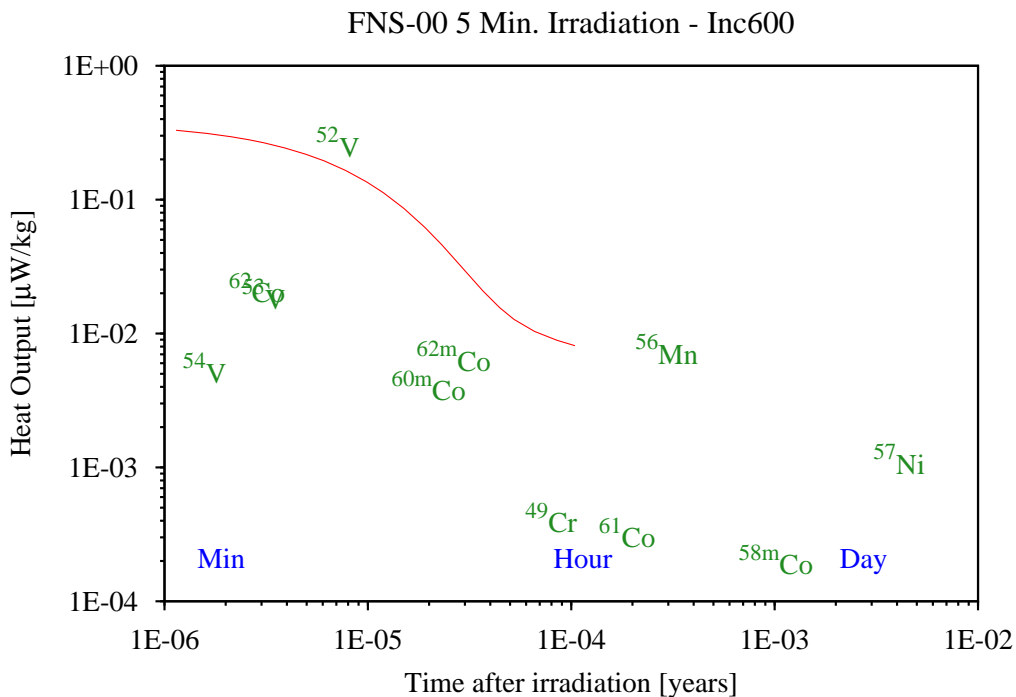
FNS-96 5 Min. Irradiation - Inc600

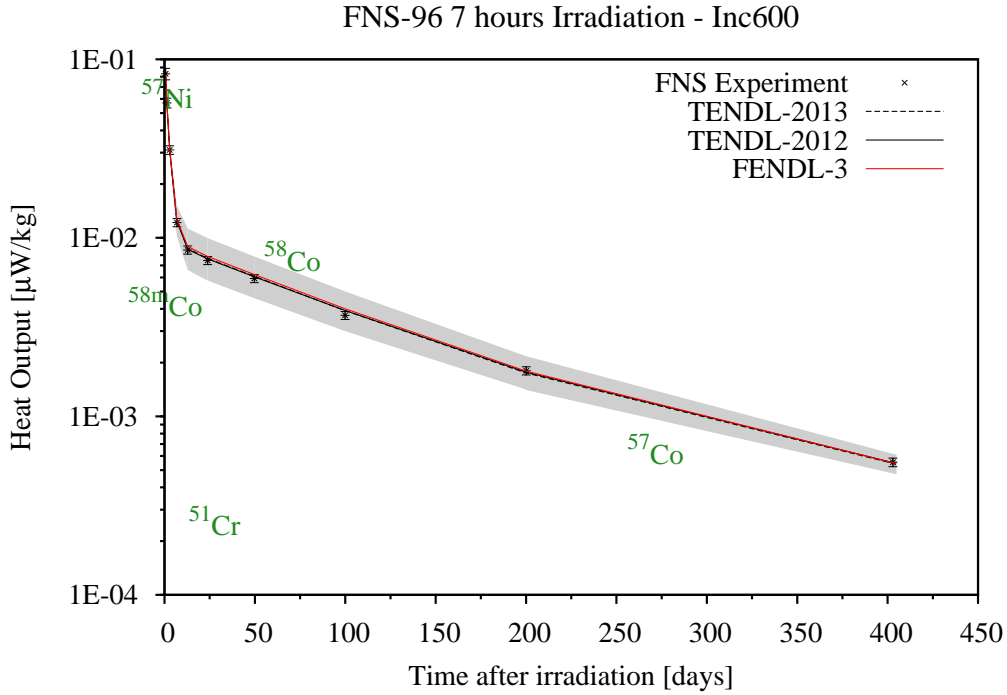


For Inconel, an interesting parallel can be drawn there when V-52 is dominant up to 30 minutes cooling time. It is produced through multiple channels from Cr-52, Cr-53 and Mn-55 and here seems to be under predicted by around 20%. This trend is corroborated in the pathways arising from Cr isotopes, although in the pure Cr graphs the under-prediction is less significant.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|--------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.60 | $4.06E-01 \pm 6\%$ | $3.30E-01 \pm 8\%$ | 1.23 | $3.33E-01$ | 1.22 | $3.32E-01$ | 1.22 |
| 0.85 | $3.84E-01 \pm 6\%$ | $3.13E-01 \pm 8\%$ | 1.23 | $3.15E-01$ | 1.22 | $3.15E-01$ | 1.22 |
| 1.12 | $3.61E-01 \pm 6\%$ | $2.95E-01 \pm 8\%$ | 1.22 | $2.97E-01$ | 1.21 | $2.97E-01$ | 1.21 |
| 1.37 | $3.41E-01 \pm 6\%$ | $2.80E-01 \pm 8\%$ | 1.22 | $2.82E-01$ | 1.21 | $2.82E-01$ | 1.21 |
| 1.62 | $3.23E-01 \pm 6\%$ | $2.66E-01 \pm 8\%$ | 1.21 | $2.68E-01$ | 1.21 | $2.68E-01$ | 1.21 |
| 2.05 | $2.95E-01 \pm 6\%$ | $2.44E-01 \pm 8\%$ | 1.21 | $2.45E-01$ | 1.21 | $2.45E-01$ | 1.20 |
| 2.60 | $2.64E-01 \pm 6\%$ | $2.19E-01 \pm 8\%$ | 1.21 | $2.19E-01$ | 1.20 | $2.20E-01$ | 1.20 |
| 3.20 | $2.33E-01 \pm 6\%$ | $1.95E-01 \pm 8\%$ | 1.20 | $1.95E-01$ | 1.19 | $1.96E-01$ | 1.19 |
| 4.08 | $1.96E-01 \pm 6\%$ | $1.65E-01 \pm 8\%$ | 1.19 | $1.65E-01$ | 1.19 | $1.67E-01$ | 1.18 |
| 5.18 | $1.60E-01 \pm 6\%$ | $1.36E-01 \pm 8\%$ | 1.18 | $1.35E-01$ | 1.18 | $1.37E-01$ | 1.17 |
| 6.28 | $1.31E-01 \pm 6\%$ | $1.12E-01 \pm 8\%$ | 1.17 | $1.12E-01$ | 1.17 | $1.13E-01$ | 1.15 |
| 7.90 | $9.98E-02 \pm 6\%$ | $8.61E-02 \pm 8\%$ | 1.16 | $8.57E-02$ | 1.16 | $8.69E-02$ | 1.15 |
| 10.02 | $7.14E-02 \pm 6\%$ | $6.21E-02 \pm 7\%$ | 1.15 | $6.18E-02$ | 1.15 | $6.28E-02$ | 1.14 |
| 12.12 | $5.27E-02 \pm 6\%$ | $4.62E-02 \pm 7\%$ | 1.14 | $4.59E-02$ | 1.15 | $4.67E-02$ | 1.13 |
| 15.23 | $3.59E-02 \pm 6\%$ | $3.13E-02 \pm 6\%$ | 1.15 | $3.11E-02$ | 1.15 | $3.17E-02$ | 1.13 |
| 19.33 | $2.47E-02 \pm 6\%$ | $2.09E-02 \pm 5\%$ | 1.18 | $2.04E-02$ | 1.21 | $2.12E-02$ | 1.17 |
| 23.40 | $1.81E-02 \pm 6\%$ | $1.56E-02 \pm 4\%$ | 1.16 | $1.52E-02$ | 1.19 | $1.58E-02$ | 1.15 |
| 27.50 | $1.45E-02 \pm 6\%$ | $1.27E-02 \pm 4\%$ | 1.14 | $1.24E-02$ | 1.17 | $1.29E-02$ | 1.13 |
| 34.63 | $1.10E-02 \pm 6\%$ | $1.04E-02 \pm 3\%$ | 1.06 | $1.01E-02$ | 1.09 | $1.04E-02$ | 1.05 |
| 44.73 | $9.03E-03 \pm 6\%$ | $8.90E-03 \pm 3\%$ | 1.01 | $8.69E-03$ | 1.04 | $8.92E-03$ | 1.01 |
| 54.85 | $8.03E-03 \pm 6\%$ | $8.11E-03 \pm 3\%$ | 0.99 | $7.95E-03$ | 1.01 | $8.12E-03$ | 0.99 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------------|-----------|--------|------|--------------|
| V52 | Cr52(n,p)V52 | 3.7m | 97.1 | 1.19 | 6% |
| | Cr53(n,d+np)V52 | | 1.9 | 1.19 | 6% |
| | Mn55(n, α)V52 | | 0.9 | 1.19 | 6% |
| Mn56 | Fe56(n,p)Mn56 | 2.5h | 98.9 | 1.01 | 6% |

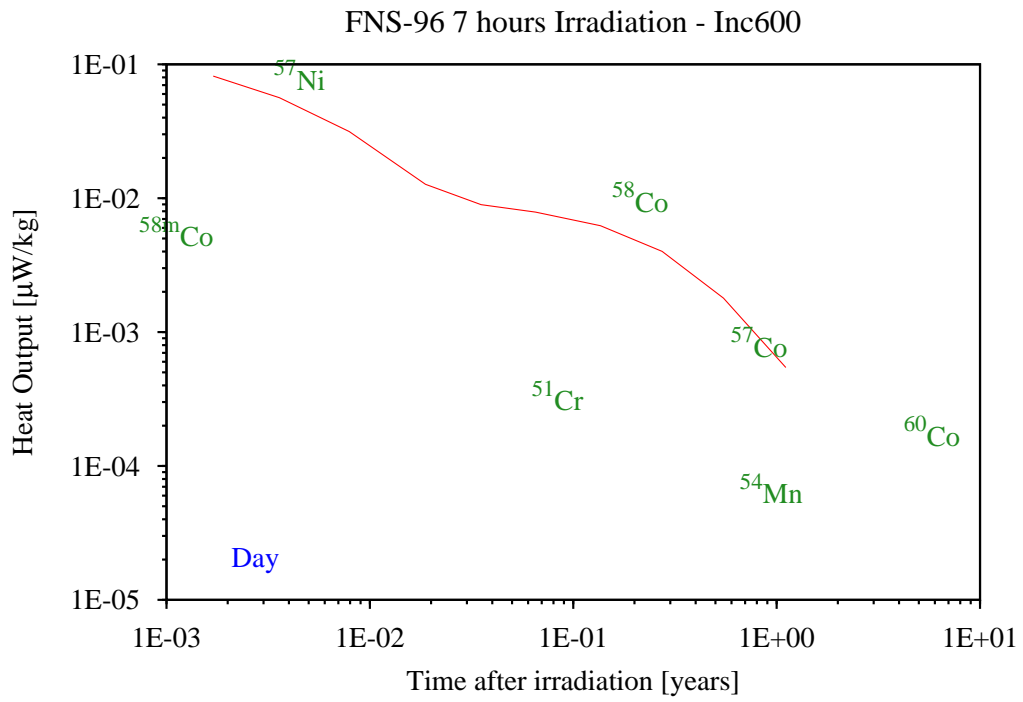




For this Inconel 600 alloy, one sees a clean agreement between the measurement and simulation.

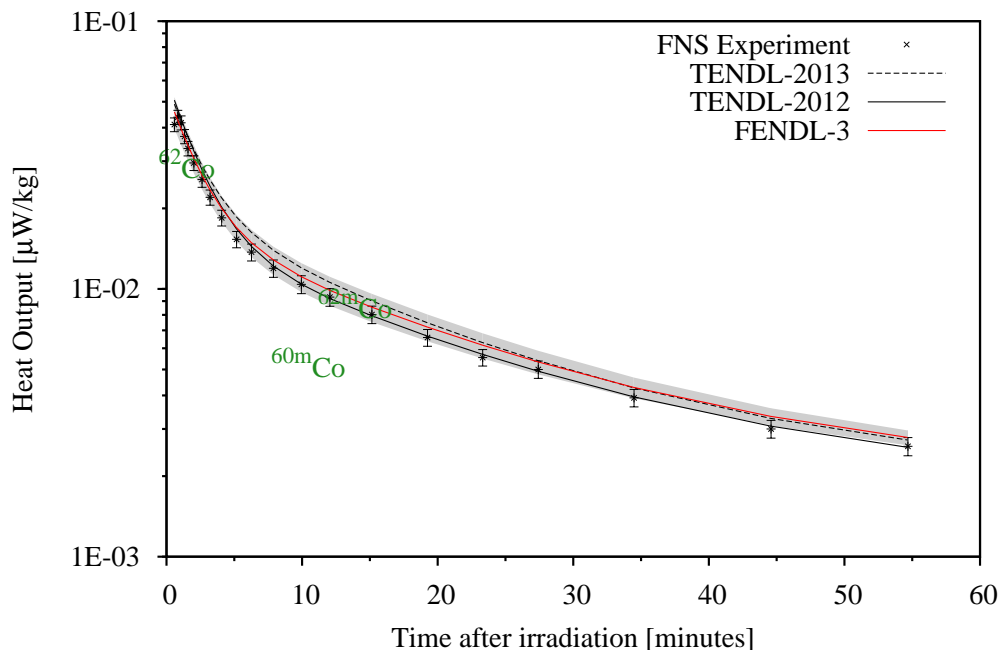
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|-----------------|------|------------|------|------------|------|
| 0.62 | 8.29E-02 +/-7% | 8.16E-02 +/-5% | 1.02 | 7.94E-02 | 1.04 | 8.08E-02 | 1.03 |
| 1.31 | 5.70E-02 +/-6% | 5.63E-02 +/-6% | 1.01 | 5.58E-02 | 1.02 | 5.60E-02 | 1.02 |
| 2.89 | 3.11E-02 +/-6% | 3.15E-02 +/-9% | 0.99 | 3.13E-02 | 0.99 | 3.13E-02 | 0.99 |
| 6.86 | 1.22E-02 +/-5% | 1.27E-02 +/-20% | 0.96 | 1.24E-02 | 0.98 | 1.25E-02 | 0.98 |
| 12.86 | 8.55E-03 +/-5% | 8.94E-03 +/-26% | 0.96 | 8.61E-03 | 0.99 | 8.72E-03 | 0.98 |
| 23.84 | 7.47E-03 +/-5% | 7.87E-03 +/-27% | 0.95 | 7.62E-03 | 0.98 | 7.67E-03 | 0.97 |
| 49.69 | 5.92E-03 +/-5% | 6.23E-03 +/-26% | 0.95 | 6.05E-03 | 0.98 | 6.10E-03 | 0.97 |
| 99.88 | 3.68E-03 +/-5% | 4.01E-03 +/-25% | 0.92 | 3.92E-03 | 0.94 | 3.91E-03 | 0.94 |
| 200.11 | 1.80E-03 +/-5% | 1.79E-03 +/-21% | 1.00 | 1.77E-03 | 1.02 | 1.75E-03 | 1.03 |
| 402.94 | 5.53E-04 +/-6% | 5.44E-04 +/-12% | 1.02 | 5.45E-04 | 1.01 | 5.39E-04 | 1.02 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|------------------|------------------|--------|------|-----|
| Ni57 | Ni58(n,2n)Ni57 | 1.4d | 100.0 | 1.02 | 6% |
| Co58 | Ni58(n,p)Co58 | 70.8d | 91.6 | 0.94 | 5% |
| | Ni58(n,p)Co58m | | 8.4 | 0.94 | 5% |
| Co57 | Ni58(n,d+np)Co57 | 271d | 99.6 | 1.02 | 5% |

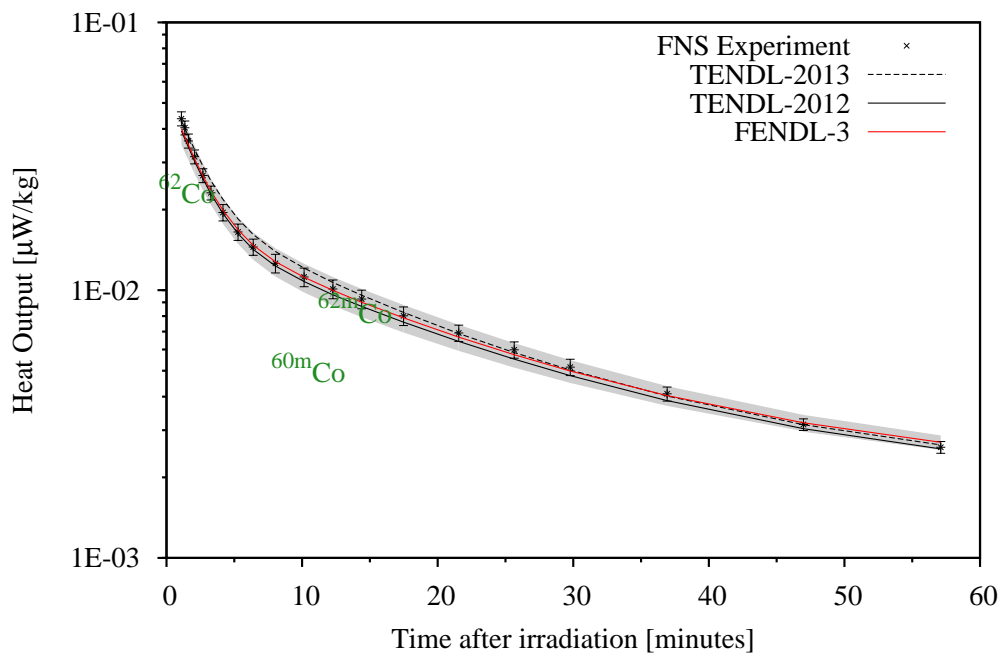


Nickel

FNS-00 5 Min. Irradiation - Ni



FNS-96 5 Min. Irradiation - Ni

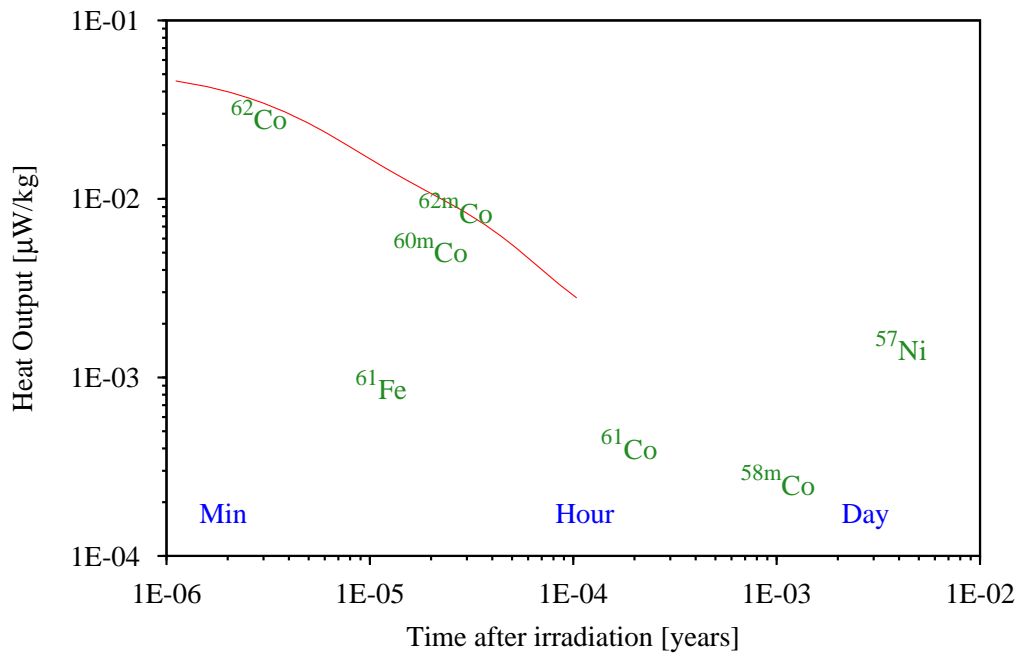


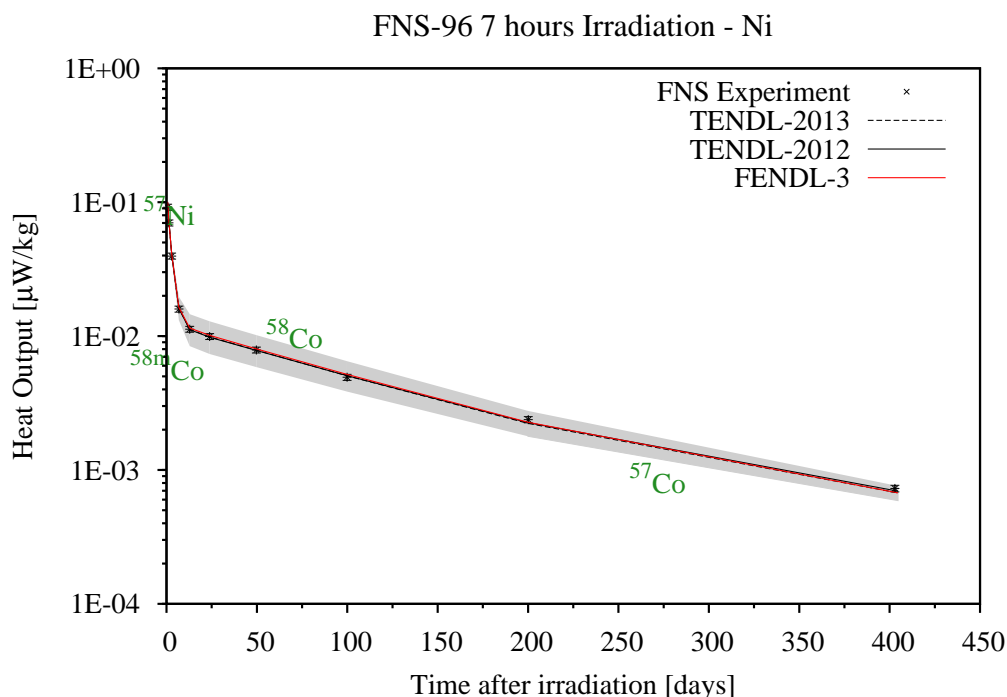
For Nickel, the two sets of experimental measurements differ. However, the code predictions stay within 10% of the measurements at all cooling times.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $4.11E-02 \pm 6\%$ | $4.58E-02 \pm 13\%$ | 0.90 | $5.07E-02$ | 0.81 | $4.90E-02$ | 0.84 |
| 0.83 | $4.38E-02 \pm 6\%$ | $4.25E-02 \pm 13\%$ | 1.03 | $4.68E-02$ | 0.94 | $4.55E-02$ | 0.96 |
| 1.08 | $4.18E-02 \pm 6\%$ | $3.95E-02 \pm 13\%$ | 1.06 | $4.32E-02$ | 0.97 | $4.24E-02$ | 0.99 |
| 1.33 | $3.71E-02 \pm 6\%$ | $3.68E-02 \pm 13\%$ | 1.01 | $3.99E-02$ | 0.93 | $3.96E-02$ | 0.94 |
| 1.58 | $3.35E-02 \pm 6\%$ | $3.44E-02 \pm 12\%$ | 0.97 | $3.70E-02$ | 0.90 | $3.70E-02$ | 0.90 |
| 2.02 | $2.95E-02 \pm 6\%$ | $3.07E-02 \pm 12\%$ | 0.96 | $3.27E-02$ | 0.90 | $3.32E-02$ | 0.89 |
| 2.62 | $2.56E-02 \pm 6\%$ | $2.66E-02 \pm 11\%$ | 0.96 | $2.79E-02$ | 0.92 | $2.89E-02$ | 0.89 |
| 3.22 | $2.20E-02 \pm 7\%$ | $2.34E-02 \pm 11\%$ | 0.94 | $2.42E-02$ | 0.91 | $2.55E-02$ | 0.86 |
| 4.07 | $1.84E-02 \pm 7\%$ | $2.00E-02 \pm 11\%$ | 0.92 | $2.02E-02$ | 0.91 | $2.19E-02$ | 0.84 |
| 5.17 | $1.53E-02 \pm 7\%$ | $1.70E-02 \pm 11\%$ | 0.90 | $1.68E-02$ | 0.91 | $1.86E-02$ | 0.83 |
| 6.27 | $1.37E-02 \pm 7\%$ | $1.49E-02 \pm 12\%$ | 0.92 | $1.44E-02$ | 0.95 | $1.63E-02$ | 0.84 |
| 7.88 | $1.19E-02 \pm 7\%$ | $1.28E-02 \pm 12\%$ | 0.93 | $1.22E-02$ | 0.98 | $1.40E-02$ | 0.86 |
| 9.95 | $1.04E-02 \pm 8\%$ | $1.11E-02 \pm 12\%$ | 0.94 | $1.04E-02$ | 1.00 | $1.20E-02$ | 0.87 |
| 12.05 | $9.32E-03 \pm 8\%$ | $9.88E-03 \pm 12\%$ | 0.94 | $9.21E-03$ | 1.01 | $1.06E-02$ | 0.88 |
| 15.15 | $8.02E-03 \pm 7\%$ | $8.55E-03 \pm 12\%$ | 0.94 | $7.94E-03$ | 1.01 | $9.03E-03$ | 0.89 |
| 19.25 | $6.58E-03 \pm 7\%$ | $7.20E-03 \pm 11\%$ | 0.91 | $6.67E-03$ | 0.99 | $7.48E-03$ | 0.88 |
| 23.32 | $5.54E-03 \pm 7\%$ | $6.17E-03 \pm 11\%$ | 0.90 | $5.70E-03$ | 0.97 | $6.31E-03$ | 0.88 |
| 27.42 | $5.00E-03 \pm 7\%$ | $5.34E-03 \pm 10\%$ | 0.94 | $4.93E-03$ | 1.02 | $5.40E-03$ | 0.93 |
| 34.48 | $3.92E-03 \pm 8\%$ | $4.29E-03 \pm 9\%$ | 0.91 | $3.95E-03$ | 0.99 | $4.27E-03$ | 0.92 |
| 44.58 | $3.00E-03 \pm 8\%$ | $3.34E-03 \pm 7\%$ | 0.90 | $3.07E-03$ | 0.98 | $3.29E-03$ | 0.91 |
| 54.68 | $2.58E-03 \pm 8\%$ | $2.79E-03 \pm 6\%$ | 0.93 | $2.56E-03$ | 1.01 | $2.73E-03$ | 0.95 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|----------------|-----------|--------|------|--------------|
| Co62 | Ni62(n,p)Co62 | 1.5m | 99.8 | 0.90 | 6% |
| Co62m | Ni62(n,p)Co62m | 13.9m | 100.0 | 0.95 | 7% |

FNS-00 5 Min. Irradiation - Ni

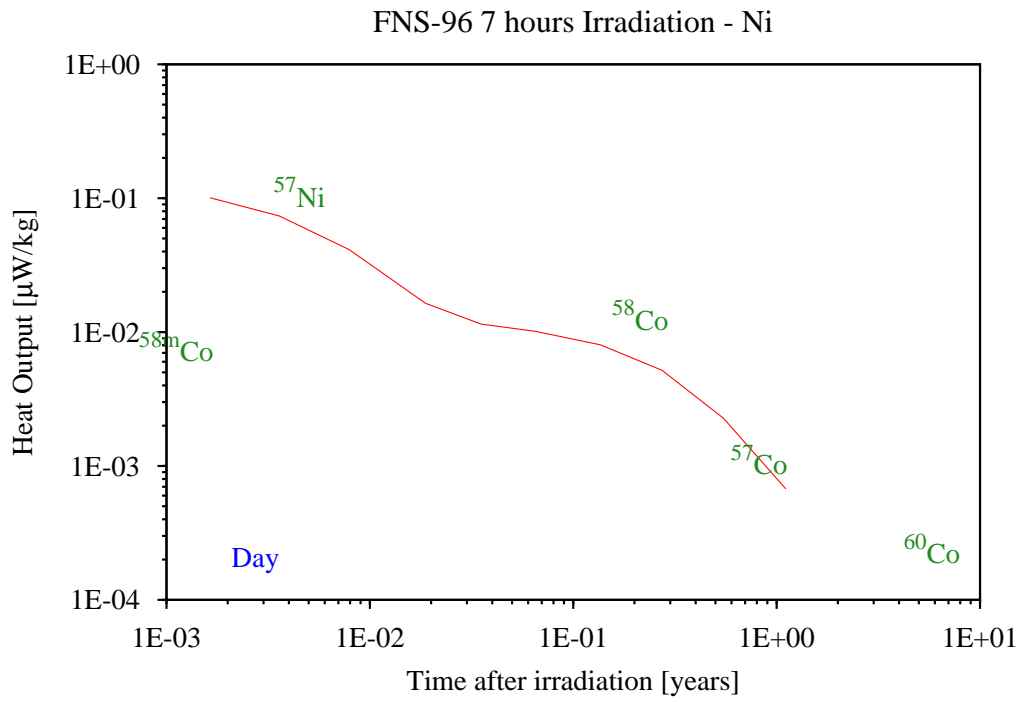




An excellent agreement exists with all databases.

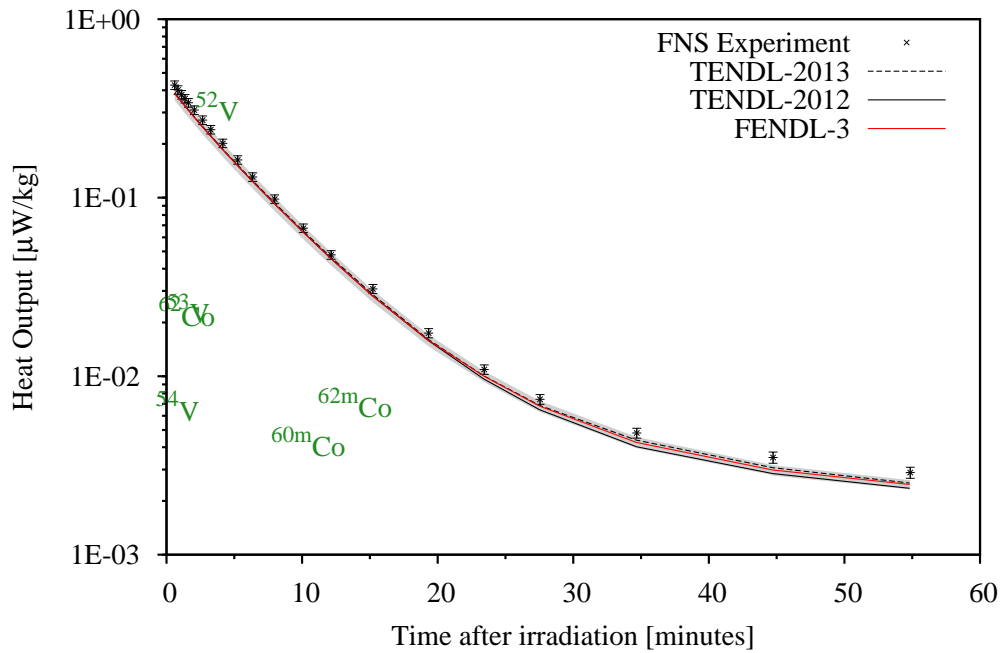
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|------------------|-------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.60 | $9.17E-02$ +/-5% | $1.01E-01$ +/-5% | 0.91 | $9.88E-02$ | 0.93 | $9.96E-02$ | 0.92 |
| 1.31 | $7.01E-02$ +/-5% | $7.37E-02$ +/-6% | 0.95 | $7.40E-02$ | 0.95 | $7.37E-02$ | 0.95 |
| 2.89 | $3.96E-02$ +/-5% | $4.12E-02$ +/-9% | 0.96 | $4.12E-02$ | 0.96 | $4.11E-02$ | 0.96 |
| 6.86 | $1.59E-02$ +/-5% | $1.64E-02$ +/-20% | 0.97 | $1.61E-02$ | 0.99 | $1.61E-02$ | 0.99 |
| 12.85 | $1.13E-02$ +/-5% | $1.15E-02$ +/-27% | 0.98 | $1.12E-02$ | 1.01 | $1.12E-02$ | 1.00 |
| 23.85 | $9.92E-03$ +/-5% | $1.01E-02$ +/-27% | 0.98 | $9.80E-03$ | 1.01 | $9.86E-03$ | 1.01 |
| 49.70 | $7.87E-03$ +/-5% | $8.02E-03$ +/-27% | 0.98 | $7.82E-03$ | 1.01 | $7.86E-03$ | 1.00 |
| 99.89 | $4.92E-03$ +/-5% | $5.17E-03$ +/-25% | 0.95 | $5.06E-03$ | 0.97 | $5.05E-03$ | 0.97 |
| 200.11 | $2.37E-03$ +/-5% | $2.27E-03$ +/-21% | 1.04 | $2.26E-03$ | 1.05 | $2.23E-03$ | 1.06 |
| 402.94 | $7.27E-04$ +/-6% | $6.74E-04$ +/-12% | 1.08 | $6.94E-04$ | 1.05 | $6.74E-04$ | 1.08 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------|-----------|--------|------|--------------|
| Ni57 | Ni58(n,2n)Ni57 | 1.4d | 100.0 | 0.92 | 5% |
| Co58 | Ni58(n,p)Co58 | 70.8d | 91.6 | 0.97 | 5% |
| | Ni58(n,p)Co58m | 8.9h | 8.4 | 0.97 | 5% |
| Co57 | Ni58(n,d+np)Co57 | 271d | 99.6 | 1.08 | 5% |

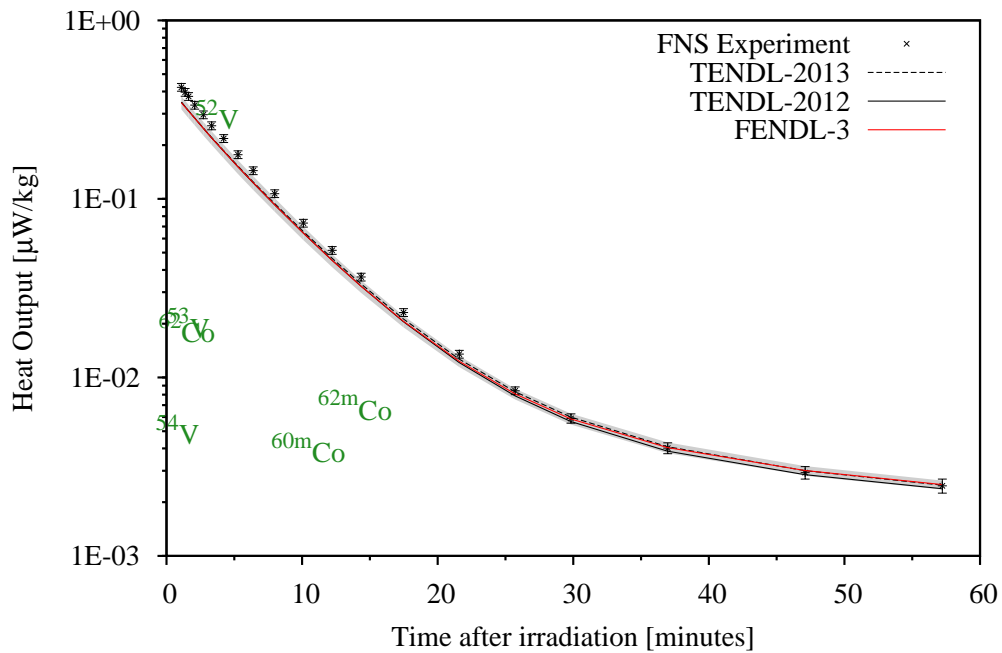


Nickel-chrome

FNS-00 5 Min. Irradiation - NiCr



FNS-96 5 Min. Irradiation - NiCr

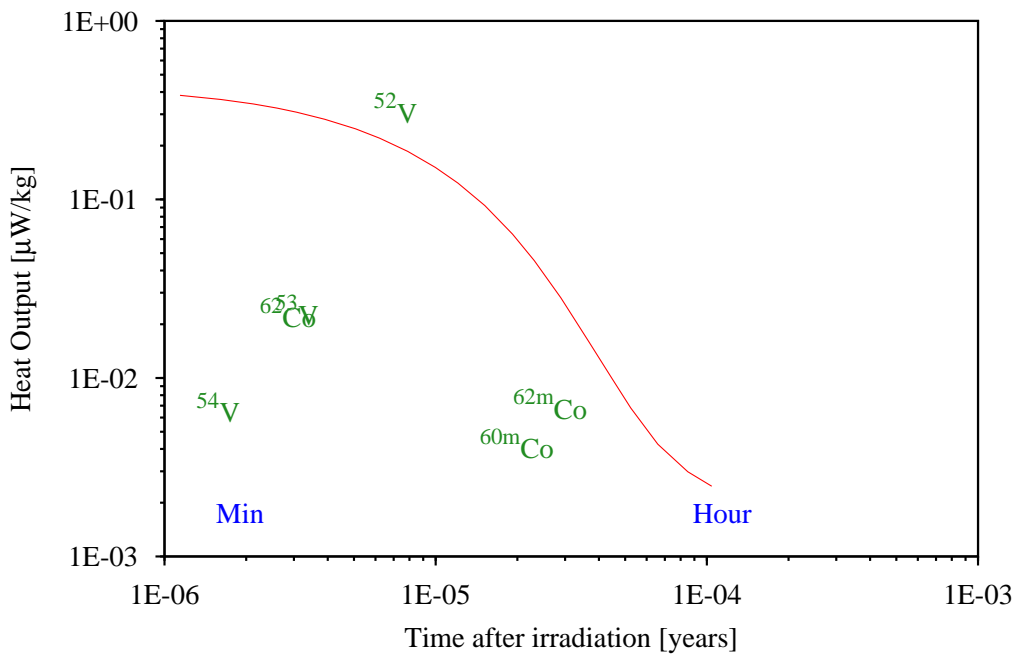


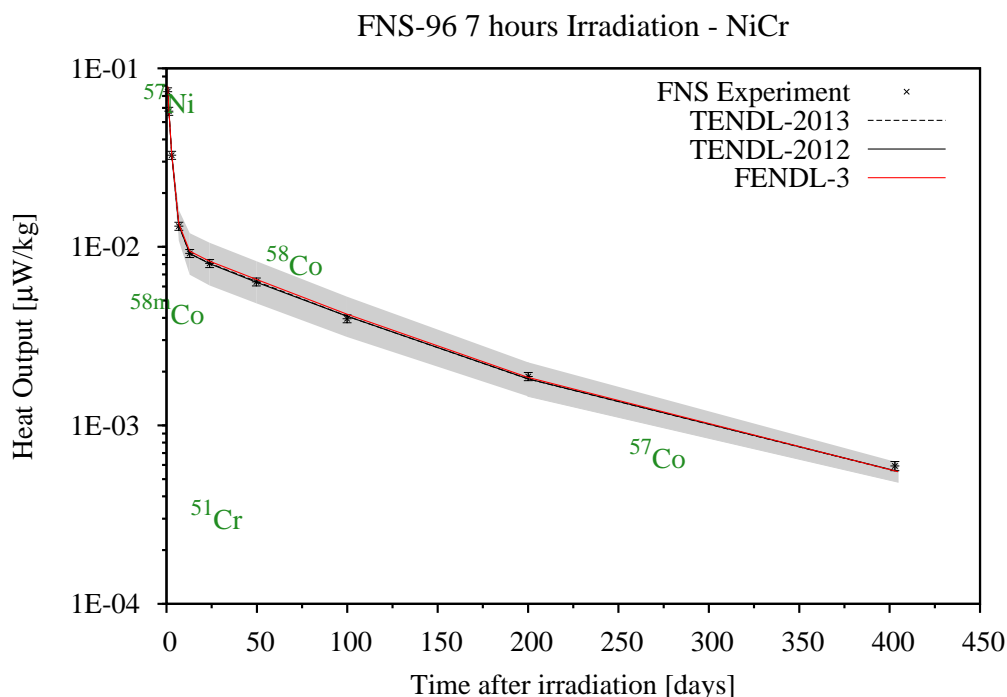
For Ni-Cr, the first 15 minutes of cooling time are dominated by the Cr isotope produced V-52 and the trend is the same (slight under-prediction) as seen in the Cr alloys.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|--------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.60 | $4.27E-01 \pm 5\%$ | $3.83E-01 \pm 8\%$ | 1.12 | $3.86E-01$ | 1.11 | $3.85E-01$ | 1.11 |
| 0.85 | $4.01E-01 \pm 5\%$ | $3.63E-01 \pm 8\%$ | 1.11 | $3.65E-01$ | 1.10 | $3.65E-01$ | 1.10 |
| 1.12 | $3.77E-01 \pm 5\%$ | $3.43E-01 \pm 8\%$ | 1.10 | $3.45E-01$ | 1.09 | $3.44E-01$ | 1.10 |
| 1.37 | $3.59E-01 \pm 5\%$ | $3.25E-01 \pm 9\%$ | 1.11 | $3.27E-01$ | 1.10 | $3.27E-01$ | 1.10 |
| 1.62 | $3.40E-01 \pm 5\%$ | $3.08E-01 \pm 9\%$ | 1.10 | $3.10E-01$ | 1.10 | $3.10E-01$ | 1.10 |
| 2.05 | $3.10E-01 \pm 5\%$ | $2.82E-01 \pm 9\%$ | 1.10 | $2.83E-01$ | 1.10 | $2.83E-01$ | 1.09 |
| 2.67 | $2.72E-01 \pm 5\%$ | $2.48E-01 \pm 9\%$ | 1.10 | $2.49E-01$ | 1.09 | $2.50E-01$ | 1.09 |
| 3.27 | $2.40E-01 \pm 5\%$ | $2.21E-01 \pm 9\%$ | 1.09 | $2.21E-01$ | 1.09 | $2.22E-01$ | 1.08 |
| 4.15 | $2.02E-01 \pm 5\%$ | $1.86E-01 \pm 9\%$ | 1.08 | $1.86E-01$ | 1.08 | $1.87E-01$ | 1.08 |
| 5.25 | $1.63E-01 \pm 5\%$ | $1.51E-01 \pm 9\%$ | 1.08 | $1.51E-01$ | 1.08 | $1.53E-01$ | 1.07 |
| 6.35 | $1.31E-01 \pm 5\%$ | $1.24E-01 \pm 9\%$ | 1.06 | $1.23E-01$ | 1.06 | $1.25E-01$ | 1.05 |
| 7.98 | $9.83E-02 \pm 5\%$ | $9.23E-02 \pm 9\%$ | 1.06 | $9.21E-02$ | 1.07 | $9.34E-02$ | 1.05 |
| 10.10 | $6.75E-02 \pm 5\%$ | $6.40E-02 \pm 9\%$ | 1.06 | $6.39E-02$ | 1.06 | $6.50E-02$ | 1.04 |
| 12.15 | $4.78E-02 \pm 5\%$ | $4.55E-02 \pm 8\%$ | 1.05 | $4.54E-02$ | 1.05 | $4.63E-02$ | 1.03 |
| 15.22 | $3.08E-02 \pm 6\%$ | $2.81E-02 \pm 8\%$ | 1.10 | $2.81E-02$ | 1.10 | $2.87E-02$ | 1.08 |
| 19.33 | $1.74E-02 \pm 6\%$ | $1.59E-02 \pm 7\%$ | 1.10 | $1.58E-02$ | 1.10 | $1.60E-02$ | 1.09 |
| 23.43 | $1.09E-02 \pm 6\%$ | $9.99E-03 \pm 7\%$ | 1.09 | $9.63E-03$ | 1.13 | $1.00E-02$ | 1.09 |
| 27.55 | $7.42E-03 \pm 6\%$ | $6.79E-03 \pm 7\%$ | 1.09 | $6.49E-03$ | 1.14 | $6.86E-03$ | 1.08 |
| 34.68 | $4.80E-03 \pm 6\%$ | $4.26E-03 \pm 7\%$ | 1.13 | $4.03E-03$ | 1.19 | $4.38E-03$ | 1.10 |
| 44.73 | $3.50E-03 \pm 7\%$ | $2.98E-03 \pm 7\%$ | 1.17 | $2.85E-03$ | 1.23 | $3.07E-03$ | 1.14 |
| 54.85 | $2.88E-03 \pm 7\%$ | $2.48E-03 \pm 6\%$ | 1.17 | $2.35E-03$ | 1.23 | $2.52E-03$ | 1.14 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| V52 | Cr52(n,p)V52 | 3.7m | 98.1 | 1.08 | 5% |
| | Cr53(n,d+np)V52 | | 1.9 | 1.08 | 5% |
| Co60m | Ni60(n,p)Co60m | 10.4m | 98.9 | 1.04 | 5% |
| | Ni61(n,d)Co60m | | 1.1 | 1.04 | 5% |
| Co62m | Ni62(n,p)Co62m | 13.9m | 100.0 | 1.08 | 6% |

FNS-00 5 Min. Irradiation - NiCr

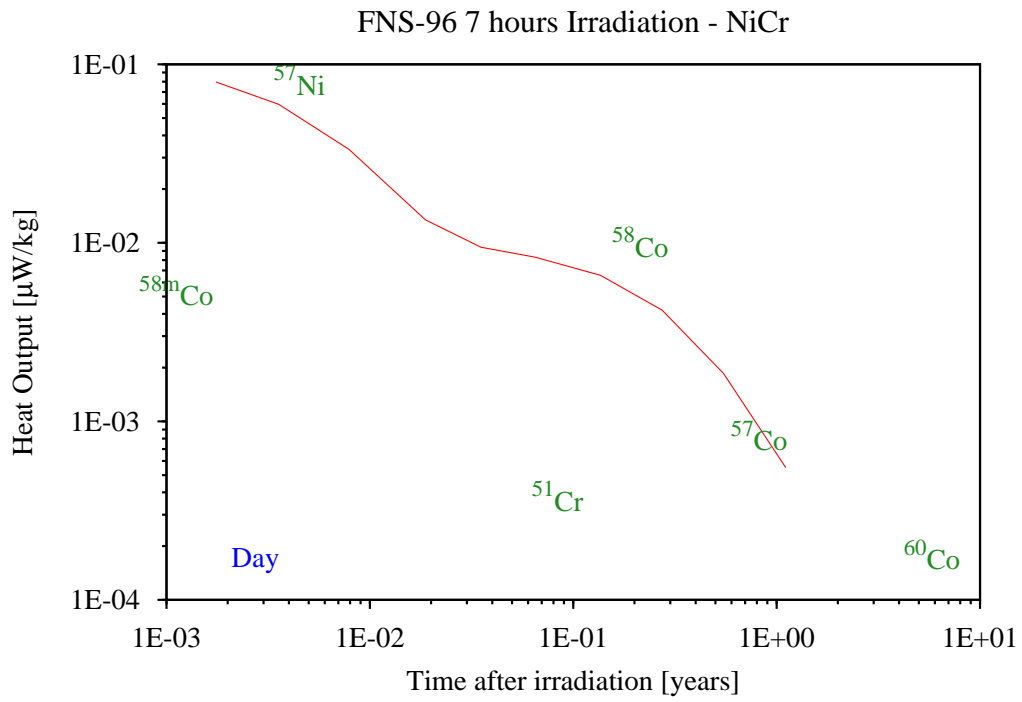




Here also a clean agreement exists between measurement and prediction.

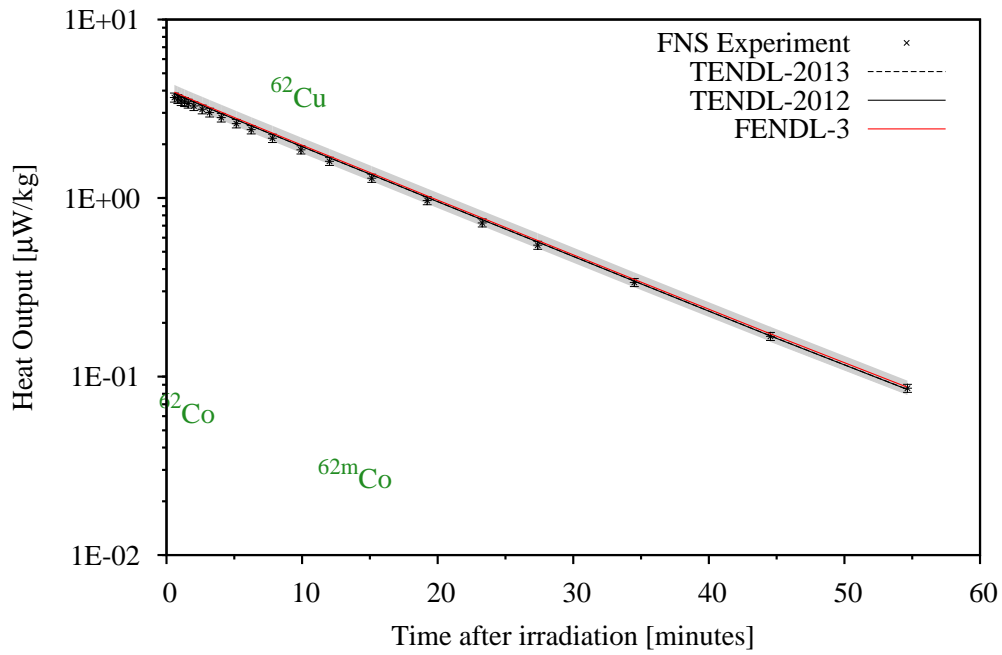
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|--------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.64 | $7.40E-02 \pm 5\%$ | $7.97E-02 \pm 5\%$ | 0.93 | $7.83E-02$ | 0.94 | $7.89E-02$ | 0.94 |
| 1.30 | $5.75E-02 \pm 5\%$ | $5.97E-02 \pm 6\%$ | 0.96 | $5.93E-02$ | 0.97 | $5.95E-02$ | 0.97 |
| 2.88 | $3.26E-02 \pm 5\%$ | $3.34E-02 \pm 9\%$ | 0.98 | $3.33E-02$ | 0.98 | $3.33E-02$ | 0.98 |
| 6.85 | $1.31E-02 \pm 5\%$ | $1.34E-02 \pm 20\%$ | 0.97 | $1.32E-02$ | 0.99 | $1.32E-02$ | 0.99 |
| 12.85 | $9.18E-03 \pm 5\%$ | $9.45E-03 \pm 26\%$ | 0.97 | $9.17E-03$ | 1.00 | $9.16E-03$ | 1.00 |
| 23.85 | $8.07E-03 \pm 5\%$ | $8.30E-03 \pm 27\%$ | 0.97 | $8.05E-03$ | 1.00 | $8.09E-03$ | 1.00 |
| 49.70 | $6.36E-03 \pm 5\%$ | $6.57E-03 \pm 26\%$ | 0.97 | $6.34E-03$ | 1.00 | $6.41E-03$ | 0.99 |
| 99.89 | $3.96E-03 \pm 5\%$ | $4.19E-03 \pm 25\%$ | 0.94 | $4.09E-03$ | 0.97 | $4.09E-03$ | 0.97 |
| 200.12 | $1.88E-03 \pm 5\%$ | $1.85E-03 \pm 22\%$ | 1.01 | $1.82E-03$ | 1.03 | $1.82E-03$ | 1.03 |
| 402.94 | $5.92E-04 \pm 6\%$ | $5.50E-04 \pm 13\%$ | 1.08 | $5.52E-04$ | 1.07 | $5.50E-04$ | 1.08 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------|-----------|--------|------|--------------|
| Ni57 | Ni58(n,2n)Ni57 | 1.4d | 100.0 | 0.97 | 5% |
| Co58 | Ni58(n,p)Co58 | 70.8d | 91.6 | 0.97 | 5% |
| | Ni58(n,p)Co58m | | 8.4 | 0.97 | 5% |
| Co57 | Ni58(n,d+np)Co57 | 271d | 99.6 | 1.03 | 6% |

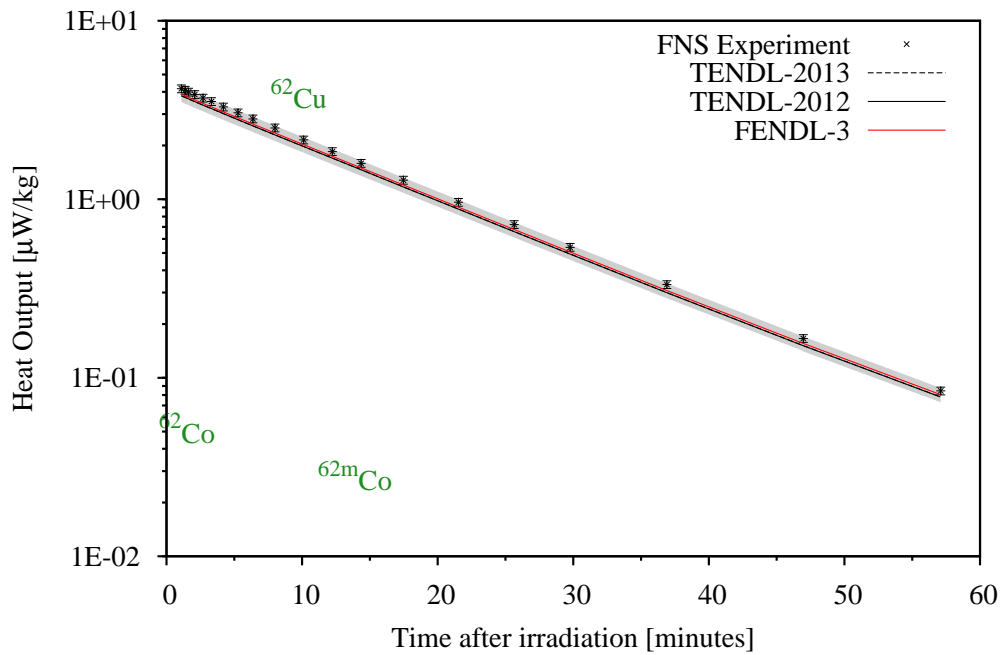


Copper

FNS-00 5 Min. Irradiation - Cu



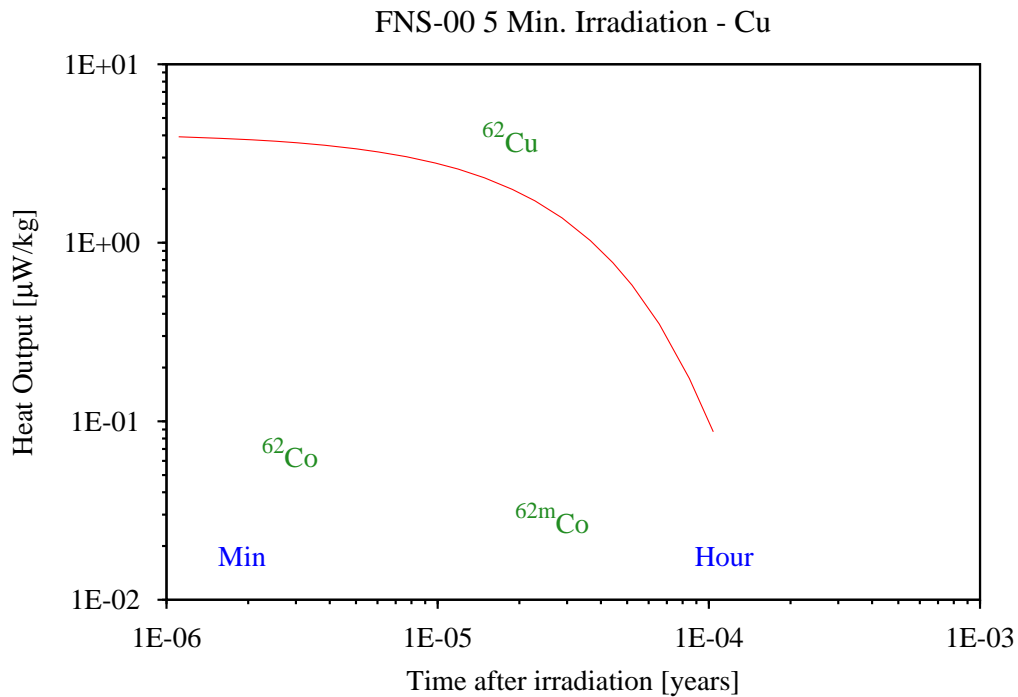
FNS-96 5 Min. Irradiation - Cu

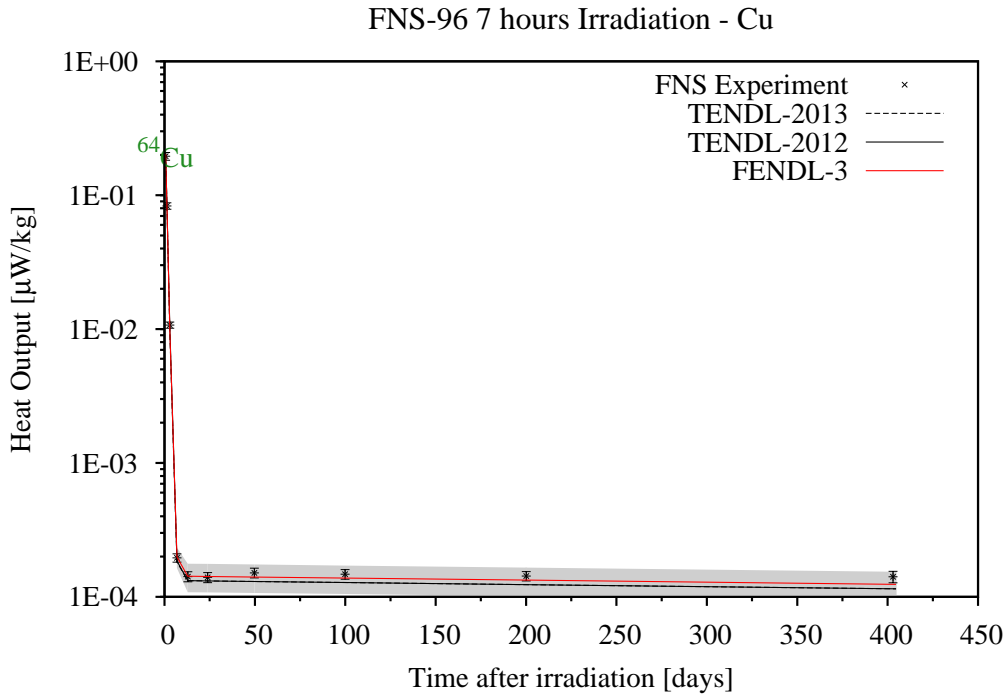


For Copper, a good agreement can be seen for both sample runs. However, the rather uniform measurements could be used to question the quoted 6% experimental uncertainty in face of the fact that the two batches seem to differ by more than this 6% value.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $3.66E+00 \pm 6\%$ | $3.92E+00 \pm 10\%$ | 0.93 | $3.86E+00$ | 0.95 | $3.86E+00$ | 0.95 |
| 0.83 | $3.59E+00 \pm 6\%$ | $3.85E+00 \pm 10\%$ | 0.93 | $3.79E+00$ | 0.95 | $3.78E+00$ | 0.95 |
| 1.08 | $3.50E+00 \pm 6\%$ | $3.77E+00 \pm 10\%$ | 0.93 | $3.72E+00$ | 0.94 | $3.71E+00$ | 0.94 |
| 1.33 | $3.45E+00 \pm 6\%$ | $3.70E+00 \pm 10\%$ | 0.93 | $3.64E+00$ | 0.95 | $3.64E+00$ | 0.95 |
| 1.60 | $3.38E+00 \pm 6\%$ | $3.63E+00 \pm 10\%$ | 0.93 | $3.57E+00$ | 0.95 | $3.57E+00$ | 0.95 |
| 2.02 | $3.28E+00 \pm 6\%$ | $3.52E+00 \pm 10\%$ | 0.93 | $3.46E+00$ | 0.95 | $3.46E+00$ | 0.95 |
| 2.63 | $3.14E+00 \pm 6\%$ | $3.36E+00 \pm 10\%$ | 0.93 | $3.30E+00$ | 0.95 | $3.30E+00$ | 0.95 |
| 3.18 | $3.01E+00 \pm 6\%$ | $3.23E+00 \pm 10\%$ | 0.93 | $3.17E+00$ | 0.95 | $3.17E+00$ | 0.95 |
| 4.03 | $2.82E+00 \pm 6\%$ | $3.03E+00 \pm 10\%$ | 0.93 | $2.98E+00$ | 0.95 | $2.98E+00$ | 0.95 |
| 5.15 | $2.61E+00 \pm 5\%$ | $2.80E+00 \pm 10\%$ | 0.93 | $2.75E+00$ | 0.95 | $2.75E+00$ | 0.95 |
| 6.25 | $2.42E+00 \pm 5\%$ | $2.59E+00 \pm 10\%$ | 0.93 | $2.54E+00$ | 0.95 | $2.54E+00$ | 0.95 |
| 7.82 | $2.16E+00 \pm 5\%$ | $2.31E+00 \pm 10\%$ | 0.94 | $2.27E+00$ | 0.95 | $2.27E+00$ | 0.95 |
| 9.92 | $1.86E+00 \pm 5\%$ | $1.99E+00 \pm 10\%$ | 0.94 | $1.95E+00$ | 0.95 | $1.96E+00$ | 0.95 |
| 12.02 | $1.61E+00 \pm 5\%$ | $1.72E+00 \pm 10\%$ | 0.94 | $1.68E+00$ | 0.95 | $1.69E+00$ | 0.95 |
| 15.13 | $1.29E+00 \pm 5\%$ | $1.38E+00 \pm 10\%$ | 0.94 | $1.35E+00$ | 0.96 | $1.35E+00$ | 0.96 |
| 19.23 | $9.68E-01 \pm 5\%$ | $1.03E+00 \pm 10\%$ | 0.94 | $1.01E+00$ | 0.96 | $1.01E+00$ | 0.96 |
| 23.28 | $7.26E-01 \pm 5\%$ | $7.74E-01 \pm 10\%$ | 0.94 | $7.57E-01$ | 0.96 | $7.58E-01$ | 0.96 |
| 27.38 | $5.44E-01 \pm 5\%$ | $5.79E-01 \pm 10\%$ | 0.94 | $5.67E-01$ | 0.96 | $5.68E-01$ | 0.96 |
| 34.50 | $3.37E-01 \pm 5\%$ | $3.51E-01 \pm 10\%$ | 0.96 | $3.43E-01$ | 0.98 | $3.43E-01$ | 0.98 |
| 44.55 | $1.68E-01 \pm 5\%$ | $1.74E-01 \pm 9\%$ | 0.97 | $1.69E-01$ | 0.99 | $1.69E-01$ | 0.99 |
| 54.65 | $8.60E-02 \pm 5\%$ | $8.73E-02 \pm 9\%$ | 0.98 | $8.47E-02$ | 1.01 | $8.49E-02$ | 1.01 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|----------------|-----------|--------|------|--------------|
| Cu62 | Cu63(n,2n)Cu62 | 9.7m | 100.0 | 0.95 | 5% |

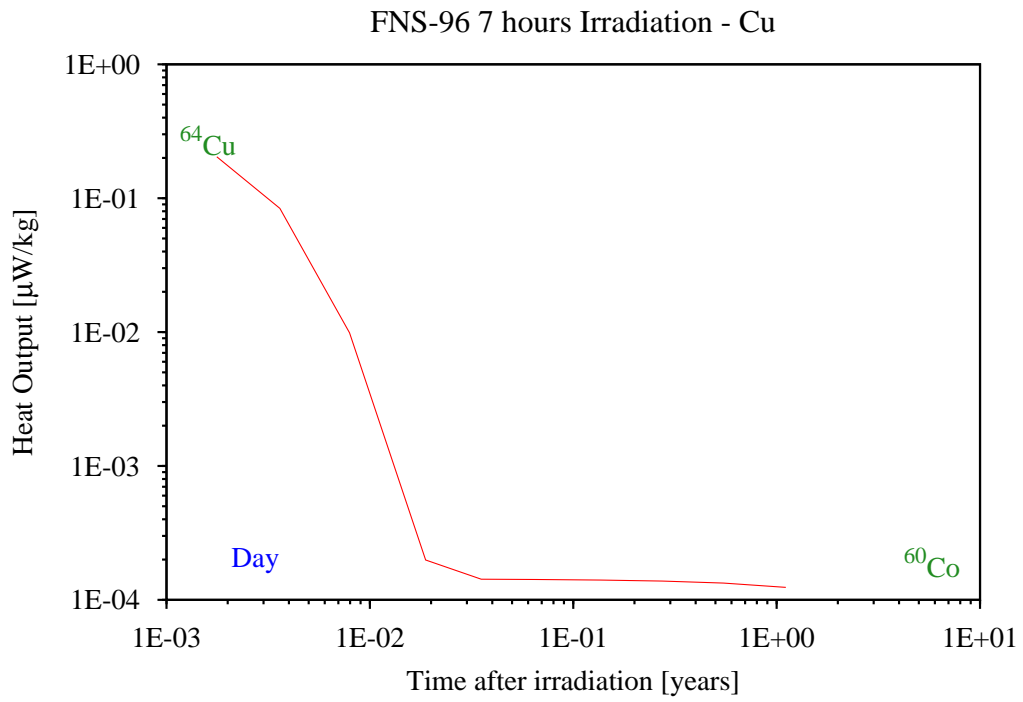




The above graph shows a good agreement, often within the experimental uncertainty.

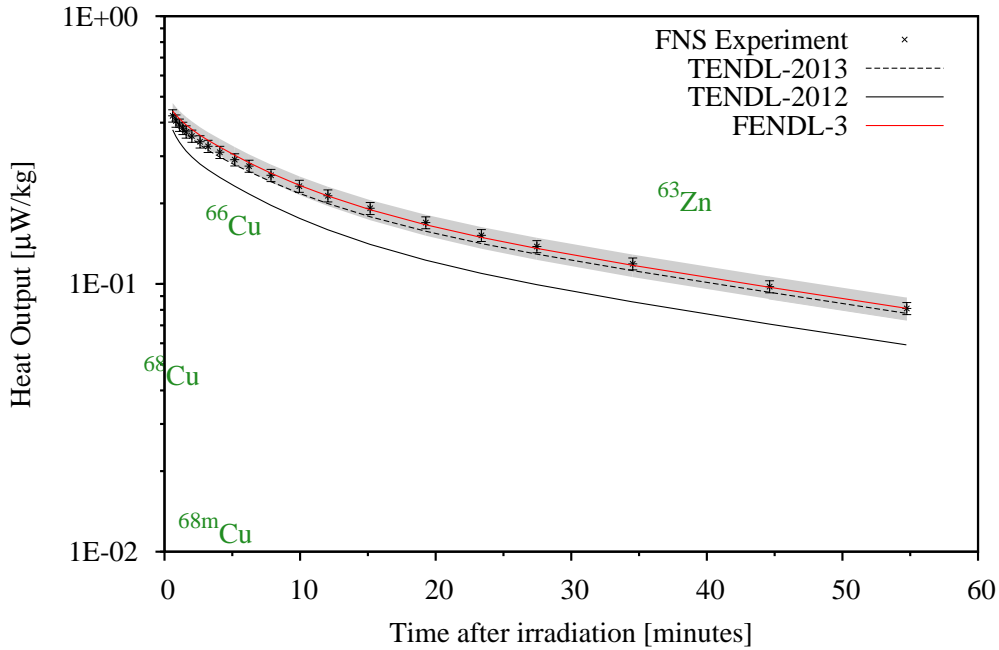
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|---------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.65 | $1.95E-01 \pm 7\%$ | $2.04E-01 \pm 10\%$ | 0.96 | $2.04E-01$ | 0.96 | $2.04E-01$ | 0.96 |
| 1.32 | $8.31E-02 \pm 6\%$ | $8.38E-02 \pm 10\%$ | 0.99 | $8.41E-02$ | 0.99 | $8.41E-02$ | 0.99 |
| 2.90 | $1.07E-02 \pm 5\%$ | $9.88E-03 \pm 10\%$ | 1.09 | $1.05E-02$ | 1.02 | $9.55E-03$ | 1.12 |
| 6.87 | $1.96E-04 \pm 7\%$ | $1.98E-04 \pm 18\%$ | 0.99 | $1.85E-04$ | 1.06 | $1.83E-04$ | 1.07 |
| 12.89 | $1.42E-04 \pm 9\%$ | $1.43E-04 \pm 24\%$ | 0.99 | $1.32E-04$ | 1.07 | $1.32E-04$ | 1.07 |
| 23.90 | $1.40E-04 \pm 9\%$ | $1.42E-04 \pm 24\%$ | 0.98 | $1.31E-04$ | 1.06 | $1.31E-04$ | 1.06 |
| 49.72 | $1.51E-04 \pm 8\%$ | $1.41E-04 \pm 24\%$ | 1.07 | $1.30E-04$ | 1.16 | $1.30E-04$ | 1.16 |
| 99.92 | $1.48E-04 \pm 8\%$ | $1.38E-04 \pm 24\%$ | 1.07 | $1.28E-04$ | 1.15 | $1.28E-04$ | 1.15 |
| 200.14 | $1.43E-04 \pm 8\%$ | $1.33E-04 \pm 24\%$ | 1.07 | $1.23E-04$ | 1.16 | $1.23E-04$ | 1.16 |
| 402.97 | $1.41E-04 \pm 10\%$ | $1.24E-04 \pm 24\%$ | 1.14 | $1.15E-04$ | 1.23 | $1.15E-04$ | 1.23 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-------------------------|-----------|--------|------|--------------|
| Cu64 | Cu65(n,2n)Cu64 | 12.7h | 99.2 | 0.96 | 7% |
| | Cu63(n,g)Cu64 | | 0.7 | 0.96 | 7% |
| Co60 | Cu63(n, α)Co60m | 10.4m | 55.3 | 1.23 | 10% |
| | Cu63(n, α)Co60 | 5.2y | 44.7 | 1.23 | 10% |



Zinc

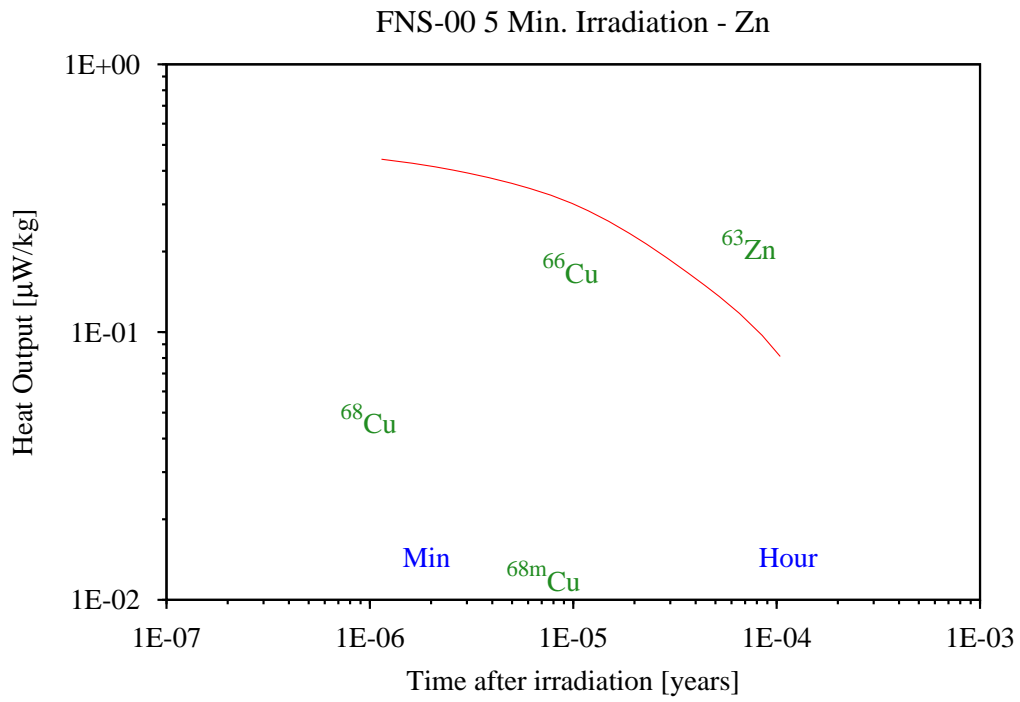
FNS-00 5 Min. Irradiation - Zn



For Zinc, in the above graph a remarkable agreement can be seen, with FENDL-3.0, TENDL-2013 but not for TENDL-2012, confirming again, if needed, the importance of this V&V process.

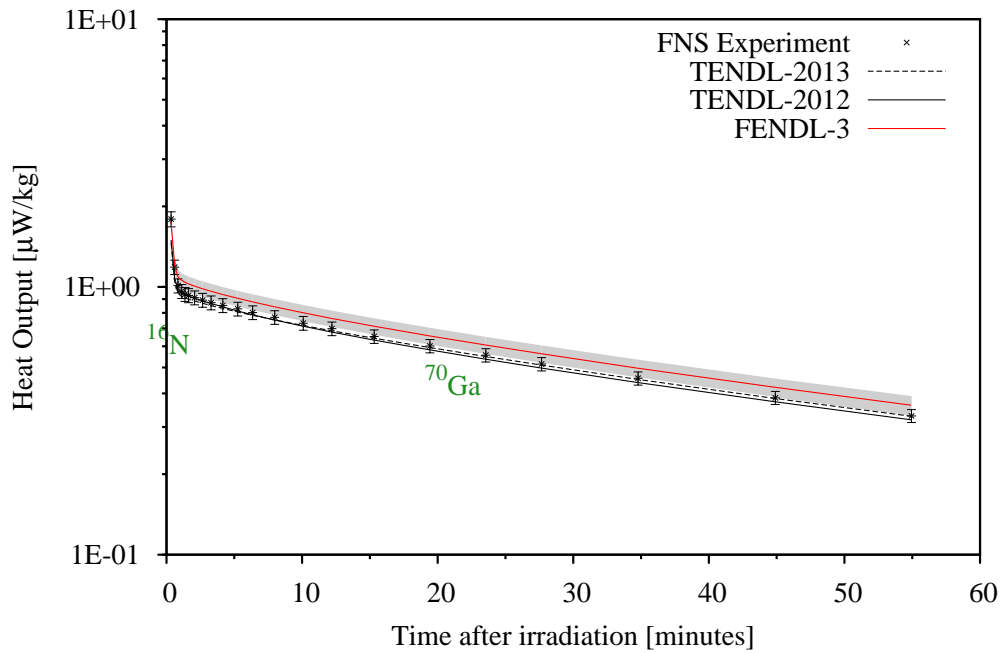
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 4.25E-01 +/-5% | 4.42E-01 +/-7% | 0.96 | 3.76E-01 | 1.13 | 4.30E-01 | 0.99 |
| 0.85 | 4.06E-01 +/-5% | 4.27E-01 +/-7% | 0.95 | 3.55E-01 | 1.14 | 4.09E-01 | 0.99 |
| 1.10 | 3.92E-01 +/-5% | 4.14E-01 +/-7% | 0.95 | 3.39E-01 | 1.16 | 3.91E-01 | 1.00 |
| 1.35 | 3.81E-01 +/-5% | 4.03E-01 +/-7% | 0.95 | 3.25E-01 | 1.17 | 3.77E-01 | 1.01 |
| 1.60 | 3.70E-01 +/-5% | 3.93E-01 +/-7% | 0.94 | 3.13E-01 | 1.18 | 3.65E-01 | 1.01 |
| 2.02 | 3.57E-01 +/-5% | 3.78E-01 +/-7% | 0.94 | 2.98E-01 | 1.20 | 3.49E-01 | 1.02 |
| 2.62 | 3.40E-01 +/-5% | 3.60E-01 +/-7% | 0.94 | 2.81E-01 | 1.21 | 3.31E-01 | 1.03 |
| 3.22 | 3.27E-01 +/-5% | 3.44E-01 +/-7% | 0.95 | 2.67E-01 | 1.23 | 3.16E-01 | 1.03 |
| 4.08 | 3.10E-01 +/-5% | 3.25E-01 +/-7% | 0.96 | 2.50E-01 | 1.24 | 2.98E-01 | 1.04 |
| 5.18 | 2.91E-01 +/-5% | 3.02E-01 +/-7% | 0.96 | 2.32E-01 | 1.25 | 2.79E-01 | 1.04 |
| 6.23 | 2.76E-01 +/-5% | 2.84E-01 +/-7% | 0.97 | 2.17E-01 | 1.27 | 2.63E-01 | 1.05 |
| 7.85 | 2.55E-01 +/-5% | 2.59E-01 +/-8% | 0.98 | 1.97E-01 | 1.29 | 2.41E-01 | 1.06 |
| 9.95 | 2.32E-01 +/-5% | 2.34E-01 +/-8% | 0.99 | 1.76E-01 | 1.32 | 2.18E-01 | 1.06 |
| 12.05 | 2.13E-01 +/-5% | 2.13E-01 +/-8% | 1.00 | 1.59E-01 | 1.34 | 2.00E-01 | 1.07 |
| 15.17 | 1.92E-01 +/-5% | 1.89E-01 +/-9% | 1.01 | 1.41E-01 | 1.36 | 1.78E-01 | 1.07 |
| 19.27 | 1.69E-01 +/-5% | 1.66E-01 +/-9% | 1.02 | 1.23E-01 | 1.38 | 1.57E-01 | 1.08 |
| 23.37 | 1.52E-01 +/-5% | 1.49E-01 +/-9% | 1.02 | 1.10E-01 | 1.39 | 1.42E-01 | 1.07 |
| 27.47 | 1.38E-01 +/-5% | 1.36E-01 +/-9% | 1.02 | 9.93E-02 | 1.39 | 1.29E-01 | 1.07 |
| 34.53 | 1.19E-01 +/-5% | 1.17E-01 +/-10% | 1.01 | 8.57E-02 | 1.39 | 1.12E-01 | 1.06 |
| 44.63 | 9.77E-02 +/-5% | 9.72E-02 +/-10% | 1.00 | 7.08E-02 | 1.38 | 9.31E-02 | 1.05 |
| 54.75 | 8.10E-02 +/-5% | 8.11E-02 +/-10% | 1.00 | 5.92E-02 | 1.37 | 7.77E-02 | 1.04 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|----------------|------------------|--------|---------|
| Zn63 | Zn64(n,2n)Zn63 | 38.4m | 100.0 | 1.06 5% |



Gallium

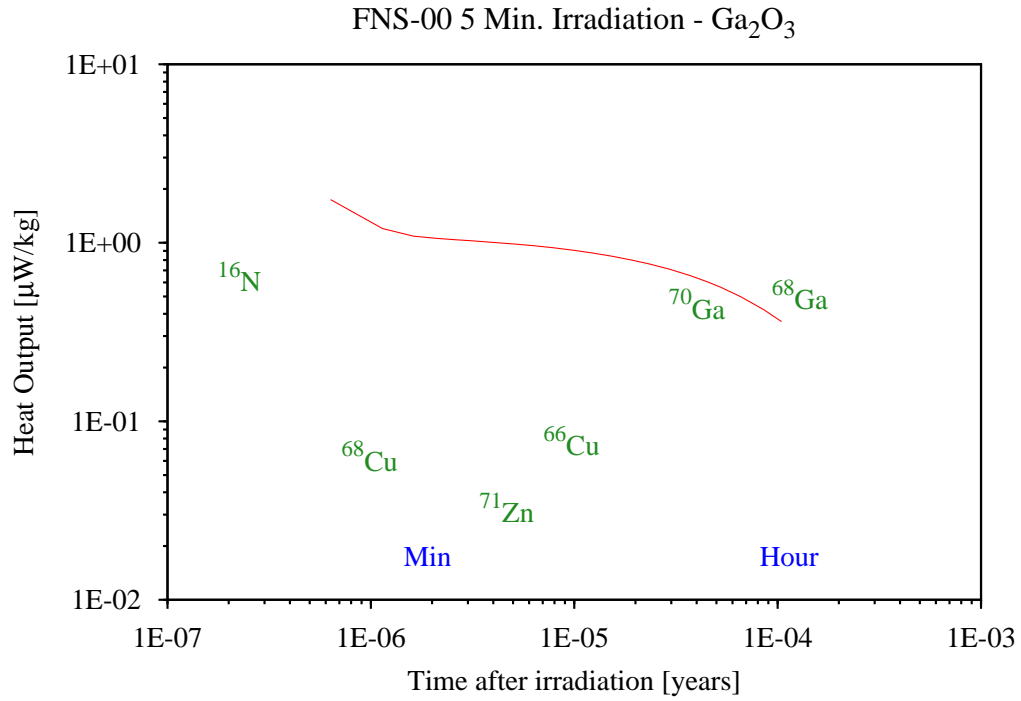
FNS-00 5 Min. Irradiation - Ga₂O₃



For Gallium, a remarkable agreement can be seen when the TENDL data libraries are used.

