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**Validation of EASY-2007 using  
integral measurements**

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# Validation of EASY-2007 using integral measurements

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## Abstract

Studies of the radioactive properties of fusion devices, including future power stations, rely on calculations of the activation of materials by neutrons produced in fusion reactions. In order for trust to be placed in the results of such calculations it is necessary that the inventory code and the data libraries are validated. This is done by comparing the predictions of the code system with activation measurements made on materials relevant to fusion technology in well-characterised neutron fields. If the ratio of results from Experiment (E) and Calculation (C) is close to 1 then the data are validated. In other cases it may be necessary to change the library data to improve the C/E ratio.

As part of the EFDA Fusion Technology Programme the European Activation File (EAF) containing relevant nuclear data library has been developed. This is used as input to the FISPACT code to calculate the activation of irradiated materials. A series of measurements on fusion relevant materials in several complementary neutron fields have been carried out over the last few years. In addition, analyses of measurements performed outside Europe and outside the fusion programme have been undertaken. The results from these measurements are presented in a series of tables, which include the pathways responsible for production of the various radionuclides. The pathways show the reactions that dominate the formation of the measured radionuclides. Knowing the reactions enables the activity measurements to be transformed into effective cross sections (average value of the cross section in the neutron spectrum) which can be compared with the EAF library value calculated in the same spectrum.

For the present validation exercise the latest version of the European Activation System

(EASY-2007) is used. Analysis of all experimental data enables effective cross sections for four hundred and seventy reactions to be calculated and these are presented in tabular form and also as plots of the C/E ratio. A graph showing the EAF cross section (including the uncertainty estimate) as a function of neutron energy is plotted for each reaction and this also contains all the available experimental differential data (extracted from the international EXFOR database). Using these graphs, an assessment is made to determine if the reaction is validated or if changes to the EAF data should be made, this assessment being quantified as the Quality score for each reaction. These assessments will be used with other information to enable improvements to be made to future EAF libraries.



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## 1. Introduction

Studies of fusion technology rely on calculations of the activation of materials arising from the operation of fusion devices that produce neutrons, typically from the D-T reaction. Such calculations are then fed into studies of the consequences of possible accidents, exposure doses of workers in the plant and the eventual disposal of materials following decommissioning. The calculations are performed by an inventory code (such as FISPACT-2007) which requires as input large amounts of nuclear data: neutron-induced cross sections on targets covering the whole periodic table, radioactive decay data such as half-lives and decay energies and the biological effects of radionuclides on humans. The nuclear data are held in libraries (such as EAF-2007) which are assembled from many data sources. Thus for some reactions the cross section has been well measured and the uncertainty is small, while for others there may be no experimental data and the data are produced by model code calculations with possible renormalisation to simple systematic formulae.

In order for trust to be placed in the results of such calculations it is necessary that the inventory code and the data libraries are validated. By this it is meant that the predictions of the code system are compared with activation measurements made on materials relevant to fusion technology in well-characterised neutron fields. In an ideal world there would be perfect agreement between the two (Experiment (E) and Calculation (C)), but because of uncertainties in the measurements and errors in the data libraries a range of C/E values is typically found.

By considering a large range of materials it is possible to cover a wide range of reactions, although it must be noted that with the current facilities, which produce a relatively feeble source of neutrons, it is only possible to validate reactions on stable or long-lived targets that give products with short to medium half-lives. By considering the C/E values it is possible to indicate which reactions are 'validated' – judged to be well described in the library and therefore to be relied on when making predictions of activation. Other reactions with C/E values far from 1 need to be improved before they can be relied on for prediction, and it is therefore necessary for the library developers to modify the cross section data in various energy regions so that when calculations are made again using the new data, C/E values closer to unity will be obtained. Such cross section modifications can be made with confidence if integral results in several complementary neutron spectra are available and if adequate experimental differential data (cross sections at particular energies rather than averaged over a neutron spectrum) exist. It is then possible to either renormalize the cross section over the entire energy range to get a better fit to the measurements or renormalize over particular energy regions.

Improvement of data libraries is therefore an additional aspect of the validation process. Only when all available measurements on all relevant materials can be accurately reproduced by the calculations, can it be said that the library is validated. Until then new integral measurements will continue to be required to provide feedback and improve the quality of the nuclear data libraries.

The names FISPACT and EAF were mentioned above. These are components of the European Activation System (EASY) that has been developed over the last 21 years, latterly as part of the EFDA Fusion Technology Programme. This co-ordinated programme has enabled the tools for library production (most recently SAFEPQAQ-II) to be developed, libraries such as EAF-97, EAF-99, EAF-2001, EAF-2003, EAF-2005 and EAF-2007 to be produced, and a series of integral measurements to be carried out on a wide range of fusion relevant materials in several complementary neutron spectra. Results from the integral measurements have been used with various versions of EAF to validate data relevant for

particular materials; also they have provided feedback to aid in the production of EAF-99 to EAF-2007. Summary reports detailing the validation of EASY-2001 [1], EASY-2003 [2] and EASY-2005 [3] have been produced. The objective of the present report is to present all the integral measurements made after 2005 within the EFDA programme and new analyses of existing data. These data are used with predictions of EASY-2007 to calculate C/E ratios for all reactions, to provide a list of reactions judged to be validated and to investigate reactions with discrepant C/E to give feedback for the production of the future library EAF-2009.

Note that most of the measurements were carried out with fusion relevant materials, resulting in small uncertainties for the activities if they are produced on major nuclides, but in larger uncertainties for those on the minor nuclides or impurities.

## 2. Neutron fields

In references 1, 2 and 3 the spectra used by the Technical University of Dresden (TUD), the Frascati Neutron Generator (FNG) group, the Forschungszentrum Karlsruhe (FZK) group, the Řež Nuclear Physics Group, the Jülich Group, the JAERI (FNS) group and from the spontaneous fission of  $^{252}\text{Cf}$  were described. These references should be consulted for details of the spectra and the original publications. However, Figure 1 - Figure 17 of reference 3 are reproduced here to show the shapes of the various neutron spectra. Following that work, new measurements have been made at FNG and at TUD using additional spectra. The FNG spectra for the rhenium and tin measurements are shown in Figure 18 and Figure 19. The TUD spectrum for the erbium and lanthanum measurements is shown in Figure 20.

The measurements at Řež were carried out in a neutron field produced by a cyclotron. Considerable effort has been taken to characterise the spectrum in detail. Note that this spectrum extends in energy above 20 MeV and is therefore very important in the validation of libraries such as EAF-2007 which extend to 60 MeV. The initial version of the spectrum is shown in Figure 12 and is termed rez\_NE, this was used in a preliminary analysis, but was recognised as incorrect as it was measured at a large distance from the sample and so was not really representative of the spectrum in the sample. Following considerable efforts a new spectrum (rez\_DF) was produced by measurement and calculation [4] and this is shown in Figure 13; this spectrum was used in the analysis of the various measurements including the new chromium measurements.

Measurements at FZK using a d-Li neutron source [5,6,7], similar to that proposed for IFMIF, but with much lower intensity have been analysed using the Intermediate Energy Activation File (IEAF) library [8,9]. The source consists of a 40 MeV beam of deuterons incident on a thick lithium target (22 mm thickness enclosed in a stainless steel case). Although a 3  $\mu\text{A}$  beam of 52 MeV deuterons was used, the approximate energy of the deuterons on entering the lithium was 40 MeV. The neutron flux was about  $4.3 \cdot 10^{11} \text{ ncm}^{-2}\text{s}^{-1}$ . The data have been analysed using EASY-2005. The spectrum, which extends above 20 MeV, is shown in Figure 14.

The importance of integral data in spectra extending above 20 MeV led to a literature search for historical measurements that could be used for validation. A series of papers from the group in Jülich led by Qaim [10,11,12,13,14,15,16,17,18,19,20,21] has been used. Three different d(Be) neutron spectra have been derived based on the work of Schweimer [22] and Meulders et al. [23]. The data have been fitted to the analytic shape shown in equation 1 below and then converted into the 211-group VITAMIN-J+ structure. In equation 1,  $\phi(E)$  is the neutron flux at energy  $E$ ,  $a = (BE_d)^{-1/2}$  and  $y = a(E - E_d / 2 + E_s)$ .  $E$  is the neutron energy,  $E_d$  is the deuteron energy,  $E_s$  and  $C$  are constants and  $B$  is the deuteron binding energy.

$$\phi(E) = Ca(1 + y^2)^{-3/2} \tag{1}$$

The three spectra are shown in Figure 15 - Figure 17. It was found that the C/E values for all reactions in the d-Be2 spectrum were large. Selecting a set of ‘well-known’ reactions ((n,α) reactions on <sup>27</sup>Al, <sup>31</sup>P, <sup>51</sup>V, <sup>55</sup>Mn, <sup>59</sup>Co and <sup>93</sup>Nb) it was found that the average C/E values was 2.15. It is believed that an error in the original data is present and it was decided to renormalize all the cross sections by a factor 2.15. In order to make this clear the spectrum is termed d-Be2a, this notation is used in Figure 16.

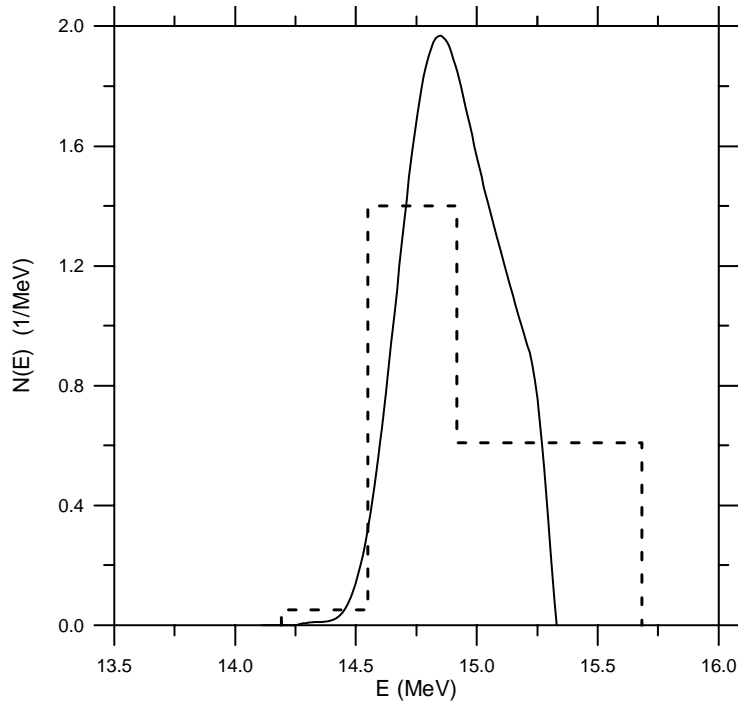


Figure 1. TUD neutron spectrum at 4° normalised to unity as determined (solid line) and in VITAMIN-J group structure (dashed line).

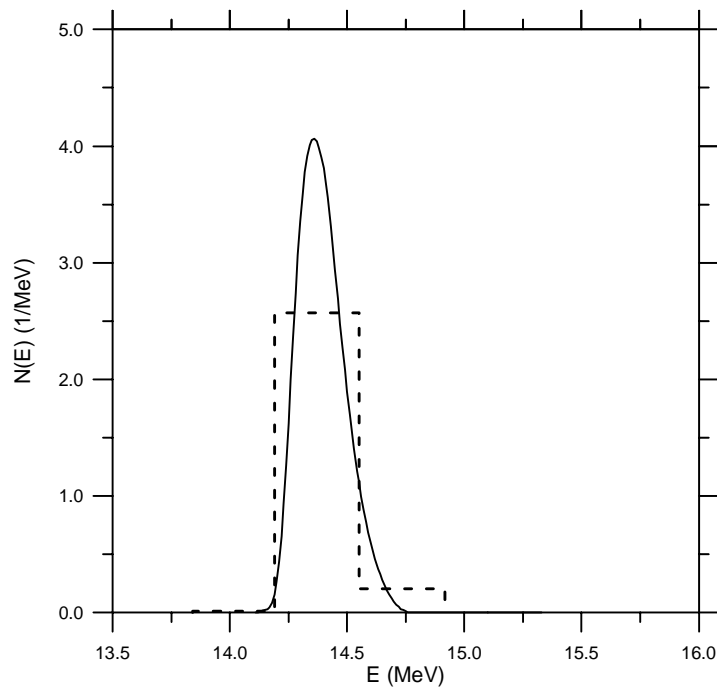


Figure 2. TUD neutron spectrum at 73° normalised to unity as determined (solid line) and in VITAMIN-J group structure (dashed line).

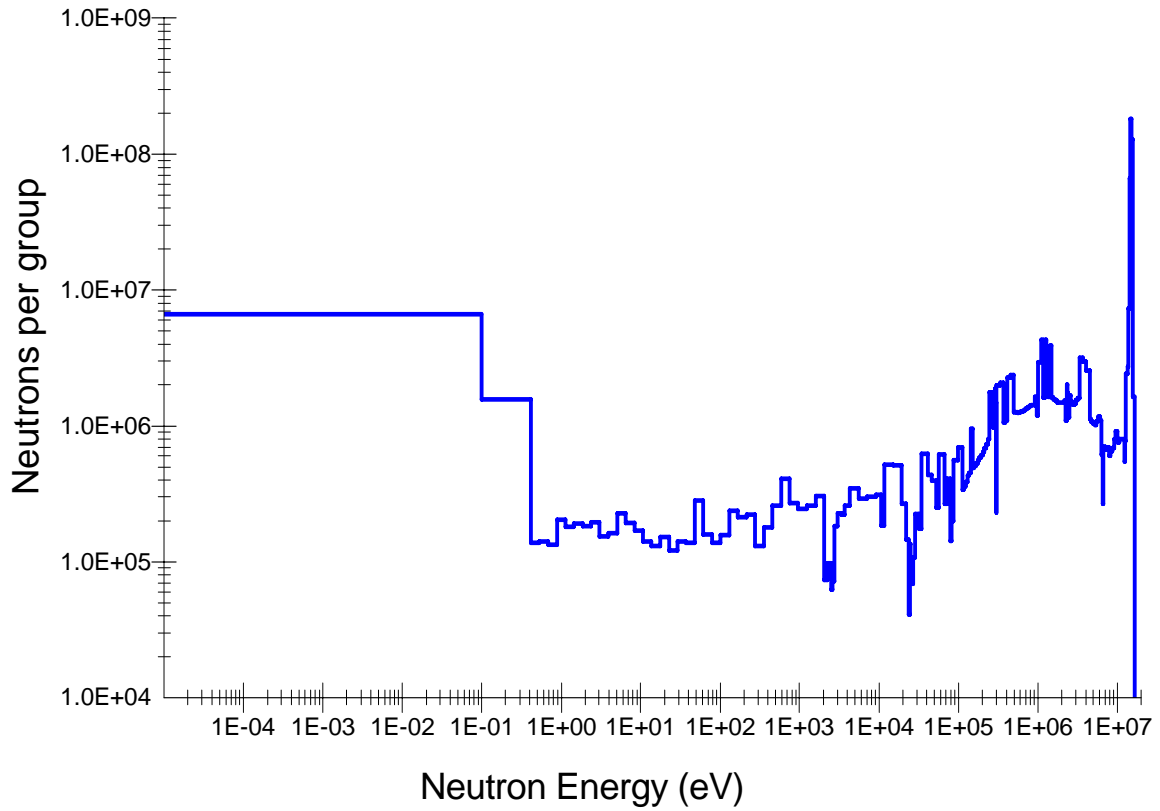


Figure 3. FNG neutron spectrum as measured for the vanadium measurements in the VITAMIN-J group structure.

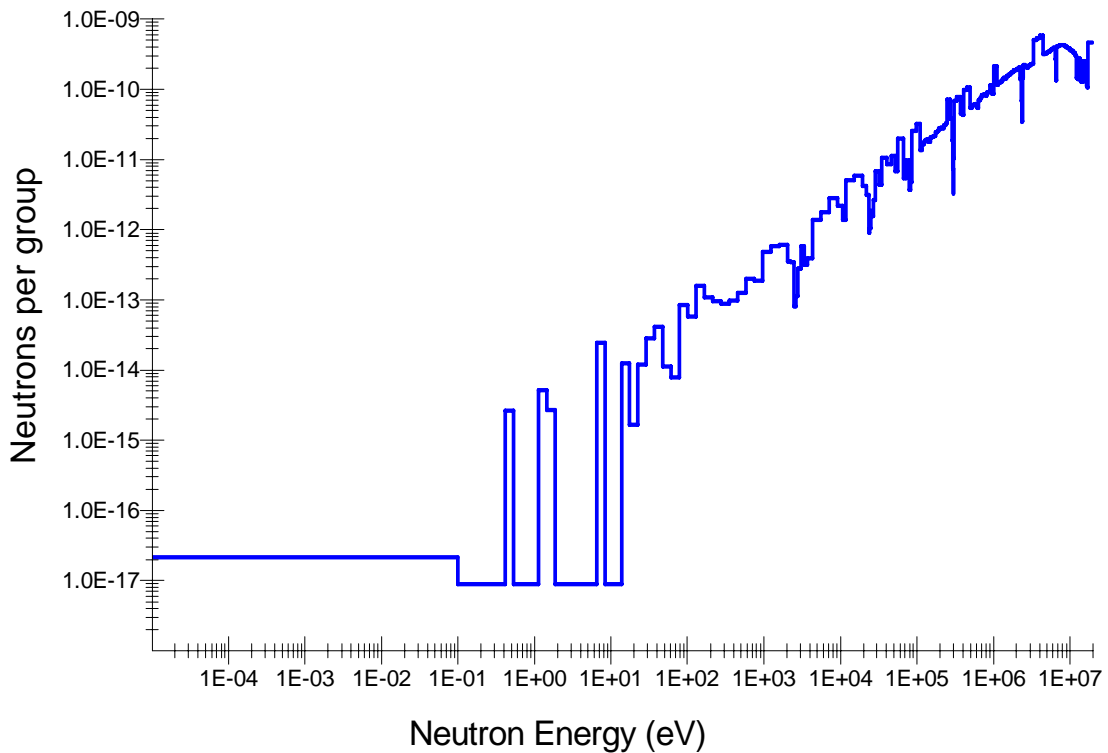


Figure 4. FZK neutron spectrum as measured in the VITAMIN-J group structure.

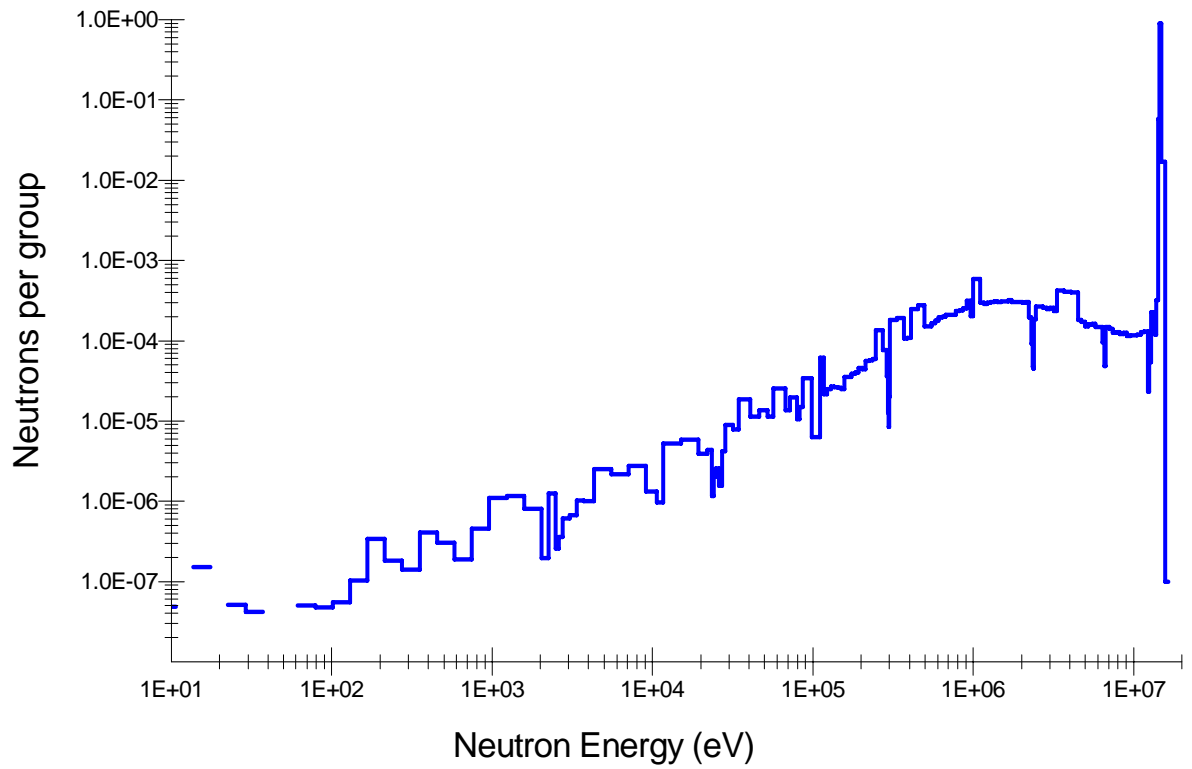


Figure 5. TUD neutron spectrum normalised to unity plotted in the VITAMIN-J group structure.

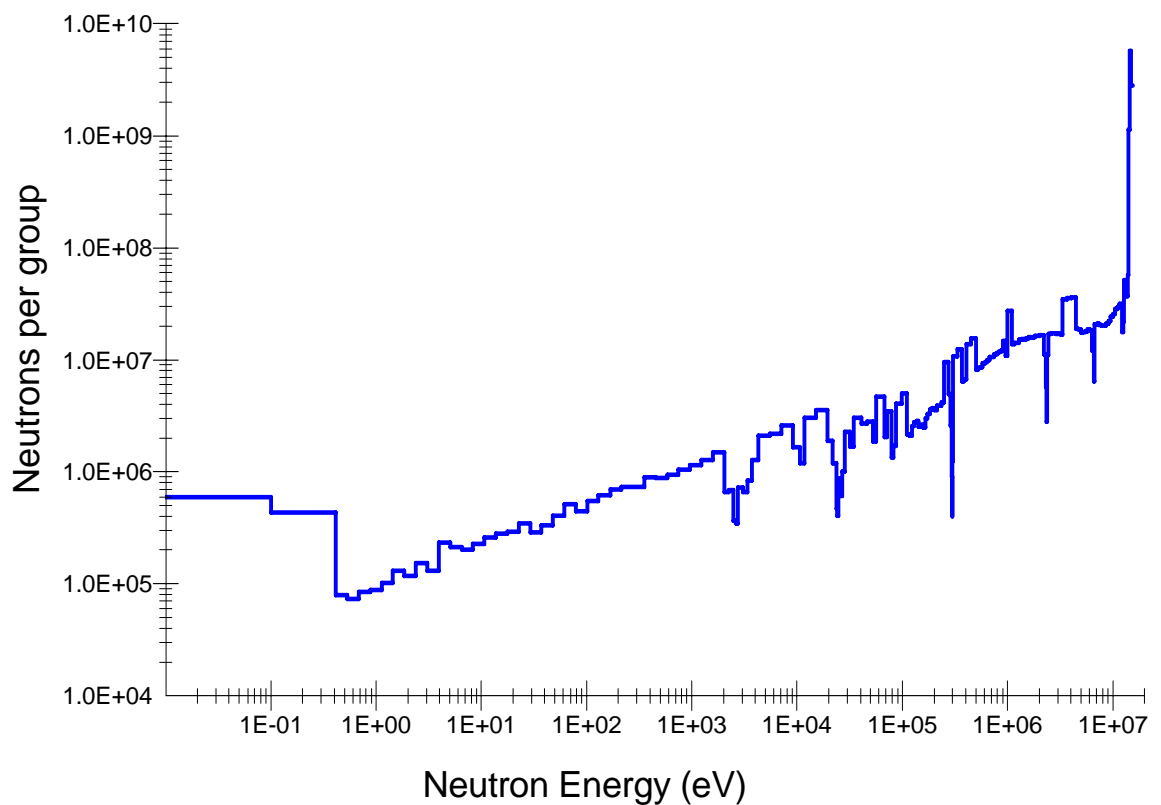


Figure 6. FNS neutron spectrum used for 5 minute irradiations plotted in the VITAMIN-J group structure.

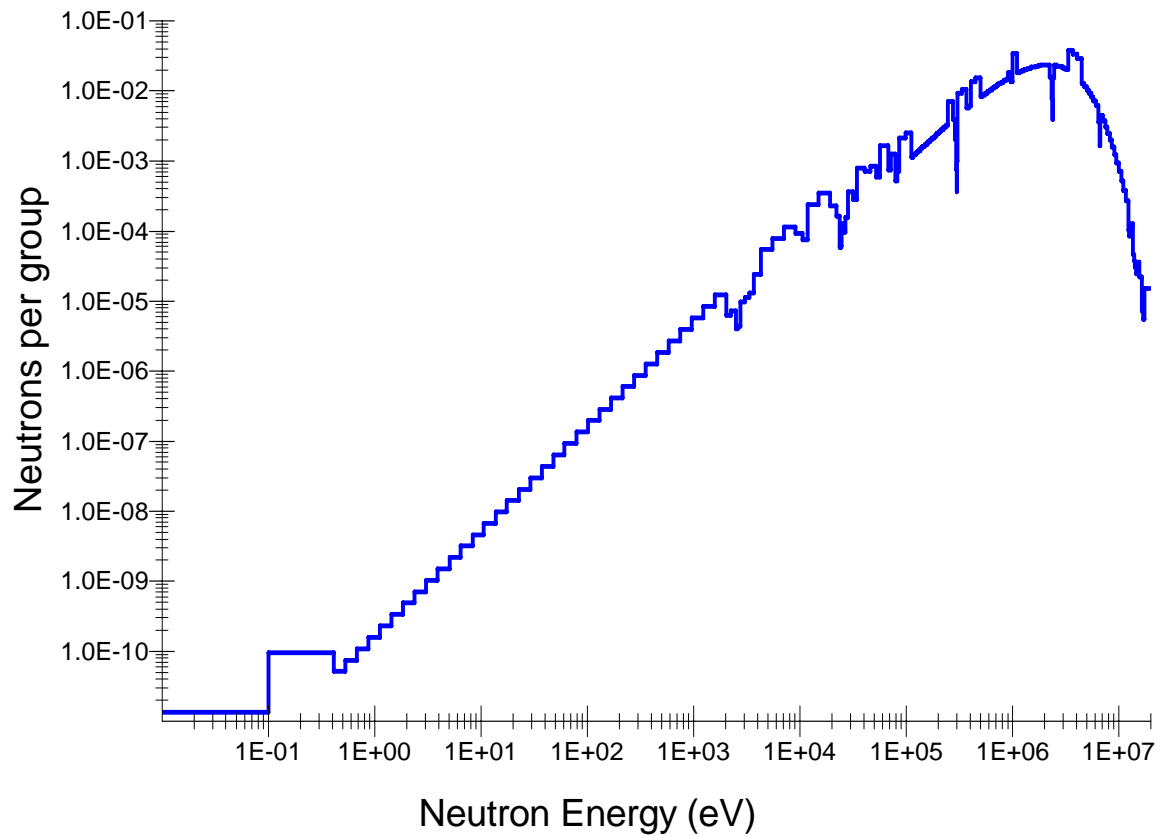


Figure 7.  $^{252}\text{Cf}$  spontaneous fission neutron spectrum plotted in the VITAMIN-J group structure.