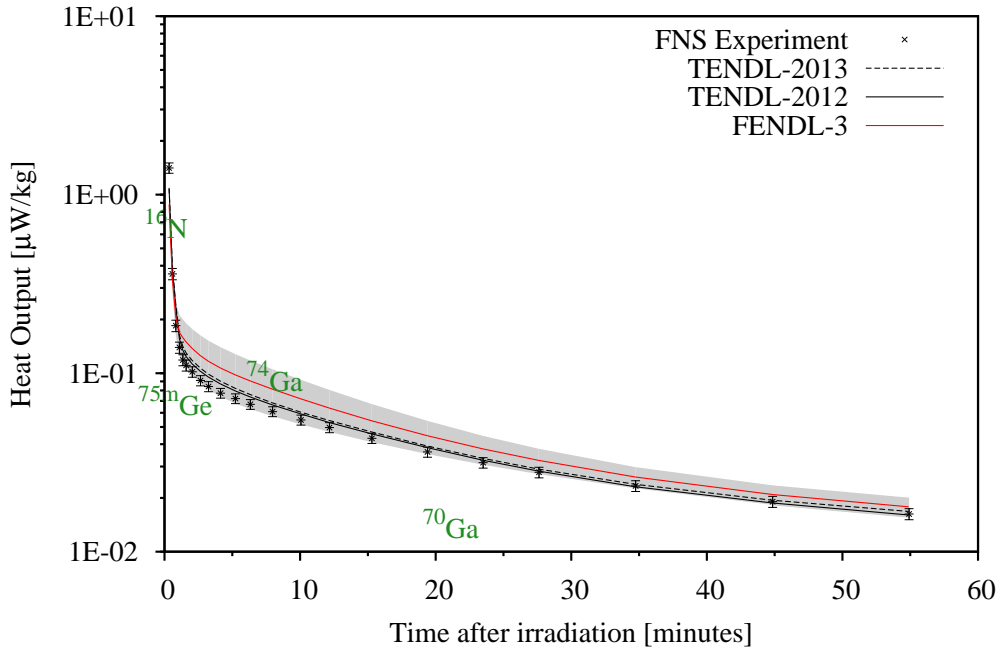
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|----------------|------|------------|------|------------|------|
| 0.33 | 1.79E+00 +/-6% | 1.75E+00 +/-5% | 1.03 | 1.50E + 00 | 1.20 | 1.46E+00 | 1.23 |
| 0.60 | 1.19E+00 +/-6% | 1.20E+00 +/-6% | 0.99 | 1.08E + 00 | 1.10 | 1.04E+00 | 1.14 |
| 0.85 | 1.01E+00 +/-6% | 1.09E+00 +/-6% | 0.93 | 9.80E - 01 | 1.03 | 9.48E-01 | 1.07 |
| 1.12 | 9.63E-01 +/-6% | 1.06E+00 +/-6% | 0.91 | 9.49E - 01 | 1.01 | 9.19E-01 | 1.05 |
| 1.37 | 9.39E-01 +/-6% | 1.04E+00 +/-6% | 0.90 | 9.36E - 01 | 1.00 | 9.09E-01 | 1.03 |
| 1.63 | 9.29E-01 +/-6% | 1.03E+00 +/-6% | 0.91 | 9.25E - 01 | 1.00 | 9.00E-01 | 1.03 |
| 2.07 | 9.12E-01 +/-6% | 1.01E+00 +/-7% | 0.91 | 9.08E - 01 | 1.00 | 8.86E-01 | 1.03 |
| 2.67 | 8.92E-01 +/-6% | 9.84E-01 +/-7% | 0.91 | 8.87E - 01 | 1.01 | 8.68E-01 | 1.03 |
| 3.28 | 8.73E-01 +/-6% | 9.64E-01 +/-7% | 0.91 | 8.67E - 01 | 1.01 | 8.52E-01 | 1.02 |
| 4.15 | 8.53E-01 +/-6% | 9.37E-01 +/-7% | 0.91 | 8.42E - 01 | 1.01 | 8.31E-01 | 1.03 |
| 5.25 | 8.28E-01 +/-6% | 9.07E-01 +/-7% | 0.91 | 8.13E - 01 | 1.02 | 8.06E-01 | 1.03 |
| 6.35 | 8.02E-01 +/-6% | 8.80E-01 +/-7% | 0.91 | 7.87E - 01 | 1.02 | 7.84E-01 | 1.02 |
| 7.98 | 7.70E-01 +/-6% | 8.43E-01 +/-7% | 0.91 | 7.53E - 01 | 1.02 | 7.53E-01 | 1.02 |
| 10.08 | 7.33E-01 +/-6% | 8.01E-01 +/-7% | 0.91 | 7.13E - 01 | 1.03 | 7.18E-01 | 1.02 |
| 12.20 | 6.99E-01 +/-6% | 7.63E-01 +/-7% | 0.92 | 6.78E - 01 | 1.03 | 6.86E-01 | 1.02 |
| 15.32 | 6.53E-01 +/-6% | 7.13E-01 +/-7% | 0.92 | 6.33E - 01 | 1.03 | 6.43E-01 | 1.02 |
| 19.43 | 6.02E-01 +/-6% | 6.56E-01 +/-7% | 0.92 | 5.82E - 01 | 1.03 | 5.94E-01 | 1.01 |
| 23.55 | 5.56E-01 +/-6% | 6.07E-01 +/-7% | 0.92 | 5.37E - 01 | 1.03 | 5.50E-01 | 1.01 |
| 27.67 | 5.15E-01 +/-6% | 5.63E-01 +/-7% | 0.92 | 4.98E - 01 | 1.03 | 5.11E-01 | 1.01 |
| 34.78 | 4.56E-01 +/-6% | 4.97E-01 +/-8% | 0.92 | 4.40E - 01 | 1.04 | 4.52E-01 | 1.01 |
| 44.90 | 3.85E-01 +/-6% | 4.22E-01 +/-8% | 0.91 | 3.72E - 01 | 1.03 | 3.83E-01 | 1.01 |
| 54.95 | 3.30E-01 +/-6% | 3.62E-01 +/-8% | 0.91 | 3.19E - 01 | 1.03 | 3.29E-01 | 1.00 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|----------------|------------------|--------|------|-----|
| N16 | O16(n,p)N16 | 7.1s | 99.9 | 1.23 | 6% |
| Ga70 | Ga69(n,γ)Ga70 | 21.1m | 1.2 | 1.01 | 6% |
| | Ga71(n,2n)Ga70 | | 98.8 | | |
| Ga68 | Ga69(n,2n)Ga68 | 1.1h | 100.0 | 1.01 | 6% |



Germanium

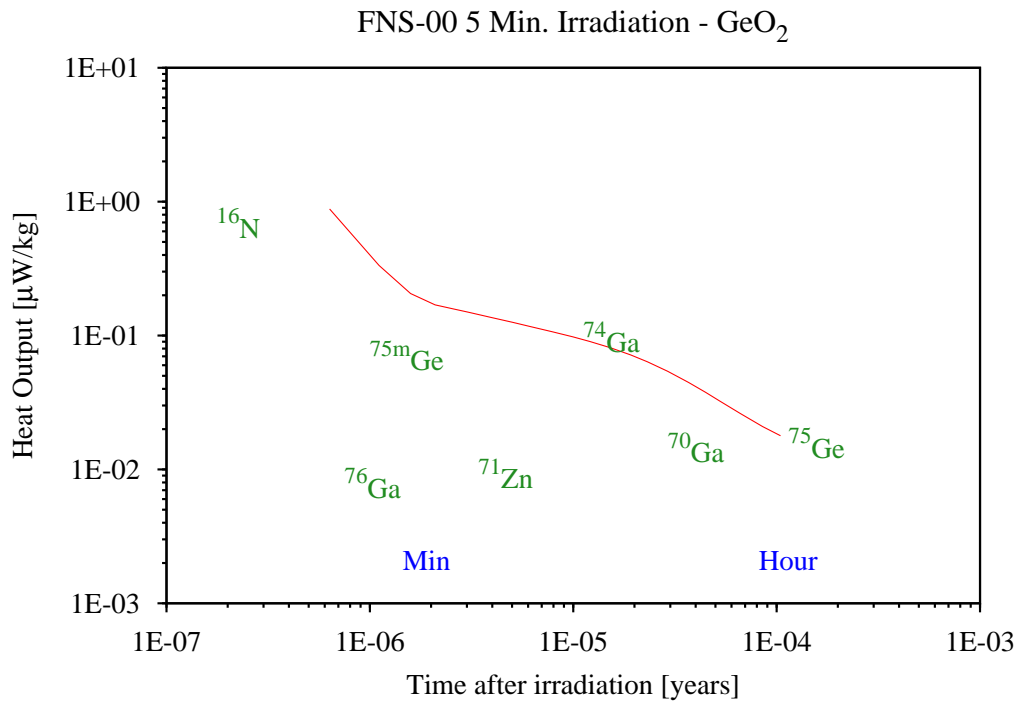
FNS-00 5 Min. Irradiation - GeO₂



For Germanium, it is clear that the changes made in the TENDL data on the complex routes of production of the Ge75 and Ga74 isotopes have improved the predictions.

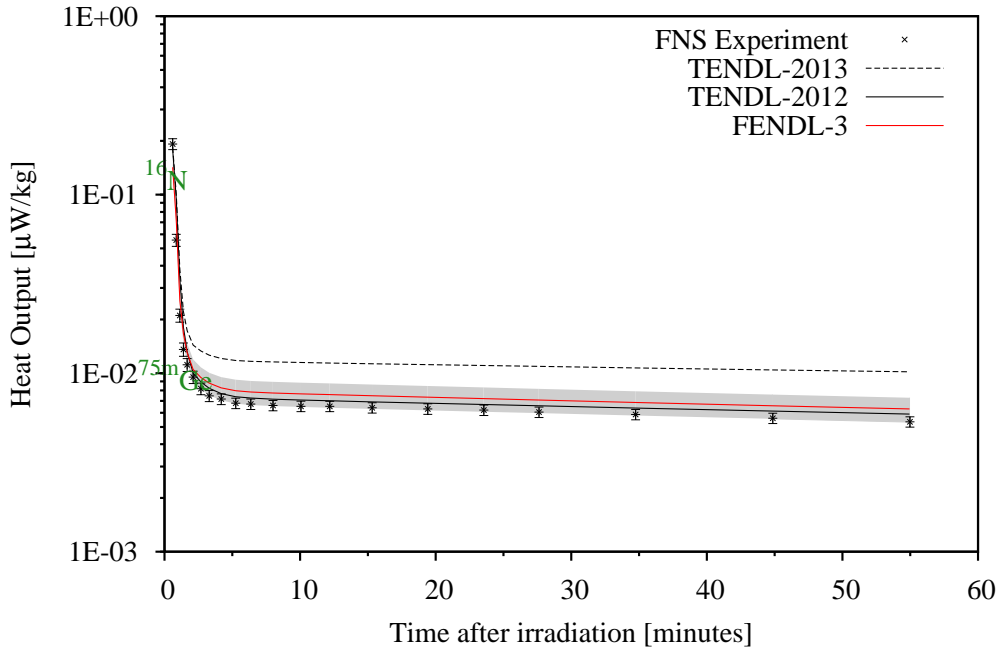
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.33 | 1.41E+00 +/-7% | 8.83E-01 +/-9% | 1.60 | 1.08E+00 | 1.31 | 1.09E+00 | 1.29 |
| 0.58 | 3.60E-01 +/-7% | 3.34E-01 +/-14% | 1.08 | 3.84E-01 | 0.94 | 3.96E-01 | 0.91 |
| 0.83 | 1.84E-01 +/-7% | 2.06E-01 +/-22% | 0.90 | 2.32E-01 | 0.79 | 2.42E-01 | 0.76 |
| 1.10 | 1.39E-01 +/-7% | 1.69E-01 +/-26% | 0.82 | 1.56E-01 | 0.90 | 1.63E-01 | 0.85 |
| 1.35 | 1.18E-01 +/-7% | 1.58E-01 +/-27% | 0.75 | 1.34E-01 | 0.88 | 1.41E-01 | 0.84 |
| 1.60 | 1.11E-01 +/-7% | 1.49E-01 +/-28% | 0.74 | 1.24E-01 | 0.89 | 1.30E-01 | 0.85 |
| 2.05 | 1.02E-01 +/-7% | 1.37E-01 +/-29% | 0.74 | 1.12E-01 | 0.91 | 1.18E-01 | 0.87 |
| 2.65 | 9.09E-02 +/-7% | 1.25E-01 +/-30% | 0.73 | 1.02E-01 | 0.89 | 1.07E-01 | 0.85 |
| 3.25 | 8.42E-02 +/-6% | 1.16E-01 +/-31% | 0.72 | 9.50E-02 | 0.89 | 9.87E-02 | 0.85 |
| 4.13 | 7.73E-02 +/-6% | 1.07E-01 +/-31% | 0.72 | 8.70E-02 | 0.89 | 9.01E-02 | 0.86 |
| 5.23 | 7.21E-02 +/-6% | 9.77E-02 +/-31% | 0.74 | 7.94E-02 | 0.91 | 8.21E-02 | 0.88 |
| 6.33 | 6.69E-02 +/-6% | 9.04E-02 +/-30% | 0.74 | 7.35E-02 | 0.91 | 7.58E-02 | 0.88 |
| 7.97 | 6.09E-02 +/-6% | 8.14E-02 +/-29% | 0.75 | 6.64E-02 | 0.92 | 6.81E-02 | 0.89 |
| 10.07 | 5.47E-02 +/-6% | 7.17E-02 +/-28% | 0.76 | 5.91E-02 | 0.93 | 6.04E-02 | 0.91 |
| 12.17 | 4.96E-02 +/-6% | 6.37E-02 +/-26% | 0.78 | 5.29E-02 | 0.94 | 5.43E-02 | 0.91 |
| 15.30 | 4.32E-02 +/-7% | 5.41E-02 +/-24% | 0.80 | 4.57E-02 | 0.94 | 4.68E-02 | 0.92 |
| 19.40 | 3.62E-02 +/-7% | 4.46E-02 +/-21% | 0.81 | 3.83E-02 | 0.94 | 3.91E-02 | 0.93 |
| 23.50 | 3.15E-02 +/-7% | 3.76E-02 +/-18% | 0.84 | 3.26E-02 | 0.97 | 3.33E-02 | 0.95 |
| 27.62 | 2.78E-02 +/-7% | 3.24E-02 +/-16% | 0.86 | 2.83E-02 | 0.98 | 2.90E-02 | 0.96 |
| 34.75 | 2.34E-02 +/-7% | 2.62E-02 +/-14% | 0.89 | 2.31E-02 | 1.01 | 2.39E-02 | 0.98 |
| 44.85 | 1.91E-02 +/-7% | 2.09E-02 +/-12% | 0.91 | 1.87E-02 | 1.02 | 1.94E-02 | 0.98 |
| 54.92 | 1.63E-02 +/-7% | 1.78E-02 +/-13% | 0.91 | 1.61E-02 | 1.01 | 1.68E-02 | 0.97 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-----------------|------------------|--------|------|-----|
| Ge75m | Ge76(n,2n)Ge75m | 47.7s | 98.4 | 0.76 | 7% |
| | Ge76(n,g)Ge75m | | 0.5 | 0.76 | 7% |
| Ga74 | Ge74(n,p)Ga74 | 8.1m | 71.8 | 0.89 | 6% |
| | Ge74(n,p)Ga74m | 9.5s | 28.1 | 0.89 | 6% |
| Ge75 | Ge76(n,2n)Ge75 | 1.3h | 40.1 | 0.97 | 7% |
| | Ge76(n,2n)Ge75m | 47.7s | 59.2 | 0.97 | 7% |
| | Ge76(n,g)Ge75 | | 0.6 | 0.97 | 7% |



Arsenic

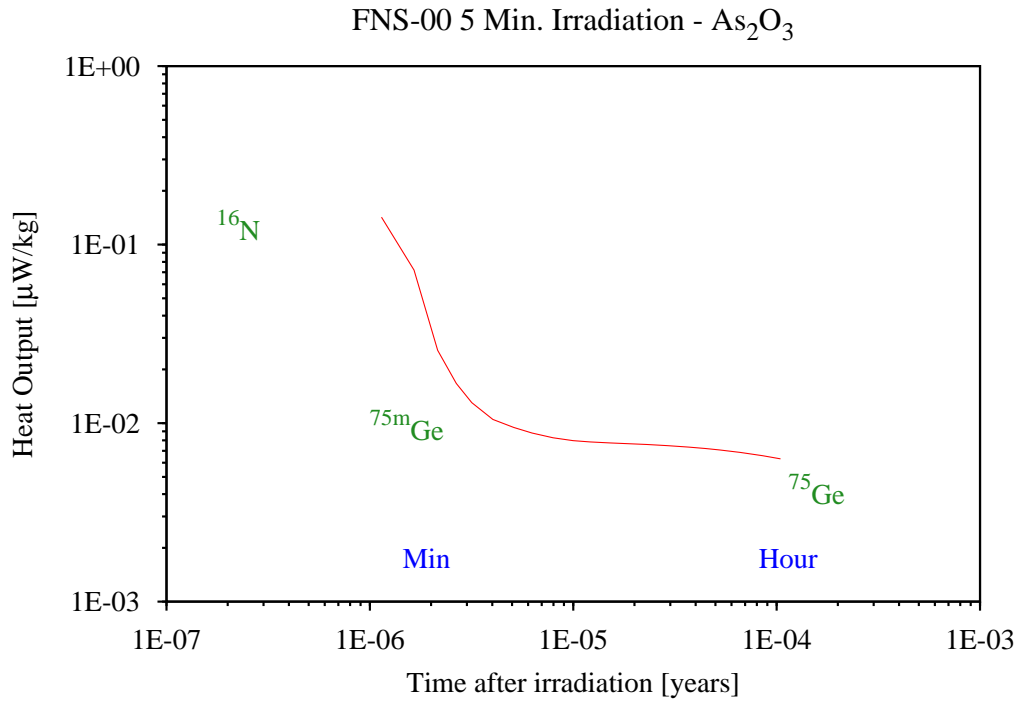
FNS-00 5 Min. Irradiation - As₂O₃



For Arsenic, the same isotope as for the germanium decay heat, Ge75, dominates, but this time produced through different paths. FENDL-3.0, TENDL-2012 leads to significantly better results than TENDL-2013.

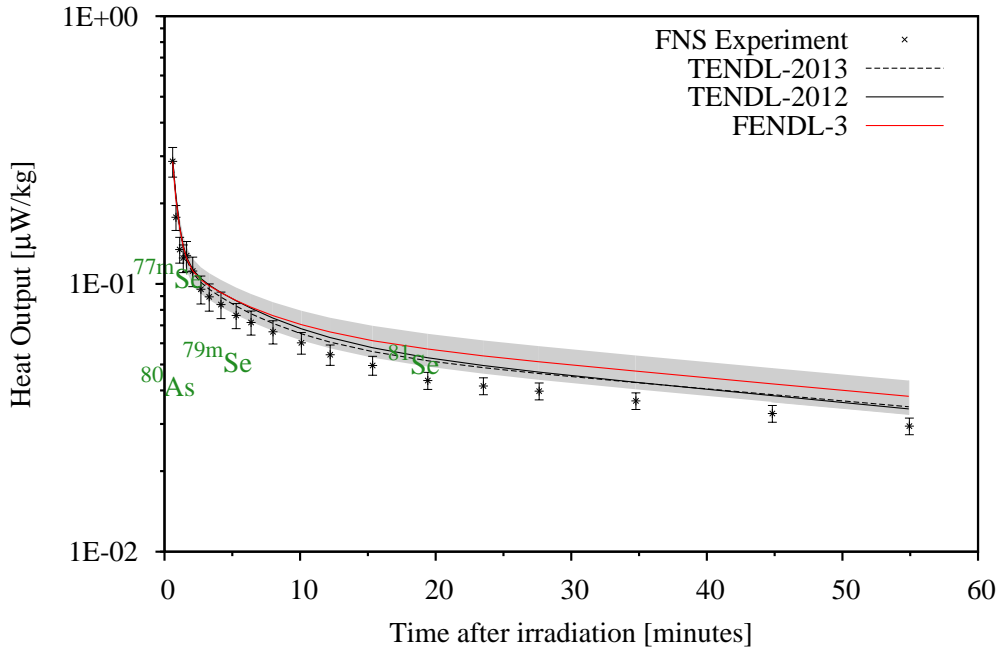
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 1.92E-01 +/-7% | 1.43E-01 +/-9% | 1.35 | 1.79E-01 | 1.07 | 1.84E-01 | 1.04 |
| 0.87 | 5.56E-02 +/-8% | 7.21E-02 +/-9% | 0.77 | 9.47E-02 | 0.59 | 1.01E-01 | 0.55 |
| 1.13 | 2.11E-02 +/-8% | 2.56E-02 +/-10% | 0.82 | 3.37E-02 | 0.63 | 3.83E-02 | 0.55 |
| 1.40 | 1.36E-02 +/-9% | 1.67E-02 +/-12% | 0.82 | 1.80E-02 | 0.75 | 2.21E-02 | 0.61 |
| 1.67 | 1.12E-02 +/-8% | 1.30E-02 +/-13% | 0.86 | 1.32E-02 | 0.85 | 1.73E-02 | 0.64 |
| 2.12 | 9.50E-03 +/-8% | 1.05E-02 +/-14% | 0.91 | 1.00E-02 | 0.95 | 1.44E-02 | 0.66 |
| 2.68 | 8.19E-03 +/-8% | 9.46E-03 +/-14% | 0.87 | 8.94E-03 | 0.92 | 1.33E-02 | 0.62 |
| 3.30 | 7.47E-03 +/-7% | 8.79E-03 +/-14% | 0.85 | 8.23E-03 | 0.91 | 1.26E-02 | 0.59 |
| 4.18 | 7.16E-03 +/-7% | 8.27E-03 +/-15% | 0.87 | 7.68E-03 | 0.93 | 1.21E-02 | 0.59 |
| 5.25 | 6.79E-03 +/-7% | 7.98E-03 +/-15% | 0.85 | 7.38E-03 | 0.92 | 1.18E-02 | 0.58 |
| 6.37 | 6.71E-03 +/-7% | 7.84E-03 +/-15% | 0.86 | 7.26E-03 | 0.92 | 1.16E-02 | 0.58 |
| 8.00 | 6.60E-03 +/-7% | 7.75E-03 +/-16% | 0.85 | 7.16E-03 | 0.92 | 1.16E-02 | 0.57 |
| 10.07 | 6.53E-03 +/-7% | 7.66E-03 +/-16% | 0.85 | 7.08E-03 | 0.92 | 1.15E-02 | 0.57 |
| 12.18 | 6.52E-03 +/-7% | 7.58E-03 +/-16% | 0.86 | 7.01E-03 | 0.93 | 1.14E-02 | 0.57 |
| 15.32 | 6.40E-03 +/-7% | 7.47E-03 +/-16% | 0.86 | 6.91E-03 | 0.93 | 1.13E-02 | 0.57 |
| 19.42 | 6.31E-03 +/-7% | 7.33E-03 +/-16% | 0.86 | 6.79E-03 | 0.93 | 1.12E-02 | 0.57 |
| 23.55 | 6.21E-03 +/-7% | 7.20E-03 +/-16% | 0.86 | 6.68E-03 | 0.93 | 1.10E-02 | 0.56 |
| 27.62 | 6.06E-03 +/-7% | 7.07E-03 +/-16% | 0.86 | 6.57E-03 | 0.92 | 1.09E-02 | 0.55 |
| 34.75 | 5.87E-03 +/-7% | 6.85E-03 +/-16% | 0.86 | 6.38E-03 | 0.92 | 1.07E-02 | 0.55 |
| 44.87 | 5.60E-03 +/-7% | 6.57E-03 +/-16% | 0.85 | 6.13E-03 | 0.91 | 1.04E-02 | 0.54 |
| 54.98 | 5.34E-03 +/-7% | 6.30E-03 +/-16% | 0.85 | 5.90E-03 | 0.91 | 1.02E-02 | 0.53 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|----------------|------------------|--------|------|-----|
| Ge75m | As75(n,p)Ge75m | 47.7s | 100.0 | 0.55 | 8% |
| Ge75 | As75(n,p)Ge75 | 1.3h | 47.3 | 0.53 | 6% |
| | As75(n,p)Ge75m | 47.7s | 52.8 | 0.53 | 6% |



Selenium

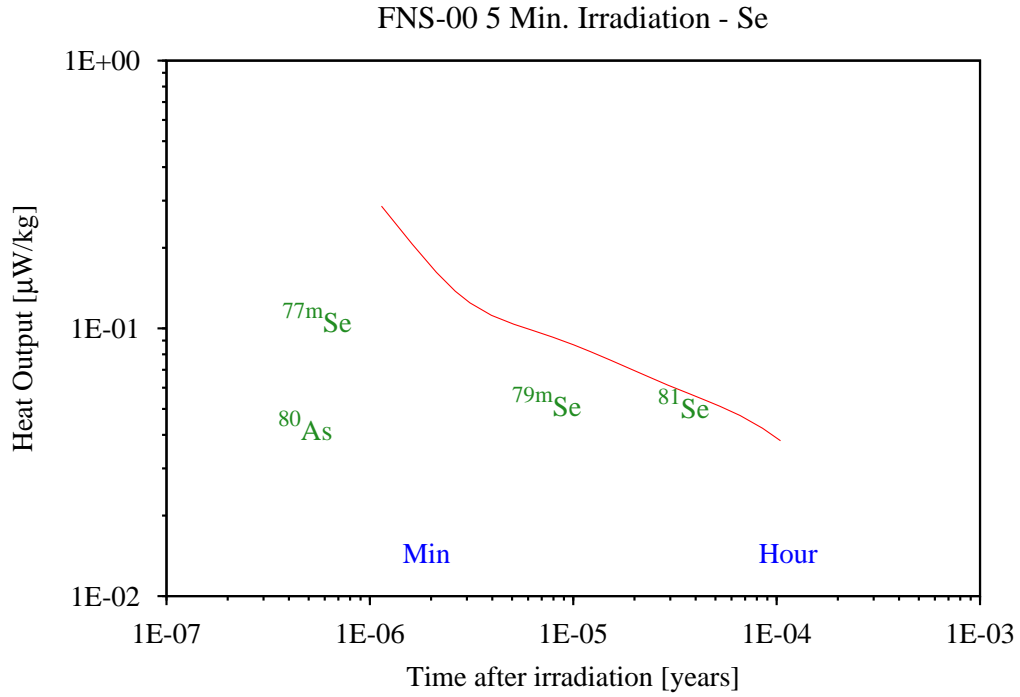
FNS-00 5 Min. Irradiation - Se



For Selenium, a complex set of pathways influence the decay heat arising from this element. The code predictions are just outside the quoted experimental uncertainties. Metastable isomers dominate at short cooling times.

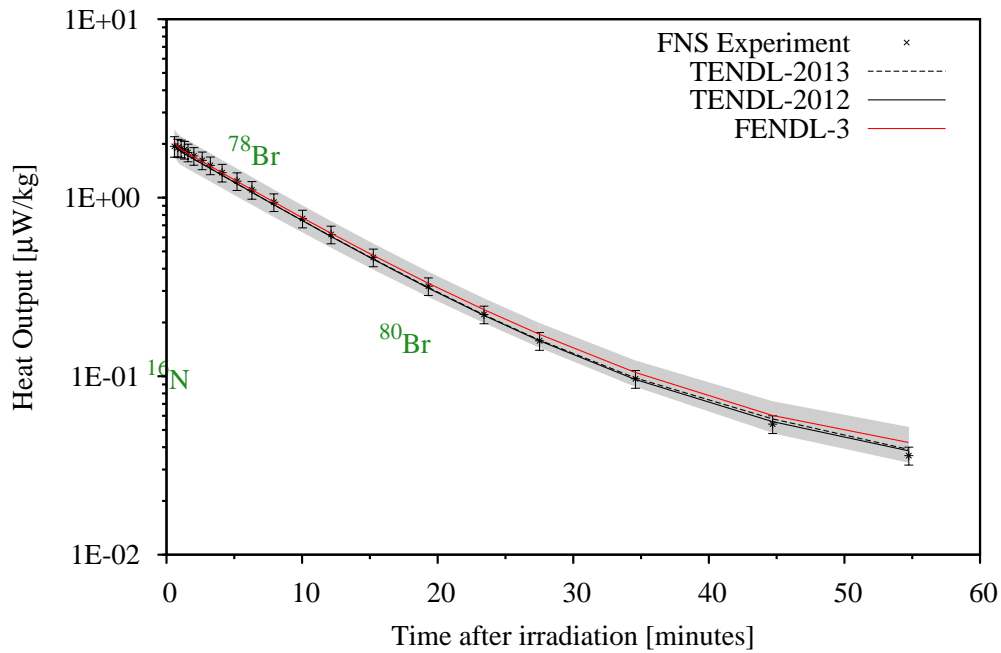
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 2.87E-01 +/-13% | 2.86E-01 +/-10% | 1.00 | 2.93E-01 | 0.98 | 2.93E-01 | 0.98 |
| 0.85 | 1.77E-01 +/-11% | 2.06E-01 +/-9% | 0.86 | 2.11E-01 | 0.84 | 2.10E-01 | 0.85 |
| 1.12 | 1.34E-01 +/-11% | 1.62E-01 +/-9% | 0.83 | 1.64E-01 | 0.82 | 1.62E-01 | 0.83 |
| 1.38 | 1.25E-01 +/-12% | 1.38E-01 +/-10% | 0.91 | 1.39E-01 | 0.90 | 1.36E-01 | 0.92 |
| 1.63 | 1.28E-01 +/-13% | 1.24E-01 +/-10% | 1.02 | 1.26E-01 | 1.01 | 1.23E-01 | 1.04 |
| 2.08 | 1.12E-01 +/-13% | 1.12E-01 +/-11% | 1.00 | 1.13E-01 | 0.99 | 1.10E-01 | 1.02 |
| 2.68 | 9.56E-02 +/-12% | 1.04E-01 +/-11% | 0.92 | 1.05E-01 | 0.91 | 1.01E-01 | 0.94 |
| 3.30 | 8.95E-02 +/-12% | 9.85E-02 +/-11% | 0.91 | 9.91E-02 | 0.90 | 9.55E-02 | 0.94 |
| 4.17 | 8.37E-02 +/-11% | 9.28E-02 +/-12% | 0.90 | 9.29E-02 | 0.90 | 8.93E-02 | 0.94 |
| 5.28 | 7.63E-02 +/-11% | 8.68E-02 +/-12% | 0.88 | 8.65E-02 | 0.88 | 8.27E-02 | 0.92 |
| 6.38 | 7.18E-02 +/-10% | 8.19E-02 +/-12% | 0.88 | 8.12E-02 | 0.88 | 7.74E-02 | 0.93 |
| 8.00 | 6.63E-02 +/-10% | 7.62E-02 +/-12% | 0.87 | 7.46E-02 | 0.89 | 7.12E-02 | 0.93 |
| 10.10 | 6.03E-02 +/-9% | 7.05E-02 +/-13% | 0.86 | 6.80E-02 | 0.89 | 6.51E-02 | 0.92 |
| 12.22 | 5.44E-02 +/-9% | 6.61E-02 +/-13% | 0.82 | 6.31E-02 | 0.86 | 6.07E-02 | 0.90 |
| 15.35 | 4.96E-02 +/-8% | 6.14E-02 +/-14% | 0.81 | 5.78E-02 | 0.86 | 5.59E-02 | 0.89 |
| 19.42 | 4.36E-02 +/-7% | 5.71E-02 +/-14% | 0.76 | 5.30E-02 | 0.82 | 5.17E-02 | 0.84 |
| 23.52 | 4.16E-02 +/-7% | 5.39E-02 +/-14% | 0.77 | 4.96E-02 | 0.84 | 4.87E-02 | 0.85 |
| 27.63 | 3.98E-02 +/-7% | 5.12E-02 +/-14% | 0.78 | 4.69E-02 | 0.85 | 4.63E-02 | 0.86 |
| 34.77 | 3.66E-02 +/-7% | 4.73E-02 +/-14% | 0.77 | 4.29E-02 | 0.85 | 4.28E-02 | 0.85 |
| 44.83 | 3.28E-02 +/-7% | 4.24E-02 +/-14% | 0.77 | 3.83E-02 | 0.86 | 3.86E-02 | 0.85 |
| 54.93 | 2.95E-02 +/-7% | 3.81E-02 +/-14% | 0.77 | 3.42E-02 | 0.86 | 3.48E-02 | 0.85 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-----------------|------------------|--------|------|-----|
| Se77m | Se77(n,n')Se77m | 17.3s | 12.4 | 0.98 | 13% |
| | Se78(n,2n)Se77m | | 86.9 | 0.98 | 13% |
| | Se78(n,g)Se77m | | 0.7 | 0.98 | 13% |
| Se81 | Se80(n,γ)Se81 | 18.45m | 2.4 | 0.84 | 7% |
| | Se82(n,2n)Se81 | 57.2m | 91.2 | 0.84 | 7% |
| | Se82(n,2n)Se81m | | 6.3 | 0.84 | 7% |



Bromine

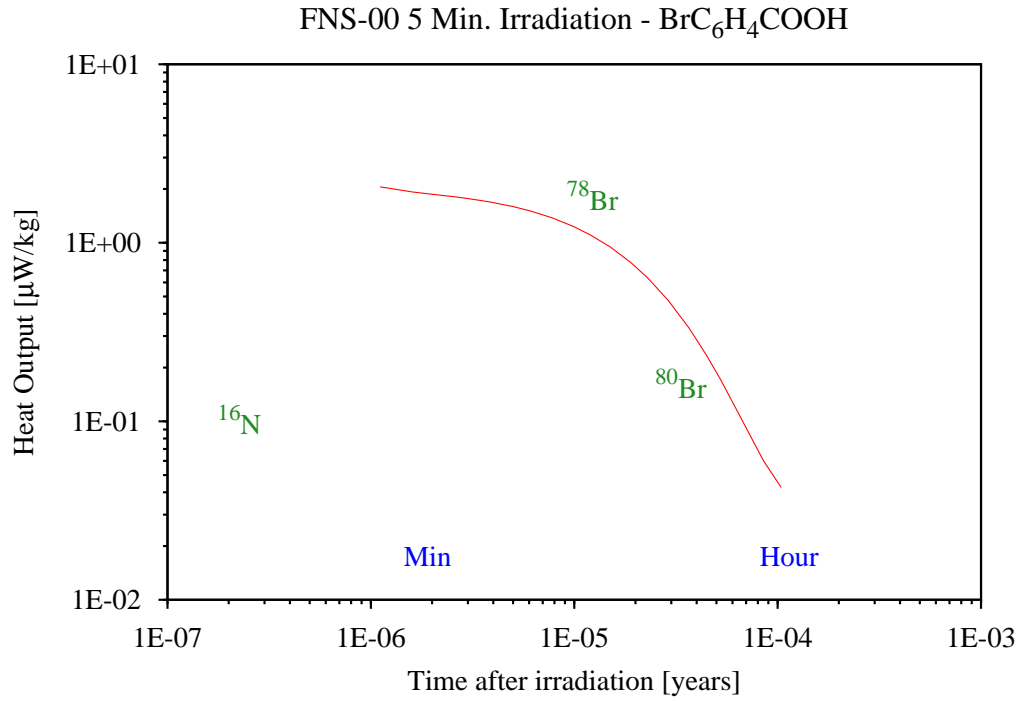
FNS-00 5 Min. Irradiation - BrC₆H₄COOH



For Bromine, the above picture not only shows a near perfect match in term of experimental and calculated values, but also, and quite uniquely, excellent agreement between the experimental and calculational uncertainties, even at cooling times as small as 30 seconds.

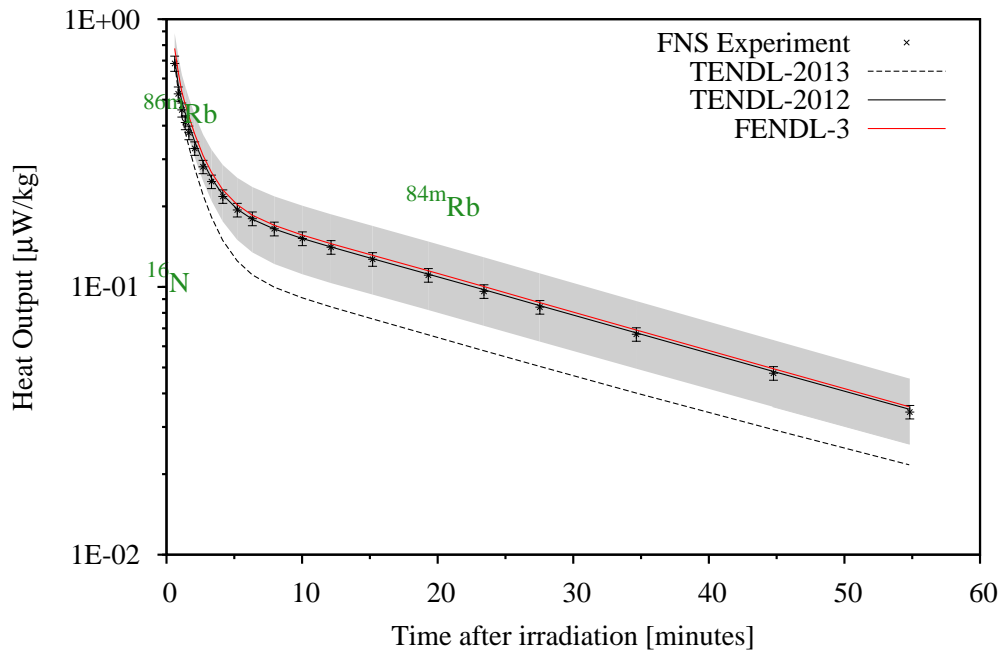
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.58 | 1.94E+00 +/-13% | 2.06E+00 +/-17% | 0.94 | 2.01E+00 | 0.96 | 2.00E+00 | 0.97 |
| 0.83 | 1.91E+00 +/-11% | 1.93E+00 +/-18% | 0.99 | 1.88E+00 | 1.02 | 1.87E+00 | 1.02 |
| 1.08 | 1.89E+00 +/-11% | 1.86E+00 +/-18% | 1.01 | 1.82E+00 | 1.04 | 1.81E+00 | 1.04 |
| 1.33 | 1.85E+00 +/-11% | 1.81E+00 +/-18% | 1.02 | 1.77E+00 | 1.05 | 1.76E+00 | 1.05 |
| 1.58 | 1.79E+00 +/-11% | 1.77E+00 +/-18% | 1.01 | 1.72E+00 | 1.04 | 1.72E+00 | 1.04 |
| 2.02 | 1.71E+00 +/-11% | 1.69E+00 +/-18% | 1.01 | 1.65E+00 | 1.04 | 1.64E+00 | 1.04 |
| 2.63 | 1.62E+00 +/-11% | 1.59E+00 +/-18% | 1.01 | 1.55E+00 | 1.04 | 1.55E+00 | 1.05 |
| 3.23 | 1.52E+00 +/-11% | 1.50E+00 +/-18% | 1.01 | 1.46E+00 | 1.04 | 1.46E+00 | 1.04 |
| 4.10 | 1.38E+00 +/-11% | 1.38E+00 +/-18% | 1.00 | 1.34E+00 | 1.03 | 1.33E+00 | 1.04 |
| 5.20 | 1.24E+00 +/-11% | 1.24E+00 +/-18% | 1.00 | 1.20E+00 | 1.03 | 1.20E+00 | 1.04 |
| 6.30 | 1.11E+00 +/-11% | 1.11E+00 +/-18% | 1.00 | 1.07E+00 | 1.03 | 1.07E+00 | 1.03 |
| 7.92 | 9.44E-01 +/-11% | 9.46E-01 +/-18% | 1.00 | 9.14E-01 | 1.03 | 9.14E-01 | 1.03 |
| 10.03 | 7.64E-01 +/-11% | 7.71E-01 +/-17% | 0.99 | 7.43E-01 | 1.03 | 7.44E-01 | 1.03 |
| 12.13 | 6.23E-01 +/-11% | 6.32E-01 +/-17% | 0.98 | 6.07E-01 | 1.03 | 6.09E-01 | 1.02 |
| 15.25 | 4.63E-01 +/-11% | 4.75E-01 +/-17% | 0.98 | 4.52E-01 | 1.02 | 4.54E-01 | 1.02 |
| 19.32 | 3.19E-01 +/-11% | 3.32E-01 +/-16% | 0.96 | 3.12E-01 | 1.02 | 3.14E-01 | 1.02 |
| 23.42 | 2.22E-01 +/-11% | 2.36E-01 +/-16% | 0.94 | 2.19E-01 | 1.01 | 2.21E-01 | 1.00 |
| 27.52 | 1.58E-01 +/-11% | 1.72E-01 +/-16% | 0.92 | 1.58E-01 | 1.00 | 1.60E-01 | 0.99 |
| 34.58 | 9.66E-02 +/-11% | 1.05E-01 +/-17% | 0.92 | 9.59E-02 | 1.01 | 9.79E-02 | 0.99 |
| 44.70 | 5.39E-02 +/-11% | 6.03E-02 +/-20% | 0.89 | 5.57E-02 | 0.97 | 5.77E-02 | 0.93 |
| 54.75 | 3.59E-02 +/-11% | 4.25E-02 +/-22% | 0.84 | 3.82E-02 | 0.94 | 3.89E-02 | 0.92 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-----------------|------------------|--------|------|-----|
| Br78 | Br79(n,2n)Br78 | 6.46m | 99.8 | 1.03 | 11% |
| Br80 | Br79(n,γ)Br80 | 17.6m | 7.9 | 1.02 | 11% |
| | Br81(n,2n)Br80 | | 90.9 | 1.02 | 11% |
| | Br81(n,2n)Br80m | | 1.1 | 1.02 | 11% |



Rubidium

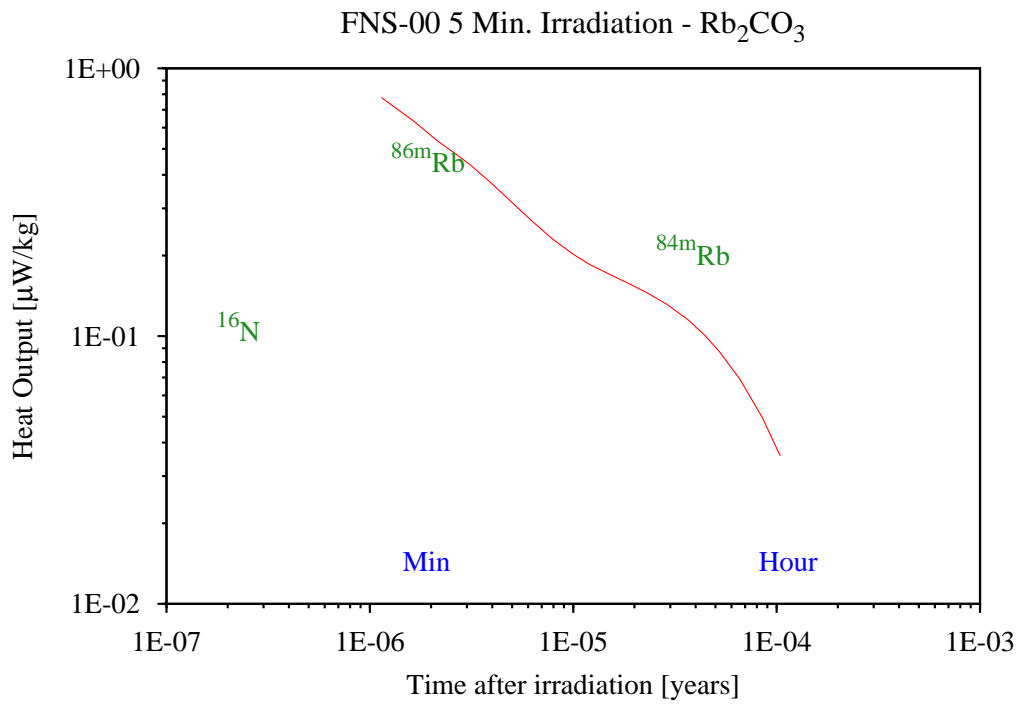
FNS-00 5 Min. Irradiation - Rb₂CO₃



Rubidium: FENDL-3.0 and TENDL-2012 perform better than TENDL-2013. The graph also shows a clean validation of the two paths leading to metastable isomers.

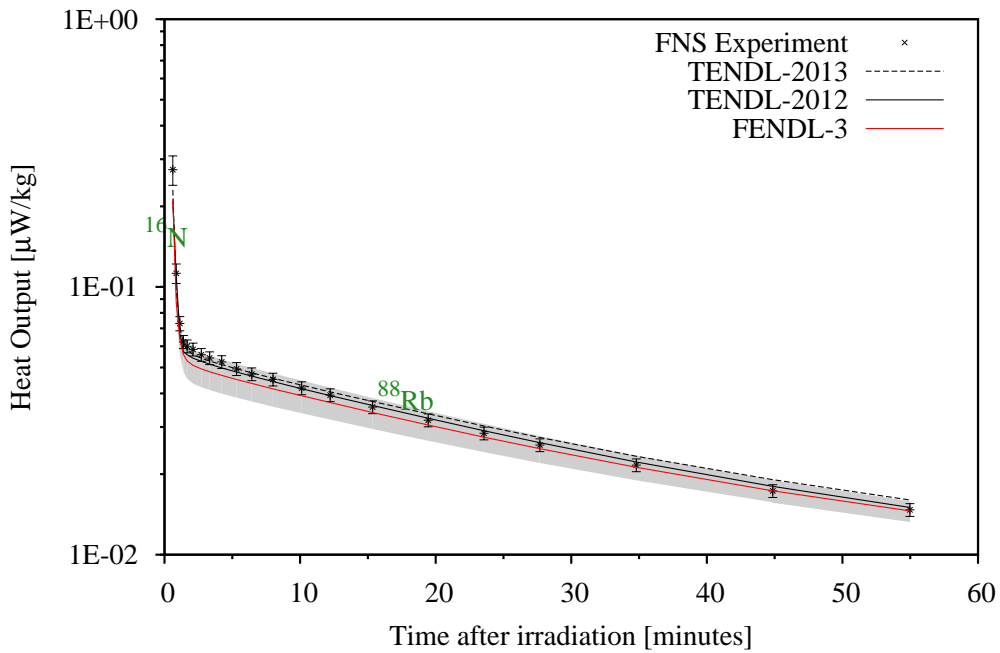
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|------------------|------|------------|------|------------|------|
| 0.60 | 6.83E-01 +/--7% | 7.77E-01 +/--14% | 0.88 | 7.12E-01 | 0.96 | 6.85E-01 | 1.00 |
| 0.87 | 5.26E-01 +/--6% | 6.34E-01 +/--15% | 0.83 | 5.69E-01 | 0.92 | 5.39E-01 | 0.98 |
| 1.13 | 4.58E-01 +/--6% | 5.35E-01 +/--16% | 0.86 | 4.94E-01 | 0.93 | 4.32E-01 | 1.06 |
| 1.38 | 4.11E-01 +/--6% | 4.80E-01 +/--17% | 0.86 | 4.46E-01 | 0.92 | 3.78E-01 | 1.09 |
| 1.65 | 3.77E-01 +/--6% | 4.34E-01 +/--17% | 0.87 | 4.04E-01 | 0.93 | 3.34E-01 | 1.13 |
| 2.08 | 3.29E-01 +/--6% | 3.72E-01 +/--18% | 0.88 | 3.49E-01 | 0.94 | 2.77E-01 | 1.19 |
| 2.70 | 2.81E-01 +/--6% | 3.10E-01 +/--20% | 0.91 | 2.93E-01 | 0.96 | 2.20E-01 | 1.28 |
| 3.32 | 2.47E-01 +/--6% | 2.68E-01 +/--22% | 0.92 | 2.55E-01 | 0.97 | 1.82E-01 | 1.36 |
| 4.15 | 2.18E-01 +/--6% | 2.31E-01 +/--24% | 0.94 | 2.21E-01 | 0.99 | 1.49E-01 | 1.46 |
| 5.22 | 1.94E-01 +/--6% | 2.03E-01 +/--26% | 0.96 | 1.95E-01 | 0.99 | 1.25E-01 | 1.55 |
| 6.33 | 1.80E-01 +/--6% | 1.85E-01 +/--27% | 0.97 | 1.79E-01 | 1.01 | 1.11E-01 | 1.62 |
| 7.95 | 1.65E-01 +/--6% | 1.70E-01 +/--28% | 0.97 | 1.64E-01 | 1.00 | 9.98E-02 | 1.65 |
| 10.02 | 1.52E-01 +/--6% | 1.56E-01 +/--29% | 0.97 | 1.52E-01 | 1.00 | 9.11E-02 | 1.66 |
| 12.13 | 1.41E-01 +/--6% | 1.45E-01 +/--29% | 0.97 | 1.41E-01 | 1.00 | 8.42E-02 | 1.67 |
| 15.20 | 1.27E-01 +/--6% | 1.31E-01 +/--29% | 0.97 | 1.28E-01 | 0.99 | 7.60E-02 | 1.67 |
| 19.32 | 1.11E-01 +/--6% | 1.15E-01 +/--29% | 0.96 | 1.12E-01 | 0.99 | 6.63E-02 | 1.67 |
| 23.42 | 9.62E-02 +/--6% | 1.00E-01 +/--29% | 0.96 | 9.77E-02 | 0.98 | 5.78E-02 | 1.67 |
| 27.53 | 8.40E-02 +/--6% | 8.75E-02 +/--29% | 0.96 | 8.52E-02 | 0.99 | 5.05E-02 | 1.66 |
| 34.65 | 6.65E-02 +/--6% | 6.91E-02 +/--28% | 0.96 | 6.74E-02 | 0.99 | 4.02E-02 | 1.66 |
| 44.77 | 4.76E-02 +/--6% | 4.95E-02 +/--28% | 0.96 | 4.84E-02 | 0.98 | 2.93E-02 | 1.62 |
| 54.82 | 3.41E-02 +/--6% | 3.57E-02 +/--27% | 0.96 | 3.50E-02 | 0.98 | 2.17E-02 | 1.57 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|-----------------|------------------|--------|---------|
| Rb86m | Rb85(n,γ)Rb86m | 1.0m | 0.7 | 1.06 6% |
| | Rb87(n,2n)Rb86m | | 99.3 | 1.06 6% |
| Rb84 | Rb85(n,2n)Rb84m | 20.4m | 100.0 | 1.67 6% |

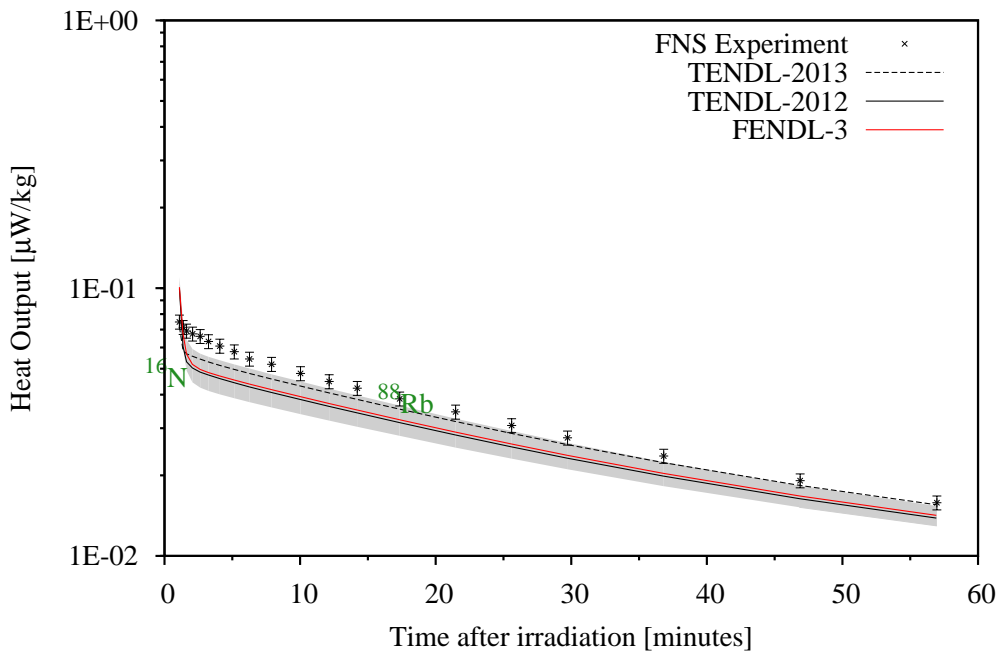


Strontium

FNS-00 5 Min. Irradiation - SrCO₃



FNS-96 5 Min. Irradiation - SrCO₃

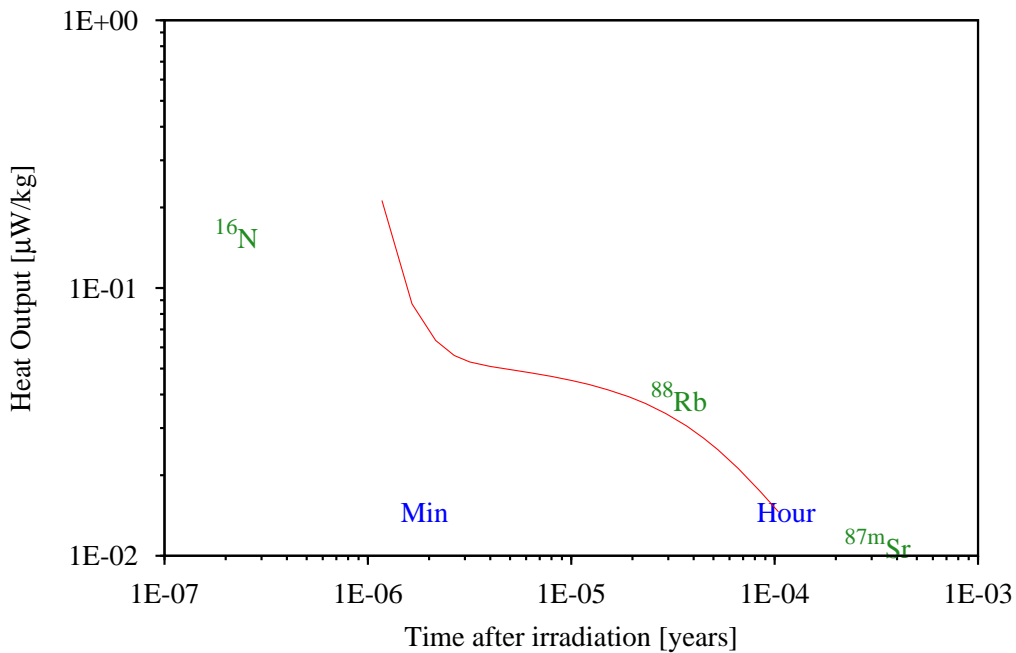


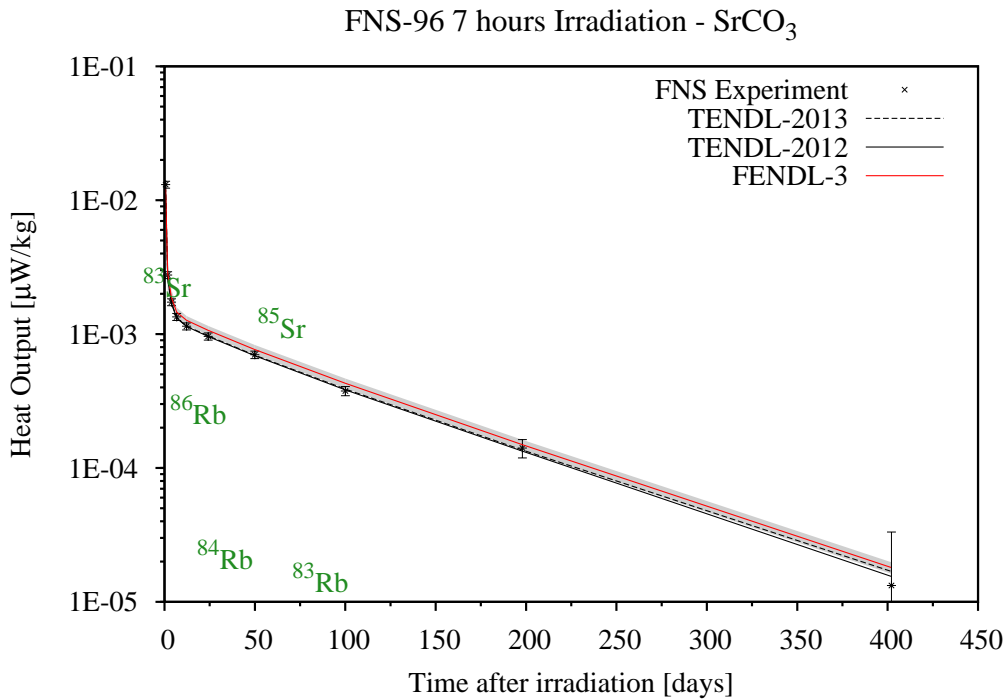
For Strontium, the two experimental measurement sets differ significantly, although the experiment data from 2000 lead to a remarkable agreement with the simulation.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C TENDL-2012 | E/C TENDL-2013 | E/C | | |
|-------|---------------------|---------------------|----------------|----------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.62 | $2.74E-01 \pm 13\%$ | $2.12E-01 \pm 8\%$ | 1.29 | $2.07E-01$ | 1.32 | $2.30E-01$ | 1.19 |
| 0.87 | $1.12E-01 \pm 8\%$ | $8.72E-02 \pm 10\%$ | 1.29 | $1.10E-01$ | 1.02 | $9.65E-02$ | 1.16 |
| 1.13 | $7.30E-02 \pm 6\%$ | $6.37E-02 \pm 12\%$ | 1.15 | $6.69E-02$ | 1.09 | $7.08E-02$ | 1.03 |
| 1.40 | $6.23E-02 \pm 6\%$ | $5.60E-02 \pm 14\%$ | 1.11 | $5.74E-02$ | 1.09 | $6.18E-02$ | 1.01 |
| 1.67 | $6.00E-02 \pm 6\%$ | $5.29E-02 \pm 14\%$ | 1.13 | $5.58E-02$ | 1.08 | $5.83E-02$ | 1.03 |
| 2.10 | $5.85E-02 \pm 6\%$ | $5.10E-02 \pm 14\%$ | 1.15 | $5.42E-02$ | 1.08 | $5.59E-02$ | 1.05 |
| 2.72 | $5.58E-02 \pm 6\%$ | $4.94E-02 \pm 15\%$ | 1.13 | $5.27E-02$ | 1.06 | $5.42E-02$ | 1.03 |
| 3.33 | $5.42E-02 \pm 6\%$ | $4.82E-02 \pm 15\%$ | 1.12 | $5.14E-02$ | 1.05 | $5.29E-02$ | 1.03 |
| 4.22 | $5.25E-02 \pm 6\%$ | $4.68E-02 \pm 15\%$ | 1.12 | $4.98E-02$ | 1.05 | $5.13E-02$ | 1.02 |
| 5.32 | $4.94E-02 \pm 6\%$ | $4.51E-02 \pm 14\%$ | 1.09 | $4.81E-02$ | 1.03 | $4.94E-02$ | 1.00 |
| 6.43 | $4.73E-02 \pm 6\%$ | $4.36E-02 \pm 14\%$ | 1.08 | $4.64E-02$ | 1.02 | $4.78E-02$ | 0.99 |
| 8.00 | $4.51E-02 \pm 5\%$ | $4.16E-02 \pm 14\%$ | 1.08 | $4.43E-02$ | 1.02 | $4.56E-02$ | 0.99 |
| 10.12 | $4.19E-02 \pm 5\%$ | $3.92E-02 \pm 14\%$ | 1.07 | $4.17E-02$ | 1.01 | $4.30E-02$ | 0.97 |
| 12.22 | $3.94E-02 \pm 5\%$ | $3.70E-02 \pm 14\%$ | 1.07 | $3.93E-02$ | 1.00 | $4.06E-02$ | 0.97 |
| 15.35 | $3.56E-02 \pm 5\%$ | $3.40E-02 \pm 13\%$ | 1.05 | $3.61E-02$ | 0.99 | $3.73E-02$ | 0.95 |
| 19.45 | $3.18E-02 \pm 5\%$ | $3.05E-02 \pm 13\%$ | 1.04 | $3.23E-02$ | 0.98 | $3.36E-02$ | 0.95 |
| 23.57 | $2.84E-02 \pm 5\%$ | $2.75E-02 \pm 12\%$ | 1.03 | $2.91E-02$ | 0.98 | $3.03E-02$ | 0.94 |
| 27.68 | $2.57E-02 \pm 5\%$ | $2.49E-02 \pm 12\%$ | 1.03 | $2.62E-02$ | 0.98 | $2.74E-02$ | 0.94 |
| 34.80 | $2.16E-02 \pm 5\%$ | $2.12E-02 \pm 11\%$ | 1.02 | $2.22E-02$ | 0.97 | $2.33E-02$ | 0.93 |
| 44.87 | $1.73E-02 \pm 5\%$ | $1.73E-02 \pm 9\%$ | 1.00 | $1.80E-02$ | 0.96 | $1.91E-02$ | 0.91 |
| 54.98 | $1.47E-02 \pm 5\%$ | $1.46E-02 \pm 9\%$ | 1.01 | $1.50E-02$ | 0.98 | $1.60E-02$ | 0.92 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C $\Delta E\%$ |
|---------|---------------|-----------|--------|------------------|
| Rb88 | Sr88(n,p)Rb88 | 17.8m | 99.9 | 0.95 5% |

FNS-00 5 Min. Irradiation - SrCO₃

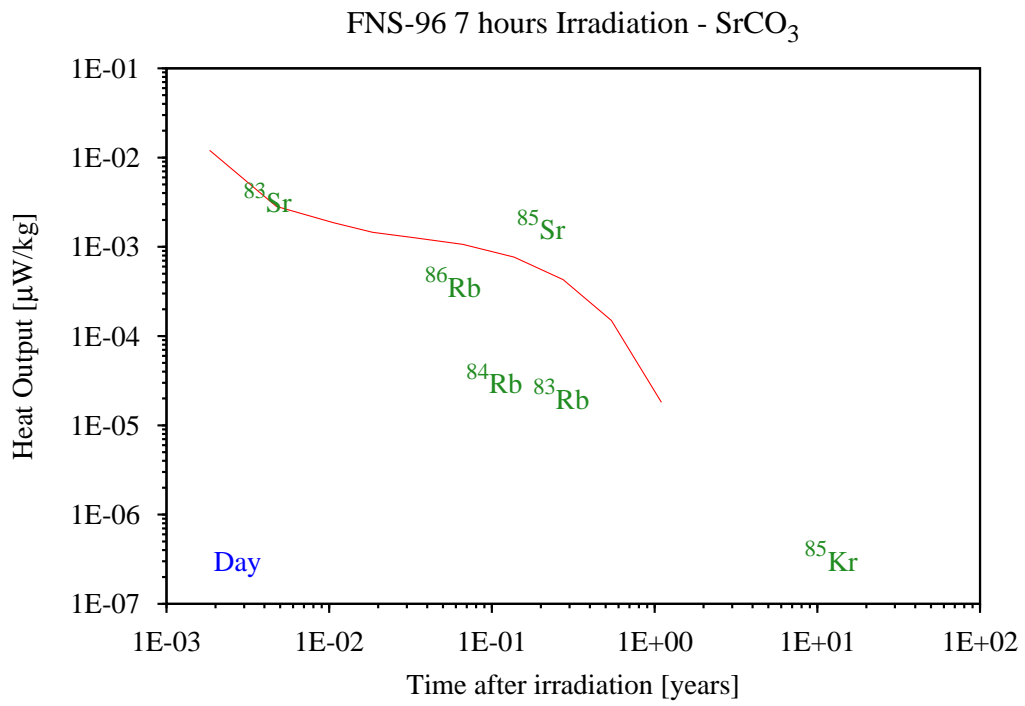




The above picture shows an unequivocal, near perfect agreement on the heat arising from complex pathways.

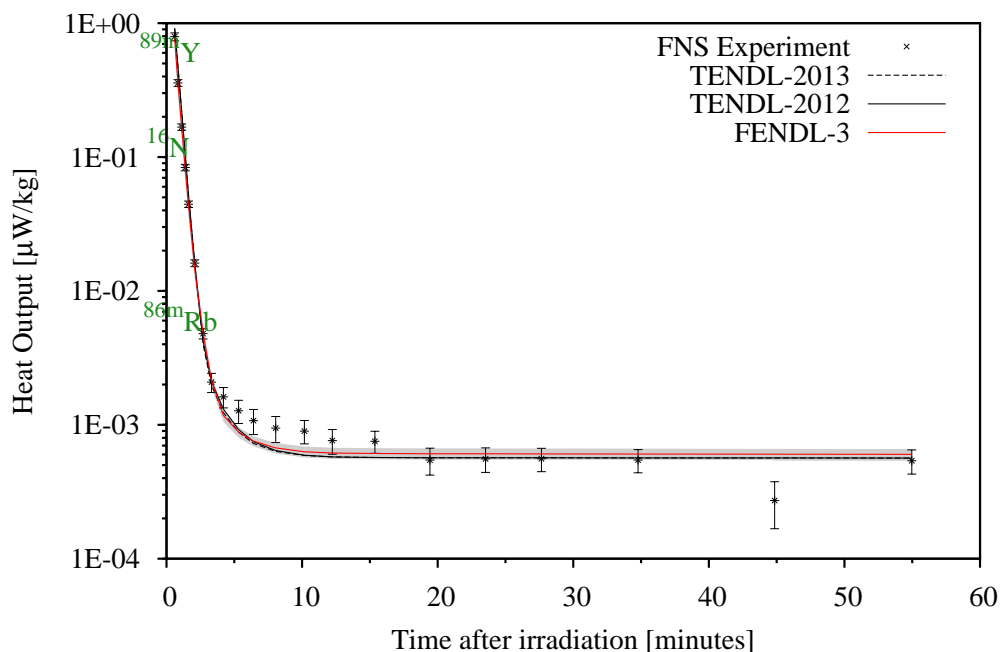
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|-----------------|------|------------|------|------------|------|
| 0.67 | 1.31E-02 +/-6% | 1.21E-02 +/-13% | 1.08 | 1.18E-02 | 1.10 | 1.28E-02 | 1.02 |
| 1.73 | 2.76E-03 +/-6% | 2.84E-03 +/-28% | 0.97 | 2.59E-03 | 1.06 | 2.62E-03 | 1.05 |
| 3.88 | 1.73E-03 +/-6% | 1.87E-03 +/-15% | 0.93 | 1.69E-03 | 1.02 | 1.71E-03 | 1.01 |
| 6.75 | 1.34E-03 +/-6% | 1.46E-03 +/-8% | 0.92 | 1.32E-03 | 1.02 | 1.32E-03 | 1.02 |
| 12.19 | 1.14E-03 +/-6% | 1.27E-03 +/-8% | 0.90 | 1.14E-03 | 1.00 | 1.15E-03 | 1.00 |
| 24.20 | 9.61E-04 +/-6% | 1.07E-03 +/-8% | 0.90 | 9.60E-04 | 1.00 | 9.71E-04 | 0.99 |
| 49.95 | 7.01E-04 +/-6% | 7.67E-04 +/-8% | 0.91 | 6.89E-04 | 1.02 | 6.96E-04 | 1.01 |
| 100.08 | 3.76E-04 +/-8% | 4.29E-04 +/-8% | 0.88 | 3.84E-04 | 0.98 | 3.89E-04 | 0.97 |
| 197.95 | 1.41E-04 +/-16% | 1.50E-04 +/-9% | 0.94 | 1.34E-04 | 1.05 | 1.36E-04 | 1.03 |
| 402.15 | 1.33E-05 +/-151% | 1.81E-05 +/-9% | 0.73 | 1.55E-05 | 0.85 | 1.69E-05 | 0.78 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-----------------|------------------|--------|------|-----|
| Sr83 | Sr84(n,2n)Sr83 | 1.3d | 86.1 | 1.05 | 6% |
| | Sr84(n,2n)Sr83m | | 13.9 | 1.05 | 6% |
| Sr85 | Sr86(n,2n)Sr85 | 64.8d | 81.5 | 0.97 | 8% |
| | Sr86(n,2n)Sr85m | | 18.5 | 0.97 | 8% |

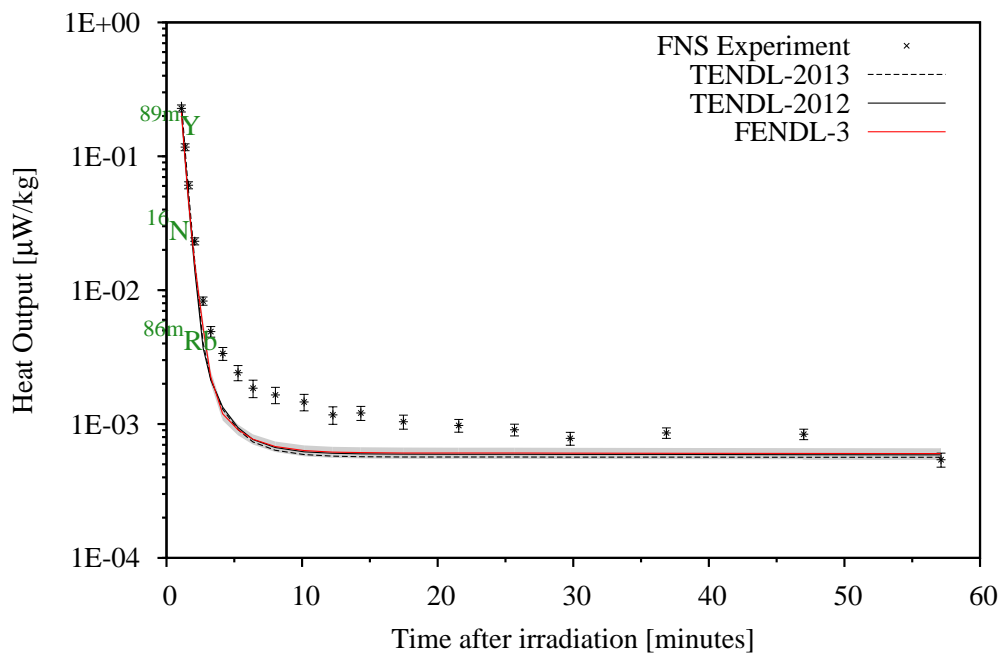


Yttrium

FNS-00 5 Min. Irradiation - Y_2O_3



FNS-96 5 Min. Irradiation - Y_2O_3

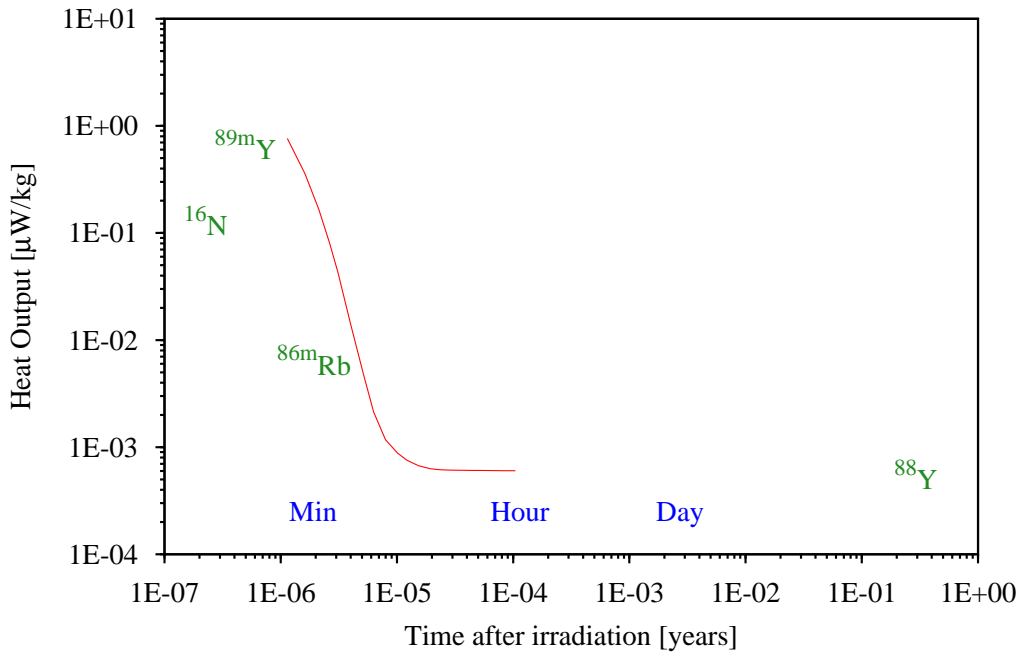


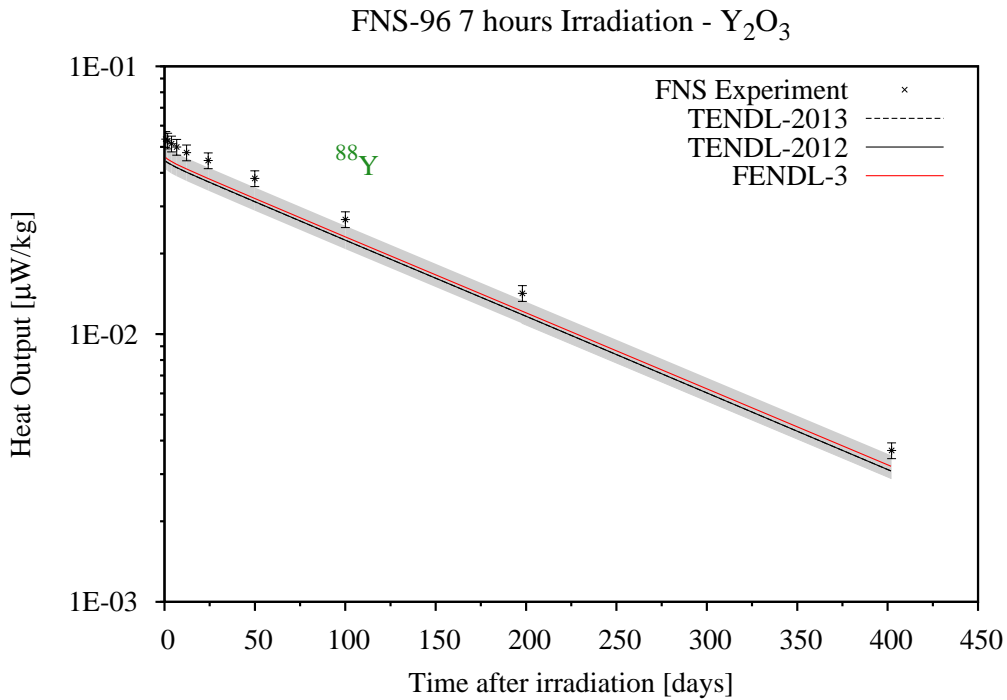
For Yttrium, here again the two experimental data sets differ significantly and the more recent one is accompanied by some rather high uncertainty levels.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|---------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.60 | $7.92E-01 \pm 7\%$ | $7.64E-01 \pm 17\%$ | 1.04 | $9.18E-01$ | 0.86 | $9.08E-01$ | 0.87 |
| 0.85 | $3.58E-01 \pm 6\%$ | $3.58E-01 \pm 18\%$ | 1.00 | $4.74E-01$ | 0.75 | $4.69E-01$ | 0.76 |
| 1.12 | $1.68E-01 \pm 6\%$ | $1.67E-01 \pm 19\%$ | 1.00 | $2.20E-01$ | 0.76 | $2.17E-01$ | 0.77 |
| 1.38 | $8.35E-02 \pm 6\%$ | $8.12E-02 \pm 19\%$ | 1.03 | $1.04E-01$ | 0.80 | $1.02E-01$ | 0.82 |
| 1.63 | $4.44E-02 \pm 6\%$ | $4.29E-02 \pm 18\%$ | 1.03 | $5.16E-02$ | 0.86 | $5.06E-02$ | 0.88 |
| 2.08 | $1.61E-02 \pm 6\%$ | $1.45E-02 \pm 16\%$ | 1.11 | $1.63E-02$ | 0.99 | $1.58E-02$ | 1.02 |
| 2.70 | $4.80E-03 \pm 9\%$ | $4.85E-03 \pm 13\%$ | 0.99 | $4.22E-03$ | 1.14 | $4.00E-03$ | 1.20 |
| 3.32 | $2.08E-03 \pm 16\%$ | $2.14E-03 \pm 11\%$ | 0.98 | $2.10E-03$ | 0.99 | $1.97E-03$ | 1.06 |
| 4.20 | $1.62E-03 \pm 17\%$ | $1.17E-03 \pm 10\%$ | 1.38 | $1.31E-03$ | 1.23 | $1.23E-03$ | 1.31 |
| 5.32 | $1.27E-03 \pm 20\%$ | $8.81E-04 \pm 9\%$ | 1.44 | $9.22E-04$ | 1.38 | $8.82E-04$ | 1.44 |
| 6.42 | $1.07E-03 \pm 21\%$ | $7.54E-04 \pm 9\%$ | 1.42 | $7.47E-04$ | 1.44 | $7.26E-04$ | 1.48 |
| 8.05 | $9.46E-04 \pm 22\%$ | $6.72E-04 \pm 9\%$ | 1.41 | $6.43E-04$ | 1.47 | $6.34E-04$ | 1.49 |
| 10.17 | $8.98E-04 \pm 20\%$ | $6.30E-04 \pm 9\%$ | 1.43 | $5.93E-04$ | 1.51 | $5.90E-04$ | 1.52 |
| 12.23 | $7.62E-04 \pm 21\%$ | $6.16E-04 \pm 10\%$ | 1.24 | $5.76E-04$ | 1.32 | $5.75E-04$ | 1.33 |
| 15.37 | $7.54E-04 \pm 19\%$ | $6.10E-04 \pm 10\%$ | 1.23 | $5.70E-04$ | 1.32 | $5.69E-04$ | 1.32 |
| 19.43 | $5.45E-04 \pm 23\%$ | $6.08E-04 \pm 10\%$ | 0.90 | $5.67E-04$ | 0.96 | $5.67E-04$ | 0.96 |
| 23.53 | $5.56E-04 \pm 21\%$ | $6.07E-04 \pm 10\%$ | 0.92 | $5.67E-04$ | 0.98 | $5.67E-04$ | 0.98 |
| 27.65 | $5.57E-04 \pm 20\%$ | $6.07E-04 \pm 10\%$ | 0.92 | $5.67E-04$ | 0.98 | $5.67E-04$ | 0.98 |
| 34.78 | $5.45E-04 \pm 20\%$ | $6.05E-04 \pm 10\%$ | 0.90 | $5.66E-04$ | 0.96 | $5.66E-04$ | 0.96 |
| 44.85 | $2.72E-04 \pm 38\%$ | $6.04E-04 \pm 10\%$ | 0.45 | $5.65E-04$ | 0.48 | $5.65E-04$ | 0.48 |
| 54.97 | $5.39E-04 \pm 20\%$ | $6.02E-04 \pm 10\%$ | 0.89 | $5.65E-04$ | 0.95 | $5.64E-04$ | 0.95 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------------|-----------|--------|------|--------------|
| N16 | O16(n,p)N16 | 7.1s | 99.9 | 0.87 | 7% |
| Y89m | Y89(n,n')Y89m | 15.6s | 100.0 | 0.87 | 6% |
| Rb86m | Y89(n, α)Rb86m | 1.0m | 100.0 | 0.77 | 6% |
| Y88 | Y89(n,2n)Y88 | 106.6d | 100.0 | 0.95 | 20% |

FNS-00 5 Min. Irradiation - Y_2O_3

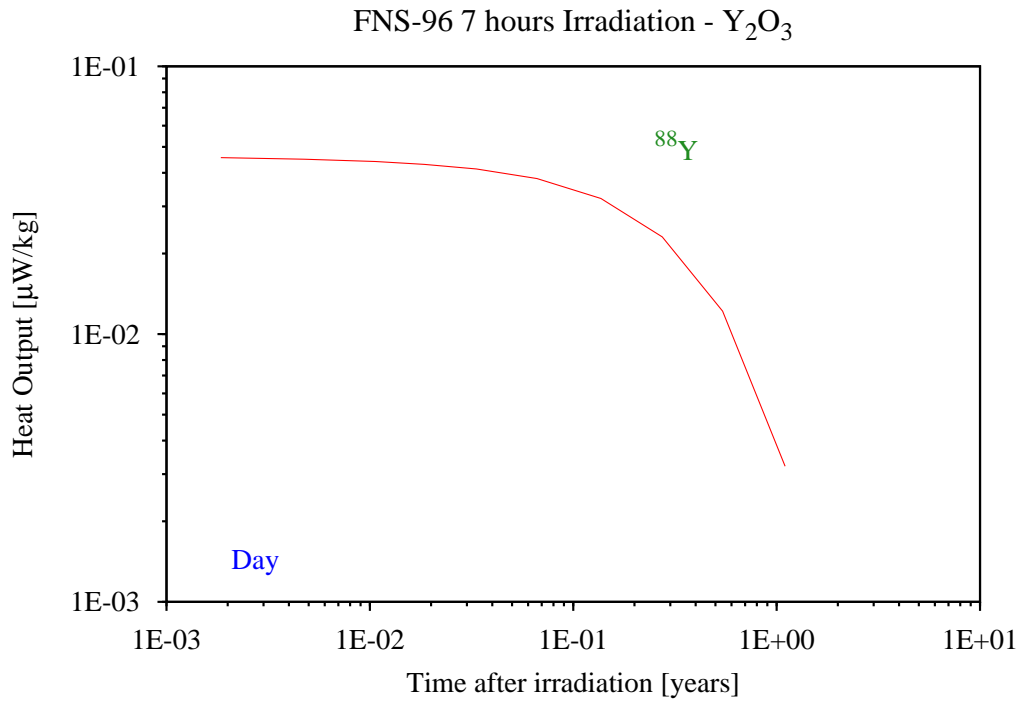




The code predictions underestimate the decay heat by around 20%, rather evenly and up to 400 days cooling. A perfect case to act on this unique pathway, although the question remains as to whether the change should be made to the cross section or decay file.

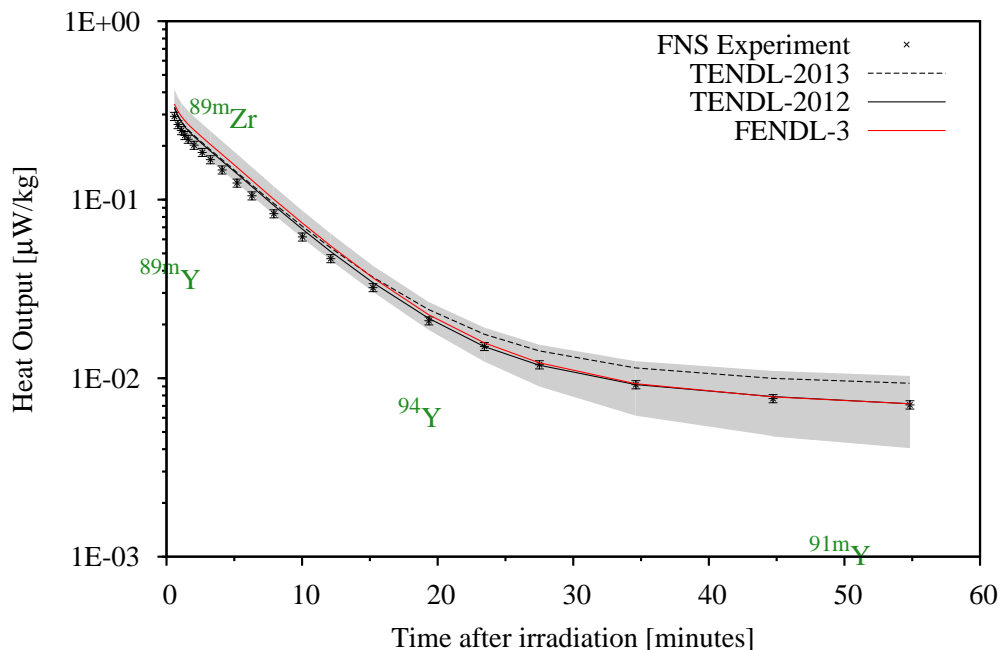
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|--------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu W/g$ | | | | | | |
| 0.68 | $5.35E-02 \pm 7\%$ | $4.56E-02 \pm 10\%$ | 1.17 | $4.42E-02$ | 1.21 | $4.42E-02$ | 1.21 |
| 1.73 | $5.27E-02 \pm 7\%$ | $4.50E-02 \pm 10\%$ | 1.17 | $4.37E-02$ | 1.21 | $4.36E-02$ | 1.21 |
| 3.89 | $5.14E-02 \pm 7\%$ | $4.41E-02 \pm 10\%$ | 1.17 | $4.29E-02$ | 1.20 | $4.28E-02$ | 1.20 |
| 6.76 | $5.00E-02 \pm 7\%$ | $4.30E-02 \pm 10\%$ | 1.16 | $4.19E-02$ | 1.19 | $4.18E-02$ | 1.19 |
| 12.20 | $4.76E-02 \pm 7\%$ | $4.14E-02 \pm 10\%$ | 1.15 | $4.02E-02$ | 1.18 | $4.02E-02$ | 1.18 |
| 24.21 | $4.45E-02 \pm 7\%$ | $3.81E-02 \pm 10\%$ | 1.17 | $3.71E-02$ | 1.20 | $3.70E-02$ | 1.20 |
| 49.96 | $3.81E-02 \pm 7\%$ | $3.21E-02 \pm 10\%$ | 1.19 | $3.12E-02$ | 1.22 | $3.12E-02$ | 1.22 |
| 100.09 | $2.68E-02 \pm 7\%$ | $2.31E-02 \pm 10\%$ | 1.16 | $2.24E-02$ | 1.19 | $2.24E-02$ | 1.19 |
| 197.96 | $1.42E-02 \pm 7\%$ | $1.22E-02 \pm 10\%$ | 1.17 | $1.18E-02$ | 1.20 | $1.18E-02$ | 1.20 |
| 402.17 | $3.67E-03 \pm 7\%$ | $3.21E-03 \pm 10\%$ | 1.14 | $3.08E-03$ | 1.19 | $3.08E-03$ | 1.19 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|--------------|-----------|--------|------|--------------|
| Y88 | Y89(n,2n)Y88 | 106d | 100.0 | 1.19 | 7% |

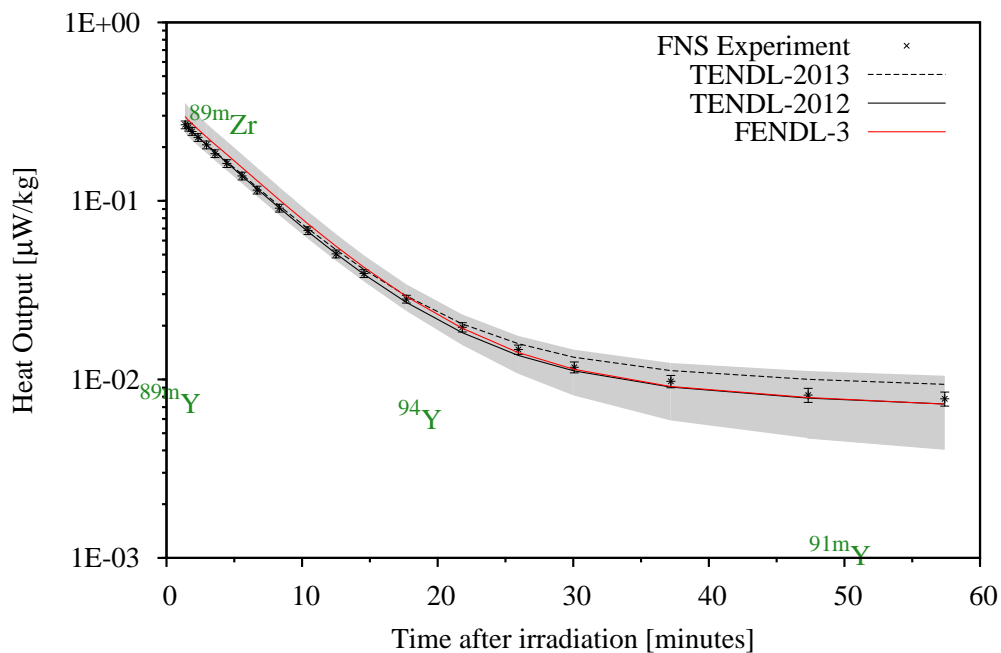


Zirconium

FNS-00 5 Min. Irradiation - Zr



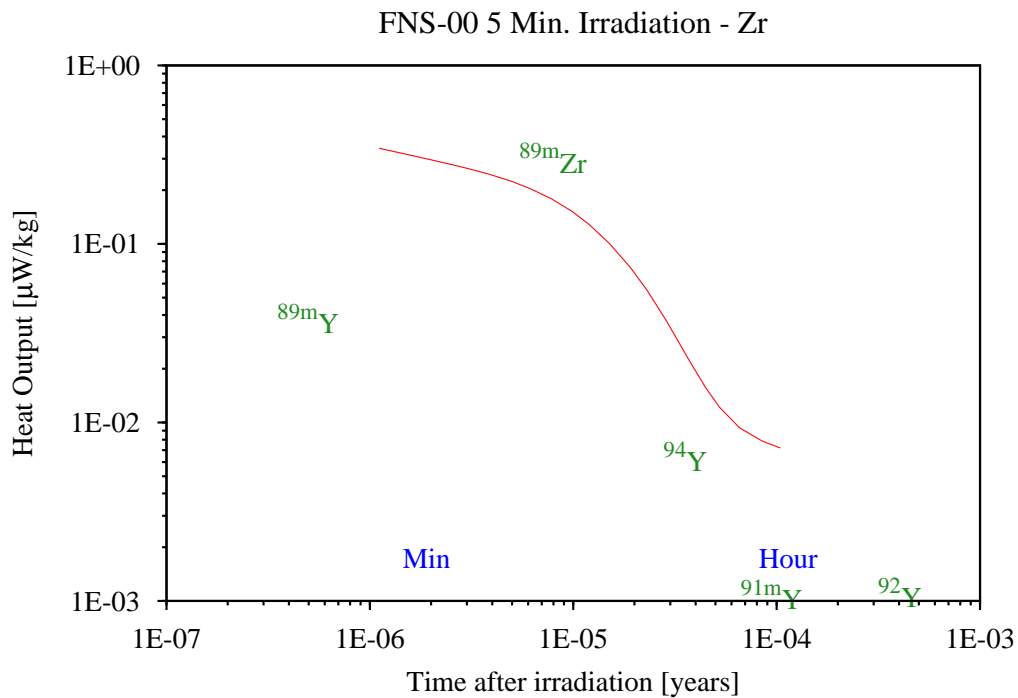
FNS-96 5 Min. Irradiation - Zr

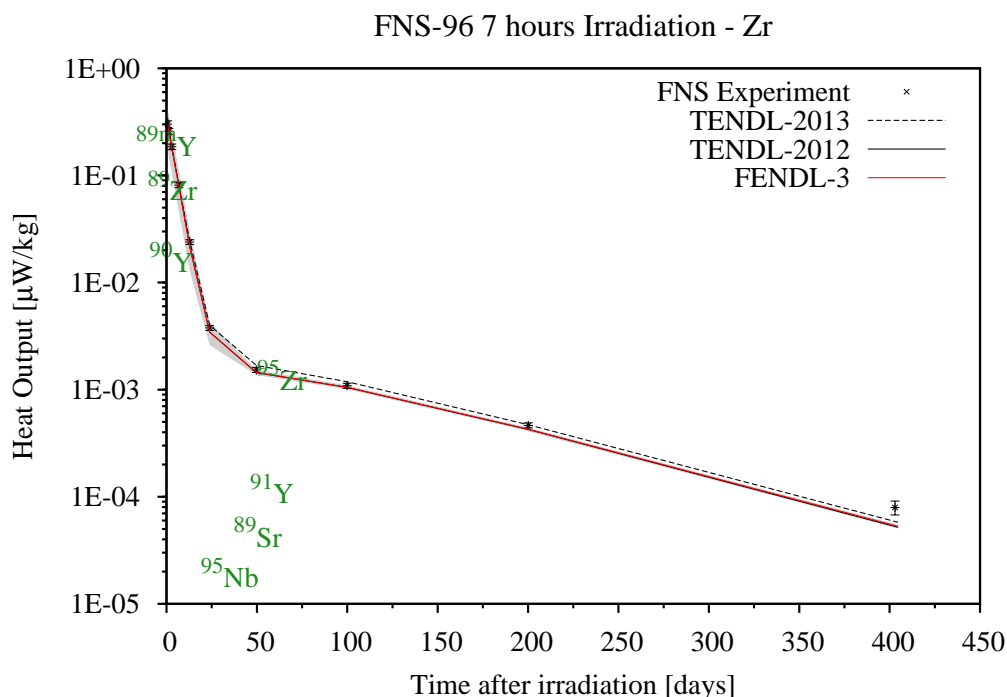


For Zirconium, a good agreement at all cooling times may be seen, when FENDL-3.0 and TENDL-2012 are used. TENDL-2013 seems to overpredict Y94 by circa 15%.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $2.93E-01 \pm 5\%$ | $3.43E-01 \pm 21\%$ | 0.85 | $3.29E-01$ | 0.89 | $3.28E-01$ | 0.89 |
| 0.85 | $2.64E-01 \pm 5\%$ | $3.12E-01 \pm 19\%$ | 0.84 | $2.94E-01$ | 0.90 | $2.95E-01$ | 0.89 |
| 1.10 | $2.44E-01 \pm 5\%$ | $2.92E-01 \pm 19\%$ | 0.83 | $2.72E-01$ | 0.90 | $2.74E-01$ | 0.89 |
| 1.35 | $2.29E-01 \pm 5\%$ | $2.77E-01 \pm 19\%$ | 0.83 | $2.56E-01$ | 0.89 | $2.59E-01$ | 0.89 |
| 1.60 | $2.18E-01 \pm 5\%$ | $2.64E-01 \pm 19\%$ | 0.82 | $2.44E-01$ | 0.90 | $2.46E-01$ | 0.88 |
| 2.03 | $2.02E-01 \pm 5\%$ | $2.46E-01 \pm 19\%$ | 0.82 | $2.26E-01$ | 0.89 | $2.29E-01$ | 0.88 |
| 2.63 | $1.84E-01 \pm 5\%$ | $2.24E-01 \pm 19\%$ | 0.82 | $2.05E-01$ | 0.90 | $2.09E-01$ | 0.88 |
| 3.23 | $1.68E-01 \pm 5\%$ | $2.04E-01 \pm 19\%$ | 0.82 | $1.87E-01$ | 0.89 | $1.90E-01$ | 0.88 |
| 4.10 | $1.47E-01 \pm 5\%$ | $1.79E-01 \pm 19\%$ | 0.82 | $1.65E-01$ | 0.89 | $1.68E-01$ | 0.88 |
| 5.20 | $1.24E-01 \pm 5\%$ | $1.52E-01 \pm 19\%$ | 0.82 | $1.40E-01$ | 0.89 | $1.42E-01$ | 0.87 |
| 6.30 | $1.05E-01 \pm 5\%$ | $1.28E-01 \pm 18\%$ | 0.82 | $1.18E-01$ | 0.89 | $1.21E-01$ | 0.87 |
| 7.92 | $8.35E-02 \pm 5\%$ | $1.01E-01 \pm 18\%$ | 0.83 | $9.29E-02$ | 0.90 | $9.54E-02$ | 0.88 |
| 10.02 | $6.19E-02 \pm 5\%$ | $7.40E-02 \pm 17\%$ | 0.84 | $6.85E-02$ | 0.90 | $7.11E-02$ | 0.87 |
| 12.12 | $4.67E-02 \pm 5\%$ | $5.52E-02 \pm 17\%$ | 0.85 | $5.12E-02$ | 0.91 | $5.38E-02$ | 0.87 |
| 15.23 | $3.22E-02 \pm 5\%$ | $3.66E-02 \pm 17\%$ | 0.88 | $3.43E-02$ | 0.94 | $3.68E-02$ | 0.87 |
| 19.35 | $2.10E-02 \pm 5\%$ | $2.27E-02 \pm 18\%$ | 0.92 | $2.16E-02$ | 0.97 | $2.42E-02$ | 0.87 |
| 23.45 | $1.51E-02 \pm 5\%$ | $1.58E-02 \pm 22\%$ | 0.95 | $1.50E-02$ | 1.00 | $1.76E-02$ | 0.85 |
| 27.50 | $1.19E-02 \pm 5\%$ | $1.22E-02 \pm 26\%$ | 0.97 | $1.18E-02$ | 1.01 | $1.42E-02$ | 0.84 |
| 34.62 | $9.20E-03 \pm 5\%$ | $9.31E-03 \pm 34\%$ | 0.99 | $9.22E-03$ | 1.00 | $1.14E-02$ | 0.81 |
| 44.73 | $7.69E-03 \pm 5\%$ | $7.86E-03 \pm 40\%$ | 0.98 | $7.88E-03$ | 0.98 | $9.98E-03$ | 0.77 |
| 54.83 | $7.09E-03 \pm 5\%$ | $7.19E-03 \pm 43\%$ | 0.99 | $7.20E-03$ | 0.99 | $9.37E-03$ | 0.76 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| Zr89m | Zr90(n,2n)Zr89m | 4.1m | 100.0 | 0.89 | 5% |
| Y94 | Zr94(n,p)Y94 | 18.7m | 100.0 | 0.87 | 5% |

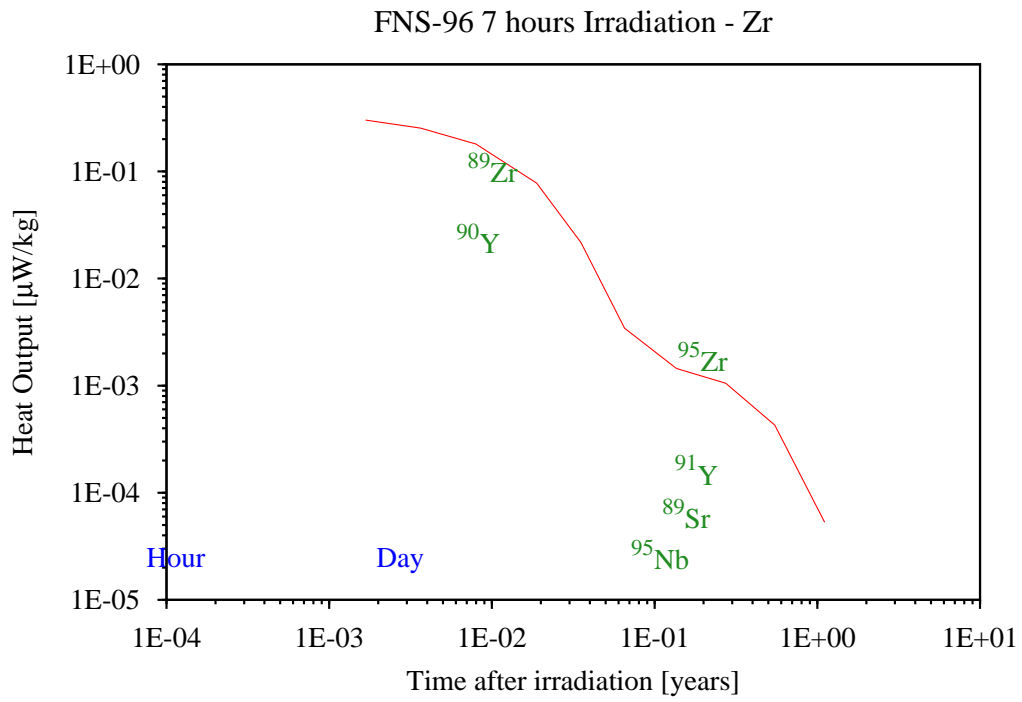




Although numerous radionuclides are present an excellent agreement exists, within the experimental uncertainty, up to a year of cooling.

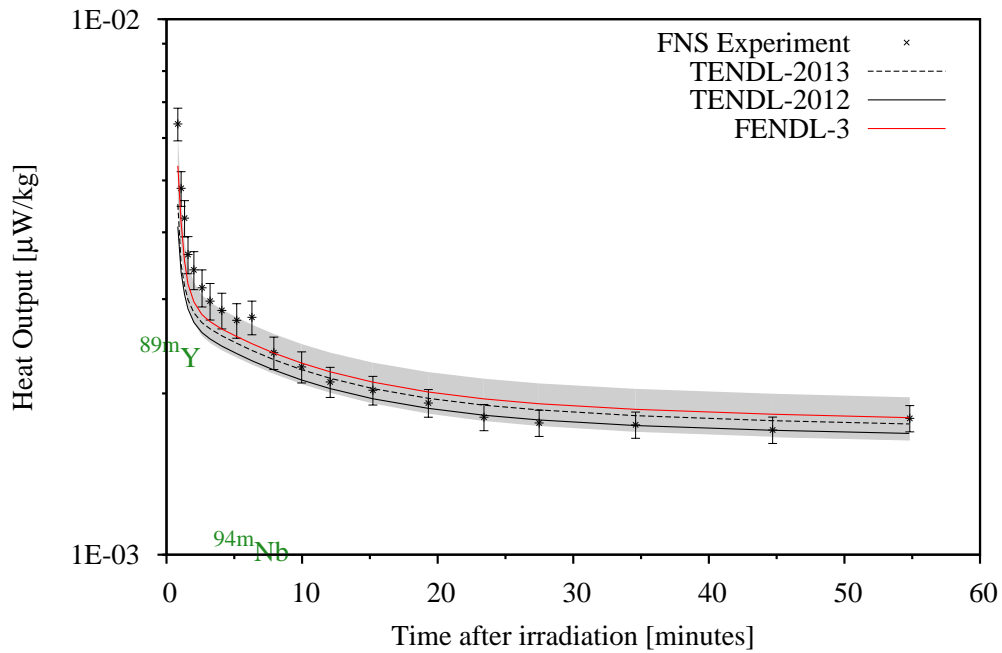
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|---------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.61 | $3.02E-01 \pm 7\%$ | $3.02E-01 \pm 41\%$ | 1.00 | $3.08E-01$ | 0.98 | $3.42E-01$ | 0.88 |
| 1.33 | $2.57E-01 \pm 7\%$ | $2.54E-01 \pm 42\%$ | 1.02 | $2.58E-01$ | 1.00 | $2.68E-01$ | 0.96 |
| 2.91 | $1.85E-01 \pm 6\%$ | $1.80E-01 \pm 42\%$ | 1.03 | $1.84E-01$ | 1.01 | $1.85E-01$ | 1.00 |
| 6.88 | $8.12E-02 \pm 5\%$ | $7.78E-02 \pm 42\%$ | 1.04 | $7.94E-02$ | 1.02 | $7.96E-02$ | 1.02 |
| 12.88 | $2.39E-02 \pm 5\%$ | $2.16E-02 \pm 40\%$ | 1.10 | $2.19E-02$ | 1.09 | $2.45E-02$ | 0.97 |
| 23.85 | $3.77E-03 \pm 5\%$ | $3.44E-03 \pm 24\%$ | 1.10 | $3.45E-03$ | 1.09 | $4.00E-03$ | 0.94 |
| 49.71 | $1.53E-03 \pm 5\%$ | $1.45E-03 \pm 5\%$ | 1.06 | $1.44E-03$ | 1.06 | $1.68E-03$ | 0.91 |
| 99.90 | $1.09E-03 \pm 5\%$ | $1.05E-03 \pm 4\%$ | 1.03 | $1.05E-03$ | 1.04 | $1.19E-03$ | 0.92 |
| 200.12 | $4.64E-04 \pm 6\%$ | $4.28E-04 \pm 4\%$ | 1.09 | $4.25E-04$ | 1.09 | $4.71E-04$ | 0.99 |
| 402.96 | $7.94E-05 \pm 15\%$ | $5.29E-05 \pm 3\%$ | 1.50 | $5.19E-05$ | 1.53 | $5.78E-05$ | 1.37 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| Zr89 | Zr90(n,2n)Zr89 | 3.2d | 83.4 | 1.00 | 6% |
| | Zr90(n,2n)Zr89m | 4.18m | 16.6 | 1.00 | 6% |
| Zr95 | Zr96(n,2n)Zr95 | 64.0d | 99.4 | 0.92 | 5% |

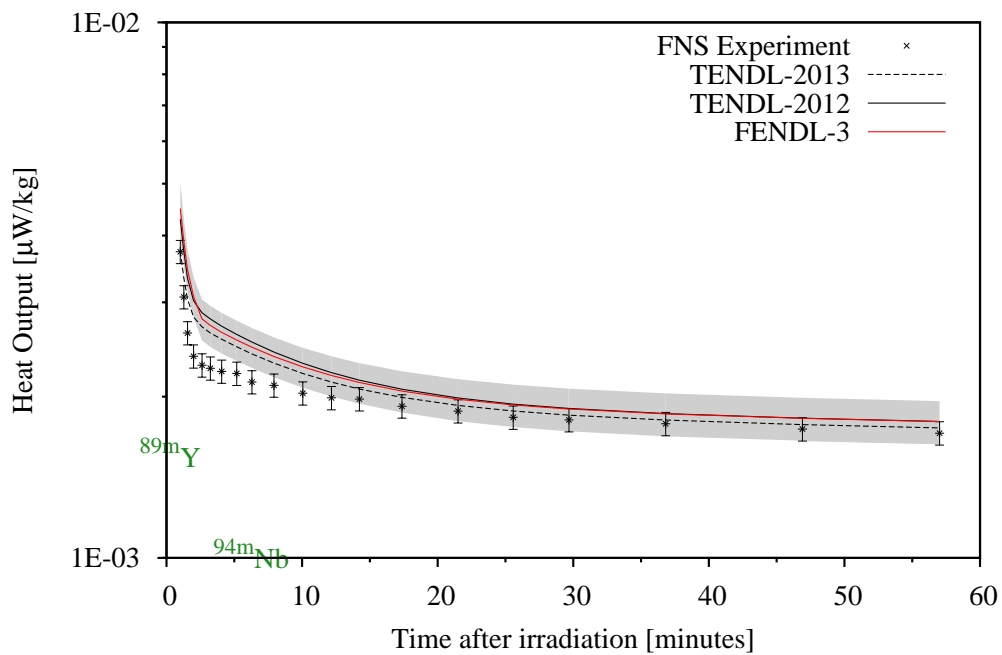


Niobium

FNS-00 5 Min. Irradiation - Nb



FNS-96 5 Min. Irradiation - Nb

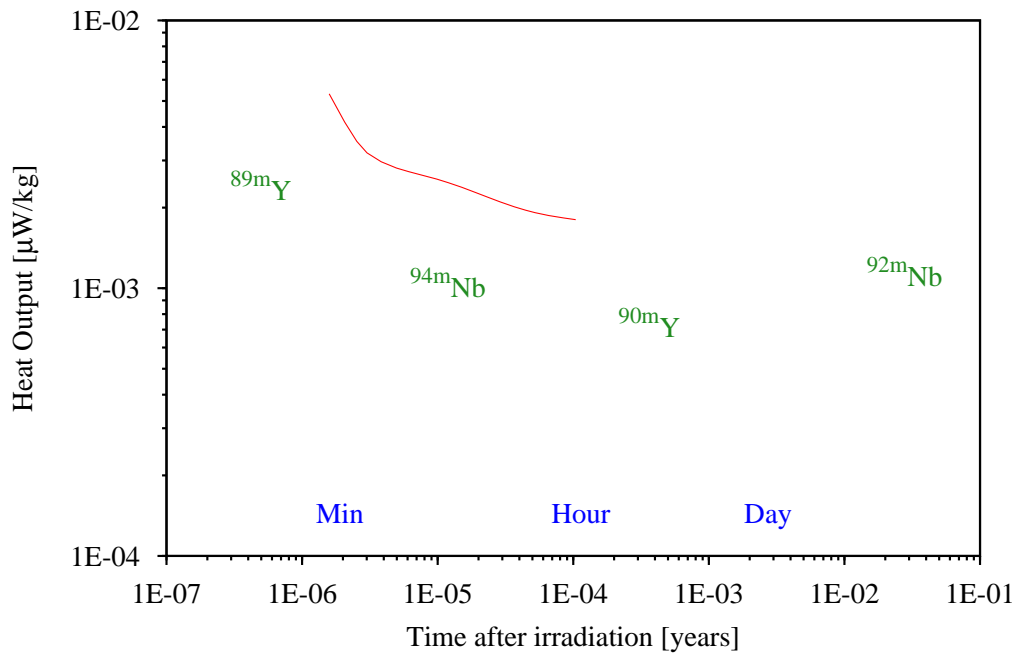


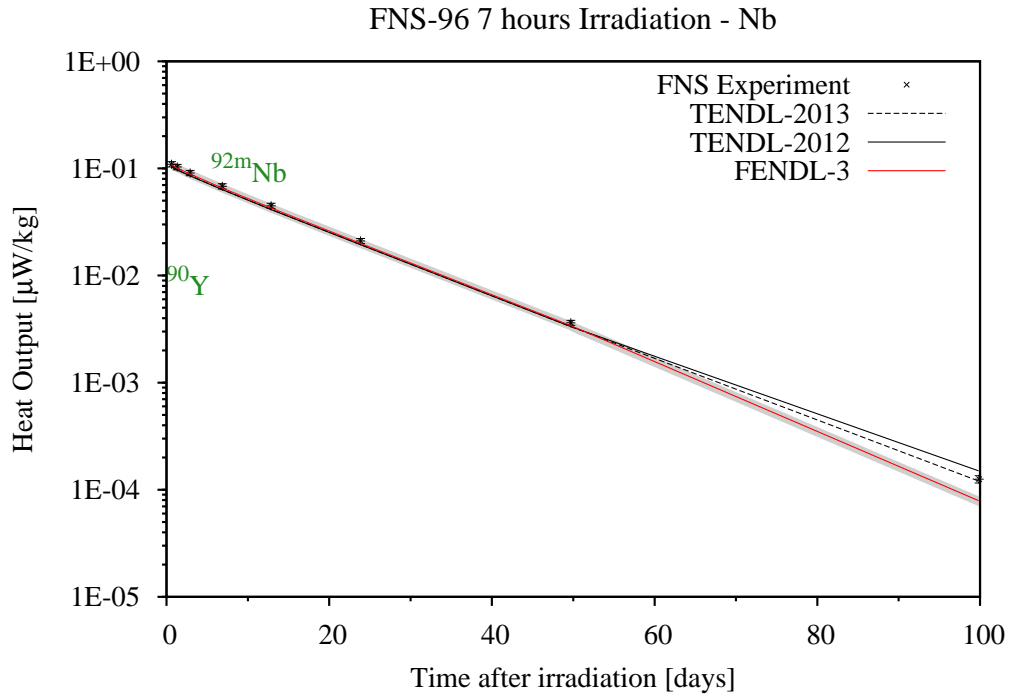
For Niobium, the difficulties in predicting its decay heat derive from the determination of the energy dependant isomeric branching ratios of the three isomers that dominate the response function.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.83 | $6.37E-03 \pm 7\%$ | $5.32E-03 \pm 14\%$ | 1.20 | $4.10E-03$ | 1.56 | $4.51E-03$ | 1.41 |
| 1.08 | $4.83E-03 \pm 7\%$ | $4.17E-03 \pm 11\%$ | 1.16 | $3.37E-03$ | 1.43 | $3.49E-03$ | 1.39 |
| 1.33 | $4.25E-03 \pm 8\%$ | $3.53E-03 \pm 9\%$ | 1.20 | $3.06E-03$ | 1.39 | $3.18E-03$ | 1.34 |
| 1.58 | $3.64E-03 \pm 8\%$ | $3.20E-03 \pm 9\%$ | 1.14 | $2.88E-03$ | 1.26 | $2.99E-03$ | 1.22 |
| 2.02 | $3.40E-03 \pm 8\%$ | $2.97E-03 \pm 9\%$ | 1.15 | $2.72E-03$ | 1.25 | $2.83E-03$ | 1.20 |
| 2.62 | $3.15E-03 \pm 8\%$ | $2.81E-03 \pm 9\%$ | 1.12 | $2.60E-03$ | 1.21 | $2.71E-03$ | 1.16 |
| 3.22 | $2.98E-03 \pm 8\%$ | $2.72E-03 \pm 9\%$ | 1.09 | $2.53E-03$ | 1.18 | $2.64E-03$ | 1.13 |
| 4.08 | $2.86E-03 \pm 8\%$ | $2.64E-03 \pm 9\%$ | 1.08 | $2.45E-03$ | 1.17 | $2.56E-03$ | 1.12 |
| 5.18 | $2.74E-03 \pm 7\%$ | $2.55E-03 \pm 9\%$ | 1.07 | $2.37E-03$ | 1.15 | $2.48E-03$ | 1.10 |
| 6.30 | $2.78E-03 \pm 7\%$ | $2.48E-03 \pm 9\%$ | 1.12 | $2.30E-03$ | 1.21 | $2.41E-03$ | 1.15 |
| 7.92 | $2.38E-03 \pm 7\%$ | $2.38E-03 \pm 9\%$ | 1.00 | $2.21E-03$ | 1.08 | $2.31E-03$ | 1.03 |
| 9.97 | $2.24E-03 \pm 7\%$ | $2.28E-03 \pm 9\%$ | 0.98 | $2.12E-03$ | 1.06 | $2.22E-03$ | 1.01 |
| 12.07 | $2.10E-03 \pm 6\%$ | $2.20E-03 \pm 9\%$ | 0.96 | $2.04E-03$ | 1.03 | $2.14E-03$ | 0.98 |
| 15.22 | $2.03E-03 \pm 6\%$ | $2.10E-03 \pm 9\%$ | 0.97 | $1.96E-03$ | 1.04 | $2.04E-03$ | 0.99 |
| 19.32 | $1.92E-03 \pm 6\%$ | $2.01E-03 \pm 9\%$ | 0.95 | $1.88E-03$ | 1.02 | $1.96E-03$ | 0.98 |
| 23.42 | $1.81E-03 \pm 6\%$ | $1.95E-03 \pm 9\%$ | 0.92 | $1.82E-03$ | 0.99 | $1.90E-03$ | 0.95 |
| 27.48 | $1.76E-03 \pm 6\%$ | $1.91E-03 \pm 9\%$ | 0.92 | $1.78E-03$ | 0.99 | $1.86E-03$ | 0.95 |
| 34.60 | $1.75E-03 \pm 6\%$ | $1.87E-03 \pm 9\%$ | 0.94 | $1.74E-03$ | 1.00 | $1.82E-03$ | 0.96 |
| 44.70 | $1.71E-03 \pm 6\%$ | $1.83E-03 \pm 9\%$ | 0.93 | $1.71E-03$ | 1.00 | $1.78E-03$ | 0.96 |
| 54.82 | $1.80E-03 \pm 6\%$ | $1.80E-03 \pm 9\%$ | 1.00 | $1.68E-03$ | 1.07 | $1.75E-03$ | 1.02 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-------------------------|-----------|--------|------|--------------|
| Y89m | Nb93(n, α)Y89m | 15.6s | 99.8 | 1.41 | 7% |
| Nb94m | Nb93(n, γ)Nb94m | 6.2m | 99.8 | 1.15 | 7% |
| Y90m | Nb93(n, α)Y90m | 3.1h | 100.0 | 1.02 | 6% |

FNS-00 5 Min. Irradiation - Nb

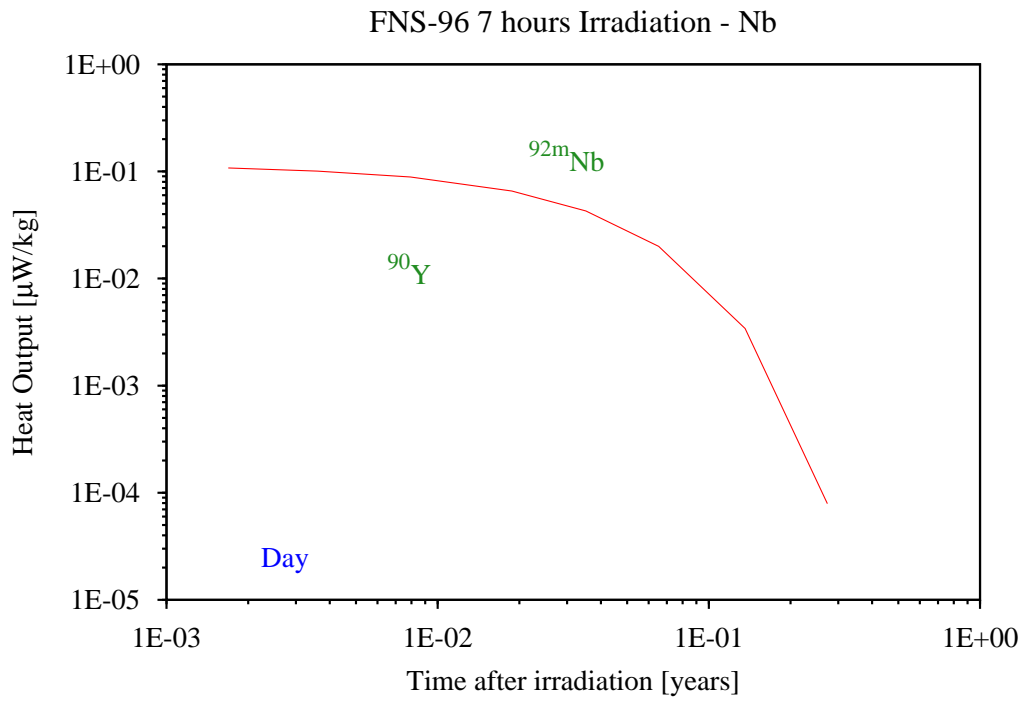




A superb agreement occurs on the route of production and decay data for the metastable isotope Nb92m, up to 100 days of cooling.

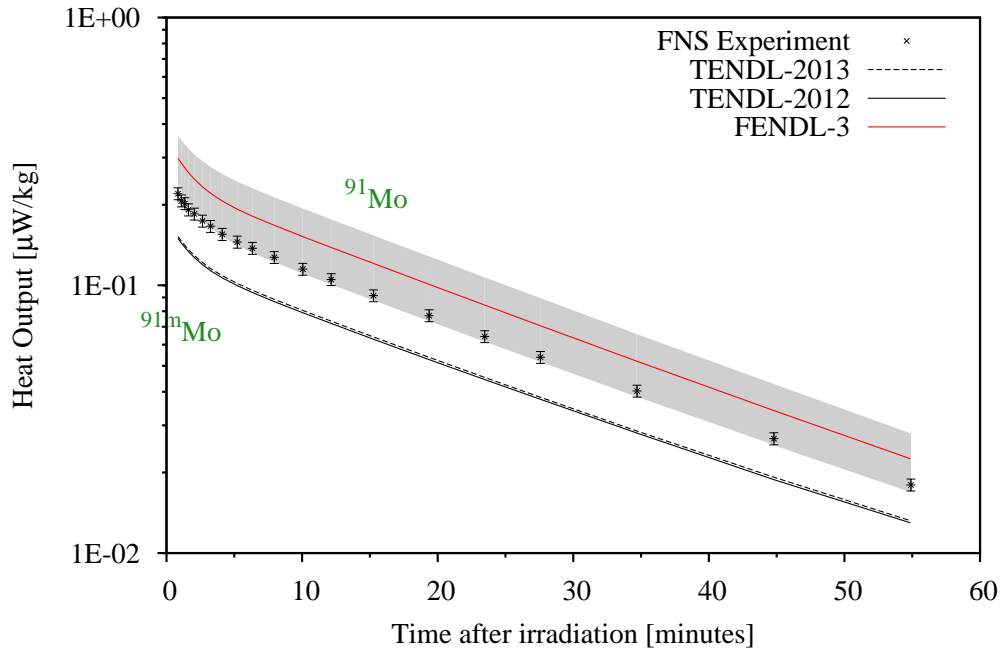
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|------------------|-------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.62 | $1.09E-01$ +/-6% | $1.08E-01$ +/-9% | 1.01 | $1.03E-01$ | 1.06 | $1.04E-01$ | 1.05 |
| 1.32 | $1.03E-01$ +/-6% | $1.01E-01$ +/-9% | 1.02 | $9.64E-02$ | 1.07 | $9.71E-02$ | 1.06 |
| 2.90 | $9.08E-02$ +/-6% | $8.86E-02$ +/-9% | 1.02 | $8.52E-02$ | 1.07 | $8.57E-02$ | 1.06 |
| 6.86 | $6.81E-02$ +/-6% | $6.56E-02$ +/-10% | 1.04 | $6.34E-02$ | 1.07 | $6.35E-02$ | 1.07 |
| 12.86 | $4.48E-02$ +/-5% | $4.27E-02$ +/-10% | 1.05 | $4.14E-02$ | 1.08 | $4.15E-02$ | 1.08 |
| 23.85 | $2.10E-02$ +/-5% | $2.00E-02$ +/-10% | 1.05 | $1.94E-02$ | 1.08 | $1.95E-02$ | 1.08 |
| 49.70 | $3.62E-03$ +/-5% | $3.42E-03$ +/-10% | 1.06 | $3.34E-03$ | 1.08 | $3.34E-03$ | 1.08 |
| 99.89 | $1.25E-04$ +/-8% | $7.91E-05$ +/-10% | 1.59 | $1.50E-04$ | 0.84 | $1.20E-04$ | 1.04 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| Nb92m | Nb93(n,2n)Nb92m | 10.1d | 100.0 | 1.08 | 5% |

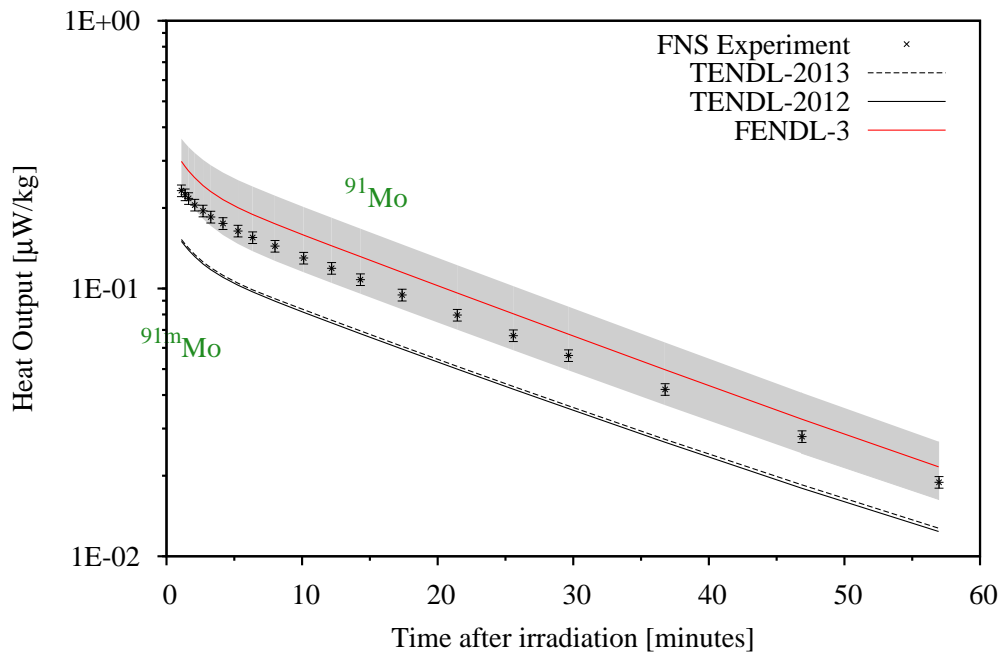


Molybdenum

FNS-00 5 Min. Irradiation - Mo



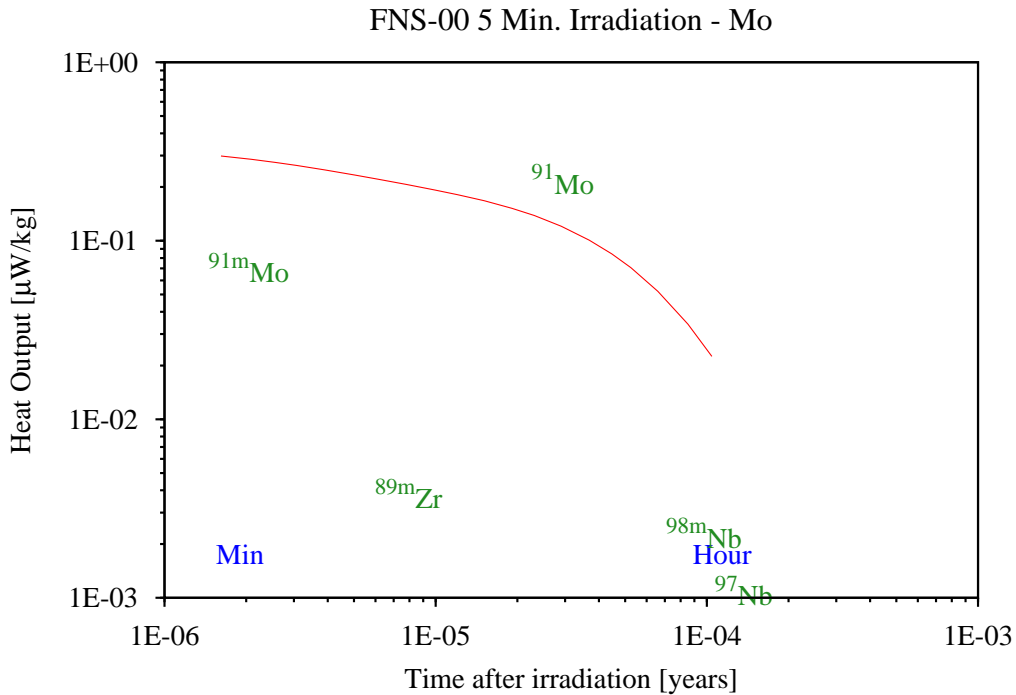
FNS-96 5 Min. Irradiation - Mo

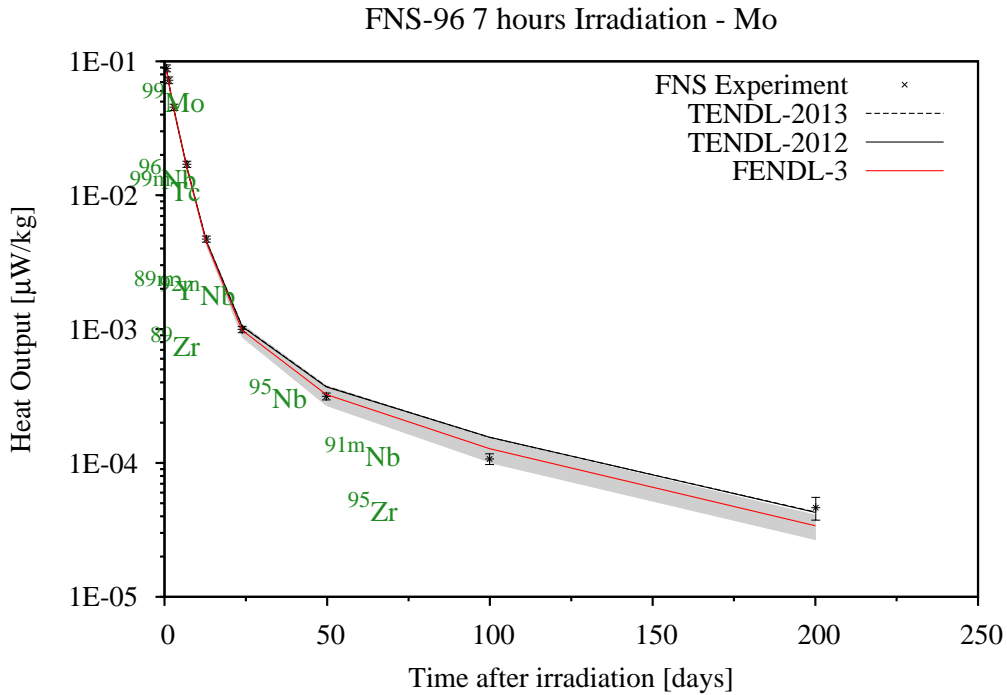


For Molybdenum, a better agreement with the experimental results was seen when the TENDL-2011 data library [11] was used to predict the experiment. However, the two experimental batches differ somewhat, well above the quoted experimental uncertainty.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.85 | $2.20E-01 \pm 5\%$ | $2.98E-01 \pm 21\%$ | 0.74 | $1.50E-01$ | 1.47 | $1.52E-01$ | 1.45 |
| 1.10 | $2.07E-01 \pm 5\%$ | $2.86E-01 \pm 21\%$ | 0.72 | $1.44E-01$ | 1.44 | $1.46E-01$ | 1.41 |
| 1.35 | $2.02E-01 \pm 5\%$ | $2.75E-01 \pm 22\%$ | 0.74 | $1.39E-01$ | 1.46 | $1.41E-01$ | 1.43 |
| 1.62 | $1.92E-01 \pm 5\%$ | $2.64E-01 \pm 23\%$ | 0.73 | $1.34E-01$ | 1.43 | $1.36E-01$ | 1.41 |
| 2.05 | $1.85E-01 \pm 5\%$ | $2.49E-01 \pm 24\%$ | 0.74 | $1.27E-01$ | 1.45 | $1.29E-01$ | 1.43 |
| 2.65 | $1.74E-01 \pm 5\%$ | $2.33E-01 \pm 25\%$ | 0.75 | $1.19E-01$ | 1.46 | $1.22E-01$ | 1.43 |
| 3.25 | $1.66E-01 \pm 5\%$ | $2.21E-01 \pm 25\%$ | 0.75 | $1.13E-01$ | 1.46 | $1.16E-01$ | 1.44 |
| 4.12 | $1.55E-01 \pm 5\%$ | $2.06E-01 \pm 26\%$ | 0.75 | $1.07E-01$ | 1.46 | $1.09E-01$ | 1.43 |
| 5.22 | $1.45E-01 \pm 5\%$ | $1.93E-01 \pm 27\%$ | 0.75 | $9.97E-02$ | 1.45 | $1.02E-01$ | 1.43 |
| 6.33 | $1.38E-01 \pm 5\%$ | $1.81E-01 \pm 27\%$ | 0.76 | $9.40E-02$ | 1.46 | $9.58E-02$ | 1.44 |
| 7.95 | $1.27E-01 \pm 5\%$ | $1.68E-01 \pm 27\%$ | 0.76 | $8.69E-02$ | 1.46 | $8.86E-02$ | 1.43 |
| 10.05 | $1.15E-01 \pm 5\%$ | $1.52E-01 \pm 27\%$ | 0.76 | $7.90E-02$ | 1.45 | $8.06E-02$ | 1.43 |
| 12.15 | $1.05E-01 \pm 5\%$ | $1.38E-01 \pm 27\%$ | 0.76 | $7.20E-02$ | 1.46 | $7.34E-02$ | 1.43 |
| 15.27 | $9.15E-02 \pm 5\%$ | $1.21E-01 \pm 27\%$ | 0.76 | $6.29E-02$ | 1.45 | $6.42E-02$ | 1.43 |
| 19.37 | $7.70E-02 \pm 5\%$ | $1.01E-01 \pm 27\%$ | 0.76 | $5.28E-02$ | 1.46 | $5.38E-02$ | 1.43 |
| 23.47 | $6.44E-02 \pm 5\%$ | $8.44E-02 \pm 27\%$ | 0.76 | $4.45E-02$ | 1.45 | $4.53E-02$ | 1.42 |
| 27.58 | $5.38E-02 \pm 5\%$ | $7.07E-02 \pm 27\%$ | 0.76 | $3.75E-02$ | 1.43 | $3.82E-02$ | 1.41 |
| 34.70 | $4.03E-02 \pm 5\%$ | $5.21E-02 \pm 26\%$ | 0.77 | $2.81E-02$ | 1.43 | $2.86E-02$ | 1.41 |
| 44.80 | $2.67E-02 \pm 5\%$ | $3.41E-02 \pm 26\%$ | 0.78 | $1.88E-02$ | 1.42 | $1.92E-02$ | 1.39 |
| 54.90 | $1.80E-02 \pm 5\%$ | $2.25E-02 \pm 24\%$ | 0.80 | $1.30E-02$ | 1.39 | $1.32E-02$ | 1.36 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| Mo91 | Mo92(n,2n)Mo91 | 15.49m | 96.4 | 1.43 | 5% |
| | Mo92(n,2n)Mo91m | 1.0m | 3.9 | 1.43 | 5% |

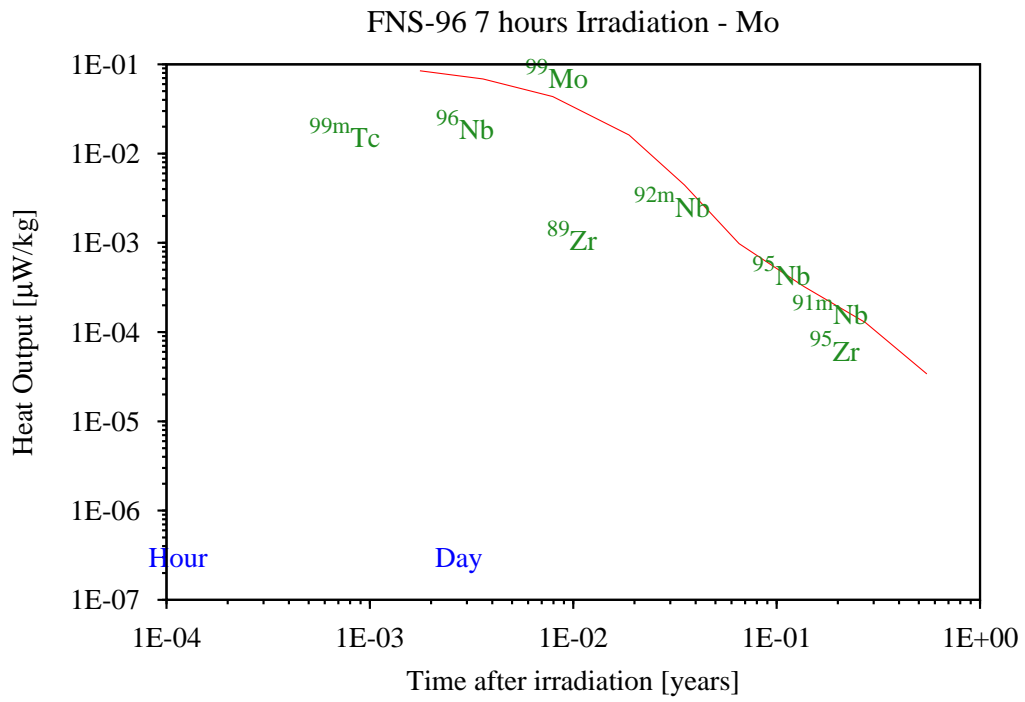




The complex time dependence of the decay heat arising from Mo is well shaped by the predicted results up to 200 days of cooling.

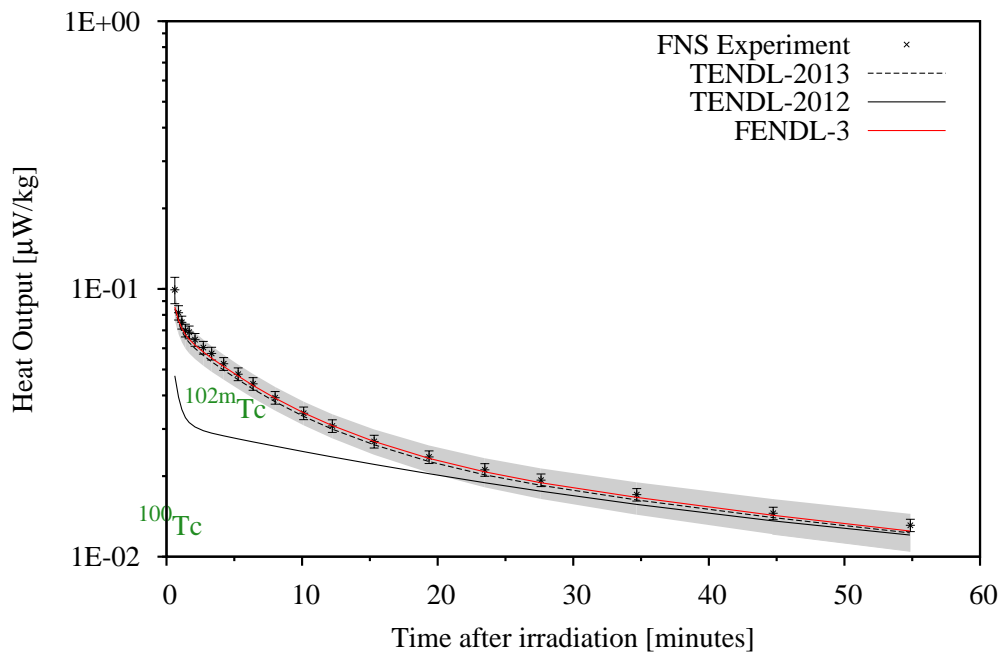
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|--------|---------------------|---------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.64 | $8.87E-02 \pm 6\%$ | $8.47E-02 \pm 7\%$ | 1.05 | $8.64E-02$ | 1.03 | $8.65E-02$ | 1.03 |
| 1.31 | $7.23E-02 \pm 6\%$ | $6.86E-02 \pm 7\%$ | 1.05 | $6.89E-02$ | 1.05 | $6.89E-02$ | 1.05 |
| 2.90 | $4.54E-02 \pm 5\%$ | $4.35E-02 \pm 7\%$ | 1.04 | $4.34E-02$ | 1.05 | $4.34E-02$ | 1.05 |
| 6.86 | $1.70E-02 \pm 5\%$ | $1.61E-02 \pm 7\%$ | 1.06 | $1.62E-02$ | 1.05 | $1.62E-02$ | 1.05 |
| 12.86 | $4.71E-03 \pm 5\%$ | $4.45E-03 \pm 7\%$ | 1.06 | $4.53E-03$ | 1.04 | $4.53E-03$ | 1.04 |
| 23.86 | $9.95E-04 \pm 5\%$ | $9.80E-04 \pm 12\%$ | 1.01 | $1.04E-03$ | 0.95 | $1.05E-03$ | 0.95 |
| 49.71 | $3.14E-04 \pm 6\%$ | $3.25E-04 \pm 18\%$ | 0.97 | $3.71E-04$ | 0.85 | $3.73E-04$ | 0.84 |
| 99.90 | $1.07E-04 \pm 9\%$ | $1.28E-04 \pm 21\%$ | 0.84 | $1.56E-04$ | 0.69 | $1.55E-04$ | 0.69 |
| 200.14 | $4.64E-05 \pm 19\%$ | $3.40E-05 \pm 21\%$ | 1.36 | $4.27E-05$ | 1.09 | $4.30E-05$ | 1.08 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|------------------------|-----------|--------|------|--------------|
| Mo99 | Mo100(n,2n)Mo99 | 2.7d | 99.6 | 1.05 | 5% |
| Nb92m | Mo92(n,p)Nb92m | 10.1d | 99.9 | 1.04 | 5% |
| Nb95 | Mo95(n,p)Nb95 | 34.9d | 90.3 | 0.95 | 6% |
| | Mo96(n,d)Nb95 | | 8.7 | | |
| Nb91m | Mo92(n,d+np)Nb91m | 60.9d | 97.8 | 0.84 | 9% |
| | Mo92(n,2n)Mo91m | | 2.2 | | |
| Zr95 | Mo98(n, α)Zr95 | 64.0d | 100.0 | 1.08 | 19% |



Ruthenium

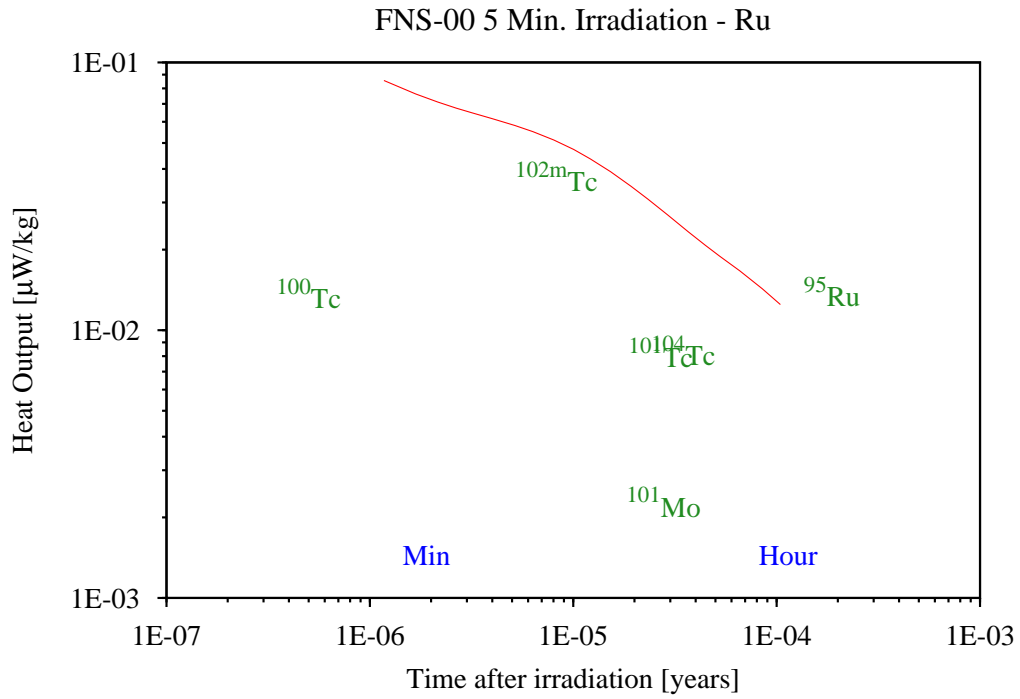
FNS-00 5 Min. Irradiation - Ru



For Ruthenium, a superb fit can be seen in the short term prediction of the decay heat of this element when the FENDL-3.0 and TENDL-2013 databases are used. The short-lived Tc102m isomer was missing in TENDL-2012, causing the under prediction.

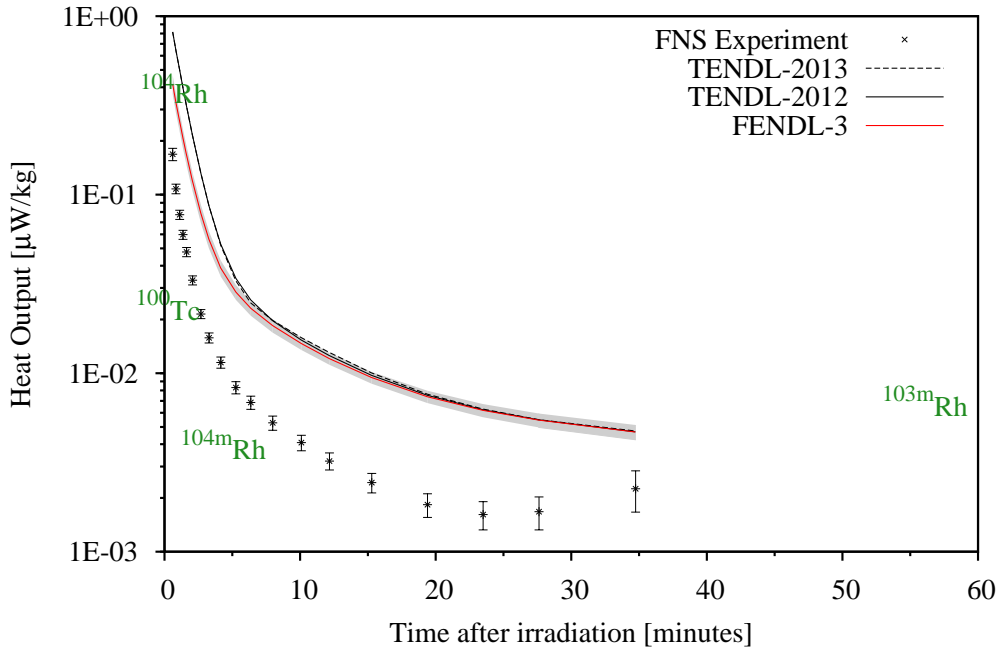
| Times Min. | FNS EXP. 5 mins $\mu\text{W/g}$ | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------------------|---------------------|------|------------|------|------------|------|
| 0.62 | $9.93E-02 \pm 11\%$ | $8.56E-02 \pm 11\%$ | 1.16 | $4.74E-02$ | 2.10 | $8.44E-02$ | 1.18 |
| 0.88 | $8.15E-02 \pm 6\%$ | $7.63E-02 \pm 11\%$ | 1.07 | $3.94E-02$ | 2.07 | $7.47E-02$ | 1.09 |
| 1.13 | $7.50E-02 \pm 6\%$ | $7.12E-02 \pm 11\%$ | 1.05 | $3.55E-02$ | 2.11 | $6.95E-02$ | 1.08 |
| 1.40 | $7.00E-02 \pm 5\%$ | $6.75E-02 \pm 11\%$ | 1.04 | $3.31E-02$ | 2.12 | $6.57E-02$ | 1.06 |
| 1.67 | $6.89E-02 \pm 5\%$ | $6.49E-02 \pm 11\%$ | 1.06 | $3.17E-02$ | 2.17 | $6.31E-02$ | 1.09 |
| 2.10 | $6.46E-02 \pm 5\%$ | $6.17E-02 \pm 11\%$ | 1.05 | $3.05E-02$ | 2.12 | $5.99E-02$ | 1.08 |
| 2.72 | $6.04E-02 \pm 5\%$ | $5.82E-02 \pm 11\%$ | 1.04 | $2.96E-02$ | 2.04 | $5.64E-02$ | 1.07 |
| 3.33 | $5.74E-02 \pm 5\%$ | $5.51E-02 \pm 11\%$ | 1.04 | $2.89E-02$ | 1.98 | $5.34E-02$ | 1.07 |
| 4.22 | $5.25E-02 \pm 5\%$ | $5.13E-02 \pm 11\%$ | 1.02 | $2.83E-02$ | 1.86 | $4.97E-02$ | 1.06 |
| 5.28 | $4.81E-02 \pm 5\%$ | $4.73E-02 \pm 10\%$ | 1.02 | $2.75E-02$ | 1.75 | $4.58E-02$ | 1.05 |
| 6.38 | $4.42E-02 \pm 5\%$ | $4.36E-02 \pm 10\%$ | 1.01 | $2.68E-02$ | 1.65 | $4.23E-02$ | 1.05 |
| 8.02 | $3.93E-02 \pm 5\%$ | $3.91E-02 \pm 10\%$ | 1.00 | $2.59E-02$ | 1.52 | $3.79E-02$ | 1.04 |
| 10.12 | $3.43E-02 \pm 5\%$ | $3.45E-02 \pm 10\%$ | 1.00 | $2.47E-02$ | 1.39 | $3.34E-02$ | 1.03 |
| 12.23 | $3.08E-02 \pm 5\%$ | $3.09E-02 \pm 10\%$ | 1.00 | $2.36E-02$ | 1.31 | $3.00E-02$ | 1.03 |
| 15.32 | $2.69E-02 \pm 5\%$ | $2.69E-02 \pm 11\%$ | 1.00 | $2.21E-02$ | 1.22 | $2.62E-02$ | 1.03 |
| 19.37 | $2.36E-02 \pm 5\%$ | $2.33E-02 \pm 12\%$ | 1.01 | $2.04E-02$ | 1.16 | $2.27E-02$ | 1.04 |
| 23.48 | $2.11E-02 \pm 5\%$ | $2.07E-02 \pm 12\%$ | 1.02 | $1.89E-02$ | 1.12 | $2.02E-02$ | 1.04 |
| 27.62 | $1.93E-02 \pm 5\%$ | $1.89E-02 \pm 13\%$ | 1.02 | $1.76E-02$ | 1.10 | $1.85E-02$ | 1.05 |
| 34.68 | $1.70E-02 \pm 5\%$ | $1.67E-02 \pm 14\%$ | 1.02 | $1.57E-02$ | 1.09 | $1.63E-02$ | 1.05 |
| 44.75 | $1.45E-02 \pm 5\%$ | $1.43E-02 \pm 15\%$ | 1.02 | $1.36E-02$ | 1.07 | $1.40E-02$ | 1.04 |
| 54.87 | $1.31E-02 \pm 5\%$ | $1.25E-02 \pm 16\%$ | 1.05 | $1.20E-02$ | 1.09 | $1.23E-02$ | 1.07 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|--------------------|-----------|--------|------|--------------|
| Tc100 | Ru100(n,p)Tc100 | 15.8s | 84.6 | 1.18 | 11% |
| | Ru101(n,d+np)Tc100 | | 15.4 | 1.18 | 11% |
| Tc102 | Ru102(n,p)Tc102 | 5.3s | 99.8 | 1.06 | 5% |
| Tc102m | Ru102(n,p)Tc102m | 4.3m | 0.0 | 1.06 | 5% |
| Ru95 | Ru96(n,2n)Ru95 | 1.6h | 100.0 | 1.07 | 5% |



Rhodium

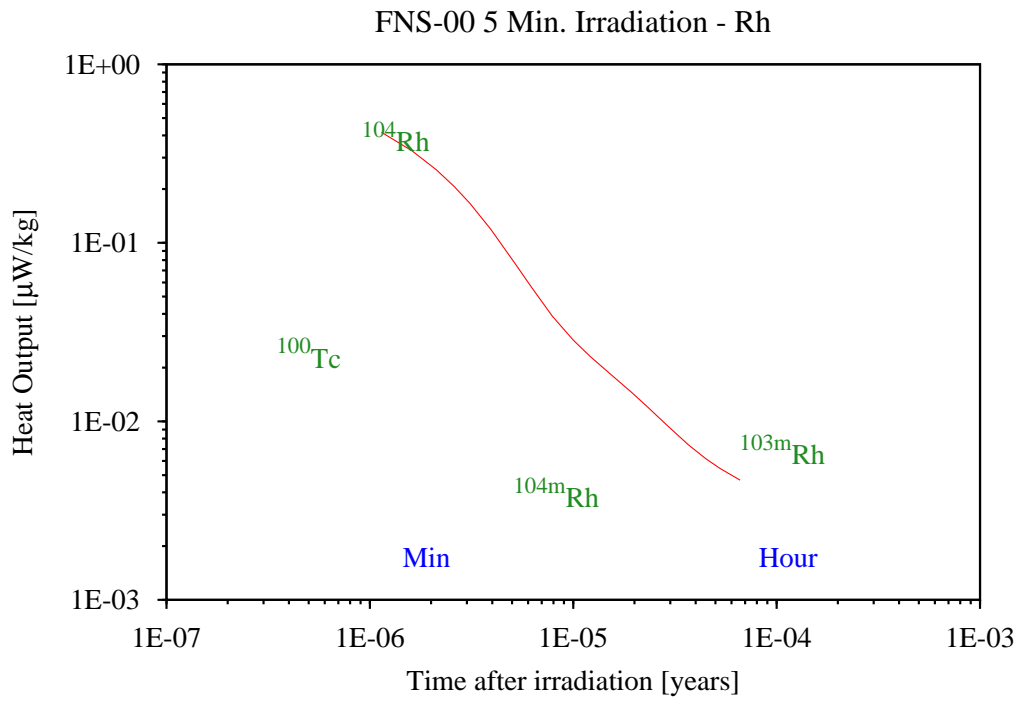
FNS-00 5 Min. Irradiation - Rh



For Rhodium, the fit is poor with all libraries for this important element. The two predominant isotopes routes of production involve a branched capture channel, which cannot be well characterized in such neutron spectra, and a super-inelastic reaction that leads to the Rh103m isomer.