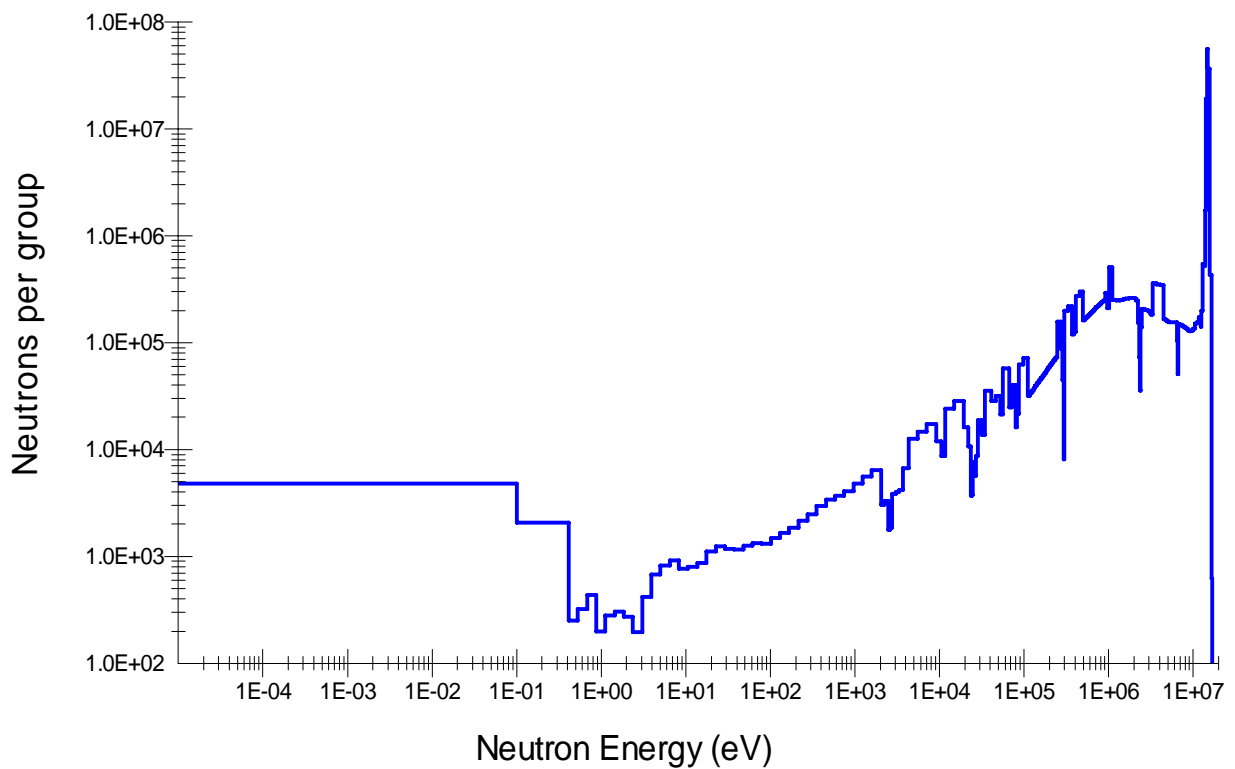


Figure 8. FNG neutron spectrum as measured for the yttrium measurements in the VITAMIN-J group structure.



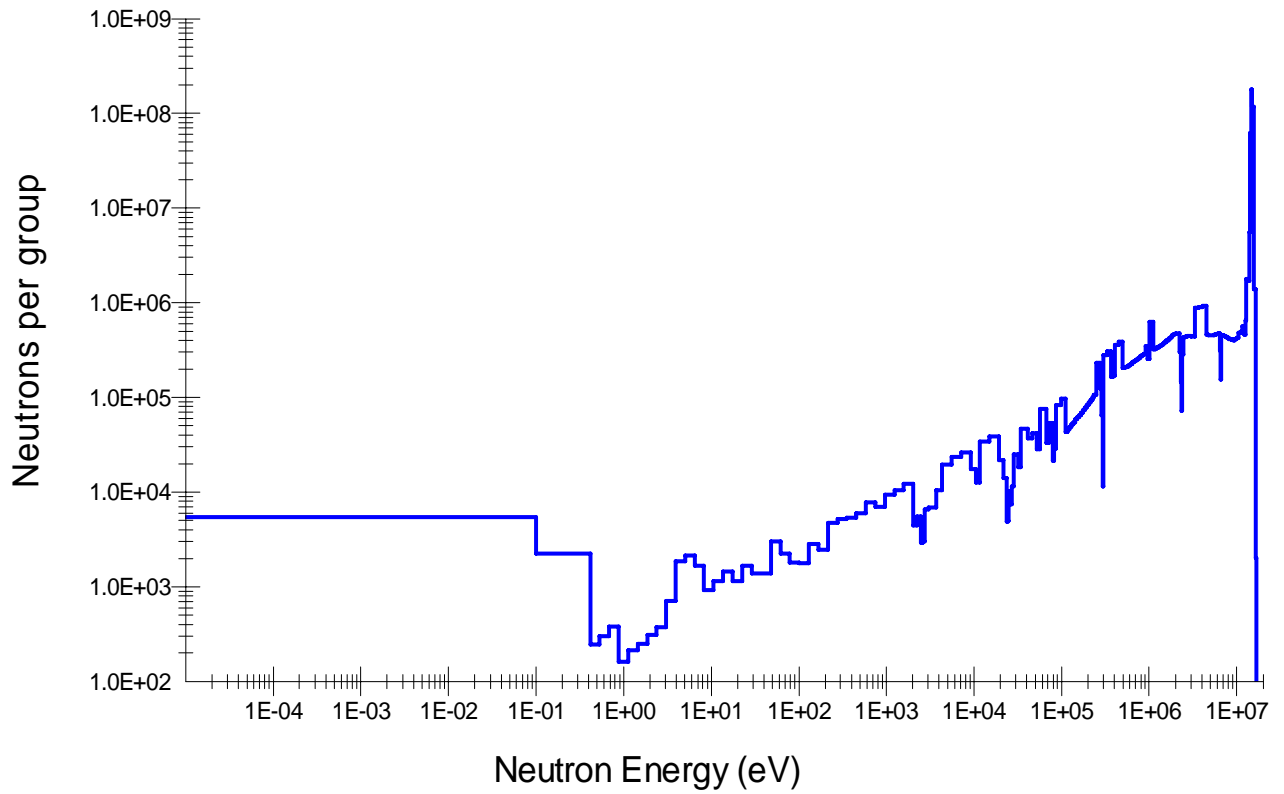


Figure 9. FNG neutron spectrum as measured for the molybdenum measurements in the VITAMIN-J group structure.

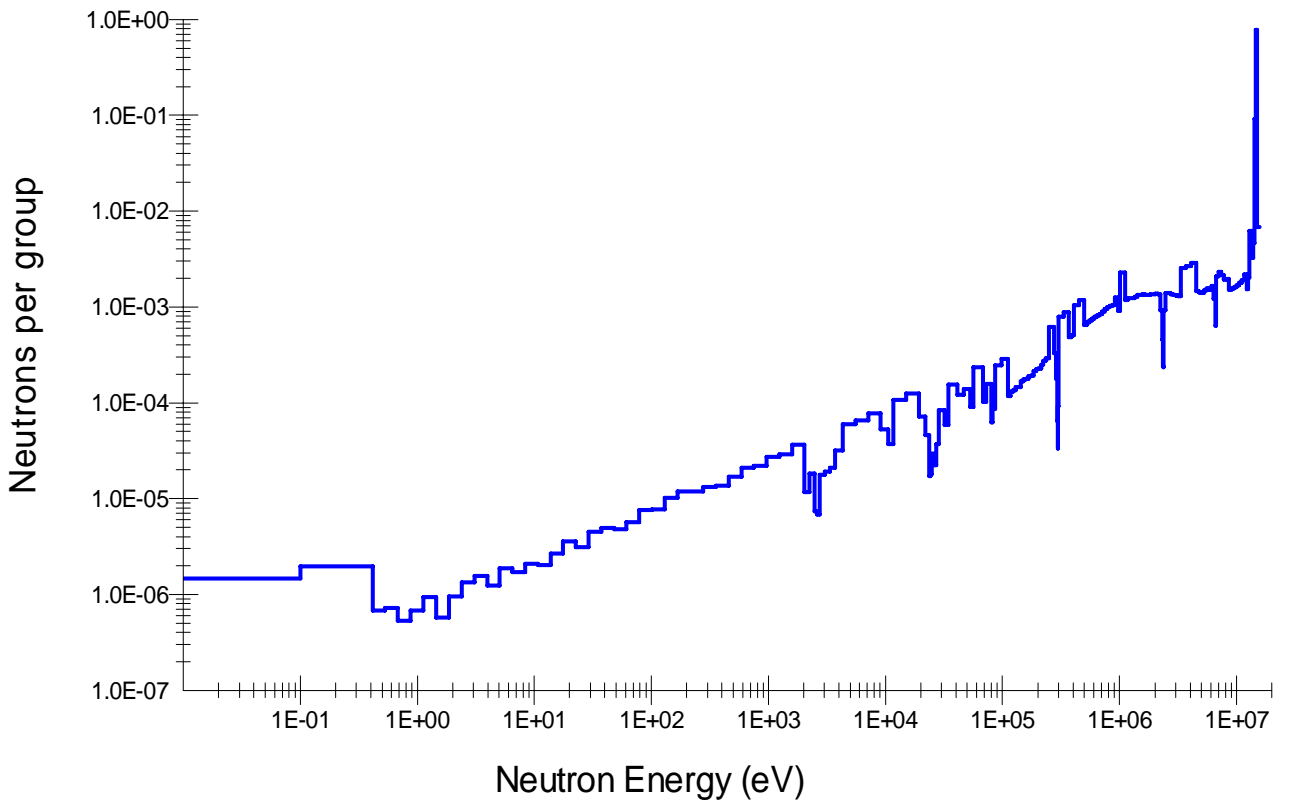


Figure 10. TUD neutron spectrum as measured for the yttrium measurements in the VITAMIN-J group structure.

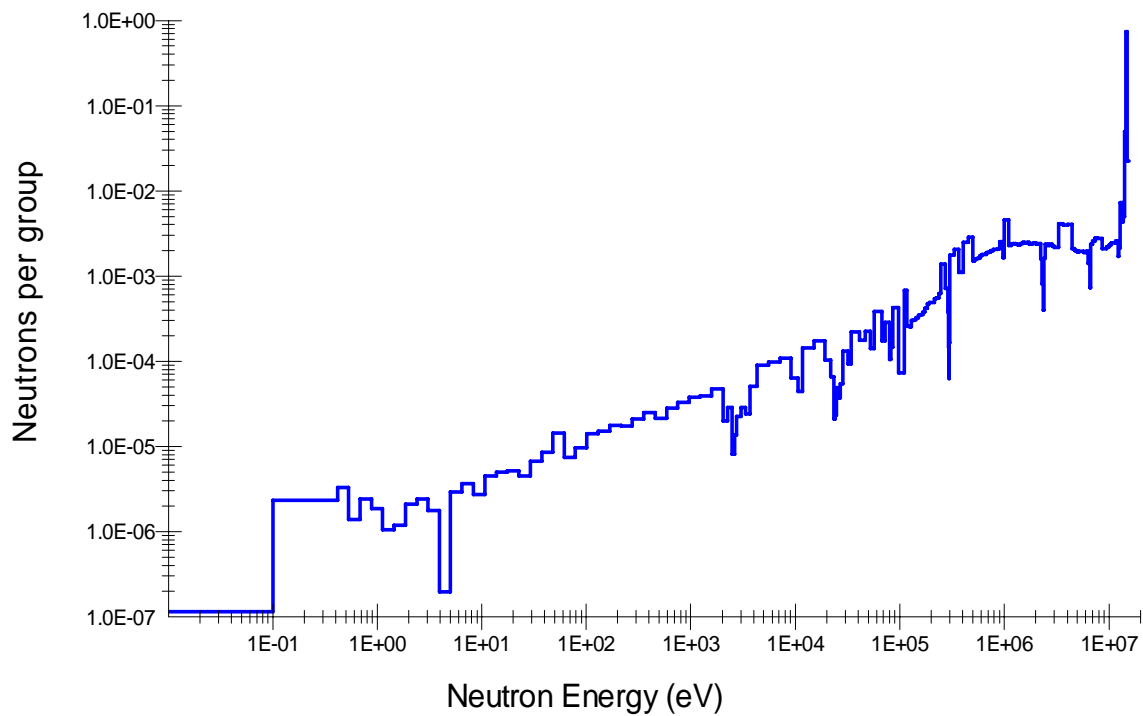


Figure 11. TUD neutron spectrum as measured for the tantalum measurements in the VITAMIN-J group structure.

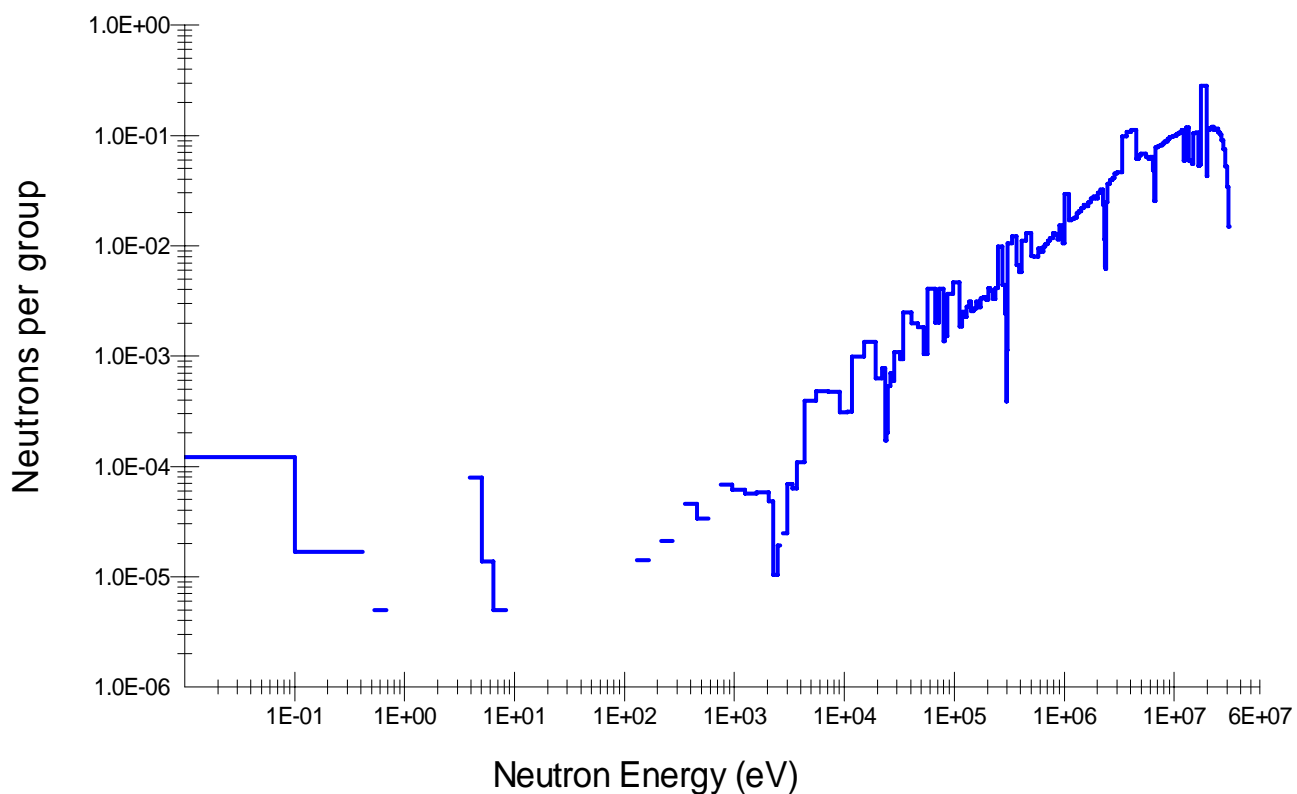


Figure 12. Preliminary Řež neutron spectrum in the VITAMIN-J+ group structure (not used for analyses).

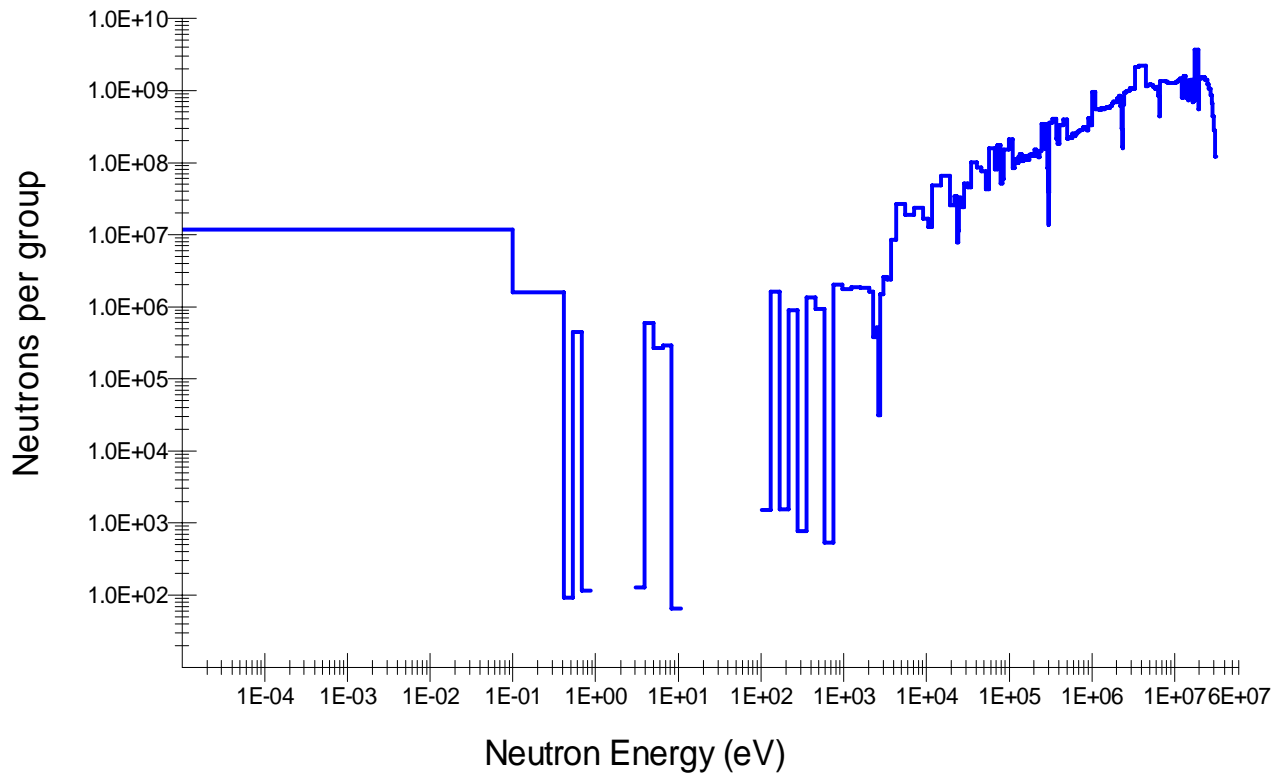


Figure 13. Řež neutron spectrum used for the analyses of the measurements in the VITAMIN-J+ group structure.

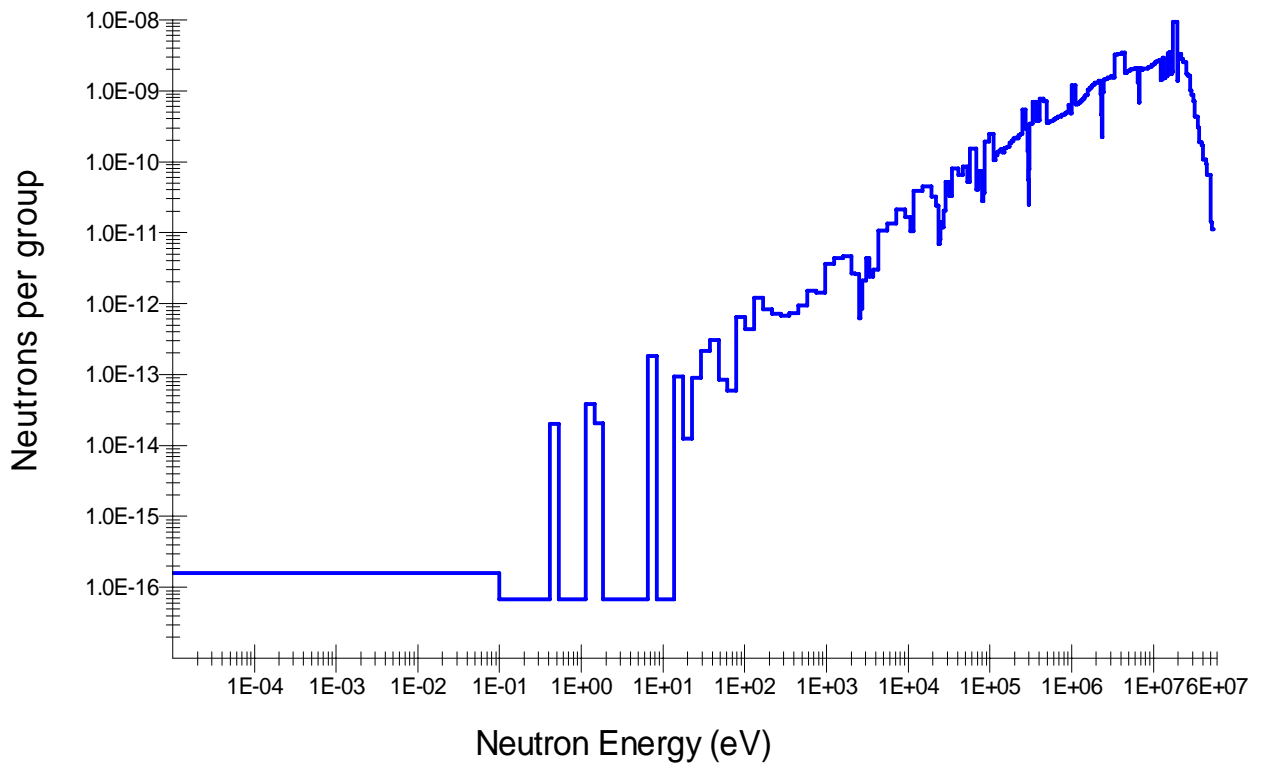


Figure 14. FZK neutron spectrum as measured in the VITAMIN-J+ group structure.

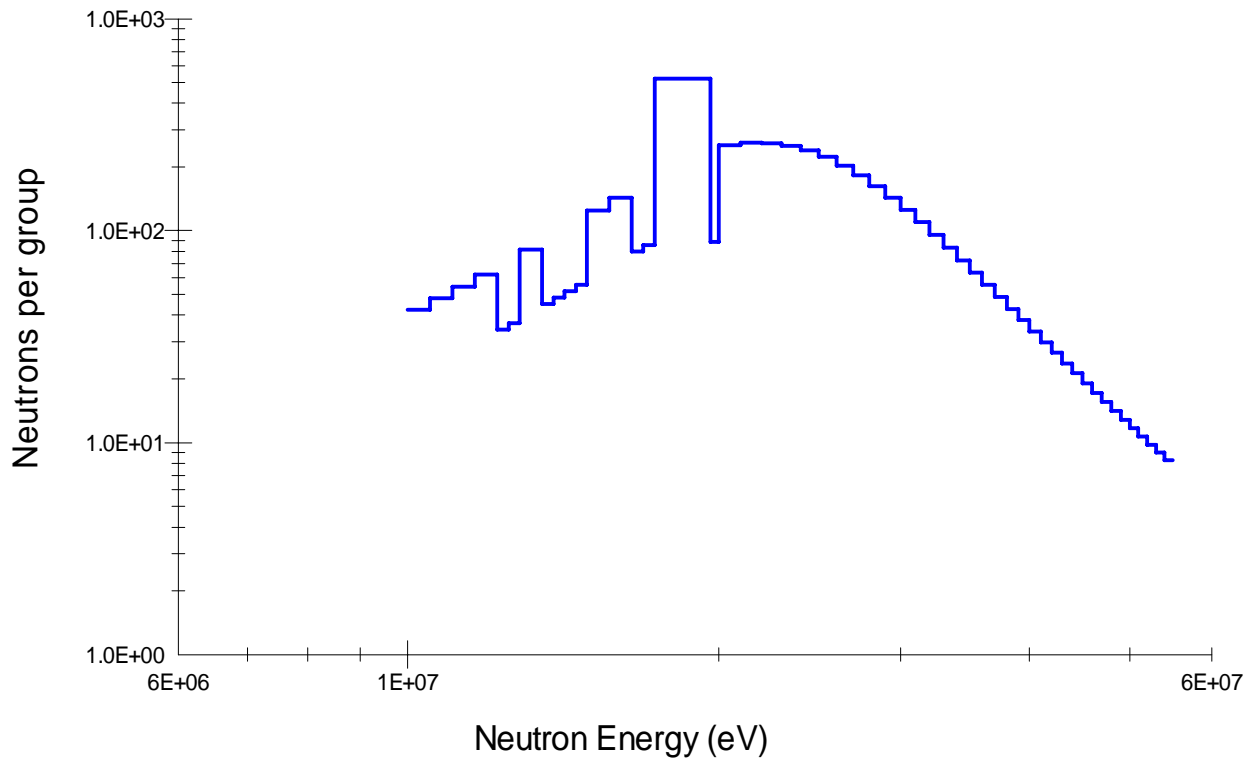


Figure 15. d-Be neutron spectrum in the VITAMIN-J+ group structure.

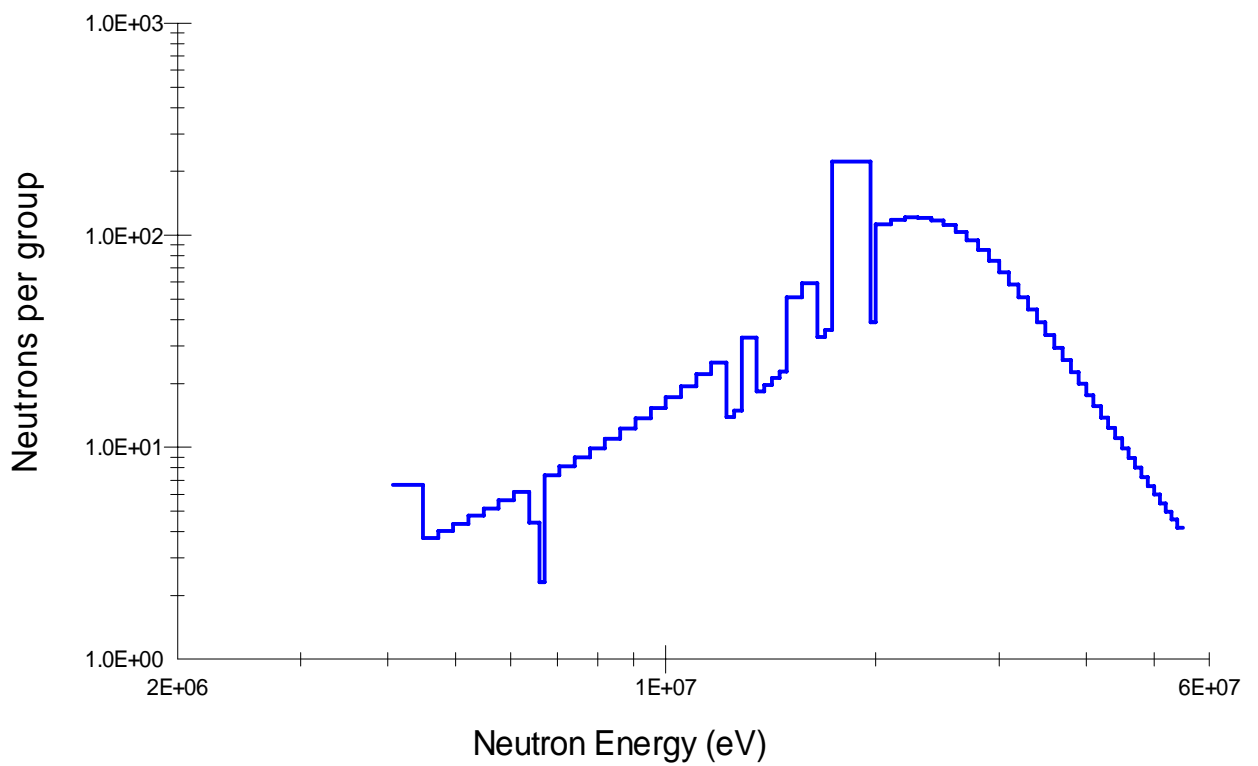


Figure 16. d-Be2a neutron spectrum in the VITAMIN-J+ group structure.