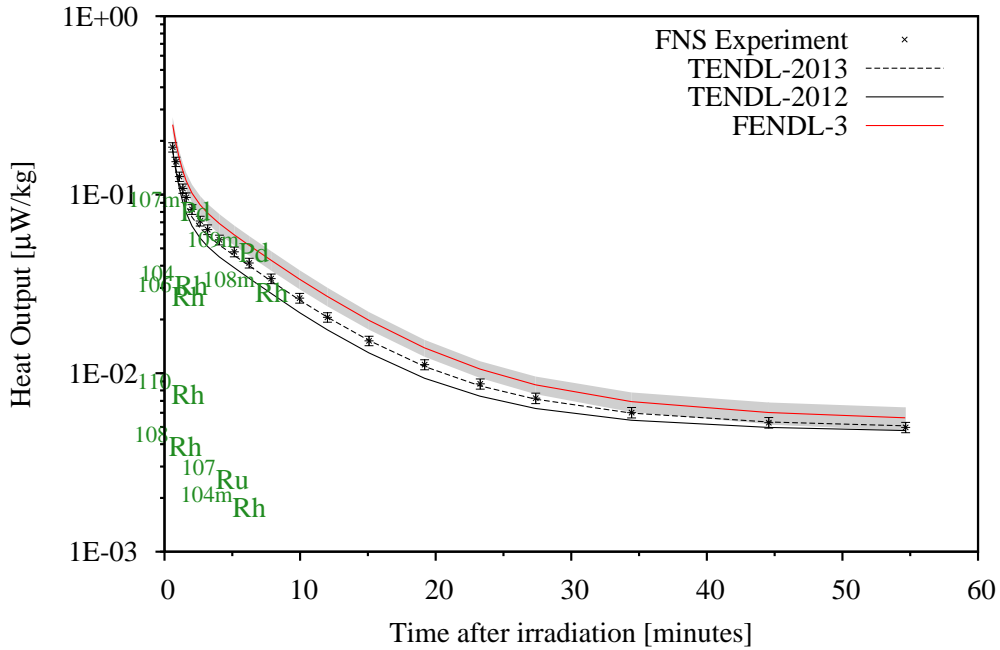
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 1.69E-01 +/-8% | 4.16E-01 +/-12% | 0.40 | 8.15E-01 | 0.21 | 8.16E-01 | 0.21 |
| 0.85 | 1.08E-01 +/-6% | 3.27E-01 +/-12% | 0.33 | 6.40E-01 | 0.17 | 6.40E-01 | 0.17 |
| 1.12 | 7.72E-02 +/-6% | 2.57E-01 +/-12% | 0.30 | 4.98E-01 | 0.16 | 4.98E-01 | 0.15 |
| 1.37 | 5.97E-02 +/-6% | 2.07E-01 +/-12% | 0.29 | 3.96E-01 | 0.15 | 3.96E-01 | 0.15 |
| 1.63 | 4.78E-02 +/-6% | 1.66E-01 +/-12% | 0.29 | 3.12E-01 | 0.15 | 3.12E-01 | 0.15 |
| 2.07 | 3.32E-02 +/-6% | 1.19E-01 +/-12% | 0.28 | 2.15E-01 | 0.15 | 2.15E-01 | 0.15 |
| 2.68 | 2.15E-02 +/-6% | 7.85E-02 +/-12% | 0.27 | 1.32E-01 | 0.16 | 1.32E-01 | 0.16 |
| 3.28 | 1.58E-02 +/-6% | 5.62E-02 +/-11% | 0.28 | 8.67E-02 | 0.18 | 8.67E-02 | 0.18 |
| 4.15 | 1.15E-02 +/-7% | 3.88E-02 +/-10% | 0.30 | 5.29E-02 | 0.22 | 5.21E-02 | 0.22 |
| 5.27 | 8.31E-03 +/-8% | 2.85E-02 +/-10% | 0.29 | 3.40E-02 | 0.24 | 3.29E-02 | 0.25 |
| 6.37 | 6.85E-03 +/-8% | 2.31E-02 +/-9% | 0.30 | 2.57E-02 | 0.27 | 2.47E-02 | 0.28 |
| 7.98 | 5.27E-03 +/-9% | 1.84E-02 +/-9% | 0.29 | 1.97E-02 | 0.27 | 1.97E-02 | 0.27 |
| 10.10 | 4.08E-03 +/-10% | 1.47E-02 +/-8% | 0.28 | 1.53E-02 | 0.27 | 1.58E-02 | 0.26 |
| 12.17 | 3.22E-03 +/-11% | 1.21E-02 +/-8% | 0.27 | 1.25E-02 | 0.26 | 1.31E-02 | 0.25 |
| 15.28 | 2.44E-03 +/-13% | 9.45E-03 +/-8% | 0.26 | 9.72E-03 | 0.25 | 1.00E-02 | 0.24 |
| 19.40 | 1.83E-03 +/-15% | 7.38E-03 +/-8% | 0.25 | 7.51E-03 | 0.24 | 7.63E-03 | 0.24 |
| 23.50 | 1.61E-03 +/-18% | 6.19E-03 +/-8% | 0.26 | 6.24E-03 | 0.26 | 6.29E-03 | 0.26 |
| 27.62 | 1.68E-03 +/-21% | 5.46E-03 +/-9% | 0.31 | 5.48E-03 | 0.31 | 5.49E-03 | 0.31 |
| 34.75 | 2.25E-03 +/-26% | 4.69E-03 +/-9% | 0.48 | 4.69E-03 | 0.48 | 4.74E-03 | 0.47 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Rh104 | Rh103(n,γ)Rh104 | 42.3s | 97.1 | 0.21 | 8% |
| | Rh103(n,γ)Rh104m | 4.3m | 2.1 | 0.21 | 7% |
| Rh103m | Rh103(n,n')Rh103m | 56.1m | 100.0 | 0.47 | 26% |



Palladium

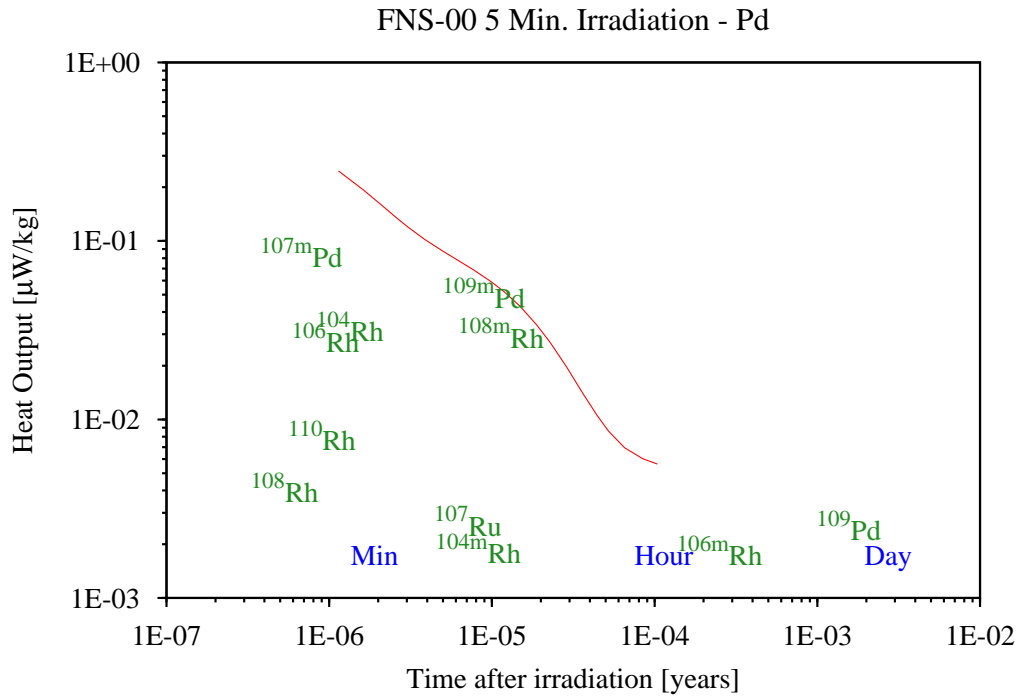
FNS-00 5 Min. Irradiation - Pd



For Palladium, TENDL-2013 now perfectly fits the experimental data, particularly at cooling times of less than 30 minutes, where the decay heat is predominantly determined by the production of metastable isomers. This proves once again the strength of the TALYS modelling processes.

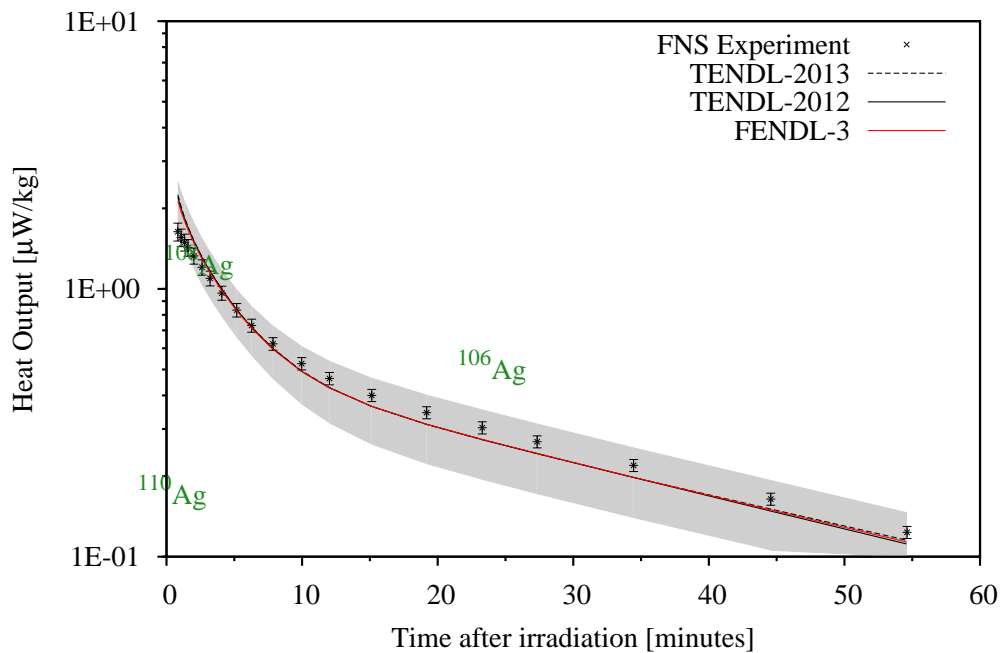
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 1.84E-01 +/-6% | 2.47E-01 +/-10% | 0.75 | 1.76E-01 | 1.05 | 1.78E-01 | 1.04 |
| 0.85 | 1.53E-01 +/-6% | 1.94E-01 +/-10% | 0.79 | 1.35E-01 | 1.14 | 1.39E-01 | 1.10 |
| 1.10 | 1.26E-01 +/-6% | 1.59E-01 +/-10% | 0.79 | 1.08E-01 | 1.17 | 1.15E-01 | 1.10 |
| 1.35 | 1.08E-01 +/-6% | 1.36E-01 +/-10% | 0.80 | 9.08E-02 | 1.19 | 9.83E-02 | 1.10 |
| 1.60 | 9.64E-02 +/-6% | 1.20E-01 +/-11% | 0.80 | 7.92E-02 | 1.22 | 8.72E-02 | 1.11 |
| 2.03 | 8.27E-02 +/-6% | 1.02E-01 +/-12% | 0.81 | 6.67E-02 | 1.24 | 7.49E-02 | 1.10 |
| 2.63 | 7.13E-02 +/-6% | 8.75E-02 +/-12% | 0.81 | 5.70E-02 | 1.25 | 6.50E-02 | 1.10 |
| 3.18 | 6.38E-02 +/-6% | 7.88E-02 +/-13% | 0.81 | 5.12E-02 | 1.24 | 5.92E-02 | 1.08 |
| 4.05 | 5.58E-02 +/-6% | 6.89E-02 +/-13% | 0.81 | 4.48E-02 | 1.25 | 5.22E-02 | 1.07 |
| 5.15 | 4.79E-02 +/-6% | 5.95E-02 +/-13% | 0.80 | 3.89E-02 | 1.23 | 4.56E-02 | 1.05 |
| 6.25 | 4.14E-02 +/-6% | 5.20E-02 +/-13% | 0.80 | 3.40E-02 | 1.22 | 4.00E-02 | 1.04 |
| 7.87 | 3.38E-02 +/-6% | 4.29E-02 +/-13% | 0.79 | 2.80E-02 | 1.21 | 3.28E-02 | 1.03 |
| 9.97 | 2.63E-02 +/-6% | 3.36E-02 +/-12% | 0.78 | 2.19E-02 | 1.20 | 2.57E-02 | 1.02 |
| 12.02 | 2.06E-02 +/-6% | 2.69E-02 +/-12% | 0.76 | 1.75E-02 | 1.17 | 2.06E-02 | 1.00 |
| 15.08 | 1.52E-02 +/-6% | 1.98E-02 +/-11% | 0.77 | 1.30E-02 | 1.17 | 1.53E-02 | 0.99 |
| 19.18 | 1.12E-02 +/-6% | 1.39E-02 +/-11% | 0.81 | 9.37E-03 | 1.19 | 1.09E-02 | 1.02 |
| 23.28 | 8.71E-03 +/-7% | 1.05E-02 +/-11% | 0.83 | 7.43E-03 | 1.17 | 8.50E-03 | 1.03 |
| 27.38 | 7.24E-03 +/-7% | 8.60E-03 +/-11% | 0.84 | 6.34E-03 | 1.14 | 7.15E-03 | 1.01 |
| 34.45 | 6.02E-03 +/-7% | 6.92E-03 +/-13% | 0.87 | 5.45E-03 | 1.10 | 5.97E-03 | 1.01 |
| 44.57 | 5.28E-03 +/-7% | 6.02E-03 +/-14% | 0.88 | 4.97E-03 | 1.06 | 5.33E-03 | 0.99 |
| 54.67 | 4.97E-03 +/-7% | 5.62E-03 +/-15% | 0.88 | 4.77E-03 | 1.04 | 5.07E-03 | 0.98 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Pd107m | Pd108(n,2n)Pd107m | 21.3s | 99.5 | 1.04 | 5% |
| Pd109m | Pd110(n,2n)Pd109m | 4.6m | 99.2 | 1.07 | 6% |
| Pd109 | Pd108(n,γ)Pd109 | 13.7h | 6.9 | 0.98 | 6% |
| | Pd110(n,2n)Pd109 | | 81.5 | 0.98 | 6% |
| | Pd110(n,2n)Pd109m | 4.6m | 11.6 | 0.98 | 6% |



Silver

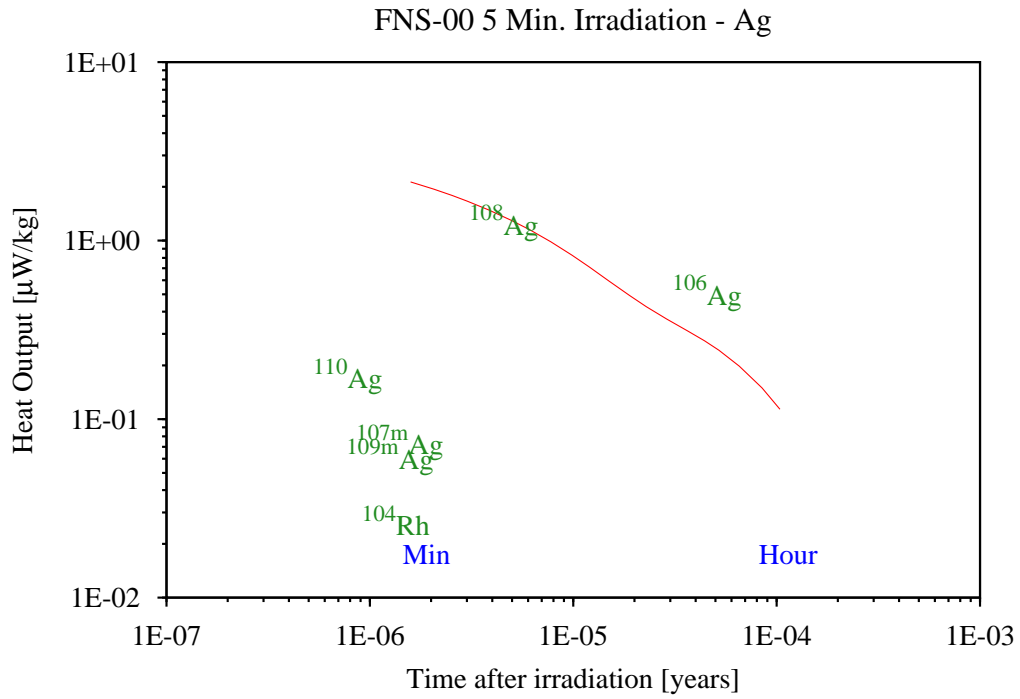
FNS-00 5 Min. Irradiation - Ag



For Silver, there is a slight over-prediction up to 5 minutes cooling, followed by a marginal under prediction at longer cooling times – in both cases dominated by (different) (n,2n) channels. The short time decay heat arising from Silver can be considered as rather well predicted.

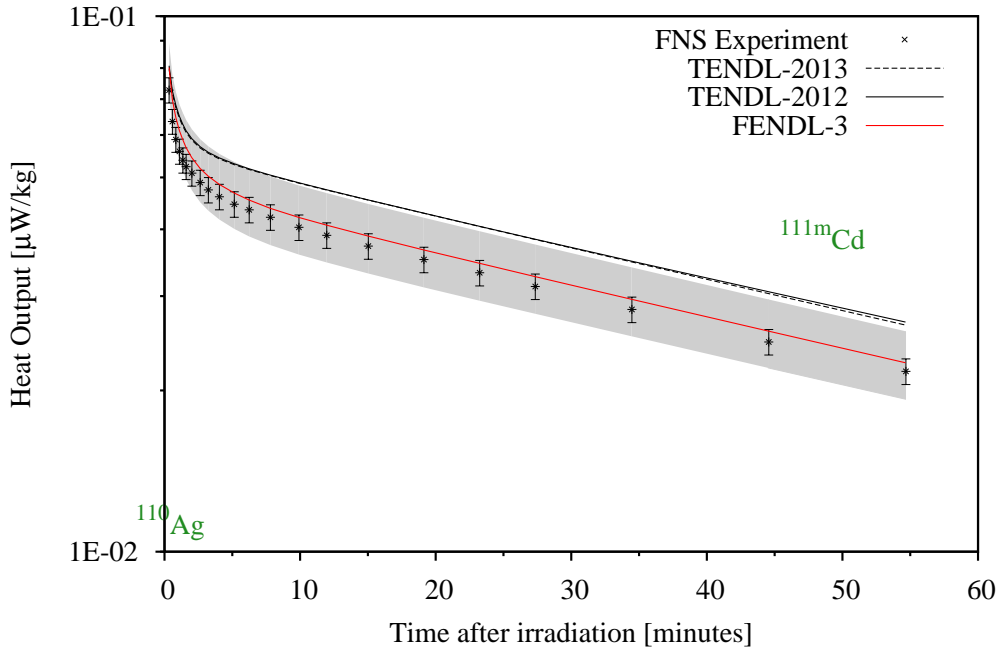
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.83 | 1.64E+00 +/-8% | 2.13E+00 +/-20% | 0.77 | 2.20E + 00 | 0.74 | 2.25E+00 | 0.73 |
| 1.08 | 1.55E+00 +/-7% | 1.94E+00 +/-20% | 0.80 | 1.99E + 00 | 0.78 | 2.03E+00 | 0.77 |
| 1.33 | 1.49E+00 +/-7% | 1.79E+00 +/-20% | 0.83 | 1.83E + 00 | 0.82 | 1.85E+00 | 0.81 |
| 1.58 | 1.43E+00 +/-7% | 1.66E+00 +/-20% | 0.86 | 1.69E + 00 | 0.84 | 1.71E+00 | 0.84 |
| 2.02 | 1.33E+00 +/-7% | 1.48E+00 +/-20% | 0.89 | 1.51E + 00 | 0.88 | 1.52E+00 | 0.88 |
| 2.62 | 1.21E+00 +/-7% | 1.30E+00 +/-20% | 0.93 | 1.31E + 00 | 0.92 | 1.32E+00 | 0.91 |
| 3.22 | 1.10E+00 +/-6% | 1.15E+00 +/-20% | 0.95 | 1.16E + 00 | 0.94 | 1.17E+00 | 0.94 |
| 4.08 | 9.65E-01 +/-6% | 9.85E-01 +/-20% | 0.98 | 9.95E - 01 | 0.97 | 9.97E-01 | 0.97 |
| 5.18 | 8.33E-01 +/-6% | 8.29E-01 +/-21% | 1.01 | 8.36E - 01 | 1.00 | 8.37E-01 | 1.00 |
| 6.28 | 7.30E-01 +/-6% | 7.13E-01 +/-21% | 1.02 | 7.18E - 01 | 1.02 | 7.19E-01 | 1.02 |
| 7.85 | 6.24E-01 +/-5% | 5.95E-01 +/-23% | 1.05 | 5.98E - 01 | 1.04 | 6.00E-01 | 1.04 |
| 9.97 | 5.26E-01 +/-5% | 4.92E-01 +/-25% | 1.07 | 4.92E - 01 | 1.07 | 4.95E-01 | 1.06 |
| 12.02 | 4.63E-01 +/-5% | 4.27E-01 +/-26% | 1.08 | 4.28E - 01 | 1.08 | 4.28E-01 | 1.08 |
| 15.13 | 4.00E-01 +/-5% | 3.64E-01 +/-28% | 1.10 | 3.64E - 01 | 1.10 | 3.64E-01 | 1.10 |
| 19.18 | 3.45E-01 +/-5% | 3.12E-01 +/-29% | 1.11 | 3.12E - 01 | 1.11 | 3.12E-01 | 1.11 |
| 23.28 | 3.03E-01 +/-5% | 2.74E-01 +/-29% | 1.10 | 2.74E - 01 | 1.11 | 2.74E-01 | 1.11 |
| 27.33 | 2.69E-01 +/-5% | 2.43E-01 +/-29% | 1.11 | 2.43E - 01 | 1.11 | 2.43E-01 | 1.11 |
| 34.45 | 2.19E-01 +/-5% | 1.98E-01 +/-29% | 1.11 | 1.98E - 01 | 1.11 | 1.98E-01 | 1.11 |
| 44.57 | 1.64E-01 +/-5% | 1.50E-01 +/-29% | 1.10 | 1.48E - 01 | 1.11 | 1.51E-01 | 1.09 |
| 54.62 | 1.23E-01 +/-5% | 1.14E-01 +/-29% | 1.09 | 1.12E - 01 | 1.10 | 1.15E-01 | 1.07 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|------------------|------------------|--------|------|-----|
| Ag108 | Ag107(n,γ)Ag108 | 2.4m | 7.2 | 0.91 | 7% |
| | Ag109(n,2n)Ag108 | | 92.5 | 0.91 | 7% |
| Ag106 | Ag107(n,2n)Ag106 | 24.0m | 100.0 | 1.11 | 5% |



Cadmium

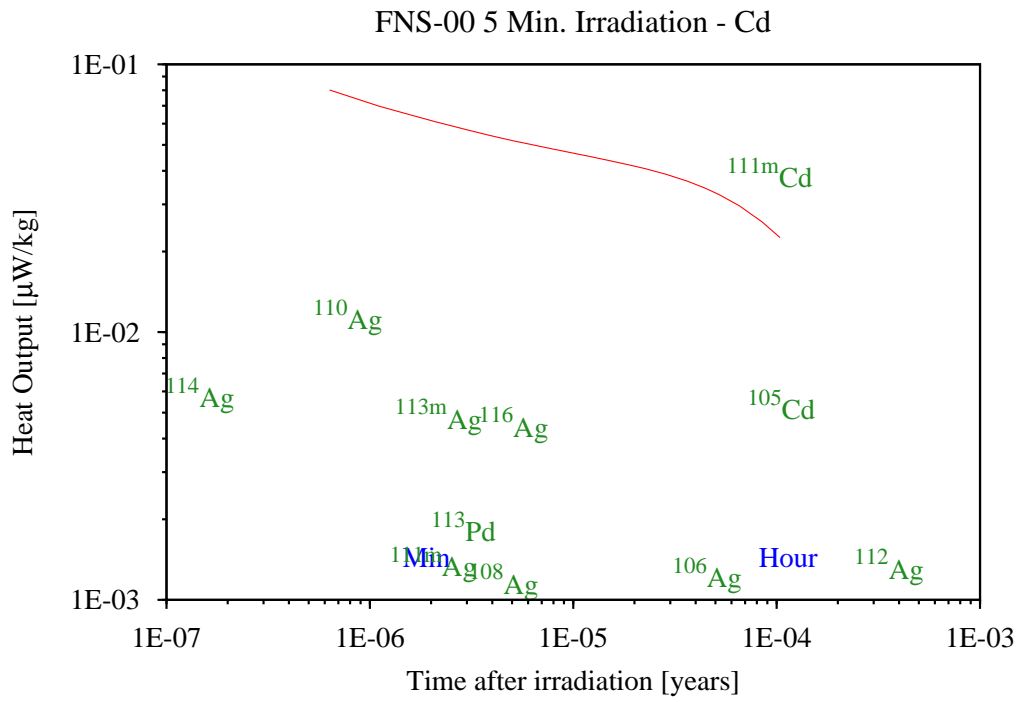
FNS-00 5 Min. Irradiation - Cd



For Cadmium, there is a good time dependant agreement for FENDL-3.0, within the quoted calculational uncertainty. However, TENDL's libraries over-predict by 20%.

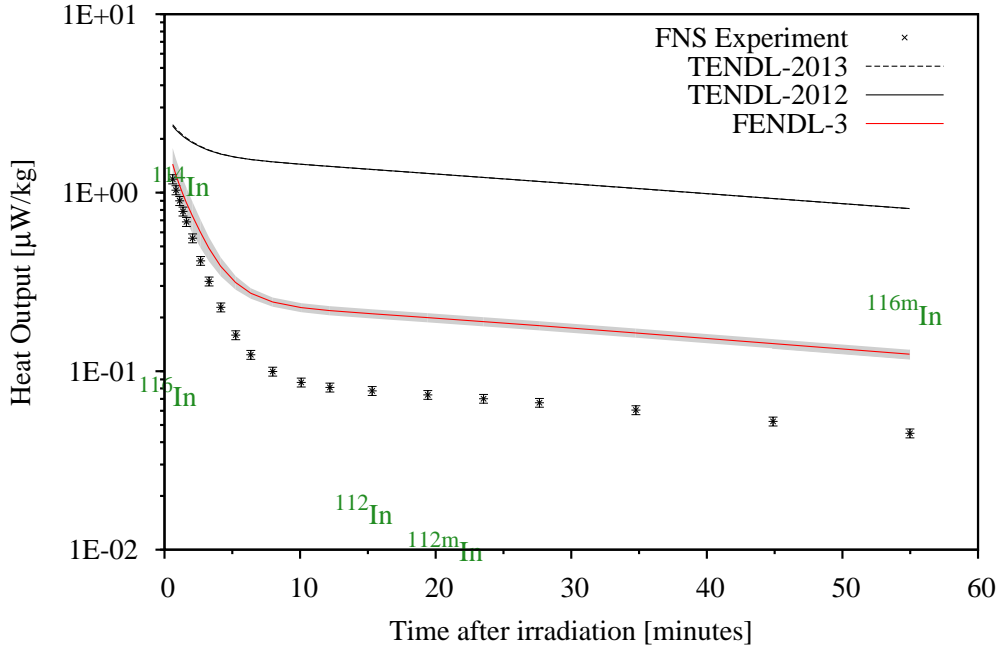
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.33 | $7.28E-02 \pm 5\%$ | $8.02E-02 \pm 11\%$ | 0.91 | $8.08E-02$ | 0.90 | $7.96E-02$ | 0.91 |
| 0.58 | $6.36E-02 \pm 5\%$ | $6.98E-02 \pm 11\%$ | 0.91 | $7.25E-02$ | 0.88 | $7.16E-02$ | 0.89 |
| 0.83 | $5.88E-02 \pm 5\%$ | $6.47E-02 \pm 12\%$ | 0.91 | $6.82E-02$ | 0.86 | $6.75E-02$ | 0.87 |
| 1.10 | $5.59E-02 \pm 5\%$ | $6.11E-02 \pm 12\%$ | 0.92 | $6.50E-02$ | 0.86 | $6.44E-02$ | 0.87 |
| 1.35 | $5.38E-02 \pm 5\%$ | $5.87E-02 \pm 12\%$ | 0.92 | $6.28E-02$ | 0.86 | $6.23E-02$ | 0.86 |
| 1.60 | $5.24E-02 \pm 5\%$ | $5.68E-02 \pm 13\%$ | 0.92 | $6.11E-02$ | 0.86 | $6.07E-02$ | 0.86 |
| 2.02 | $5.09E-02 \pm 5\%$ | $5.44E-02 \pm 13\%$ | 0.94 | $5.90E-02$ | 0.86 | $5.87E-02$ | 0.87 |
| 2.63 | $4.89E-02 \pm 5\%$ | $5.19E-02 \pm 13\%$ | 0.94 | $5.70E-02$ | 0.86 | $5.67E-02$ | 0.86 |
| 3.23 | $4.74E-02 \pm 5\%$ | $5.02E-02 \pm 14\%$ | 0.94 | $5.57E-02$ | 0.85 | $5.54E-02$ | 0.85 |
| 4.05 | $4.60E-02 \pm 5\%$ | $4.85E-02 \pm 14\%$ | 0.95 | $5.44E-02$ | 0.85 | $5.41E-02$ | 0.85 |
| 5.15 | $4.45E-02 \pm 5\%$ | $4.67E-02 \pm 14\%$ | 0.95 | $5.30E-02$ | 0.84 | $5.28E-02$ | 0.84 |
| 6.25 | $4.35E-02 \pm 5\%$ | $4.54E-02 \pm 14\%$ | 0.96 | $5.19E-02$ | 0.84 | $5.17E-02$ | 0.84 |
| 7.82 | $4.21E-02 \pm 5\%$ | $4.38E-02 \pm 15\%$ | 0.96 | $5.05E-02$ | 0.83 | $5.04E-02$ | 0.84 |
| 9.92 | $4.03E-02 \pm 5\%$ | $4.21E-02 \pm 15\%$ | 0.96 | $4.89E-02$ | 0.83 | $4.88E-02$ | 0.83 |
| 11.97 | $3.90E-02 \pm 5\%$ | $4.07E-02 \pm 15\%$ | 0.96 | $4.74E-02$ | 0.82 | $4.73E-02$ | 0.82 |
| 15.03 | $3.72E-02 \pm 5\%$ | $3.88E-02 \pm 15\%$ | 0.96 | $4.54E-02$ | 0.82 | $4.53E-02$ | 0.82 |
| 19.13 | $3.51E-02 \pm 5\%$ | $3.66E-02 \pm 15\%$ | 0.96 | $4.29E-02$ | 0.82 | $4.28E-02$ | 0.82 |
| 23.25 | $3.32E-02 \pm 5\%$ | $3.45E-02 \pm 15\%$ | 0.96 | $4.05E-02$ | 0.82 | $4.05E-02$ | 0.82 |
| 27.35 | $3.13E-02 \pm 5\%$ | $3.26E-02 \pm 15\%$ | 0.96 | $3.83E-02$ | 0.82 | $3.83E-02$ | 0.82 |
| 34.47 | $2.83E-02 \pm 5\%$ | $2.96E-02 \pm 15\%$ | 0.96 | $3.49E-02$ | 0.81 | $3.48E-02$ | 0.81 |
| 44.57 | $2.46E-02 \pm 5\%$ | $2.58E-02 \pm 15\%$ | 0.95 | $3.06E-02$ | 0.81 | $3.03E-02$ | 0.81 |
| 54.68 | $2.17E-02 \pm 5\%$ | $2.25E-02 \pm 14\%$ | 0.96 | $2.68E-02$ | 0.81 | $2.65E-02$ | 0.82 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-------------------|-----------|--------|------|--------------|
| Cd111m | Cd111(n,n')Cd111m | 48.5m | 19.7 | 0.81 | 5% |
| | Cd112(n,2n)Cd111m | | 80.2 | 0.81 | 5% |



Indium

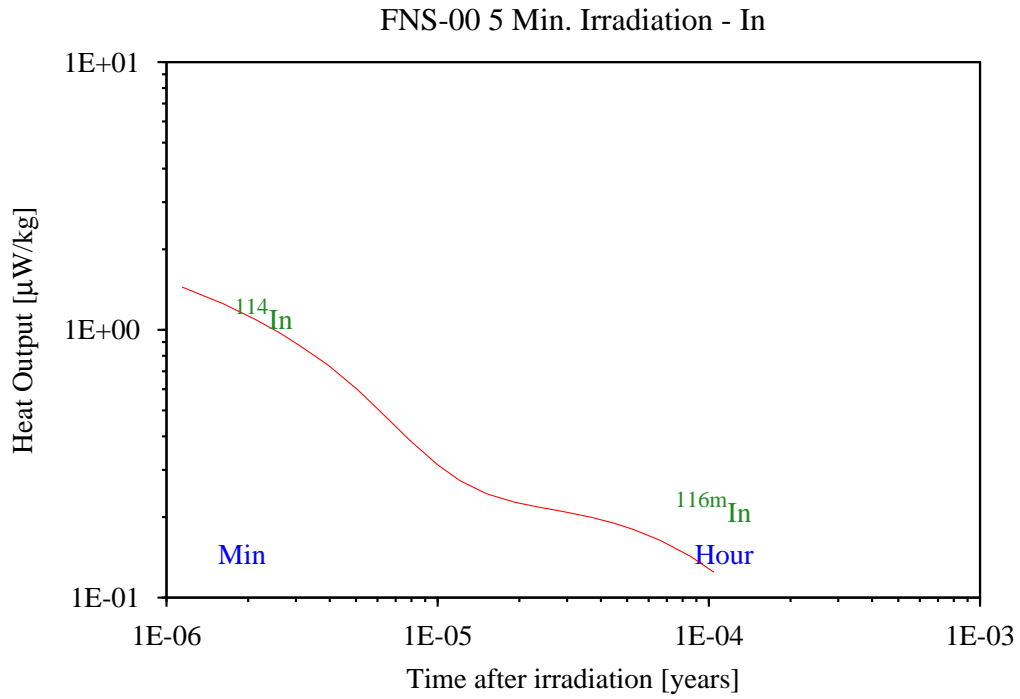
FNS-00 5 Min. Irradiation - In



For Indium, a large over-prediction can be seen for this element at all cooling times. The poor characterization of the thermal profile of the neutron spectrum may have an influence on the predicted results for this neutron absorber, although this tendency is not seen for all neutron absorbers.

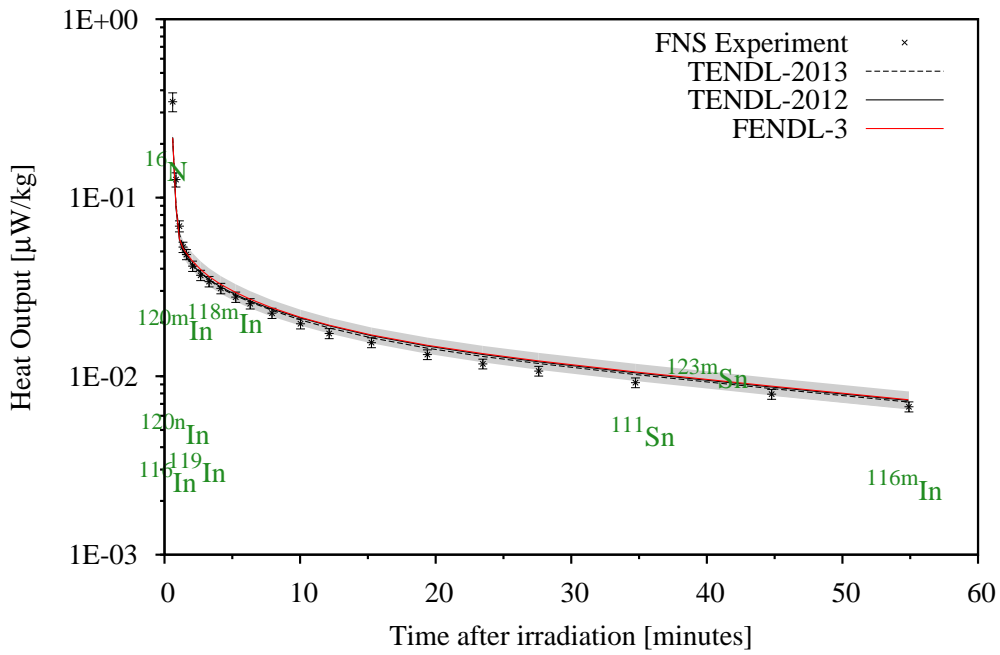
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 1.19E+00 +/-6% | 1.45E+00 +/-23% | 0.82 | 2.37E+00 | 0.50 | 2.41E+00 | 0.50 |
| 0.85 | 1.03E+00 +/-6% | 1.25E+00 +/-23% | 0.82 | 2.25E+00 | 0.46 | 2.28E+00 | 0.45 |
| 1.12 | 9.00E-01 +/-6% | 1.09E+00 +/-23% | 0.82 | 2.15E+00 | 0.42 | 2.18E+00 | 0.41 |
| 1.37 | 7.85E-01 +/-6% | 9.78E-01 +/-22% | 0.80 | 2.07E+00 | 0.38 | 2.09E+00 | 0.37 |
| 1.62 | 6.87E-01 +/-6% | 8.78E-01 +/-21% | 0.78 | 2.00E+00 | 0.34 | 2.02E+00 | 0.34 |
| 2.07 | 5.56E-01 +/-6% | 7.41E-01 +/-20% | 0.75 | 1.91E+00 | 0.29 | 1.92E+00 | 0.29 |
| 2.67 | 4.15E-01 +/-6% | 5.97E-01 +/-18% | 0.70 | 1.80E+00 | 0.23 | 1.82E+00 | 0.23 |
| 3.28 | 3.19E-01 +/-6% | 4.88E-01 +/-15% | 0.65 | 1.72E+00 | 0.18 | 1.73E+00 | 0.18 |
| 4.15 | 2.28E-01 +/-6% | 3.87E-01 +/-12% | 0.59 | 1.64E+00 | 0.14 | 1.65E+00 | 0.14 |
| 5.25 | 1.59E-01 +/-6% | 3.14E-01 +/-9% | 0.51 | 1.58E+00 | 0.10 | 1.58E+00 | 0.10 |
| 6.37 | 1.24E-01 +/-6% | 2.73E-01 +/-7% | 0.45 | 1.53E+00 | 0.08 | 1.53E+00 | 0.08 |
| 7.98 | 9.95E-02 +/-6% | 2.44E-01 +/-6% | 0.41 | 1.49E+00 | 0.07 | 1.49E+00 | 0.07 |
| 10.08 | 8.65E-02 +/-6% | 2.27E-01 +/-6% | 0.38 | 1.44E+00 | 0.06 | 1.44E+00 | 0.06 |
| 12.20 | 8.10E-02 +/-6% | 2.18E-01 +/-6% | 0.37 | 1.40E+00 | 0.06 | 1.40E+00 | 0.06 |
| 15.32 | 7.76E-02 +/-6% | 2.10E-01 +/-6% | 0.37 | 1.35E+00 | 0.06 | 1.35E+00 | 0.06 |
| 19.42 | 7.37E-02 +/-6% | 1.99E-01 +/-6% | 0.37 | 1.28E+00 | 0.06 | 1.28E+00 | 0.06 |
| 23.53 | 7.01E-02 +/-6% | 1.89E-01 +/-6% | 0.37 | 1.22E+00 | 0.06 | 1.22E+00 | 0.06 |
| 27.65 | 6.66E-02 +/-6% | 1.80E-01 +/-6% | 0.37 | 1.16E+00 | 0.06 | 1.16E+00 | 0.06 |
| 34.77 | 6.05E-02 +/-6% | 1.64E-01 +/-6% | 0.37 | 1.06E+00 | 0.06 | 1.06E+00 | 0.06 |
| 44.88 | 5.23E-02 +/-6% | 1.43E-01 +/-6% | 0.37 | 9.28E-01 | 0.06 | 9.27E-01 | 0.06 |
| 54.98 | 4.49E-02 +/-6% | 1.24E-01 +/-6% | 0.36 | 8.15E-01 | 0.06 | 8.14E-01 | 0.06 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|---------------------------|-----------|--------|------|--------------|
| In114 | In115(n,2n)In114 | 1.1m | 99.1 | 0.42 | 5% |
| In116m | In115(n, γ)In116m | 54.6m | 95.7 | 0.06 | 5% |
| | In115(n, γ)In116n | 2.1s | 4.3 | 0.06 | 5% |

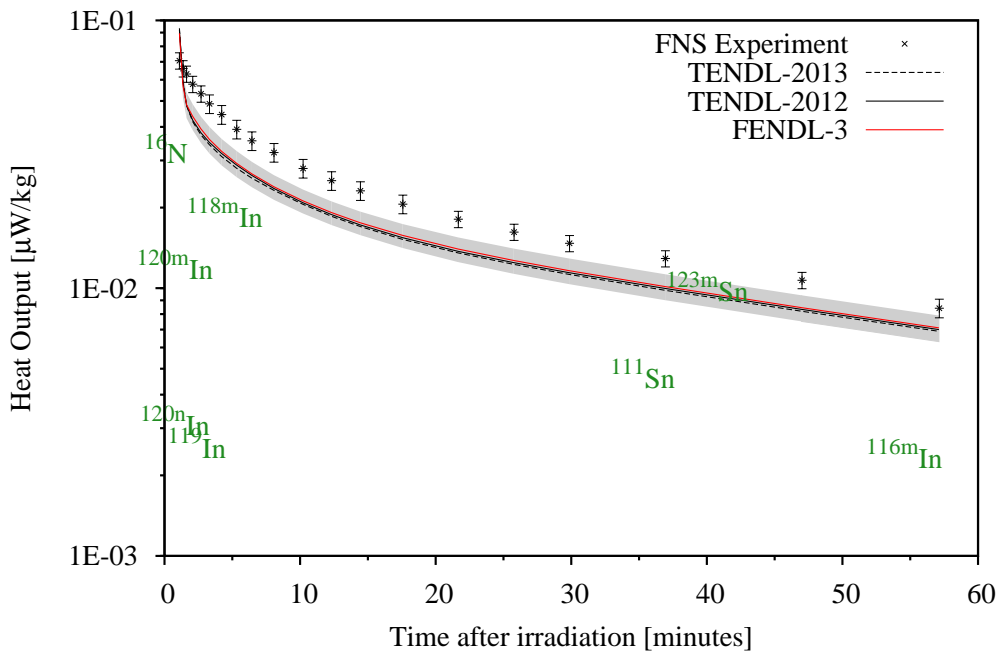


Tin

FNS-00 5 Min. Irradiation - SnO₂



FNS-96 5 Min. Irradiation - SnO₂

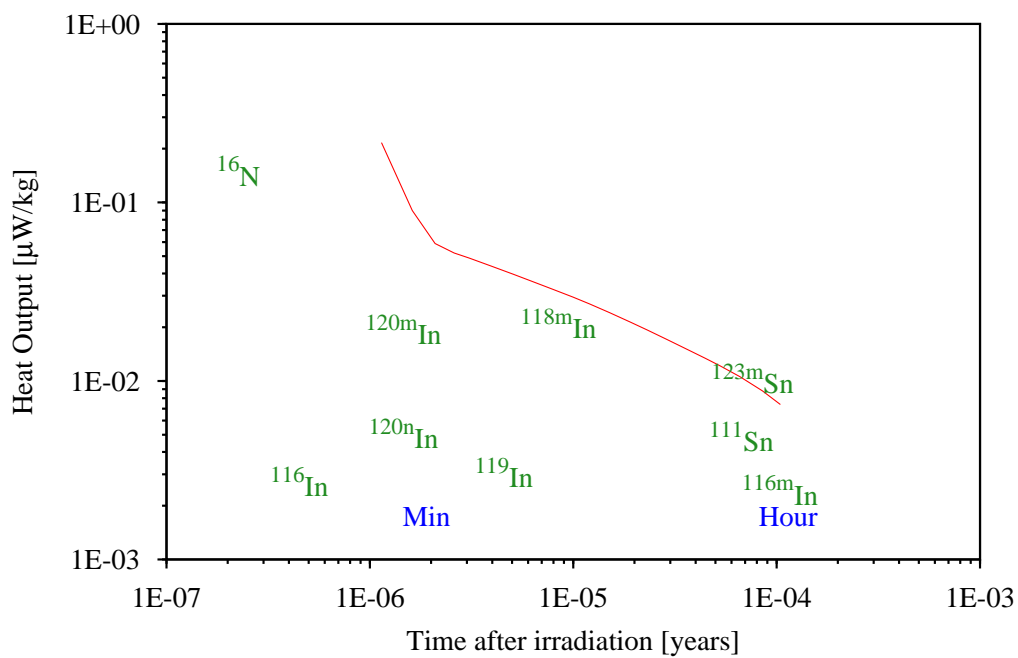


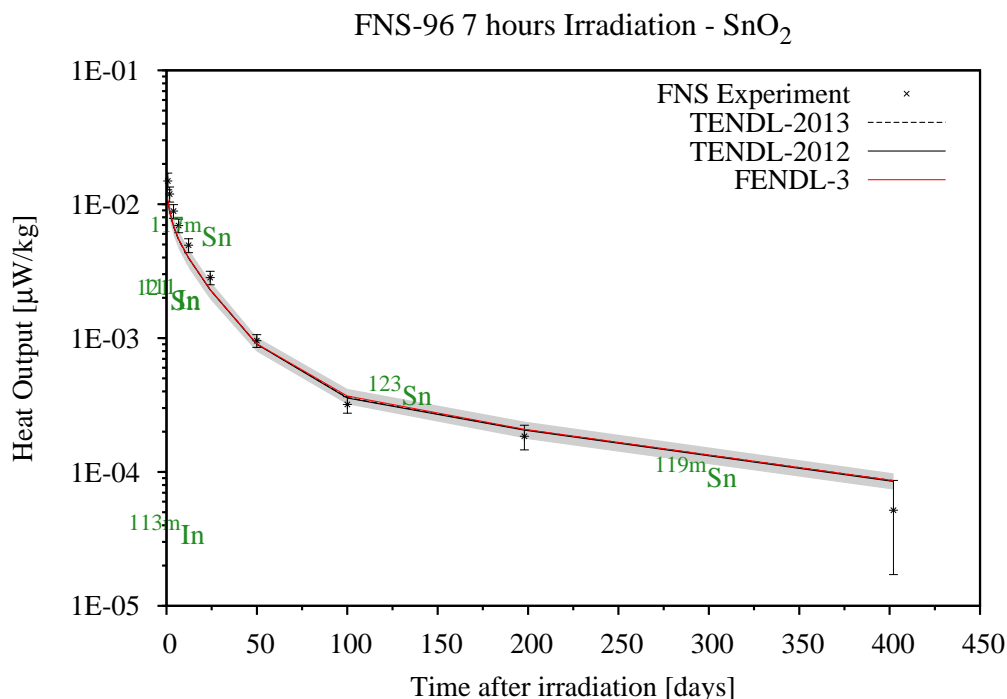
For Tin, the two experimental result sets differ, although the simulation produces much better agreement with the most recent one, particularly at very short cooling times.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C TENDL-2012 | E/C TENDL-2013 | E/C | | |
|-------|---------------------|---------------------|----------------|----------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.60 | $3.45E-01 \pm 12\%$ | $2.16E-01 \pm 7\%$ | 1.59 | $2.15E-01$ | 1.61 | $2.18E-01$ | 1.58 |
| 0.85 | $1.26E-01 \pm 9\%$ | $9.00E-02 \pm 8\%$ | 1.40 | $8.75E-02$ | 1.44 | $9.19E-02$ | 1.37 |
| 1.10 | $6.93E-02 \pm 7\%$ | $5.88E-02 \pm 10\%$ | 1.18 | $5.83E-02$ | 1.19 | $6.28E-02$ | 1.10 |
| 1.37 | $5.28E-02 \pm 7\%$ | $5.21E-02 \pm 11\%$ | 1.01 | $5.07E-02$ | 1.04 | $5.29E-02$ | 1.00 |
| 1.62 | $4.81E-02 \pm 7\%$ | $4.88E-02 \pm 11\%$ | 0.99 | $4.66E-02$ | 1.03 | $4.79E-02$ | 1.00 |
| 2.07 | $4.14E-02 \pm 7\%$ | $4.41E-02 \pm 11\%$ | 0.94 | $4.19E-02$ | 0.99 | $4.28E-02$ | 0.97 |
| 2.67 | $3.67E-02 \pm 7\%$ | $3.96E-02 \pm 11\%$ | 0.93 | $3.79E-02$ | 0.97 | $3.82E-02$ | 0.96 |
| 3.28 | $3.39E-02 \pm 7\%$ | $3.62E-02 \pm 11\%$ | 0.94 | $3.48E-02$ | 0.97 | $3.47E-02$ | 0.98 |
| 4.15 | $3.10E-02 \pm 7\%$ | $3.27E-02 \pm 11\%$ | 0.95 | $3.17E-02$ | 0.98 | $3.11E-02$ | 1.00 |
| 5.25 | $2.77E-02 \pm 7\%$ | $2.95E-02 \pm 11\%$ | 0.94 | $2.86E-02$ | 0.97 | $2.82E-02$ | 0.98 |
| 6.32 | $2.55E-02 \pm 7\%$ | $2.70E-02 \pm 11\%$ | 0.94 | $2.64E-02$ | 0.97 | $2.60E-02$ | 0.98 |
| 7.93 | $2.25E-02 \pm 7\%$ | $2.41E-02 \pm 11\%$ | 0.93 | $2.38E-02$ | 0.95 | $2.34E-02$ | 0.96 |
| 10.03 | $1.97E-02 \pm 6\%$ | $2.14E-02 \pm 10\%$ | 0.92 | $2.12E-02$ | 0.93 | $2.07E-02$ | 0.95 |
| 12.15 | $1.73E-02 \pm 6\%$ | $1.93E-02 \pm 10\%$ | 0.90 | $1.92E-02$ | 0.91 | $1.86E-02$ | 0.93 |
| 15.27 | $1.54E-02 \pm 6\%$ | $1.70E-02 \pm 10\%$ | 0.91 | $1.69E-02$ | 0.91 | $1.64E-02$ | 0.94 |
| 19.38 | $1.32E-02 \pm 6\%$ | $1.49E-02 \pm 10\%$ | 0.89 | $1.48E-02$ | 0.90 | $1.44E-02$ | 0.92 |
| 23.48 | $1.17E-02 \pm 6\%$ | $1.34E-02 \pm 11\%$ | 0.88 | $1.32E-02$ | 0.89 | $1.29E-02$ | 0.91 |
| 27.60 | $1.07E-02 \pm 6\%$ | $1.22E-02 \pm 11\%$ | 0.88 | $1.21E-02$ | 0.89 | $1.18E-02$ | 0.91 |
| 34.73 | $9.20E-03 \pm 6\%$ | $1.06E-02 \pm 11\%$ | 0.87 | $1.04E-02$ | 0.88 | $1.02E-02$ | 0.90 |
| 44.78 | $7.92E-03 \pm 6\%$ | $8.80E-03 \pm 11\%$ | 0.90 | $8.70E-03$ | 0.91 | $8.52E-03$ | 0.93 |
| 54.90 | $6.74E-03 \pm 6\%$ | $7.38E-03 \pm 11\%$ | 0.91 | $7.31E-03$ | 0.92 | $7.16E-03$ | 0.94 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|---------------------|-----------|--------|------|--------------|
| In120m | Sn120(n,p)In120m | 46.2s | 99.9 | 1.58 | 12% |
| In118m | Sn118(n,p)In118m | 4.4m | 90.4 | 1.00 | 7% |
| | Sn118(n,p)In118n | 8.5s | 8.3 | 1.00 | 7% |
| | Sn119(n,d+np)In118m | | 0.8 | 1.00 | 7% |
| Sn123m | Sn124(n,2n)Sn123m | 40.0m | 99.8 | 0.93 | 6% |

FNS-00 5 Min. Irradiation - SnO₂

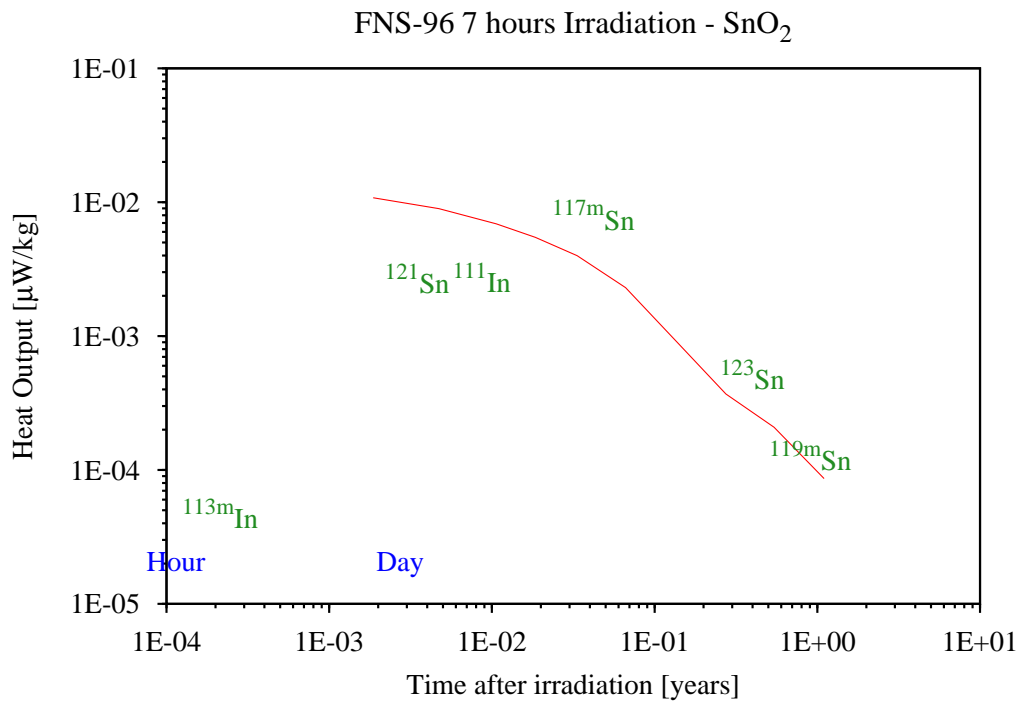




The above graph shows a relatively good agreement across all cooling times. It also shows the limit of the experimental measurement technique, with the large uncertainty after 13 months of cooling reflecting the fact that the heat output is approaching the pico-watt limit of sensitivity.

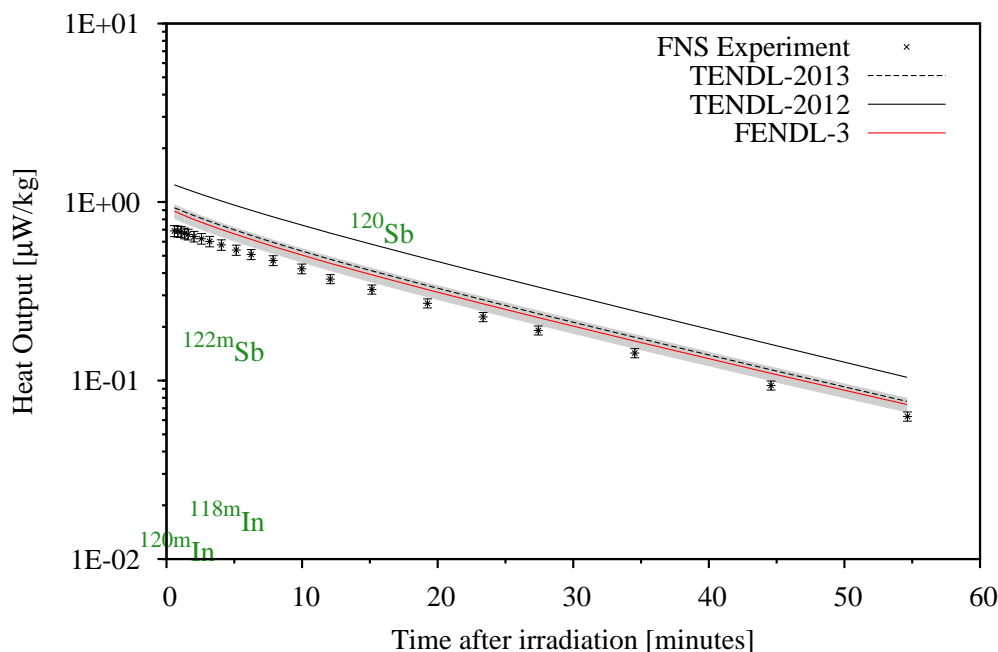
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|-----------------|------|------------|------|------------|------|
| 0.68 | 1.49E-02 +/-14% | 1.08E-02 +/-17% | 1.38 | 1.05E-02 | 1.42 | 1.06E-02 | 1.41 |
| 1.73 | 1.19E-02 +/-13% | 8.96E-03 +/-15% | 1.33 | 8.79E-03 | 1.36 | 8.82E-03 | 1.35 |
| 3.88 | 8.88E-03 +/-12% | 6.89E-03 +/-14% | 1.29 | 6.86E-03 | 1.29 | 6.77E-03 | 1.31 |
| 6.75 | 6.93E-03 +/-12% | 5.47E-03 +/-15% | 1.27 | 5.44E-03 | 1.27 | 5.40E-03 | 1.28 |
| 12.20 | 4.94E-03 +/-12% | 3.99E-03 +/-16% | 1.24 | 3.97E-03 | 1.24 | 3.96E-03 | 1.25 |
| 24.20 | 2.83E-03 +/-12% | 2.30E-03 +/-15% | 1.23 | 2.29E-03 | 1.23 | 2.29E-03 | 1.23 |
| 49.95 | 9.57E-04 +/-11% | 9.05E-04 +/-12% | 1.06 | 8.99E-04 | 1.06 | 9.03E-04 | 1.06 |
| 100.08 | 3.20E-04 +/-14% | 3.69E-04 +/-13% | 0.87 | 3.57E-04 | 0.90 | 3.60E-04 | 0.89 |
| 197.93 | 1.85E-04 +/-21% | 2.09E-04 +/-14% | 0.89 | 2.05E-04 | 0.90 | 2.08E-04 | 0.89 |
| 402.13 | 5.18E-05 +/-67% | 8.62E-05 +/-13% | 0.60 | 8.50E-05 | 0.61 | 8.63E-05 | 0.60 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Sn117m | Sn118(n,2n)Sn117m | 13.6d | 93.7 | 1.25 | 12% |
| | Sn117(n,n')Sn117m | | 6.2 | | |
| Sn123 | Sn124(n,2n)Sn123 | 129d | 99.9 | 0.89 | 14% |
| Sn119m | Sn120(n,2n)Sn119m | 293d | 94.0 | 0.60 | 67% |
| | Sn119(n,n')Sn119m | | 5.8 | | |



Antimony

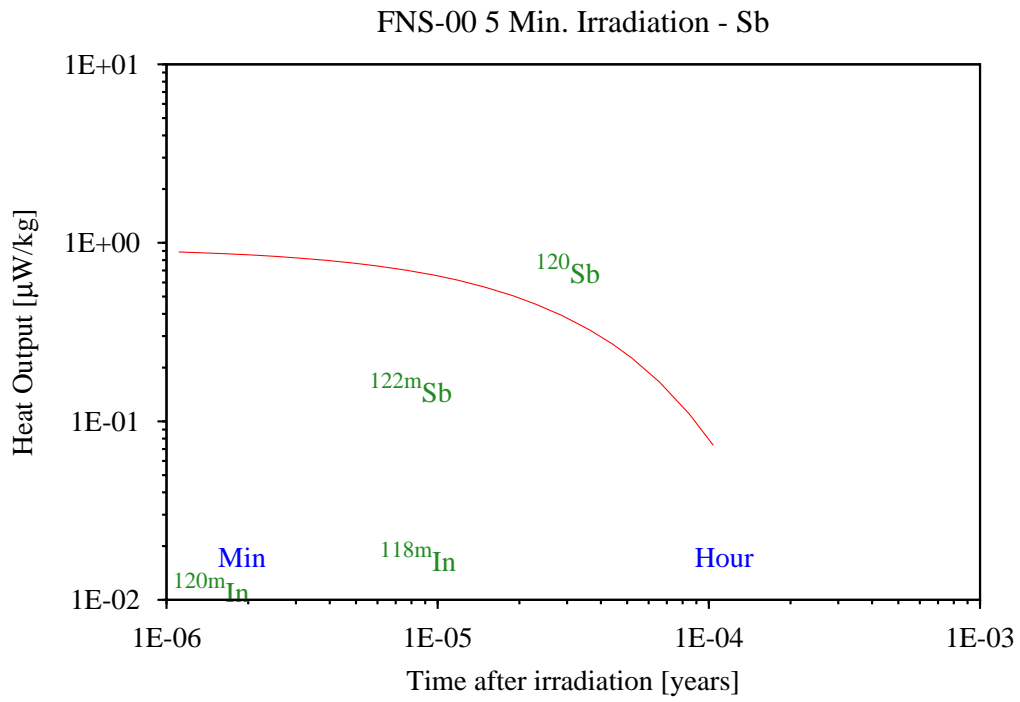
FNS-00 5 Min. Irradiation - Sb



For Antimony, TENDL-2013 results are very similar to FENDL-3.0 ones, but still over-predict by circa 20% at all cooling times.

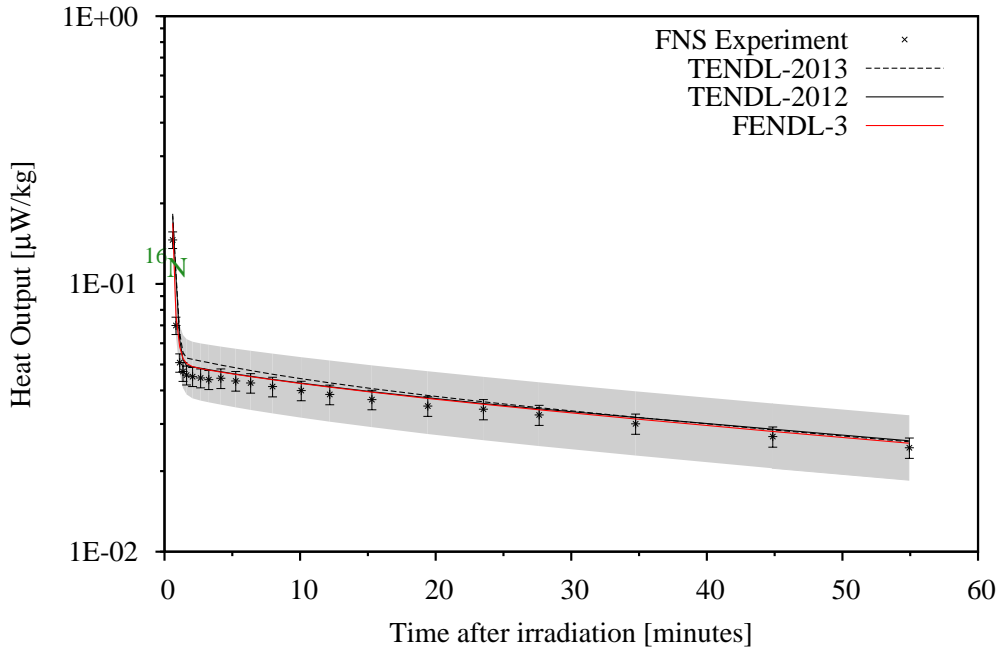
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.58 | 6.89E-01 +/-7% | 8.89E-01 +/-9% | 0.77 | 1.25E + 00 | 0.55 | 9.28E-01 | 0.74 |
| 0.83 | 6.86E-01 +/-7% | 8.71E-01 +/-9% | 0.79 | 1.23E + 00 | 0.56 | 9.12E-01 | 0.75 |
| 1.08 | 6.81E-01 +/-7% | 8.55E-01 +/-9% | 0.80 | 1.21E + 00 | 0.56 | 8.96E-01 | 0.76 |
| 1.33 | 6.68E-01 +/-7% | 8.39E-01 +/-9% | 0.80 | 1.19E + 00 | 0.56 | 8.80E-01 | 0.76 |
| 1.60 | 6.59E-01 +/-7% | 8.23E-01 +/-9% | 0.80 | 1.17E + 00 | 0.56 | 8.65E-01 | 0.76 |
| 2.03 | 6.41E-01 +/-7% | 7.99E-01 +/-9% | 0.80 | 1.14E + 00 | 0.56 | 8.40E-01 | 0.76 |
| 2.58 | 6.23E-01 +/-7% | 7.70E-01 +/-9% | 0.81 | 1.10E + 00 | 0.56 | 8.10E-01 | 0.77 |
| 3.18 | 6.02E-01 +/-7% | 7.40E-01 +/-9% | 0.81 | 1.07E + 00 | 0.56 | 7.80E-01 | 0.77 |
| 4.05 | 5.75E-01 +/-7% | 7.02E-01 +/-9% | 0.82 | 1.01E + 00 | 0.57 | 7.39E-01 | 0.78 |
| 5.15 | 5.38E-01 +/-7% | 6.57E-01 +/-9% | 0.82 | 9.54E - 01 | 0.56 | 6.92E-01 | 0.78 |
| 6.25 | 5.09E-01 +/-6% | 6.17E-01 +/-9% | 0.82 | 8.99E - 01 | 0.57 | 6.50E-01 | 0.78 |
| 7.87 | 4.70E-01 +/-6% | 5.64E-01 +/-9% | 0.83 | 8.26E - 01 | 0.57 | 5.94E-01 | 0.79 |
| 9.98 | 4.23E-01 +/-6% | 5.05E-01 +/-9% | 0.84 | 7.43E - 01 | 0.57 | 5.32E-01 | 0.80 |
| 12.08 | 3.70E-01 +/-6% | 4.54E-01 +/-9% | 0.82 | 6.70E - 01 | 0.55 | 4.78E-01 | 0.77 |
| 15.15 | 3.24E-01 +/-6% | 3.91E-01 +/-9% | 0.83 | 5.80E - 01 | 0.56 | 4.12E-01 | 0.79 |
| 19.25 | 2.71E-01 +/-6% | 3.23E-01 +/-10% | 0.84 | 4.80E - 01 | 0.56 | 3.40E-01 | 0.80 |
| 23.35 | 2.27E-01 +/-6% | 2.69E-01 +/-10% | 0.84 | 4.00E - 01 | 0.57 | 2.83E-01 | 0.80 |
| 27.42 | 1.91E-01 +/-6% | 2.25E-01 +/-10% | 0.85 | 3.34E - 01 | 0.57 | 2.37E-01 | 0.81 |
| 34.53 | 1.42E-01 +/-6% | 1.66E-01 +/-10% | 0.86 | 2.45E - 01 | 0.58 | 1.75E-01 | 0.81 |
| 44.58 | 9.39E-02 +/-6% | 1.10E-01 +/-9% | 0.86 | 1.60E - 01 | 0.59 | 1.15E-01 | 0.82 |
| 54.65 | 6.30E-02 +/-6% | 7.33E-02 +/-9% | 0.86 | 1.04E - 01 | 0.60 | 7.65E-02 | 0.82 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|------------------|------------------|--------|---------|
| Sb120 | Sb121(n,2n)Sb120 | 15.9m | 100.0 | 0.79 6% |



Tellurium

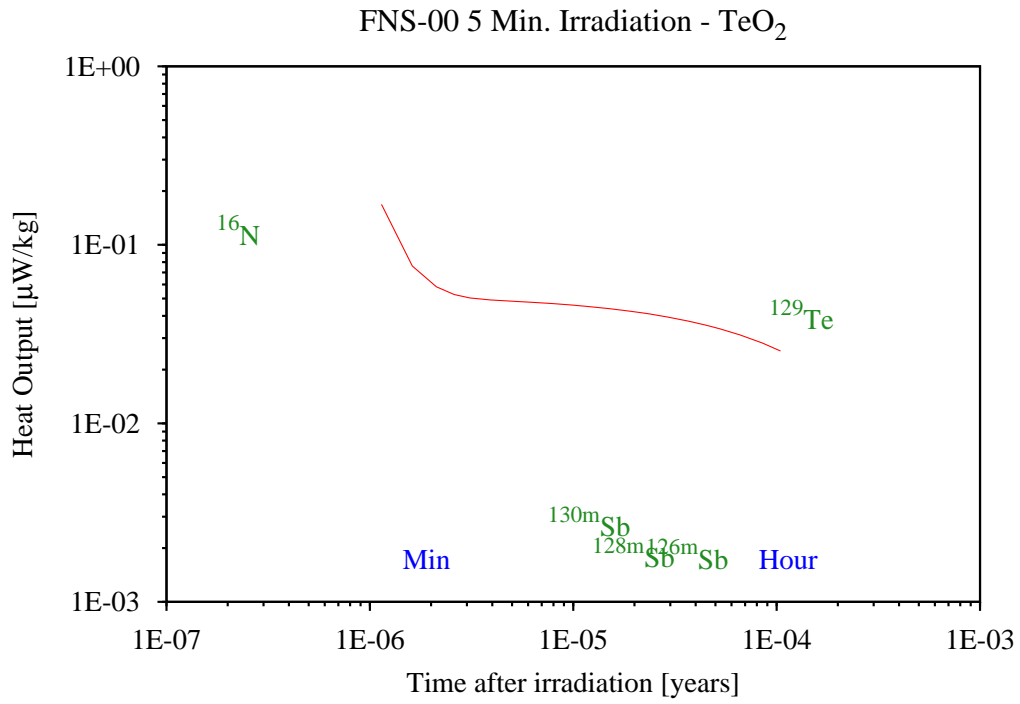
FNS-00 5 Min. Irradiation - TeO₂



For Tellurium, an excellent agreement can be seen, at all cooling times, within the uncertainty of the experiment, which even allows for the decay of the short-lived N16 to be observed.

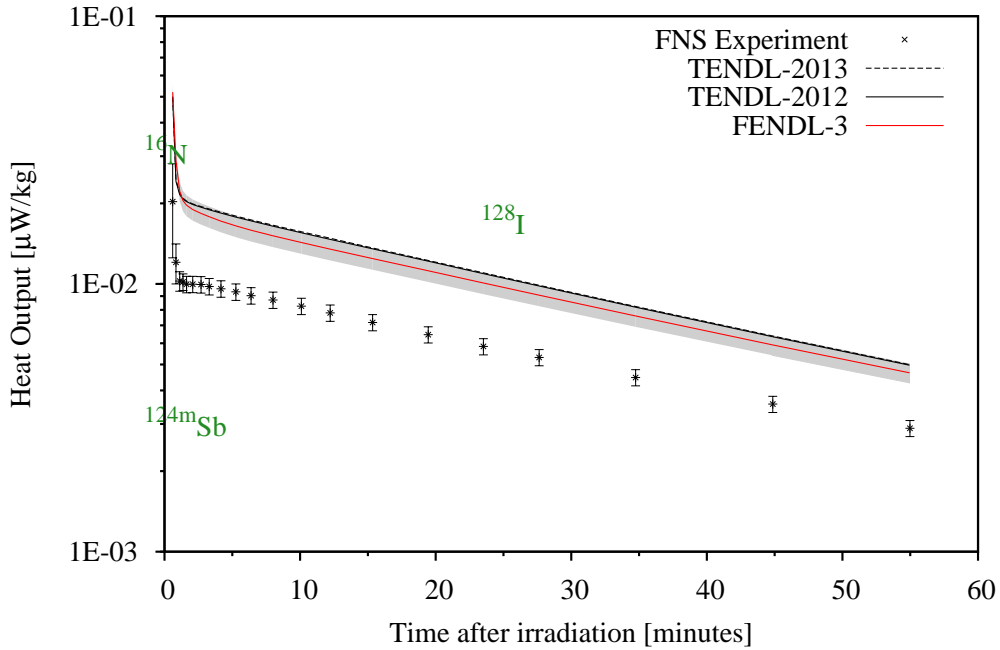
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.60 | 1.46E-01 +/-7% | 1.68E-01 +/-10% | 0.87 | 1.79E-01 | 0.82 | 1.83E-01 | 0.80 |
| 0.85 | 6.99E-02 +/-7% | 7.61E-02 +/-16% | 0.92 | 1.06E-01 | 0.66 | 1.10E-01 | 0.64 |
| 1.12 | 5.08E-02 +/-8% | 5.82E-02 +/-20% | 0.87 | 6.20E-02 | 0.82 | 6.55E-02 | 0.78 |
| 1.37 | 4.71E-02 +/-8% | 5.27E-02 +/-22% | 0.89 | 5.21E-02 | 0.90 | 5.55E-02 | 0.85 |
| 1.63 | 4.56E-02 +/-8% | 5.04E-02 +/-23% | 0.90 | 4.95E-02 | 0.92 | 5.29E-02 | 0.86 |
| 2.07 | 4.51E-02 +/-8% | 4.91E-02 +/-24% | 0.92 | 4.90E-02 | 0.92 | 5.23E-02 | 0.86 |
| 2.67 | 4.45E-02 +/-8% | 4.83E-02 +/-24% | 0.92 | 4.84E-02 | 0.92 | 5.15E-02 | 0.86 |
| 3.27 | 4.39E-02 +/-8% | 4.77E-02 +/-24% | 0.92 | 4.78E-02 | 0.92 | 5.08E-02 | 0.86 |
| 4.15 | 4.44E-02 +/-8% | 4.69E-02 +/-24% | 0.95 | 4.70E-02 | 0.94 | 4.98E-02 | 0.89 |
| 5.25 | 4.34E-02 +/-8% | 4.59E-02 +/-25% | 0.95 | 4.61E-02 | 0.94 | 4.86E-02 | 0.89 |
| 6.35 | 4.27E-02 +/-8% | 4.51E-02 +/-25% | 0.95 | 4.52E-02 | 0.94 | 4.75E-02 | 0.90 |
| 7.97 | 4.13E-02 +/-8% | 4.39E-02 +/-25% | 0.94 | 4.40E-02 | 0.94 | 4.60E-02 | 0.90 |
| 10.08 | 4.00E-02 +/-8% | 4.25E-02 +/-25% | 0.94 | 4.26E-02 | 0.94 | 4.43E-02 | 0.90 |
| 12.18 | 3.86E-02 +/-8% | 4.12E-02 +/-26% | 0.94 | 4.13E-02 | 0.93 | 4.27E-02 | 0.90 |
| 15.30 | 3.70E-02 +/-8% | 3.94E-02 +/-26% | 0.94 | 3.96E-02 | 0.93 | 4.07E-02 | 0.91 |
| 19.42 | 3.50E-02 +/-8% | 3.74E-02 +/-26% | 0.94 | 3.76E-02 | 0.93 | 3.83E-02 | 0.91 |
| 23.52 | 3.40E-02 +/-9% | 3.55E-02 +/-27% | 0.96 | 3.58E-02 | 0.95 | 3.63E-02 | 0.94 |
| 27.63 | 3.24E-02 +/-9% | 3.39E-02 +/-27% | 0.96 | 3.42E-02 | 0.95 | 3.45E-02 | 0.94 |
| 34.75 | 3.00E-02 +/-9% | 3.13E-02 +/-27% | 0.96 | 3.17E-02 | 0.95 | 3.18E-02 | 0.95 |
| 44.87 | 2.69E-02 +/-9% | 2.81E-02 +/-27% | 0.96 | 2.87E-02 | 0.94 | 2.85E-02 | 0.94 |
| 54.93 | 2.44E-02 +/-9% | 2.54E-02 +/-27% | 0.96 | 2.60E-02 | 0.94 | 2.58E-02 | 0.95 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|------------------|------------------|--------|---------|
| N16 | O16(n,p)N16 | 7.1s | 99.9 | 0.80 7% |
| Te129 | Te130(n,2n)Te129 | 1.1h | 99.7 | 0.95 8% |



Iodine

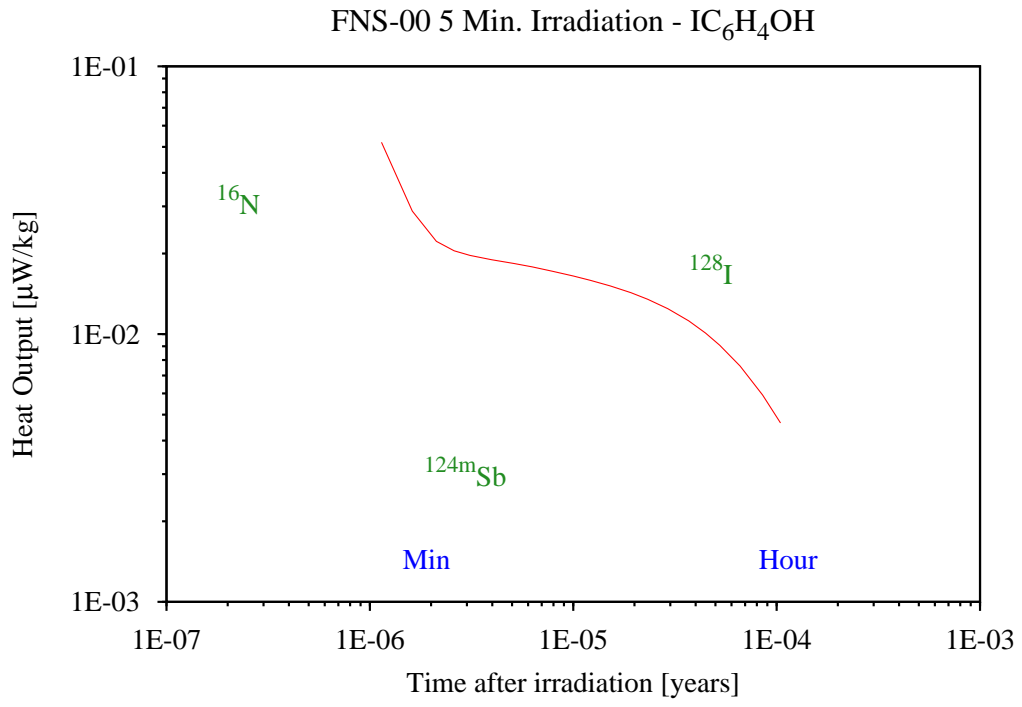
FNS-00 5 Min. Irradiation - IC₆H₄OH



For Iodine, a rather systematic code over-prediction is observed for the sample compound, however here again the major channel involved is a capture for which the thermal part cannot be accurately predicted.