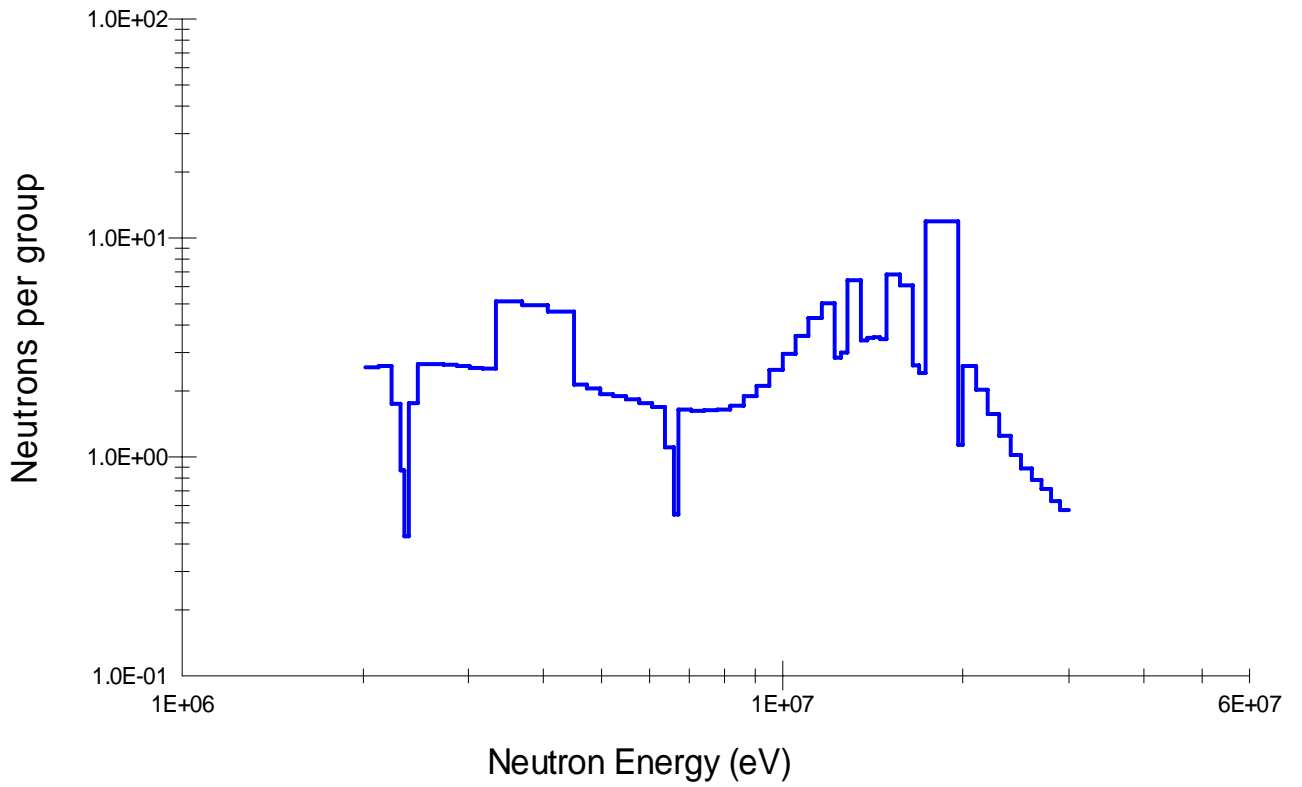


Figure 17. d-Be3 neutron spectrum in the VITAMIN-J+ group structure.

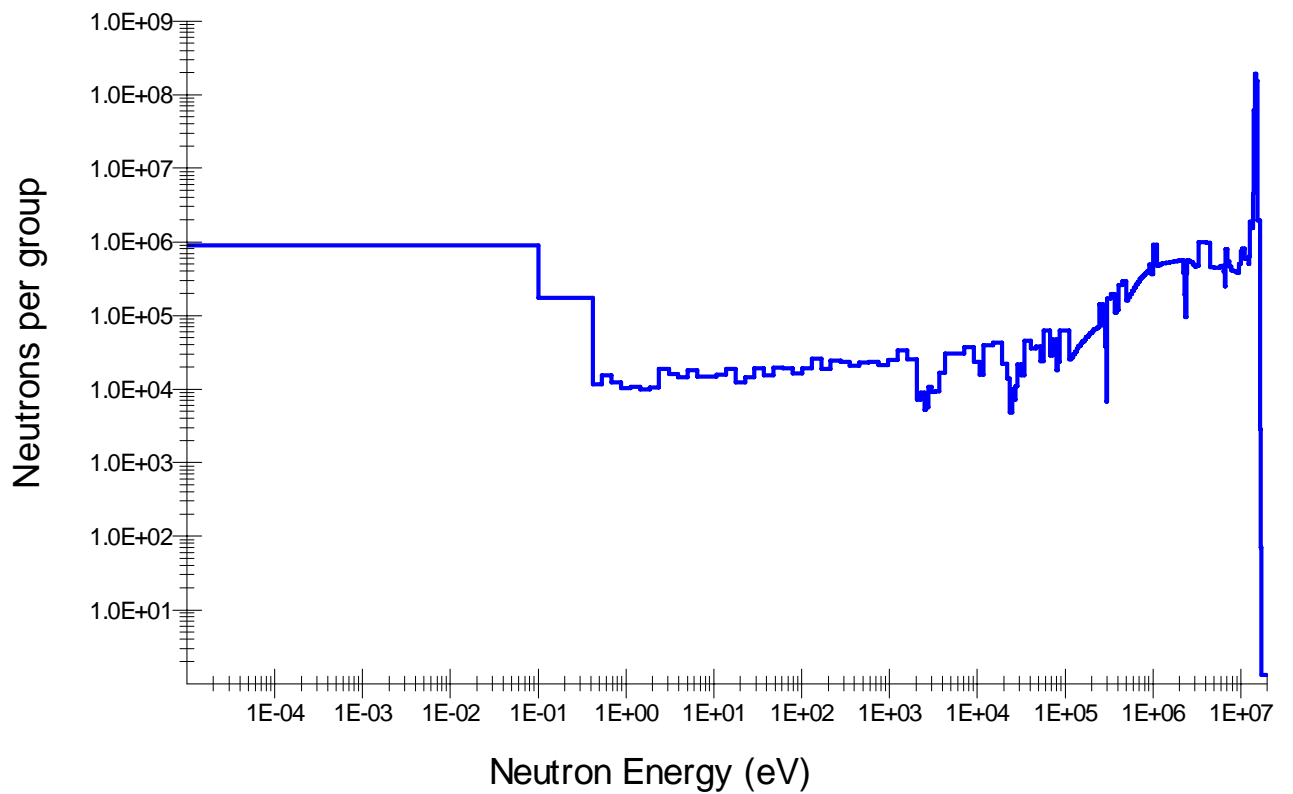


Figure 18. FNG neutron spectrum as measured for the rehenium measurements in the VITAMIN-J group structure.

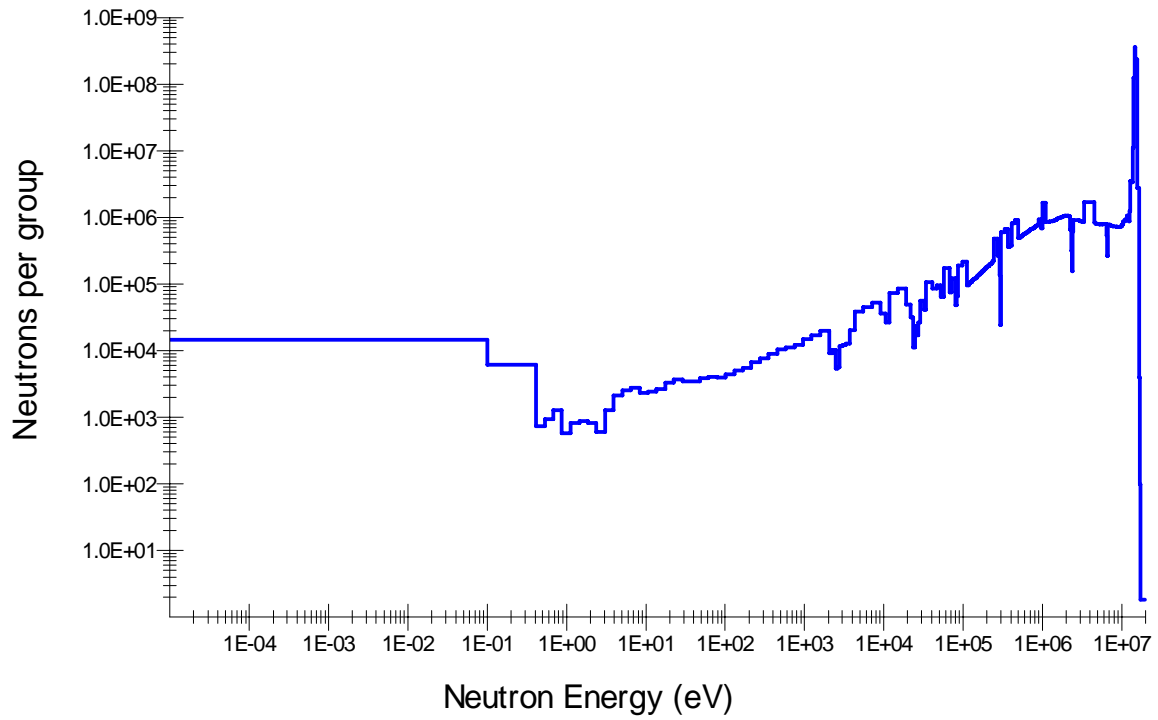


Figure 19. FNG neutron spectrum as measured for the tin measurements in the VITAMIN-J group structure

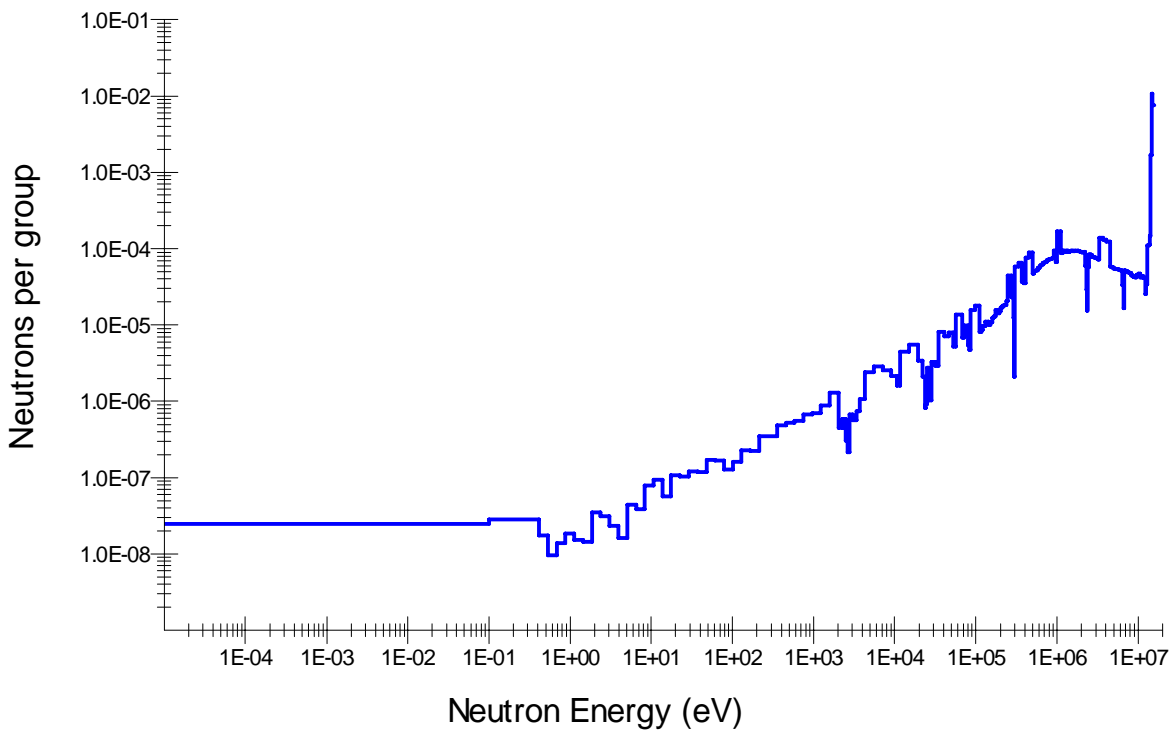


Figure 20. TUD neutron spectrum as measured for the erbium and lanthanum measurements in the VITAMIN-J group structure

### 3. Calculational method

Calculations were made using EASY-2007 [24]. Details of the experimental set-up (material composition, irradiation time, flux etc) were used to create the FISPACT input file to model each experiment. FISPACT-2007 contains options to calculate the pathways of formation of the measured radionuclides, so that the reactions involved and their importance (percentage

contribution) can be easily found. The uncertainty in the calculated activity can also be obtained. This is based on the uncertainty in the reaction cross sections (uncertainty in the half-lives can be included, but typically these are insignificant). Thus for each set of measurements the experimental activities at specified decay times are tabulated and the C/E values are calculated. In the subsequent Tables 1 - 11, C/E and pathway data for the EASY-2007 calculations are shown.  $\delta$  is the experimental uncertainty and  $\Delta$  is the calculated uncertainty using data in EAF-2007. The Pathway column shows pathways that are important in producing the product. Note that generic pathways are shown in which the contribution from the pathway containing  $\dots X^m(IT)X^g \dots$  is added to the pathway containing  $\dots X^g \dots$ . In cases where the effective cross sections can be extracted this has been done. Cross section curves taken from EAF-2007 [25] produced by SAFEPAQ-II [26] are displayed for each of the listed reactions. For reactions where there are several integral measurements in different neutron spectra it is useful to indicate the energies that the measurements cover. This is done by plotting the C/E values as a function of energy. The measurement is shown at an energy that corresponds to the peak in the reaction rate and an energy ‘error bar’ is shown. The error bar covers energies within which 90% of the reaction rate occurs. The standard C/E diagram for the reaction gives the page number on which the corresponding extended C/E plot can be found (using the symbol  $\blacktriangleright$  page number). A total of 26 extended C/E plots are given.

## 4. Comparison of calculated and measured activities

### 4.1. Rhenium

A reason for considering rhenium as an element to study is that rhenium is a common alloying element for tungsten; this material is envisaged as a first wall and divertor armour for future fusion power plants.

#### 4.1.1. FNG measurements of rhenium

Data for the FNG measurements on rhenium are available in [27]. C/E and pathway data for the EASY-2007 calculations are shown in Table 1. The irradiation was made in the fng\_Re spectrum.

**Table 1.** FNG results for rhenium

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Re-188m	0.95	10.9	62.6	Re187(n, $\gamma$ )Re188m	100.0
Ta-184	0.93	10.1	20.0	Re187(n, $\alpha$ )Ta184	100.0
Re-188	0.63	1.5	21.7	Re187(n, $\gamma$ )Re188	97.0
				Re187(n, $\gamma$ )Re188m(IT)Re188	3.0
W-187	0.92	11.7	9.0	Re187(n,p)W187	100.0
Re-186	0.97	1.5	14.1	Re187(n,2n)Re186	88.3
				Re185(n, $\gamma$ )Re186	11.7
Re-184	0.73	1.5	15.0	Re185(n,2n)Re184	100.0
Re-183	0.64	23.6	200.0	Re185(n,3n)Re183	100.0
Re-184m	1.10	8.2	20.0	Re185(n,2n)Re184m	100.0

### 4.2. Tin

A reason for considering tin as an element to study is that this is a major constituent of superconducting coils in ITER and future fusion power plants.

#### 4.2.1. FNG measurements of tin

Data for the FNG measurements on tin are available in [28,29]. C/E and pathway data for the EASY-2007 calculations are shown in Table 2. Irradiation was in the fng\_Sn spectrum.

**Table 2.** FNG results for tin

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Sn-111	0.91	8.3	15.1	Sn112(n,2n)Sn111	100.0
Sn-123m	0.88	3.1	19.9	Sn124(n,2n)Sn123m	99.7
In-117	0.77	3.3	18.2	Sn117(n,p)In117	69.5
				Sn118(n,d)In117	13.6
				Sn117(n,p)In117m(IT)In117	6.3
				Sn118(n,d)In117m(IT)In117	5.0
				Sn120(n, $\alpha$ )Cd117m( $\beta^-$ )In117	3.8
				Sn119(n,t)In117	0.7
In-116m	1.00	3.0	15.4	Sn116(n,p)In116m	66.0
				Sn116(n,p)In116n(IT)In116m	26.7
				Sn117(n,d)In116m	6.3
				Sn117(n,d)In116n(IT)In116m	1.0
In-113m	0.56	23.4	108.2	Sn114(n,d)In113m	82.9
				Sn114(n,2n)Sn113m(IT)Sn113( $\beta^+$ )In113m	10.1
				Sn114(n,2n)Sn113( $\beta^+$ )In113m	4.4
				Sn115(n,t)In113m	2.4
In-117m	0.75	12.4	27.8	Sn117(n,p)In117m	49.9
				Sn118(n,d)In117m	40.2
				Sn120(n, $\alpha$ )Cd117( $\beta^-$ )In117m	7.5
				Sn119(n,t)In117m	2.4
Cd-117g	0.61	13.8	20.1	Sn120(n, $\alpha$ )Cd117	100.0
Cd-117m	0.66	15.7	20.1	Sn120(n, $\alpha$ )Cd117m	100.0
In-115m	0.52	9.6	139.9	Sn116(n,d)In115m	88.3
				Sn117(n,t)In115m	5.8
				Sn115(n,p)In115m	4.0
Cd-115g	0.58	19.3	19.9	Sn118(n, $\alpha$ )Cd115	98.9
				Sn119(n, $n'\alpha$ )Cd115	1.1
In-111	0.99	2.5	15.9	Sn112(n,2n)Sn111( $\beta^+$ )In111	92.7
				Sn112(n,d)In111	6.1
				Sn112(n,d)In111m(IT)In111	1.2
Sn-117m	0.59	2.5	18.8	Sn118(n,2n)Sn117m	93.6
				Sn117(n, $n'$ )Sn117m	6.4
Sn-113	0.62	4.8	18.2	Sn114(n,2n)Sn113m(IT)Sn113	69.9
				Sn114(n,2n)Sn113	28.9
				Sn112(n,g)Sn113	0.8
Sn-123g	0.53	40.5	20.0	Sn124(n,2n)Sn123	99.9

### 4.3.Erbium

A reason for considering erbium as an element to study is that this being considered as a constituent of the insulating coating for liquid metal blankets and as a tritium barrier.

#### 4.3.1. TUD measurements of erbium

Data for the TUD measurements on erbium are available in [30,31]. C/E and pathway data for the EASY-2007 calculations are shown in Table 3. Irradiation was in the tud\_Er spectrum. The first six entries in the table correspond to the short irradiation (1300 s) while the last entry corresponds to the long irradiation (8.54 h).

**Table 3.** TUD results for erbium

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Er-161	1.08	8.4	7.0	Er162(n,2n)Er161	100.0
Ho-167	0.95	5.6	26.0	Er167(n,p)Ho167	84.7
				Er168(n,d)Ho167	13.9
Ho-168	0.97	7.5	14.0	Er168(n,p)Ho168	100.0
Ho-170g	0.64	18.7	63.0	Er170(n,p)Ho170g	100.0
Er-163	0.77	9.4	15.0	Er164(n,2n)Er163	100.0
Ho-169	0.89	23.5	179.0	Er170(n,d)Ho169	100.0
Ho-166g	0.90	6.0	59.0	Er166(n,p)Ho166g	93.1
				Er167(n,d)Ho166g	6.7



#### 4.4. Lanthanum

A reason for considering lanthanum as an element to study is that this may be used in the oxide form ( $\text{La}_2\text{O}_3$ ) as a heat shield.

##### 4.4.1. TUD measurements of lanthanum

Data for the TUD measurements on lanthanum are available in [30,32]. C/E and pathway data for the EASY-2007 calculations are shown in Table 4 for irradiation in the tud\_Er spectrum.

**Table 4.** TUD results for lanthanum

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Cs-136	1.03	7.8	28.0	La139(n, $\alpha$ )Cs136	100.0
Ba-139	0.97	23.8	18.0	La139(n,p)Ba139	100.0
La-140	0.95	6.3	43.0	La139(n, $\gamma$ )La140	100.0

#### 4.5. Yttrium

The FNG experimental results given in [3] have been re-analysed using EASY-2007. There are small differences, especially in the pathway percentages.

##### 4.5.1. FNG measurements of yttrium

Data for the FNG measurements on yttrium are available in [33]. C/E and pathway data for the EASY-2007 calculations are shown in Table 5 for irradiation in the fng\_Y spectrum.

**Table 5.** FNG results for yttrium (revised)

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Y-88	1.02	1.0	10.0	Y89(n,2n)Y88	100.0
Y-90m	1.23	3.0	48.1	Y89(n, $\gamma$ )Y90m	96.2
				Zr90(n,p)Y90m	3.7
Zr-89	1.13	12.0	16.7	Zr90(n,2n)Zr89	81.4
				Zr90(n,2n)Zr89m(IT)Zr89	17.8
Rb-86	0.44	13.0	15.4	Y89(n, $\alpha$ )Rb86	71.3
				Y89(n, $\alpha$ )Rb86m(IT)Rb86	29.4
Y-89m	1.04	6.0	15.0	Y89(n,n')Y89m	100.0
Rb-86m	0.90	13.0	20.0	Y89(n, $\alpha$ )Rb86m	100.0

#### 4.6. Molybdenum

The FNG experimental results given in [3] have been re-analysed using EASY-2007. There are small differences, especially in the pathway percentages.

##### 4.6.1. FNG measurements of molybdenum

Data for the FNG measurements on molybdenum are available in [34]. C/E and pathway data for the EASY-2007 calculations are shown in Table 6 for irradiation in the fng\_Mo spectrum.

**Table 6.** FNG results for molybdenum (revised)

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Tc99m	1.08	3.5	8.0	Mo100(n,2n)Mo99( $\beta^-$ )Tc99m	99.3
				Mo98(n, $\gamma$ )Mo99( $\beta^-$ )Tc99m	0.7
Mo-99	1.09	3.3	8.0	Mo100(n,2n)Mo99	99.3
				Mo98(n, $\gamma$ )Mo99	0.7
Nb-95m	1.00	9.0	20.1	Mo95(n,p)Nb95m	88.9
				Mo96(n,d)Nb95m	10.6

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Nb-96	1.07	5.6	14.9	Mo96(n,p)Nb96	91.6
				Mo97(n,d)Nb96	7.9
Nb-92m	1.00	3.8	20.0	Mo92(n,p)Nb92m	100.0
Zr-89g	1.00	8.7	15.9	Mo92(n, $\alpha$ )Zr89g( $\beta^+$ )Y89m	75.4
				Mo92(n, $\alpha$ )Zr89m(IT)Zr89( $\beta^+$ )Y89m	24.6
Nb-95g	1.05	8.7	21.1	Mo95(n,p)Nb95g	88.9
				Mo96(n,d)Nb95g	10.6

## 4.7. Tantalum

The FNG experimental results given in [3] have been re-analysed using EASY-2007. There are small differences, especially in the pathway percentages.

### 4.7.1. FNG measurements of tantalum

Data for the FNG measurements on tantalum are available in [35]. C/E and pathway data for the EASY-2007 calculations are shown in Table 7 for irradiation in the fng\_Ta spectrum.

**Table 7.** FNG results for tantalum (revised)

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Ta-180g	1.04	2.3	20.0	Ta181(n,2n)Ta180	100.0
Lu-178m	1.02	12.0	20.0	Ta181(n, $\alpha$ )Lu178m	100.0
Lu-178g	0.44	40.0	20.0	Ta181(n, $\alpha$ )Lu178g	100.0
Hf-180m	4.76	19.0	188.8	Ta181(n,d)Hf180m	100.0
Ta-182n	0.52	34.5	45.0	Ta181(n, $\gamma$ )Ta182n	100.0
Ta-182	0.88	6.9	49.0	Ta181(n, $\gamma$ )Ta182	94.4
				Ta181(n, $\gamma$ )Ta182m(IT)Ta182	5.6
Hf-181	0.98	12.7	15.0	Ta181(n,p)Hf181	100.0

## 4.8. JAERI heat measurements

A decay heat experiment was conducted by JAERI as a task of ITER/EDA using the FNS. Originally in 1996, 32 relevant materials were irradiated by JAERI/FNS, for 5 minutes and 7 hours, and decay heat values measured over a wide cooling time range: from a few tens of seconds up to 400 days [36,37]. Additionally, in 1998-99, 73 samples for all naturally existing elements, but excluding very light elements and the noble gases, were prepared for a new measurement campaign in the same assembly [38]. The physical forms of the samples were metallic foil, metallic powder, oxide, carbonate, carbide, dioxide, etc. with masses ranging from 4 to 100 mg. The size of the foil samples was 25 x 25 mm<sup>2</sup> while the powders were sandwiched by adhesive plastic tape of 24 x 24 mm<sup>2</sup>. Use of thin samples minimised the self-absorption of  $\beta$  rays emitted in the sample and allowed their measurement.

The decay heat in each irradiated sample was measured in the Whole Energy Absorption Spectrometer (WEAS) which comprises two large bismuth-germanate BGO scintillators in a geometry arrangement which provides almost 100% detection efficiency for both  $\beta$  and  $\gamma$  rays, but without differentiating them. Correction factors needed to be applied for  $\gamma$  ray efficiency and for  $\beta$  and electron energy loss in the sample itself (generally less than 15%) and other effects such as the decay due to plastic tape. Overall the experimental errors ranged from 6 to 10% for most cases but larger uncertainties occurred when the heat power was weak or near the experimental measurement threshold.

These data have been analysed by Sublet using EASY-2001 in [39,40], and with EASY-2003 in [2]. These results remained unchanged in the EAF-2005 validation exercise. The data have been reanalysed and better scrutinised using EAF-2007 [41] and the C/E and pathway data are shown in Table 8 and Table 9. Some reactions (labelled by †) were measured on more than one material, for these the average values are shown in the tables. The new analysis

allows data for additional reactions to be included, but it was also found that several reactions could no longer be included in the tables as they are not shown as important by the new analysis (see section 6).