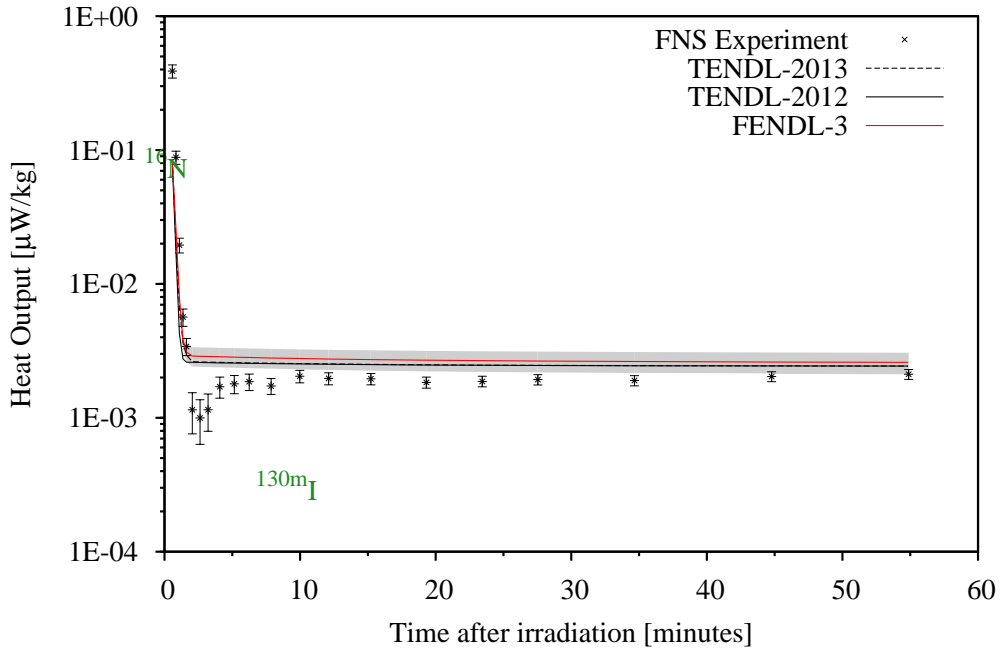
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|----------------|------|------------|------|------------|------|
| 0.60 | 2.03E-02 +/-38% | 5.20E-02 +/-7% | 0.39 | 4.98E-02 | 0.41 | 5.01E-02 | 0.40 |
| 0.85 | 1.20E-02 +/-17% | 2.88E-02 +/-7% | 0.42 | 2.41E-02 | 0.50 | 2.45E-02 | 0.49 |
| 1.12 | 1.03E-02 +/-8% | 2.22E-02 +/-8% | 0.46 | 2.16E-02 | 0.48 | 2.19E-02 | 0.47 |
| 1.37 | 1.02E-02 +/-7% | 2.05E-02 +/-9% | 0.50 | 2.07E-02 | 0.49 | 2.09E-02 | 0.49 |
| 1.63 | 9.97E-03 +/-7% | 1.97E-02 +/-9% | 0.51 | 2.03E-02 | 0.49 | 2.04E-02 | 0.49 |
| 2.08 | 9.98E-03 +/-7% | 1.90E-02 +/-9% | 0.53 | 1.98E-02 | 0.50 | 1.99E-02 | 0.50 |
| 2.70 | 9.95E-03 +/-7% | 1.83E-02 +/-9% | 0.54 | 1.93E-02 | 0.51 | 1.94E-02 | 0.51 |
| 3.30 | 9.78E-03 +/-7% | 1.78E-02 +/-9% | 0.55 | 1.89E-02 | 0.52 | 1.91E-02 | 0.51 |
| 4.17 | 9.59E-03 +/-7% | 1.72E-02 +/-9% | 0.56 | 1.84E-02 | 0.52 | 1.85E-02 | 0.52 |
| 5.27 | 9.34E-03 +/-7% | 1.65E-02 +/-9% | 0.57 | 1.78E-02 | 0.53 | 1.79E-02 | 0.52 |
| 6.38 | 9.04E-03 +/-7% | 1.59E-02 +/-9% | 0.57 | 1.72E-02 | 0.53 | 1.73E-02 | 0.52 |
| 8.00 | 8.71E-03 +/-7% | 1.51E-02 +/-9% | 0.58 | 1.64E-02 | 0.53 | 1.66E-02 | 0.53 |
| 10.10 | 8.26E-03 +/-7% | 1.43E-02 +/-9% | 0.58 | 1.55E-02 | 0.53 | 1.57E-02 | 0.53 |
| 12.22 | 7.80E-03 +/-7% | 1.35E-02 +/-9% | 0.58 | 1.47E-02 | 0.53 | 1.48E-02 | 0.53 |
| 15.35 | 7.18E-03 +/-7% | 1.24E-02 +/-9% | 0.58 | 1.35E-02 | 0.53 | 1.36E-02 | 0.53 |
| 19.45 | 6.47E-03 +/-7% | 1.12E-02 +/-9% | 0.58 | 1.22E-02 | 0.53 | 1.22E-02 | 0.53 |
| 23.52 | 5.84E-03 +/-7% | 1.01E-02 +/-9% | 0.58 | 1.09E-02 | 0.53 | 1.10E-02 | 0.53 |
| 27.63 | 5.31E-03 +/-7% | 9.08E-03 +/-9% | 0.59 | 9.83E-03 | 0.54 | 9.89E-03 | 0.54 |
| 34.75 | 4.47E-03 +/-7% | 7.59E-03 +/-9% | 0.59 | 8.19E-03 | 0.55 | 8.24E-03 | 0.54 |
| 44.87 | 3.56E-03 +/-7% | 5.92E-03 +/-9% | 0.60 | 6.35E-03 | 0.56 | 6.39E-03 | 0.56 |
| 54.98 | 2.89E-03 +/-7% | 4.66E-03 +/-8% | 0.62 | 4.97E-03 | 0.58 | 5.00E-03 | 0.58 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|---------------|------------------|--------|---------|
| I128 | I127(n,γ)I128 | 24.9m | 100.0 | 0.53 6% |



Caesium

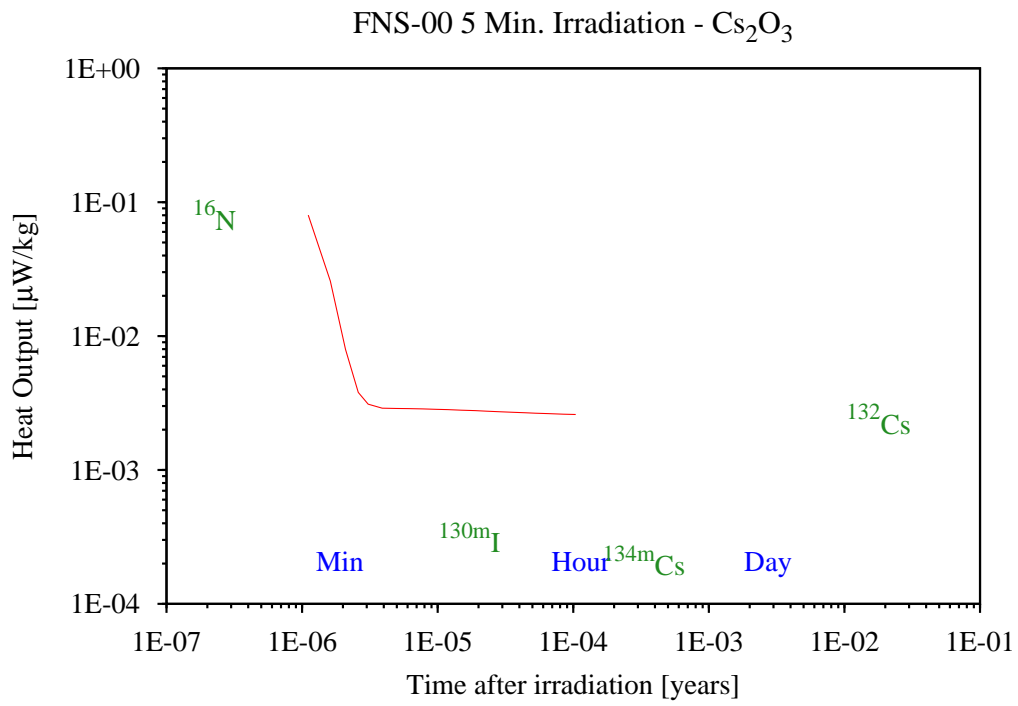
FNS-00 5 Min. Irradiation - Cs₂O₃



For Caesium, a surprising, but not un-physical upward short-term trend in the experimental heat measurements heat is observed, that may be caused by isomeric states that are unidentified in the calculational scheme, or by a larger than expected subtraction of the tape contribution.

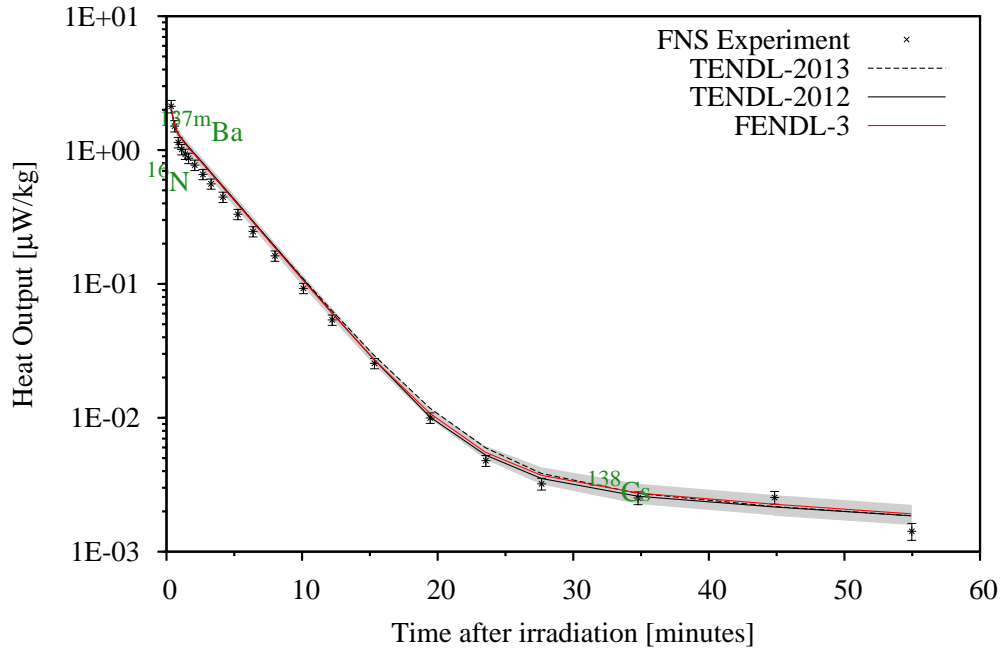
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.58 | 3.89E-01 +/-11% | 8.01E-02 +/-10% | 4.85 | 7.58E-02 | 5.13 | 8.56E-02 | 4.54 |
| 0.85 | 8.81E-02 +/-11% | 2.58E-02 +/-9% | 3.42 | 1.70E-02 | 5.18 | 2.00E-02 | 4.40 |
| 1.10 | 1.95E-02 +/-13% | 7.95E-03 +/-9% | 2.45 | 4.23E-03 | 4.61 | 6.72E-03 | 2.90 |
| 1.37 | 5.66E-03 +/-15% | 3.79E-03 +/-13% | 1.49 | 2.76E-03 | 2.05 | 3.62E-03 | 1.56 |
| 1.62 | 3.42E-03 +/-15% | 3.10E-03 +/-15% | 1.10 | 2.60E-03 | 1.31 | 2.96E-03 | 1.15 |
| 2.05 | 1.15E-03 +/-34% | 2.89E-03 +/-16% | 0.40 | 2.60E-03 | 0.44 | 2.62E-03 | 0.44 |
| 2.62 | 9.98E-04 +/-37% | 2.88E-03 +/-17% | 0.35 | 2.59E-03 | 0.39 | 2.61E-03 | 0.38 |
| 3.22 | 1.15E-03 +/-31% | 2.87E-03 +/-17% | 0.40 | 2.58E-03 | 0.44 | 2.60E-03 | 0.44 |
| 4.08 | 1.71E-03 +/-18% | 2.86E-03 +/-17% | 0.60 | 2.57E-03 | 0.66 | 2.59E-03 | 0.66 |
| 5.15 | 1.79E-03 +/-16% | 2.84E-03 +/-17% | 0.63 | 2.56E-03 | 0.70 | 2.58E-03 | 0.69 |
| 6.25 | 1.86E-03 +/-14% | 2.82E-03 +/-17% | 0.66 | 2.55E-03 | 0.73 | 2.57E-03 | 0.72 |
| 7.87 | 1.73E-03 +/-14% | 2.80E-03 +/-17% | 0.62 | 2.54E-03 | 0.68 | 2.56E-03 | 0.68 |
| 9.98 | 2.04E-03 +/-11% | 2.77E-03 +/-17% | 0.74 | 2.53E-03 | 0.81 | 2.54E-03 | 0.81 |
| 12.10 | 1.97E-03 +/-10% | 2.75E-03 +/-17% | 0.72 | 2.51E-03 | 0.78 | 2.52E-03 | 0.78 |
| 15.22 | 1.95E-03 +/-10% | 2.72E-03 +/-17% | 0.72 | 2.50E-03 | 0.78 | 2.51E-03 | 0.78 |
| 19.32 | 1.84E-03 +/-9% | 2.69E-03 +/-17% | 0.68 | 2.48E-03 | 0.74 | 2.49E-03 | 0.74 |
| 23.43 | 1.87E-03 +/-9% | 2.67E-03 +/-18% | 0.70 | 2.47E-03 | 0.76 | 2.47E-03 | 0.76 |
| 27.53 | 1.93E-03 +/-9% | 2.65E-03 +/-18% | 0.73 | 2.46E-03 | 0.78 | 2.46E-03 | 0.78 |
| 34.67 | 1.90E-03 +/-9% | 2.63E-03 +/-18% | 0.72 | 2.45E-03 | 0.78 | 2.45E-03 | 0.78 |
| 44.78 | 2.03E-03 +/-9% | 2.61E-03 +/-18% | 0.78 | 2.44E-03 | 0.83 | 2.44E-03 | 0.83 |
| 54.88 | 2.12E-03 +/-8% | 2.60E-03 +/-18% | 0.81 | 2.43E-03 | 0.87 | 2.43E-03 | 0.87 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|------------------|------------------|--------|---------|
| Cs132 | Cs133(n,2n)Cs132 | 6.5d | 100.0 | 0.87 8% |

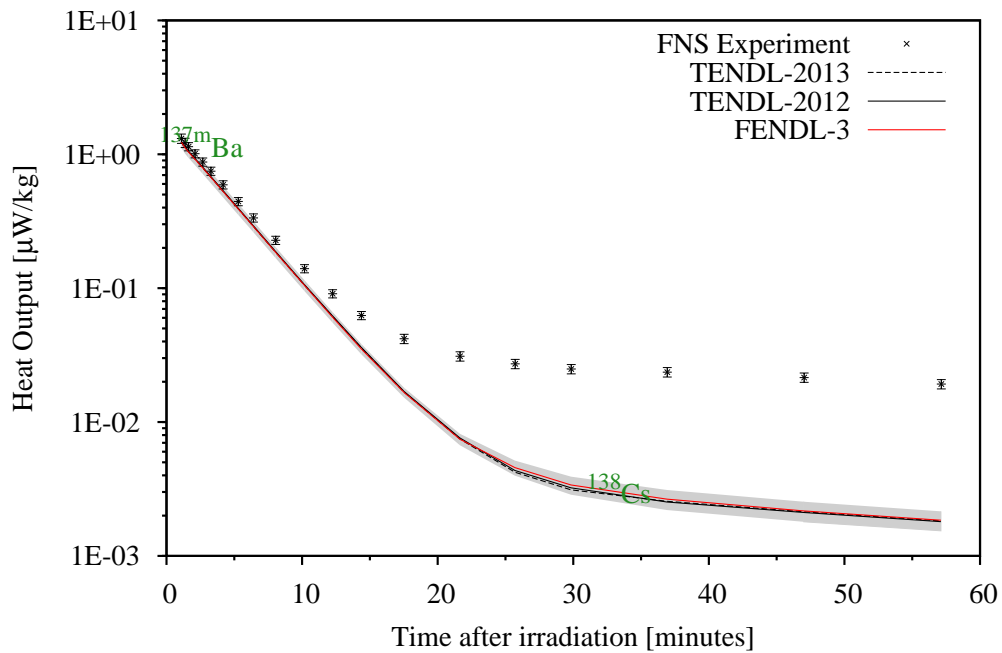


Barium

FNS-00 5 Min. Irradiation - BaCO₃



FNS-96 5 Min. Irradiation - BaCO₃

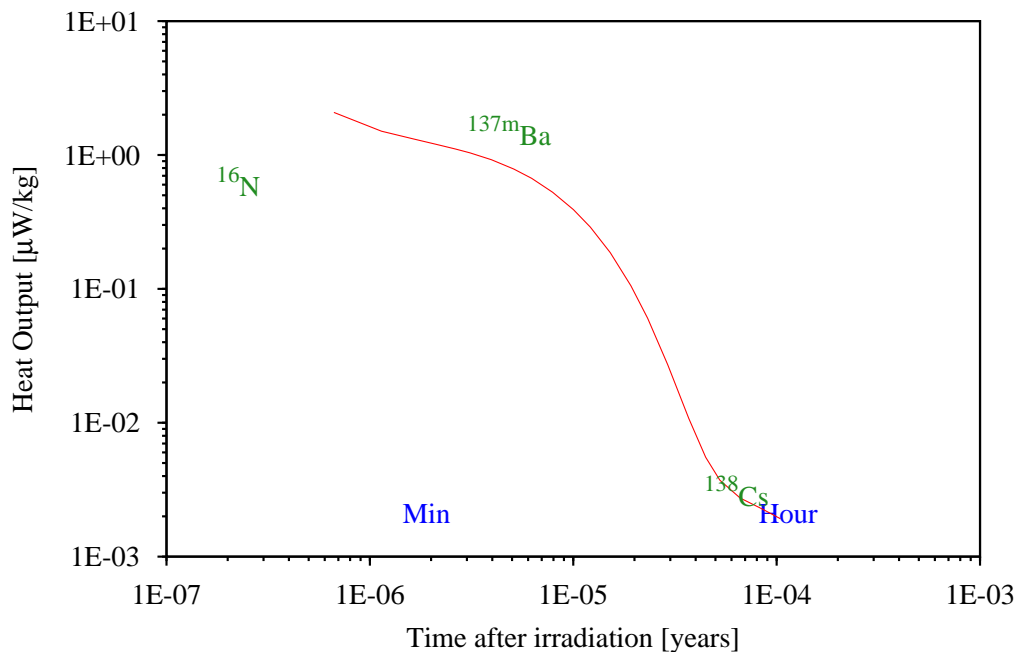


For Barium, once again the two sets of experimental measurements differ. The 1996 sample may have contained some unidentified impurities, possibly Fluorine.

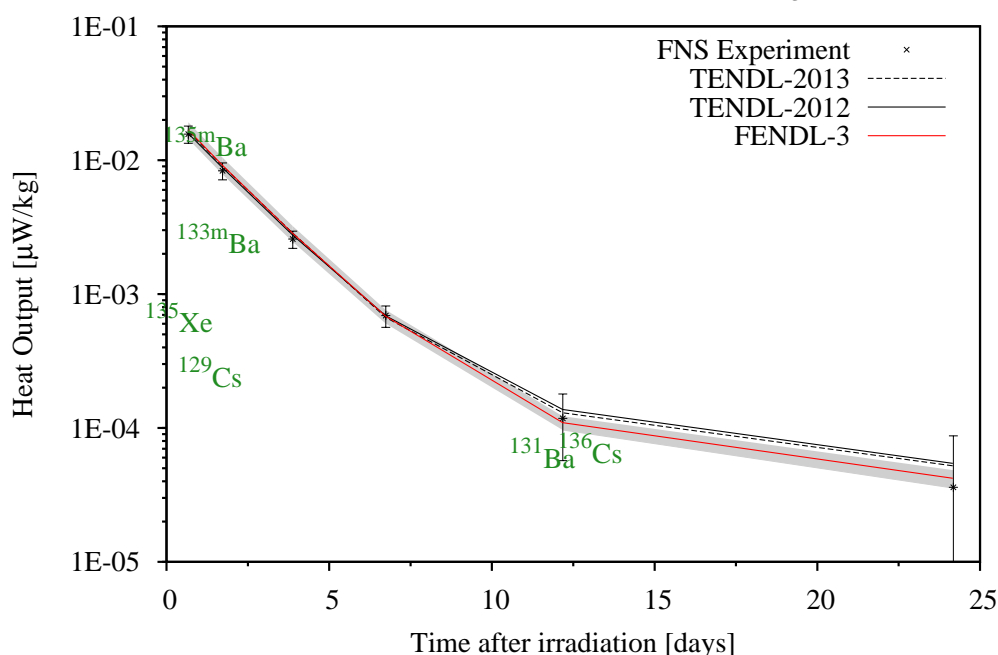
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|---------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.35 | $2.12E+00 \pm 11\%$ | $2.08E+00 \pm 7\%$ | 1.02 | $2.04E+00$ | 1.04 | $2.02E+00$ | 1.05 |
| 0.60 | $1.51E+00 \pm 10\%$ | $1.50E+00 \pm 9\%$ | 1.00 | $1.49E+00$ | 1.01 | $1.48E+00$ | 1.02 |
| 0.87 | $1.14E+00 \pm 9\%$ | $1.32E+00 \pm 9\%$ | 0.87 | $1.32E+00$ | 0.86 | $1.31E+00$ | 0.87 |
| 1.12 | $1.01E+00 \pm 9\%$ | $1.20E+00 \pm 10\%$ | 0.84 | $1.22E+00$ | 0.83 | $1.21E+00$ | 0.84 |
| 1.38 | $9.32E-01 \pm 9\%$ | $1.11E+00 \pm 10\%$ | 0.84 | $1.13E+00$ | 0.82 | $1.12E+00$ | 0.83 |
| 1.63 | $8.69E-01 \pm 9\%$ | $1.04E+00 \pm 10\%$ | 0.84 | $1.06E+00$ | 0.82 | $1.04E+00$ | 0.83 |
| 2.08 | $7.72E-01 \pm 9\%$ | $9.22E-01 \pm 10\%$ | 0.84 | $9.38E-01$ | 0.82 | $9.28E-01$ | 0.83 |
| 2.68 | $6.58E-01 \pm 9\%$ | $7.86E-01 \pm 10\%$ | 0.84 | $8.00E-01$ | 0.82 | $7.91E-01$ | 0.83 |
| 3.28 | $5.59E-01 \pm 9\%$ | $6.68E-01 \pm 10\%$ | 0.84 | $6.80E-01$ | 0.82 | $6.72E-01$ | 0.83 |
| 4.17 | $4.45E-01 \pm 9\%$ | $5.26E-01 \pm 10\%$ | 0.85 | $5.36E-01$ | 0.83 | $5.30E-01$ | 0.84 |
| 5.27 | $3.31E-01 \pm 9\%$ | $3.91E-01 \pm 10\%$ | 0.85 | $3.98E-01$ | 0.83 | $3.94E-01$ | 0.84 |
| 6.38 | $2.46E-01 \pm 9\%$ | $2.89E-01 \pm 10\%$ | 0.85 | $2.95E-01$ | 0.84 | $2.92E-01$ | 0.84 |
| 8.00 | $1.62E-01 \pm 9\%$ | $1.87E-01 \pm 9\%$ | 0.87 | $1.91E-01$ | 0.85 | $1.90E-01$ | 0.85 |
| 10.10 | $9.27E-02 \pm 9\%$ | $1.05E-01 \pm 9\%$ | 0.88 | $1.08E-01$ | 0.86 | $1.09E-01$ | 0.85 |
| 12.22 | $5.38E-02 \pm 9\%$ | $6.04E-02 \pm 9\%$ | 0.89 | $6.07E-02$ | 0.89 | $6.30E-02$ | 0.85 |
| 15.33 | $2.55E-02 \pm 9\%$ | $2.72E-02 \pm 9\%$ | 0.94 | $2.71E-02$ | 0.94 | $2.92E-02$ | 0.87 |
| 19.45 | $9.97E-03 \pm 9\%$ | $1.08E-02 \pm 9\%$ | 0.92 | $1.01E-02$ | 0.98 | $1.18E-02$ | 0.85 |
| 23.55 | $4.78E-03 \pm 9\%$ | $5.52E-03 \pm 11\%$ | 0.87 | $5.27E-03$ | 0.91 | $5.97E-03$ | 0.80 |
| 27.67 | $3.21E-03 \pm 10\%$ | $3.73E-03 \pm 15\%$ | 0.86 | $3.53E-03$ | 0.91 | $3.84E-03$ | 0.83 |
| 34.78 | $2.52E-03 \pm 11\%$ | $2.74E-03 \pm 17\%$ | 0.92 | $2.60E-03$ | 0.97 | $2.73E-03$ | 0.92 |
| 44.85 | $2.54E-03 \pm 11\%$ | $2.26E-03 \pm 17\%$ | 1.12 | $2.16E-03$ | 1.18 | $2.17E-03$ | 1.17 |
| 54.97 | $1.42E-03 \pm 14\%$ | $1.92E-03 \pm 17\%$ | 0.74 | $1.85E-03$ | 0.77 | $1.86E-03$ | 0.76 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-------------------|-----------|--------|------|--------------|
| N16 | O16(n,p)N16 | 7.1s | 99.9 | 1.05 | 10% |
| Ba137m | Ba137(n,n')Ba137m | 2.5m | 3.6 | 0.83 | 8% |
| | Ba138(n,2n)Ba137m | | 95.3 | 0.83 | 8% |
| Cs138 | Ba138(n,p)Cs138 | 33.4m | 85.2 | 0.92 | 10% |
| | Ba138(n,p)Cs138m | 2.9m | 15.0 | 0.92 | 10% |

FNS-00 5 Min. Irradiation - BaCO₃



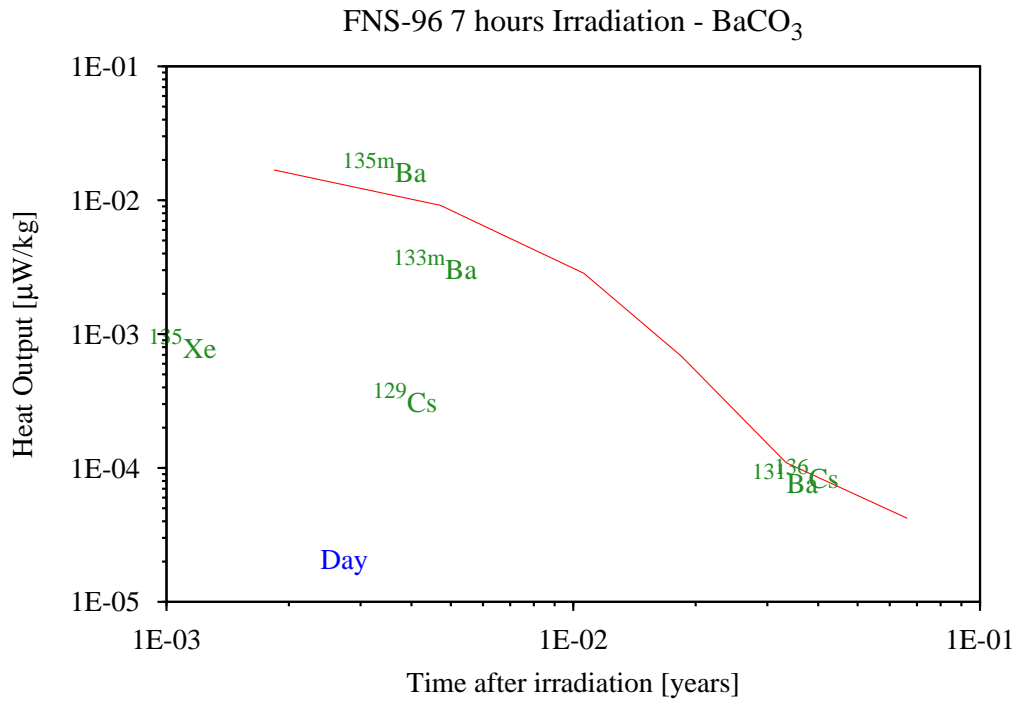
FNS-96 7 hours Irradiation - BaCO₃



A relatively good agreement is seen between experiment and calculation for cooling times from one day up nearly a month.

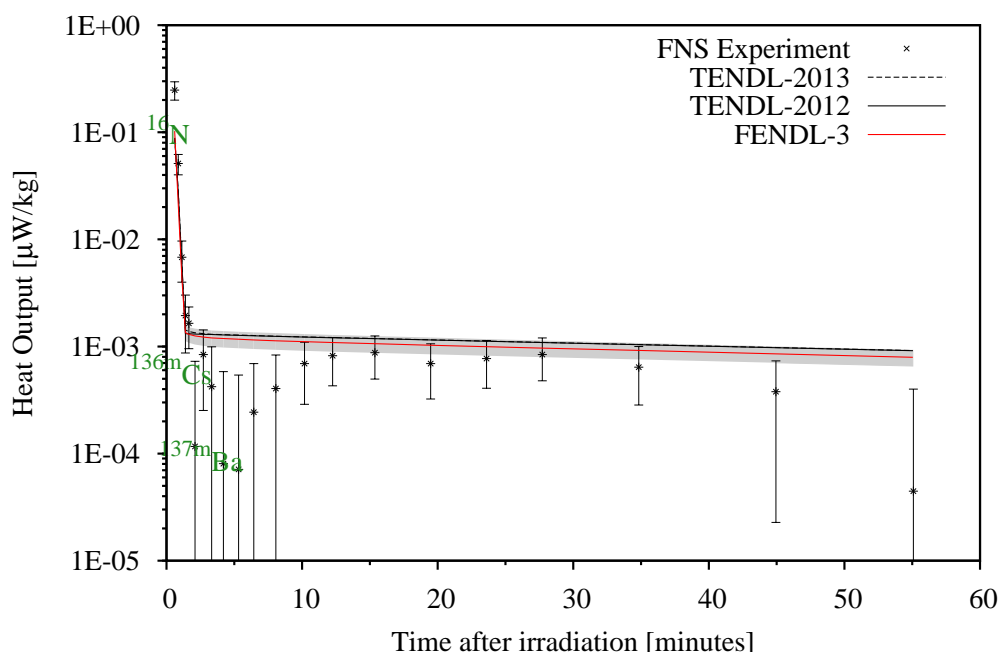
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|-------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.67 | $1.57E-02$ +/-15% | $1.68E-02$ +/-14% | 0.93 | $1.58E-02$ | 0.99 | $1.63E-02$ | 0.96 |
| 1.72 | $8.33E-03$ +/-14% | $9.14E-03$ +/-14% | 0.91 | $8.78E-03$ | 0.95 | $9.08E-03$ | 0.92 |
| 3.88 | $2.58E-03$ +/-15% | $2.84E-03$ +/-14% | 0.91 | $2.76E-03$ | 0.93 | $2.86E-03$ | 0.90 |
| 6.74 | $6.90E-04$ +/-18% | $6.82E-04$ +/-12% | 1.01 | $6.88E-04$ | 1.00 | $6.68E-04$ | 1.03 |
| 12.18 | $1.18E-04$ +/-52% | $1.10E-04$ +/-12% | 1.08 | $1.37E-04$ | 0.86 | $1.30E-04$ | 0.91 |
| 24.18 | $3.60E-05$ +/-143% | $4.20E-05$ +/-15% | 0.86 | $5.44E-05$ | 0.66 | $5.21E-05$ | 0.69 |

| Product | Pathways | T _{1/2} | Path % | E/C | $\Delta\text{E}\%$ |
|---------|-------------------|------------------|--------|------|--------------------|
| Ba135m | Ba136(n,2n)Ba135m | 1.1d | 88.2 | 0.96 | 15% |
| | Ba135(n,n')Ba135m | | 11.8 | 0.96 | 15% |
| Ba133m | Ba134(n,2n)Ba133m | 1.5d | 100.0 | 0.92 | 14% |
| Ba131 | Ba132(n,2n)Ba131 | 11.5d | 35.7 | 0.91 | 52% |
| | Ba132(n,2n)Ba131m | | 63.6 | 0.91 | 52% |



Lanthanum

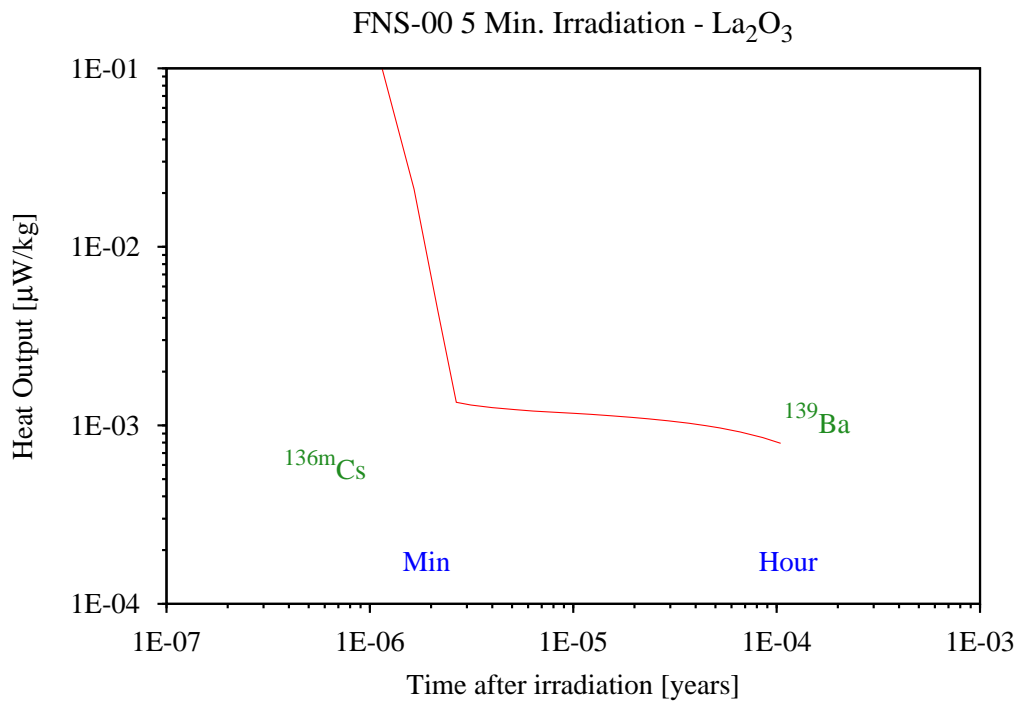
FNS-00 5 Min. Irradiation - La₂O₃



For Lanthanum, the rather large and honest experimental uncertainties do not permit an in-depth investigation, although the overall trend seems to be present in the calculations.

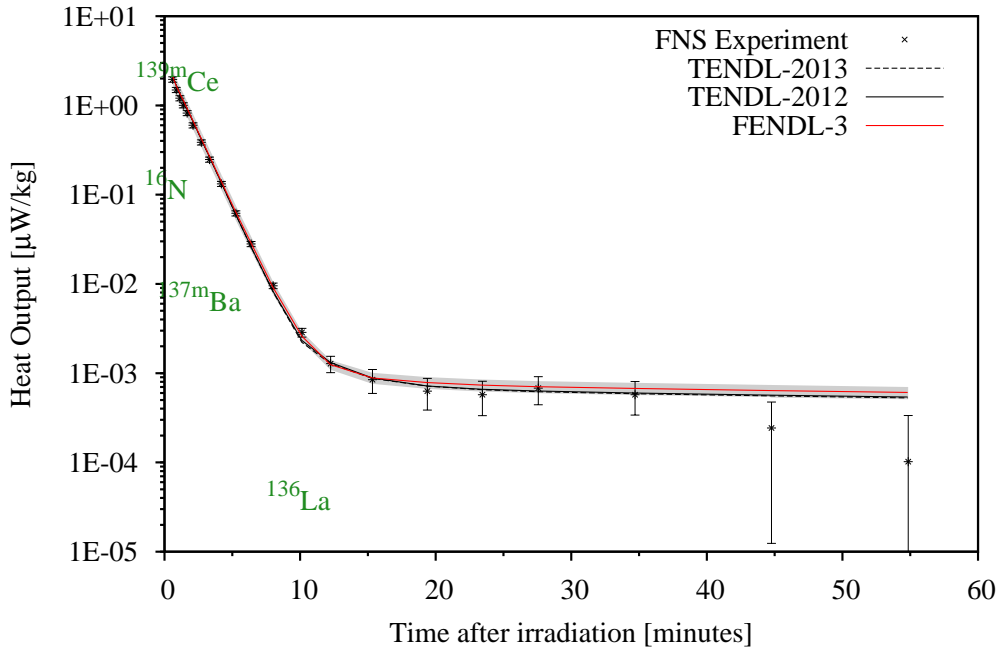
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|------------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.60 | 2.48E-01 +/-19% | 1.02E-01 +/-10% | 2.42 | 8.82E-02 | 2.81 | 8.87E-02 | 2.79 |
| 0.87 | 5.11E-02 +/-22% | 2.11E-02 +/-9% | 2.42 | 2.78E-02 | 1.84 | 2.81E-02 | 1.82 |
| 1.13 | 6.81E-03 +/-41% | 4.43E-03 +/-9% | 1.54 | 5.78E-03 | 1.18 | 5.97E-03 | 1.14 |
| 1.40 | 1.94E-03 +/-55% | 1.34E-03 +/-16% | 1.45 | 1.32E-03 | 1.48 | 1.43E-03 | 1.36 |
| 1.65 | 1.65E-03 +/-42% | 1.30E-03 +/-17% | 1.27 | 1.31E-03 | 1.25 | 1.38E-03 | 1.19 |
| 2.10 | 1.17E-04 +/-524% | 1.26E-03 +/-17% | 0.09 | 1.31E-03 | 0.09 | 1.34E-03 | 0.09 |
| 2.72 | 8.40E-04 +/-70% | 1.22E-03 +/-17% | 0.69 | 1.30E-03 | 0.65 | 1.32E-03 | 0.64 |
| 3.33 | 4.22E-04 +/-135% | 1.20E-03 +/-17% | 0.35 | 1.29E-03 | 0.33 | 1.30E-03 | 0.32 |
| 4.20 | 8.05E-05 +/-623% | 1.19E-03 +/-18% | 0.07 | 1.28E-03 | 0.06 | 1.29E-03 | 0.06 |
| 5.32 | 7.13E-05 +/-659% | 1.17E-03 +/-18% | 0.06 | 1.27E-03 | 0.06 | 1.28E-03 | 0.06 |
| 6.43 | 2.43E-04 +/-184% | 1.15E-03 +/-18% | 0.21 | 1.26E-03 | 0.19 | 1.26E-03 | 0.19 |
| 8.07 | 4.05E-04 +/-106% | 1.13E-03 +/-18% | 0.36 | 1.24E-03 | 0.33 | 1.25E-03 | 0.32 |
| 10.18 | 6.91E-04 +/-58% | 1.11E-03 +/-18% | 0.62 | 1.22E-03 | 0.56 | 1.23E-03 | 0.56 |
| 12.25 | 8.20E-04 +/-48% | 1.09E-03 +/-18% | 0.75 | 1.21E-03 | 0.68 | 1.21E-03 | 0.68 |
| 15.37 | 8.76E-04 +/-43% | 1.06E-03 +/-18% | 0.83 | 1.18E-03 | 0.74 | 1.19E-03 | 0.74 |
| 19.48 | 6.92E-04 +/-53% | 1.03E-03 +/-18% | 0.67 | 1.15E-03 | 0.60 | 1.15E-03 | 0.60 |
| 23.60 | 7.72E-04 +/-47% | 9.96E-04 +/-18% | 0.77 | 1.12E-03 | 0.69 | 1.12E-03 | 0.69 |
| 27.72 | 8.40E-04 +/-43% | 9.67E-04 +/-18% | 0.87 | 1.09E-03 | 0.77 | 1.09E-03 | 0.77 |
| 34.83 | 6.42E-04 +/-56% | 9.18E-04 +/-18% | 0.70 | 1.04E-03 | 0.62 | 1.04E-03 | 0.62 |
| 44.95 | 3.78E-04 +/-94% | 8.53E-04 +/-17% | 0.44 | 9.74E-04 | 0.39 | 9.78E-04 | 0.39 |
| 55.08 | 4.45E-05 +/-799% | 7.93E-04 +/-17% | 0.06 | 9.14E-04 | 0.05 | 9.18E-04 | 0.05 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|-----------------|------------------|--------|----------|
| Ba139 | La139(n,p)Ba139 | 1.3h | 100.0 | 0.77 43% |



Cerium

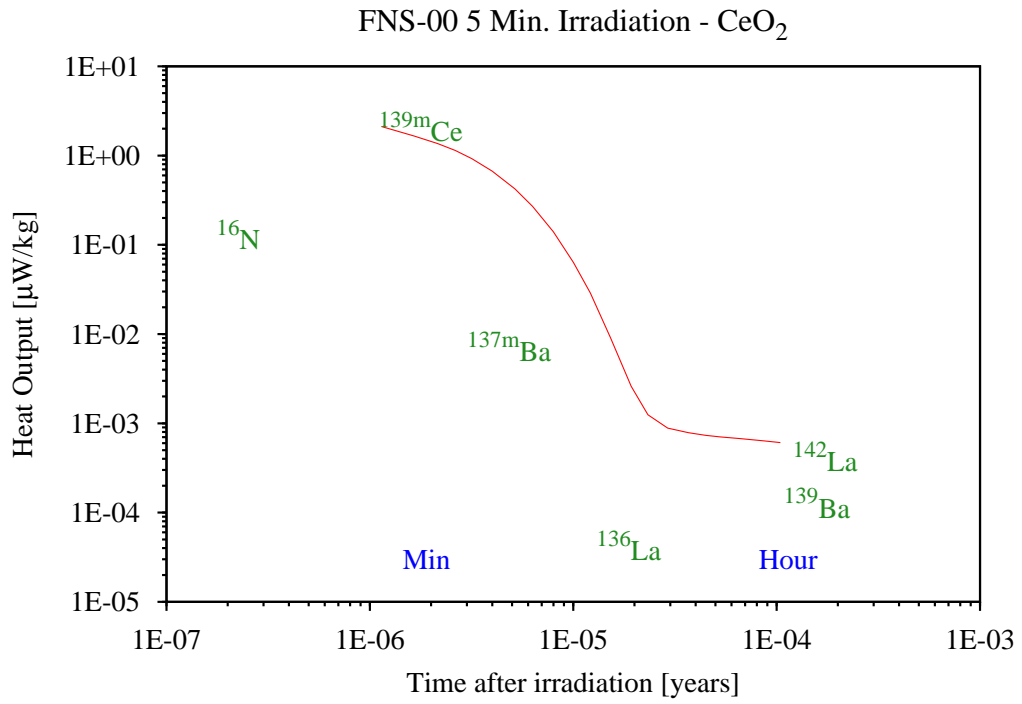
FNS-00 5 Min. Irradiation - CeO₂



For Cerium, a good agreement exists up to 30 minutes cooling, and beyond this the large experimental uncertainties might explain the significant disagreement.

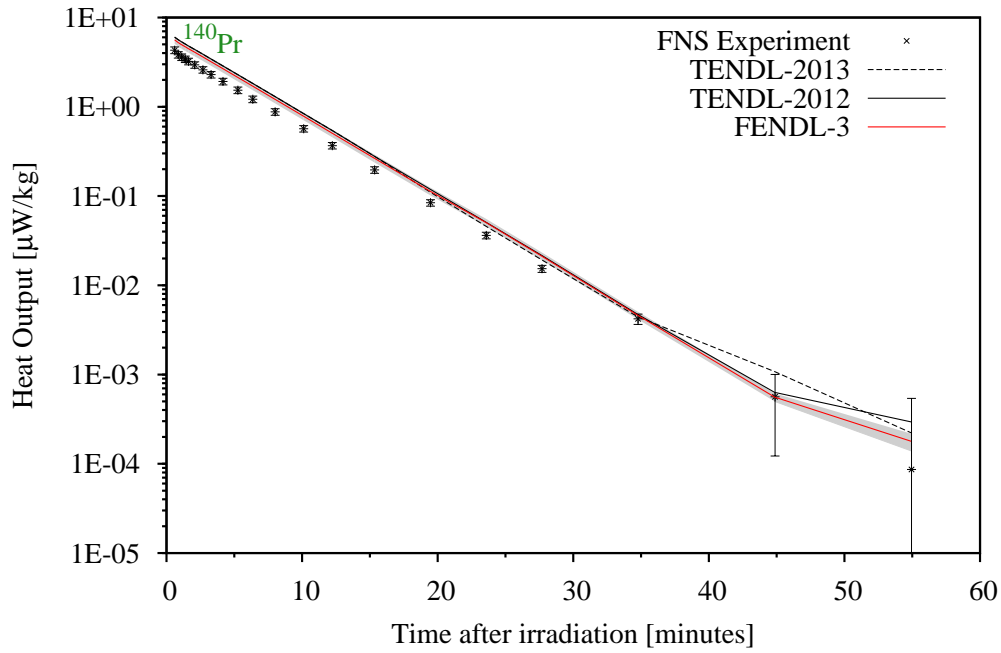
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|------------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.60 | 1.96E+00 +/-7% | 2.12E+00 +/-19% | 0.92 | 2.11E+00 | 0.93 | 2.11E+00 | 0.93 |
| 0.87 | 1.49E+00 +/-7% | 1.66E+00 +/-19% | 0.90 | 1.68E+00 | 0.89 | 1.68E+00 | 0.89 |
| 1.13 | 1.21E+00 +/-7% | 1.36E+00 +/-20% | 0.89 | 1.35E+00 | 0.89 | 1.35E+00 | 0.89 |
| 1.38 | 1.00E+00 +/-7% | 1.14E+00 +/-20% | 0.88 | 1.12E+00 | 0.89 | 1.12E+00 | 0.89 |
| 1.67 | 8.21E-01 +/-7% | 9.24E-01 +/-20% | 0.89 | 9.12E-01 | 0.90 | 9.12E-01 | 0.90 |
| 2.10 | 5.99E-01 +/-7% | 6.69E-01 +/-20% | 0.90 | 6.61E-01 | 0.91 | 6.61E-01 | 0.91 |
| 2.72 | 3.86E-01 +/-7% | 4.23E-01 +/-20% | 0.91 | 4.16E-01 | 0.93 | 4.17E-01 | 0.93 |
| 3.32 | 2.47E-01 +/-7% | 2.70E-01 +/-19% | 0.92 | 2.64E-01 | 0.94 | 2.65E-01 | 0.93 |
| 4.20 | 1.32E-01 +/-7% | 1.40E-01 +/-19% | 0.94 | 1.36E-01 | 0.97 | 1.36E-01 | 0.97 |
| 5.27 | 6.19E-02 +/-7% | 6.34E-02 +/-19% | 0.98 | 5.95E-02 | 1.04 | 5.97E-02 | 1.04 |
| 6.38 | 2.80E-02 +/-7% | 2.89E-02 +/-18% | 0.97 | 2.62E-02 | 1.07 | 2.60E-02 | 1.08 |
| 8.02 | 9.53E-03 +/-7% | 9.09E-03 +/-16% | 1.05 | 8.21E-03 | 1.16 | 8.12E-03 | 1.17 |
| 10.13 | 2.86E-03 +/-11% | 2.60E-03 +/-13% | 1.10 | 2.33E-03 | 1.23 | 2.22E-03 | 1.29 |
| 12.25 | 1.28E-03 +/-21% | 1.25E-03 +/-12% | 1.03 | 1.32E-03 | 0.97 | 1.27E-03 | 1.00 |
| 15.33 | 8.47E-04 +/-30% | 8.86E-04 +/-14% | 0.96 | 8.85E-04 | 0.96 | 8.73E-04 | 0.97 |
| 19.38 | 6.29E-04 +/-39% | 7.86E-04 +/-15% | 0.80 | 7.19E-04 | 0.88 | 7.16E-04 | 0.88 |
| 23.45 | 5.73E-04 +/-42% | 7.36E-04 +/-15% | 0.78 | 6.61E-04 | 0.87 | 6.52E-04 | 0.88 |
| 27.57 | 6.79E-04 +/-35% | 7.06E-04 +/-16% | 0.96 | 6.31E-04 | 1.08 | 6.19E-04 | 1.10 |
| 34.70 | 5.73E-04 +/-41% | 6.74E-04 +/-16% | 0.85 | 6.00E-04 | 0.96 | 5.88E-04 | 0.98 |
| 44.77 | 2.43E-04 +/-95% | 6.39E-04 +/-15% | 0.38 | 5.67E-04 | 0.43 | 5.56E-04 | 0.44 |
| 54.85 | 1.02E-04 +/-229% | 6.09E-04 +/-15% | 0.17 | 5.40E-04 | 0.19 | 5.29E-04 | 0.19 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|-------------------|------------------|--------|----------|
| Ce139m | Ce140(n,2n)Ce139m | 56.1s | 98.8 | 0.93 7% |
| Ba137m | Ce140(n,α)Ba137m | 2.5m | 99.3 | 0.93 7% |
| La142 | Ce142(n,p)La142 | 1.5h | 100.0 | 0.96 41% |



Praseodymium

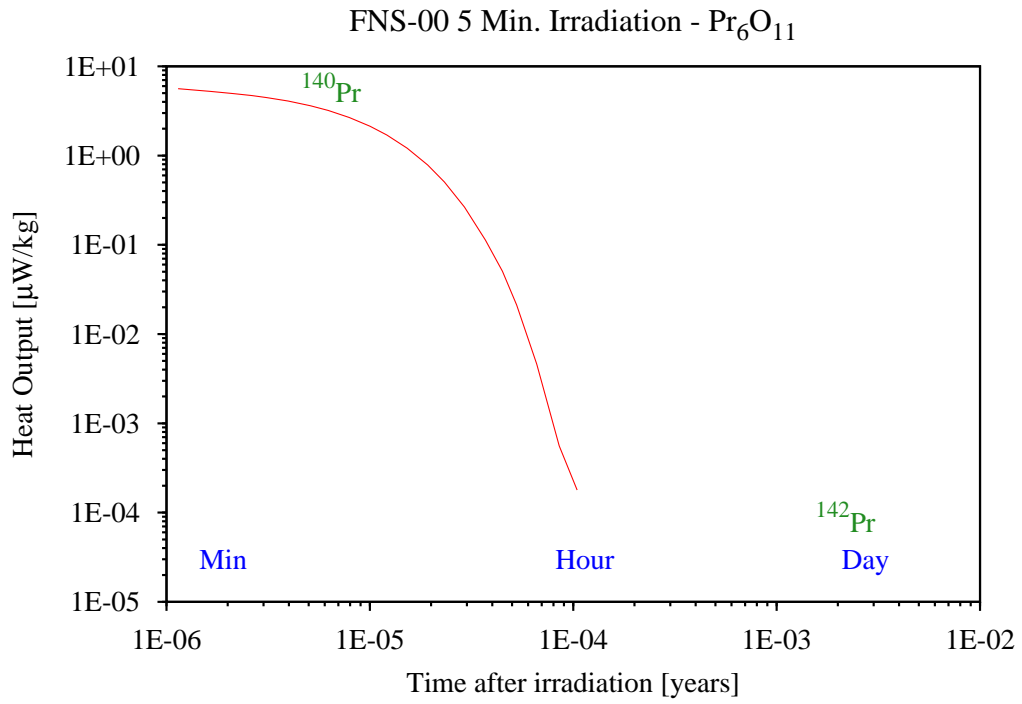
FNS-00 5 Min. Irradiation - Pr₆O₁₁



For Praseodymium, a systematic 30% over-prediction exists in the calculation, which may indicate that a cross section and/or decay data correction is foreseeable.

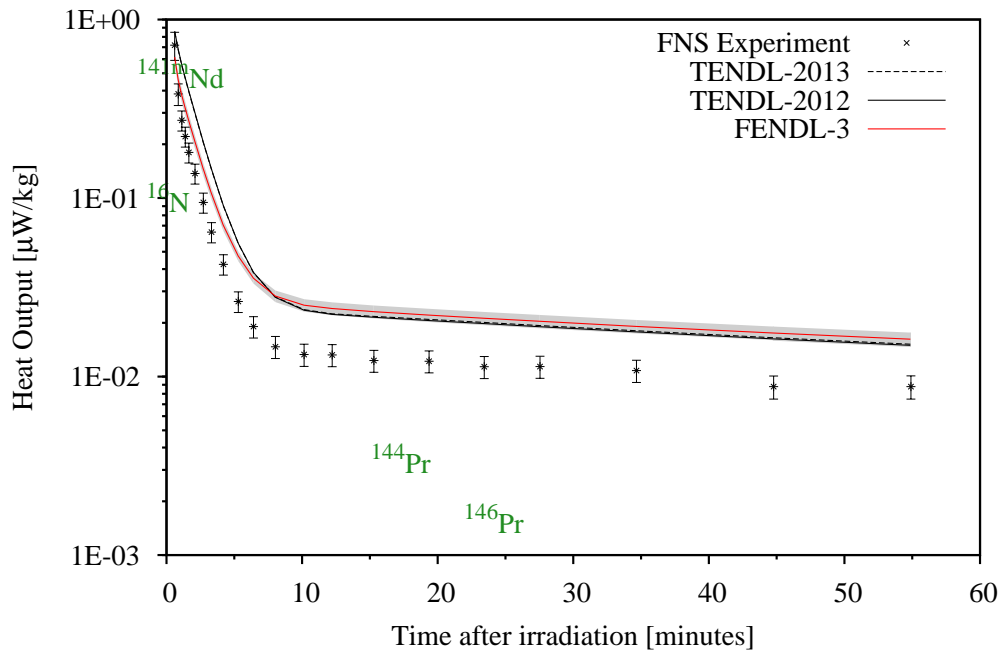
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 4.31E+00 +/-9% | 5.62E+00 +/-10% | 0.77 | 6.03E+00 | 0.72 | 6.03E+00 | 0.72 |
| 0.87 | 3.83E+00 +/-8% | 5.23E+00 +/-10% | 0.73 | 5.64E+00 | 0.68 | 5.64E+00 | 0.68 |
| 1.12 | 3.60E+00 +/-8% | 4.96E+00 +/-10% | 0.73 | 5.33E+00 | 0.68 | 5.33E+00 | 0.68 |
| 1.38 | 3.42E+00 +/-8% | 4.70E+00 +/-10% | 0.73 | 5.04E+00 | 0.68 | 5.04E+00 | 0.68 |
| 1.63 | 3.22E+00 +/-8% | 4.46E+00 +/-10% | 0.72 | 4.79E+00 | 0.67 | 4.79E+00 | 0.67 |
| 2.08 | 2.95E+00 +/-8% | 4.08E+00 +/-10% | 0.72 | 4.38E+00 | 0.67 | 4.38E+00 | 0.67 |
| 2.68 | 2.60E+00 +/-8% | 3.62E+00 +/-10% | 0.72 | 3.89E+00 | 0.67 | 3.89E+00 | 0.67 |
| 3.28 | 2.29E+00 +/-8% | 3.20E+00 +/-10% | 0.72 | 3.44E+00 | 0.67 | 3.44E+00 | 0.67 |
| 4.17 | 1.92E+00 +/-8% | 2.67E+00 +/-10% | 0.72 | 2.87E+00 | 0.67 | 2.87E+00 | 0.67 |
| 5.27 | 1.53E+00 +/-8% | 2.13E+00 +/-10% | 0.72 | 2.29E+00 | 0.67 | 2.29E+00 | 0.67 |
| 6.37 | 1.22E+00 +/-8% | 1.70E+00 +/-10% | 0.71 | 1.83E+00 | 0.67 | 1.83E+00 | 0.67 |
| 8.02 | 8.77E-01 +/-8% | 1.21E+00 +/-10% | 0.72 | 1.30E+00 | 0.67 | 1.30E+00 | 0.67 |
| 10.12 | 5.68E-01 +/-8% | 7.86E-01 +/-10% | 0.72 | 8.40E-01 | 0.68 | 8.40E-01 | 0.68 |
| 12.23 | 3.67E-01 +/-8% | 5.06E-01 +/-10% | 0.73 | 5.42E-01 | 0.68 | 5.42E-01 | 0.68 |
| 15.35 | 1.96E-01 +/-8% | 2.65E-01 +/-10% | 0.74 | 2.79E-01 | 0.70 | 2.79E-01 | 0.70 |
| 19.47 | 8.40E-02 +/-8% | 1.13E-01 +/-10% | 0.74 | 1.19E-01 | 0.71 | 1.11E-01 | 0.76 |
| 23.58 | 3.62E-02 +/-8% | 5.06E-02 +/-10% | 0.71 | 5.09E-02 | 0.71 | 4.58E-02 | 0.79 |
| 27.70 | 1.53E-02 +/-9% | 2.12E-02 +/-10% | 0.72 | 2.16E-02 | 0.71 | 1.92E-02 | 0.80 |
| 34.78 | 4.20E-03 +/-13% | 4.61E-03 +/-10% | 0.91 | 4.71E-03 | 0.89 | 4.43E-03 | 0.95 |
| 44.88 | 5.63E-04 +/-78% | 5.58E-04 +/-10% | 1.01 | 6.32E-04 | 0.89 | 1.08E-03 | 0.52 |
| 54.95 | 8.63E-05 +/-526% | 1.79E-04 +/-22% | 0.48 | 2.95E-04 | 0.29 | 2.23E-04 | 0.39 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|------------------|------------------|--------|---------|
| Pr140 | Pr141(n,2n)Pr140 | 3.3m | 99.6 | 0.67 8% |



Neodymium

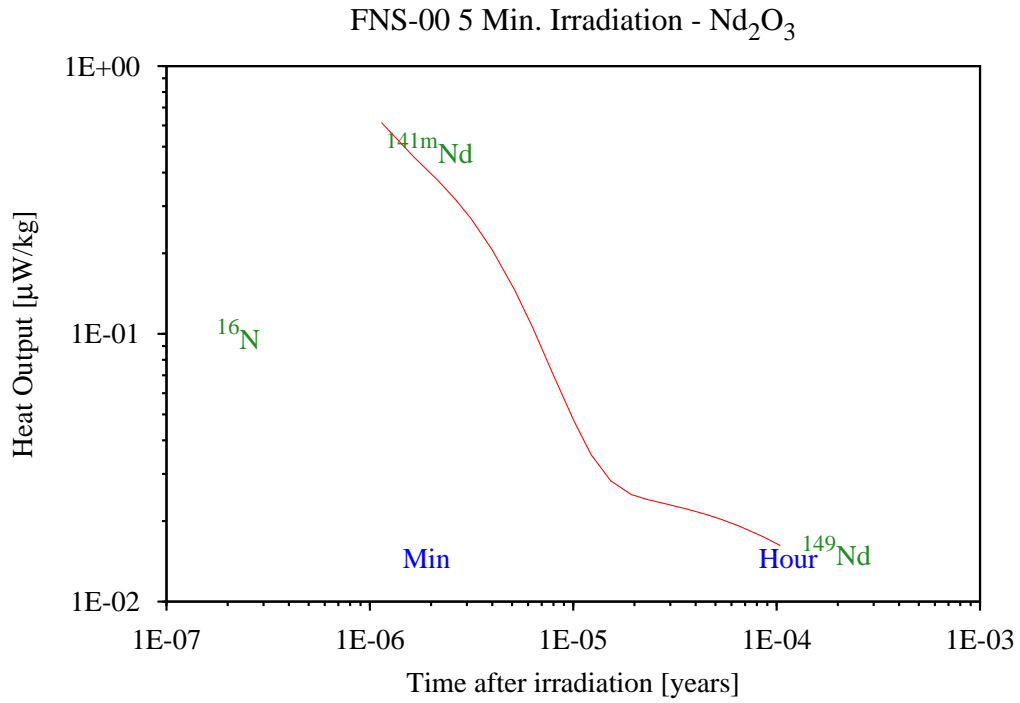
FNS-00 5 Min. Irradiation - Nd₂O₃



For Neodymium, the rather uniform and significant 50% over-prediction appearing after a few minutes of cooling may need to be acted upon. The Nd141m isomer half life seems to be well predicted although its level may also be on the high side.

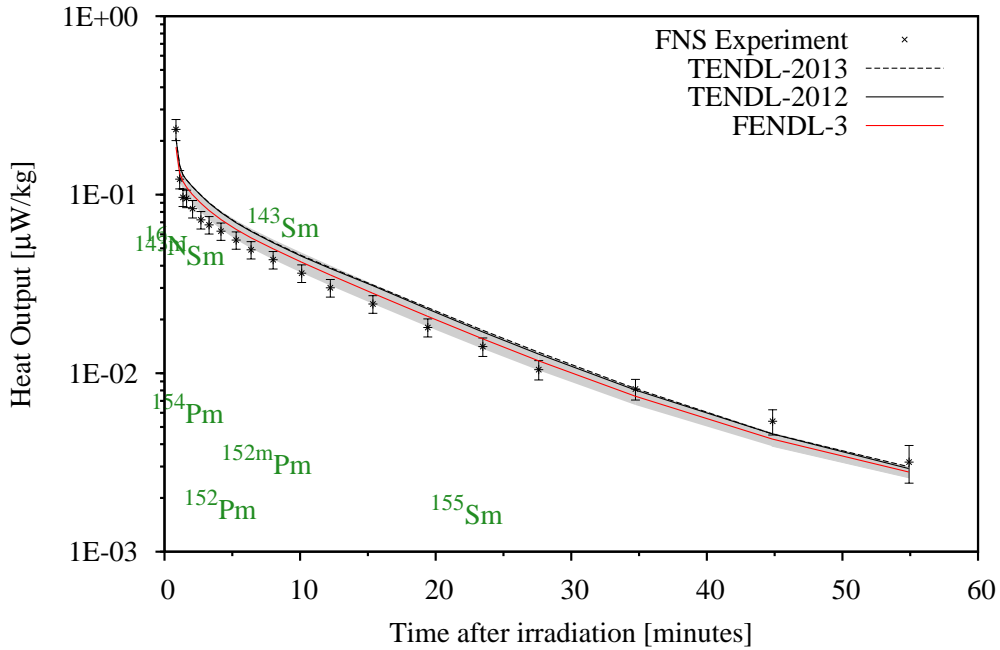
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.60 | 7.19E-01 +/-18% | 6.16E-01 +/-8% | 1.17 | 8.61E-01 | 0.83 | 8.54E-01 | 0.84 |
| 0.87 | 3.83E-01 +/-14% | 4.57E-01 +/-9% | 0.84 | 6.79E-01 | 0.56 | 6.73E-01 | 0.57 |
| 1.13 | 2.72E-01 +/-13% | 3.75E-01 +/-9% | 0.73 | 5.56E-01 | 0.49 | 5.51E-01 | 0.49 |
| 1.38 | 2.21E-01 +/-13% | 3.18E-01 +/-9% | 0.70 | 4.70E-01 | 0.47 | 4.66E-01 | 0.47 |
| 1.65 | 1.80E-01 +/-13% | 2.70E-01 +/-9% | 0.67 | 3.97E-01 | 0.45 | 3.93E-01 | 0.46 |
| 2.10 | 1.37E-01 +/-13% | 2.06E-01 +/-9% | 0.67 | 2.99E-01 | 0.46 | 2.97E-01 | 0.46 |
| 2.72 | 9.44E-02 +/-13% | 1.45E-01 +/-8% | 0.65 | 2.05E-01 | 0.46 | 2.04E-01 | 0.46 |
| 3.32 | 6.44E-02 +/-13% | 1.06E-01 +/-8% | 0.61 | 1.45E-01 | 0.44 | 1.44E-01 | 0.45 |
| 4.20 | 4.25E-02 +/-13% | 7.02E-02 +/-7% | 0.61 | 9.06E-02 | 0.47 | 9.01E-02 | 0.47 |
| 5.30 | 2.63E-02 +/-13% | 4.73E-02 +/-6% | 0.56 | 5.57E-02 | 0.47 | 5.56E-02 | 0.47 |
| 6.42 | 1.90E-02 +/-14% | 3.55E-02 +/-7% | 0.54 | 3.83E-02 | 0.50 | 3.81E-02 | 0.50 |
| 8.03 | 1.47E-02 +/-14% | 2.83E-02 +/-7% | 0.52 | 2.78E-02 | 0.53 | 2.79E-02 | 0.53 |
| 10.15 | 1.33E-02 +/-14% | 2.51E-02 +/-8% | 0.53 | 2.35E-02 | 0.57 | 2.37E-02 | 0.56 |
| 12.22 | 1.32E-02 +/-14% | 2.40E-02 +/-8% | 0.55 | 2.23E-02 | 0.59 | 2.25E-02 | 0.59 |
| 15.30 | 1.23E-02 +/-14% | 2.31E-02 +/-8% | 0.53 | 2.15E-02 | 0.57 | 2.17E-02 | 0.57 |
| 19.37 | 1.22E-02 +/-14% | 2.21E-02 +/-8% | 0.55 | 2.06E-02 | 0.59 | 2.09E-02 | 0.58 |
| 23.43 | 1.14E-02 +/-14% | 2.12E-02 +/-8% | 0.54 | 1.98E-02 | 0.57 | 2.01E-02 | 0.56 |
| 27.55 | 1.14E-02 +/-14% | 2.04E-02 +/-9% | 0.56 | 1.90E-02 | 0.60 | 1.93E-02 | 0.59 |
| 34.67 | 1.08E-02 +/-14% | 1.91E-02 +/-9% | 0.57 | 1.78E-02 | 0.61 | 1.81E-02 | 0.60 |
| 44.78 | 8.78E-03 +/-15% | 1.75E-02 +/-9% | 0.50 | 1.63E-02 | 0.54 | 1.65E-02 | 0.53 |
| 54.90 | 8.79E-03 +/-15% | 1.62E-02 +/-9% | 0.54 | 1.50E-02 | 0.59 | 1.52E-02 | 0.58 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Nd141m | Nd142(n,2n)Nd141m | 1.0m | 98.6 | 0.49 | 13% |
| Nd149 | Nd148(n,γ)Nd149 | 1.7h | 0.7 | 0.59 | 15% |
| | Nd150(n,2n)Nd149 | | 99.3 | 0.59 | 15% |



Samarium

FNS-00 5 Min. Irradiation - Sm₂O₃

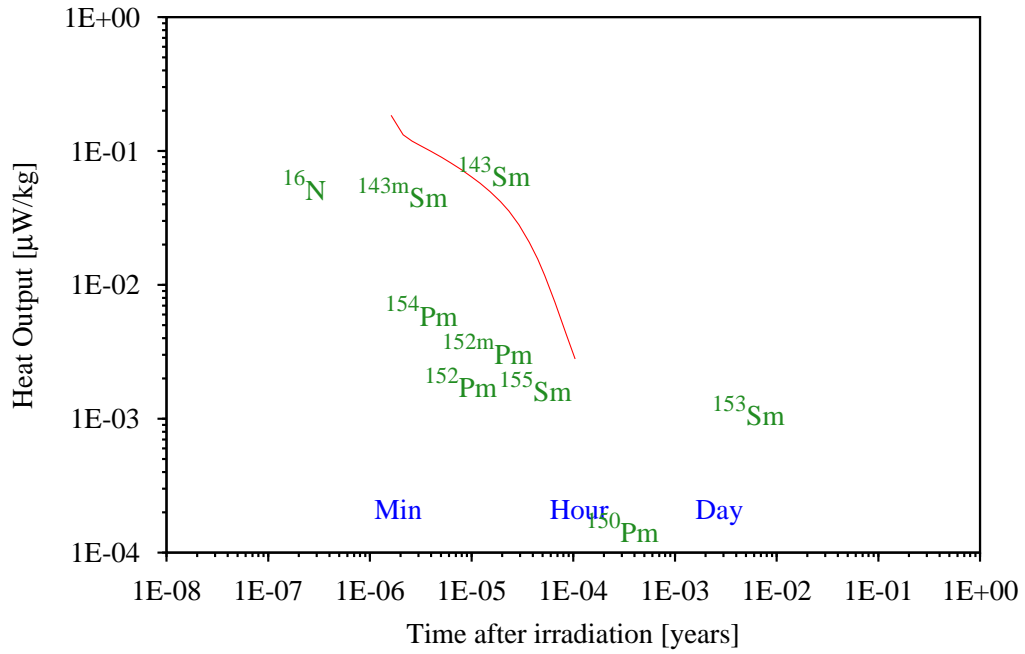


For Samarium, a good agreement exists, fully endorsed by both the quoted experimental and calculational uncertainties. This provides, once again, proof of the well founded processes that allow the build-up of the European Activation and TENDL covariance data files.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.85 | 2.32E-01 +/-14% | 1.85E-01 +/-8% | 1.26 | 2.06E-01 | 1.12 | 2.06E-01 | 1.12 |
| 1.12 | 1.22E-01 +/-12% | 1.32E-01 +/-10% | 0.93 | 1.46E-01 | 0.84 | 1.46E-01 | 0.84 |
| 1.37 | 9.67E-02 +/-11% | 1.19E-01 +/-10% | 0.82 | 1.29E-01 | 0.75 | 1.29E-01 | 0.75 |
| 1.63 | 9.53E-02 +/-11% | 1.10E-01 +/-10% | 0.87 | 1.21E-01 | 0.79 | 1.21E-01 | 0.79 |
| 2.07 | 8.34E-02 +/-11% | 1.00E-01 +/-11% | 0.83 | 1.11E-01 | 0.75 | 1.11E-01 | 0.75 |
| 2.68 | 7.23E-02 +/-11% | 8.96E-02 +/-11% | 0.81 | 9.92E-02 | 0.73 | 9.95E-02 | 0.73 |
| 3.28 | 6.78E-02 +/-11% | 8.16E-02 +/-11% | 0.83 | 8.99E-02 | 0.75 | 9.03E-02 | 0.75 |
| 4.17 | 6.24E-02 +/-11% | 7.25E-02 +/-12% | 0.86 | 7.95E-02 | 0.79 | 7.98E-02 | 0.78 |
| 5.28 | 5.57E-02 +/-11% | 6.39E-02 +/-12% | 0.87 | 6.97E-02 | 0.80 | 7.00E-02 | 0.80 |
| 6.38 | 4.91E-02 +/-11% | 5.74E-02 +/-13% | 0.86 | 6.23E-02 | 0.79 | 6.27E-02 | 0.78 |
| 8.02 | 4.32E-02 +/-11% | 4.97E-02 +/-13% | 0.87 | 5.38E-02 | 0.80 | 5.41E-02 | 0.80 |
| 10.12 | 3.63E-02 +/-11% | 4.19E-02 +/-13% | 0.87 | 4.52E-02 | 0.80 | 4.56E-02 | 0.80 |
| 12.23 | 3.01E-02 +/-11% | 3.56E-02 +/-13% | 0.85 | 3.86E-02 | 0.78 | 3.90E-02 | 0.77 |
| 15.37 | 2.44E-02 +/-11% | 2.81E-02 +/-13% | 0.87 | 3.09E-02 | 0.79 | 3.12E-02 | 0.78 |
| 19.42 | 1.80E-02 +/-12% | 2.08E-02 +/-12% | 0.87 | 2.29E-02 | 0.79 | 2.33E-02 | 0.77 |
| 23.48 | 1.41E-02 +/-12% | 1.56E-02 +/-12% | 0.90 | 1.70E-02 | 0.83 | 1.74E-02 | 0.81 |
| 27.60 | 1.05E-02 +/-12% | 1.17E-02 +/-12% | 0.89 | 1.28E-02 | 0.82 | 1.31E-02 | 0.80 |
| 34.73 | 8.15E-03 +/-13% | 7.43E-03 +/-11% | 1.10 | 8.05E-03 | 1.01 | 8.22E-03 | 0.99 |
| 44.85 | 5.37E-03 +/-16% | 4.27E-03 +/-9% | 1.26 | 4.57E-03 | 1.18 | 4.57E-03 | 1.18 |
| 54.92 | 3.18E-03 +/-24% | 2.80E-03 +/-7% | 1.14 | 2.92E-03 | 1.09 | 2.99E-03 | 1.06 |

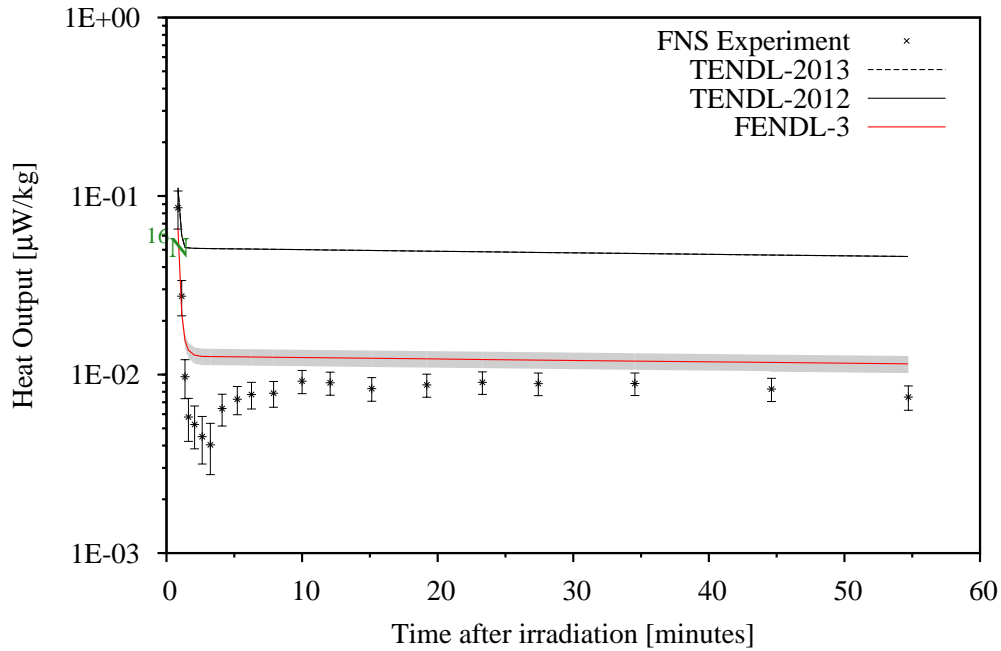
| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Sm143m | Sm144(n,2n)Sm143m | 1.1m | 98.5 | 0.84 | 12% |
| Sm143 | Sm144(n,2n)Sm143 | 8.7m | 58.7 | 0.80 | 11% |
| | Sm144(n,2n)Sm143m | 1.1m | 41.5 | 0.80 | 11% |

FNS-00 5 Min. Irradiation - Sm₂O₃



Europium

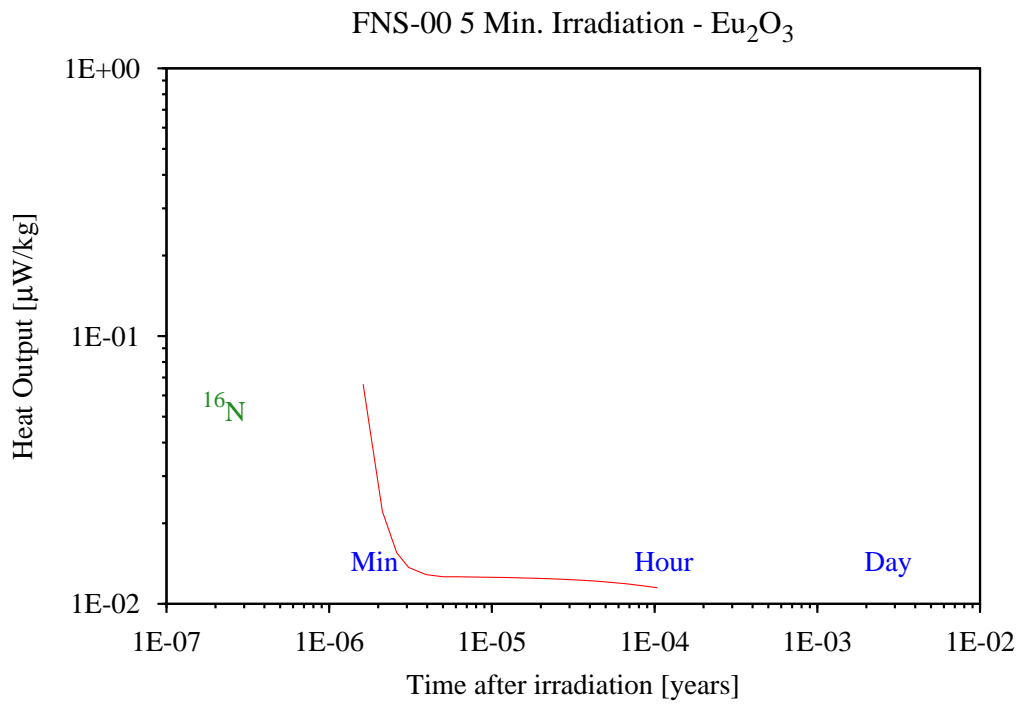
FNS-00 5 Min. Irradiation - Eu_2O_3



For Europium, as with Caesium, an upward trend can be seen at short cooling times, with the possibility of missing isomeric states in the databases, although here there is also a contribution through a capture channel that TENDL tends to over-predict.