**Table 8.** JAERI results for various materials, 5 min irradiation (revised)

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
N-13	1.053	15.0	15.0	N14(n,2n)N13	100.0
N-16 <sup>†</sup>	1.019	2.6	10.0	O16(n,p)N16	99.9
O-19	1.010	5.0	15.0	F19(n,p)O19	100.0
F-18	0.917	5.0	10.0	F19(n,2n)F18	100.0
Ne-23	1.190	5.0	20.0	Na23(n,p)Ne23	100.0
Ne-23	0.990	11.0	10.0	Mg26(n, $\alpha$ )Ne23	100.0
Na-24	1.351	40.0	45.0	Na23(n, $\gamma$ )Na24	63.8
			30.0	Na23(n, $\gamma$ )Na24m(IT)Na24	36.1
Na-24	1.163	11.0	61.0	Mg24(n,p)Na24	68.3
			61.0	Mg24(n,p)Na24m(IT)Na24	30.5
			170.0	Mg25(n,d)Na24	0.7
Na-25	1.000	11.0	11.0	Mg25(n,p)Na25	95.6
			200.0	Mg26(n,d)Na25	4.4
Mg-27	1.042	5.0	10.0	Al27(n,p)Mg27	100.0
Mg-27	1.042	8.0	10.0	Si30(n, $\alpha$ )Mg27	99.9
Al-28	1.099	9.0	5.0	Si28(n,p)Al28	99.5
Al-28	0.870	15.0	10.0	P31(n, $\alpha$ )Al28	100.0
Al-29	1.031	8.0	10.0	Si29(n,p)Al29	98.2
			190.0	Si30(n,d)Al29	1.7
Si-31	1.010	7.0	12.0	S34(n, $\alpha$ )Si31	53.8
			200.0	S32(n,2p)Si31	46.1
P-34	0.971	6.0	10.0	S34(n,p)P34	100.0
P-34	0.980	5.0	15.0	Cl37(n, $\alpha$ )P34	99.6
S-37	1.250	5.0	20.0	Cl37(n,p)S37	100.0
Cl-34m	1.429	5.0	30.0	Cl35(n,2n)Cl34m	100.0
Cl38	1.205	6.0	61.0	K41(n, $\alpha$ )Cl38	71.1
			61.0	K41(n, $\alpha$ )Cl38m(IT)Cl38	25.4
			210.0	K39(n,2p)Cl38	2.3
			210.0	K39(n,2p)Cl38m(IT)Cl38	1.1
K-38g	1.282	6.0	20.0	K39(n,2n)K38g	100.0
K-44	0.962	8.0	10.0	Ca44(n,p)K44	100.0
Ar-41	1.176	6.0	10.0	K41(n,p)Ar41	100.0
Sc-44g	1.075	5.0	15.0	Sc45(n,2n)Sc44g	99.9
Sc-48	1.053	5.0	10.0	Ti48(n,p)Sc48	99.1
			140.0	Ti49(n,d)Sc48	0.8
Sc-50	1.030	5.0	63.0	Ti50(n,p)Sc50	87.0
			63.0	Ti50(n,p)Sc50m(IT)Sc50	12.9
Ti-51	1.136	5.0	10.0	V51(n,p)Ti51	100.0
V-52	1.099	5.0	15.0	Mn55(n, $\alpha$ )V52	100.0
V-52 <sup>†</sup>	0.969	2.2	10.0	Cr52(n,p)V52	97.7
			130.0	Cr53(n,d)V52	2.3
Cr-49	0.513	5.0	7.0	Cr50(n,2n)Cr49	100.0
Cr-55	1.099	5.0	20.0	Mn55(n,p)Cr55	100.0
Mn-56	1.010	6.0	12.0	Mn55(n, $\gamma$ )Mn56	100.0
Mn-56	1.099	5.0	3.0	Fe56(n,p)Mn56	99.6
Mn-56	1.099	5.0	10.0	Co59(n, $\alpha$ )Mn56	100.0
Co-60m	0.917	6.0	30.0	Ni60(n,p)Co60m	98.9
			130.0	Ni61(n,d)Co60m	1.1
Co-62g	1.010	6.0	20.0	Ni62(n,p)Co62g	99.8
Co-62m <sup>†</sup>	0.963	5.0	20.0	Ni62(n,p)Co62m	100.0
Cu-62	1.075	5.0	5.0	Cu63(n,2n)Cu62	100.0
Zn-63	1.000	5.0	10.0	Zn64(n,2n)Zn63	100.0
Ga-68	1.099	5.0	10.0	Ga69(n,2n)Ga68	100.0
Ga-70	1.087	5.0	15.0	Ga71(n,2n)Ga70	98.9

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
			30.0	Ga69(n, $\gamma$ )Ga70	1.0
Ga-74	1.389	6.0	63.0	Ge74(n,p)Ga74	69.7
			63.0	Ge74(n,p)Ga74m(IT)Ge74	30.2
Ge-75	1.111	7.0	40.0	Ge76(n,2n)Ge75	33.3
			20.0	Ge76(n,2n)Ge75m(IT)Ge75	65.9
Ge-75	1.176	6.0	30.0	As75(n,p)Ge75	58.6
			30.0	As75(n,p)Ge75m(IT)Ge75	41.3
Ge-75m	1.266	7.0	20.0	Ge76(n,2n)Ge75m	99.6
Ge-75m	0.990	8.0	30.0	As75(n,p)Ge75m	100.0
Se77m	1.149	10.0	25.0	Se77(n,n')Se77m	16.7
			20.0	Se78(n,2n)Se77m	82.9
Se-81	1.299	7.0	20.0	Se82(n,2n)Se81	91.4
			20.0	Se82(n,2n)Se81m(IT)Se81	7.0
			43.0	Se80(n, $\gamma$ )Se81	1.4
Br-78	1.000	11.0	15.0	Br79(n,2n)Br78	100.0
Br-80g	1.163	11.0	20.0	Br81(n,2n)Br80g	93.3
			58.0	Br79(n, $\gamma$ )Br80g	5.6
Rb-84	1.020	5.0	30.0	Rb85(n,2n)Rb84	93.7
			30.0	Rb85(n,2n)Rb84m(IT)Rb84	6.2
Rb-86m	1.149	5.0	30.0	Rb87(n,2n)Rb86m	99.5
			45.0	Rb85(n, $\gamma$ )Rb86m	0.5
Rb-86m	1.010	5.0	20.0	Y89(n, $\alpha$ )Rb86m	100.0
Rb-88	0.962	5.0	15.0	Sr88(n,p)Rb88	100.0
Y-88	1.124	20.0	10.0	Y89(n,2n)Y88	100.0
Y-89m	1.000	5.0	15.0	Y89(n,n')Y89m	100.0
Y-89m	0.962	7.0	30.0	Nb93(n,n' $\alpha$ )Y89m	100.0
Y-90m	1.000	5.0	20.0	Nb93(n, $\alpha$ )Y90m	100.0
Y-94	1.031	5.0	20.0	Zr94(n,p)Y94	99.9
Zr-89m	1.220	5.0	20.0	Zr90(n,2n)Zr89m	100.0
Nb-94m	1.042	6.0	52.0	Nb93(n, $\gamma$ )Nb94m	100.0
Mo-91	1.333	5.0	20.0	Mo92(n,2n)Mo91	95.2
			20.0	Mo92(n,2n)Mo91m(IT)Mo91	4.7
Mo-91m	1.316	5.0	20.0	Mo92(n,2n)Mo91m	100.0
Tc-100	0.840	11.0	27.0	Ru100(n,p)Tc100	87.3
			150.0	Ru101(n,d)Tc100	12.6
Tc-102m	1.020	5.0	20.0	Ru102(n,p)Tc102m	99.9
Ru-95	0.980	5.0	10.0	Ru96(n,2n)Ru95	100.0
Rh-104	2.500	8.0	82.0	Rh103(n, $\gamma$ )Rh104	95.9
			74.0	Rh103(n, $\gamma$ )Rh104m(IT)Rh104	4.0
Rh-103m	3.846	18.0	10.0	Rh103(n,n')Rh103m	100.0
Rh-108m	1.316	6.0	30.0	Pd108(n,p)Rh108m	99.9
Pd-107m	1.282	5.0	20.0	Pd108(n,2n)Pd107m	99.7
Pd-109	1.149	6.0	20.0	Pd110(n,2n)Pd109	86.5
			20.0	Pd110(n,2n)Pd109m(IT)Pd109	9.6
			81.0	Pd108(n, $\gamma$ )Pd109	3.7
Pd-109m	1.266	6.0	20.0	Pd110(n,2n)Pd109m	99.5
Ag-106g	0.901	5.0	20.0	Ag107(n,2n)Ag106g	100.0
Ag-108g	1.111	6.0	20.0	Ag109(n,2n)Ag108g	95.4
			49.0	Ag107(n, $\gamma$ )Ag108g	4.5
Ag-114	1.053	5.0	67.0	Cd114(n,p)Ag114	36.0
			67.0	Cd114(n,p)Ag114m(IT)Ag114	64.0
Cd-111m	1.042	5.0	20.0	Cd111(n,n')Cd111m	11.8
			20.0	Cd112(n,2n)Cd111m	88.0
In-114g	1.205	5.0	10.0	In115(n,2n)In114g	99.5
In116(m+n)	2.632	5.0	22.0	In115(n, $\gamma$ )In116m	47.7
			93.0	In115(n, $\gamma$ )In116n(IT)In116m	52.7
In118(m+n)	1.042	6.0	20.0	Sn118(n,p)In118m	86.8
			20.0	Sn118(n,p)In118n(IT)In118m	12.2
			180.0	Sn119(n,d)In118m	0.8
In-120m	0.680	9.0	20.0	Sn120(n,p)In120m	100.0
Sn-123m	1.149	6.0	10.0	Sn124(n,2n)Sn123m	99.8

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Sb-120g	1.205	6.0	15.0	Sb121(n,2n)Sb120g	100.0
Te-129g	1.042	8.0	15.0	Te130(n,2n)Te129g	99.7
I-128	1.695	6.0	21.0	I127(n, $\gamma$ )I128	100.0
Cs-132	1.235	8.0	20.0	Cs133(n,2n)Cs132	100.0
Cs-138	1.099	10.0	61.0	Ba138(n,p)Cs138	78.9
			61.0	Ba138(n,p)Cs138m(IT)Cs138	21.0
Ba-137m	1.176	8.0	15.0	Ba138(n,2n)Ba137m	97.0
			30.0	Ba137(n,n')Ba137m	2.9
Ba-137m	1.042	6.0	30.0	Ce140(n, $\alpha$ )Ba137m	100.0
Ba-139	1.163	40.0	18.0	La139(n,p)Ba139	100.0
La-142	1.053	10.0	17.0	Ce142(n,p)La142	100.0
Ce-139m	1.042	6.0	20.0	Ce140(n,2n)Ce139m	100.0
Pr-140	1.370	8.0	15.0	Pr141(n,2n)Pr140	100.0
Nd-141m	1.333	13.0	20.0	Nd142(n,2n)Nd141m	100.0
Nd-149	1.818	14.0	10.0	Nd150(n,2n)Nd149	99.3
			43.0	Nd148(n, $\gamma$ )Nd149	0.6
Sm143	1.111	11.0	20.0	Sm144(n,2n)Sm143	64.1
			20.0	Sm144(n,2n)Sm143m(IT)Sm143	35.8
Sm-143m	1.136	11.0	20.0	Sm144(n,2n)Sm143m	100.0
Eu-152m	1.613	15.0	19.0	Eu151(n, $\gamma$ )Eu152m	53.5
			10.0	Eu153(n,2n)Eu152m	46.4
Eu-160	0.885	25.0	30.0	Gd160(n,p)Eu160	100.0
Gd-159	1.205	19.0	8.0	Gd160(n,2n)Gd159	98.5
			39.0	Gd158(n, $\gamma$ )Gd159	1.4
Gd-159	1.042	941.0	20.0	Tb159(n,p)Gd159	100.0
Gd-161	1.818	19.0	36.0	Gd160(n, $\gamma$ )Gd161	100.0
Tb-158m	1.351	174.0	20.0	Tb159(n,2n)Tb158m	100.0
Tb-162	1.667	13.0	12.0	Dy162(n,p)Tb162	89.3
			180.0	Dy163(n,d)Tb162	10.4
Tb-164	1.515	11.0	18.0	Dy164(n,p)Tb164	100.0
Dy-165	2.778	22.0	38.0	Dy164(n, $\gamma$ )Dy165	47.9
			40.0	Dy164(n, $\gamma$ )Dy165m(IT)Dy165	52.0
Dy-165m	1.351	14.0	40.0	Dy164(n, $\gamma$ )Dy165m	100.0
Ho-164	1.190	14.0	20.0	Ho165(n,2n)Ho164	97.3
			20.0	Ho165(n,2n)Ho164m(IT)Ho164	2.6
Ho-164m	1.136	14.0	20.0	Ho165(n,2n)Ho164m	100.0
Ho-168	1.020	10.0	14.0	Er168(n,p)Ho168	99.7
Er-165	4.545	37.0	20.0	Er166(n,2n)Er165	99.6
Tm-168	0.877	20.0	8.0	Tm169(n,2n)Tm168	100.0
Tm-174	1.235	20.0	15.0	Yb174(n,p)Tm174	99.8
Yb-167	1.124	72.0	15.0	Yb168(n,2n)Yb167	100.0
Lu-176m	1.190	20.0	20.0	Lu175(n, $\gamma$ )Lu176m	88.8
			100.0	Lu176(n,n')Lu176m	11.1
Lu-180	1.961	6.0	30.0	Hf180(n,p)Lu180	100.0
Hf-179m	0.990	6.0	93.0	Hf178(n, $\gamma$ )Hf179m	12.0
			20.0	Hf180(n,2n)Hf179m	82.5
			50.0	Hf179(n,n')Hf179m	5.4
Ta-180g	0.990	13.0	20.0	Ta181(n,2n)Ta180g	99.9
W-185m	1.852	13.0	20.0	W186(n,2n)W185m	99.9
Ta-186	2.041	13.0	14.0	W186(n,p)Ta186	100.0
W-185m	1.149	11.0	67.0	Re185(n,p)W185m	96.8
			85.0	Re187(n,t)W185m	3.1
Re-186g	1.149	8.0	63.0	Re185(n, $\gamma$ )Re186g	4.4
			15.0	Re187(n,2n)Re186g	95.5
Os-190m	2.439	5.0	75.0	Os190(n,n')Os190m	93.0
			90.0	Os192(n,3n)Os190m	6.8
Ir192m	1.961	17.0	61.0	Ir191(n, $\gamma$ )Ir192m	18.2
			20.0	Ir193(n,2n)Ir192m	81.7
Pt-197m	1.163	6.0	20.0	Pt198(n,2n)Pt197m	99.4
			48.0	Pt196(n, $\gamma$ )Pt197m	0.5
Au-195m	1.266	6.0	63.0	Au197(n,3n)Au195m	100.0

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Au-196m	1.099	11.0	20.0	Au197(n,2n)Au196m	100.0
Au-196n	1.370	5.0	20.0	Au197(n,2n)Au196n	100.0
Au-197m	1.667	12.0	15.0	Au197(n,n')Au197m	100.0
Hg-199m	0.877	8.0	15.0	Hg199(n,n')Hg199m	9.1
			20.0	Hg200(n,2n)Hg199m	90.6
Hg-205	0.787	5.0	25.0	Tl205(n,p)Hg205	100.0
Tl-202	1.205	13.0	15.0	Tl203(n,2n)Tl202	100.0
Tl-206	0.794	5.0	120.0	Tl205(n, $\gamma$ )Tl206	99.9
Tl-206	1.408	13.0	50.0	Bi209(n, $\alpha$ )Tl206	99.5
Tl-208	0.704	5.0	20.0	Pb208(n,p)Tl208	100.0
Pb-203m	0.658	5.0	25.0	Pb204(n,2n)Pb203m	99.1
Pb-204m	1.064	26.0	20.0	Pb204(n,n')Pb204m	100.0
Pb-209	1.190	90.0	38.0	Bi209(n,p)Pb209	100.0

**Table 9.** JAERI results for various materials, 7 hour irradiation (revised)

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Na-22	0.704	5.0	20.0	Na23(n,2n)Na22	100.0
Na-24	1.136	13.0	50.0	Na23(n, $\gamma$ )Na24	73.5
			49.0	Na23(n, $\gamma$ )Na24m(IT)Na24	26.5
Na-24	0.990	6.0	60.0	Al27(n, $\alpha$ )Na24	69.1
			60.0	Al27(n, $\alpha$ )Na24m(IT)Na24	30.9
P-32	0.980	7.0	10.0	S32(n,p)P32	99.4
K-42	0.794	21.0	48.0	K41(n, $\gamma$ )K42	100.0
K-42	0.833	8.0	10.0	Ca42(n,p)K42	97.3
			120.0	Ca43(n,d)K42	2.7
Ca-47	0.885	18.0	10.0	Ca48(n,2n)Ca47	99.9
Sc-46	0.926	5.0	20.0	Ti46(n,p)Sc46	67.5
			10.0	Ti46(n,p)Sc46m(IT)Sc46	17.5
			130.0	Ti47(n,d)Sc46	12.7
			130.0	Ti47(n,d)Sc46m(IT)Sc46	2.3
Sc-48	0.935	5.0	10.0	Ti48(n,p)Sc48	99.4
Sc-48	0.909	5.0	6.0	V51(n, $\alpha$ )Sc48	100
Cr-51	1.075	5.0	5.0	Cr52(n,2n)Cr51	99.9
Mn-54	1.023	5.0	10.0	Mn55(n,2n)Mn54	100.0
Mn-54 <sup>†</sup>	0.967	6.0	10.0	Fe54(n,p)Mn54	99.8
Mn-56	0.980	5.0	46.0	Mn55(n, $\gamma$ )Mn56	100.0
Mn-56	0.971	5.0	3.0	Fe56(n,p)Mn56	99.7
Co-57 <sup>†</sup>	0.974	5.0	11.0	Ni58(n,n'p)Co57	99.6
Co-58 <sup>†</sup>	1.025	5.0	30.0	Ni58(n,p)Co58	83.0
			30.0	Ni58(n,p)Co58m(IT)Co58	17.0
Co-58	0.917	5.0	40.0	Co59(n,2n)Co58	65.4
			20.0	Co59(n,2n)Co58m(IT)Co58	34.6
Co-58m	1.370	5.0	20.0	Co59(n,2n)Co58m	100.0
Co-60	0.935	8.0	30.0	Cu63(n, $\alpha$ )Co60	76.6
				Cu63(n, $\alpha$ )Co60m(IT)Co60	23.1
Ni-57 <sup>†</sup>	1.010	5.0	5.0	Ni58(n,2n)Ni57	100.0
Cu-64	1.010	5.0	8.0	Cu65(n,2n)Cu64	99.2
Sr-83	1.020	5.0	61.0	Sr84(n,2n)Sr83	85.0
			61.0	Sr84(n,2n)Sr83m(IT)Sr83	15.0
Sr-85	0.971	15.0	40.0	Sr86(n,2n)Sr85	83.6
			40.0	Sr86(n,2n)Sr85m(IT)Sr85	16.4
Sr-87m	0.885	5.0	10.0	Sr88(n,2n)Sr87m	96.6
			20.0	Sr87(n,n')Sr87m	3.4
Y-88	0.855	6.0	10.0	Y89(n,2n)Y88	100.0
Zr-89	0.971	6.0	20.0	Zr90(n,2n)Zr89	82.6
				Zr90(n,2n)Zr89m(IT)Zr89	17.4
Zr-95	0.926	5.0	5.0	Zr96(n,2n)Zr95	99.5
Zr-95	0.741	19.0	10.0	Mo98(n, $\alpha$ )Zr95	100.0
Nb-91m	0.741	19.0	40.0	Mo92(n,n'p)Nb91m	89.5

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
			20.0	Mo92(n,2n)Mo91m( $\beta^-$ )Nb91m	10.3
Nb-92m	0.962	5.0	10.0	Nb93(n,2n)Nb92m	100.0
Nb-92m	0.943	5.0	20.0	Mo92(n,p)Nb92m	99.9
Nb-95g	1.205	9.0	20.0	Mo95(n,p)Nb95g	90.3
			100.0	Mo96(n,d)Nb95g	8.7
Mo-99	0.962	5.0	8.0	Mo100(n,2n)Mo99	99.4
Sn-117m	0.806	11.0	20.0	Sn118(n,2n)Sn117m	93.4
			30.0	Sn117(n,n')Sn117m	6.4
Sn-119m	1.124	20.0	30.0	Sn120(n,2n)Sn119m	93.9
			100.0	Sn119(n,n')Sn119m	5.9
Sn-123g	0.952	10.0	20.0	Sn124(n,2n)Sn123g	99.9
Ba-131	0.943	51.0	20.0	Ba132(n,2n)Ba131	35.7
			20.0	Ba132(n,2n)Ba131m(IT)Ba131	63.6
Ba-133m	1.075	14.0	15.0	Ba134(n,2n)Ba133m	99.9
Ba-135m	1.080	14.0	10.0	Ba136(n,2n)Ba135m	85.5
			20.0	Ba135(n,n')Ba135m	14.4
Ta-180g	1.408	10.0	20.0	Ta181(n,2n)Ta180g	99.9
Hf-181	0.735	21.0	15.0	Ta181(n,p)Hf181	100.0
Ta-182	0.735	21.0	47.0	Ta181(n, $\gamma$ )Ta182	79.4
			50.0	Ta181(n, $\gamma$ )Ta182m(IT)Ta182	20.1
Ta-184	1.136	7.0	10.0	W184(n,p)Ta184	99.8
W-181	1.220	14.0	8.0	W182(n,2n)W181	99.6
W-185	1.220	14.0	20.0	W186(n,2n)W185	60.0
			20.0	W186(n,2n)W185m(IT)W185	39.8
Re-184g	0.855	5.0	15.0	Re185(n,2n)Re184g	99.9
Re-184m	0.917	6.0	20.0	Re185(n,2n)Re184m	100.0
Re-186g	1.111	9.0	15.0	Re187(n,2n)Re186g	99.6
Pb203	0.943	5.0	25.0	Pb204(n,2n)Pb203	49.2
			25.0	Pb204(n,2n)Pb203m(IT)Pb203	50.3
Hg-203	0.317	63.0	24.0	Pb206(n, $\alpha$ )Hg203	99.0
			200.0	Pb207(n,n' $\alpha$ )Hg203	1.0

## 4.9. High energy data

### 4.9.1. Řež measurements of chromium

The measurements at Řež on chromium [42,43] have been analysed using the EAF-2007 library and the C/E and pathway data are shown in Table 10 and Table 11 for irradiation in the rez\_DF spectrum. Table 10 shows results for the short irradiation (11.3 min) and Table 11 results for the long irradiation (89.2 min).

**Table 10.** Řež results for chromium (short irradiation)

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Sc-48	0.749	20.0	200.0	Cr-52(n, $\alpha$ )Sc-48	99.9
				Cr-50(n,3p)Sc-48	0.1
Ti-51	1.728	3.0	94.7	Cr-54(n, $\alpha$ )Ti-51	49.3
				Cr-52(n,2p)Ti-51	48.2
V-52	1.279	4.6	49.6	Cr-52(n,p)V-52	90.6
				Cr-53(n,d)V-52	9.2
V-53	2.285	48.2	23.3	Cr-53(n,p)V-53	81.2
				Cr-54(n,d)V-53	18.8
Cr-48	2.003	50.0	200.0	Cr-50(n,3n)Cr-48	100.0
Cr-49	0.977	2.0	5.4	Cr-50(n,2n)Cr-49	100.0
Cr-51	1.181	2.0	4.5	Cr-52(n,2n)Cr-51	98.4
				Cr-50(n, $\gamma$ )Cr-51	1.6

**Table 11.** Řež results for chromium (long irradiation)

Product	C/E	$\delta$ (%)	$\Delta$ (%)	Pathway	(%)
Sc-46	0.476	4.0	208.3	Cr-50(n,p $\alpha$ )Sc-46	81.7
				Cr-50(n,p $\alpha$ )Sc-46m(IT)Sc-46	18.3
Sc-48	0.616	10.0	200.0	Cr-52(n,p $\alpha$ )Sc-48	99.9
				Cr-50(n,3p)Sc-48	0.1
V-48	1.704	5.0	170.7	Cr-50(n,t)V-48	99.9
Cr-48	2.461	8.0	200.0	Cr-50(n,3n)Cr-48	100.0
Cr-49	0.793	6.0	5.4	Cr-50(n,2n)Cr-49	100.0
Cr-51	1.031	2.0	4.5	Cr-52(n,2n)Cr-51	98.4
				Cr-53(n,3n)Cr-51	1.4

## 5. Effective cross sections and discussion

In the tables given above it can be seen that for many of the product nuclides a single pathway dominates the production. In such cases (and also for some others – see following section) it is possible to extract an effective cross section (cross section averaged in the neutron spectrum) that can be used directly in SAFEPAQ-II. During EAF library development, as the cross sections are adjusted, it is possible to see the change of the effective values in the spectra of interest. These values can be compared with the experimental values and the library cross sections can be adjusted to improve the C/E values. Values of effective cross sections (Table 12) and graphs for EAF-2007 are shown below. Values of C/E taken from Tables 1-11 are also included. The Quality score is a value from 0 to 6 indicating the degree to which the EAF data are backed up by experiment. 0 = no experimental data, 1 = weak disagreement with differential data, 2 = weak agreement with differential data, 3 = strong disagreement with differential data, 4 = strong agreement with differential data, 5 = conflicting differential and integral data, 6 = agreement between differential and integral data (validated).

### 5.1. Formalism for effective cross sections

In reference 2 a formula was derived that enabled measurements to be used even if a nuclide was produced by several reactions in parallel. If a single reaction produces all the nuclide of interest then the ratio of measured to predicted quantities ( $r$ ) is identical to the ratio of effective cross sections ( $k$ ). If a pathway produces a fraction  $f$  of the nuclide, then it was shown that the relationship between  $k$  and  $r$  is given by equation 2. Reaction fractions and cross sections (except for the reaction studied) are fixed (to library values) in the calculation. The uncertainty of this procedure is not taken into account in the analysis.

$$k = \frac{rf}{1 - r(1 - f)} \quad (2)$$

This equation is used to extract the effective cross sections listed in the tables above.



**Table 12.** Summary of reactions with integral data

**Reaction (bold), spectrum (bold)** - new integral data not available for validation of EAF-2005.

**Reaction (bold)** - new or modified data compared to EAF-2005.1 in EAF-2007, the earlier C/E value (from EAF-2005) is shown in the Comment column for comparison as C/E(5) if it differs from the present value.

**(n,t) and (n,h) data** - Data from all three d-Be spectra are treated as pure (n,t) and (n,h) reactions with corresponding (n,xt) for tritium counting and (n,t+) and (n,h+) for activation data. The latter C/E's are shown in the Comment column. For pairs of reactions, the one that has cross section data shown is indicated by *italics*.

**(n,n'p) and (n,d) data** - For most reactions  $\sigma(n,n'p) > \sigma(n,d)$  and (n,n'p) data are show. The (n,d+) C/E's are given in the Comment column. For pairs of reactions, the one with cross section data shown is printed in *italics*.

**d\_Be2a data** - Cross sections measured with d\_Be2 spectrum have been increased by a factor of 2.15, as described in the text.

**QS** - the Quality Score, scores in (brackets) are not used as the total cross section (FS=99) is measured in the integral experiment and only partial data (FS=0,1or 2) exist in the EAF data file. QS\* indicates that the score differs from the value given in the distributed EAF-2007 file due to new experimental data obtained after the library release or errors in EAF-2007.

**Spectrum** - the irradiation spectrum.

C/E<sup>†</sup> indicates that the integral data should be disregarded.

**Comment** - Comments on QS = 5 assignments: [5<sub>0</sub>] = differential data are missing and unsatisfactory agreement with integral data. [5<sub>1</sub>] = unsatisfactory agreement with differential and integral data. [5<sub>2</sub>] = satisfactory agreement with differential and unsatisfactory agreement with integral data. [5<sub>3</sub>] = differential data are missing and satisfactory agreement with integral data. [5<sub>4</sub>] = unsatisfactory agreement with differential data and satisfactory agreement with integral data.

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
<b>Li-7(n,n<math>\alpha</math>)</b>	5	d-Be	3.92E-01	6.50E-02	0.418	C/E(5) = 0.661 [5 <sub>3</sub> ]
Be-9(n,t)/(n,xt)	5	d-Be	4.40E-02	1.20E-02	0.531	/0.616 [5 <sub>2</sub> ]
B-10(n,t)	6	cf252_flux_1	5.00E-02	2.50E-02	1.093	
<b>B-11(n,t)/(n,xt)</b>	5	d-Be	7.09E-02	1.18E-02	0.131	/0.227 C/E(5) = 0.140 [5 <sub>2</sub> ]
C-12(n,t)/(n,xt)	5	d-Be	8.60E-03	2.40E-03	0.562	/1.072 [5 <sub>3</sub> ]
N-14(n,2n)	6	fns_5min	6.62E-03	9.94E-04	1.053	C/E(5) = 0.863
<b>N-14(n,<math>\gamma</math>)</b>	5	cf252_flux_1	4.80E-06	2.40E-06	26.92	[5 <sub>2</sub> ]
<b>N-14(n,t)/(n,xt)</b>	5	d-Be	3.00E-02	8.00E-03	0.311	/0.546 C/E(5) = 0.316 [5 <sub>2</sub> ]/6
<b>O-16(n,p)</b>	6	fns_5min	3.23E-02	8.45E-04	1.019	C/E(5) = 1.000
O-16(n,t)/(n,xt)	5	d-Be	8.47E-03	1.49E-03	0.492	/0.791 [5 <sub>2</sub> ]/6
<b>F-19(n,2n)</b>	6	fns_5min	4.78E-02	2.39E-03	0.917	C/E(5) = 0.911
		cf252_flux_1	1.08E-05	1.60E-06	1.639 <sup>†</sup>	
		cf252_flux_1	1.63E-05	5.00E-07	1.086	
F-19(n,p)	6	fns_5min	1.62E-02	8.11E-04	1.010	C/E(5) = 1.064
F-19(n,t)/(n,xt)	5	d-Be	2.70E-02	6.00E-03	0.255	/0.842 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ne-20(n,t)/(n,xt)	5	d-Be	6.82E-03	1.50E-03	0.457	/0.833 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ne-20(n,t)/(n,t+)	5	d-Be	7.50E-03	1.50E-03	0.414	/1.932 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
<b>Na-23(n,2n)</b>	6	fns_7hour	3.90E-02	1.95E-03	0.704 <sup>†</sup>	C/E(5) = 0.861
		fzk_1	4.60E-03	2.76E-03	1.080	C/E(5) = 1.286
Na-23(n, $\gamma$ )	(6)	cf252_flux_1	3.35E-04	1.50E-05	0.639	
		<b>fns_7hour</b>	3.09E-04	4.01E-05	1.033	
		<b>fns_5min</b>	2.92E-04	1.17E-04	1.352	
<b>Na-23(n,p)</b>	6*	fns_5min	3.03E-02	1.51E-03	1.190	C/E(5) = 1.429
<b>Na-23(n,t)/(n,xt)</b>	5*	d-Be	1.45E-02	2.5E-03	0.649	/0.951 C/E(5) = 0.650 [5 <sub>2</sub> ]/6
<b>Mg-24(n,p)</b>	(5)*	fns_5min	1.57E-01	1.73E-02	1.165	C/E(5) = 1.088 [5 <sub>2</sub> ]
		cf252_flux_1	1.94E-03	9.29E-05	1.347	C/E(5) = 1.131
		cf252_flux_1	2.01E-03	6.00E-05	1.300	C/E(5) = 1.091
Mg-24(n,t)/(n,xt)	5	d-Be	4.38E-03	8.11E-04	0.447	/0.697 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Mg-24(n,t)/(n,t+)	5*	<b>d-Be</b>	6.90E-03	1.00E-03	0.279	/2.571 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Mg-25(n,p)	6	fns_5min	5.71E-02	6.29E-03	1.000	C/E(5) = 1.148
Mg-26(n, $\alpha$ )	6*	fns_5min	5.27E-02	5.80E-03	0.990	C/E(5) = 1.504
		fng_heat	8.69E-02	9.56E-03	0.622 <sup>†</sup>	
Al-27(n,p)	6	fns_5min	5.71E-02	2.86E-03	1.074	
		cf252_flux_1	4.89E-03	1.79E-04	0.962	
		cf252_flux_1	4.80E-03	9.00E-05	0.980	
<b>Al-27(n,t)/(n,xt)</b>	6	d-Be3	1.40E-03	4.20E-04	1.090	/1.189 C/E(5) = 1.081
		d-Be3	1.51E-03	3.00E-04	1.011	/1.103 C/E(5) = 1.002
		d-Be	7.80E-03	1.20E-03	0.557	/0.951 C/E(5) = 0.546
<b>Al-27(n,h)/(n,h+)</b>	5	d-Be2a	3.18E-03	5.80E-04	0.157	/0.560 C/E(5) = 0.089