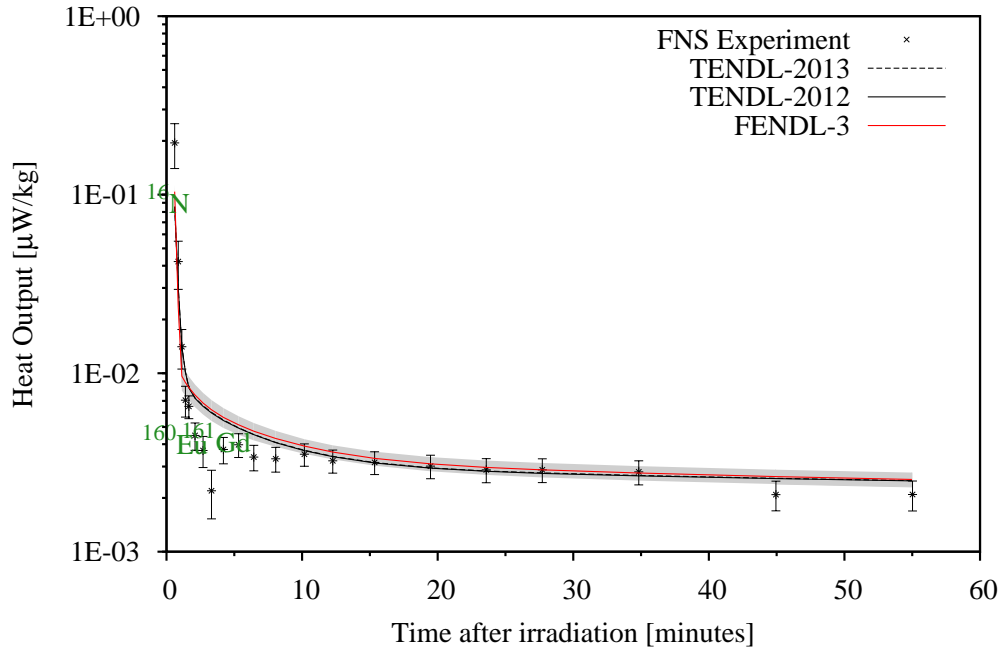
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-------------------|-------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.85 | $8.60E-02$ +/-24% | $6.60E-02$ +/-8% | 1.30 | $1.11E-01$ | 0.77 | $1.11E-01$ | 0.77 |
| 1.12 | $2.75E-02$ +/-22% | $2.22E-02$ +/-7% | 1.24 | $6.02E-02$ | 0.46 | $6.02E-02$ | 0.46 |
| 1.37 | $9.72E-03$ +/-25% | $1.55E-02$ +/-9% | 0.63 | $5.15E-02$ | 0.19 | $5.16E-02$ | 0.19 |
| 1.62 | $5.79E-03$ +/-27% | $1.37E-02$ +/-10% | 0.42 | $5.12E-02$ | 0.11 | $5.12E-02$ | 0.11 |
| 2.07 | $5.25E-03$ +/-27% | $1.29E-02$ +/-10% | 0.41 | $5.09E-02$ | 0.10 | $5.09E-02$ | 0.10 |
| 2.63 | $4.49E-03$ +/-30% | $1.26E-02$ +/-11% | 0.36 | $5.09E-02$ | 0.09 | $5.09E-02$ | 0.09 |
| 3.23 | $4.04E-03$ +/-32% | $1.26E-02$ +/-11% | 0.32 | $5.08E-02$ | 0.08 | $5.08E-02$ | 0.08 |
| 4.10 | $6.45E-03$ +/-20% | $1.26E-02$ +/-11% | 0.51 | $5.07E-02$ | 0.13 | $5.07E-02$ | 0.13 |
| 5.22 | $7.27E-03$ +/-18% | $1.26E-02$ +/-11% | 0.58 | $5.06E-02$ | 0.14 | $5.06E-02$ | 0.14 |
| 6.27 | $7.72E-03$ +/-17% | $1.25E-02$ +/-11% | 0.62 | $5.05E-02$ | 0.15 | $5.05E-02$ | 0.15 |
| 7.90 | $7.85E-03$ +/-16% | $1.25E-02$ +/-11% | 0.63 | $5.03E-02$ | 0.16 | $5.03E-02$ | 0.16 |
| 10.00 | $9.18E-03$ +/-15% | $1.25E-02$ +/-11% | 0.74 | $5.01E-02$ | 0.18 | $5.01E-02$ | 0.18 |
| 12.07 | $8.99E-03$ +/-15% | $1.24E-02$ +/-11% | 0.72 | $4.99E-02$ | 0.18 | $4.99E-02$ | 0.18 |
| 15.13 | $8.34E-03$ +/-15% | $1.23E-02$ +/-11% | 0.68 | $4.95E-02$ | 0.17 | $4.96E-02$ | 0.17 |
| 19.20 | $8.76E-03$ +/-15% | $1.22E-02$ +/-11% | 0.72 | $4.91E-02$ | 0.18 | $4.91E-02$ | 0.18 |
| 23.30 | $9.05E-03$ +/-14% | $1.21E-02$ +/-11% | 0.75 | $4.87E-02$ | 0.19 | $4.87E-02$ | 0.19 |
| 27.42 | $8.90E-03$ +/-15% | $1.21E-02$ +/-11% | 0.74 | $4.83E-02$ | 0.18 | $4.83E-02$ | 0.18 |
| 34.55 | $8.91E-03$ +/-14% | $1.19E-02$ +/-11% | 0.75 | $4.76E-02$ | 0.19 | $4.76E-02$ | 0.19 |
| 44.62 | $8.29E-03$ +/-15% | $1.17E-02$ +/-11% | 0.71 | $4.67E-02$ | 0.18 | $4.67E-02$ | 0.18 |
| 54.72 | $7.47E-03$ +/-16% | $1.15E-02$ +/-11% | 0.65 | $4.58E-02$ | 0.16 | $4.58E-02$ | 0.16 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|---------------------------|-----------|--------|------|--------------|
| Eu152m | Eu151(n, γ)Eu152m | 9.2h | 93.2 | 0.19 | 15% |
| | Eu153(n,2n)Eu152m | | 6.8 | 0.19 | 15% |



Gadolinium

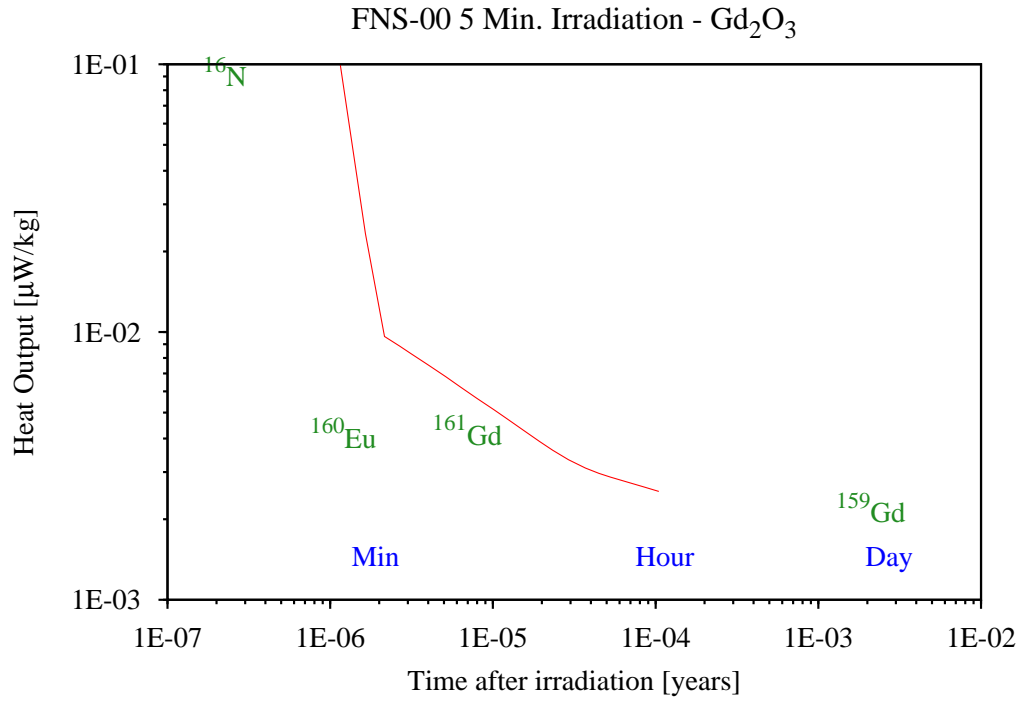
FNS-00 5 Min. Irradiation - Gd₂O₃



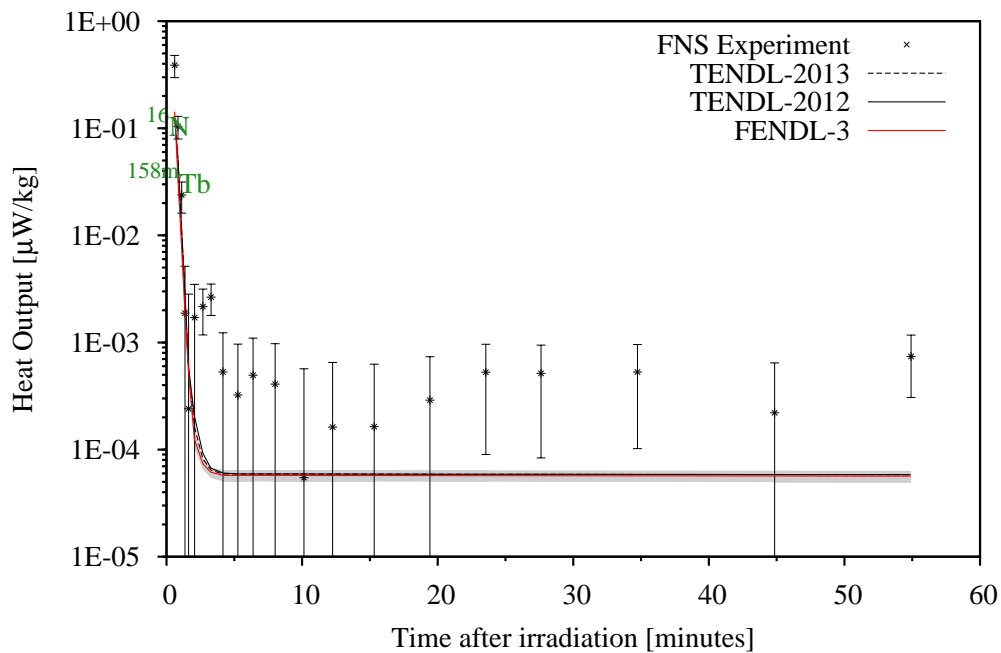
For Gadolinium, the fluctuation with time of the measured decay heat, as well as the large number of contributing isotopes and their complex production routes, leads to difficulties in the interpretation, although the E/C are fairly consistent.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.60 | 1.95E-01 +/-28% | 1.04E-01 +/-9% | 1.87 | 8.57E-02 | 2.28 | 8.57E-02 | 2.28 |
| 0.87 | 4.22E-02 +/-30% | 2.33E-02 +/-10% | 1.81 | 3.00E-02 | 1.41 | 3.00E-02 | 1.41 |
| 1.13 | 1.41E-02 +/-25% | 9.63E-03 +/-17% | 1.46 | 1.41E-02 | 1.00 | 1.41E-02 | 0.99 |
| 1.40 | 7.06E-03 +/-20% | 8.87E-03 +/-16% | 0.80 | 1.01E-02 | 0.70 | 1.02E-02 | 0.69 |
| 1.65 | 6.51E-03 +/-15% | 8.30E-03 +/-15% | 0.78 | 8.29E-03 | 0.79 | 8.33E-03 | 0.78 |
| 2.10 | 4.48E-03 +/-17% | 7.54E-03 +/-14% | 0.59 | 7.23E-03 | 0.62 | 7.27E-03 | 0.62 |
| 2.70 | 3.69E-03 +/-20% | 6.81E-03 +/-14% | 0.54 | 6.52E-03 | 0.57 | 6.58E-03 | 0.56 |
| 3.32 | 2.19E-03 +/-30% | 6.24E-03 +/-13% | 0.35 | 5.99E-03 | 0.37 | 6.03E-03 | 0.36 |
| 4.20 | 3.74E-03 +/-17% | 5.65E-03 +/-13% | 0.66 | 5.43E-03 | 0.69 | 5.47E-03 | 0.68 |
| 5.32 | 3.97E-03 +/-15% | 5.13E-03 +/-12% | 0.77 | 4.93E-03 | 0.81 | 4.94E-03 | 0.80 |
| 6.43 | 3.39E-03 +/-16% | 4.74E-03 +/-11% | 0.72 | 4.53E-03 | 0.75 | 4.54E-03 | 0.75 |
| 8.05 | 3.32E-03 +/-16% | 4.31E-03 +/-10% | 0.77 | 4.09E-03 | 0.81 | 4.10E-03 | 0.81 |
| 10.17 | 3.51E-03 +/-14% | 3.90E-03 +/-9% | 0.90 | 3.68E-03 | 0.95 | 3.70E-03 | 0.95 |
| 12.27 | 3.23E-03 +/-15% | 3.62E-03 +/-9% | 0.89 | 3.41E-03 | 0.95 | 3.42E-03 | 0.94 |
| 15.35 | 3.17E-03 +/-15% | 3.33E-03 +/-9% | 0.95 | 3.14E-03 | 1.01 | 3.16E-03 | 1.00 |
| 19.47 | 3.01E-03 +/-15% | 3.10E-03 +/-9% | 0.97 | 2.94E-03 | 1.03 | 2.95E-03 | 1.02 |
| 23.58 | 2.88E-03 +/-15% | 2.97E-03 +/-9% | 0.97 | 2.82E-03 | 1.02 | 2.83E-03 | 1.01 |
| 27.72 | 2.87E-03 +/-15% | 2.87E-03 +/-9% | 1.00 | 2.75E-03 | 1.05 | 2.76E-03 | 1.04 |
| 34.83 | 2.80E-03 +/-15% | 2.76E-03 +/-9% | 1.02 | 2.66E-03 | 1.05 | 2.67E-03 | 1.05 |
| 44.95 | 2.09E-03 +/-19% | 2.64E-03 +/-9% | 0.79 | 2.57E-03 | 0.81 | 2.58E-03 | 0.81 |
| 55.02 | 2.09E-03 +/-19% | 2.54E-03 +/-9% | 0.82 | 2.49E-03 | 0.84 | 2.50E-03 | 0.84 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|------------------|------------------|--------|------|-----|
| Eu160 | Gd160(n,p)Eu160 | 38.0s | 98.9 | 0.99 | 25% |
| Gd161 | Gd160(n,γ)Gd161 | 3.6m | 99.4 | 0.68 | 17% |
| Gd159 | Gd158(n,γ)Gd159 | 18.4h | 1.5 | 0.84 | 19% |
| | Gd160(n,2n)Gd159 | | 98.5 | 0.84 | 19% |



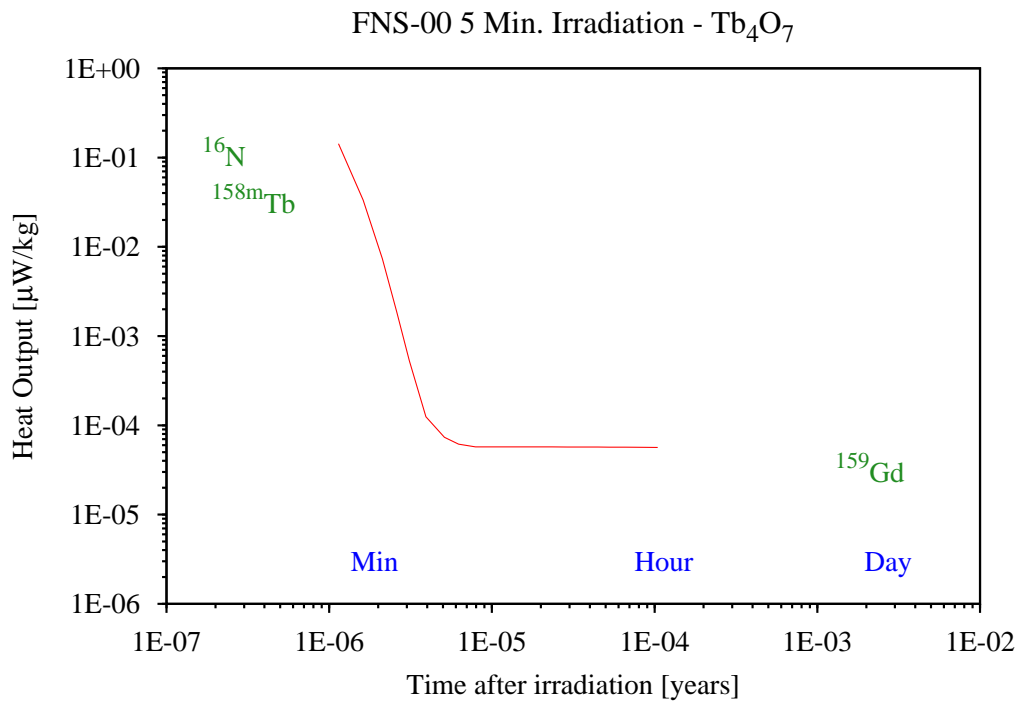
Terbium

FNS-00 5 Min. Irradiation - Tb₄O₇

For Terbium, the short lived Tb158m isomer seems to be predicted with some accuracy. At longer cooling times the measurements need to be viewed with caution due to the large, uneven uncertainties.

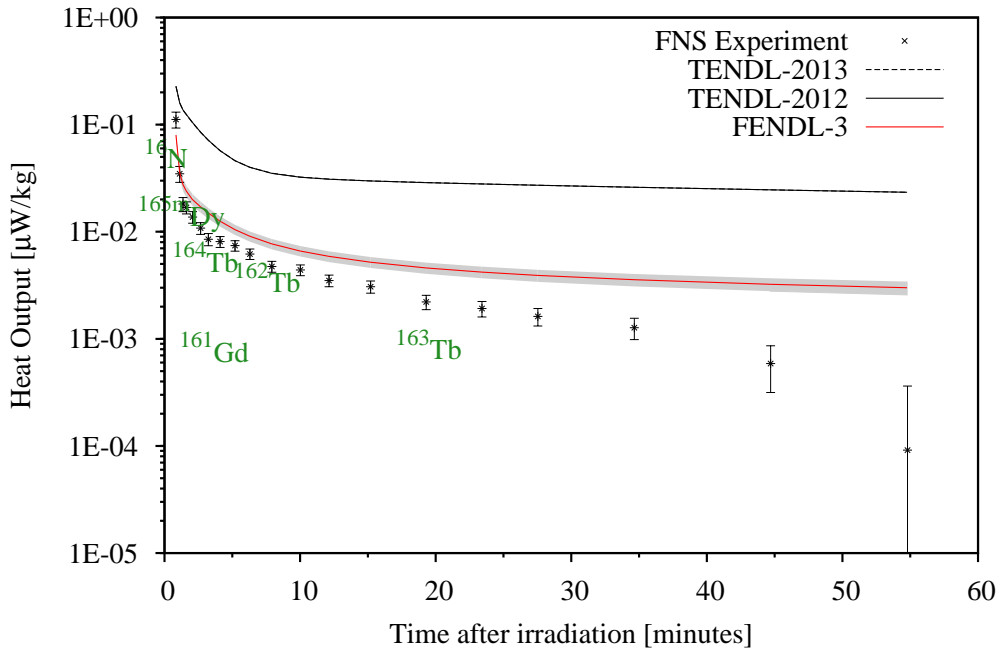
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|-------|------------|-------|------------|-------|
| 0.60 | 3.88E-01 +/-23% | 1.43E-01 +/-10% | 2.71 | 1.25E-01 | 3.10 | 1.25E-01 | 3.10 |
| 0.85 | 1.04E-01 +/-24% | 3.34E-02 +/-13% | 3.12 | 5.15E-02 | 2.03 | 5.14E-02 | 2.03 |
| 1.12 | 2.38E-02 +/-32% | 7.36E-03 +/-17% | 3.23 | 1.10E-02 | 2.16 | 1.09E-02 | 2.19 |
| 1.37 | 1.88E-03 +/-174% | 1.87E-03 +/-23% | 1.00 | 2.85E-03 | 0.66 | 2.75E-03 | 0.68 |
| 1.63 | 2.41E-04 +/-1077% | 5.31E-04 +/-27% | 0.45 | 5.84E-04 | 0.41 | 5.58E-04 | 0.43 |
| 2.07 | 1.70E-03 +/-105% | 1.25E-04 +/-17% | 13.69 | 2.04E-04 | 8.34 | 1.62E-04 | 10.53 |
| 2.68 | 2.16E-03 +/-46% | 7.35E-05 +/-12% | 29.44 | 9.22E-05 | 23.46 | 8.17E-05 | 26.48 |
| 3.28 | 2.65E-03 +/-32% | 6.15E-05 +/-12% | 43.08 | 6.71E-05 | 39.51 | 6.44E-05 | 41.15 |
| 4.17 | 5.31E-04 +/-132% | 5.74E-05 +/-12% | 9.24 | 6.06E-05 | 8.76 | 5.93E-05 | 8.95 |
| 5.27 | 3.23E-04 +/-199% | 5.74E-05 +/-12% | 5.63 | 5.92E-05 | 5.46 | 5.92E-05 | 5.45 |
| 6.38 | 4.94E-04 +/-122% | 5.74E-05 +/-12% | 8.61 | 5.92E-05 | 8.35 | 5.92E-05 | 8.35 |
| 8.02 | 4.08E-04 +/-139% | 5.74E-05 +/-12% | 7.12 | 5.91E-05 | 6.90 | 5.92E-05 | 6.90 |
| 10.13 | 5.46E-05 +/-942% | 5.73E-05 +/-12% | 0.95 | 5.91E-05 | 0.92 | 5.91E-05 | 0.92 |
| 12.25 | 1.62E-04 +/-302% | 5.73E-05 +/-12% | 2.83 | 5.91E-05 | 2.74 | 5.91E-05 | 2.74 |
| 15.32 | 1.64E-04 +/-283% | 5.72E-05 +/-12% | 2.86 | 5.90E-05 | 2.78 | 5.90E-05 | 2.77 |
| 19.43 | 2.90E-04 +/-154% | 5.71E-05 +/-12% | 5.07 | 5.89E-05 | 4.92 | 5.90E-05 | 4.92 |
| 23.55 | 5.27E-04 +/-83% | 5.71E-05 +/-12% | 9.24 | 5.88E-05 | 8.96 | 5.89E-05 | 8.95 |
| 27.62 | 5.14E-04 +/-84% | 5.70E-05 +/-12% | 9.03 | 5.87E-05 | 8.76 | 5.88E-05 | 8.75 |
| 34.73 | 5.29E-04 +/-81% | 5.68E-05 +/-12% | 9.31 | 5.86E-05 | 9.03 | 5.87E-05 | 9.02 |
| 44.85 | 2.20E-04 +/-193% | 5.66E-05 +/-12% | 3.89 | 5.84E-05 | 3.77 | 5.85E-05 | 3.77 |
| 54.92 | 7.40E-04 +/-59% | 5.64E-05 +/-12% | 13.11 | 5.82E-05 | 12.71 | 5.83E-05 | 12.70 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|------|
| Tb158m | Tb159(n,2n)Tb158m | 10.8s | 100.0 | 0.68 | 174% |
| Gd159 | Tb159(n,p)Gd159 | 18.4h | 100.0 | 0.92 | 942% |



Dysprosium

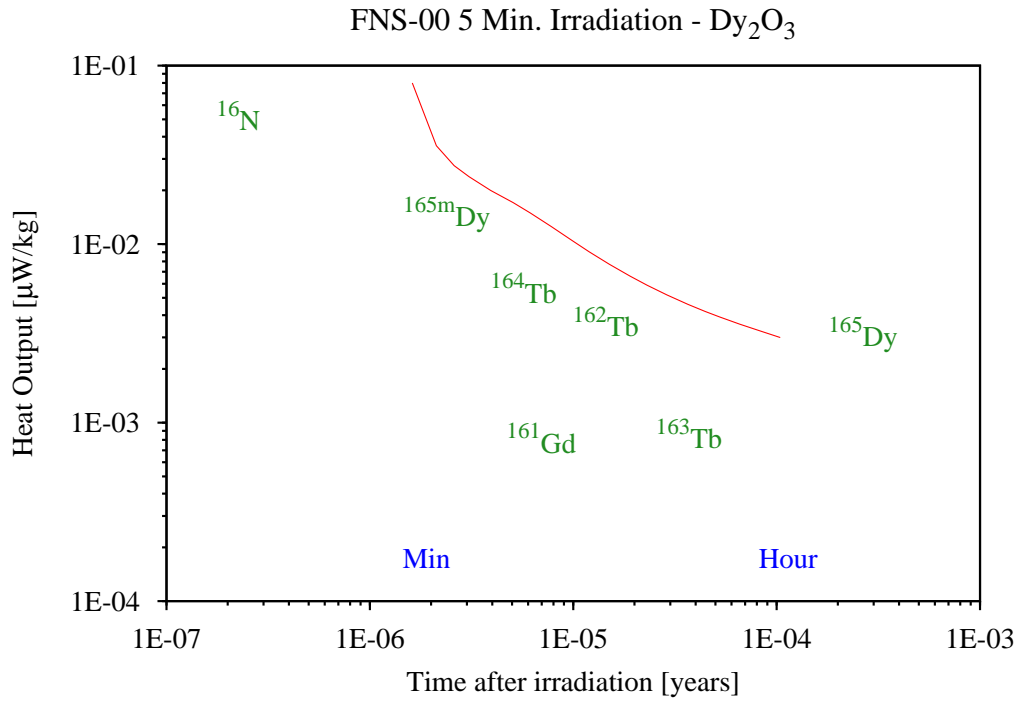
FNS-00 5 Min. Irradiation - Dy₂O₃



For Dysprosium, the complex routes of production and the presence of many contributing isotopes, make interpretation of the results extremely difficult. However, TENDL production pathways need to be carefully examined and compared with the FENDL ones.

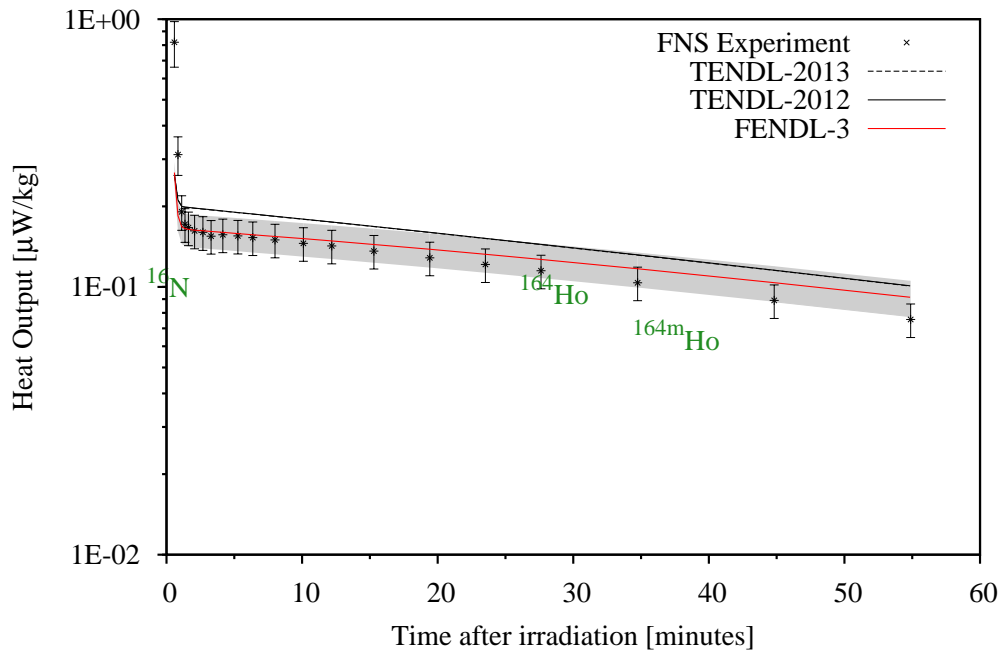
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.85 | 1.12E-01 +/-17% | 8.00E-02 +/-8% | 1.40 | 2.29E-01 | 0.49 | 2.28E-01 | 0.49 |
| 1.12 | 3.48E-02 +/-17% | 3.56E-02 +/-11% | 0.98 | 1.60E-01 | 0.22 | 1.59E-01 | 0.22 |
| 1.37 | 1.81E-02 +/-15% | 2.75E-02 +/-12% | 0.66 | 1.37E-01 | 0.13 | 1.37E-01 | 0.13 |
| 1.62 | 1.69E-02 +/-13% | 2.39E-02 +/-13% | 0.71 | 1.24E-01 | 0.14 | 1.24E-01 | 0.14 |
| 2.07 | 1.37E-02 +/-13% | 2.00E-02 +/-13% | 0.69 | 1.05E-01 | 0.13 | 1.04E-01 | 0.13 |
| 2.67 | 1.08E-02 +/-13% | 1.71E-02 +/-12% | 0.63 | 8.50E-02 | 0.13 | 8.48E-02 | 0.13 |
| 3.23 | 8.50E-03 +/-13% | 1.49E-02 +/-11% | 0.57 | 7.14E-02 | 0.12 | 7.13E-02 | 0.12 |
| 4.10 | 8.08E-03 +/-12% | 1.25E-02 +/-11% | 0.65 | 5.71E-02 | 0.14 | 5.71E-02 | 0.14 |
| 5.20 | 7.42E-03 +/-11% | 1.05E-02 +/-11% | 0.71 | 4.61E-02 | 0.16 | 4.61E-02 | 0.16 |
| 6.30 | 6.20E-03 +/-11% | 9.06E-03 +/-11% | 0.68 | 3.99E-02 | 0.16 | 4.00E-02 | 0.16 |
| 7.92 | 4.74E-03 +/-12% | 7.71E-03 +/-11% | 0.61 | 3.51E-02 | 0.13 | 3.52E-02 | 0.13 |
| 10.02 | 4.39E-03 +/-11% | 6.61E-03 +/-11% | 0.66 | 3.23E-02 | 0.14 | 3.24E-02 | 0.14 |
| 12.13 | 3.50E-03 +/-12% | 5.89E-03 +/-11% | 0.60 | 3.09E-02 | 0.11 | 3.10E-02 | 0.11 |
| 15.20 | 3.07E-03 +/-13% | 5.19E-03 +/-12% | 0.59 | 2.98E-02 | 0.10 | 2.98E-02 | 0.10 |
| 19.30 | 2.21E-03 +/-15% | 4.60E-03 +/-12% | 0.48 | 2.88E-02 | 0.08 | 2.88E-02 | 0.08 |
| 23.42 | 1.92E-03 +/-17% | 4.19E-03 +/-12% | 0.46 | 2.79E-02 | 0.07 | 2.79E-02 | 0.07 |
| 27.53 | 1.62E-03 +/-19% | 3.91E-03 +/-13% | 0.41 | 2.72E-02 | 0.06 | 2.72E-02 | 0.06 |
| 34.65 | 1.27E-03 +/-23% | 3.56E-03 +/-13% | 0.36 | 2.60E-02 | 0.05 | 2.60E-02 | 0.05 |
| 44.70 | 5.88E-04 +/-46% | 3.24E-03 +/-14% | 0.18 | 2.46E-02 | 0.02 | 2.46E-02 | 0.02 |
| 54.80 | 9.15E-05 +/-296% | 3.00E-03 +/-14% | 0.03 | 2.34E-02 | 0.00 | 2.34E-02 | 0.00 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|--------------------|------------------|--------|------|-----|
| Dy165m | Dy164(n,γ)Dy165m | 1.2m | 98.5 | 0.13 | 15% |
| Tb164 | Dy164(n,p)Tb164 | 3.0m | 99.2 | 0.12 | 13% |
| Tb162 | Dy162(n,p)Tb162 | 7.6m | 95.4 | 0.13 | 12% |
| | Dy163(n,d+np)Tb162 | | 4.4 | 0.13 | 12% |
| Dy165 | Dy164(n,γ)Dy165 | 2.3h | 41.5 | 0.05 | 23% |
| | Dy164(n,γ)Dy165m | 1.2m | 58.9 | 0.05 | 23% |



Holmium

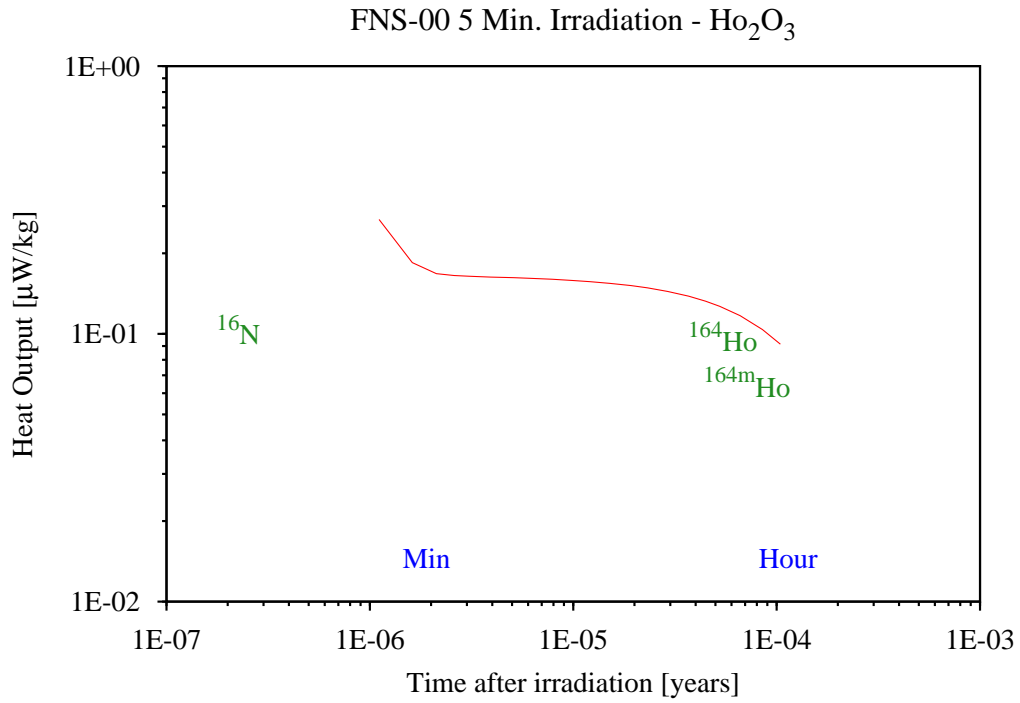
FNS-00 5 Min. Irradiation - Ho₂O₃



For the lanthanide Holmium, the interpretation is not too bad, and the experiment gives a rare insight into possible half life and/or branching ratio corrections. As a reminder, the decay data was the only reason behind the factor two over-prediction in the previous generation of libraries.

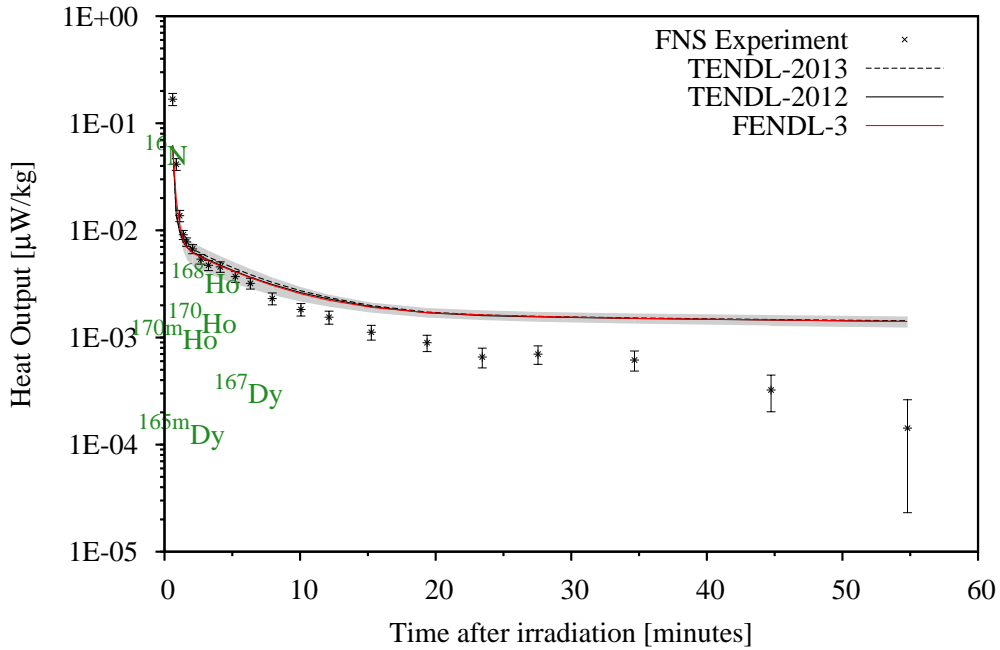
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.58 | 8.20E-01 +/-19% | 2.67E-01 +/-9% | 3.07 | 2.62E-01 | 3.13 | 2.62E-01 | 3.13 |
| 0.85 | 3.12E-01 +/-16% | 1.84E-01 +/-12% | 1.69 | 2.11E-01 | 1.48 | 2.11E-01 | 1.48 |
| 1.12 | 1.91E-01 +/-15% | 1.68E-01 +/-14% | 1.14 | 2.00E-01 | 0.95 | 2.00E-01 | 0.96 |
| 1.37 | 1.71E-01 +/-14% | 1.65E-01 +/-14% | 1.04 | 1.99E-01 | 0.86 | 1.99E-01 | 0.86 |
| 1.62 | 1.67E-01 +/-14% | 1.64E-01 +/-14% | 1.01 | 1.98E-01 | 0.84 | 1.98E-01 | 0.84 |
| 2.07 | 1.62E-01 +/-14% | 1.63E-01 +/-14% | 0.99 | 1.97E-01 | 0.82 | 1.97E-01 | 0.82 |
| 2.68 | 1.60E-01 +/-14% | 1.62E-01 +/-14% | 0.99 | 1.96E-01 | 0.82 | 1.95E-01 | 0.82 |
| 3.28 | 1.55E-01 +/-14% | 1.61E-01 +/-14% | 0.96 | 1.94E-01 | 0.80 | 1.94E-01 | 0.80 |
| 4.15 | 1.57E-01 +/-14% | 1.60E-01 +/-14% | 0.98 | 1.92E-01 | 0.82 | 1.92E-01 | 0.82 |
| 5.27 | 1.55E-01 +/-14% | 1.58E-01 +/-14% | 0.98 | 1.90E-01 | 0.82 | 1.89E-01 | 0.82 |
| 6.37 | 1.53E-01 +/-14% | 1.57E-01 +/-14% | 0.98 | 1.87E-01 | 0.82 | 1.87E-01 | 0.82 |
| 8.00 | 1.50E-01 +/-14% | 1.54E-01 +/-14% | 0.97 | 1.84E-01 | 0.82 | 1.83E-01 | 0.82 |
| 10.10 | 1.45E-01 +/-14% | 1.51E-01 +/-14% | 0.96 | 1.79E-01 | 0.81 | 1.79E-01 | 0.81 |
| 12.18 | 1.42E-01 +/-14% | 1.48E-01 +/-14% | 0.96 | 1.75E-01 | 0.81 | 1.74E-01 | 0.82 |
| 15.30 | 1.36E-01 +/-14% | 1.44E-01 +/-14% | 0.94 | 1.68E-01 | 0.81 | 1.68E-01 | 0.81 |
| 19.42 | 1.29E-01 +/-14% | 1.38E-01 +/-15% | 0.93 | 1.60E-01 | 0.80 | 1.60E-01 | 0.80 |
| 23.52 | 1.21E-01 +/-14% | 1.32E-01 +/-15% | 0.92 | 1.52E-01 | 0.80 | 1.52E-01 | 0.80 |
| 27.62 | 1.15E-01 +/-14% | 1.27E-01 +/-15% | 0.91 | 1.44E-01 | 0.80 | 1.44E-01 | 0.80 |
| 34.75 | 1.04E-01 +/-14% | 1.17E-01 +/-15% | 0.89 | 1.32E-01 | 0.79 | 1.32E-01 | 0.79 |
| 44.82 | 8.90E-02 +/-14% | 1.04E-01 +/-15% | 0.86 | 1.16E-01 | 0.77 | 1.15E-01 | 0.77 |
| 54.88 | 7.56E-02 +/-14% | 9.15E-02 +/-15% | 0.83 | 1.01E-01 | 0.75 | 1.01E-01 | 0.75 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Ho164 | Ho165(n,2n)Ho164 | 28.6m | 95.7 | 0.80 | 14% |
| | Ho165(n,2n)Ho164m | 37.6m | 4.3 | 0.80 | 14% |
| Ho164m | Ho165(n,2n)Ho164m | 37.6m | 100.0 | 0.75 | 14% |



Erbium

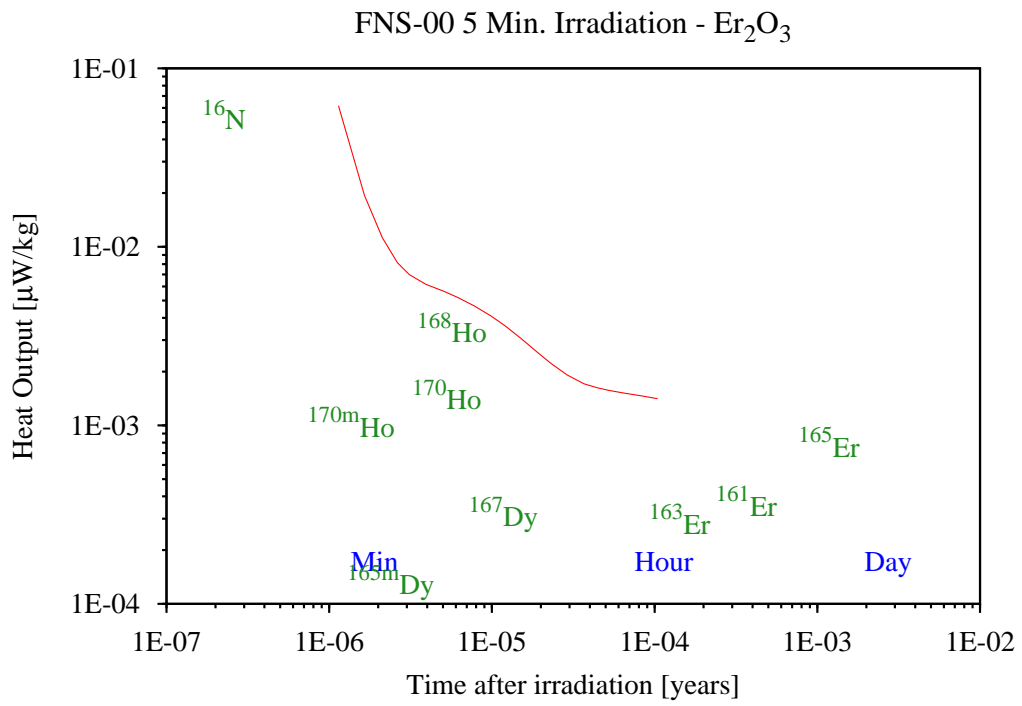
FNS-00 5 Min. Irradiation - Er₂O₃



For Erbium, here again a rare insight of what may be a half life problem, shadowing the response of the isotopes that shape the decay heat underneath.

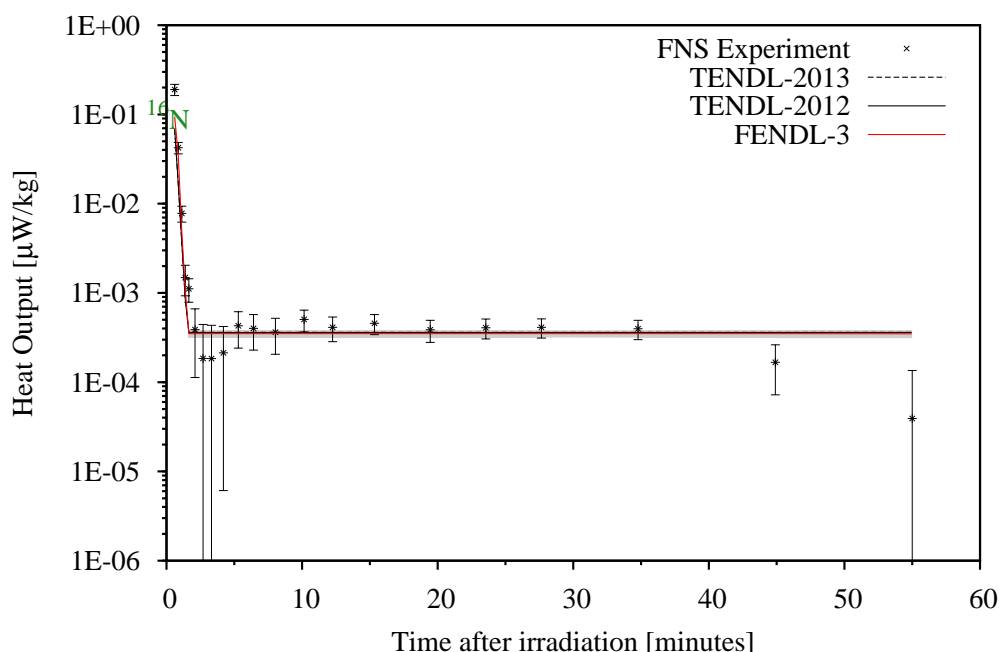
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 1.68E-01 +/-13% | 6.17E-02 +/-9% | 2.72 | 6.19E-02 | 2.71 | 6.22E-02 | 2.70 |
| 0.87 | 4.15E-02 +/-12% | 1.94E-02 +/-11% | 2.13 | 1.39E-02 | 3.00 | 1.41E-02 | 2.94 |
| 1.12 | 1.37E-02 +/-12% | 1.13E-02 +/-16% | 1.22 | 9.64E-03 | 1.42 | 1.00E-02 | 1.37 |
| 1.38 | 9.10E-03 +/-10% | 8.13E-03 +/-21% | 1.12 | 7.79E-03 | 1.17 | 8.20E-03 | 1.11 |
| 1.63 | 7.79E-03 +/-9% | 6.99E-03 +/-23% | 1.11 | 6.99E-03 | 1.11 | 7.42E-03 | 1.05 |
| 2.07 | 6.71E-03 +/-10% | 6.17E-03 +/-25% | 1.09 | 6.26E-03 | 1.07 | 6.68E-03 | 1.00 |
| 2.68 | 5.39E-03 +/-10% | 5.62E-03 +/-24% | 0.96 | 5.72E-03 | 0.94 | 6.12E-03 | 0.88 |
| 3.25 | 4.73E-03 +/-11% | 5.20E-03 +/-24% | 0.91 | 5.29E-03 | 0.89 | 5.65E-03 | 0.84 |
| 4.12 | 4.57E-03 +/-11% | 4.65E-03 +/-24% | 0.98 | 4.73E-03 | 0.97 | 5.04E-03 | 0.91 |
| 5.22 | 3.70E-03 +/-11% | 4.09E-03 +/-22% | 0.90 | 4.15E-03 | 0.89 | 4.40E-03 | 0.84 |
| 6.33 | 3.20E-03 +/-12% | 3.61E-03 +/-21% | 0.89 | 3.66E-03 | 0.87 | 3.86E-03 | 0.83 |
| 7.95 | 2.31E-03 +/-13% | 3.07E-03 +/-19% | 0.75 | 3.12E-03 | 0.74 | 3.27E-03 | 0.71 |
| 10.07 | 1.83E-03 +/-13% | 2.56E-03 +/-15% | 0.71 | 2.62E-03 | 0.70 | 2.73E-03 | 0.67 |
| 12.13 | 1.54E-03 +/-14% | 2.22E-03 +/-13% | 0.69 | 2.29E-03 | 0.68 | 2.36E-03 | 0.65 |
| 15.25 | 1.12E-03 +/-16% | 1.91E-03 +/-11% | 0.58 | 1.94E-03 | 0.58 | 1.98E-03 | 0.56 |
| 19.37 | 8.93E-04 +/-17% | 1.71E-03 +/-10% | 0.52 | 1.70E-03 | 0.52 | 1.73E-03 | 0.52 |
| 23.43 | 6.57E-04 +/-21% | 1.62E-03 +/-10% | 0.40 | 1.60E-03 | 0.41 | 1.62E-03 | 0.40 |
| 27.55 | 6.98E-04 +/-20% | 1.57E-03 +/-11% | 0.44 | 1.55E-03 | 0.45 | 1.58E-03 | 0.44 |
| 34.67 | 6.16E-04 +/-21% | 1.51E-03 +/-11% | 0.41 | 1.50E-03 | 0.41 | 1.52E-03 | 0.40 |
| 44.73 | 3.24E-04 +/-37% | 1.46E-03 +/-11% | 0.22 | 1.45E-03 | 0.22 | 1.47E-03 | 0.22 |
| 54.80 | 1.42E-04 +/-84% | 1.41E-03 +/-11% | 0.10 | 1.41E-03 | 0.10 | 1.43E-03 | 0.10 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|------------------|------------------|--------|----------|
| Ho168 | Er168(n,p)Ho168 | 2.9m | 74.2 | 0.94 10% |
| | Er168(n,p)Ho168m | 2.2m | 25.9 | 0.94 10% |
| Er165 | Er166(n,2n)Er165 | 10.3h | 99.6 | 0.22 37% |



Thulium

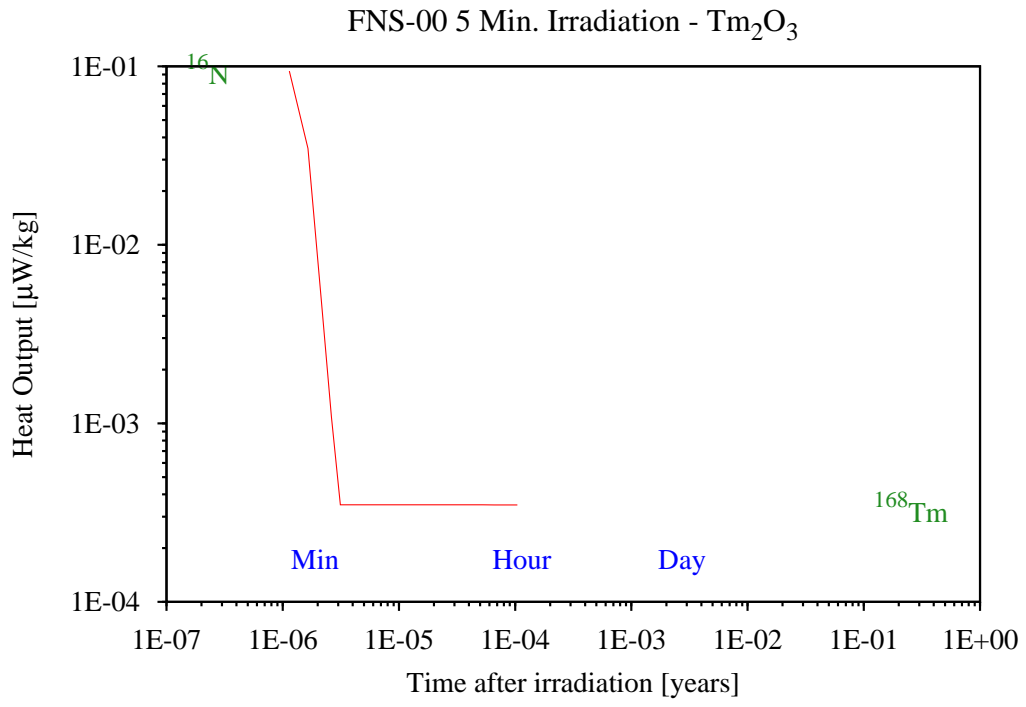
FNS-00 5 Min. Irradiation - Tm₂O₃



For the lanthanide Thulium, the representation of the experimental data is not too bad, allowing for the large experimental uncertainties at short and long cooling times, and the possibility of some missing isomers in the calculational paths.

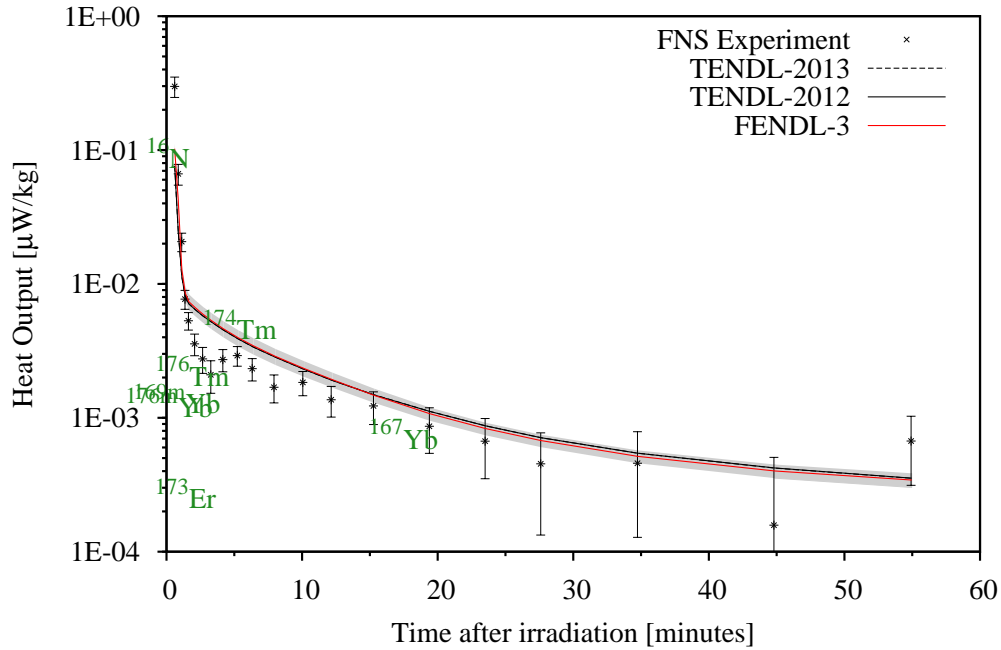
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.60 | 1.90E-01 +/-14% | 9.41E-02 +/-10% | 2.02 | 6.82E-02 | 2.78 | 6.81E-02 | 2.79 |
| 0.87 | 4.24E-02 +/-15% | 3.47E-02 +/-10% | 1.22 | 1.68E-02 | 2.53 | 1.67E-02 | 2.53 |
| 1.13 | 7.78E-03 +/-20% | 4.80E-03 +/-9% | 1.62 | 3.62E-03 | 2.15 | 3.62E-03 | 2.15 |
| 1.38 | 1.49E-03 +/-38% | 1.08E-03 +/-7% | 1.38 | 8.48E-04 | 1.75 | 8.49E-04 | 1.75 |
| 1.65 | 1.12E-03 +/-30% | 3.50E-04 +/-10% | 3.19 | 3.61E-04 | 3.09 | 3.62E-04 | 3.08 |
| 2.10 | 3.88E-04 +/-71% | 3.50E-04 +/-10% | 1.11 | 3.61E-04 | 1.08 | 3.62E-04 | 1.07 |
| 2.70 | 1.85E-04 +/-140% | 3.50E-04 +/-10% | 0.53 | 3.61E-04 | 0.51 | 3.62E-04 | 0.51 |
| 3.32 | 1.84E-04 +/-136% | 3.50E-04 +/-10% | 0.53 | 3.61E-04 | 0.51 | 3.62E-04 | 0.51 |
| 4.20 | 2.14E-04 +/-97% | 3.50E-04 +/-10% | 0.61 | 3.61E-04 | 0.59 | 3.62E-04 | 0.59 |
| 5.30 | 4.29E-04 +/-44% | 3.50E-04 +/-10% | 1.23 | 3.61E-04 | 1.19 | 3.62E-04 | 1.18 |
| 6.42 | 4.01E-04 +/-43% | 3.50E-04 +/-10% | 1.15 | 3.61E-04 | 1.11 | 3.62E-04 | 1.11 |
| 8.03 | 3.62E-04 +/-43% | 3.49E-04 +/-10% | 1.04 | 3.61E-04 | 1.00 | 3.62E-04 | 1.00 |
| 10.15 | 5.04E-04 +/-27% | 3.49E-04 +/-10% | 1.44 | 3.61E-04 | 1.40 | 3.62E-04 | 1.39 |
| 12.25 | 4.11E-04 +/-31% | 3.49E-04 +/-10% | 1.18 | 3.61E-04 | 1.14 | 3.62E-04 | 1.13 |
| 15.33 | 4.57E-04 +/-25% | 3.49E-04 +/-10% | 1.31 | 3.61E-04 | 1.27 | 3.62E-04 | 1.26 |
| 19.45 | 3.87E-04 +/-28% | 3.49E-04 +/-10% | 1.11 | 3.61E-04 | 1.07 | 3.62E-04 | 1.07 |
| 23.55 | 4.07E-04 +/-25% | 3.49E-04 +/-10% | 1.17 | 3.61E-04 | 1.13 | 3.62E-04 | 1.13 |
| 27.65 | 4.12E-04 +/-24% | 3.49E-04 +/-10% | 1.18 | 3.61E-04 | 1.14 | 3.62E-04 | 1.14 |
| 34.78 | 3.97E-04 +/-25% | 3.49E-04 +/-10% | 1.14 | 3.61E-04 | 1.10 | 3.62E-04 | 1.10 |
| 44.90 | 1.67E-04 +/-57% | 3.49E-04 +/-10% | 0.48 | 3.61E-04 | 0.46 | 3.62E-04 | 0.46 |
| 55.00 | 3.92E-05 +/-245% | 3.49E-04 +/-10% | 0.11 | 3.61E-04 | 0.11 | 3.62E-04 | 0.11 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|------------------|------------------|--------|----------|
| Tm168 | Tm169(n,2n)Tm168 | 93.1d | 100.0 | 1.10 25% |



Ytterbium

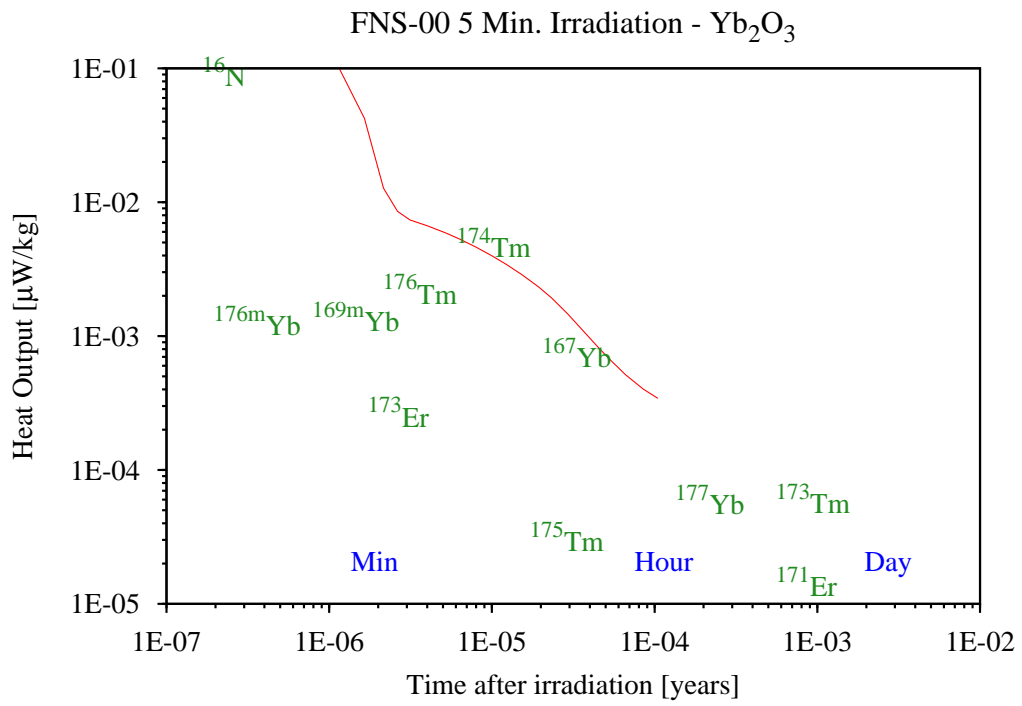
FNS-00 5 Min. Irradiation - Yb₂O₃



For Ytterbium, one can see a reasonable agreement for this element, given the high experimental uncertainties and the many isotopes underlying the response function.

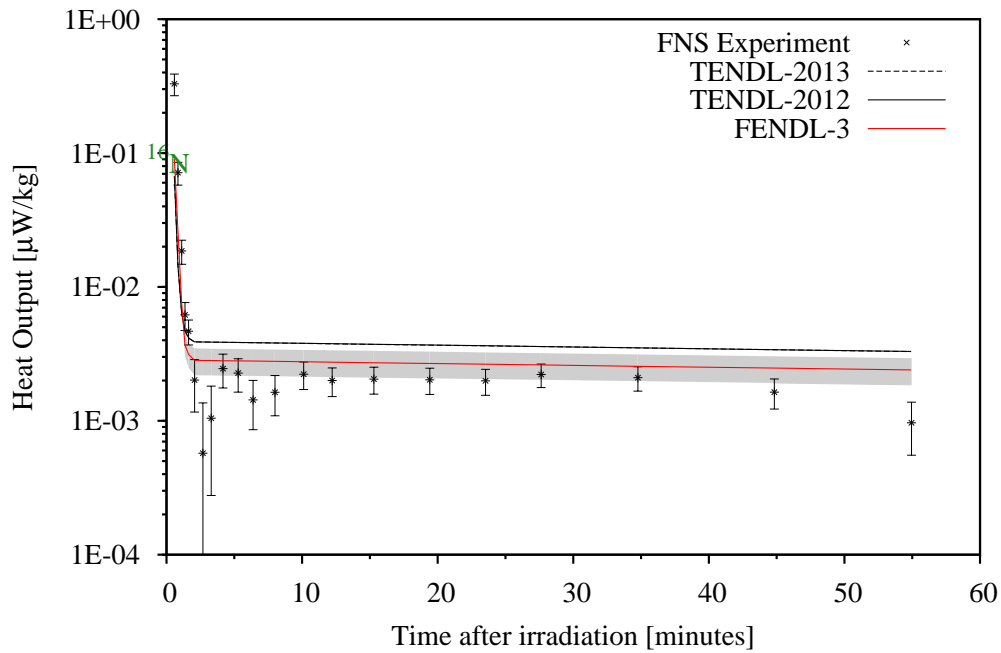
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C TENDL-2012 | E/C TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|----------------|----------------|------|
| 0.60 | 2.99E-01 +/-17% | 1.02E-01 +/-9% | 2.92 | 7.63E-02 | 3.92 |
| 0.87 | 6.64E-02 +/-18% | 4.23E-02 +/-8% | 1.57 | 2.46E-02 | 2.70 |
| 1.12 | 2.07E-02 +/-16% | 1.27E-02 +/-10% | 1.62 | 1.13E-02 | 1.83 |
| 1.37 | 7.71E-03 +/-16% | 8.54E-03 +/-13% | 0.90 | 8.04E-03 | 0.96 |
| 1.62 | 5.31E-03 +/-15% | 7.37E-03 +/-14% | 0.72 | 7.10E-03 | 0.75 |
| 2.07 | 3.57E-03 +/-18% | 6.67E-03 +/-14% | 0.53 | 6.45E-03 | 0.55 |
| 2.67 | 2.75E-03 +/-22% | 5.93E-03 +/-14% | 0.46 | 5.76E-03 | 0.48 |
| 3.27 | 2.10E-03 +/-27% | 5.32E-03 +/-14% | 0.39 | 5.19E-03 | 0.40 |
| 4.15 | 2.72E-03 +/-19% | 4.63E-03 +/-14% | 0.59 | 4.53E-03 | 0.60 |
| 5.22 | 2.92E-03 +/-17% | 3.96E-03 +/-14% | 0.74 | 3.88E-03 | 0.75 |
| 6.32 | 2.33E-03 +/-19% | 3.45E-03 +/-14% | 0.68 | 3.37E-03 | 0.69 |
| 7.93 | 1.69E-03 +/-24% | 2.88E-03 +/-14% | 0.59 | 2.84E-03 | 0.60 |
| 10.05 | 1.84E-03 +/-21% | 2.33E-03 +/-13% | 0.79 | 2.30E-03 | 0.80 |
| 12.15 | 1.36E-03 +/-26% | 1.93E-03 +/-13% | 0.71 | 1.90E-03 | 0.72 |
| 15.27 | 1.23E-03 +/-27% | 1.47E-03 +/-12% | 0.83 | 1.48E-03 | 0.83 |
| 19.38 | 8.66E-04 +/-37% | 1.07E-03 +/-11% | 0.81 | 1.11E-03 | 0.78 |
| 23.50 | 6.69E-04 +/-48% | 8.30E-04 +/-11% | 0.81 | 8.71E-04 | 0.77 |
| 27.60 | 4.53E-04 +/-71% | 6.75E-04 +/-11% | 0.67 | 7.10E-04 | 0.64 |
| 34.73 | 4.57E-04 +/-72% | 5.15E-04 +/-11% | 0.89 | 5.44E-04 | 0.84 |
| 44.80 | 1.58E-04 +/-221% | 4.01E-04 +/-12% | 0.39 | 4.22E-04 | 0.37 |
| 54.92 | 6.70E-04 +/-53% | 3.43E-04 +/-12% | 1.95 | 3.54E-04 | 1.89 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|------------------|------------------|--------|----------|
| Tm174 | Yb174(n,p)Tm174 | 5.4m | 99.6 | 0.69 20% |
| Yb167 | Yb168(n,2n)Yb167 | 17.5m | 100.0 | 0.78 37% |



Lutetium

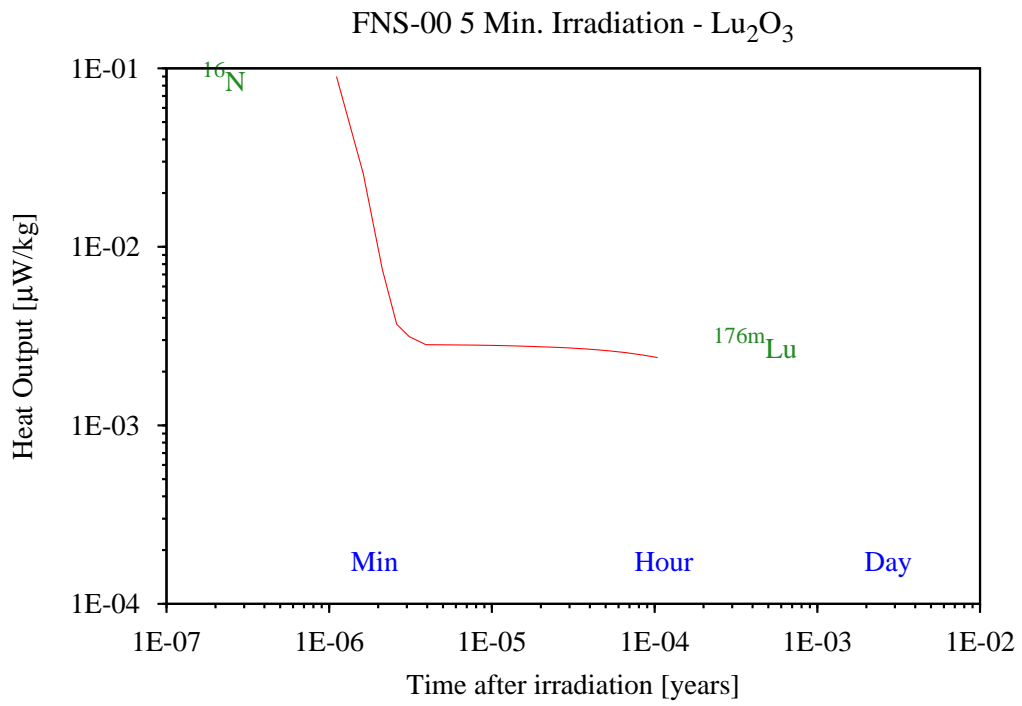
FNS-00 5 Min. Irradiation - Lu₂O₃



For Lutetium, once again the experimental results in the minute ranges show some structures, possibly underlying a lack of isomeric state and associated decay data, or an incorrect level of the subtracted tape contribution.

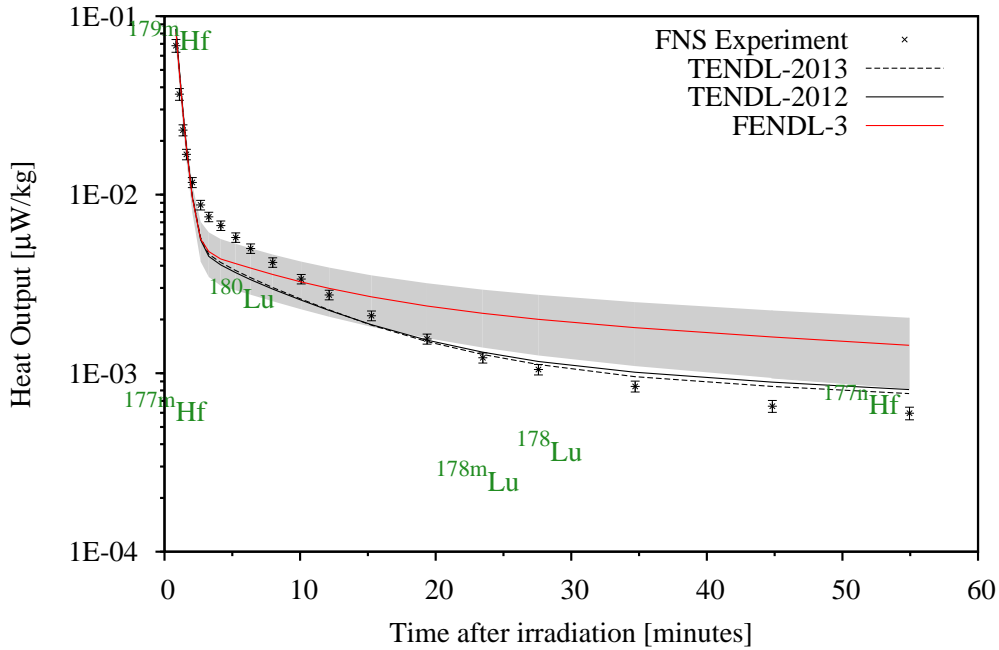
| Times | FNS EXP. 5 mins | FENDL-3 | E/C TENDL-2012 | | E/C TENDL-2013 | | E/C |
|-------|------------------|-----------------|----------------|----------|----------------|----------|------|
| Min. | μW/g | | | | | | |
| 0.58 | 3.29E-01 +/-18% | 9.01E-02 +/-10% | 3.65 | 6.72E-02 | 4.89 | 6.72E-02 | 4.90 |
| 0.85 | 7.14E-02 +/-19% | 2.59E-02 +/-9% | 2.76 | 1.43E-02 | 4.99 | 1.43E-02 | 5.00 |
| 1.12 | 1.86E-02 +/-20% | 7.47E-03 +/-11% | 2.48 | 6.36E-03 | 2.92 | 6.35E-03 | 2.92 |
| 1.37 | 6.19E-03 +/-24% | 3.69E-03 +/-18% | 1.68 | 4.70E-03 | 1.32 | 4.70E-03 | 1.32 |
| 1.63 | 4.67E-03 +/-21% | 3.14E-03 +/-20% | 1.49 | 4.16E-03 | 1.12 | 4.15E-03 | 1.13 |
| 2.07 | 2.01E-03 +/-42% | 2.83E-03 +/-23% | 0.71 | 3.89E-03 | 0.52 | 3.88E-03 | 0.52 |
| 2.68 | 5.73E-04 +/-137% | 2.83E-03 +/-23% | 0.20 | 3.88E-03 | 0.15 | 3.88E-03 | 0.15 |
| 3.30 | 1.05E-03 +/-74% | 2.82E-03 +/-23% | 0.37 | 3.87E-03 | 0.27 | 3.87E-03 | 0.27 |
| 4.17 | 2.45E-03 +/-28% | 2.81E-03 +/-23% | 0.87 | 3.86E-03 | 0.63 | 3.86E-03 | 0.64 |
| 5.28 | 2.27E-03 +/-28% | 2.80E-03 +/-23% | 0.81 | 3.85E-03 | 0.59 | 3.84E-03 | 0.59 |
| 6.38 | 1.43E-03 +/-40% | 2.79E-03 +/-23% | 0.51 | 3.84E-03 | 0.37 | 3.83E-03 | 0.37 |
| 8.00 | 1.63E-03 +/-33% | 2.78E-03 +/-23% | 0.59 | 3.82E-03 | 0.43 | 3.81E-03 | 0.43 |
| 10.12 | 2.23E-03 +/-23% | 2.76E-03 +/-23% | 0.81 | 3.79E-03 | 0.59 | 3.79E-03 | 0.59 |
| 12.22 | 2.00E-03 +/-24% | 2.74E-03 +/-23% | 0.73 | 3.77E-03 | 0.53 | 3.76E-03 | 0.53 |
| 15.30 | 2.05E-03 +/-23% | 2.72E-03 +/-23% | 0.75 | 3.73E-03 | 0.55 | 3.73E-03 | 0.55 |
| 19.42 | 2.02E-03 +/-22% | 2.68E-03 +/-23% | 0.75 | 3.68E-03 | 0.55 | 3.68E-03 | 0.55 |
| 23.53 | 1.99E-03 +/-22% | 2.65E-03 +/-23% | 0.75 | 3.64E-03 | 0.55 | 3.63E-03 | 0.55 |
| 27.63 | 2.21E-03 +/-20% | 2.61E-03 +/-23% | 0.85 | 3.59E-03 | 0.62 | 3.58E-03 | 0.62 |
| 34.77 | 2.10E-03 +/-21% | 2.55E-03 +/-23% | 0.82 | 3.51E-03 | 0.60 | 3.50E-03 | 0.60 |
| 44.83 | 1.64E-03 +/-25% | 2.48E-03 +/-23% | 0.66 | 3.40E-03 | 0.48 | 3.40E-03 | 0.48 |
| 54.95 | 9.65E-04 +/-43% | 2.40E-03 +/-23% | 0.40 | 3.29E-03 | 0.29 | 3.29E-03 | 0.29 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Lu176m | Lu175(n,γ)Lu176m | 3.6h | 91.6 | 0.60 | 21% |
| | Lu176(n,n')Lu176m | | 8.4 | 0.60 | 21% |



Hafnium

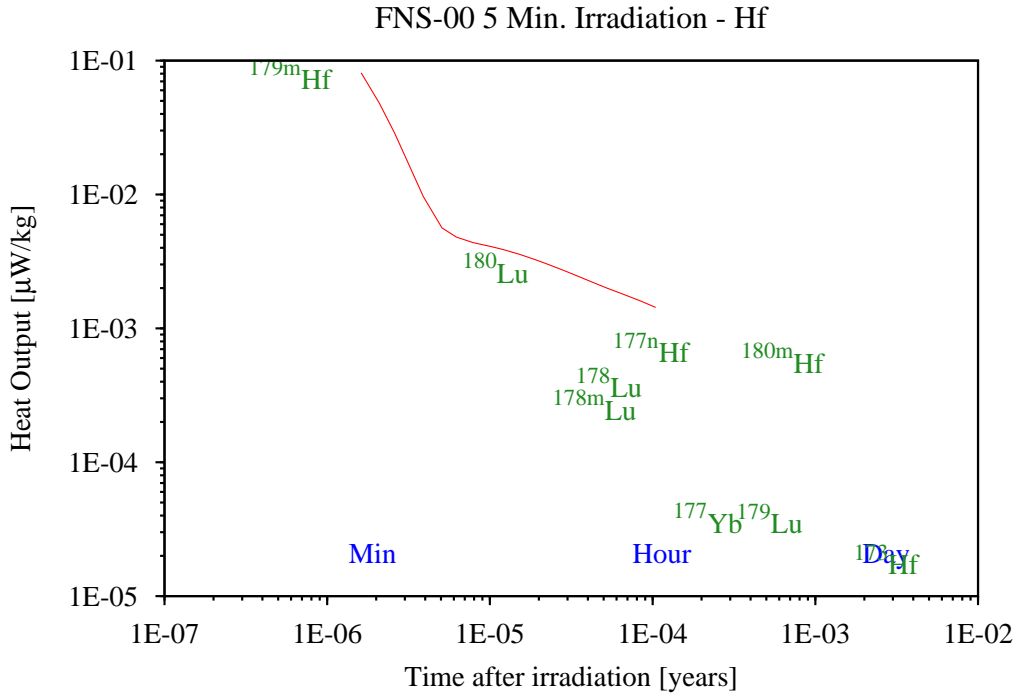
FNS-00 5 Min. Irradiation - Hf



For Hafnium, the analysis of this element with anterior databases was extremely poorly interpreted because of a gross overestimation of the Hf177(n,n') channel. With this overshadowing effect now taken out one can still observe half life and/or branching ratio inconsistencies, but TENDL's libraries shows a significant improvement over the earlier databases.