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		d-Be2a	2.80E-03	5.60E-04	0.178	/0.636 C/E(5) =0.100
Al-27(n, $\alpha$ )	(6)	fzk_1	3.40E-02	6.80E-03	0.876	C/E(5) =1.044 C/E(5) =1.253 C/E(5) =0.741 C/E(5) =1.187 C/E(5) =0.226
		fng_vanad	9.46E-02	8.92E-03	0.869	
		sneg_1	1.25E-01	2.25E-02	0.874	
		sneg_2	1.35E-01	2.29E-02	0.870	
		fng_f82h	6.66E-02	6.86E-03	1.470 <sup>†</sup>	
		cf252_flux_1	1.01E-03	2.20E-05	1.043	
		cf252_flux_1	8.60E-04	5.00E-05	1.220	
		rez_DF	2.47E-02	2.90E-04	1.260	
		d-Be2a	4.45E-02	6.45E-03	0.757	
		d-Be3	4.50E-02	8.00E-03	1.189	
rez_DF	1.37E-01	2.65E-03	0.227 <sup>†</sup>			
fns_7hour	1.11E-01	6.63E-03	0.990			
Al-27(n,2n $\alpha$ )	5	rez_DF	3.76E-05	7.52E-06	0.331	[5 <sub>3</sub> ]
Si-28(n,p)	6	fns_5min	1.94E-01	1.75E-02	1.099	C/E(5) =1.078
		fng_SiC	2.10E-01	6.29E-03	0.993	
		fzk_1	6.30E-02	1.57E-02	1.529	
		sneg_1	2.79E-01	1.24E-02	0.817	
		cf252_flux_1	7.12E-03	2.35E-04	1.035	
		cf252_flux_1	9.66E-03	5.50E-04	0.763 <sup>†</sup>	
Si-28(n,t)/(n,xt)	(5)	d-Be	3.75E-03	8.23E-04	0.330	/0.582 C/E(5) =0.392 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Si-29(n,p)	6	fns_5min	1.13E-01	9.05E-03	1.032	C/E(5) =1.047
		fng_SiC	1.16E-01	5.79E-03	0.989	
		fzk_1	3.20E-02	4.80E-03	1.213	
		sneg_1	1.32E-01	4.11E-03	0.970	
		cf252_flux_1	1.79E-03	7.90E-04	2.028	
Si-29(n,2p)	5	fzk_1	8.60E-06	1.03E-06	0.403	[5 <sub>4</sub> ]
Si-30(n,p)	6	sneg_1	7.35E-02	3.27E-03	0.912	
Si-30(n, $\alpha$ )	6	fns_5min	5.93E-02	4.74E-03	1.042	
		fng_SiC	5.47E-02	2.19E-03	1.114	
		sneg_1	7.36E-02	4.42E-03	0.949	
P-31(n,p)	6	cf252_flux_1	3.35E-02	2.00E-03	0.918	
P-31(n,t)/(n,xt)	5	d-Be	7.80E-03	1.2E-03	0.763	/1.208 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
P-31(n,h)/(n,h <sup>+</sup> )	5	d-Be2a	2.88E-03	5.80E-04	0.234	/1.186 C/E(5) =2.049 [5 <sub>1</sub> ]/[5 <sub>4</sub> ]
P-31(n, $\alpha$ )	6	fns_5min	1.21E-01	1.81E-02	0.870	C/E(5) =0.865
		d-Be2a	3.74E-02	6.45E-03	0.950	C/E(5) =0.944
P-31(n,2 $\alpha$ )	(5)	d-Be2a	6.45E-05	2.15E-05	10.30	C/E(5) =9.223 [5 <sub>0</sub> ]
S-32(n,p)	6	fns_7hour	2.25E-01	1.57E-02	0.980	C/E(5) =0.952
		cf252_flux_1	6.46E-02	3.80E-03	1.164	C/E(5) =1.092
		cf252_flux_1	7.25E-02	2.95E-03	1.037	C/E(5) =0.973
		cf252_flux_1	6.84E-02	3.42E-04	1.099	C/E(5) =1.031
S-32(n,t)/(n,xt)	5	d-Be	4.13E-03	7.86E-04	0.608	/1.114 C/E(5) =0.552 [5 <sub>2</sub> ]/6
S-34(n,p)	6*	fns_5min	7.23E-02	4.34E-03	0.971	
S-34(n, $\alpha$ )	6	fns_5min	1.16E-01	8.13E-03	1.019	C/E(5) =0.863
Cl-35(n,2n)m	5*	fns_5min	6.32E-03	3.16E-04	1.429	C/E(5) =1.103 [5 <sub>2</sub> ]
Cl-35(n,t)/(n,xt)	5	d-Be	7.61E-03	1.52E-03	0.684	/1.104 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Cl-37(n,p)	6*	fns_5min	1.79E-02	8.94E-04	1.250	C/E(5) =1.251
Cl-37(n, $\alpha$ )	6	fns_5min	2.75E-02	1.37E-03	0.980	C/E(5) =1.087
Ar-40(n,t)/(n,xt)	(5)	d-Be	5.20E-03	1.20E-03	0.425	/0.972 C/E(5) =0.428 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ar-40(n,t)/(n,t <sup>+</sup> )	(5)	d-Be	1.90E-02	5.00E-03	0.116	/1.342 C/E(5) =0.117 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
K-39(n,2n)g	6*	fns_5min	4.93E-03	2.96E-04	1.282	C/E(5) =1.329
K-39(n,2 $\alpha$ )	5	d-Be2a	2.15E-04	1.08E-04	14.15	[5 <sub>1</sub> ]
K-41(n, $\gamma$ )	6*	fns_7hour	9.95E-04	2.09E-04	0.794	
K-41(n,h)/(n,h <sup>+</sup> )	5	d-Be2a	1.44E-03	4.30E-04	0.329	/0.583 C/E(5) =4.313 [5 <sub>1</sub> ]/[5 <sub>4</sub> ]
K-41(n,p)	6*	fns_5min	3.63E-02	2.18E-03	1.176	
K-41(n, $\alpha$ )	(5)	fns_5min	2.38E-02	1.43E-03	1.214	C/E(5) =1.095 [5 <sub>2</sub> ]
Ca-40(n,t)/(n,xt)	(5)	d-Be	4.94E-03	8.24E-04	0.338	/0.684 C/E(5) =15.41 [5 <sub>1</sub> ]/[5 <sub>4</sub> ]
Ca-40(n,t)/(n,t <sup>+</sup> )	(5)	d-Be	9.50E-03	1.50E-03	0.176	/1.345 C/E(5) =8.027 [5 <sub>1</sub> ]/[5 <sub>4</sub> ]
Ca-40(n,h)/(n,h <sup>+</sup> )	5	d-Be2a	6.02E-03	1.20E-03	0.460	/19.872 C/E(5) =0.156 [5 <sub>3</sub> ]/[5 <sub>0</sub> ]
Ca-42(n,p)	5*	fns_7hour	2.07E-01	1.65E-02	0.829	[5 <sub>3</sub> ]
Ca-44(n,p)	6	fns_5min	3.76E-02	3.01E-03	0.962	C/E(5) =1.042

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
Ca-44(n,t)/(n,t+)	5	d-Be	2.10E-02	4.00E-03	0.094	/1.376 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ca-48(n,2n)	6	fns_7hour	9.03E-01	1.63E-01	0.885	C/E(5)=0.847
Sc-45(n,2n)g	5	fns_5min fng_ScSmGd	1.69E-01 1.19E-01	8.43E-03 3.81E-04	1.075 1.630	[5 <sub>2</sub> ]
Sc-45(n,2n)m	6*	fng_ScSmGd	1.09E-01	5.11E-03	1.090	
Sc-45(n,h)/(n,h+)	5	d-Be2a d-Be2a	1.87E-03 3.18E-03	4.30E-04 6.35E-04	0.390 0.230	/1.144 C/E(5)=64.22 [5 <sub>1</sub> ]/[5 <sub>4</sub> ] /0.673 C/E(5)=37.80
Sc-45(n, $\alpha$ )	6*	fng_ScSmGd d-Be2a	4.74E-02 1.38E-02	4.13E-03 2.37E-03	1.100 1.379 <sup>†</sup>	C/E(5)=1.370
Ti-46(n,2n)	6	sneg_1 cf252_flux_1	5.82E-02 9.30E-05	7.57E-03 3.10E-05	1.106 0.150 <sup>†</sup>	C/E(5)=1.150 C/E(5)=0.156
Ti-46(n,n't)	5	fzk_ss316	1.97E-03	5.11E-04	0.031	[5 <sub>0</sub> ]
Ti-46(n,p)g	6	fns_7hour	2.18E-01	1.09E-02	0.826	
Ti-46(n,p)	(6)	fzk_2 cf252_flux_1 cf252_flux_1 cf252_flux_1 cf252_flux_1 rez_DF sneg_1 fng_vanad fzk_1 d-Be3 fns_7hour	1.21E-01 1.38E-02 1.36E-02 1.24E-02 1.39E-02 6.07E-02 4.31E-01 1.03E-01 8.10E-02 1.26E-01 2.48E-01	1.32E-02 3.00E-04 1.21E-03 1.20E-03 1.21E-03 1.82E-03 3.58E-02 6.29E-03 1.10E-02 2.40E-02 1.24E-02	0.909 0.976 0.990 1.086 0.969 1.713 <sup>†</sup> 0.519 1.673 <sup>†</sup> 1.349 1.168 0.914	C/E(5)=1.717           C/E(5)=1.169
Ti-46(n,t)g	5	fzk_ss316	4.35E-03	6.05E-04	0.089	C/E(5)=6.018 [5 <sub>1</sub> ]
Ti-46(n,t)m	5	fzk_ss316	2.59E-03	7.25E-04	0.042	C/E(5)=2.226 [5 <sub>1</sub> ]
Ti-47(n,3n)	5	d-Be3	1.10E-03	2.50E-04	0.736	[5 <sub>3</sub> ]
Ti-47(n,p)	6	cf252_flux_1 cf252_flux_1 cf252_flux_1 cf252_flux_1 cf252_flux_1	2.03E-02 1.89E-02 1.94E-02 2.20E-02 2.16E-02	1.10E-03 4.00E-04 9.70E-05 9.00E-04 1.18E-03	1.010 1.085 1.057 0.932 0.949	
Ti-48(n,p)	6	fns_7hour fns_5min fng_heat cf252_flux_1 cf252_flux_1 cf252_flux_1 fzk_ss316 fzk_1	6.31E-02 5.23E-02 8.53E-02 4.20E-04 4.17E-04 3.80E-04 9.52E-03 4.61E-03	3.16E-03 2.61E-03 1.15E-02 1.00E-05 1.59E-05 2.00E-05 6.32E-04 4.61E-04	0.935 1.053 0.666 0.959 0.966 1.060 2.099 <sup>†</sup> 2.806 <sup>†</sup>	C/E(5)=0.925 C/E(5)=1.077       C/E(5)=2.118
Ti-48(n,n'p)/(n,d+)	5*	fzk_ss316	1.37E-01	3.24E-03	0.296	/0.352 [5 <sub>0</sub> ]/[5 <sub>2</sub> ]
Ti-48(n,t)g/(n,t+)	5	d-Be	1.16E-02	1.50E-03	0.126	/2.265 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ti-48(n,t)m/(n,t+)m	5	d-Be	8.20E-03	1.00E-03	0.058	/0.799 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ti-48(n,t)/(n,xt)	(5)	d-Be d-Be3	9.61E-04 7.03E-05	2.29E-04 2.05E-05	2.939 2.896	/3.239 [5 <sub>0</sub> ]/[5 <sub>3</sub> ] /2.911
Ti-49(n,p)	6	fng_heat	2.36E-02	4.25E-03	1.369	
Ti-50(n,p)	(6)	fns_5min fng_heat	1.33E-02 1.34E-02	6.65E-04 2.43E-03	0.971 1.004	C/E(5)=0.901 C/E(5)=0.985
Ti-50(n, $\alpha$ )	5	fng_vanad	9.19E-03	2.05E-03	0.714	[5 <sub>2</sub> ]
V-51(n,4n)	5	fzk_ss316 fzk_ss316	3.65E-04 3.15E-04	1.47E-05 1.25E-05	0.580 0.673	[5 <sub>3</sub> ]
V-51(n,n' $\alpha$ )	6	fzk_ss316 d-Be2a d-Be3 rez_DF	5.33E-03 9.03E-03 3.50E-03 4.58E-03	1.27E-04 2.15E-03 8.00E-04 6.01E-05	1.333 2.792 <sup>†</sup> 1.144 1.300	C/E(5)=0.255 C/E(5)=0.534 C/E(5)=0.218 C/E(5)=0.248
V-51(n, $\gamma$ )	6	fng_vanad sneg_1 cf252_flux_1	6.53E-02 1.60E-03 2.80E-03	3.98E-03 2.40E-04 3.00E-04	1.045 0.376 <sup>†</sup> 0.748	
V-51(n,p)	6	fns_5min fng_vanad sneg_1 cf252_flux_1	2.36E-02 2.01E-02 2.75E-02 7.10E-04	1.18E-03 1.11E-03 1.92E-03 1.10E-04	1.136 1.094 1.071 1.000	

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		cf252_flux_1	9.30E-04	1.00E-04	0.763	
		cf252_flux_1	7.13E-04	5.88E-05	0.996	
<b>V-51(n,t)/(n,xt)</b>	6	d-Be3	5.00E-04	1.50E-04	0.839	/0.922 C/E(5)=0.793
		d-Be	4.40E-03	1.00E-03	0.648	/1.092 C/E(5)=0.579
<b>V-51(n,h)/(n,h+)</b>	5	d-Be2a	1.59E-03	4.30E-04	0.319	/0.469 C/E(5)=0.095 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
		d-Be2a	1.34E-03	2.69E-04	0.378	/0.555 C/E(5)=0.112
		d-Be3	2.50E-04	8.00E-05	0.085	/0.089 C/E(5)=0.029
<b>V-51(n,<math>\alpha</math>)</b>	6	fns_7hour	1.72E-02	8.62E-04	0.909	C/E(5)=0.901
		fng_f82h	1.67E-02	4.00E-03	0.879	
		sneg_1	1.70E-02	6.38E-04	1.034	
		sneg_2	1.59E-02	7.39E-04	1.008	
		cf252_flux_1	3.88E-05	1.20E-06	1.015	
		fzk_ss316	6.69E-03	2.78E-04	0.847	C/E(5)=0.837
		fzk_ss316	6.27E-03	1.54E-04	0.902	C/E(5)=0.892
		fzk_ss316	5.80E-03	1.36E-04	0.976	C/E(5)=0.965
		fng_vanad	1.34E-02	6.97E-04	0.933	
		d-Be2a	1.05E-02	1.72E-03	0.839	C/E(5)=0.816
		rez_DF	5.29E-03	9.40E-05	0.881	C/E(5)=0.870
V-51(n,p $\alpha$ )	5	fzk_ss316	3.27E-05	5.40E-06	0.415	[5 <sub>3</sub> ]
		fzk_ss316	3.12E-05	3.61E-06	0.434	
<b>V-51(n,2n<math>\alpha</math>)</b>	(5)	fzk_ss316	5.25E-04	1.34E-05	0.912	[5 <sub>3</sub> ]
		fzk_ss316	6.66E-04	2.38E-05	0.720	
<b>Cr-50(n,2n)</b>	5*	fng_vanad	2.29E-02	4.29E-03	0.787	C/E(5)=0.954 [5 <sub>2</sub> ]
		fng_Cr	3.01E-02	5.82E-03	0.731	C/E(5)=0.888
		fzk_ss316	3.50E-02	1.23E-02	0.761	C/E(5)=0.703
		fzk_ss316	6.79E-02	1.90E-02	0.393	C/E(5)=0.363
		fzk_ss316	3.61E-02	1.34E-02	0.738	C/E(5)=0.682
		rez_DF	2.27E-02	4.54E-04	0.977	
		rez_DF	2.79E-02	1.68E-03	0.793	
		fns_5min	4.28E-02	2.14E-03	0.513	
Cr-50(n,3n)	5	fzk_ss316	2.14E-04	5.36E-05	1.492	[5 <sub>4</sub> ]
		fzk_ss316	2.89E-04	8.68E-05	1.106	
		d-Be3	7.00E-05	3.00E-05	0.808	
		rez_DF	9.10E-05	3.10E-06	1.479	
		rez_DF	6.72E-05	3.36E-05	2.003	
		rez_DF	5.47E-05	4.38E-06	2.461	
Cr-50(n,t)	5	fzk_2	2.70E-04	5.40E-05	0.040	C/E(5)=0.912 [5 <sub>2</sub> ]
		fzk_ss316	4.42E-03	1.84E-04	0.121	C/E(5)=1.975
		fzk_ss316	4.33E-03	2.21E-04	0.124	C/E(5)=2.018
		rez_DF	2.52E-03	5.79E-05	0.172	C/E(5)=2.802
		rez_DF	2.54E-04	1.27E-05	1.704	
<b>Cr-50(n,p<math>\alpha</math>)</b>	(5)	fzk_ss316	3.04E-03	2.49E-04	0.265 <sup>†</sup>	[5 <sub>3</sub> ]
		rez_DF	1.56E-03	4.08E-05	0.401	
		rez_DF	1.47E-03	5.88E-05	0.426	
<b>Cr-52(n,2n)</b>	6	fns_7hour	3.18E-01	1.59E-02	1.075	C/E(5)=1.000
		fzk_2	3.90E-02	5.85E-03	1.241	
		fng_Cr	3.38E-01	3.05E-02	1.044	
		fng_cucrzt	4.62E-01	3.69E-02	0.760	
		tud_cucrzt	3.27E-01	3.53E-02	1.160	
		fng_vanad	2.76E-01	2.27E-02	1.042	
		fng_f82h	3.25E-01	4.12E-02	1.024	
		fng_eurofer	3.18E-01	2.26E-02	0.977	
		sneg_1	5.18E-01	1.26E-02	0.812	
		fzk_ss316	1.79E-01	4.00E-03	1.003	C/E(5)=0.996
		fzk_ss316	1.77E-01	3.76E-03	1.015	C/E(5)=1.008
		fzk_ss316	1.98E-01	6.02E-03	0.908	C/E(5)=0.902
		rez_DF	1.31E-01	9.71E-04	1.108	C/E(5)=1.099
		rez_DF	1.22E-01	2.44E-03	1.185	
		rez_DF	1.40E-01	2.81E-03	1.032	
<b>Cr-52(n,p)</b>	6	fns_5min	6.95E-02	1.56E-03	0.968	C/E(5)=0.740
		sneg_1	9.97E-02	4.49E-03	0.740	C/E(5)=0.941
		fng_Cr	7.12E-02	9.92E-03	0.941	C/E(5)=0.934

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		cf252_flux_1 <b>rez_DF</b>	1.07E-03 1.80E-02	7.00E-05 8.30E-04	1.218 1.317 <sup>†</sup>	C/E(5)=1.218
Cr-52(n,t)/(n,xt)	5	d-Be3 d-Be3	2.03E-04 1.65E-04	6.09E-05 3.35E-05	1.106 1.341	/1.132 [5 <sub>3</sub> ]/[5 <sub>3</sub> ] /1.372
Cr-52(n,t)/(n,t+)	5	d-Be	3.05E-02	3.50E-03	0.071 <sup>†</sup>	/1.510 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
<b>Cr-52(n,p<math>\alpha</math>)</b>	5*	<b>rez_DF</b> <b>rez_DF</b>	5.15E-05 6.27E-05	1.03E-05 6.27E-06	0.749 0.616	[5 <sub>3</sub> ]
Cr-52(n,d $\alpha$ )	5	fzk_ss316	4.54E-06	4.16E-07	0.858	[5 <sub>3</sub> ]
Cr-53(n,3n)	5	d-Be3	1.06E-02	1.6E-03	0.769	[5 <sub>3</sub> ]
<b>Cr-53(n,p)</b>	6	sneg_1 cf252_flux_1 <b>rez_DF</b>	5.95E-02 3.06E-04 3.84E-03	5.89E-03 2.70E-05 1.85E-03	0.811 1.880 <sup>†</sup> 3.256 <sup>†</sup>	C/E(5)=0.817 C/E(5)=1.817
<b>Cr-53(n,h)/(n,h+)</b>	5	d-Be3	2.60E-04	8.00E-05	0.073	/0.077 C/E(5)=0.024 [5 <sub>0</sub> ]/[5 <sub>0</sub> ]
<b>Cr-54(n,<math>\alpha</math>)</b>	5*	<b>rez_DF</b>	5.14E-04	1.54E-05	6.891	[5 <sub>2</sub> ]
Mn-55(n,2n)	6	fns_7hour cf252_flux_1 cf252_flux_1	7.62E-01 5.80E-04 4.08E-04	3.81E-02 1.40E-04 9.00E-06	1.023 0.977 1.390 <sup>†</sup>	C/E(5)=0.973 C/E(5)=0.896 C/E(5)=1.273
<b>Mn-55(n,<math>\gamma</math>)</b>	6	fns_7hour fns_5min	8.32E-04 3.97E-03	4.16E-05 2.38E-04	0.980 1.010	C/E(5)=0.950 C/E(5)=1.006
<b>Mn-55(n,p)</b>	6	fns_5min	2.85E-02	1.42E-03	1.099	C/E(5)=1.177
<b>Mn-55(n,t)/(n,xt)</b>	6	d-Be d-Be3 d-Be3	4.90E-03 6.40E-04 1.40E-03	1.20E-03 2.00E-04 2.80E-04	0.912 1.532 0.700	/1.474 C/E(5)=0.840 /1.671 C/E(5)=1.484 /0.764 C/E(5)=0.678
<b>Mn-55(n,h)/(n,h+)</b>	5*	d-Be2a d-Be2a	1.38E-03 1.79E-03	6.88E-04 3.59E-04	0.260 0.200	/0.474 C/E(5)=0.080 [5 <sub>1</sub> ]/[5 <sub>4</sub> ] /0.365 C/E(5)=0.061
<b>Mn-55(n,<math>\alpha</math>)</b>	6	fns_5min d-Be2a	1.92E-02 7.31E-03	9.62E-04 1.51E-03	1.099 1.123	C/E(5)=1.081 C/E(5)=1.105
Mn-55(n,2 $\alpha$ )	5	d-Be2a	6.45E-05	4.30E-05	0.421	[5 <sub>3</sub> ]
Fe-54(n,2n)	(5)	sneg_1	9.23E-03	2.58E-03	2.039	C/E(5)=1.124 [5 <sub>2</sub> ]
<b>Fe-54(n,3n)g</b>	5	fzk_ss316 fzk_ss316 rez_DF	1.08E-04 1.17E-04 3.76E-05	5.38E-05 1.63E-05 1.09E-06	4.314 3.978 3.923	[5 <sub>2</sub> ]
Fe-54(n,p)	6	fns_7hour sneg_1 sneg_2 fzk_2 fng_f82h cf252_flux_1 cf252_flux_1 cf252_flux_1 cf252_flux_1 cf252_flux_1 fzk_1 fzk_ss316 fzk_ss316 rez_DF fng_eurofer fng_vanad	3.39E-01 3.09E-01 3.43E-01 2.87E-01 2.69E-01 8.46E-02 9.25E-02 8.78E-02 8.76E-02 7.90E-02 2.82E-01 2.04E-01 1.96E-01 1.79E-01 2.46E-01 2.44E-01	2.04E-02 1.54E-02 1.71E-02 4.30E-02 1.90E-02 2.00E-03 5.00E-03 8.78E-04 4.35E-03 3.00E-03 2.82E-02 4.56E-03 4.58E-03 1.43E-03 1.70E-02 7.42E-02	0.967 0.950 1.044 0.972 1.083 1.030 0.942 0.993 0.995 1.103 0.981 1.115 1.164 1.278 1.057 1.021	C/E(5)=0.992
<b>Fe-54(n,t)g/(n,t+)g</b>	5*	d-Be rez_DF <b>fzk_ss316</b>	1.70E-02 3.23E-04 2.83E-02	4.00E-03 2.90E-06 7.07E-03	0.075 0.714 0.010 <sup>†</sup>	/1.970 C/E(5)=0.089 [5 <sub>2</sub> ]/[5 <sub>2</sub> ] /7.527 C/E(5)=1.081 /0.200
<b>Fe-54(n,t)m/(n,t+)m</b>	5	d-Be	7.00E-03	1.00E-03	0.136	/2.281 C/E(5)=0.186 [5 <sub>1</sub> ]/[5 <sub>4</sub> ]
<b>Fe-54(n,t)</b>	(6)	fzk_2 fzk_ss316 fzk_ss316	9.00E-05 7.36E-04 6.55E-04	1.80E-05 2.00E-05 1.87E-05	0.110 <sup>†</sup> 0.734 0.824	C/E(5)=0.781 C/E(5)=1.117 C/E(5)=1.255
<b>Fe-54(n,<math>\alpha</math>)</b>	6	fng_SiC	8.22E-02	4.11E-03	0.923	
<b>Fe-56(n,p)</b>	6	fns_5min fns_7hour fng_f82h fng_SiC fng_vanad sneg_1	9.05E-02 1.07E-01 9.31E-02 9.58E-02 9.16E-02 1.07E-01	2.26E-03 5.36E-03 6.58E-03 4.79E-03 1.45E-02 3.27E-03	1.049 0.971 0.996 0.973 0.848 0.959	C/E(5)=1.039

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		sneg_2	1.10E-01	4.59E-03	1.014	
		cf252_flux_1	1.15E-03	8.00E-05	1.259	
		cf252_flux_1	1.45E-03	6.00E-05	0.998	
		cf252_flux_1	1.45E-03	3.50E-05	0.998	
		cf252_flux_1	1.18E-03	8.00E-05	1.227	
		cf252_flux_1	1.40E-03	1.68E-05	1.034	
		fzk_ss316	3.43E-02	9.91E-04	1.043	C/E(5)=1.046
		fzk_ss316	3.36E-02	9.90E-04	1.067	C/E(5)=1.069
		rez_DF	2.32E-02	4.13E-04	1.372	C/E(5)=1.374
<b>Fe-56(n,t)/(n,xt)</b>	6	d-Be3	3.90E-04	1.17E-04	1.287	/1.339 C/E(5)=1.196
		d-Be3	3.99E-04	7.99E-05	1.255	/1.307 C/E(5)=1.166
<b>Fe-56(n,t)/(n,t+)</b>	6	d-Be	4.10E-02	6.00E-03	0.093	/1.875 C/E(5)=0.081
<b>Fe-56(n,h)/(n,h+)</b>	5	d-Be2a	5.41E-03	5.31E-04	0.138	/1.138 C/E(5)=0.043 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
<b>Fe-57(n,p)</b>	6	sneg_1	7.12E-02	9.26E-03	0.777	C/E(5)=1.110
Fe-58(n, $\gamma$ )	6	fng_SiC	1.26E-03	6.30E-05	1.145	
		fng_eurofer	2.48E-02	4.27E-03	0.776	
		fng_f82h	5.98E-03	5.14E-04	0.920	
		rez_DF	1.78E-03	6.18E-05	1.027	
<b>Co-59(n,2n)m</b>	6*	fns_7hour	3.37E-01	1.69E-02	1.370 <sup>†</sup>	C/E(5)=1.389
		rez_DF	1.31E-01	2.62E-02	1.109	C/E(5)=1.108
<b>Co-59(n,2n)</b>	(5)	fns_7hour	7.37E-01	3.69E-02	0.917	C/E(5)=0.956 [5 <sub>2</sub> ]
		cf252_flux_1	5.70E-04	3.00E-05	0.709	
		rez_DF	1.19E-01	2.38E-02	1.787	
Co-59(n,3n)	6	rez_DF	2.47E-02	9.89E-04	0.761	
		d-Be3	1.12E-02	1.80E-03	0.765	
<b>Co-59(n,<math>\gamma</math>)</b>	(6)	cf252_flux_1	6.97E-03	3.40E-04	0.685	
		fng_eurofer	7.25E-01	1.22E-01	0.863	
<b>Co-59(n,p)</b>	6	cf252_flux_1	1.96E-03	1.00E-05	0.869	
		rez_DF	1.53E-02	6.13E-04	1.196	C/E(5)=1.197
Co-59(n,t)/(n,xt)	6	d-Be3	6.40E-04	2.00E-04	1.175	/1.348
		d-Be3	4.90E-04	9.80E-05	1.534	/1.761
		d-Be	3.10E-03	7.00E-04	1.044	/2.040
<b>Co-59(n,h)/(n,h+)</b>	5	d-Be2a	1.44E-03	5.80E-04	0.316	/0.986 C/E(5)=2.916 [5 <sub>1</sub> ]/[5 <sub>4</sub> ]
		d-Be2a	1.47E-03	2.44E-04	0.309	/0.964 C/E(5)=2.853
<b>Co-59(n,<math>\alpha</math>)</b>	6	fns_5min	2.53E-02	1.27E-03	1.099	
		cf252_flux_1	2.00E-04	1.00E-05	1.118	
		cf252_flux_1	2.17E-04	1.40E-05	1.031	
		cf252_flux_1	2.22E-04	4.00E-06	1.008	
		cf252_flux_1	2.00E-04	1.00E-05	1.118	
		rez_DF	6.74E-03	2.70E-04	1.132	C/E(5)=1.127
		d-Be2a	8.39E-03	1.72E-03	1.180	C/E(5)=1.162
Co-59(n,2 $\alpha$ )	5	d-Be2a	1.08E-04	6.45E-05	0.633	[5 <sub>3</sub> ]
<b>Ni-58(n,2n)</b>	6	fns_7hour	3.26E-02	1.63E-03	1.010	C/E(5)=1.012
		fng_f82h	3.65E-02	1.01E-02	0.891	
		fzk_2	5.42E-03	5.42E-04	0.964	
		sneg_1	4.37E-02	3.06E-03	0.964	
		sneg_2	3.27E-02	2.29E-03	0.958	
		cf252_flux_1	8.95E-06	2.80E-07	1.076	C/E(5)=1.074
		fzk_ss316	1.94E-02	1.93E-03	1.255	C/E(5)=1.238
		fzk_ss316	2.57E-02	6.16E-03	0.947	C/E(5)=0.934
		rez_DF	1.54E-02	6.45E-04	1.267	C/E(5)=1.242
Ni-58(n,3n)	5	fzk_ss316	4.48E-04	2.50E-05	0.284	[5 <sub>3</sub> ]
		d-Be3	2.00E-05	1.00E-05	1.219	
<b>Ni-58(n,n'p)/(n,d+)</b>	6	fns_7hour	6.26E-01	3.13E-02	0.946	/0.974 C/E(5)=0.920
		fng_vanad	5.29E-01	1.07E-01	0.886	/0.913
		fzk_2	1.07E-01	1.07E-02	0.812	/0.843
		sneg_1	7.20E-01	5.04E-02	0.915	/0.943
		sneg_2	6.43E-01	3.86E-02	0.945	/0.972
		fng_f82h	5.08E-01	4.79E-02	1.085	/1.117
		fng_eurofer	4.76E-01	1.38E-01	1.056	/1.089
		fzk_ss316	2.44E-01	5.63E-03	1.028	/1.080 C/E(5)=1.034
		fzk_ss316	3.34E-01	3.39E-02	0.752	/0.791 C/E(5)=0.757

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		rez_DF	2.13E-01	4.02E-03	0.957	/1.005 C/E(5)=0.961
<b>Ni-58(n,p)</b>	(6)	fns_7hour	3.04E-01	1.52E-02	1.025	C/E(5)=0.998
		fzk_2	4.37E-01	4.37E-02	0.777	C/E(5)=0.772
		fng_vanad	2.72E-01	4.09E-02	0.897	C/E(5)=0.882
		sneg_1	2.98E-01	2.09E-02	0.932	C/E(5)=0.914
		cf252_flux_1	9.50E-02	4.50E-03	1.254	C/E(5)=1.237
		cf252_flux_1	1.05E-01	5.00E-03	1.135	C/E(5)=1.119
		cf252_flux_1	1.13E-01	4.80E-03	1.051	C/E(5)=1.036
		cf252_flux_1	1.19E-01	6.00E-03	1.001	C/E(5)=0.987
		cf252_flux_1	1.21E-01	2.00E-03	0.985	C/E(5)=0.971
		fzk_ss316	2.43E-01	5.39E-03	1.081	C/E(5)=1.140
fzk_ss316	2.22E-01	1.33E-02	1.183	C/E(5)=1.248		
rez_DF	2.10E-01	2.68E-03	1.282	C/E(5)=1.333		
<b>Ni-58(n,t)</b>	6	fzk_2	4.40E-05	1.10E-05	0.407	C/E(5)=0.406
		fzk_ss316	2.94E-04	7.77E-06	1.290	C/E(5)=1.003
		fzk_ss316	4.97E-02	1.56E-03	0.008 <sup>†</sup>	C/E(5)=0.006
		d-Be3	2.43E-04	8.96E-05	0.882	/0.965 C/E(5)=0.735
		d-Be3	1.79E-04	3.58E-05	1.198	/1.310 C/E(5)=0.998
<b>Ni-58(n,t)/(n,t+)</b>	6	d-Be	3.50E-02	6.00E-03	0.041	/1.641 C/E(5)=0.031
		rez_DF	3.39E-03	8.25E-05	0.091 <sup>†</sup>	/1.604 C/E(5)=0.071
<b>Ni-60(n,p)m</b>	6	fns_5min	6.90E-02	4.14E-03	0.917	C/E(5)=0.790
		fng_heat	6.45E-02	8.39E-03	1.214	
<b>Ni-60(n,p)</b>	(6)	fzk_2	5.52E-02	5.52E-03	0.771	
		sneg_1	1.51E-01	1.20E-02	0.857	
		sneg_2	1.62E-01	1.29E-02	0.902	
		fzk_ss316	5.56E-02	2.25E-03	0.865	C/E(5)=0.868
		fzk_ss316	1.90E+0	2.75E-01	0.025 <sup>†</sup>	
d-Be3	8.20E-02	1.60E-02	0.841	C/E(5)=0.842		
<b>Ni-60(n,t)/(n,t+)</b>	(6)	d-Be	6.10E-02	8.00E-03	0.044	/1.560 C/E(5)=0.052
Ni-60(n,2p)	5	fzk_ss316	8.62E-04	1.55E-04	0.926	[5 <sub>3</sub> ]
<b>Ni-61(n,p)</b>	5	fzk_2	1.88E-02	2.82E-03	1.722	[5 <sub>2</sub> ]
<b>Ni-62(n,n'p)/(n,d+)</b>	5*	fzk_ss316	6.38E-03	2.17E-03	4.255	/4.887 C/E(5)=4.367 [5 <sub>2</sub> ]
Ni-62(n,p)g	6	fns_5min	1.87E-02	1.12E-03	1.010	C/E(5)=1.042
		fng_heat	2.22E-02	2.99E-03	0.881	C/E(5)=0.832
Ni-62(n,p)m	6	fns_5min	1.69E-02	8.44E-04	0.963	C/E(5)=1.075
		fng_heat	1.85E-02	2.50E-03	0.915	C/E(5)=0.911
Ni-62(n, $\alpha$ )	6*	fzk_2	4.60E-03	4.60E-04	0.974	C/E(5) = 0.773
		sneg_1	3.40E-02	4.11E-03	0.646	C/E(5) = 0.606
<b>Cu-63(n,2n)</b>	6	fns_5min	4.59E-01	2.30E-02	1.075	
		tud_cucrzt	4.91E-01	5.55E-02	1.090	
		cf252_flux_1	3.00E-04	2.70E-05	0.718 <sup>†</sup>	
		cf252_flux_1	1.83E-04	7.00E-06	1.177	
<b>Cu-63(n,3n)</b>	6	d-Be3	4.26E-03	1.21E-03	0.666	C/E(5)=0.818
<b>Cu-63(n,<math>\gamma</math>)</b>	5	cf252_flux_1	1.76E-02	1.40E-03	0.591	[5 <sub>2</sub> ]
Cu-63(n,t)/(n,xt)	5	d-Be3	8.20E-04	2.63E-04	1.748	/1.923 [5 <sub>3</sub> ]
		d-Be	5.31E-03	1.43E-03	1.068	/1.719
<b>Cu-63(n,h)/(n,h+)</b>	5	d-Be2a	3.91E-03	7.82E-04	0.490	/0.751 C/E(5)=0.017 [5 <sub>1</sub> ]/[5 <sub>4</sub> ]
Cu-63(n, $\alpha$ )	(6)	fns_7hour	4.70E-02	3.76E-03	0.935	C/E(5)=1.001
		fng_SiC	1.99E-02	9.94E-04	1.970 <sup>†</sup>	
		fzk_2	1.50E-02	1.50E-03	0.843	
		fng_cucrzt	3.51E-02	3.16E-03	1.143	
		tud_cucrzt	3.44E-02	3.34E-03	1.299	
		cf252_flux_1	6.71E-04	1.80E-05	0.890	
		cf252_flux_1	7.09E-04	1.70E-05	0.843	
		fng_vanad	2.24E-02	8.93E-03	1.456	
<b>Cu-65(n,2n)</b>	6	fns_7hour	8.83E-01	4.42E-02	1.010	C/E(5)=0.900
		fng_SiC	9.40E-01	1.88E-02	0.900	C/E(5)=0.856
		fzk_2	1.57E-01	1.57E-02	0.856	C/E(5)=1.053
		fng_cucrzt	9.79E-01	6.86E-02	0.876	C/E(5)=0.876
		tud_cucrzt	8.16E-01	2.84E-01	1.151	C/E(5)=1.151
		cf252_flux_1	6.65E-04	2.30E-05	1.088	C/E(5)=1.088
<b>Cu-65(n,<math>\gamma</math>)</b>	6	cf252_flux_1	8.00E-03	1.20E-03	0.863	

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
Cu-65(n, $\alpha$ )m	6	fng_cucrzt	5.80E-03	8.71E-04	1.161	
		tud_cucrzt	4.83E-03	5.50E-04	1.530 <sup>†</sup>	
		fzk_2	1.21E-03	1.94E-04	0.996	
Cu-65(n,n' $\alpha$ )	6	fng_SiC	1.25E-03	1.25E-04	1.439	
		fzk_2	7.10E-04	1.42E-04	1.092	
		fng_cucrzt	2.27E-03	2.27E-04	0.783	
		tud_cucrzt	1.50E-03	1.36E-04	1.090	C/E(5)=1.090
		d-Be3	5.10E-03	1.20E-03	1.038	C/E(5)=1.017
Cu-65(n,p)	6	fng_SiC	2.12E-02	1.06E-03	0.935	
		fzk_2	7.40E-03	7.40E-04	0.909	
		fng_cucrzt	2.16E-02	1.30E-03	0.933	
		tud_cucrzt	1.85E-02	1.37E-03	1.190	
		d-Be3	1.20E-03	3.00E-03	1.005	
Zn-64(n,2n)	6	fns_5min	1.51E-01	7.54E-03	1.000	C/E(5)=0.987
Zn-64(n,p)	6	cf252_flux_1	4.11E-02	1.30E-03	0.938	C/E(5)=1.074
		cf252_flux_1	3.82E-02	1.50E-03	1.009	C/E(5)=1.155
		cf252_flux_1	4.64E-02	2.30E-03	0.831	C/E(5)=0.951
		cf252_flux_1	3.94E-02	1.00E-03	0.979	C/E(5)=1.120
		cf252_flux_1	4.18E-02	1.75E-03	0.922	C/E(5)=1.055
		cf252_flux_1	4.13E-02	2.82E-03	0.934	C/E(5)=1.068
Zn-64(n,t)/(n,t <sup>+</sup> )	6	d-Be	6.70E-02	8.00E-03	0.098	/1.592 C/E(5)=0.075
Zn-64(n,h)/(n,h <sup>+</sup> )	5	d-Be2a	1.94E-02	3.88E-03	0.131	/2.314 C/E(5)=0.041 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Zn-66(n,2 $\alpha$ )	5	d-Be2a	6.45E-05	4.30E-05	1.032	[5 <sub>3</sub> ]
Zn-67(n,h)/(n,h <sup>+</sup> )	5	d-Be2a	9.89E-04	2.80E-04	0.159	/0.769 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Zn-68(n, $\gamma$ )m	5	cf252_flux_1	1.85E-03	1.20E-04	0.246	[5 <sub>2</sub> ]
Zn-68(n,h)/(n,h <sup>+</sup> )	5	d-Be2a	1.05E-03	3.66E-04	0.477	/0.547 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Zn-68(n, $\alpha$ )	6	d-Be2a	4.08E-03	8.60E-04	1.373	
Ga-69(n,2n)	6	fns_5min	7.82E-01	3.91E-02	1.099	
Ga-69(n,t)/(n,xt)	5	d-Be	4.27E-03	8.13E-04	1.180	/2.022 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Ga-71(n,2n)	6	fns_5min	8.99E-01	4.50E-02	1.088	
Ge-74(n,p)	(5)	fns_5min	1.32E-02	7.93E-04	1.389	C/E(5)=1.800 [5 <sub>1</sub> ]
Ge-74(n,t)/(n,t <sup>+</sup> )	5	d-Be	6.20E-02	1.30E-02	0.036	/0.278 [5 <sub>0</sub> ]/[5 <sub>0</sub> ]
Ge-76(n,2n)m	6	fns_5min	6.47E-01	4.53E-02	1.267	C/E(5)=0.884
Ge-76(n,2n)	(6)	fns_5min	1.03E+0	7.18E-02	1.112	C/E(5)=1.100 [5 <sub>4</sub> ]
As-75(n,p)m	6	fns_5min	1.05E-02	8.43E-04	0.990	C/E(5)=0.838
As-75(n,p)	(6)	fns_5min	1.86E-02	1.12E-03	1.177	C/E(5)=1.158
As-75(n,t)/(n,xt)	(5)	d-Be	3.80E-03	8.00E-04	1.038	/1.914 C/E(5)=1.235 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
As-75(n,h)/(n,h <sup>+</sup> )	5	d-Be2a	1.03E-03	4.30E-04	0.473	/0.587 C/E(5)=4.739 [5 <sub>1</sub> ]/[5 <sub>1</sub> ]
		d-Be2a	1.49E-03	2.99E-04	0.326	/0.405 C/E(5)=3.268
As-75(n, $\alpha$ )	6	d-Be2a	4.73E-03	1.08E-03	1.104	
Se-78(n,2n)m	6	fns_5min	5.76E-01	5.76E-02	1.186	C/E(5)=1.087
Se-80(n,t)/(n,t <sup>+</sup> )	5	d-Be	5.50E-02	1.20E-02	0.040	/0.246 [5 <sub>0</sub> ]/[5 <sub>0</sub> ]
Se-82(n,2n)	(5)	fns_5min	1.00E+0	7.02E-02	1.305	[5 <sub>2</sub> ]
Br-79(n,2n)	6	fns_5min	8.18E-01	9.00E-02	1.000	C/E(5)=0.990
Br-81(n,2n)g	6	fns_5min	3.37E-01	3.71E-02	1.177	C/E(5)=1.069
Rb-85(n,2n)	(6)	fns_5min	9.19E-01	4.59E-02	1.020	
Rb-87(n,2n)m	6	fns_5min	4.19E-01	2.09E-02	1.150	C/E(5)=1.074
Sr-84(n,2n)	(6)	fns_7hour	6.37E-01	3.19E-02	1.020	C/E(5)=1.010
Sr-84(n, $\gamma$ )m	6	cf252_flux_1	2.42E-01	2.70E-02	0.192 <sup>†</sup>	
		cf252_flux_1	3.54E-02	2.34E-03	1.312	
Sr-86(n,2n)	(6)	fns_7hour	9.93E-01	1.49E-01	0.971	C/E(5)=1.020
Sr-86(n, $\gamma$ )m	5	cf252_flux_1	1.82E-01	2.20E-02	0.093	[5 <sub>2</sub> ]
Sr-88(n,2n)m	6	fns_7hour	2.53E-01	1.27E-02	0.881	C/E(5)=0.882
Sr-88(n,p)	6	fns_5min	1.42E-02	7.09E-04	0.962	C/E(5)=0.909
Y-89(n,n' $\alpha$ )m	6	fns_5min	3.60E-01	1.80E-02	1.000	C/E(5)=0.971
		fng_Y	3.31E-01	1.99E-02	1.042	
Y-89(n,2n)	6	fns_7hour	1.06E+0	6.35E-02	0.885	C/E(5)=0.862
		fns_5min	8.15E-01	1.63E-01	1.124	C/E(5)=1.111
		fng_Y	8.91E-01	8.91E-03	1.021	
		tud_Y	8.00E-01	9.00E-02	1.138	C/E(5)=1.130
		rez_DF	1.94E-01	5.82E-03	1.482 <sup>†</sup>	C/E(5)=1.489



Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
<b>Y-89(n,3n)</b>	(5)	rez_DF	4.61E-02	1.38E-03	0.562	C/E(5)=0.584 [5 <sub>2</sub> ]
<b>Y-89(n,<math>\gamma</math>)m</b>	6	tud_Y	3.82E-04	1.96E-04	1.137	C/E(5)=1.140
		fng_Y	3.57E-04	1.07E-05	1.239	C/E(5)=1.229
<b>Y-89(n,t)/(n,xt)</b>	(6)	d-Be	6.50E-03	2.00E-03	1.110	/1.370 C/E(5)=1.060
Y-89(n, $\alpha$ )m	6	fns_5min	1.83E-03	9.14E-05	1.010	C/E(5)=0.972
		fng_Y	2.03E-03	2.64E-04	0.903	
Y-89(n, $\alpha$ )	(5)	fng_Y	1.42E-02	1.84E-03	0.444	[5 <sub>2</sub> ]
<b>Zr-90(n,2n)m</b>	6	fns_5min	1.16E-01	5.81E-03	1.220	
		fng_heat	1.17E-01	3.52E-03	1.273	
<b>Zr-90(n,2n)</b>	(6)	fns_7hour	7.11E-01	4.27E-02	0.965	C/E(5)=0.971
		fng_cucrzr	9.24E-01	6.47E-02	0.750 <sup>†</sup>	
		tud_cucrzr	6.71E-01	6.91E-02	1.120	
		cf252_flux_1	2.67E-04	1.50E-05	0.815	
		cf252_flux_1	2.21E-04	6.00E-06	0.985	
		rez_DF	1.86E-01	5.57E-03	1.504 <sup>†</sup>	C/E(5)=1.493
		fng_Y	6.07E-01	7.28E-02	1.133	C/E(5)=1.131
<b>Zr-90(n,p)m</b>	6	fng_heat	9.83E-03	7.87E-04	1.189	C/E(5)=1.170
		cf252_flux_1	4.50E-05	6.00E-06	1.367 <sup>†</sup>	C/E(5)=1.346
<b>Zr-90(n,t)/(n,t+)</b>	6	d-Be	5.10E-02	1.10E-02	0.105	/1.087 C/E(5)=0.057
Zr-94(n, $\gamma$ )	6	cf252_flux_1	8.75E-03	6.50E-04	0.722	C/E(5)=0.663
<b>Zr-94(n,p)</b>	6	fns_5min	6.93E-03	3.47E-04	1.031	C/E(5)=1.099
<b>Zr-96(n,2n)</b>	6	fns_7hour	1.57E+0	7.83E-02	0.926	C/E(5)=0.943
		fzk_1	5.47E-01	8.21E-02	0.605 <sup>†</sup>	
Zr-96(n, $\gamma$ )	5	cf252_flux_1	4.17E-03	2.10E-04	3.447	[5 <sub>2</sub> ]
<b>Nb-93(n,2n)m</b>	6	fns_7hour	4.67E-01	2.34E-02	0.962	C/E(5)=0.952
		fng_SiC	3.93E-01	1.18E-02	1.059	
		fzk_2	2.76E-01	4.14E-02	0.295 <sup>†</sup>	C/E(5)=0.294
		fzk_ss316	1.58E-01	1.58E-02	0.892	C/E(5)=0.895
		fzk_ss316	1.07E-01	2.90E-02	1.316	C/E(5)=1.321
		rez_DF	1.23E-01	3.68E-03	0.951	C/E(5)=0.956
		fng_vanad	4.81E-01	6.59E-02	0.718	
		fzk_1	8.21E-02	7.80E-02	0.413 <sup>†</sup>	
		d-Be3	1.78E-01	2.40E-02	1.176	C/E(5)=1.178
		d-Be3	2.02E-01	2.40E-02	1.036	C/E(5)=1.038
Nb-93(n,3n)m	5	rez_DF	1.84E-02	1.66E-03	0.803	[5 <sub>4</sub> ]
<b>Nb-93(n,4n)</b>	(5)	rez_DF	1.93E-05	2.51E-06	2.319	C/E(5)=2.056 [5 <sub>3</sub> ]
<b>Nb-93(n,n'<math>\alpha</math>)m</b>	6	fns_5min	2.89E-03	2.02E-04	0.962	C/E(5)=1.010
Nb-93(n, $\gamma$ )m	6	fns_5min	4.65E-03	2.79E-04	1.042	C/E(5)=0.885
		fng_heat	1.24E-02	2.10E-03	0.199 <sup>†</sup>	
Nb-93(n,t)/(n,xt)	6*	d-Be3	6.10E-04	2.00E-04	0.626	/0.926 C/E(5)=0.361
		d-Be3	4.90E-04	9.80E-05	0.780	/1.153 C/E(5)=0.449
		d-Be	4.10E-03	8.00E-04	0.332	/1.391 C/E(5)=0.145
<b>Nb-93(n,h)m/(n,h+)m</b>	5*	d-Be2a	2.15E-04	6.45E-05	1.712	/2.179 C/E(5)=6.236 [5 <sub>4</sub> ]/[5 <sub>4</sub> ]
<b>Nb-93(n,h)/(n,h+)</b>	(5)	d-Be2a	1.61E-03	2.80E-04	0.337	/0.423 C/E(5)=1.062 [5 <sub>0</sub> ]/[5 <sub>0</sub> ]
		d-Be2a	1.54E-03	3.08E-04	0.353	/0.443 C/E(5)=1.112
Nb-93(n, $\alpha$ )g	5*	fng_heat	4.46E-02	7.58E-03	0.151	C/E(5)=0.157 [5 <sub>2</sub> ]
Nb-93(n, $\alpha$ )m	6	fns_5min	5.16E-03	2.58E-04	1.000	C/E(5)=1.001
		fng_SiC	4.76E-03	2.86E-04	1.070	
		d-Be2a	1.93E-03	4.30E-04	1.231	
		d-Be3	2.80E-03	3.00E-04	0.918	
Nb-93(n, $\alpha$ )	(6)	d-Be2a	4.09E-03	4.30E-04	1.279	
		d-Be3	3.80E-03	5.00E-04	1.575 <sup>†</sup>	
<b>Nb-93(n,2<math>\alpha</math>)</b>	(5)	d-Be2a	1.93E-04	1.08E-04	0.020	C/E(5)=0.046 [5 <sub>0</sub> ]
<b>Mo-92(n,2n)m</b>	5*	<b>fns 5min</b>	2.77E-02	1.38E-03	1.316	[5 <sub>2</sub> ]
Mo-92(n,2n)	(5)	fns_5min	2.23E-01	1.12E-02	1.334	C/E(5)=1.003 [5 <sub>2</sub> ]
		fng_heat	2.14E-01	2.35E-02	1.461	C/E(5)=1.080
		fng_Mo	2.35E-01	2.83E-03	1.321	C/E(5)=0.977
Mo-92(n,3n)	5	fzk_ss316	2.92E-03	1.61E-03	1.677	[5 <sub>3</sub> ]
<b>Mo-92(n,n'p)m/(n,d+)m</b>	6	fns_7hour	1.99E-01	3.78E-02	0.710	/0.719 C/E(5)=0.951
<b>Mo-92(n,n'<math>\alpha</math>)</b>	6*	fzk_ss316	3.99E-03	2.39E-03	1.732	C/E(5)=0.430
<b>Mo-92(n,p)m</b>	6	fns_7hour	6.37E-02	3.18E-03	0.943	C/E(5)=0.952

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		fzk_ss316	3.29E-02	1.61E-03	1.228	C/E(5)=1.211
		fng_Mo	5.49E-02	2.09E-03	0.999	C/E(5)=0.976
<b>Mo-92(n,p)</b>	(5)	cf252_flux_1	1.68E-02	7.00E-04	0.761	C/E(5)=0.723 [5 <sub>1</sub> ]
<b>Mo-92(n,t)</b> <i>/(n,xt)</i>	(5)	fzk_ss316	4.91E-04	2.40E-05	1.025	C/E(5)=1.412 [5 <sub>4</sub> ]/[5 <sub>4</sub> ]
		d-Be	4.05E-03	4.87E-04	0.556	/0.854 C/E(5)=0.703
<b>Mo-92(n,t)/(n,t+)</b>	(5)	d-Be	3.70E-02	4.00E-03	0.061	/3.841 C/E(5)=0.077 [5 <sub>1</sub> ]/[5 <sub>1</sub> ]
Mo-92(n, $\alpha$ )	(6)	sneg_1	2.27E-02	2.04E-03	1.314	
		cf252_flux_1	4.20E-04	2.00E-05	0.229 <sup>†</sup>	
		fzk_ss316	8.69E-03	3.84E-04	1.432	
		<b>fng_Mo</b>	2.68E-02	2.33E-03	1.000	
Mo-92(n,2 $\alpha$ )m	5	d-Be2a	4.51E-04	2.80E-04	0.010	[5 <sub>0</sub> ]
Mo-92(n,p $\alpha$ )	5	fzk_ss316	1.51E-03	5.13E-04	0.553	[5 <sub>3</sub> ]
Mo-92(n,d $\alpha$ )m	5	fzk_ss316	1.48E-05	4.15E-06	0.119	[5 <sub>0</sub> ]
<b>Mo-92(n,2n<math>\alpha</math>)</b>	(5)	fzk_ss316	1.30E-03	2.46E-04	0.409	[5 <sub>3</sub> ]
Mo-92(n,3n $\alpha$ )	5	fzk_ss316	1.17E-03	2.68E-04	0.026	[5 <sub>0</sub> ]
Mo-95(n,3n)m	5	fzk_ss316	8.38E-03	1.39E-03	0.988	[5 <sub>3</sub> ]
Mo-95(n,p)g	6	fns_7hour	2.71E-02	2.44E-03	1.232	C/E(5)=1.028
		fng_vanad	4.25E-02	1.54E-02	0.619	C/E(5)=0.610
		sneg_1	3.73E-02	3.32E-03	0.977	C/E(5)=0.956
		fng_Mo	3.18E-02	2.78E-03	1.052	C/E(5)=1.055
Mo-95(n,p)m	6	cf252_flux_1	1.44E-04	1.44E-04	0.517 <sup>†</sup>	C/E(5)=0.569
		fng_Mo	7.30E-03	6.58E-04	0.997	C/E(5)=1.041
		<b>fzk_ss316</b>	5.41E-03	7.03E-04	0.642 <sup>†</sup>	
Mo-95(n,p)	(5)	cf252_flux_1	2.20E-02	2.00E-03	0.013	[5 <sub>2</sub> ]
<b>Mo-96(n,n'p)/(n,d+)</b>	(6)	<b>fzk_ss316</b>	9.30E-03	4.15E-04	1.541	/1.925
<b>Mo-96(n,p)</b>	6	sneg_1	2.08E-02	2.08E-03	1.159	C/E(5)=1.174
		fng_Mo	2.03E-02	1.14E-03	1.075	C/E(5)=1.174
<b>Mo-98(n,<math>\gamma</math>)</b>	6	cf252_flux_1	2.63E-02	1.30E-03	1.045	
<b>Mo-98(n,p)m</b>	5*	fng_heat	6.18E-03	6.80E-04	0.610	C/E(5)=0.898 [5 <sub>2</sub> ]
Mo-98(n,t)/(n,xt)	5	d-Be3	5.04E-04	1.63E-04	1.169	/1.262 [5 <sub>3</sub> ]
Mo-98(n, $\alpha$ )	5*	fns_7hour	8.36E-03	1.59E-03	0.741	C/E(5)=0.878 [5 <sub>3</sub> ]
<b>Mo-100(n,2n)</b>	6	fns_7hour	1.49E+0	4.04E-02	0.962	C/E(5)=0.952
		sneg_1	1.53E+0	1.22E-01	0.990	
		sneg_2	1.51E+0	1.21E-01	0.989	
		fng_vanad	1.12+E0	3.63E-01	0.988	C/E(5)=0.987
		fzk_ss316	4.13E-01	9.55E-03	1.063	C/E(5)=1.065
		fzk_ss316	3.28E-01	1.31E-01	1.337	C/E(5)=1.339
		fng_Mo	1.29E+0	4.04E-02	1.086	C/E(5)=1.082
<b>Mo-100(n,<math>\gamma</math>)</b>	6	cf252_flux_1	1.48E-02	1.11E-03	0.956	
<b>Mo-100(n,<math>\alpha</math>)</b>	5	fzk_ss316	8.16E-02	1.71E-02	0.018	[5 <sub>2</sub> ]
<b>Ru-96(n,2n)</b>	6	fns_5min	5.45E-01	2.73E-02	0.980	C/E(5)=1.010
<b>Ru-100(n,p)</b>	6*	<b>fns_5min</b>	3.05E-02	3.35E-03	0.821	
<b>Ru-102(n,p)m</b>	6	fns_5min	6.75E-03	3.37E-04	1.020	C/E(5)=0.854
<b>Rh-103(n,n'm)</b>	5	fns_5min	7.55E-02	1.36E-02	3.846	C/E(5)=2.222 [5 <sub>2</sub> ]
<b>Rh-103(n,2n)g</b>	5	rez_DF	7.05E-01	3.52E-02	0.272	C/E(5)=0.232 [5 <sub>2</sub> ]
Rh-103(n,3n)m	5	rez_DF	5.51E-02	2.20E-03	1.450	[5 <sub>2</sub> ]
<b>Rh-103(n,4n)</b>	(5)	rez_DF	2.93E-04	1.17E-05	2.366	[5 <sub>3</sub> ]
<b>Rh-103(n,<math>\gamma</math>)</b>	(5)	<b>fns_5min</b>	2.68E-02	2.15E-03	2.504	[5 <sub>2</sub> ]
Rh-103(n,p)	5	rez_DF	4.75E-03	1.90E-04	1.910	[5 <sub>2</sub> ]
<b>Pd-106(n,t)/(n,t+)</b>	(5)	d-Be	3.60E-02	6.00E-03	0.061	/0.630 C/E(5)=0.081 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
<b>Pd-108(n,2n)m</b>	5*	fns_5min	3.35E-01	1.68E-02	1.283	C/E(5)=1.251 [5 <sub>2</sub> ]
<b>Pd-108(n,p)m</b>	6*	<b>fns_5min</b>	6.17E-03	3.70E-04	1.316	
<b>Pd-110(n,2n)m</b>	6	fns_5min	3.66E-01	2.19E-02	1.268	C/E(5)=1.112
<b>Pd-110(n,2n)</b>	(6)	<b>fns_5min</b>	1.46E+0	8.73E-02	1.156	
Ag-107(n,2n)g	6	fns_5min	6.94E-01	3.47E-02	0.901	C/E(5)=0.909
		fng_heat	7.45E-01	8.19E-02	0.870	
Ag-107(n,t)/(n,xt)	5	d-Be3	4.99E-04	1.59E-04	2.782 <sup>†</sup>	/3.058 [5 <sub>2</sub> ]/[5 <sub>2</sub> ]
		d-Be	4.54E-03	8.26E-04	1.258	/2.079
<b>Ag-107(n,h)/(n,h+)</b>	(5)	d-Be2a	3.30E-03	6.61E-04	0.180	/0.209 C/E(5)=0.061 [5 <sub>0</sub> ]/[5 <sub>0</sub> ]
		d-Be2a	2.24E-03	3.57E-04	0.265	/0.308 C/E(5)=0.090
<b>Ag-109(n,2n)g</b>	6	fns_5min	5.95E-01	3.57E-02	1.117	C/E(5)=1.067