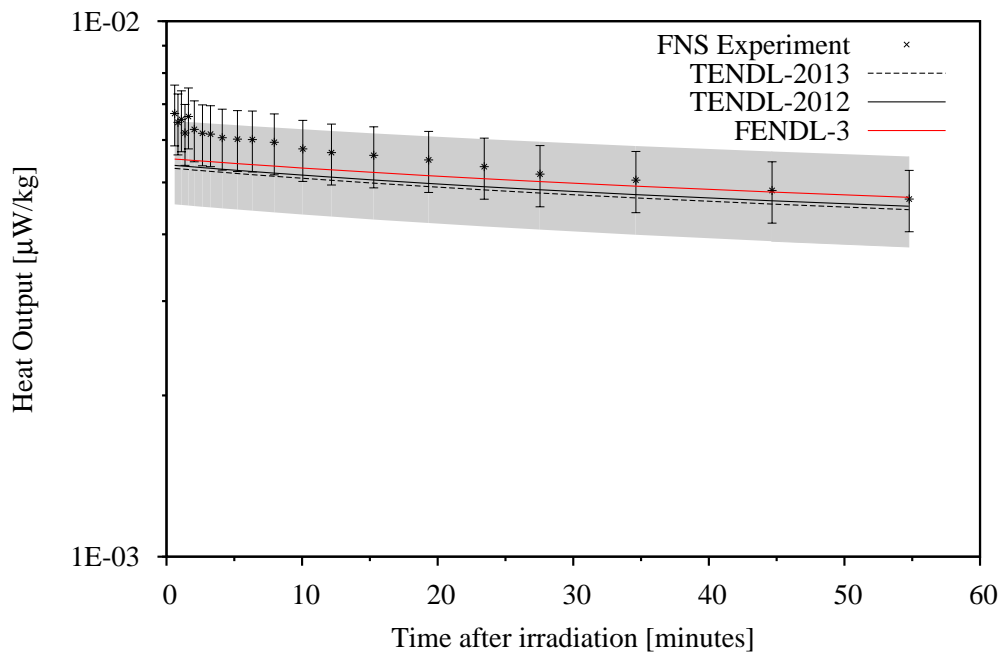
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.85 | 6.84E-02 +/-8% | 8.11E-02 +/-16% | 0.84 | 8.48E-02 | 0.81 | 8.47E-02 | 0.81 |
| 1.10 | 3.65E-02 +/-8% | 4.81E-02 +/-16% | 0.76 | 4.94E-02 | 0.74 | 4.92E-02 | 0.74 |
| 1.37 | 2.30E-02 +/-7% | 2.86E-02 +/-15% | 0.80 | 2.92E-02 | 0.79 | 2.89E-02 | 0.79 |
| 1.62 | 1.68E-02 +/-7% | 1.82E-02 +/-15% | 0.92 | 1.86E-02 | 0.91 | 1.85E-02 | 0.91 |
| 2.05 | 1.17E-02 +/-6% | 9.63E-03 +/-17% | 1.22 | 9.73E-03 | 1.20 | 9.86E-03 | 1.19 |
| 2.67 | 8.75E-03 +/-6% | 5.64E-03 +/-25% | 1.55 | 5.58E-03 | 1.57 | 5.75E-03 | 1.52 |
| 3.27 | 7.51E-03 +/-6% | 4.80E-03 +/-28% | 1.56 | 4.51E-03 | 1.67 | 4.63E-03 | 1.62 |
| 4.15 | 6.71E-03 +/-6% | 4.37E-03 +/-29% | 1.54 | 4.05E-03 | 1.66 | 4.17E-03 | 1.61 |
| 5.25 | 5.76E-03 +/-6% | 4.11E-03 +/-29% | 1.40 | 3.66E-03 | 1.57 | 3.76E-03 | 1.53 |
| 6.35 | 4.99E-03 +/-6% | 3.88E-03 +/-29% | 1.29 | 3.34E-03 | 1.49 | 3.43E-03 | 1.45 |
| 7.98 | 4.18E-03 +/-6% | 3.57E-03 +/-29% | 1.17 | 2.96E-03 | 1.41 | 3.02E-03 | 1.38 |
| 10.08 | 3.37E-03 +/-6% | 3.25E-03 +/-30% | 1.04 | 2.57E-03 | 1.31 | 2.60E-03 | 1.30 |
| 12.15 | 2.75E-03 +/-6% | 2.99E-03 +/-31% | 0.92 | 2.25E-03 | 1.22 | 2.26E-03 | 1.21 |
| 15.27 | 2.10E-03 +/-6% | 2.68E-03 +/-32% | 0.78 | 1.87E-03 | 1.12 | 1.86E-03 | 1.13 |
| 19.37 | 1.55E-03 +/-6% | 2.38E-03 +/-34% | 0.65 | 1.53E-03 | 1.02 | 1.50E-03 | 1.03 |
| 23.48 | 1.22E-03 +/-7% | 2.16E-03 +/-36% | 0.56 | 1.31E-03 | 0.93 | 1.27E-03 | 0.96 |
| 27.58 | 1.05E-03 +/-7% | 2.00E-03 +/-37% | 0.52 | 1.16E-03 | 0.90 | 1.12E-03 | 0.94 |
| 34.72 | 8.44E-04 +/-7% | 1.80E-03 +/-39% | 0.47 | 1.01E-03 | 0.83 | 9.55E-04 | 0.88 |
| 44.83 | 6.53E-04 +/-8% | 1.59E-03 +/-41% | 0.41 | 8.91E-04 | 0.73 | 8.43E-04 | 0.78 |
| 54.95 | 5.96E-04 +/-8% | 1.43E-03 +/-43% | 0.42 | 8.10E-04 | 0.74 | 7.68E-04 | 0.78 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Hf179m | Hf178(n,γ)Hf179m | 18.6s | 15.4 | 0.81 | 8% |
| | Hf179(n,n')Hf179m | | 2.6 | 0.81 | 8% |
| | Hf180(n,2n)Hf179m | | 81.9 | 0.81 | 8% |
| Lu180 | Hf180(n,p)Lu180 | 5.7m | 100.0 | 1.53 | 6% |
| Lu178 | Hf178(n,p)Lu178 | 28.4m | 96.3 | 0.94 | 7% |
| | Hf179(n,d)Lu178 | | 3.5 | 0.94 | 7% |

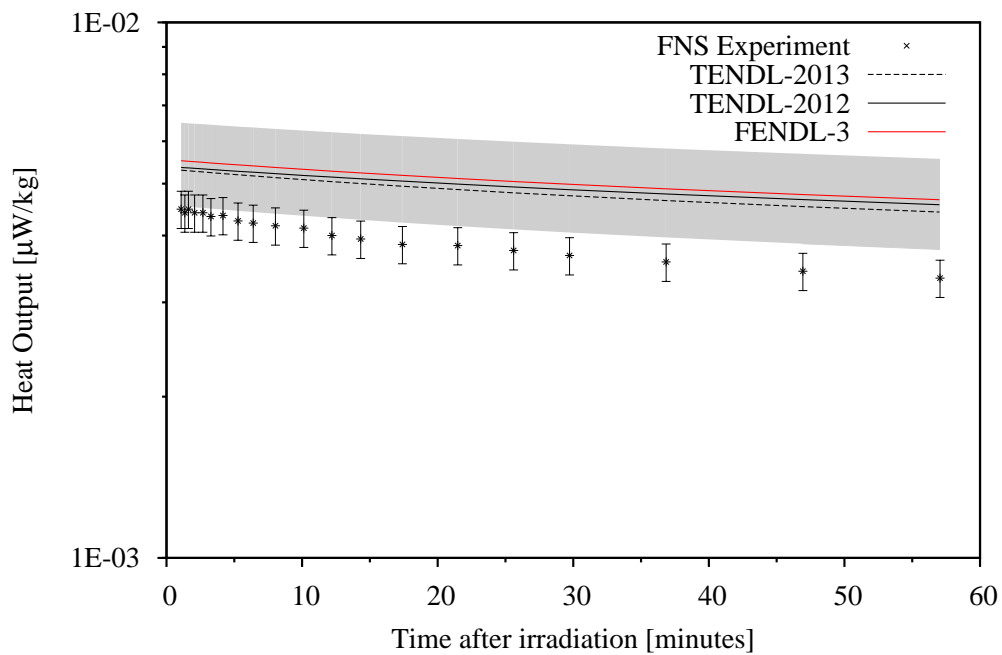


Tantalum

FNS-00 5 Min. Irradiation - Ta



FNS-96 5 Min. Irradiation - Ta

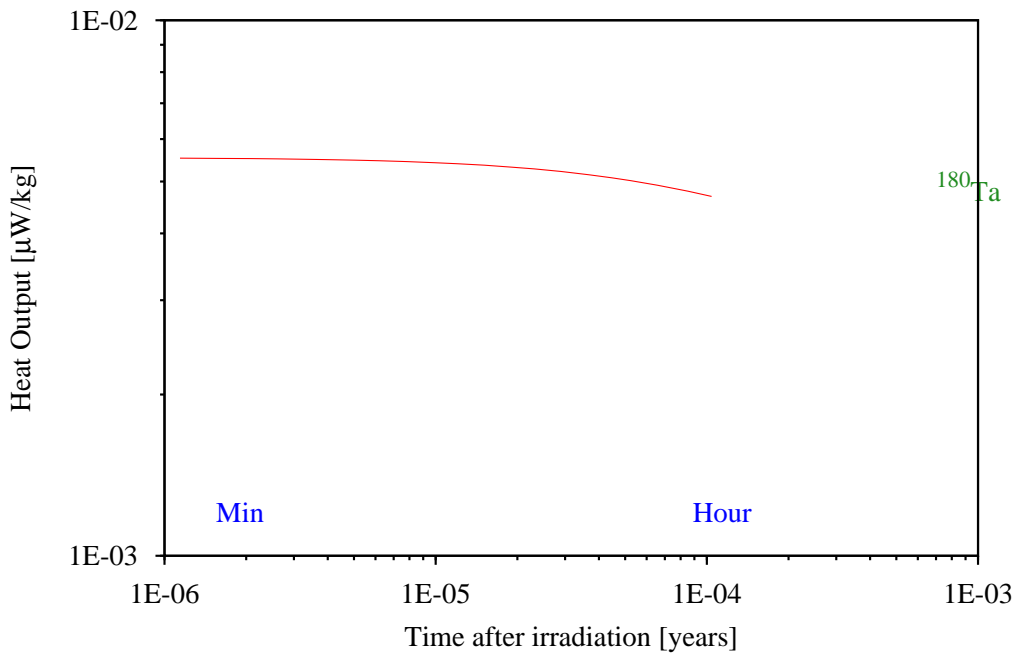


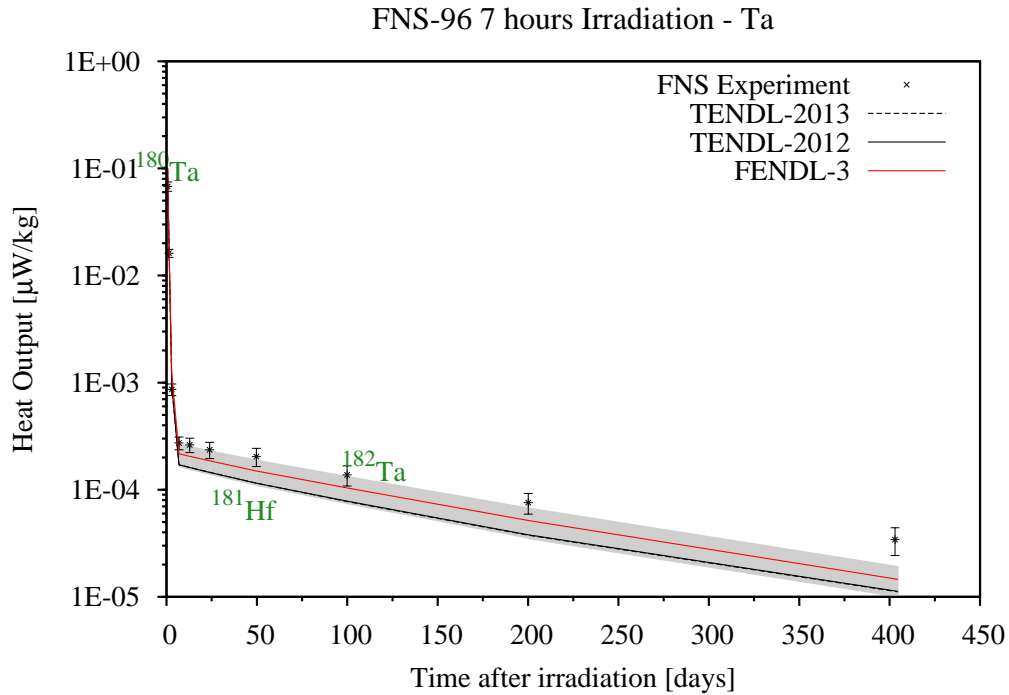
For Tantalum, once again there are some noticeable differences between the two experiments, but a within the experimental uncertainty band agreement exists for the latest, 2000, experiment.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C TENDL-2012 | E/C TENDL-2013 | E/C |
|-------|---------------------|---------------------|----------------|----------------|------|
| Min. | $\mu\text{W/g}$ | | | | |
| 0.60 | $6.72E-03 \pm 13\%$ | $5.53E-03 \pm 18\%$ | 1.22 | $5.38E-03$ | 1.25 |
| 0.85 | $6.47E-03 \pm 13\%$ | $5.52E-03 \pm 18\%$ | 1.17 | $5.37E-03$ | 1.20 |
| 1.10 | $6.56E-03 \pm 13\%$ | $5.52E-03 \pm 18\%$ | 1.19 | $5.37E-03$ | 1.22 |
| 1.37 | $6.18E-03 \pm 13\%$ | $5.51E-03 \pm 18\%$ | 1.12 | $5.36E-03$ | 1.15 |
| 1.62 | $6.64E-03 \pm 13\%$ | $5.50E-03 \pm 18\%$ | 1.21 | $5.35E-03$ | 1.24 |
| 2.05 | $6.28E-03 \pm 13\%$ | $5.49E-03 \pm 18\%$ | 1.14 | $5.34E-03$ | 1.18 |
| 2.65 | $6.17E-03 \pm 13\%$ | $5.48E-03 \pm 18\%$ | 1.13 | $5.33E-03$ | 1.16 |
| 3.25 | $6.15E-03 \pm 13\%$ | $5.46E-03 \pm 18\%$ | 1.13 | $5.31E-03$ | 1.16 |
| 4.12 | $6.06E-03 \pm 13\%$ | $5.45E-03 \pm 18\%$ | 1.11 | $5.29E-03$ | 1.15 |
| 5.23 | $6.02E-03 \pm 13\%$ | $5.42E-03 \pm 18\%$ | 1.11 | $5.27E-03$ | 1.14 |
| 6.33 | $6.01E-03 \pm 13\%$ | $5.40E-03 \pm 18\%$ | 1.11 | $5.24E-03$ | 1.15 |
| 7.95 | $5.94E-03 \pm 13\%$ | $5.36E-03 \pm 18\%$ | 1.11 | $5.20E-03$ | 1.14 |
| 10.05 | $5.77E-03 \pm 13\%$ | $5.32E-03 \pm 18\%$ | 1.09 | $5.16E-03$ | 1.12 |
| 12.17 | $5.68E-03 \pm 13\%$ | $5.28E-03 \pm 18\%$ | 1.08 | $5.11E-03$ | 1.11 |
| 15.28 | $5.62E-03 \pm 13\%$ | $5.22E-03 \pm 18\%$ | 1.08 | $5.05E-03$ | 1.11 |
| 19.33 | $5.51E-03 \pm 13\%$ | $5.15E-03 \pm 18\%$ | 1.07 | $4.98E-03$ | 1.11 |
| 23.43 | $5.35E-03 \pm 13\%$ | $5.08E-03 \pm 19\%$ | 1.05 | $4.91E-03$ | 1.09 |
| 27.55 | $5.18E-03 \pm 13\%$ | $5.02E-03 \pm 19\%$ | 1.03 | $4.84E-03$ | 1.07 |
| 34.62 | $5.05E-03 \pm 13\%$ | $4.92E-03 \pm 19\%$ | 1.03 | $4.74E-03$ | 1.06 |
| 44.67 | $4.83E-03 \pm 13\%$ | $4.80E-03 \pm 19\%$ | 1.01 | $4.62E-03$ | 1.05 |
| 54.78 | $4.66E-03 \pm 13\%$ | $4.69E-03 \pm 19\%$ | 0.99 | $4.51E-03$ | 1.03 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C $\Delta E\%$ |
|---------|------------------|-----------|--------|------------------|
| Ta180 | Ta181(n,2n)Ta180 | 8.0h | 99.9 | 1.05 13% |

FNS-00 5 Min. Irradiation - Ta

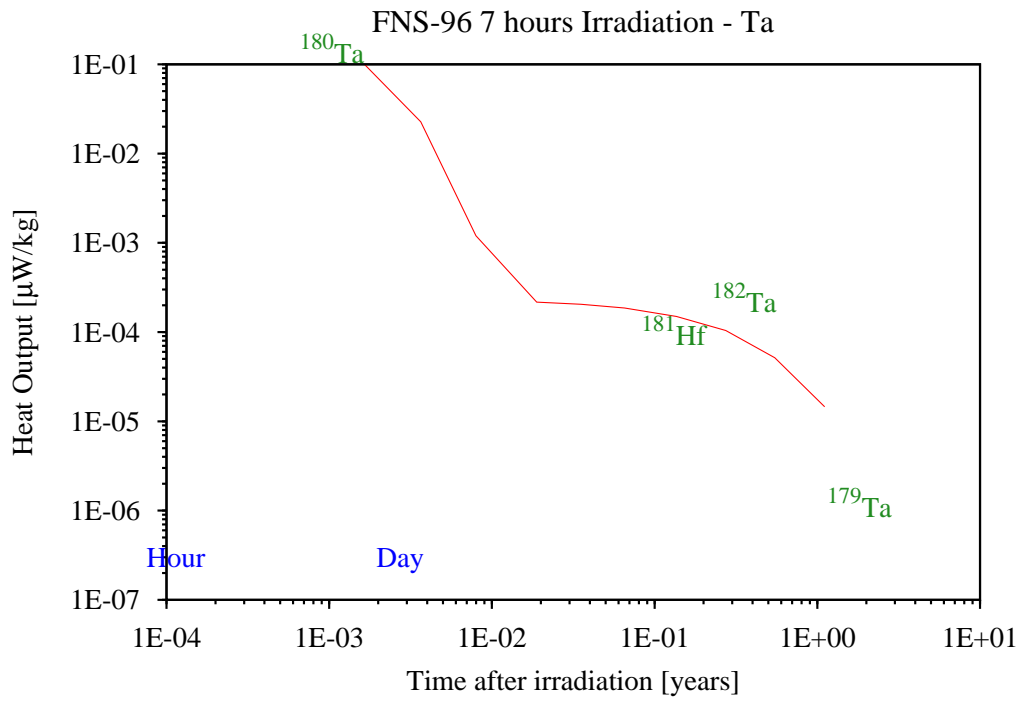




The presence of capture pathways, multiple isomeric states, do not allow for a definite interpretation to be made in this case.

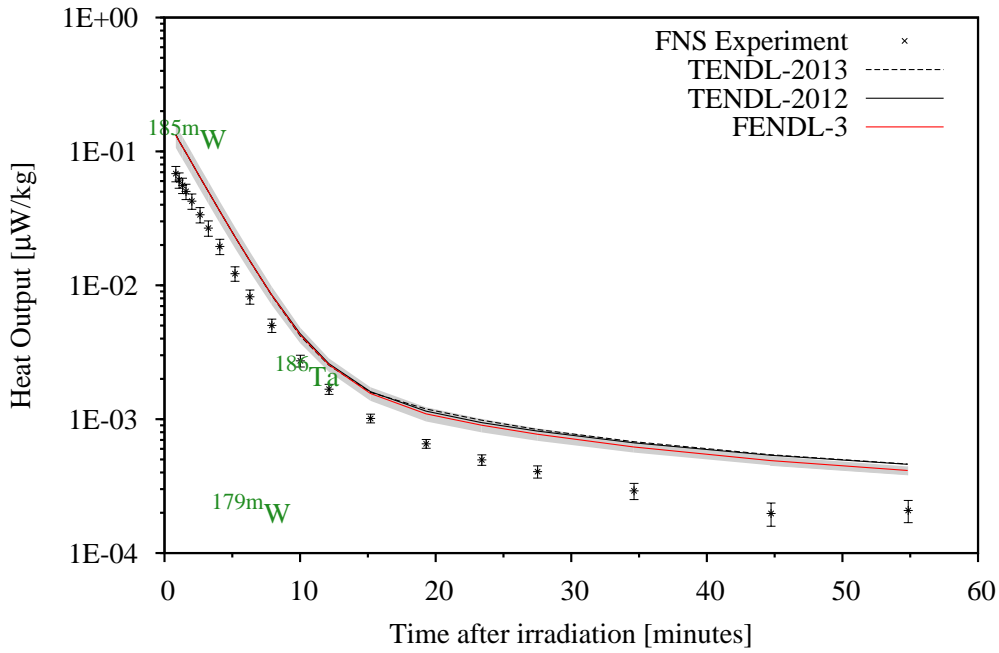
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------|-------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.60 | $6.79E-02$ +/-10% | $9.95E-02$ +/-20% | 0.68 | $1.00E-01$ | 0.68 | $9.89E-02$ | 0.69 |
| 1.33 | $1.62E-02$ +/-9% | $2.27E-02$ +/-20% | 0.71 | $1.99E-02$ | 0.81 | $1.97E-02$ | 0.82 |
| 2.91 | $8.64E-04$ +/-12% | $1.20E-03$ +/-17% | 0.72 | $9.34E-04$ | 0.92 | $9.14E-04$ | 0.94 |
| 6.88 | $2.73E-04$ +/-14% | $2.17E-04$ +/-25% | 1.26 | $1.71E-04$ | 1.60 | $1.71E-04$ | 1.60 |
| 12.88 | $2.63E-04$ +/-15% | $2.05E-04$ +/-25% | 1.28 | $1.61E-04$ | 1.63 | $1.62E-04$ | 1.63 |
| 23.88 | $2.36E-04$ +/-17% | $1.86E-04$ +/-26% | 1.27 | $1.45E-04$ | 1.63 | $1.45E-04$ | 1.62 |
| 49.72 | $2.04E-04$ +/-19% | $1.50E-04$ +/-27% | 1.36 | $1.15E-04$ | 1.77 | $1.15E-04$ | 1.77 |
| 99.91 | $1.38E-04$ +/-21% | $1.04E-04$ +/-29% | 1.32 | $7.82E-05$ | 1.76 | $7.76E-05$ | 1.77 |
| 200.13 | $7.57E-05$ +/-22% | $5.17E-05$ +/-32% | 1.47 | $3.79E-05$ | 2.00 | $3.77E-05$ | 2.01 |
| 402.97 | $3.42E-05$ +/-29% | $1.46E-05$ +/-33% | 2.35 | $1.12E-05$ | 3.05 | $1.11E-05$ | 3.07 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|---------------------------|-----------|--------|------|--------------|
| Ta180 | Ta181(n,2n)Ta180 | 8.0h | 99.7 | 0.69 | 10% |
| Hf181 | Ta181(n,p)Hf181 | 42.3d | 100.0 | 1.77 | 19% |
| Ta182 | Ta181(n, γ)Ta182 | 114d | 59.6 | 2.00 | 22% |
| | Ta181(n, γ)Ta182m | 0.3s | 38.2 | 2.00 | 22% |
| | Ta181(n, γ)Ta182n | 15.8m | 2.2 | 2.00 | 22% |

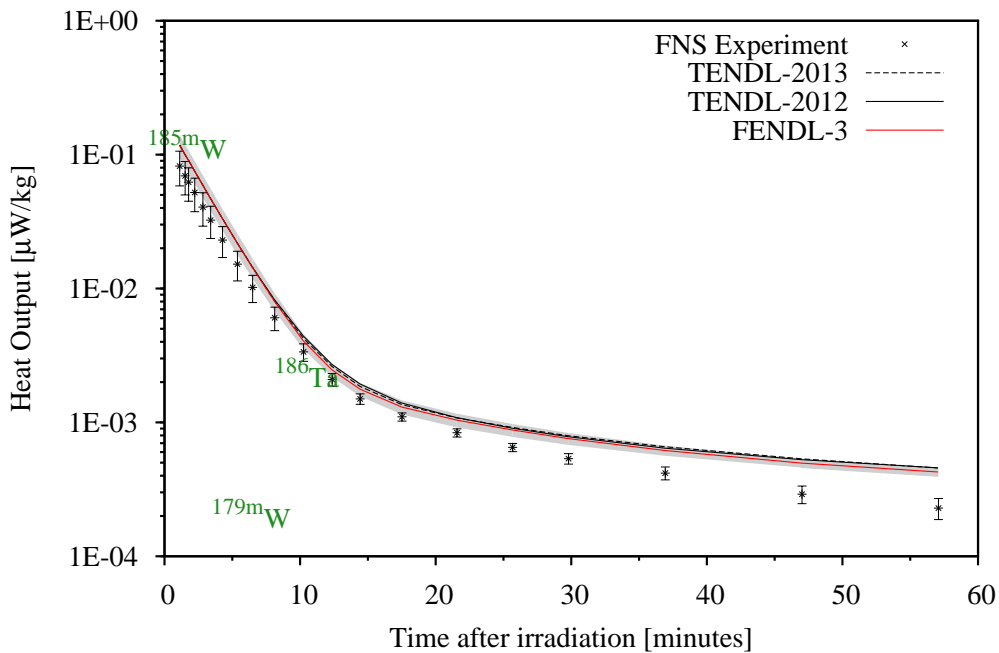


Tungsten

FNS-00 5 Min. Irradiation - W



FNS-96 5 Min. Irradiation - W

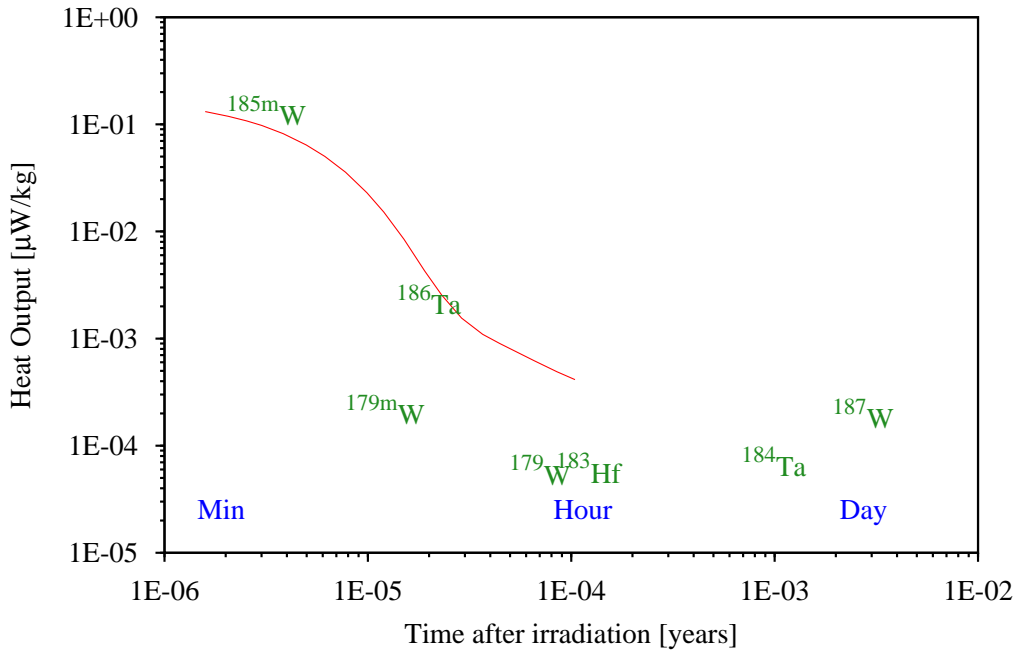


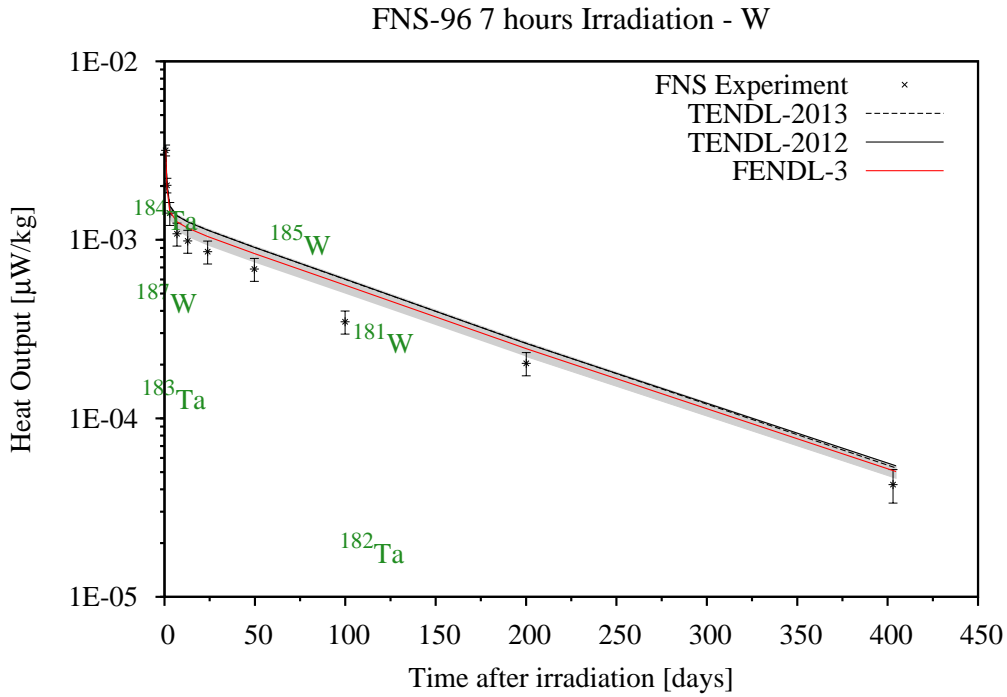
For Tungsten, a better than expected level of agreement is observed for this particularly troublesome, in nuclear data terms, element. The systematic code over-prediction on both batches (although by more in the 2000 case) may need to be addressed via an in-depth analysis of the two production routes involved.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|---------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.83 | $6.83E-02 \pm 13\%$ | $1.32E-01 \pm 19\%$ | 0.52 | $1.33E-01$ | 0.51 | $1.33E-01$ | 0.51 |
| 1.08 | $6.11E-02 \pm 13\%$ | $1.19E-01 \pm 19\%$ | 0.51 | $1.19E-01$ | 0.51 | $1.19E-01$ | 0.51 |
| 1.33 | $5.57E-02 \pm 13\%$ | $1.08E-01 \pm 19\%$ | 0.52 | $1.08E-01$ | 0.52 | $1.08E-01$ | 0.52 |
| 1.58 | $5.03E-02 \pm 13\%$ | $9.77E-02 \pm 19\%$ | 0.51 | $9.77E-02$ | 0.51 | $9.76E-02$ | 0.52 |
| 2.02 | $4.25E-02 \pm 13\%$ | $8.20E-02 \pm 19\%$ | 0.52 | $8.20E-02$ | 0.52 | $8.19E-02$ | 0.52 |
| 2.62 | $3.36E-02 \pm 13\%$ | $6.43E-02 \pm 19\%$ | 0.52 | $6.43E-02$ | 0.52 | $6.42E-02$ | 0.52 |
| 3.23 | $2.67E-02 \pm 13\%$ | $5.01E-02 \pm 19\%$ | 0.53 | $5.02E-02$ | 0.53 | $5.01E-02$ | 0.53 |
| 4.08 | $1.95E-02 \pm 13\%$ | $3.57E-02 \pm 19\%$ | 0.55 | $3.58E-02$ | 0.54 | $3.57E-02$ | 0.55 |
| 5.20 | $1.22E-02 \pm 12\%$ | $2.30E-02 \pm 18\%$ | 0.53 | $2.30E-02$ | 0.53 | $2.30E-02$ | 0.53 |
| 6.30 | $8.22E-03 \pm 12\%$ | $1.52E-02 \pm 17\%$ | 0.54 | $1.52E-02$ | 0.54 | $1.52E-02$ | 0.54 |
| 7.92 | $5.02E-03 \pm 11\%$ | $8.46E-03 \pm 16\%$ | 0.59 | $8.47E-03$ | 0.59 | $8.39E-03$ | 0.60 |
| 10.02 | $2.73E-03 \pm 10\%$ | $4.26E-03 \pm 13\%$ | 0.64 | $4.35E-03$ | 0.63 | $4.19E-03$ | 0.65 |
| 12.13 | $1.68E-03 \pm 9\%$ | $2.55E-03 \pm 12\%$ | 0.66 | $2.59E-03$ | 0.65 | $2.53E-03$ | 0.66 |
| 15.20 | $1.01E-03 \pm 8\%$ | $1.55E-03 \pm 12\%$ | 0.65 | $1.60E-03$ | 0.63 | $1.59E-03$ | 0.64 |
| 19.30 | $6.55E-04 \pm 8\%$ | $1.09E-03 \pm 12\%$ | 0.60 | $1.15E-03$ | 0.57 | $1.19E-03$ | 0.55 |
| 23.40 | $4.96E-04 \pm 9\%$ | $9.01E-04 \pm 12\%$ | 0.55 | $9.43E-04$ | 0.53 | $9.82E-04$ | 0.51 |
| 27.52 | $4.05E-04 \pm 11\%$ | $7.71E-04 \pm 11\%$ | 0.53 | $8.16E-04$ | 0.50 | $8.38E-04$ | 0.48 |
| 34.63 | $2.91E-04 \pm 14\%$ | $6.20E-04 \pm 9\%$ | 0.47 | $6.66E-04$ | 0.44 | $6.79E-04$ | 0.43 |
| 44.73 | $1.97E-04 \pm 20\%$ | $4.90E-04 \pm 8\%$ | 0.40 | $5.37E-04$ | 0.37 | $5.42E-04$ | 0.36 |
| 54.85 | $2.08E-04 \pm 19\%$ | $4.14E-04 \pm 7\%$ | 0.50 | $4.60E-04$ | 0.45 | $4.62E-04$ | 0.45 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| W185m | W186(n,2n)W185m | 1.6m | 98.1 | 0.52 | 13% |
| Ta186 | W186(n,p)Ta186 | 10.5m | 100.0 | 0.63 | 13% |

FNS-00 5 Min. Irradiation - W

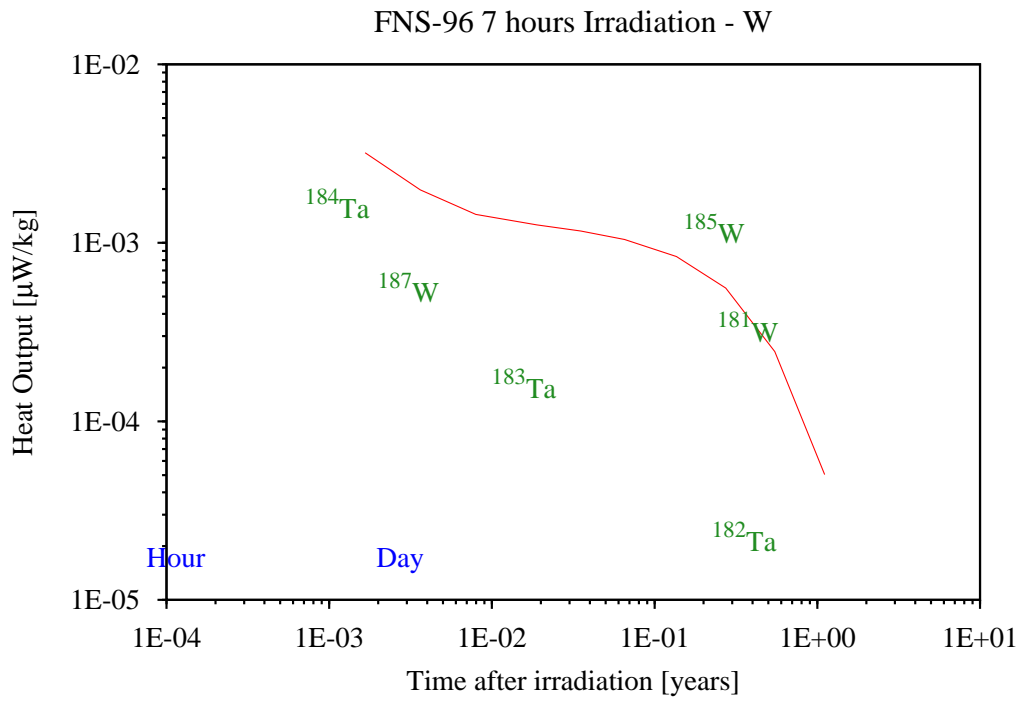




There seems to be a systematic 20-30% overestimation for some of the predominant isotopes, most notably W181 and W185.

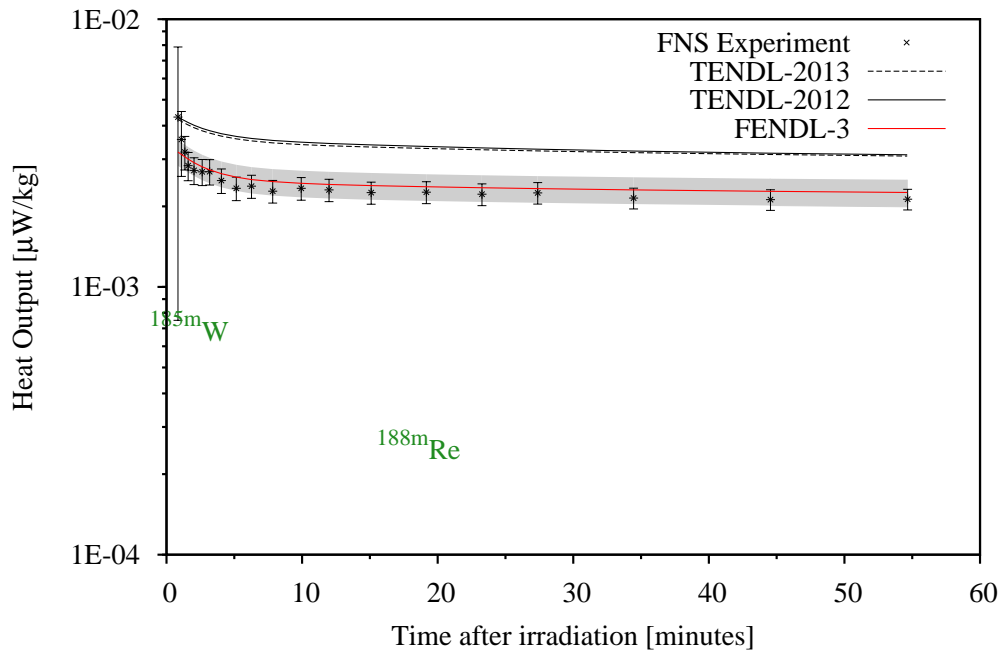
| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------|-------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.61 | $3.17E-03$ +/-7% | $3.20E-03$ +/-10% | 0.99 | $3.34E-03$ | 0.95 | $3.29E-03$ | 0.97 |
| 1.33 | $2.02E-03$ +/-9% | $1.98E-03$ +/-9% | 1.02 | $2.09E-03$ | 0.97 | $2.09E-03$ | 0.97 |
| 2.91 | $1.41E-03$ +/-15% | $1.44E-03$ +/-10% | 0.98 | $1.55E-03$ | 0.91 | $1.54E-03$ | 0.91 |
| 6.88 | $1.08E-03$ +/-15% | $1.26E-03$ +/-11% | 0.86 | $1.36E-03$ | 0.79 | $1.36E-03$ | 0.79 |
| 12.87 | $9.86E-04$ +/-15% | $1.17E-03$ +/-11% | 0.85 | $1.26E-03$ | 0.78 | $1.26E-03$ | 0.78 |
| 23.87 | $8.58E-04$ +/-15% | $1.04E-03$ +/-11% | 0.82 | $1.13E-03$ | 0.76 | $1.13E-03$ | 0.76 |
| 49.71 | $6.87E-04$ +/-15% | $8.38E-04$ +/-11% | 0.82 | $9.07E-04$ | 0.76 | $9.08E-04$ | 0.76 |
| 99.90 | $3.48E-04$ +/-15% | $5.58E-04$ +/-10% | 0.62 | $6.03E-04$ | 0.58 | $6.01E-04$ | 0.58 |
| 200.12 | $2.03E-04$ +/-15% | $2.46E-04$ +/-10% | 0.83 | $2.63E-04$ | 0.77 | $2.64E-04$ | 0.77 |
| 402.95 | $4.26E-05$ +/-21% | $5.03E-05$ +/-8% | 0.85 | $5.42E-05$ | 0.79 | $5.27E-05$ | 0.81 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-----------------|-----------|--------|------|--------------|
| Ta184 | W184(n,p)Ta184 | 8.7h | 99.7 | 0.97 | 7% |
| W185 | W186(n,2n)W185 | 75.1d | 63.9 | 0.76 | 15% |
| | W186(n,2n)W185m | 1.6m | 35.8 | 0.76 | 15% |
| W181 | W182(n,2n)W181 | 120d | 99.3 | 0.77 | 15% |
| | W183(n,3n)W181 | 120d | 0.7 | 0.77 | 15% |

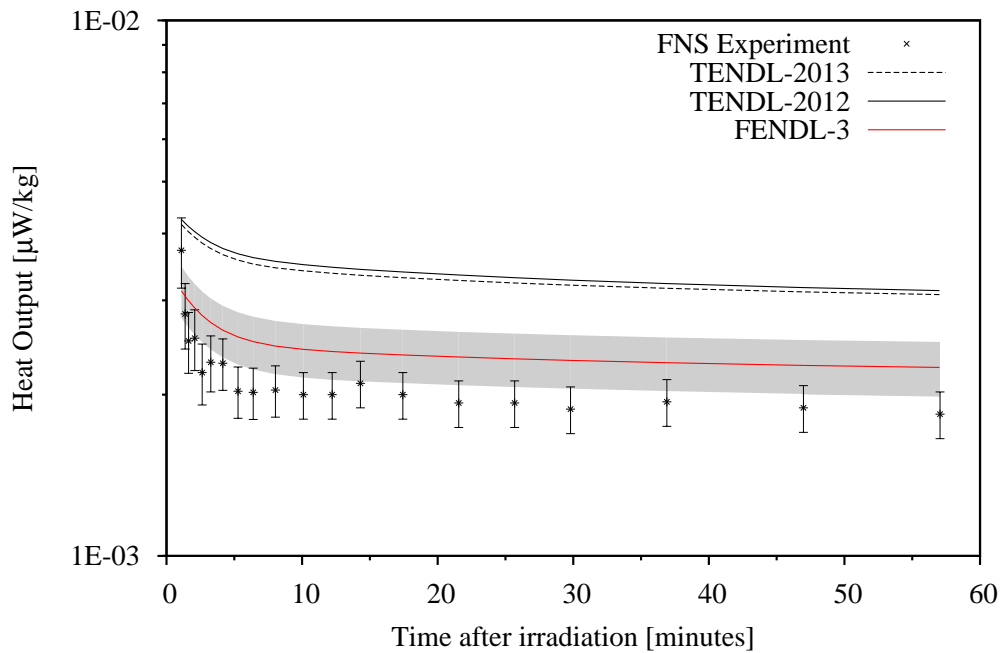


Rhenium

FNS-00 5 Min. Irradiation - Re



FNS-96 5 Min. Irradiation - Re

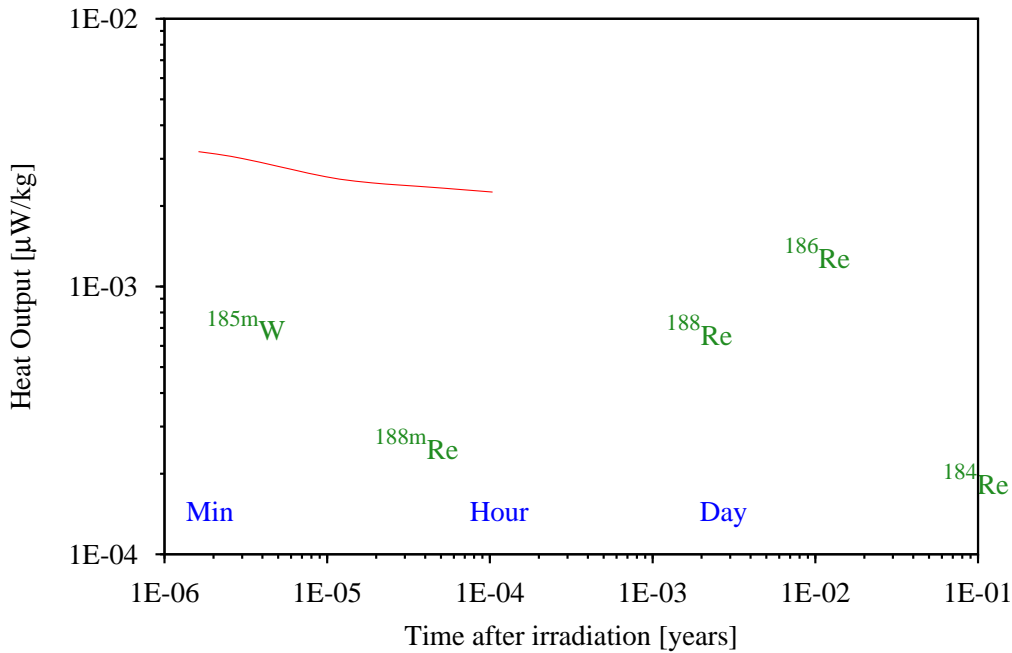


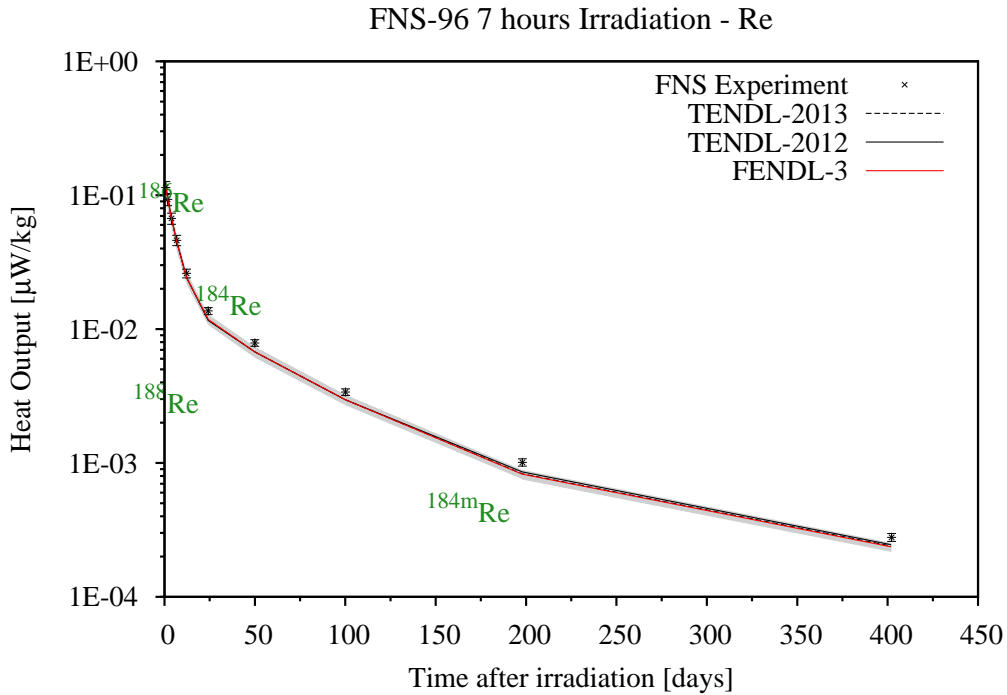
Rhenium: there is quite good agreement to the newer experimental results for this element with FENDL-3.0, nearly within the experimental uncertainties. However, the experimental result from the 1996 batch is significantly different. This could be due to the rarely observed shadow or iceberg effect. Furthermore, Re188 response is over-predicted by TENDL's libraries, shadowing the Re186 one. Effect seen in the next page Log-Log graph.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-------------------|-------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.85 | $4.31E-03$ +/-83% | $3.19E-03$ +/-11% | 1.35 | $4.31E-03$ | 1.00 | $4.22E-03$ | 1.02 |
| 1.10 | $3.55E-03$ +/-27% | $3.12E-03$ +/-11% | 1.14 | $4.24E-03$ | 0.84 | $4.15E-03$ | 0.86 |
| 1.35 | $3.19E-03$ +/-14% | $3.06E-03$ +/-11% | 1.04 | $4.17E-03$ | 0.76 | $4.09E-03$ | 0.78 |
| 1.60 | $2.84E-03$ +/-12% | $3.00E-03$ +/-11% | 0.94 | $4.11E-03$ | 0.69 | $4.03E-03$ | 0.70 |
| 2.03 | $2.72E-03$ +/-12% | $2.91E-03$ +/-11% | 0.94 | $4.02E-03$ | 0.68 | $3.94E-03$ | 0.69 |
| 2.63 | $2.69E-03$ +/-11% | $2.81E-03$ +/-11% | 0.96 | $3.91E-03$ | 0.69 | $3.83E-03$ | 0.70 |
| 3.18 | $2.69E-03$ +/-11% | $2.74E-03$ +/-11% | 0.98 | $3.83E-03$ | 0.70 | $3.75E-03$ | 0.72 |
| 4.05 | $2.50E-03$ +/-11% | $2.65E-03$ +/-11% | 0.94 | $3.74E-03$ | 0.67 | $3.66E-03$ | 0.68 |
| 5.15 | $2.33E-03$ +/-10% | $2.57E-03$ +/-11% | 0.91 | $3.65E-03$ | 0.64 | $3.57E-03$ | 0.65 |
| 6.27 | $2.38E-03$ +/-10% | $2.52E-03$ +/-11% | 0.94 | $3.59E-03$ | 0.66 | $3.51E-03$ | 0.68 |
| 7.83 | $2.28E-03$ +/-10% | $2.47E-03$ +/-11% | 0.92 | $3.52E-03$ | 0.65 | $3.45E-03$ | 0.66 |
| 9.93 | $2.33E-03$ +/-10% | $2.44E-03$ +/-11% | 0.96 | $3.47E-03$ | 0.67 | $3.40E-03$ | 0.69 |
| 11.98 | $2.30E-03$ +/-10% | $2.41E-03$ +/-11% | 0.95 | $3.43E-03$ | 0.67 | $3.37E-03$ | 0.68 |
| 15.10 | $2.25E-03$ +/-9% | $2.39E-03$ +/-11% | 0.94 | $3.39E-03$ | 0.66 | $3.33E-03$ | 0.68 |
| 19.17 | $2.26E-03$ +/-9% | $2.37E-03$ +/-11% | 0.95 | $3.35E-03$ | 0.67 | $3.29E-03$ | 0.69 |
| 23.27 | $2.22E-03$ +/-9% | $2.35E-03$ +/-11% | 0.95 | $3.31E-03$ | 0.67 | $3.25E-03$ | 0.68 |
| 27.38 | $2.25E-03$ +/-9% | $2.33E-03$ +/-11% | 0.96 | $3.27E-03$ | 0.69 | $3.22E-03$ | 0.70 |
| 34.45 | $2.15E-03$ +/-9% | $2.30E-03$ +/-11% | 0.93 | $3.22E-03$ | 0.67 | $3.17E-03$ | 0.68 |
| 44.55 | $2.12E-03$ +/-9% | $2.27E-03$ +/-12% | 0.93 | $3.16E-03$ | 0.67 | $3.12E-03$ | 0.68 |
| 54.67 | $2.13E-03$ +/-9% | $2.25E-03$ +/-12% | 0.94 | $3.12E-03$ | 0.68 | $3.08E-03$ | 0.69 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|--------------------------|-----------|--------|------|--------------|
| W185m | Re185(n,p)W185m | 1.6m | 96.7 | 0.70 | 12% |
| | Re187(n,t+nd)W185m | | 3.1 | 0.70 | 12% |
| Re188 | Re187(n, γ)Re188 | 16.9h | 100.0 | 0.69 | 9% |
| Re186 | Re185(n, γ)Re186 | 3.7d | 9.2 | 0.69 | 9% |
| | Re187(n,2n)Re186 | | 90.8 | 0.69 | 9% |

FNS-00 5 Min. Irradiation - Re

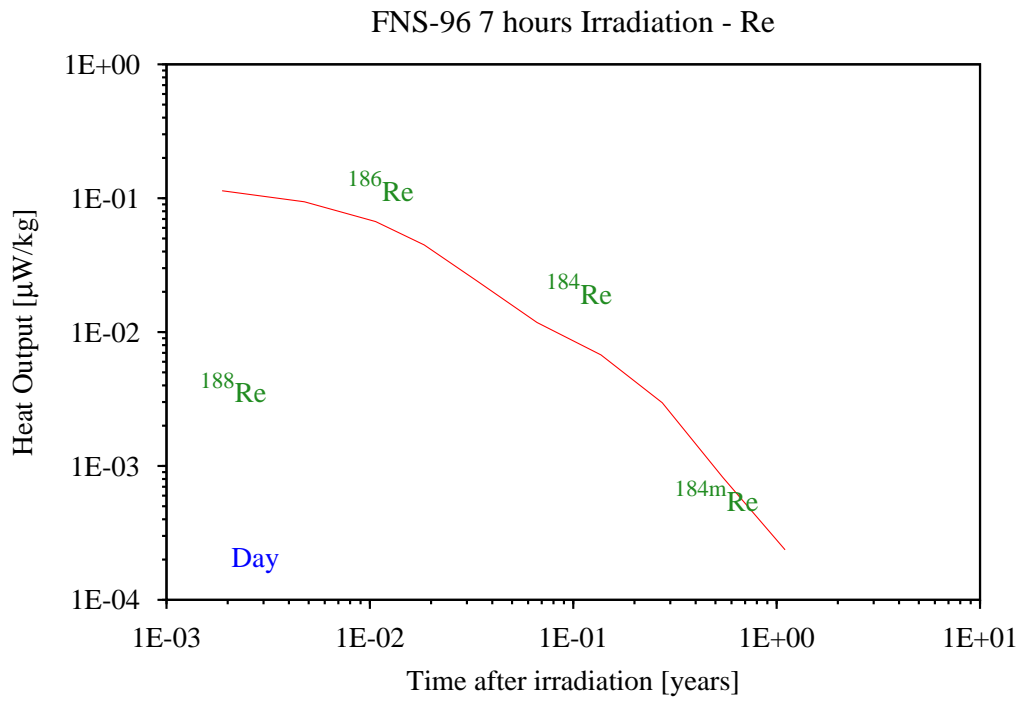




A much better agreement, compared to the 5-minutes analysis, is seen from half a day up to more than a year of cooling. Note in this case the unusual case of metastable isomer having a half-life greater than the ground (Re184m vs. Re184).

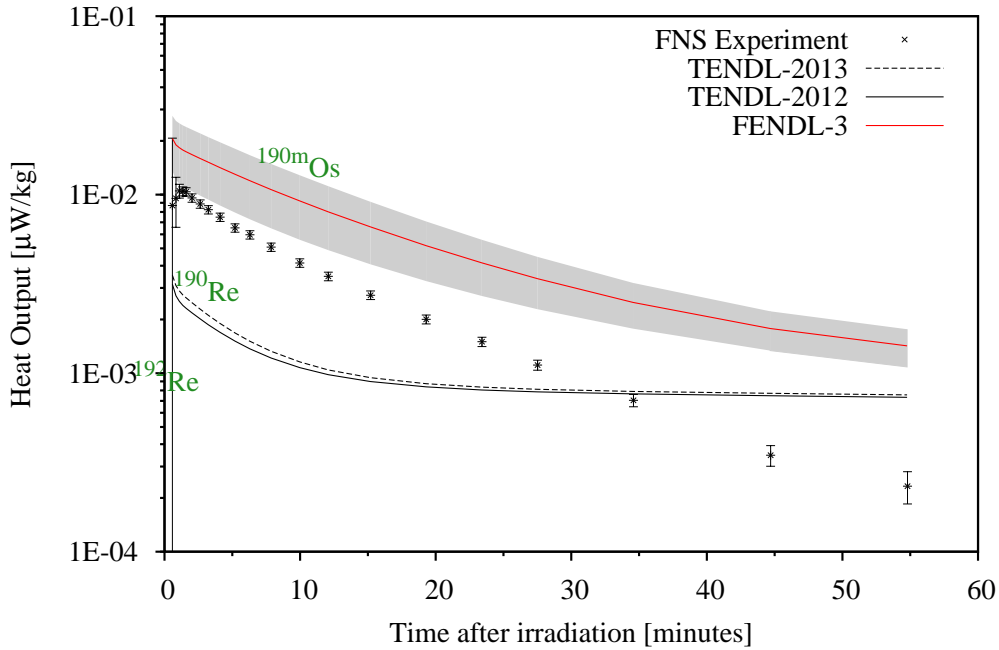
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|-----------------|------|------------|------|------------|------|
| 0.69 | 1.14E-01 +/-11% | 1.14E-01 +/-16% | 1.00 | 1.20E-01 | 0.95 | 1.19E-01 | 0.96 |
| 1.74 | 9.32E-02 +/-10% | 9.40E-02 +/-16% | 0.99 | 9.66E-02 | 0.96 | 9.63E-02 | 0.97 |
| 3.90 | 6.71E-02 +/-10% | 6.69E-02 +/-15% | 1.00 | 6.75E-02 | 0.99 | 6.75E-02 | 0.99 |
| 6.76 | 4.61E-02 +/-9% | 4.48E-02 +/-14% | 1.03 | 4.51E-02 | 1.02 | 4.50E-02 | 1.02 |
| 12.21 | 2.61E-02 +/-8% | 2.42E-02 +/-10% | 1.08 | 2.43E-02 | 1.07 | 2.42E-02 | 1.08 |
| 24.22 | 1.37E-02 +/-6% | 1.18E-02 +/-9% | 1.16 | 1.16E-02 | 1.18 | 1.17E-02 | 1.16 |
| 49.97 | 7.88E-03 +/-6% | 6.75E-03 +/-9% | 1.17 | 6.75E-03 | 1.17 | 6.76E-03 | 1.17 |
| 100.10 | 3.39E-03 +/-6% | 2.97E-03 +/-9% | 1.14 | 2.97E-03 | 1.14 | 2.97E-03 | 1.14 |
| 197.96 | 1.01E-03 +/-6% | 8.24E-04 +/-8% | 1.23 | 8.59E-04 | 1.18 | 8.31E-04 | 1.22 |
| 402.17 | 2.78E-04 +/-7% | 2.36E-04 +/-7% | 1.18 | 2.45E-04 | 1.13 | 2.40E-04 | 1.16 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Re186 | Re187(n,2n)Re186 | 3.7d | 98.6 | 0.99 | 10% |
| | Re185(n,γ)Re186 | 3.7d | 1.3 | 0.99 | 10% |
| Re184 | Re185(n,2n)Re184 | 37.9d | 99.9 | 1.17 | 5% |
| Re184m | Re185(n,2n)Re184m | 168d | 100.0 | 1.22 | 6% |



Osmium

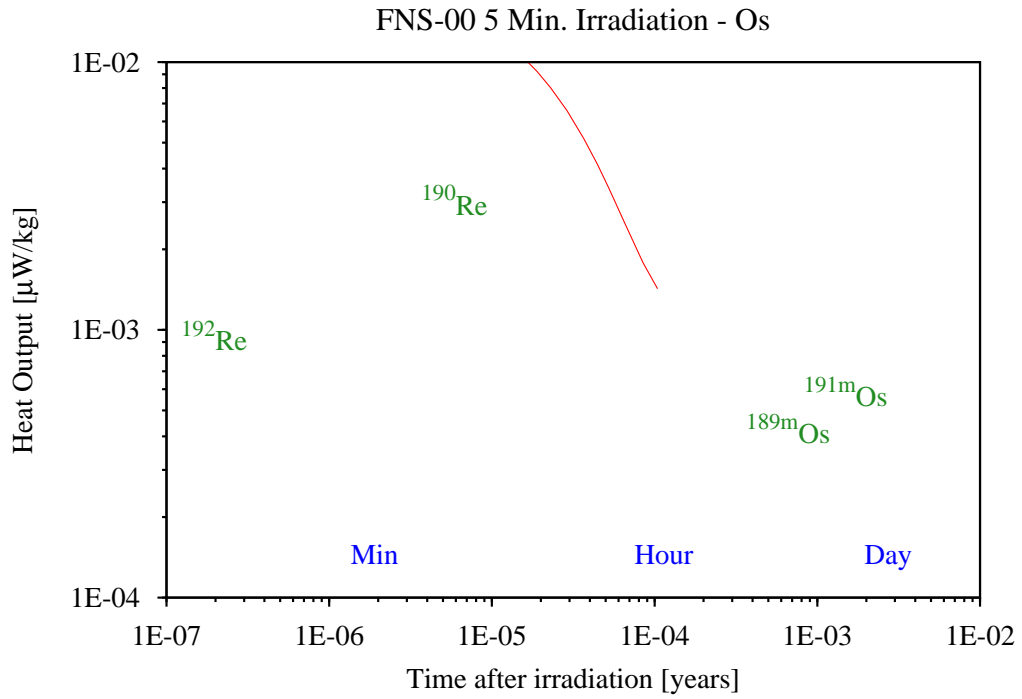
FNS-00 5 Min. Irradiation - Os



For Osmium, here again the correction made on a grossly overestimated (n,n') channel provide a better estimate of the heat output levels (compared with FENDL-3.0), although major disagreement still exists between databases for both the isotopic contributions and their heat-output levels. TENDL's libraries are lacking production pathways for Os190m.

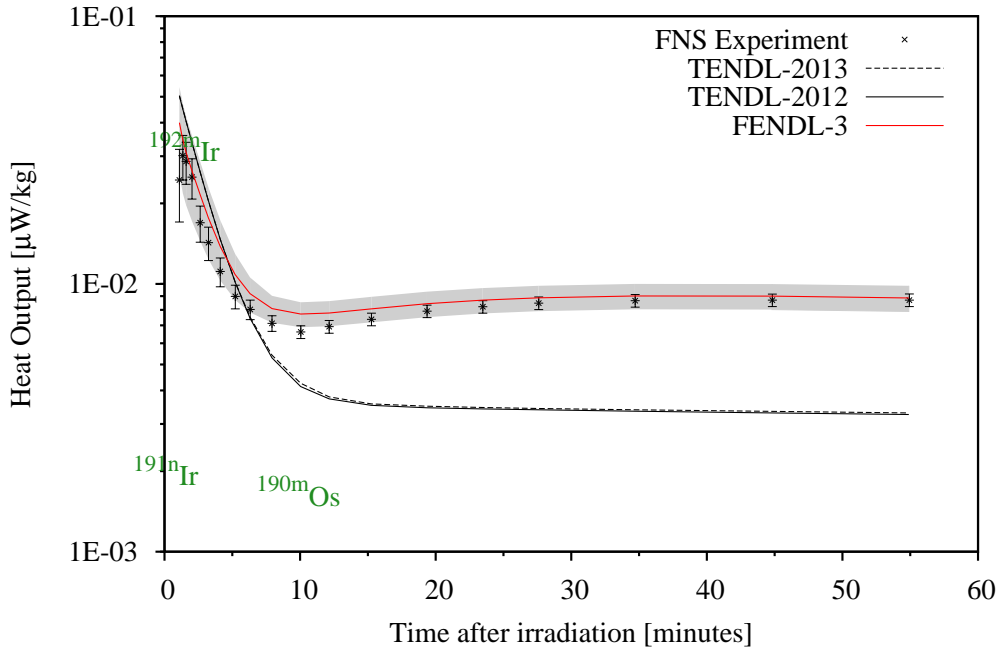
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|----------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.58 | $8.70E-03 \pm 138\%$ | $2.06E-02 \pm 34\%$ | 0.42 | $3.15E-03$ | 2.76 | $3.54E-03$ | 2.46 |
| 0.85 | $9.54E-03 \pm 31\%$ | $1.90E-02 \pm 36\%$ | 0.50 | $2.71E-03$ | 3.52 | $3.09E-03$ | 3.08 |
| 1.10 | $1.05E-02 \pm 9\%$ | $1.83E-02 \pm 37\%$ | 0.57 | $2.52E-03$ | 4.16 | $2.89E-03$ | 3.63 |
| 1.35 | $1.04E-02 \pm 6\%$ | $1.78E-02 \pm 37\%$ | 0.59 | $2.39E-03$ | 4.36 | $2.74E-03$ | 3.81 |
| 1.60 | $1.04E-02 \pm 5\%$ | $1.74E-02 \pm 38\%$ | 0.60 | $2.31E-03$ | 4.49 | $2.64E-03$ | 3.93 |
| 2.03 | $9.59E-03 \pm 5\%$ | $1.68E-02 \pm 38\%$ | 0.57 | $2.18E-03$ | 4.40 | $2.48E-03$ | 3.87 |
| 2.63 | $8.88E-03 \pm 5\%$ | $1.60E-02 \pm 38\%$ | 0.56 | $2.01E-03$ | 4.41 | $2.28E-03$ | 3.89 |
| 3.23 | $8.24E-03 \pm 5\%$ | $1.52E-02 \pm 38\%$ | 0.54 | $1.87E-03$ | 4.41 | $2.11E-03$ | 3.91 |
| 4.10 | $7.48E-03 \pm 5\%$ | $1.42E-02 \pm 39\%$ | 0.53 | $1.69E-03$ | 4.42 | $1.90E-03$ | 3.94 |
| 5.20 | $6.51E-03 \pm 5\%$ | $1.30E-02 \pm 39\%$ | 0.50 | $1.51E-03$ | 4.31 | $1.68E-03$ | 3.87 |
| 6.30 | $5.96E-03 \pm 5\%$ | $1.20E-02 \pm 39\%$ | 0.50 | $1.37E-03$ | 4.36 | $1.51E-03$ | 3.95 |
| 7.87 | $5.08E-03 \pm 5\%$ | $1.07E-02 \pm 39\%$ | 0.48 | $1.22E-03$ | 4.18 | $1.33E-03$ | 3.83 |
| 9.98 | $4.15E-03 \pm 5\%$ | $9.22E-03 \pm 39\%$ | 0.45 | $1.07E-03$ | 3.86 | $1.16E-03$ | 3.59 |
| 12.08 | $3.49E-03 \pm 5\%$ | $8.02E-03 \pm 39\%$ | 0.43 | $9.81E-04$ | 3.55 | $1.04E-03$ | 3.34 |
| 15.20 | $2.74E-03 \pm 6\%$ | $6.60E-03 \pm 38\%$ | 0.41 | $8.98E-04$ | 3.05 | $9.44E-04$ | 2.90 |
| 19.30 | $2.00E-03 \pm 6\%$ | $5.18E-03 \pm 37\%$ | 0.39 | $8.38E-04$ | 2.39 | $8.73E-04$ | 2.29 |
| 23.42 | $1.50E-03 \pm 6\%$ | $4.15E-03 \pm 35\%$ | 0.36 | $8.05E-04$ | 1.86 | $8.35E-04$ | 1.80 |
| 27.52 | $1.11E-03 \pm 7\%$ | $3.38E-03 \pm 32\%$ | 0.33 | $7.86E-04$ | 1.41 | $8.13E-04$ | 1.37 |
| 34.58 | $7.04E-04 \pm 8\%$ | $2.49E-03 \pm 29\%$ | 0.28 | $7.66E-04$ | 0.92 | $7.91E-04$ | 0.89 |
| 44.70 | $3.47E-04 \pm 13\%$ | $1.78E-03 \pm 25\%$ | 0.19 | $7.47E-04$ | 0.46 | $7.71E-04$ | 0.45 |
| 54.80 | $2.33E-04 \pm 21\%$ | $1.42E-03 \pm 24\%$ | 0.16 | $7.32E-04$ | 0.32 | $7.55E-04$ | 0.31 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Re190 | Os190(n,p)Re190 | 3.1m | 100.0 | 3.91 | 5% |
| Os190m | Os190(n,n')Os190m | 9.9m | 0.0 | 0.00 | 5% |
| | Os192(n,3n)Os190m | | 0.0 | 0.00 | 5% |



Iridium

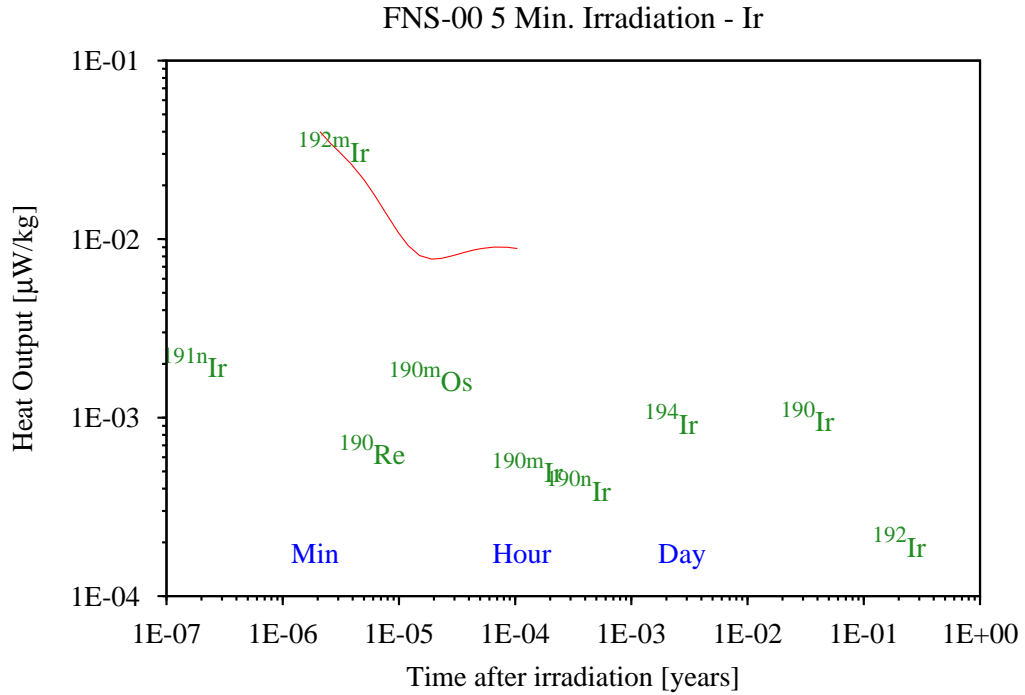
FNS-00 5 Min. Irradiation - Ir



For Iridium, a most interesting experimental decay heat shape can be seen, underpinning an increase in heat due to the presence of an isomeric daughter with a half-life shorter than the parent, coupled with a potent decay heat. TENDL’s libraries are lacking the Os190m and Ir192n production pathways that are present in FENDL-3.0. Note that along the direct (n,d) production route for Os190m there is also a decay path from the long-lived Ir192n.