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		fng_heat	7.57E-01	8.32E-02	0.909	
Cd-110(n, $\gamma$ )	(5)	cf252_flux_1	2.04E-01	7.00E-03	0.194	[5 <sub>2</sub> ]
Cd-112(n,2n)m	6	fns_5min fng_heat	5.28E-01 6.89E-01	2.64E-02 2.07E-02	1.048 0.835	C/E(5)=1.073
Cd-114(n,p)	(6)	fns_5min	7.78E-03	3.89E-04	1.053	
Cd-116(n, $\gamma$ )	(5)	cf252_flux_1	3.80E-02	1.40E-02	0.261	[5 <sub>2</sub> ]
In-113(n,2n)m	5	cf252_flux_1	3.75E-03	1.85E-03	0.307	[5 <sub>2</sub> ]
In-113(n,2n)	(5)	cf252_flux_1	9.50E-03	4.75E-03	0.150	[5 <sub>2</sub> ]
In-115(n,2n)g	5*	fns_5min	1.99E-01	9.93E-03	1.206	C/E(5)=1.192 [5 <sub>2</sub> ]
In-115(n,n' $\alpha$ )	(5)	d-Be2a	3.66E-03	6.45E-04	3.207	[5 <sub>2</sub> ]
In-115(n, $\gamma$ )m	5	cf252_flux_1 cf252_flux_1	1.24E-01 1.39E-01	3.60E-03 6.00E-02	0.612 0.546	C/E(5)=0.385 [5 <sub>1</sub> ] C/E(5)=0.343
In-115(n, $\gamma$ )	(5)	fns_5min	5.18E-02	2.59E-03	3.328	C/E(5)=3.368 [5 <sub>2</sub> ]
In-115(n,t)/(n,xt)	(6)	d-Be	3.90E-03	7.99E-04	1.032	/1.860 C/E(5)=1.319
In-115(n,h)g/(n,h+)g	5	d-Be2a	2.15E-04	6.45E-05	0.376	/0.874 C/E(5)=0.078 [5 <sub>4</sub> ]/[5 <sub>4</sub> ]
In-115(n,h)/(n,h+)	(5)	d-Be2a	1.04E-03	2.14E-04	0.258	/0.280 C/E(5)=0.092 [5 <sub>1</sub> ]/[5 <sub>1</sub> ]
In-115(n, $\alpha$ )	5	d-Be2a	2.58E-03	6.45E-04	1.615	[5 <sub>2</sub> ]
Sn-112(n,2n)	6	fng_heat fng_Sn	1.67E+0 1.17E+0	2.25E-01 1.05E-01	0.666 <sup>†</sup> 0.947	
Sn-114(n,2n)	(5)	fng_Sn	1.94E+0	9.37E-02	0.620	[5 <sub>2</sub> ]
Sn-114(n,n'p)m/(n,d+)m	5*	fng_Sn	4.23E-03	9.91E-04	0.362	/0.514 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Sn-116(n,p)	(5)	fng_Sn	2.47E-02	7.41E-04	0.997	[5 <sub>3</sub> ]
Sn-116(n,n'p)m/(n,d+)m	5*	fng_Sn	1.10E-03	1.05E-04	0.181	/0.487 [5 <sub>0</sub> ]/[5 <sub>0</sub> ]
Sn-117(n,p)m	5*	fng_Sn	5.16E-03	6.39E-04	0.595	[5 <sub>2</sub> ]
Sn-117(n,p)	(5)	fng_Sn	1.98E-02	6.55E-04	0.705	[5 <sub>1</sub> ]
Sn-118(n,2n)m	5*	fns_7hour fng_Sn	9.55E-01 1.32E+0	1.05E-01 3.27E-02	0.795 0.572	C/E(5)=0.787 [5 <sub>2</sub> ]
Sn-118(n,p)m	6	fns_5min	6.69E-03	4.02E-04	0.910	C/E(5)=0.940
Sn-118(n, $\alpha$ )g	5*	fng_Sn	1.23E-03	2.37E-04	0.582	[5 <sub>2</sub> ]
Sn-120(n,2n)m	6	fns_7hour	5.77E-01	1.15E-01	1.133	C/E(5)=1.336
Sn-120(n,p)m	5*	fns_5min	4.91E-03	4.42E-04	0.680	C/E(5)=0.952 [5 <sub>2</sub> ]
Sn-120(n, $\alpha$ )g	5*	fng_Sn	3.84E-04	5.32E-05	0.610	[5 <sub>1</sub> ]
Sn-120(n, $\alpha$ )m	5	fng_Sn	3.90E-04	6.11E-05	0.661	[5 <sub>2</sub> ]
Sn-124(n,2n)g	6	fns_7hour fng_Sn	1.25E+0 2.21E+0	1.25E-01 8.96E-01	0.952 0.529 <sup>†</sup>	C/E(5)=1.354
Sn-124(n,2n)m	6	fns_5min fng_Sn	4.15E-01 5.60E-01	2.49E-02 1.71E-02	1.150 0.881	C/E(5)=1.112
Sb-121(n,2n)g	6	fns_5min	7.79E-01	4.67E-02	1.205	
Sb-121(n,t)/(n,xt)	(5)	d-Be	4.50E-03	1.36E-03	1.057	/1.944 C/E(5)=1.371 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Te-128(n,t)/(n,t+)	(5)	d-Be	2.50E-02	6.00E-03	0.069	/0.528 C/E(5)=0.094 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Te-130(n,2n)g	6	fns_5min	5.64E-01	4.51E-02	1.042	C/E(5)=1.053
I-127(n,2n)	6	cf252_flux_1	2.07E-03	7.00E-05	1.085	
I-127(n, $\gamma$ )	5	fns_5min	1.93E-02	1.16E-03	1.695	C/E(5)=1.666 [5 <sub>2</sub> ]
I-127(n,h)/(n,h+)	5	d-Be2a	5.59E-04	1.08E-04	0.588	/0.627 C/E(5)=0.210 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
I-127(n, $\alpha$ )/(n, $\alpha$ +)m	(5)	d-Be2a	1.93E-03	3.23E-04	2.738	/2.924 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Cs-133(n,2n)	6	fns_5min	1.06E+0	8.46E-02	1.235	C/E(5)=1.190
Cs-133(n,h)/(n,h+)	5	d-Be2a	4.78E-04	9.02E-05	0.611	/0.648 C/E(5)=0.219 [5 <sub>4</sub> ]/[5 <sub>4</sub> ]
Ba-132(n,2n)	(6)	fns_7hour	1.47E+0	7.51E-01	0.943	C/E(5)=1.042
Ba-134(n,2n)m	6	fns_7hour	7.14E-01	9.99E-02	1.075	C/E(5)=1.099
Ba-134(n, $\gamma$ )	(5)	cf252_flux_1	2.55E-01	2.80E-02	0.197	[5 <sub>2</sub> ]
Ba-134(n,t)/(n,t+)	5	d-Be	1.50E-02	2.00E-03	0.228	/1.269 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ba-136(n,2n)m	6	fns_7hour	8.90E-01	1.25E-01	1.095	C/E(5)=1.076
Ba-136(n, $\gamma$ )	(5)	cf252_flux_1	2.93E-01	2.90E-02	0.049	C/E(5)=0.197 [5 <sub>2</sub> ]
Ba-138(n,2n)m	6	fns_5min	6.85E-01	5.48E-02	1.183	C/E(5)=1.099
Ba-138(n, $\gamma$ )	6*	cf252_flux_1 cf252_flux_1	3.80E-03 1.30E-03	4.00E-04 2.60E-04	0.416 <sup>†</sup> 1.216	
Ba-138(n,p)	(6)	fns_5min	2.70E-03	2.70E-04	1.099	C/E(5)=1.112
La-139(n, $\gamma$ )	6*	tud_Er	2.48E-03	1.56E-04	0.950	
La-139(n,p)	6	fns_5min tud_Er	3.66E-03 4.00E-03	1.46E-03 9.53E-04	1.163 0.970	C/E(5)=1.483

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
La-139(n,t)/(n,xt)	(6)	d-Be	7.00E-03	1.50E-03	0.453	/0.909 C/E(5)=0.469
La-139(n,h)/(n,h+)	5	d-Be2a	4.52E-04	8.60E-05	0.502	/0.525 C/E(5)=0.186 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
		d-Be2a	4.65E-04	6.15E-05	0.488	/0.511 C/E(5)=0.181
La-139(n, $\alpha$ )/(n, $\alpha$ +)	(6)	d-Be2a	2.04E-03	3.23E-04	1.387	/1.520 C/E(5)=1.205
		tud Er	2.05E-03	2.05E-03	1.090	
Ce-140(n,2n)m	6	fns_5min	6.86E-01	4.11E-02	1.099	
Ce-140(n, $\alpha$ )m	6	fns_5min	2.85E-03	1.71E-04	1.042	C/E(5)=1.108
Ce-142(n,p)	6*	fns_5min	4.81E-03	4.81E-04	1.053	C/E(5)=2.581
Pr-141(n,2n)	5	fns_5min	1.03E+0	8.21E-02	1.370	C/E(5)=1.384 [5 <sub>2</sub> ]
Pr-141(n,t)/(n,xt)	(6)	d-Be	9.40E-03	2.00E-03	0.810	/1.135 C/E(5)=0.805
Pr-141(n,t)/(n,t+)	(6)	d-Be	2.30E-02	6.00E-03	0.331 <sup>†</sup>	/1.186 C/E(5)=0.329
Nd-142(n,2n)m	6	fns_5min	4.22E-01	5.49E-02	1.333	
Nd-146(n,h)/(n,h+)	5	d-Be2a	2.58E-04	8.60E-05	0.719	/0.747 C/E(5)=0.267 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Nd-146(n, $\alpha$ )/(n, $\alpha$ +)	6	d-Be2a	2.15E-03	3.23E-04	1.350	/1.448
Nd-150(n,2n)	5	fns_5min	8.08E-01	1.13E-01	1.829	C/E(5)=1.812 [5 <sub>2</sub> ]
Sm-144(n,2n)m	6	fns_5min	4.61E-01	5.07E-02	1.136	C/E(5)=0.984
Sm-144(n,2n)	(6)	fns_5min	1.08E+0	1.19E-01	1.111	C/E(5)=1.148
Sm-150(n,p)	6	fng_ScSmGd	6.05E-03	7.26E-04	1.245	
Sm-152(n, $\alpha$ )	6	fng_ScSmGd	2.55E-03	3.06E-04	0.803	
Sm-154(n,2n)	6	fng_ScSmGd	1.84E+0	6.42E-02	0.939	
Eu-151(n, $\gamma$ )m	5	fns_5min	1.01E-01	1.51E-02	3.452	C/E(5)=2.609 [5 <sub>2</sub> ]
Gd-158(n,p)	6	fng_ScSmGd	3.17E-03	1.46E-04	1.170	
Gd-158(n, $\alpha$ )	5	fng_ScSmGd	1.11E-03	6.67E-05	2.005	[5 <sub>2</sub> ]
Gd-160(n,2n)	5	fns_5min	1.20E+0	2.27E-01	1.209	[5 <sub>2</sub> ]
		fng_ScSmGd	1.96E+0	6.08E-02	0.779	
Gd-160(n, $\gamma$ )	6	fns_5min	3.28E-03	6.23E-04	1.818	C/E(5)=1.563
Gd-160(n,p)	5	fns_5min	2.24E-03	5.61E-04	0.885	C/E(5)=0.942 [5 <sub>3</sub> ]
Tb-159(n,2n)m	5	fns_5min	3.69E-01	6.43E-01	1.351	C/E(5)=0.262 [5 <sub>4</sub> ]
Tb-159(n,p)	6*	fns_5min	4.68E-03	4.40E-02	1.042	C/E(5)=0.109
Tb-159(n,t)/(n,xt)	5	d-Be	7.90E-03	2.00E-03	0.628	/1.127 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Tb-159(n, $\alpha$ )/(n, $\alpha$ +)	6*	d-Be2a	1.55E-03	2.58E-04	2.827	/2.948
Dy-156(n,2n)	6	fng_Dy	1.53E+0	8.09E-02	1.120	
Dy-158(n,2n)	6	fng_Dy	1.92E+0	7.28E-02	0.969	
Dy-162(n,p)	6	fns_5min	2.14E-03	2.79E-04	1.811 <sup>†</sup>	C/E(5)=1.482
		fng_Dy	4.08E-03	1.92E-04	1.000	
Dy-162(n,t)/(n,t+)	5	d-Be	1.60E-02	3.30E-03	0.218	/1.039 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Dy-163(n,p)	6	fng_Dy	3.33E-03	1.37E-04	0.957	
Dy-164(n, $\gamma$ )g	5	fng_Dy	2.97E-02	1.34E-03	0.752	C/E(5)=1.980 [5 <sub>4</sub> ]
Dy-164(n, $\gamma$ )m	6	fns_5min	8.89E-02	1.24E-02	1.351	C/E(5)=0.852
Dy-164(n, $\gamma$ )	(5)	fns_5min	6.89E-02	1.52E-02	2.783	C/E(5)=2.767 [5 <sub>2</sub> ]
Dy-164(n,p)	5	fns_5min	1.64E-03	1.81E-04	1.515	C/E(5)=1.432 [5 <sub>2</sub> ]
Ho-165(n,2n)m	6*	fns_5min	5.64E-01	7.89E-02	1.136	C/E(5)=0.485
Ho-165(n,2n)	(6)	fns_5min	1.44E+0	2.01E-01	1.191	C/E(5)=0.529
Ho-165(n,t)/(n,xt)	5	d-Be	9.80E-03	2.00E-03	0.484	/0.889 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Ho-165(n,h)/(n,h+)	5*	d-Be2a	1.72E-04	4.30E-05	0.694	/0.733 C/E(5)=0.271 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Ho-165(n, $\alpha$ )/(n, $\alpha$ +)	6*	d-Be2a	1.85E-03	3.23E-04	1.026	/1.112
Er-162(n,2n)	6*	tud Er	1.42E+0	1.19E-01	1.080	
Er-164(n,2n)	5*	tud Er	1.84E+0	1.73E-01	0.770	[5 <sub>2</sub> ]
Er-166(n,2n)	5*	fns_5min	3.75E-01	1.39E-01	4.611	C/E(5)=1.267 [5 <sub>2</sub> ]
Er-166(n,p)g	6*	tud Er	3.50E-03	2.20E-04	0.893	
Er-167(n,p)	6*	tud Er	2.87E-03	1.61E-04	0.942	
Er-168(n,p)	6	fns_5min	2.47E-03	2.47E-04	1.020	C/E(5)=1.010
		tud Er	2.39E-03	1.79E-04	0.970	
Er-170(n,p)g	5*	tud Er	1.52E-03	2.84E-04	0.640	[5 <sub>4</sub> ]
Er-170(n,d)/(n,d+)	6*	tud Er	1.69E-04	3.97E-05	0.703	/0.890
Tm-169(n,2n)	6	fns_5min	1.98E+0	4.75E-01	0.877	C/E(5)=0.870
Yb-168(n,2n)	6	fns_5min	1.50E+0	1.08E+0	1.124	C/E(5)=1.219
Yb-174(n,p)	6*	fns_5min	2.22E-03	4.43E-04	1.235	C/E(5)=1.375
Yb-174(n,h)/(n,h+)	5	d-Be2a	2.15E-04	5.38E-05	0.411	/0.430 C/E(5)=0.162 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Yb-174(n, $\alpha$ )/(n, $\alpha$ +)	6	d-Be2a	1.93E-03	3.23E-04	1.686	/1.744

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
<b>Lu-175(n,<math>\gamma</math>)m</b>	6	fns_5min	5.01E-02	1.00E-02	1.220	C/E(5)=1.203
Lu-175(n,2n)g	5	rez_DF	5.94E-01	1.78E-02	0.634	[5 <sub>2</sub> ]
Lu-175(n,3n)	5*	rez_DF	1.68E-01	5.04E-03	1.465	[5 <sub>2</sub> ]
<b>Lu-175(n,4n)</b>	(5)	rez_DF	1.74E-02	5.23E-04	1.362	C/E(5)=1.184 [5 <sub>3</sub> ]
Hf-174(n,2n)	6	fng_hafnium	1.86E+0	3.73E-01	0.942	C/E(5)=1.000
<b>Hf-176(n,2n)</b>	6	fng_hafnium	1.75E+0	1.96E-01	1.024	
<b>Hf-177(n,n')n</b>	5	fng_heat	4.42E-03	7.07E-04	1.270	C/E(5)=1.124 [5 <sub>3</sub> ]
<b>Hf-178(n,p)m</b>	6	fng_hafnium	5.94E-04	1.08E-04	1.039	
<b>Hf-178(n,p)</b>	(6)	fng_hafnium	3.67E-03	1.18E-03	0.781	
Hf-179(n,p)	5	fng_hafnium	1.08E-02	2.51E-03	0.599	C/E(5)=0.593 [5 <sub>2</sub> ]
<b>Hf-180(n,n')m</b>	6	fng_hafnium	1.14E-02	6.65E-04	1.948	C/E(5)=0.987
Hf-180(n,2n)m	6	fns_5min fng_heat	5.42E-01 6.29E-01	3.25E-02 1.01E-01	0.988 0.868	C/E(5)=1.607
Hf-180(n, $\gamma$ )	5	fng_hafnium	9.28E-03	1.51E-03	0.507	[5 <sub>2</sub> ]
<b>Hf-180(n,p)</b>	6	fns_5min fng_hafnium fng_heat	1.20E-03 3.87E-03 3.85E-03	7.18E-05 9.36E-04 6.16E-04	1.961 <sup>†</sup> 0.614 0.640	C/E(5)=3.775
<b>Ta-181(n,2n)g</b>	6	fns_7hour fns_5min fng_Ta tud_Ta rez_DF rez_DF	7.93E-01 1.05E+0 1.01E+0 8.11E-01 2.92E-01 3.30E-01	7.93E-02 1.37E-01 2.32E-02 2.08E-01 8.07E-03 3.99E-03	1.409 0.990 1.036 1.227 1.024 0.906	C/E(5)=1.376 C/E(5)=0.967 C/E(5)=1.009 C/E(5)=1.190 C/E(5)=1.008 C/E(5)=0.891
<b>Ta-181(n,n'<math>\alpha</math>)m</b>	5*	rez_DF	3.00E-05	1.23E-06	3.138	C/E(5)=0.660 [5 <sub>3</sub> ]
<b>Ta-181(n,n'<math>\alpha</math>)</b>	(5)	rez_DF	4.91E-04	6.61E-06	2.615	C/E(5)=0.314 [5 <sub>3</sub> ]
Ta-181(n,4n)m	5	rez_DF	1.25E-02	2.36E-04	0.255	[5 <sub>0</sub> ]
<b>Ta-181(n,<math>\gamma</math>)n</b>	6*	fng_Ta	1.20E-04	4.13E-05	0.521	
<b>Ta-181(n,<math>\gamma</math>)</b>	(6)	fng_eurofer cf252_flux_1 cf252_flux_1 fng_Ta rez_DF rez_DF fns_7hour	1.19E+0 1.20E-01 8.92E-02 4.21E-02 2.30E-01 3.38E-02 1.36E-02	1.79E-01 6.50E-03 1.07E-03 2.90E-03 3.27E-03 2.91E-04 2.85E-03	1.118 0.835 1.122 0.876 0.296 <sup>†</sup> 2.018 <sup>†</sup> 0.734	C/E(5)=0.882
<b>Ta-181(n,p)</b>	6*	fns_7hour fng_Ta tud_Ta rez_DF	4.43E-03 3.40E-03 2.94E-03 1.74E-03	9.31E-04 4.31E-04 3.85E-04 1.65E-05	0.735 0.978 1.010 1.126	C/E(5)=0.663
<b>Ta-181(n,n'p)m/(n,d+)m</b>	6*	fng_Ta tud_Ta rez_DF rez_DF	1.61E-04 1.37E-04 2.50E-03 2.00E-03	3.06E-05 1.61E-05 3.97E-04 3.06E-05	1.030 0.948 0.447 0.559	/4.758 C/E(5)=3.727 /4.831 C/E(5)=3.889 /0.620 C/E(5)=0.173 /0.776 C/E(5)=0.719
Ta-181(n,t)n	5	rez_DF	2.83E-06	6.01E-08	0.846	[5 <sub>3</sub> ]
<b>Ta-181(n,t)/(n,xt)</b>	(6)	d-Be3 d-Be	5.90E-04 4.50E-03	2.40E-04 1.30E-03	0.694 0.528	/0.859 C/E(5)=1.531 /1.156 C/E(5)=0.761
<b>Ta-181(n,h)/(n,h+)</b>	5	d-Be2a	9.20E-05	2.59E-05	1.049	/1.119 C/E(5)=0.417 [5 <sub>4</sub> ]/[5 <sub>4</sub> ]
<b>Ta-181(n,<math>\alpha</math>)g</b>	5	fng_Ta	1.01E-03	4.04E-04	0.440	[5 <sub>2</sub> ]
<b>Ta-181(n,<math>\alpha</math>)m</b>	6	fng_Ta tud_Ta	2.31E-04 2.20E-04	2.77E-05 2.30E-05	1.017 0.925	C/E(5)=1.013 C/E(5)=0.920
<b>W-180(n,2n)m</b>	6	fzk_2	8.70E-02	2.61E-02	1.117	
<b>W-180(n,3n)</b>	5	fzk_2	1.71E-02	2.56E-03	1.003	[5 <sub>3</sub> ]
<b>W-182(n,2n)</b>	6	fns_7hour fng_tung fzk_2 fng_eurofer	1.58E+0 1.37E+0 5.39E-01 1.44E+0	2.21E-01 1.75E-01 7.24E-02 1.66E-01	1.221 1.153 0.750 1.106	C/E(5)=1.235
<b>W-182(n,p)</b>	(6)	sneg_1 fng_tung	6.30E-03 3.73E-03	2.02E-03 6.19E-04	0.852 1.062	C/E(5)=0.928 C/E(5)=1.157

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		sneg_1 sneg_2 fzk_ss316 fzk_2 <b>rez_DF</b>	4.44E-03 3.87E-03 2.92E-02 7.10E-04 2.75E-03	3.02E-04 8.12E-04 3.80E-03 1.06E-04 1.10E-04	1.208 1.067 0.154 <sup>†</sup> 1.201 1.318	C/E(5)=1.316 C/E(5)=1.162 C/E(5)=0.167 C/E(5)=1.309
<b>W-182(n,<math>\alpha</math>)n/(n,<math>\alpha^+</math>)n</b>	6*	rez_DF	2.48E-05	1.81E-06	0.320	/0.320
<b>W-183(n,p)</b>	5	sneg_1 sneg_2 fng_f82h	4.42E-03 4.75E-03 3.15E-03	3.45E-04 4.51E-04 2.71E-04	1.465 1.119 1.647	[5 <sub>2</sub> ]
W-183(n, $\alpha$ )m /(n, $\alpha^+$ )m	6*	fzk_2 rez_DF	1.80E-05 2.23E-05	3.60E-06 6.67E-07	0.778 2.500 <sup>†</sup>	/2.502
<b>W-184(n,n'p)/(n,d<sup>+</sup>)</b>	5*	fzk_ss316 rez_DF rez_DF	9.80E-03 2.68E-03 2.65E-03	1.20E-03 7.38E-05 1.35E-04	0.473 1.226 1.239	/0.651 C/E(5)=0.658 [5 <sub>4</sub> ]/[5 <sub>4</sub> ] /1.739 C/E(5)=1.694 /1.758 C/E(5)=1.712
<b>W-184(n,p)</b>	6	fns_7hour fng_tung fng_f82h sneg_1 fzk_ss316 fzk_2 <b>rez_DF</b>	2.25E-03 2.63E-03 1.98E-03 2.78E-03 9.08E-04 6.29E-04 1.26E-03	1.58E-04 2.28E-04 2.94E-04 1.80E-04 3.13E-04 9.43E-05 3.78E-05	1.136 0.911 1.276 1.173 4.057 <sup>†</sup> 0.902 2.361	C/E(5)=1.064    C/E(5)=4.071
<b>W-184(n,t)/(n,t<sup>+</sup>)</b>	(5)	d-Be	1.20E-02	2.00E-03	0.098	/0.623 C/E(5)=0.141 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
W-184(n, $\alpha$ )	6	fng_tung fzk_2 sneg_1 sneg_2 rez_DF	6.27E-04 1.66E-04 7.52E-04 5.35E-04 3.33E-04	5.39E-05 2.49E-05 5.64E-05 9.64E-05 1.51E-05	1.234 1.022 1.394 1.491 2.015 <sup>†</sup>	C/E(5)=1.927
<b>W-186(n,2n)m</b>	6	fns_5min fng_tung sneg_1	3.36E-01 5.71E-01 7.83E-01	4.37E-02 9.30E-02 5.64E-02	1.853 <sup>†</sup> 0.943 0.880	C/E(5)=1.888
<b>W-186(n,2n)</b>	(6)	fns_7hour fzk_2 fng_tung <b>rez_DF</b>	1.38E+0 4.86E-01 1.34E+0 5.41E-01	1.93E-01 6.84E-02 1.65E-01 1.78E-02	1.221 0.872 0.984 0.802	C/E(5)=1.235
W-186(n,n'p)/(n,d <sup>+</sup> )	5	fng_tung fzk_2 rez_DF	1.74E-04 3.38E-04 2.73E-03	2.50E-05 1.01E-04 6.53E-05	0.094 0.164 1.210	/0.427 C/E(5)=4.187 [5 <sub>2</sub> ]/[5 <sub>2</sub> ] /0.349 C/E(5)=0.785 /1.615 C/E(5)=0.771
<b>W-186(n,n'<math>\alpha</math>)m</b>	5*	fzk_2 rez_DF	2.00E-06 4.55E-05	8.00E-07 6.83E-06	1.591 4.198 <sup>†</sup>	C/E(5) = 1.055 [5 <sub>4</sub> ]
<b>W-186(n,<math>\gamma</math>)</b>	6	fng_f82h fng_tung sneg_1 rez_DF rez_DF <b>fzk_ss316</b>	3.48E-01 1.29E+0 4.34E-03 1.32E-01 3.10E-02 2.28E-02	2.46E-02 8.29E-02 3.90E-04 1.13E-03 9.30E-04 1.48E-03	0.926 1.011 0.931 0.179 <sup>†</sup> 0.762 0.668	
W-186(n,p)	6	fns_5min fng_tung fzk_2 sneg_1	1.01E-03 1.84E-03 5.44E-04 2.29E-03	1.31E-04 2.75E-04 8.16E-05 3.66E-04	2.041 <sup>†</sup> 1.005 1.001 1.119	C/E(5)=1.661
<b>W-186(n,h)/(n,h<sup>+</sup>)</b>	5	d-Be2a	1.18E-04	3.23E-05	0.497	/0.519 C/E(5)=0.195 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
W-186(n, $\alpha$ )  /(n, $\alpha^+$ ) /(n, $\alpha^+$ )	6	fng_tung fzk_2 sneg_1 d-Be2a rez_DF	5.33E-04 1.27E-04 7.18E-04 1.40E-03 4.62E-04	8.43E-05 1.90E-05 1.08E-04 2.15E-04 2.31E-05	0.962 0.990 0.978 1.443 1.436 <sup>†</sup>	/1.488 /1.436 C/E(5)=1.808
<b>Re-185(n,2n)g</b>	5	fns_7hour fng_heat <b>fng_Re</b>	1.64E+0 2.19E+0 1.87E+0	8.22E-02 3.28E-01 2.82E-01	0.855 0.625 0.735	C/E(5)=0.833 [5 <sub>2</sub> ]
<b>Re-185(n,2n)m</b>	6	fns_7hour <b>fng_Re</b>	3.68E-01 2.99E-01	2.21E-02 6.46E-02	0.917 1.103	C/E(5)=0.901
<b>Re-185(n,3n)</b>	5*	<b>fng_Re</b>	4.41E-02	1.37E-02	0.643	[5 <sub>3</sub> ]
Re-185(n,p)m	6*	fns_5min	2.17E-03	2.38E-04	1.155	C/E(5)=1.172