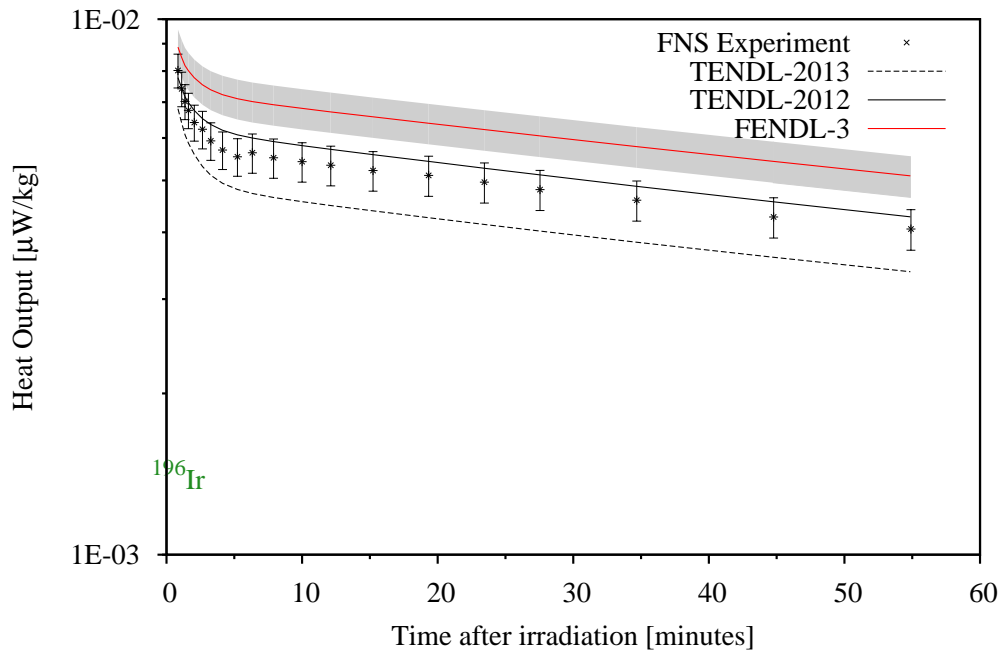
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 1.10 | 2.44E-02 +/-30% | 4.00E-02 +/-36% | 0.61 | 5.03E-02 | 0.49 | 5.05E-02 | 0.48 |
| 1.35 | 3.01E-02 +/-19% | 3.45E-02 +/-37% | 0.87 | 4.49E-02 | 0.67 | 4.51E-02 | 0.67 |
| 1.60 | 2.87E-02 +/-18% | 3.10E-02 +/-36% | 0.93 | 4.04E-02 | 0.71 | 4.05E-02 | 0.71 |
| 2.03 | 2.50E-02 +/-17% | 2.64E-02 +/-35% | 0.95 | 3.37E-02 | 0.74 | 3.36E-02 | 0.74 |
| 2.63 | 1.69E-02 +/-15% | 2.15E-02 +/-33% | 0.79 | 2.62E-02 | 0.65 | 2.61E-02 | 0.65 |
| 3.25 | 1.43E-02 +/-14% | 1.76E-02 +/-30% | 0.81 | 2.04E-02 | 0.70 | 2.04E-02 | 0.70 |
| 4.12 | 1.11E-02 +/-12% | 1.38E-02 +/-25% | 0.81 | 1.47E-02 | 0.76 | 1.47E-02 | 0.76 |
| 5.22 | 8.98E-03 +/-10% | 1.08E-02 +/-20% | 0.83 | 1.02E-02 | 0.88 | 1.02E-02 | 0.88 |
| 6.32 | 8.02E-03 +/-8% | 9.20E-03 +/-15% | 0.87 | 7.44E-03 | 1.08 | 7.52E-03 | 1.07 |
| 7.93 | 7.13E-03 +/-7% | 8.09E-03 +/-11% | 0.88 | 5.30E-03 | 1.35 | 5.42E-03 | 1.31 |
| 10.05 | 6.61E-03 +/-5% | 7.72E-03 +/-11% | 0.86 | 4.14E-03 | 1.60 | 4.26E-03 | 1.55 |
| 12.15 | 6.92E-03 +/-5% | 7.79E-03 +/-11% | 0.89 | 3.72E-03 | 1.86 | 3.79E-03 | 1.83 |
| 15.27 | 7.38E-03 +/-5% | 8.07E-03 +/-11% | 0.91 | 3.52E-03 | 2.10 | 3.57E-03 | 2.07 |
| 19.37 | 7.91E-03 +/-5% | 8.43E-03 +/-11% | 0.94 | 3.45E-03 | 2.29 | 3.49E-03 | 2.26 |
| 23.48 | 8.22E-03 +/-5% | 8.70E-03 +/-11% | 0.94 | 3.41E-03 | 2.41 | 3.45E-03 | 2.38 |
| 27.60 | 8.48E-03 +/-5% | 8.88E-03 +/-11% | 0.96 | 3.39E-03 | 2.50 | 3.43E-03 | 2.47 |
| 34.72 | 8.66E-03 +/-5% | 9.02E-03 +/-11% | 0.96 | 3.35E-03 | 2.59 | 3.39E-03 | 2.55 |
| 44.83 | 8.70E-03 +/-5% | 9.01E-03 +/-11% | 0.97 | 3.30E-03 | 2.64 | 3.34E-03 | 2.60 |
| 54.93 | 8.70E-03 +/-5% | 8.86E-03 +/-11% | 0.98 | 3.25E-03 | 2.68 | 3.30E-03 | 2.64 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|------------------------------------|------------------|--------|------|-----|
| Ir192m | Ir191(n,γ)Ir192m | 1.4m | 51.1 | 0.67 | 19% |
| | Ir193(n,2n)Ir192m | | 47.8 | 0.67 | 19% |
| Os190m | Ir191(n,d)Os190m | 9.9m | 0.0 | 2.50 | 5% |
| Ir192n | Ir191(n,2n)Ir192n(β ⁺) | 241y | 0.0 | 2.70 | 5% |
| Ir194 | Ir193(n,γ)Ir194 | 19.3h | 100.0 | 2.70 | 5% |
| Ir190 | Ir191(n,2n)Ir190 | 12d | 100.0 | 2.70 | 5% |



Platinum

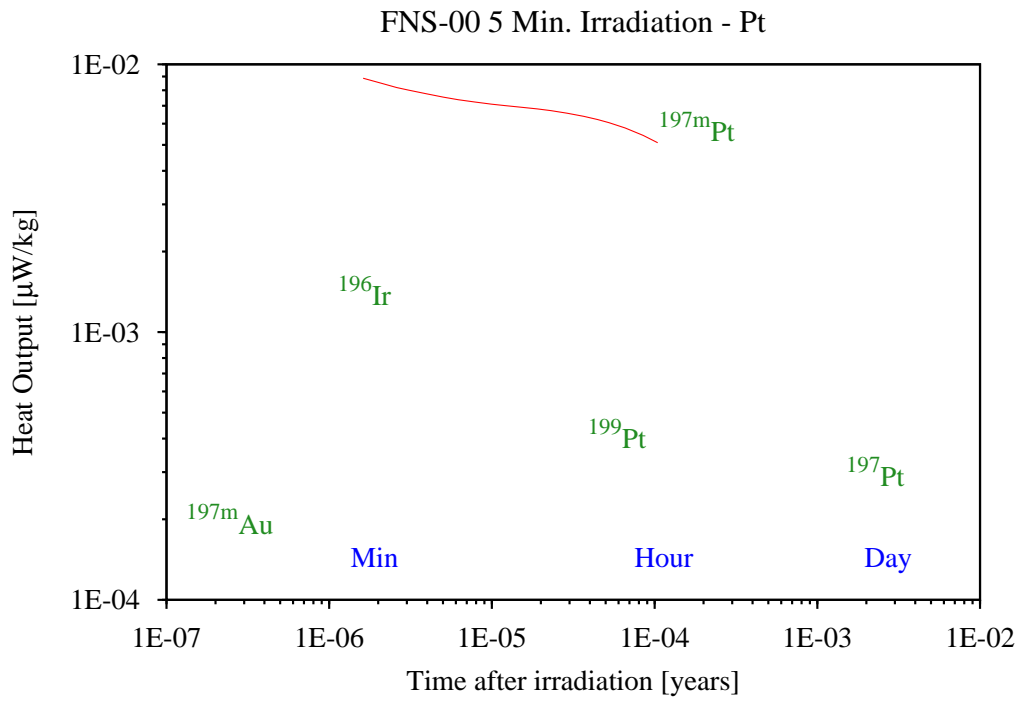
FNS-00 5 Min. Irradiation - Pt



For Platinum, the above graph may indicate an over-prediction, of 20%, in the production of Pt197m when FENDL-3.0 is used, an under-prediction of 15% if it is TENDL-2013 but TENDL-2012 gives much better results.

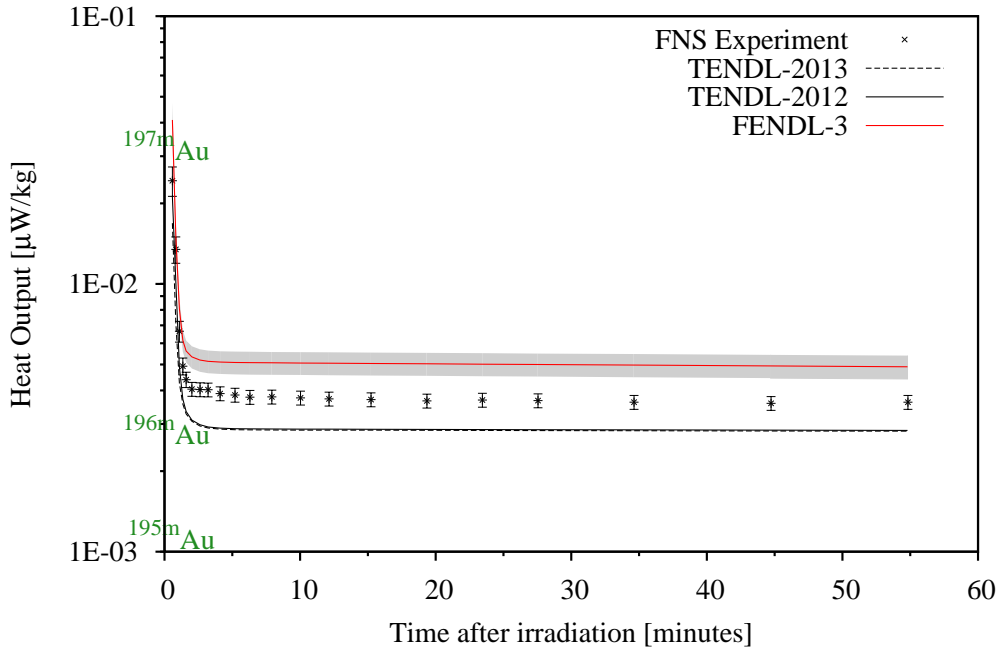
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|----------------|------|------------|------|------------|------|
| 0.85 | 8.02E-03 +/-7% | 8.87E-03 +/-8% | 0.90 | 7.78E-03 | 1.03 | 6.80E-03 | 1.18 |
| 1.12 | 7.41E-03 +/-7% | 8.48E-03 +/-8% | 0.87 | 7.43E-03 | 1.00 | 6.40E-03 | 1.16 |
| 1.37 | 7.02E-03 +/-8% | 8.19E-03 +/-8% | 0.86 | 7.16E-03 | 0.98 | 6.08E-03 | 1.15 |
| 1.62 | 6.76E-03 +/-8% | 8.01E-03 +/-8% | 0.84 | 6.98E-03 | 0.97 | 5.87E-03 | 1.15 |
| 2.05 | 6.41E-03 +/-8% | 7.77E-03 +/-8% | 0.83 | 6.75E-03 | 0.95 | 5.59E-03 | 1.15 |
| 2.65 | 6.23E-03 +/-8% | 7.54E-03 +/-8% | 0.83 | 6.52E-03 | 0.96 | 5.31E-03 | 1.17 |
| 3.27 | 5.93E-03 +/-8% | 7.38E-03 +/-8% | 0.80 | 6.36E-03 | 0.93 | 5.11E-03 | 1.16 |
| 4.13 | 5.70E-03 +/-8% | 7.23E-03 +/-8% | 0.79 | 6.20E-03 | 0.92 | 4.94E-03 | 1.15 |
| 5.23 | 5.53E-03 +/-8% | 7.10E-03 +/-9% | 0.78 | 6.08E-03 | 0.91 | 4.81E-03 | 1.15 |
| 6.33 | 5.63E-03 +/-8% | 7.02E-03 +/-9% | 0.80 | 6.00E-03 | 0.94 | 4.73E-03 | 1.19 |
| 7.90 | 5.51E-03 +/-8% | 6.92E-03 +/-9% | 0.80 | 5.91E-03 | 0.93 | 4.65E-03 | 1.19 |
| 10.00 | 5.42E-03 +/-8% | 6.81E-03 +/-9% | 0.80 | 5.81E-03 | 0.93 | 4.56E-03 | 1.19 |
| 12.12 | 5.34E-03 +/-9% | 6.71E-03 +/-9% | 0.80 | 5.71E-03 | 0.93 | 4.49E-03 | 1.19 |
| 15.23 | 5.22E-03 +/-9% | 6.57E-03 +/-9% | 0.79 | 5.59E-03 | 0.93 | 4.39E-03 | 1.19 |
| 19.33 | 5.11E-03 +/-9% | 6.39E-03 +/-9% | 0.80 | 5.42E-03 | 0.94 | 4.26E-03 | 1.20 |
| 23.45 | 4.96E-03 +/-9% | 6.22E-03 +/-9% | 0.80 | 5.27E-03 | 0.94 | 4.14E-03 | 1.20 |
| 27.55 | 4.81E-03 +/-9% | 6.06E-03 +/-9% | 0.79 | 5.12E-03 | 0.94 | 4.02E-03 | 1.19 |
| 34.68 | 4.59E-03 +/-9% | 5.78E-03 +/-9% | 0.79 | 4.88E-03 | 0.94 | 3.83E-03 | 1.20 |
| 44.78 | 4.27E-03 +/-9% | 5.43E-03 +/-9% | 0.79 | 4.56E-03 | 0.94 | 3.59E-03 | 1.19 |
| 54.90 | 4.06E-03 +/-9% | 5.10E-03 +/-9% | 0.80 | 4.27E-03 | 0.95 | 3.37E-03 | 1.20 |

| Product | Pathways | T _{1/2} | Path % | E/C ΔE% |
|---------|-------------------|------------------|--------|---------|
| Pt197m | Pt198(n,2n)Pt197m | 1.5m | 100.0 | 1.15 8% |



Gold

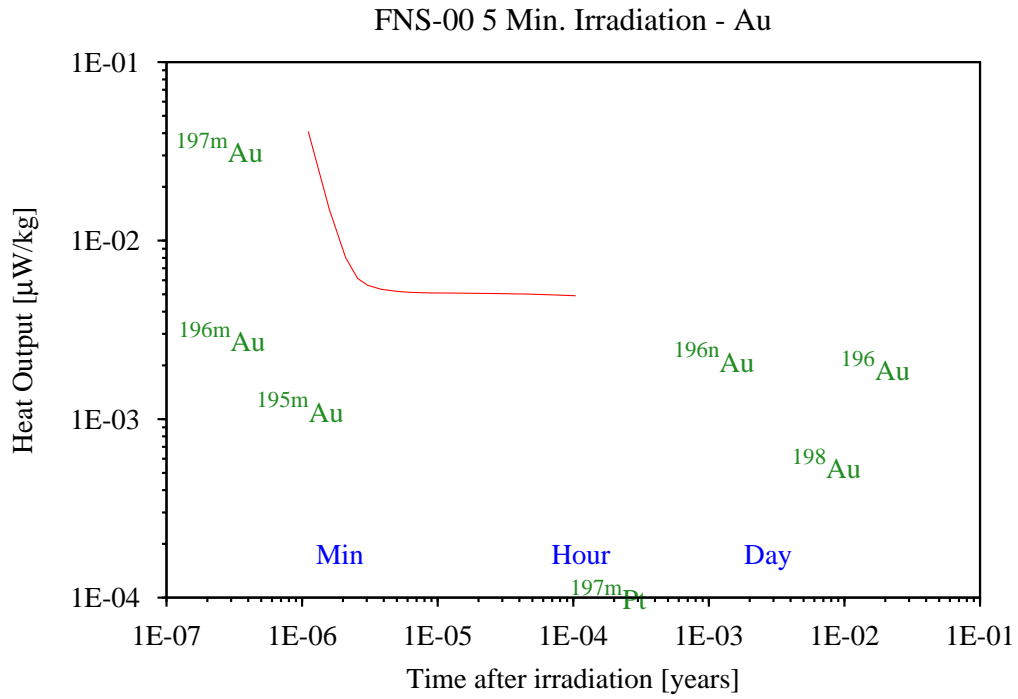
FNS-00 5 Min. Irradiation - Au



Gold: from such a picture above one may deduce that there could be an over-prediction with FENDL-3.0 of the heat generated by the Au196m isomer at a level of about 30%. However, Au196m production paths are lacking in the TENDL libraries.

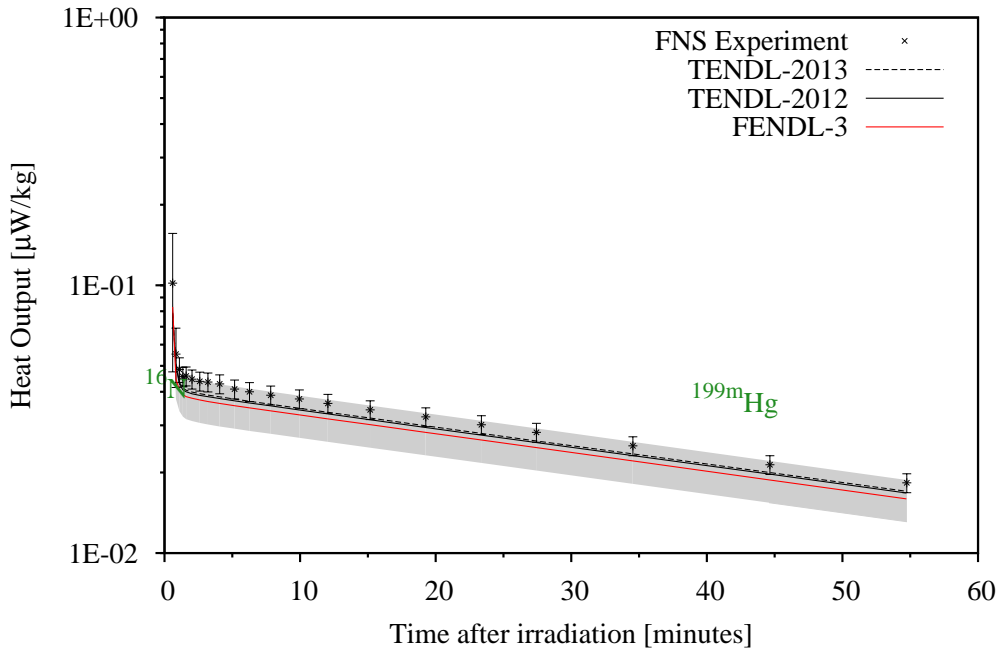
| Times Min. | FNS EXP. 5 mins μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|-------------------------|-----------------|------|------------|------|------------|------|
| 0.58 | 2.43E-02 +/-13% | 4.09E-02 +/-16% | 0.59 | 2.11E-02 | 1.15 | 1.69E-02 | 1.44 |
| 0.83 | 1.35E-02 +/-11% | 1.50E-02 +/-12% | 0.89 | 1.02E-02 | 1.32 | 7.15E-03 | 1.88 |
| 1.10 | 6.66E-03 +/-9% | 8.06E-03 +/-9% | 0.83 | 4.89E-03 | 1.36 | 4.26E-03 | 1.56 |
| 1.35 | 4.93E-03 +/-7% | 6.14E-03 +/-9% | 0.80 | 3.71E-03 | 1.33 | 3.56E-03 | 1.38 |
| 1.60 | 4.39E-03 +/-7% | 5.62E-03 +/-9% | 0.78 | 3.34E-03 | 1.31 | 3.27E-03 | 1.34 |
| 2.02 | 4.05E-03 +/-6% | 5.34E-03 +/-10% | 0.76 | 3.10E-03 | 1.30 | 3.07E-03 | 1.32 |
| 2.62 | 4.03E-03 +/-6% | 5.20E-03 +/-10% | 0.78 | 2.98E-03 | 1.35 | 2.95E-03 | 1.37 |
| 3.22 | 4.02E-03 +/-6% | 5.14E-03 +/-10% | 0.78 | 2.92E-03 | 1.38 | 2.90E-03 | 1.39 |
| 4.10 | 3.89E-03 +/-6% | 5.11E-03 +/-10% | 0.76 | 2.89E-03 | 1.35 | 2.87E-03 | 1.36 |
| 5.20 | 3.85E-03 +/-6% | 5.09E-03 +/-10% | 0.76 | 2.88E-03 | 1.34 | 2.86E-03 | 1.35 |
| 6.30 | 3.78E-03 +/-6% | 5.08E-03 +/-10% | 0.74 | 2.88E-03 | 1.31 | 2.85E-03 | 1.33 |
| 7.92 | 3.79E-03 +/-6% | 5.07E-03 +/-10% | 0.75 | 2.87E-03 | 1.32 | 2.85E-03 | 1.33 |
| 10.03 | 3.75E-03 +/-6% | 5.07E-03 +/-10% | 0.74 | 2.87E-03 | 1.31 | 2.85E-03 | 1.32 |
| 12.13 | 3.72E-03 +/-6% | 5.06E-03 +/-10% | 0.74 | 2.87E-03 | 1.30 | 2.84E-03 | 1.31 |
| 15.23 | 3.70E-03 +/-6% | 5.05E-03 +/-10% | 0.73 | 2.87E-03 | 1.29 | 2.84E-03 | 1.30 |
| 19.35 | 3.66E-03 +/-6% | 5.03E-03 +/-10% | 0.73 | 2.86E-03 | 1.28 | 2.84E-03 | 1.29 |
| 23.45 | 3.68E-03 +/-6% | 5.02E-03 +/-10% | 0.73 | 2.86E-03 | 1.29 | 2.84E-03 | 1.30 |
| 27.55 | 3.67E-03 +/-6% | 5.00E-03 +/-10% | 0.73 | 2.86E-03 | 1.28 | 2.83E-03 | 1.29 |
| 34.63 | 3.62E-03 +/-6% | 4.98E-03 +/-10% | 0.73 | 2.85E-03 | 1.27 | 2.83E-03 | 1.28 |
| 44.73 | 3.58E-03 +/-6% | 4.94E-03 +/-10% | 0.73 | 2.84E-03 | 1.26 | 2.82E-03 | 1.27 |
| 54.83 | 3.62E-03 +/-6% | 4.91E-03 +/-10% | 0.74 | 2.84E-03 | 1.27 | 2.82E-03 | 1.28 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Au197m | Au197(n,n')Au197m | 7.7s | 100.0 | 1.44 | 13% |
| Au196 | Au197(n,2n)Au196m | 8.1s | 5.6 | 1.28 | 6% |
| | Au197(n,2n)Au196 | 6.1d | 94.4 | 1.28 | 6% |



Mercury

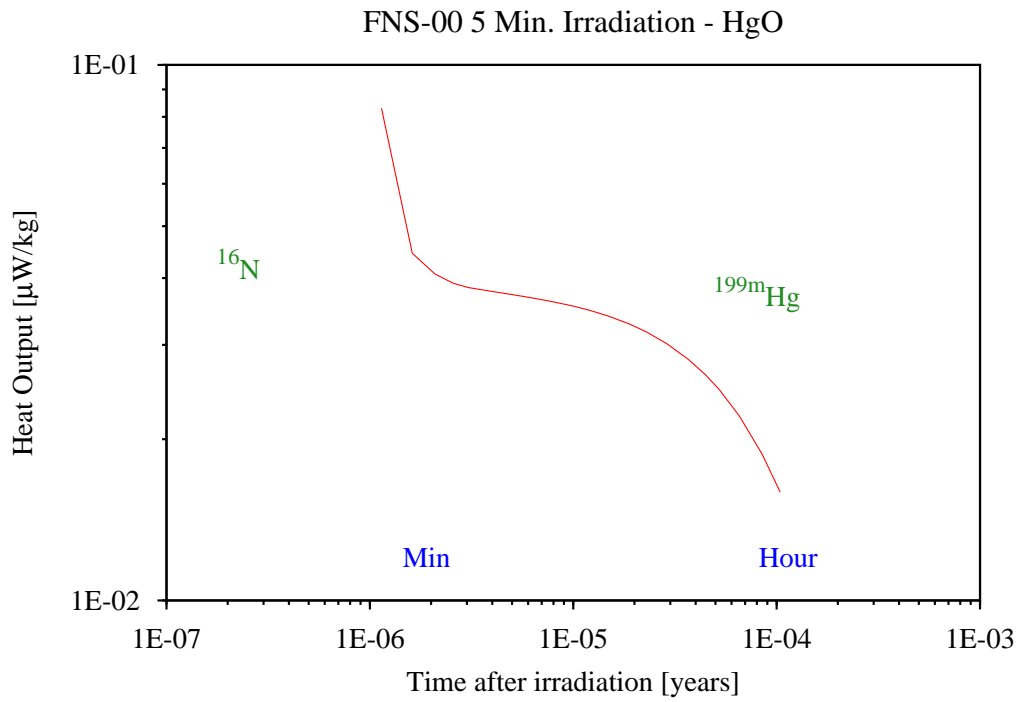
FNS-00 5 Min. Irradiation - HgO



For Mercury, with both (n,2n) and (n,n') routes of production for the unique predominant Hg199m isotope, the choices for small modification are both many-fold and also subtle in their requirements. However, the C/E agreement is excellent. Experimental and calculational uncertainties are also fairly similar.

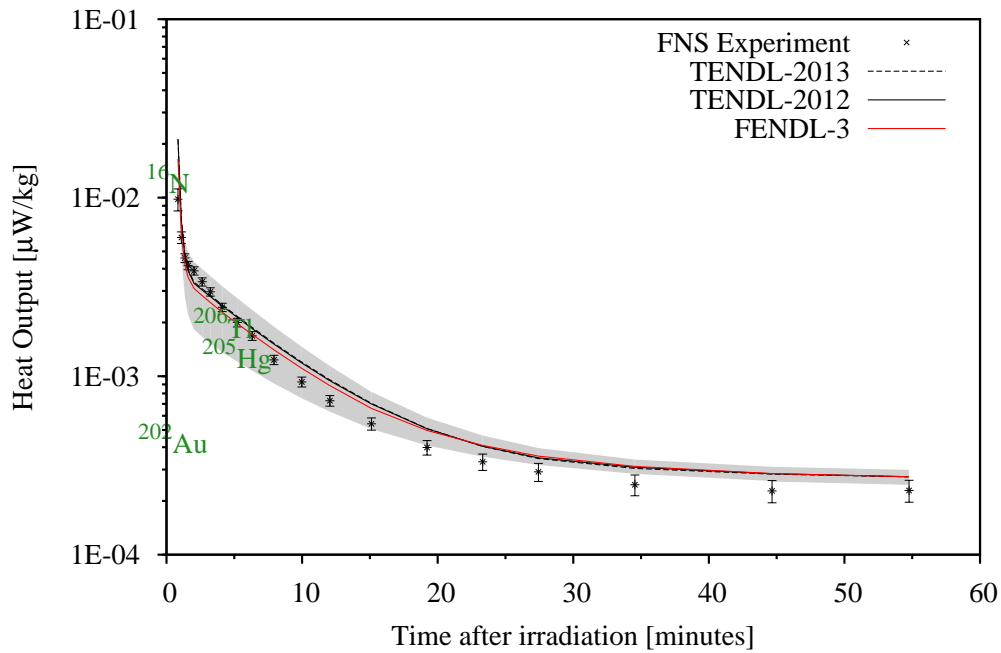
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.60 | 1.02E-01 +/-53% | 8.30E-02 +/-10% | 1.23 | 7.85E-02 | 1.30 | 7.90E-02 | 1.29 |
| 0.85 | 5.54E-02 +/-25% | 4.45E-02 +/-15% | 1.24 | 5.02E-02 | 1.10 | 5.08E-02 | 1.09 |
| 1.10 | 4.85E-02 +/-11% | 4.07E-02 +/-17% | 1.19 | 4.28E-02 | 1.13 | 4.33E-02 | 1.12 |
| 1.35 | 4.56E-02 +/-8% | 3.91E-02 +/-17% | 1.17 | 4.07E-02 | 1.12 | 4.13E-02 | 1.10 |
| 1.60 | 4.58E-02 +/-8% | 3.84E-02 +/-18% | 1.19 | 4.00E-02 | 1.14 | 4.06E-02 | 1.13 |
| 2.03 | 4.46E-02 +/-8% | 3.78E-02 +/-18% | 1.18 | 3.93E-02 | 1.13 | 3.99E-02 | 1.12 |
| 2.60 | 4.38E-02 +/-8% | 3.73E-02 +/-18% | 1.17 | 3.88E-02 | 1.13 | 3.94E-02 | 1.11 |
| 3.20 | 4.35E-02 +/-8% | 3.68E-02 +/-18% | 1.18 | 3.84E-02 | 1.13 | 3.89E-02 | 1.12 |
| 4.07 | 4.28E-02 +/-8% | 3.62E-02 +/-18% | 1.18 | 3.78E-02 | 1.13 | 3.83E-02 | 1.12 |
| 5.17 | 4.10E-02 +/-8% | 3.55E-02 +/-18% | 1.15 | 3.70E-02 | 1.11 | 3.76E-02 | 1.09 |
| 6.27 | 4.00E-02 +/-8% | 3.49E-02 +/-18% | 1.15 | 3.64E-02 | 1.10 | 3.69E-02 | 1.09 |
| 7.83 | 3.89E-02 +/-8% | 3.40E-02 +/-18% | 1.14 | 3.54E-02 | 1.10 | 3.60E-02 | 1.08 |
| 9.95 | 3.76E-02 +/-8% | 3.28E-02 +/-18% | 1.15 | 3.42E-02 | 1.10 | 3.47E-02 | 1.08 |
| 12.05 | 3.62E-02 +/-8% | 3.17E-02 +/-18% | 1.14 | 3.31E-02 | 1.09 | 3.36E-02 | 1.08 |
| 15.17 | 3.43E-02 +/-8% | 3.02E-02 +/-18% | 1.14 | 3.15E-02 | 1.09 | 3.19E-02 | 1.07 |
| 19.27 | 3.23E-02 +/-8% | 2.82E-02 +/-18% | 1.14 | 2.95E-02 | 1.10 | 2.99E-02 | 1.08 |
| 23.37 | 3.01E-02 +/-8% | 2.64E-02 +/-18% | 1.14 | 2.76E-02 | 1.09 | 2.80E-02 | 1.08 |
| 27.43 | 2.82E-02 +/-8% | 2.48E-02 +/-18% | 1.14 | 2.59E-02 | 1.09 | 2.62E-02 | 1.08 |
| 34.55 | 2.51E-02 +/-8% | 2.21E-02 +/-18% | 1.14 | 2.31E-02 | 1.09 | 2.35E-02 | 1.07 |
| 44.65 | 2.14E-02 +/-8% | 1.87E-02 +/-18% | 1.14 | 1.97E-02 | 1.08 | 2.00E-02 | 1.07 |
| 54.75 | 1.83E-02 +/-8% | 1.59E-02 +/-18% | 1.15 | 1.68E-02 | 1.09 | 1.70E-02 | 1.08 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Hg199m | Hg199(n,n')Hg199m | 42.1m | 12.1 | 1.08 | 8% |
| | Hg200(n,2n)Hg199m | | 87.6 | 1.08 | 8% |



Thallium

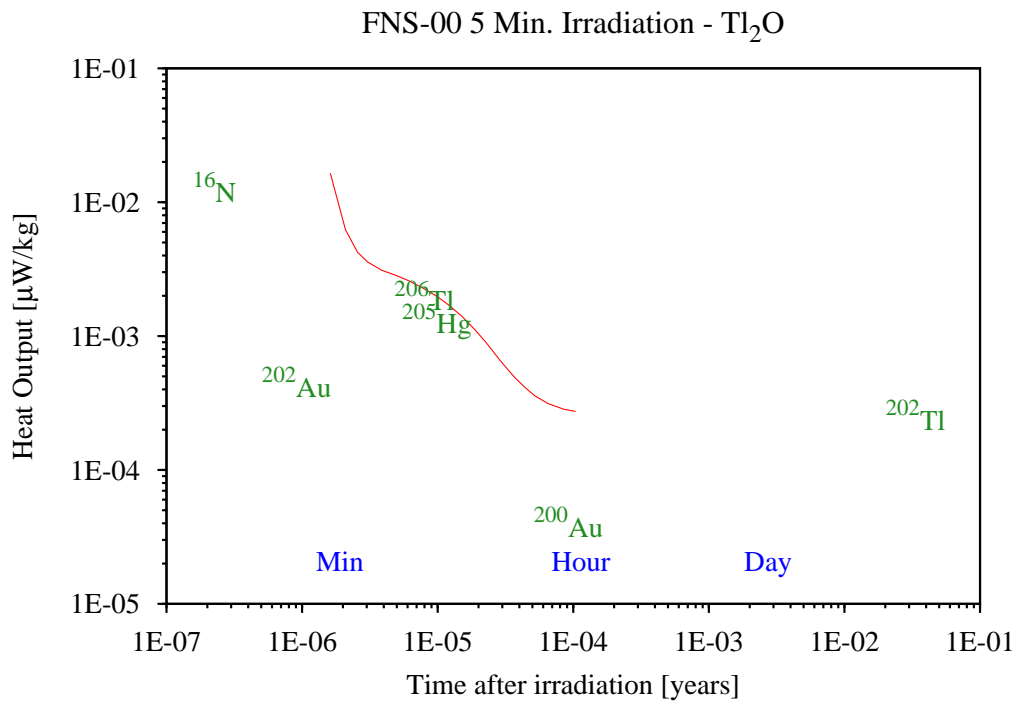
FNS-00 5 Min. Irradiation - Tl₂O



For Thallium, an excellent agreement can be seen when the TENDL-2013,-2012 or FENDL-3.0 databases are used. TENDL-2011 [11] performed poorly.

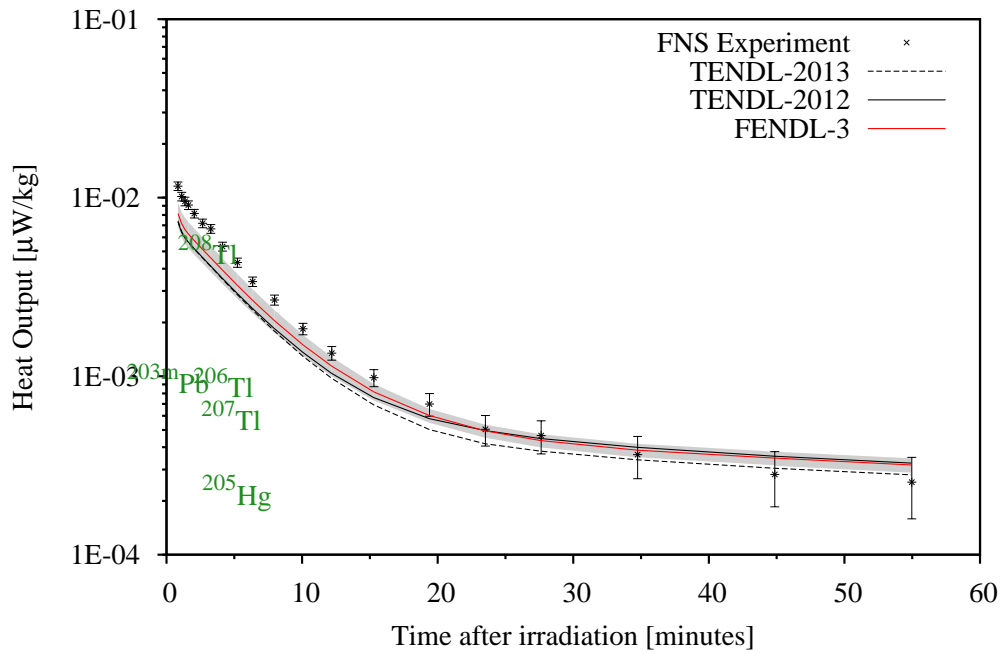
| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|-----------------|-----------------|------|------------|------|------------|------|
| Min. | μW/g | | | | | | |
| 0.85 | 9.81E-03 +/-14% | 1.65E-02 +/-12% | 0.60 | 2.12E-02 | 0.46 | 2.13E-02 | 0.46 |
| 1.10 | 5.99E-03 +/-7% | 6.21E-03 +/-24% | 0.96 | 7.38E-03 | 0.81 | 7.47E-03 | 0.80 |
| 1.35 | 4.59E-03 +/-6% | 4.23E-03 +/-34% | 1.08 | 4.72E-03 | 0.97 | 4.79E-03 | 0.96 |
| 1.60 | 4.17E-03 +/-5% | 3.58E-03 +/-38% | 1.17 | 3.88E-03 | 1.07 | 3.95E-03 | 1.06 |
| 2.03 | 3.89E-03 +/-5% | 3.10E-03 +/-41% | 1.25 | 3.31E-03 | 1.18 | 3.37E-03 | 1.16 |
| 2.63 | 3.38E-03 +/-5% | 2.82E-03 +/-41% | 1.20 | 3.04E-03 | 1.11 | 3.09E-03 | 1.09 |
| 3.23 | 2.97E-03 +/-5% | 2.58E-03 +/-41% | 1.15 | 2.79E-03 | 1.06 | 2.84E-03 | 1.05 |
| 4.12 | 2.43E-03 +/-5% | 2.28E-03 +/-40% | 1.07 | 2.47E-03 | 0.98 | 2.51E-03 | 0.97 |
| 5.22 | 2.00E-03 +/-6% | 1.97E-03 +/-39% | 1.01 | 2.14E-03 | 0.94 | 2.17E-03 | 0.92 |
| 6.32 | 1.68E-03 +/-6% | 1.71E-03 +/-37% | 0.98 | 1.85E-03 | 0.91 | 1.88E-03 | 0.90 |
| 7.93 | 1.23E-03 +/-6% | 1.40E-03 +/-35% | 0.88 | 1.51E-03 | 0.82 | 1.53E-03 | 0.81 |
| 9.98 | 9.29E-04 +/-6% | 1.11E-03 +/-32% | 0.84 | 1.18E-03 | 0.78 | 1.20E-03 | 0.78 |
| 12.05 | 7.29E-04 +/-7% | 8.87E-04 +/-29% | 0.82 | 9.44E-04 | 0.77 | 9.54E-04 | 0.76 |
| 15.12 | 5.41E-04 +/-8% | 6.61E-04 +/-23% | 0.82 | 7.00E-04 | 0.77 | 7.05E-04 | 0.77 |
| 19.22 | 3.99E-04 +/-9% | 4.97E-04 +/-18% | 0.80 | 5.08E-04 | 0.79 | 5.09E-04 | 0.78 |
| 23.32 | 3.31E-04 +/-11% | 4.10E-04 +/-14% | 0.81 | 4.05E-04 | 0.82 | 4.04E-04 | 0.82 |
| 27.43 | 2.91E-04 +/-12% | 3.57E-04 +/-11% | 0.81 | 3.49E-04 | 0.83 | 3.46E-04 | 0.84 |
| 34.55 | 2.47E-04 +/-13% | 3.13E-04 +/-9% | 0.79 | 3.09E-04 | 0.80 | 3.04E-04 | 0.81 |
| 44.67 | 2.28E-04 +/-14% | 2.85E-04 +/-9% | 0.80 | 2.84E-04 | 0.80 | 2.83E-04 | 0.81 |
| 54.77 | 2.29E-04 +/-14% | 2.74E-04 +/-9% | 0.84 | 2.74E-04 | 0.84 | 2.73E-04 | 0.84 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|------------------|------------------|--------|------|-----|
| Tl206 | Tl205(n,γ)Tl206 | 4.2m | 99.5 | 0.98 | 5% |
| Hg205 | Tl205(n,p)Hg205 | 5.2m | 99.7 | 0.94 | 6% |
| Tl202 | Tl203(n,2n)Tl202 | 12.2d | 100.0 | 0.84 | 14% |

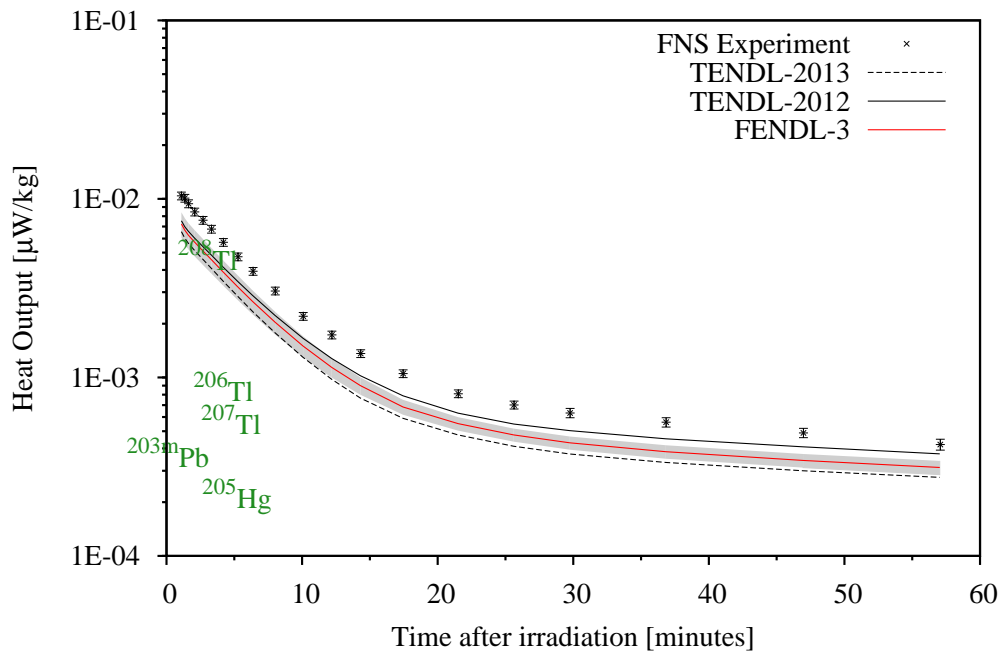


Lead

FNS-00 5 Min. Irradiation - Pb



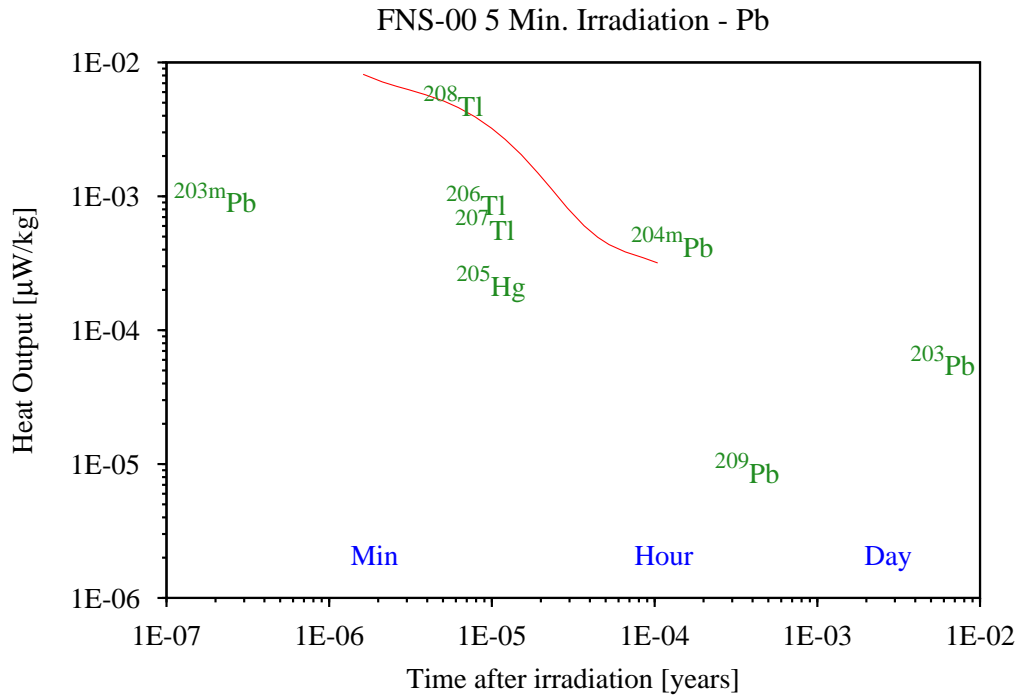
FNS-96 5 Min. Irradiation - Pb

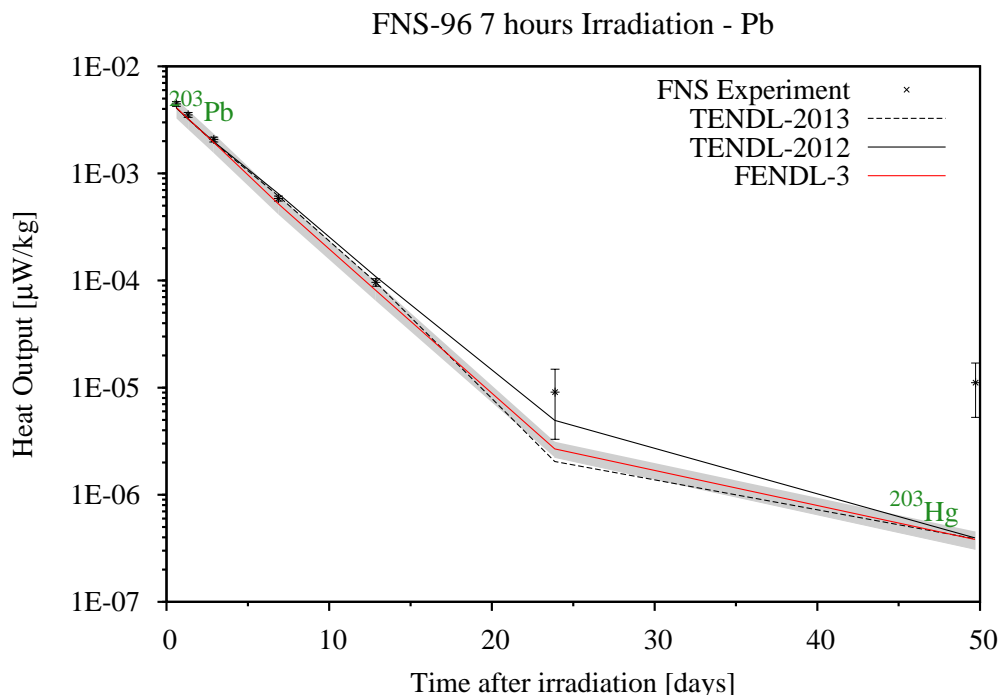


For lead, the experimental data sets are somewhat different, although the more recent one seems better predicted by the calculations, particularly at longer cooling times. However, in both batches the short term heat predictions seem to be low compared with the measured ones.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|---------------------|---------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.85 | $1.16E-02 \pm 6\%$ | $8.14E-03 \pm 15\%$ | 1.43 | $7.31E-03$ | 1.59 | $7.41E-03$ | 1.57 |
| 1.12 | $1.01E-02 \pm 6\%$ | $7.14E-03 \pm 16\%$ | 1.42 | $6.36E-03$ | 1.60 | $6.46E-03$ | 1.57 |
| 1.37 | $9.53E-03 \pm 6\%$ | $6.62E-03 \pm 17\%$ | 1.44 | $5.94E-03$ | 1.60 | $5.97E-03$ | 1.60 |
| 1.62 | $9.09E-03 \pm 6\%$ | $6.25E-03 \pm 17\%$ | 1.45 | $5.63E-03$ | 1.61 | $5.61E-03$ | 1.62 |
| 2.05 | $8.14E-03 \pm 6\%$ | $5.75E-03 \pm 17\%$ | 1.42 | $5.18E-03$ | 1.57 | $5.15E-03$ | 1.58 |
| 2.67 | $7.19E-03 \pm 6\%$ | $5.13E-03 \pm 17\%$ | 1.40 | $4.62E-03$ | 1.55 | $4.59E-03$ | 1.57 |
| 3.27 | $6.69E-03 \pm 6\%$ | $4.60E-03 \pm 16\%$ | 1.46 | $4.14E-03$ | 1.62 | $4.11E-03$ | 1.63 |
| 4.13 | $5.32E-03 \pm 6\%$ | $3.92E-03 \pm 16\%$ | 1.36 | $3.53E-03$ | 1.51 | $3.49E-03$ | 1.52 |
| 5.23 | $4.33E-03 \pm 6\%$ | $3.23E-03 \pm 16\%$ | 1.34 | $2.90E-03$ | 1.49 | $2.86E-03$ | 1.52 |
| 6.35 | $3.39E-03 \pm 6\%$ | $2.66E-03 \pm 15\%$ | 1.27 | $2.39E-03$ | 1.41 | $2.35E-03$ | 1.44 |
| 7.97 | $2.67E-03 \pm 6\%$ | $2.05E-03 \pm 15\%$ | 1.31 | $1.85E-03$ | 1.45 | $1.79E-03$ | 1.50 |
| 10.07 | $1.84E-03 \pm 7\%$ | $1.50E-03 \pm 14\%$ | 1.23 | $1.36E-03$ | 1.36 | $1.29E-03$ | 1.43 |
| 12.18 | $1.35E-03 \pm 9\%$ | $1.14E-03 \pm 12\%$ | 1.18 | $1.04E-03$ | 1.30 | $9.73E-04$ | 1.38 |
| 15.30 | $9.80E-04 \pm 11\%$ | $8.17E-04 \pm 11\%$ | 1.20 | $7.58E-04$ | 1.29 | $6.90E-04$ | 1.42 |
| 19.40 | $6.98E-04 \pm 15\%$ | $6.02E-04 \pm 9\%$ | 1.16 | $5.78E-04$ | 1.21 | $5.03E-04$ | 1.39 |
| 23.52 | $5.04E-04 \pm 19\%$ | $4.94E-04 \pm 8\%$ | 1.02 | $4.96E-04$ | 1.02 | $4.18E-04$ | 1.21 |
| 27.63 | $4.65E-04 \pm 21\%$ | $4.36E-04 \pm 8\%$ | 1.07 | $4.47E-04$ | 1.04 | $3.80E-04$ | 1.22 |
| 34.75 | $3.63E-04 \pm 27\%$ | $3.85E-04 \pm 9\%$ | 0.94 | $3.99E-04$ | 0.91 | $3.40E-04$ | 1.07 |
| 44.87 | $2.82E-04 \pm 34\%$ | $3.48E-04 \pm 9\%$ | 0.81 | $3.56E-04$ | 0.79 | $3.05E-04$ | 0.92 |
| 54.97 | $2.55E-04 \pm 38\%$ | $3.18E-04 \pm 9\%$ | 0.80 | $3.26E-04$ | 0.78 | $2.80E-04$ | 0.91 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|-------------------|-----------|--------|------|--------------|
| Pb203m | Pb204(n,2n)Pb203m | 6.2s | 100.0 | 1.57 | 6% |
| Tl208 | Pb208(n,p)Tl208 | 3.0m | 100.0 | 1.63 | 6% |
| Pb204m | Pb204(n,n')Pb204m | 1.1h | 100.0 | 0.91 | 38% |

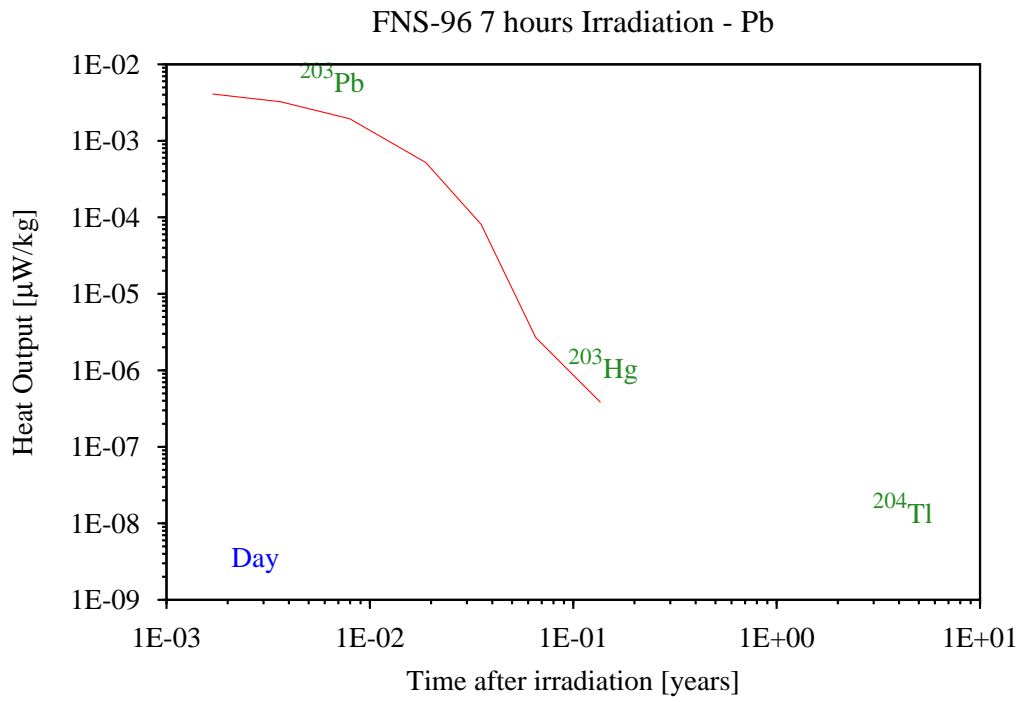




A good agreement is seen in the above graph, although large discrepancies and uncertainties occur in both the measurements and TENDL's results beyond 20 days of cooling.

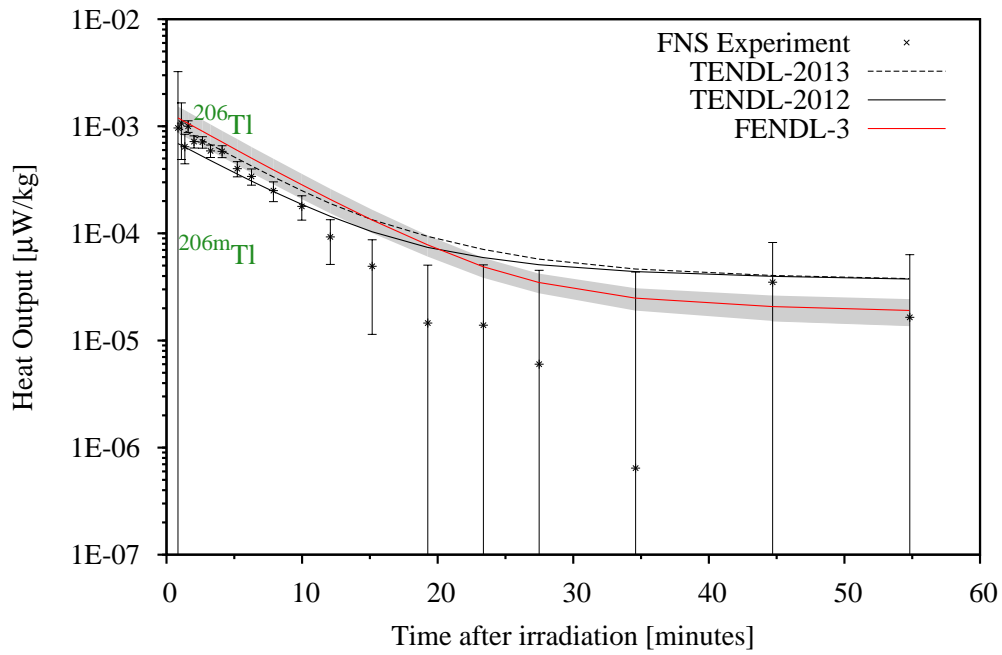
| Times Days | FNS EXP. 7 hrs μW/g | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|---------------|------------------------|-----------------|-------|------------|-------|------------|-------|
| 0.61 | 4.46E-03 +/-5% | 4.09E-03 +/-20% | 1.09 | 4.07E-03 | 1.10 | 4.07E-03 | 1.09 |
| 1.33 | 3.52E-03 +/-5% | 3.24E-03 +/-20% | 1.09 | 3.22E-03 | 1.09 | 3.22E-03 | 1.09 |
| 2.91 | 2.08E-03 +/-5% | 1.94E-03 +/-20% | 1.07 | 1.98E-03 | 1.05 | 1.95E-03 | 1.07 |
| 6.88 | 5.83E-04 +/-5% | 5.20E-04 +/-20% | 1.12 | 6.49E-04 | 0.90 | 6.17E-04 | 0.95 |
| 12.87 | 9.62E-05 +/-8% | 8.09E-05 +/-20% | 1.19 | 1.09E-04 | 0.88 | 9.64E-05 | 1.00 |
| 23.88 | 9.09E-06 +/-64% | 2.68E-06 +/-17% | 3.39 | 4.95E-06 | 1.83 | 2.04E-06 | 4.45 |
| 49.73 | 1.11E-05 +/-53% | 3.82E-07 +/-19% | 29.12 | 3.95E-07 | 28.19 | 3.89E-07 | 28.64 |

| Product | Pathways | T _{1/2} | Path % | E/C | ΔE% |
|---------|-------------------|------------------|--------|------|-----|
| Pb203 | Pb204(n,2n)Pb203 | 2.1d | 49.4 | 1.07 | 5% |
| | Pb204(n,2n)Pb203m | | 50.6 | 1.07 | 5% |
| Hg203 | Pb206(n,α)Hg203 | 46.6d | 97.3 | 4.45 | 64% |
| Hg203 | Pb207(n,nα)Hg203 | 46.6d | 2.7 | 4.45 | 64% |

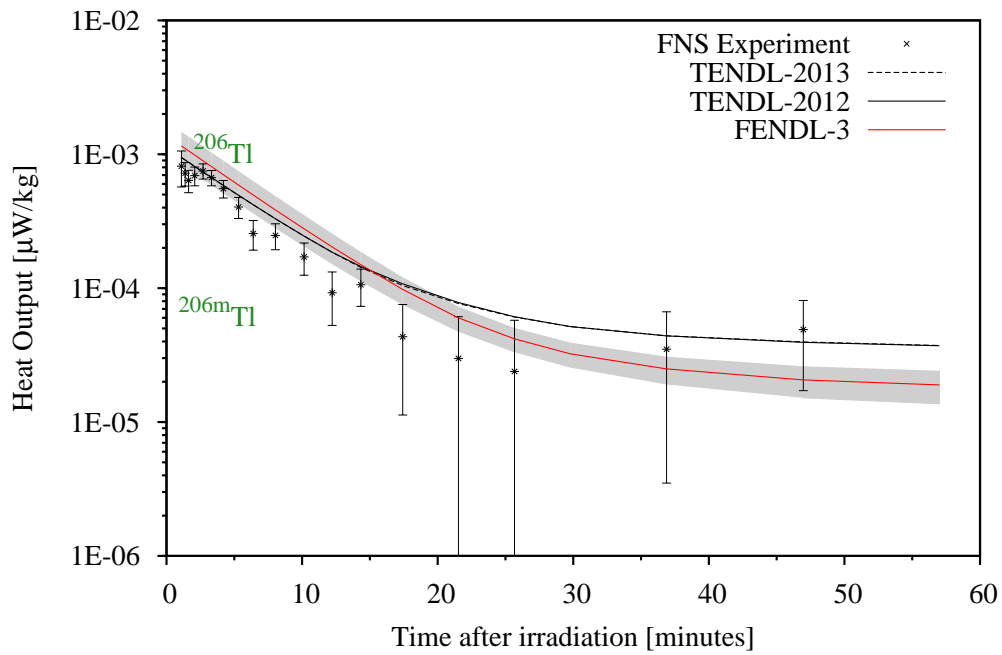


Bismuth

FNS-00 5 Min. Irradiation - Bi



FNS-96 5 Min. Irradiation - Bi

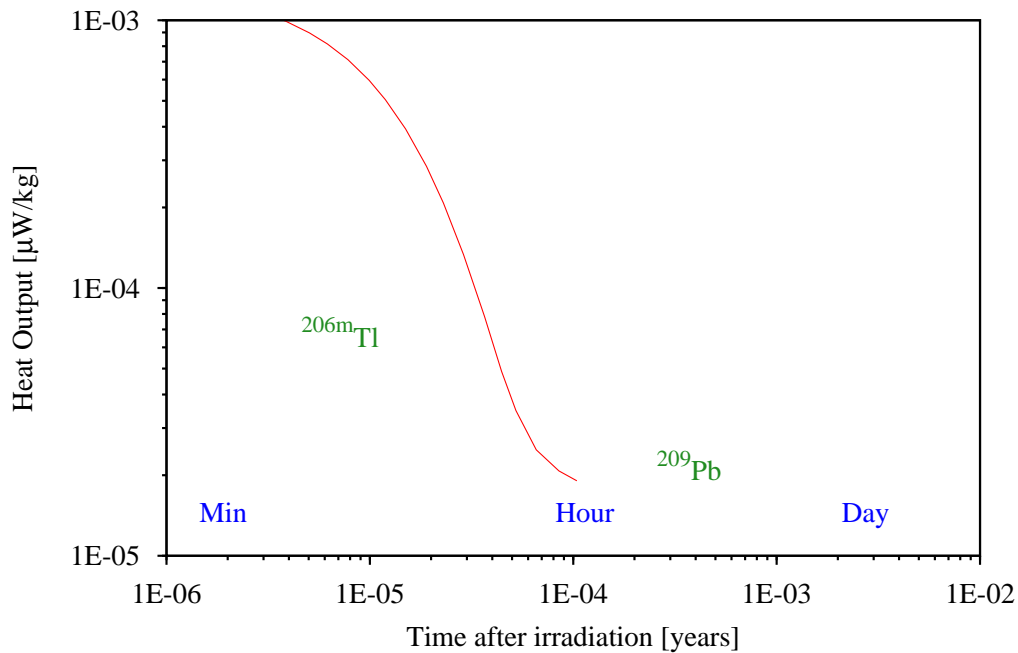


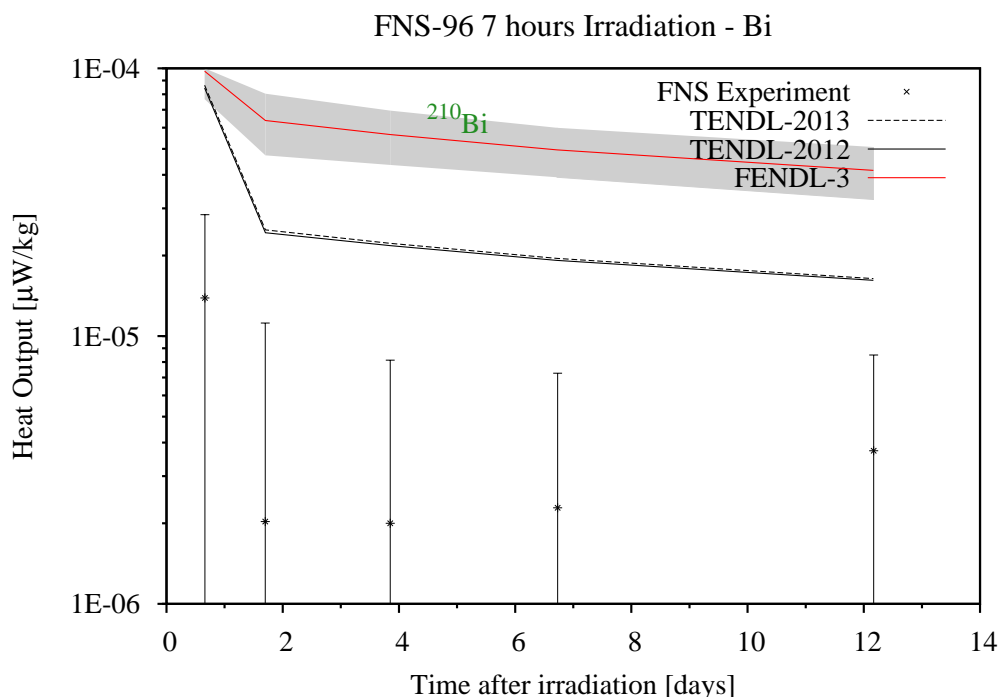
For Bismuth, some large differences and uncertainties can be seen between the two experimental data-sets. This is also the case in the predictions derived from the different databases.

| Times | FNS EXP. 5 mins | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|---------------------|-------------------|------|------------|------|------------|------|
| Min. | $\mu\text{W/g}$ | | | | | | |
| 0.85 | $9.65E-04$ +/-235% | $1.20E-03$ +/-28% | 0.81 | $6.89E-04$ | 1.40 | $9.81E-04$ | 0.98 |
| 1.10 | $1.07E-03$ +/-54% | $1.15E-03$ +/-28% | 0.93 | $6.63E-04$ | 1.61 | $9.43E-04$ | 1.14 |
| 1.35 | $6.44E-04$ +/-31% | $1.11E-03$ +/-28% | 0.58 | $6.39E-04$ | 1.01 | $9.07E-04$ | 0.71 |
| 1.60 | $1.00E-03$ +/-12% | $1.06E-03$ +/-28% | 0.94 | $6.15E-04$ | 1.63 | $8.72E-04$ | 1.15 |
| 2.03 | $7.20E-04$ +/-13% | $9.91E-04$ +/-28% | 0.73 | $5.76E-04$ | 1.25 | $8.15E-04$ | 0.88 |
| 2.65 | $7.12E-04$ +/-12% | $8.98E-04$ +/-28% | 0.79 | $5.24E-04$ | 1.36 | $7.41E-04$ | 0.96 |
| 3.25 | $5.89E-04$ +/-13% | $8.16E-04$ +/-28% | 0.72 | $4.79E-04$ | 1.23 | $6.75E-04$ | 0.87 |
| 4.10 | $5.83E-04$ +/-13% | $7.12E-04$ +/-27% | 0.82 | $4.22E-04$ | 1.38 | $5.92E-04$ | 0.99 |
| 5.22 | $4.02E-04$ +/-16% | $5.96E-04$ +/-27% | 0.67 | $3.58E-04$ | 1.12 | $5.00E-04$ | 0.81 |
| 6.27 | $3.41E-04$ +/-17% | $5.05E-04$ +/-27% | 0.67 | $3.08E-04$ | 1.11 | $4.27E-04$ | 0.80 |
| 7.88 | $2.51E-04$ +/-21% | $3.93E-04$ +/-27% | 0.64 | $2.46E-04$ | 1.02 | $3.37E-04$ | 0.74 |
| 9.98 | $1.79E-04$ +/-26% | $2.85E-04$ +/-26% | 0.63 | $1.87E-04$ | 0.96 | $2.51E-04$ | 0.71 |
| 12.08 | $9.27E-05$ +/-45% | $2.08E-04$ +/-26% | 0.45 | $1.44E-04$ | 0.64 | $1.90E-04$ | 0.49 |
| 15.17 | $4.92E-05$ +/-77% | $1.34E-04$ +/-25% | 0.37 | $1.04E-04$ | 0.48 | $1.34E-04$ | 0.37 |
| 19.27 | $1.46E-05$ +/-247% | $7.82E-05$ +/-22% | 0.19 | $7.41E-05$ | 0.20 | $9.39E-05$ | 0.16 |
| 23.37 | $1.39E-05$ +/-266% | $4.88E-05$ +/-21% | 0.28 | $5.95E-05$ | 0.23 | $7.08E-05$ | 0.20 |
| 27.48 | $6.00E-06$ +/-653% | $3.48E-05$ +/-21% | 0.17 | $5.10E-05$ | 0.12 | $5.75E-05$ | 0.10 |
| 34.60 | $6.43E-07$ +/-6683% | $2.49E-05$ +/-24% | 0.03 | $4.40E-05$ | 0.01 | $4.65E-05$ | 0.01 |
| 44.70 | $3.50E-05$ +/-134% | $2.08E-05$ +/-27% | 1.69 | $3.97E-05$ | 0.88 | $4.05E-05$ | 0.86 |
| 54.82 | $1.64E-05$ +/-285% | $1.91E-05$ +/-28% | 0.86 | $3.75E-05$ | 0.44 | $3.78E-05$ | 0.43 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|--------------------------|-----------|--------|------|--------------|
| Tl206 | Bi209(n, α)Tl206 | 4.2m | 100.0 | 0.81 | 16% |
| Pb209 | Bi209(n,p)Pb209 | 3.2h | 100.0 | 0.43 | 285% |

FNS-00 5 Min. Irradiation - Bi

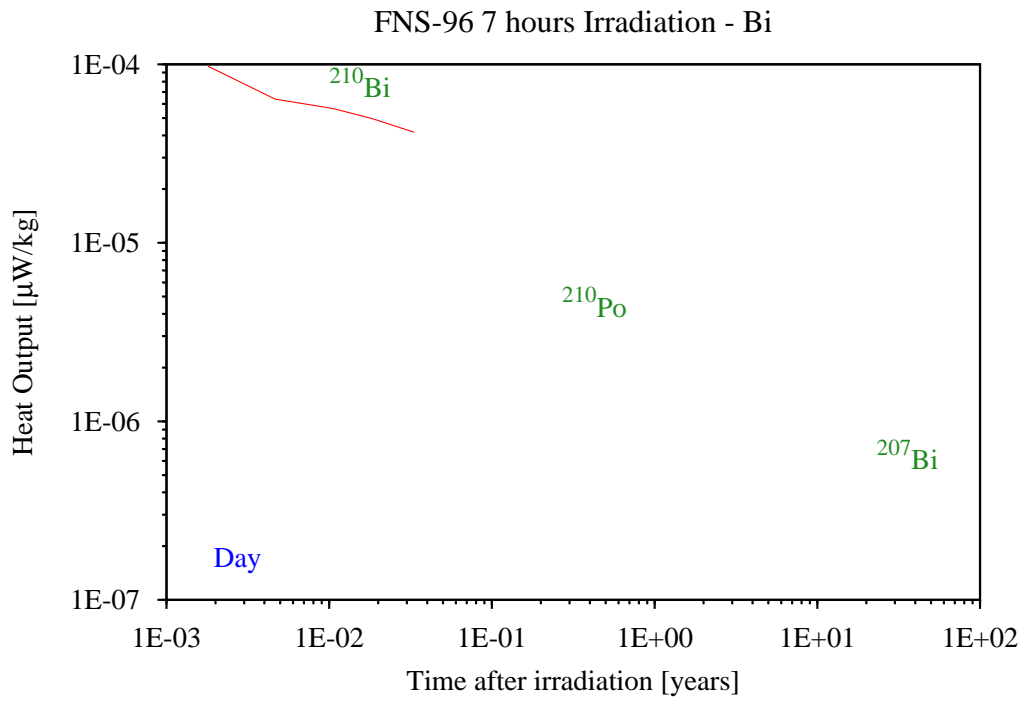




A poor C/E agreement on this important element, but the response profile seems to be reasonable shaped.

| Times | FNS EXP. 7 hrs | FENDL-3 | E/C | TENDL-2012 | E/C | TENDL-2013 | E/C |
|-------|--------------------|-------------------|------|------------|------|------------|------|
| Days | $\mu\text{W/g}$ | | | | | | |
| 0.66 | $1.39E-05$ +/-105% | $9.76E-05$ +/-21% | 0.14 | $8.45E-05$ | 0.16 | $8.65E-05$ | 0.16 |
| 1.70 | $2.03E-06$ +/-451% | $6.39E-05$ +/-26% | 0.03 | $2.43E-05$ | 0.08 | $2.49E-05$ | 0.08 |
| 3.85 | $2.00E-06$ +/-307% | $5.66E-05$ +/-23% | 0.04 | $2.18E-05$ | 0.09 | $2.22E-05$ | 0.09 |
| 6.73 | $2.28E-06$ +/-218% | $4.96E-05$ +/-21% | 0.05 | $1.92E-05$ | 0.12 | $1.95E-05$ | 0.12 |
| 12.17 | $3.73E-06$ +/-128% | $4.16E-05$ +/-22% | 0.09 | $1.61E-05$ | 0.23 | $1.64E-05$ | 0.23 |

| Product | Pathways | $T_{1/2}$ | Path % | E/C | $\Delta E\%$ |
|---------|--------------------------|-----------|--------|------|--------------|
| Tl206 | Bi209(n, α)Tl206 | 4.2m | 100.0 | 0.16 | 105% |
| Pb209 | Bi209(n,p)Pb209 | 3.2h | 100.0 | 0.08 | 105% |
| Bi210 | Bi209(n, γ)Bi210 | 5.0d | 100.0 | 0.12 | 218% |



5 Analysis of the results

From such a validation exercise a lot of information can be extracted from the results. However, its uniqueness and specificities require caution to be applied when drawing or projecting conclusions from the results.

5.1 General comments

The time dependence of the comparison has been clearly established and it was not surprising to see some fluctuations in the degree of agreement with cooling time. This is due to the fact that the set of predominant radionuclides evolves with time in direct relation with their appropriate half-lives. A clear picture emerges in that the comparative results for short cooling times, less than one hour, tend to be worse than the results for cooling times greater than a day but shorter than a year. This was expected, since the nuclear database (production cross sections and decay data) tends to be less qualified for these short-lived nuclides. This is due to difficulties encountered when assessing short half-life isotopes and isomers. Having said that, the agreement reached on the prediction of some short lived isomers is rather good. A specificity that is unique to properly assembled nuclear data file that contains all necessary branching ratios. All major transport libraries are missing details of such information. The overall results are surprisingly good on exotic material samples, even more so when allowing for certain experimental difficulties.

What has been clearly demonstrated by this validation exercise is that the calculational method used by the FISPACT-II to predict the decay power and associated uncertainty of structural materials under a hard fusion neutron field is adequate. When the nuclear data are known with sufficient accuracy the code predictions are within the boundaries defined by the experimental uncertainty. However, the nuclear databases, TENDL-2013, -2012 and FENDL-3.0 tend to give different results because of variation in the data they contain for the cross sections and decay of the radionuclides involved. The majority of the results are satisfactory and give credit to the work performed in assembling such large libraries. However, the level of accuracy of the cross sections and decay data tested by this validation exercise span from a few percent, which is acceptable, to orders of magnitude. When the latter case occurs then very specific and time consuming studies need to be performed before any action is taken to correct the nuclear databases. Such remarks are in line with the results of earlier international code comparisons on decay heat, including [4, 5] and some performed on fission fuel materials [12].

All the cross section paths linked with an E/C values greater than 10% have been analysed in line with other validation studies, (FNG Frascati, SNEG-13 Sergiev Posad, D-Be Cyclotron Karlsruhe, etc.) and compared with the experimental database EXFOR [13]. The decay data of the radionuclides produced still needs to be checked in more detail. If the results corroborate one another there will be more incentive

and firm grounds to apply an appropriate correction in the next generation of truly general-purpose nuclear data-files.

5.2 Experimental, calculational uncertainty and E/C

When concerned with uncertainties related to the activation calculations themselves, one has to acknowledge the complexity and magnitude of the nuclear data libraries. The TENDL-2013 general-purpose file [8] contains the neutron-induced reactions on stable and unstable targets including actinides. If a reaction can produce one, two or more isomers, the cross sections for producing the ground and the different isomeric states are all given separately.

The FENDL-3.0 library contains 816 target nuclides ranging from ^1H to ^{257}Fm with 65,565 reactions kinematically allowed below 60 MeV. A complementary and unique uncertainty file EAF_2010_UN, in pseudo ENDF-6/mf-33 format, has been generated for all reactions in a two-energies group structure for the threshold reactions and four-groups for (n, γ), (n,f) or any other non-threshold reactions. The error estimates for this file are adopted either from experimental information or from systematic fits of experimental data to simple equations.

The TENDL-2013,-2012 library contains 2630, -2434 target nuclides ranging from ^1H to ^{262}Lr with all reactions kinematically allowed up to 200 MeV. Quite importantly covariance-variances information (mf31-35, 40) are uniquely stored for incident particles with energies from 10^{-5}eV up to 200 MeV. Above the upper energy of the resolved resonance range, for each of the 2630, -2434 isotopes, a Monte Carlo method, in which the covariance data come from uncertainties of the nuclear model calculations, is used. Short-range, self-scaling variance components are also specified for each mt, reactions type. The data format used to store the variance-covariance information has been made fully compliant with the ENDF-6 format [14] description and the files are read directly by FISPACT-II without any further intermediate processing. Variance and covariance data are re-used by FISPACT-II to create uncertainty predictions and sensitivity analyses.

Systematic experimental uncertainty, calculational uncertainty and E over C values have been quoted and calculated in a way that allows a direct comparison to be made. The Total Monte Carlo (TMC) method method used for the generation of qualitative variance information in TENDL-2013, compared to what was done in EAF_2010 uncertainty file is a significant achievement, when the calculational uncertainties quoted in the tables are of the same order of the E/C values. This demonstrates that the method chosen to calculate those uncertainties in the TALYS code system is not only valid but adequate. Of course, the same remarks as for the cross section and decay data file apply: even if the bulk of the data seems to be satisfactory, certain specific data entries need to be revisited in line with the findings of this validation exercise and other studies.

6 Conclusions

The experimental time dependent decay power measurement program at JAEA FNS combined with the code simulations performed in this study provide a unique check of the calculational method and nuclear databases associated with the prediction of decay power for the set of material samples analysed. The results of the comparison give confidence in most of the decay heat values calculated, although the predominantly 14 MeV neutron spectrum in FNS means that the low neutron energy reactions of importance in other devices have not yet been fully considered[15]. This statement limits the scope of validation and possible conclusions reached in this study to the decay power predicted through the identified pathways. However, it covers the decay data of all the isotopes involved irrespective of their production routes.

For the third time, experimental uncertainty, calculational uncertainty and E/C values have been systematically produced. Their direct comparison demonstrates that the method chosen to calculate and propagate these uncertainties in the EASY-II code system is verified and validated (V&V), and that the uncertainties file should be further improved along the same lines.

From the results, a set of inadequacies, not only in the cross sections but also in the decay libraries, have been identified that will require some corrective actions to be taken. These corrections and/or amendments will benefit the next generation of the FENDL library cross sections, associated variance and covariances, and decays data files. As expected, they impact both the production paths and/or decay data of some specific radionuclides without impairing the overall picture. A large proportion of the decay powers calculated in this validation exercise are in good agreement (within a few %) with the experimental values for cooling times spanning from tens of seconds - and this is a unique insight, up to more than a year.

Maintenance and testing of activation inventory code systems and libraries is essential for many projects in order to present a sound and well validated safety assessment. Licensing authorities will require evidence of experimental validation. However, the relevance of the experimental irradiation conditions and set-up to those that are likely to exist in a device needs to be carefully considered in order for such an assessment and validation to be applicable to the data predicted for the next generation of plants.

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