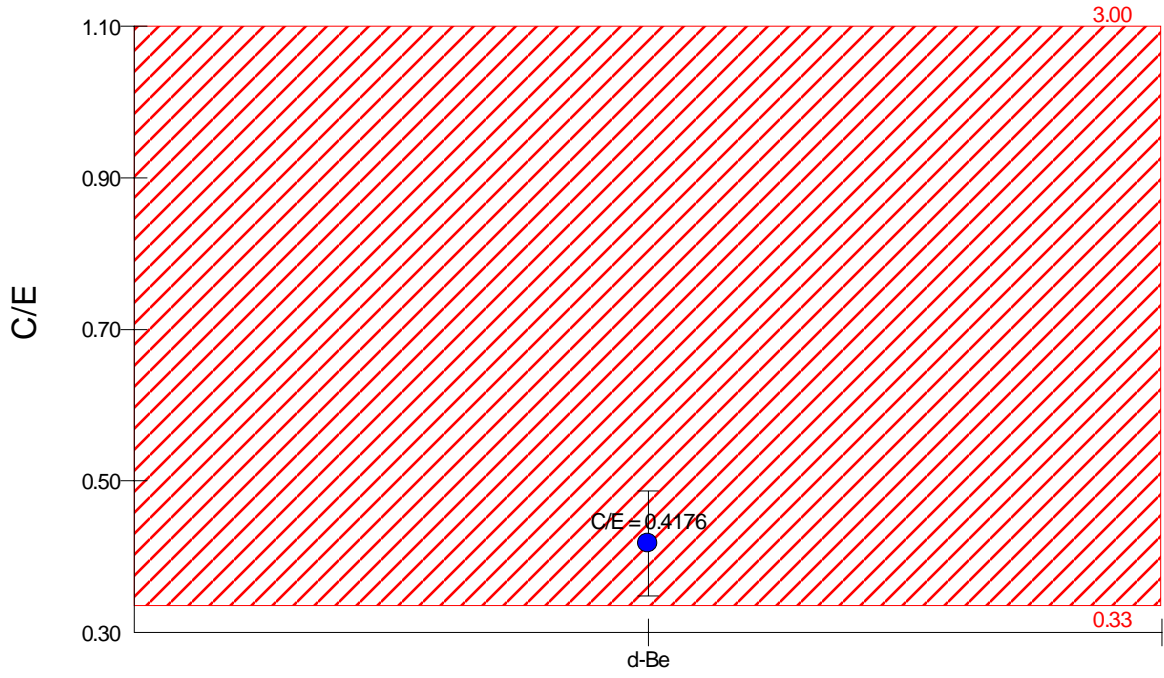
Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
		fng_heat	4.79E-03	7.18E-04	0.546	
Re-187(n,2n)g	6	fns_7hour	1.68E+0	1.51E-01	1.112	C/E(5)=1.129
		fns_5min	1.50E+0	1.20E-01	1.158	C/E(5)=1.228
		fng_heat	2.00E+0	2.59E-01	0.893	
		fng_Re	1.86E+0	2.64E-01	0.961	
Re-187(n, $\gamma$ )m	6*	fng_heat	3.64E-03	5.46E-04	0.500	
		fng_Re	7.02E-03	4.46E-03	0.948	
Re-187(n, $\gamma$ )	(6)	fng_Re	3.19E-01	6.93E-02	0.635	
Re-187(n,p)	6*	fng_Re	4.43E-03	6.55E-04	0.919	
Re-187(n,t)/(n,xt)	(5)	d-Be	3.30E-03	5.63E-04	0.904	/2.223 C/E(5)=1.324 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Re-187(n, $\alpha$ )	6*	fng_Re	7.10E-04	1.59E-04	0.931	
Os-190(n,n')m	5	fns_5min	7.04E-03	3.52E-04	2.735	C/E(5)=2.272 [5 <sub>2</sub> ]
Ir-193(n,2n)m	5	fns_5min	2.06E-01	3.50E-02	2.498	C/E(5)=3.428 [5 <sub>2</sub> ]
Pt-198(n,2n)m	6	fns_5min	7.97E-01	4.78E-02	1.164	C/E(5)=1.178
Au-197(n,n')m	5	fns_5min	1.94E-01	2.33E-02	1.667	C/E(5)=1.639 [5 <sub>2</sub> ]
Au-197(n,2n)m	6*	fns_5min	1.01E-01	1.12E-02	1.099	C/E(5)=1.670
Au-197(n,2n)n	6*	fns_5min	9.50E-02	4.75E-03	1.370 <sup>†</sup>	C/E(5)=1.437
		rez_DF	3.46E-02	1.73E-03	1.238	C/E(5)=1.262
Au-197(n,2n)	(6)	cf252_flux_1	4.30E-03	5.00E-04	1.334 <sup>†</sup>	C/E(5)=1.335
		cf252_flux_1	5.27E-03	2.26E-04	1.089	C/E(5)=1.090
		cf252_flux_1	5.25E-03	3.10E-04	1.093	
		cf252_flux_1	5.80E-03	2.90E-04	0.989	C/E(5)=0.990
		cf252_flux_1	5.50E-03	1.40E-04	1.043	C/E(5)=1.044
		rez_DF	4.99E-01	2.00E-02	1.086	
Au-197(n,3n)m	5	fns_5min	1.18E-03	7.08E-05	1.266	C/E(5)=1.554 [5 <sub>3</sub> ]
Au-197(n,3n)	(6)	rez_DF	2.75E-01	1.38E-02	0.913	C/E(5)=1.554
Au-197(n,4n)	(6)	rez_DF	2.88E-02	8.64E-04	0.526	C/E(5)=0.594
Au-197(n, $\gamma$ )	(6)	cf252_flux_1	1.10E-01	5.00E-03	0.673	
		cf252_flux_1	7.70E-02	7.70E-05	0.962	
		cf252_flux_1	7.80E-02	3.00E-03	0.950	
Au-197(n,t)/(n,xt)	(5)	d-Be	3.90E-03	9.00E-04	0.726	/1.466 C/E(5)=1.072 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Au-197(n,h)g/(n,h+)g	5	d-Be2a	1.07E-04	3.23E-05	0.195	/0.210 C/E(5)=0.094 [5 <sub>0</sub> ]/[5 <sub>0</sub> ]
Au-197(n,h)/(n,h+)	(5)	d-Be2a	8.03E-05	1.95E-05	0.951	/1.010 C/E(5)=0.369 [5 <sub>3</sub> ]/[5 <sub>3</sub> ]
Au-197(n, $\alpha$ )g/(n, $\alpha$ +)g	6	d-Be2a	1.44E-03	2.15E-04	1.631	/1.650
Au-197(n, $\alpha$ )m/(n, $\alpha$ +)m	6	d-Be2a	1.07E-04	2.15E-05	0.782	/1.433
Hg-198(n, $\gamma$ )	(5)	cf252_flux_1	1.68E-01	6.00E-03	0.143	[5 <sub>2</sub> ]
Hg-200(n,2n)m	6	fns_5min	8.24E-01	6.59E-02	0.866	C/E(5)=0.870
Tl-203(n,2n)	6	fns_5min	1.41E+0	1.84E-01	1.205	C/E(5)=1.211
Tl-205(n, $\gamma$ )	(6)	fns_5min	2.53E-03	1.27E-04	0.793	C/E(5)=0.954
Tl-205(n,p)	6	fns_5min	1.93E-03	9.63E-05	0.787	C/E(5)=1.010
Tl-205(n,t)/(n,xt)	6	d-Be3	6.07E-04	2.80E-04	1.137	/1.183 C/E(5)=0.774
		d-Be	4.60E-03	1.35E-03	1.189	/1.640 C/E(5)=0.601
Tl-205(n,t)/(n,t+)	6	d-Be	2.00E-02	4.00E-03	0.251	/0.780
Pb-204(n,n')m	6	fns_5min	5.24E-02	1.36E-02	1.064	C/E(5)=1.154
		fng_heat	5.62E-02	4.49E-03	0.940	
		tud_Pb	6.19E-02	5.63E-03	0.920	
Pb-204(n,2n)m	5	fns_5min	1.51E+0	7.57E-02	0.656	C/E(5)=0.679 [5 <sub>2</sub> ]
Pb-204(n,2n)	(6)	fns_7hour	2.20E+0	1.10E-01	0.943	C/E(5)=0.934
		fng_heat	2.41E+0	1.69E-01	0.839	
		tud_Pb	1.94E+0	1.67E-01	0.966	C/E(5)=0.970
Pb-206(n,p)	(5)	fng_heat	1.11E-02	2.89E-03	0.256	C/E(5)=0.143 [5 <sub>2</sub> ]
Pb-206(n, $\alpha$ )	6	tud_Pb	5.02E-04	5.42E-05	0.761	C/E(5)=0.747
		fns_7hour	1.29E-03	8.11E-04	0.315 <sup>†</sup>	
Pb-208(n,p)	5	fns_5min	1.21E-03	6.03E-05	0.704	C/E(5)=0.771 [5 <sub>2</sub> ]
		fng_heat	2.56E-03	4.61E-04	0.350	
		tud_Pb	8.38E-04	8.88E-05	0.864	C/E(5)=0.860
Pb-208(n,t)/(n,xt)	(5)	d-Be3	5.81E-04	1.76E-04	0.360	/0.407 C/E(5)=0.879 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Pb-208(n,t)/(n,t+)	(5)	d-Be	1.60E-02	3.00E-03	0.126	/0.697 C/E(5)=0.193 [5 <sub>0</sub> ]/[5 <sub>3</sub> ]
Bi-209(n,3n)	6	rez_DF	2.96E-01	2.09E-02	0.868	
Bi-209(n,4n)	6	rez_DF	3.01E-02	8.53E-04	0.775	
Bi-209(n,p)	5*	fns_5min	2.01E-03	1.81E-03	1.190	[5 <sub>4</sub> ]

Reaction	QS	Spectrum	$\sigma$ (b)	$\Delta\sigma$ (b)	C/E	Comment
<b>Bi-209(n,t)/(n,xt)</b>	(5)	d-Be3	7.80E-04	2.50E-04	1.258	/0.988 C/E(5)=0.446 [5 <sub>4</sub> ]/[5 <sub>4</sub> ]
		d-Be	3.70E-03	7.00E-04	1.380	/2.217 C/E(5)=0.374
<b>Bi-209(n,h)/(n,h+)</b>	(5)	d-Be2a	6.14E-05	2.05E-05	1.727	/1.800 C/E(5)=0.688 [5 <sub>4</sub> ]/[5 <sub>4</sub> ]
<b>Bi-209(n,<math>\alpha</math>)</b>	(6)	<b>fns 5min</b>	5.81E-04	7.56E-05	1.411	
<b>Th-232(n,f)</b>	6	cf252_flux_1	8.94E-02	2.40E-03	0.915	C/E(5)=0.839
		cf252_flux_1	8.47E-02	4.90E-03	0.965	C/E(5)=0.885
Pa-231(n,f)	6	cf252_flux_1	9.70E-01	4.50E-02	0.891	
U-233(n,f)	6	cf252_flux_1	1.95E+0	3.12E-02	0.942	
		cf252_flux_1	1.89E+0	4.80E-02	0.969	
U-234(n,f)	6	cf252_flux_1	1.20E+0	1.40E-02	0.992	
U-235(n,f)	6	cf252_flux_1	1.27E+0	1.82E-02	0.962	
		cf252_flux_1	1.21E+0	2.20E-02	1.003	
		cf252_flux_1	1.22E+0	1.90E-02	1.002	
		cf252_flux_1	1.05E+0	3.10E-02	1.158	
		cf252_flux_1	1.23E+0	1.70E-02	0.987	
U-236(n,f)	6	cf252_flux_1	6.12E-01	8.00E-03	0.987	
<b>U-238(n,2n)</b>	5	cf252_flux_1	1.92E-01	1.90E-03	0.106	[5 <sub>2</sub> ]
		cf252_flux_1	1.22E-02	1.50E-03	1.670	
U-238(n,f)	6	cf252_flux_1	3.29E-01	1.00E-02	0.960	
		cf252_flux_1	3.24E-01	1.40E-02	0.975	
		cf252_flux_1	2.88E-01	7.00E-03	1.096	
		cf252_flux_1	3.08E-01	1.70E-02	1.025	
		cf252_flux_1	3.32E-01	5.00E-03	0.951	
		cf252_flux_1	3.11E-01	1.40E-02	1.016	
<b>Np-237(n,2n)m</b>	5	cf252_flux_1	4.66E-03	4.66E-04	0.621	[5 <sub>2</sub> ]
Np-237(n,f)	6	cf252_flux_1	1.26E+0	6.00E-02	1.044	
		cf252_flux_1	1.38E+0	1.00E-01	0.953	
		cf252_flux_1	1.37E+0	2.00E-02	0.963	
		cf252_flux_1	1.44E+0	2.29E-02	0.912	
Pu-239(n,f)	6	cf252_flux_1	1.80E+0	6.00E-02	0.999	
		cf252_flux_1	1.84E+0	2.40E-02	0.975	
		cf252_flux_1	1.86E+0	3.01E-02	0.966	
		cf252_flux_1	1.79E+0	4.10E-02	1.004	
Pu-240(n,f)	6	cf252_flux_1	1.34E+0	3.20E-02	1.025	
		cf252_flux_1	1.31E+0	3.00E-02	1.046	
Pu-241(n,f)	6*	cf252_flux_1	1.62E+0	8.00E-02	1.004	
		cf252_flux_1	1.74E+0	5.40E-02	0.930	
Am-243(n,f)	6	cf252_flux_1	1.14E+0	2.30E-02	1.001	

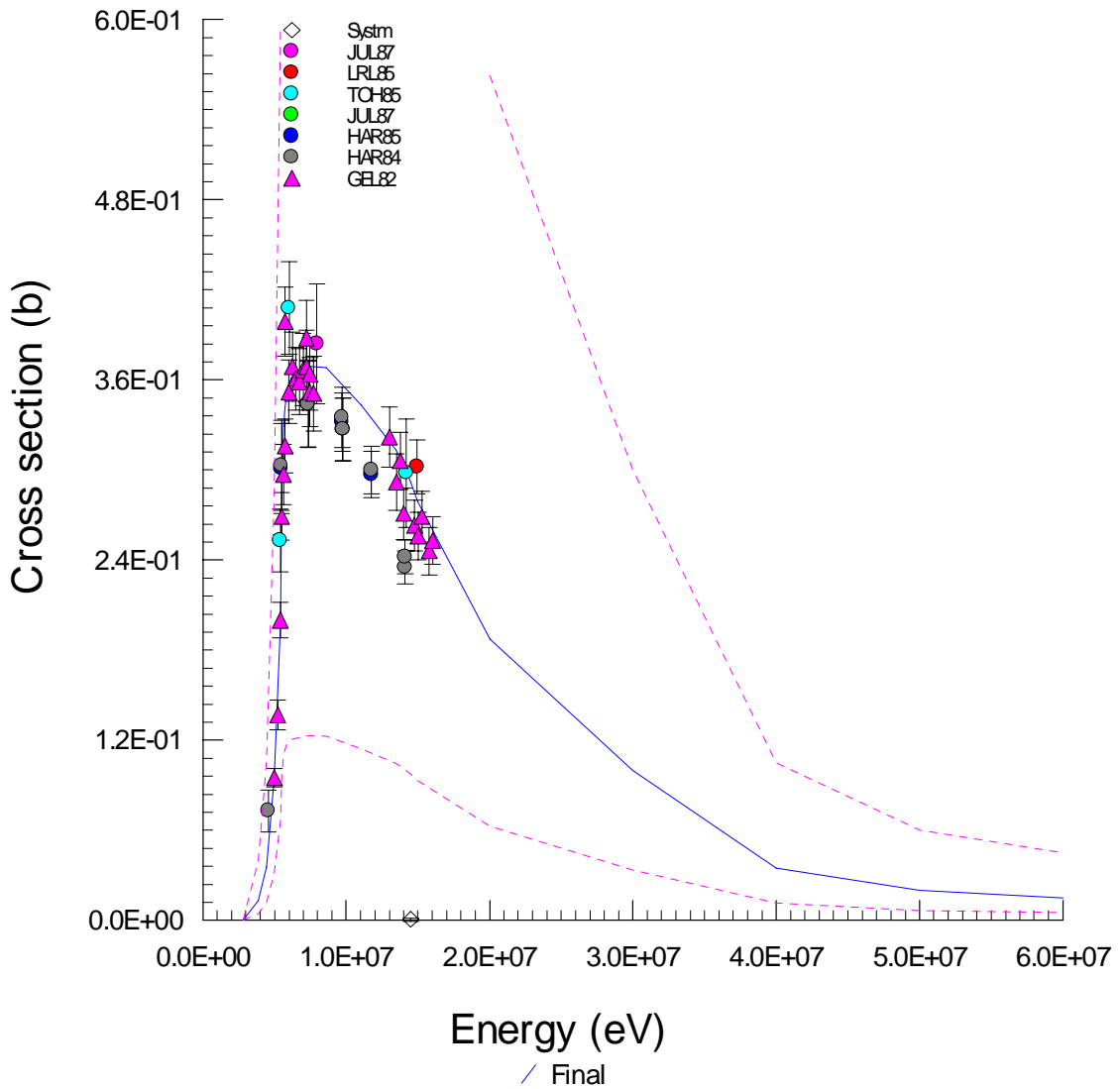
In the rest of the report, individual reactions are illustrated using two figures. The first figure shows the ratio of the calculated effective cross section and the effective cross section extracted from the measurements. The EAF uncertainty is shown as a band about the C/E = 1 value. Note that in the case of a capture reaction the uncertainty at high energy is used. Each C/E has error bars corresponding to the experimental uncertainty. Agreement between the calculated and measured values is assumed when the error bar overlaps the calculated error band. In the second figure the EAF-2007 cross section data with dotted lines indicating the library uncertainty value and differential experimental data from EXFOR shown as symbols with the quoted uncertainty for each point are plotted.



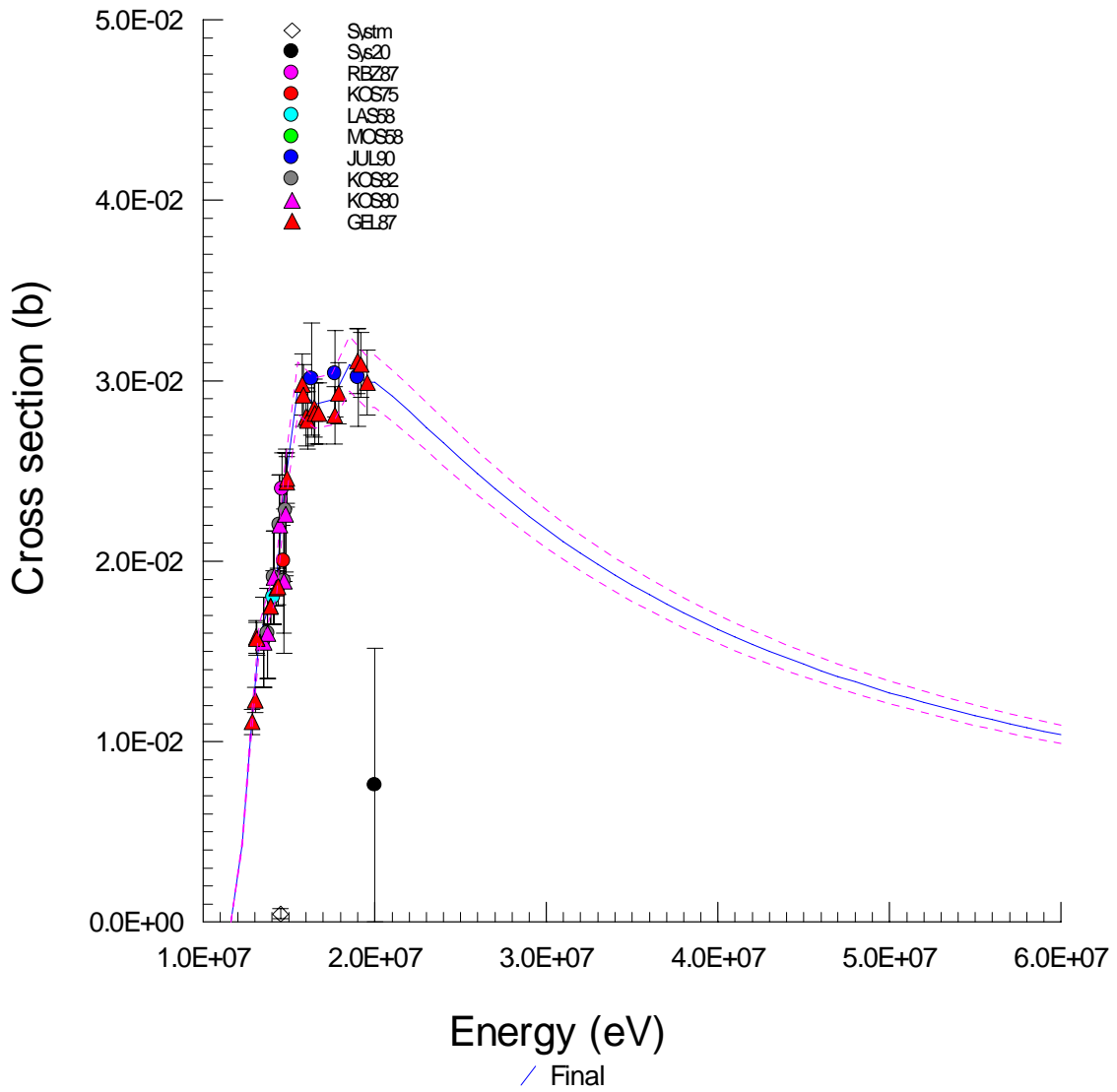
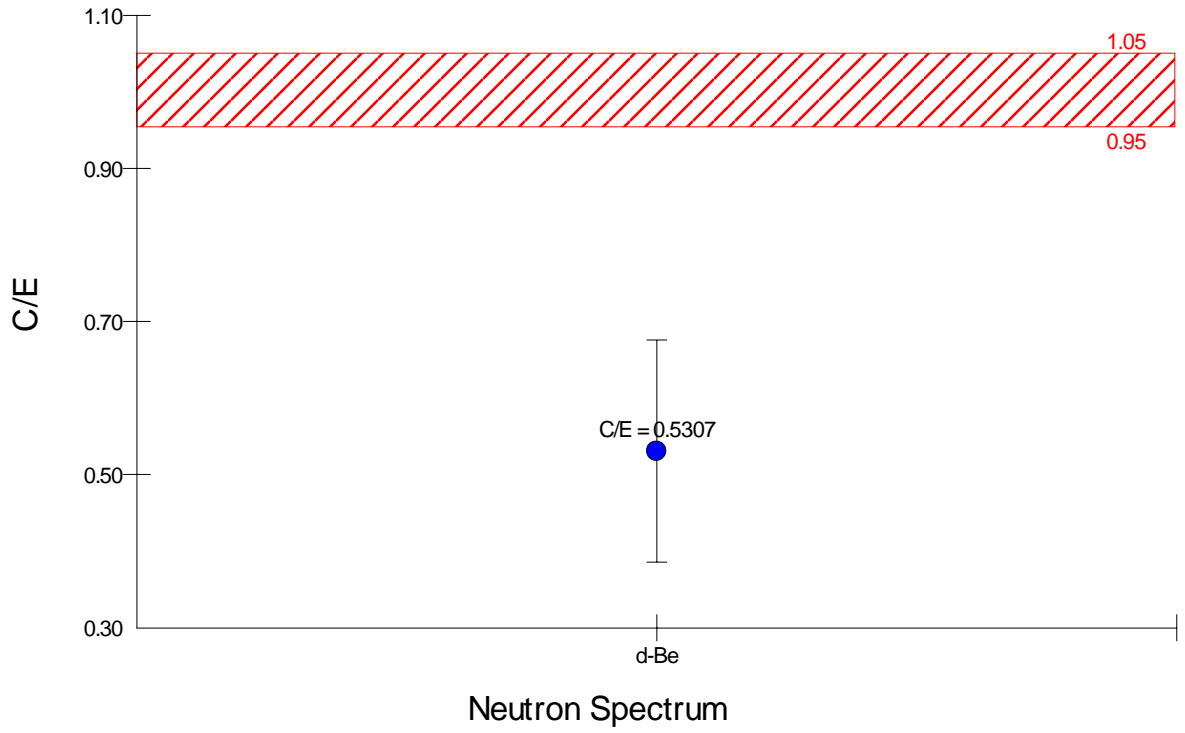
# ${}^7\text{Li}(n,n'\alpha){}^3\text{H}$

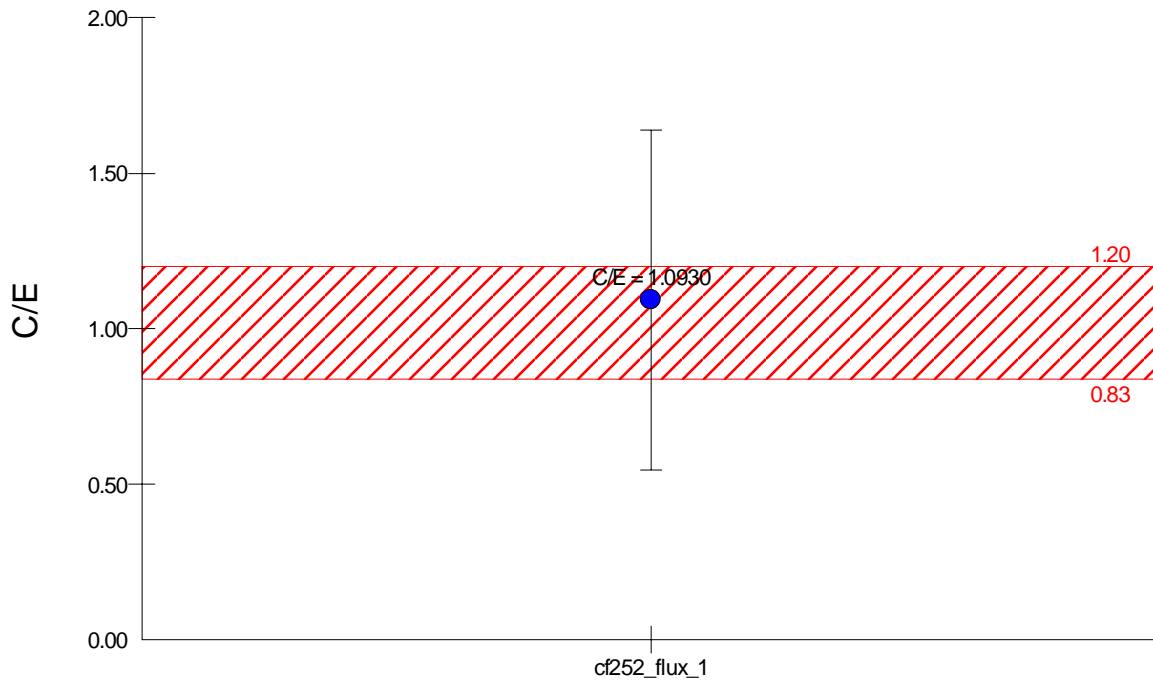
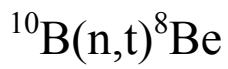


Neutron Spectrum

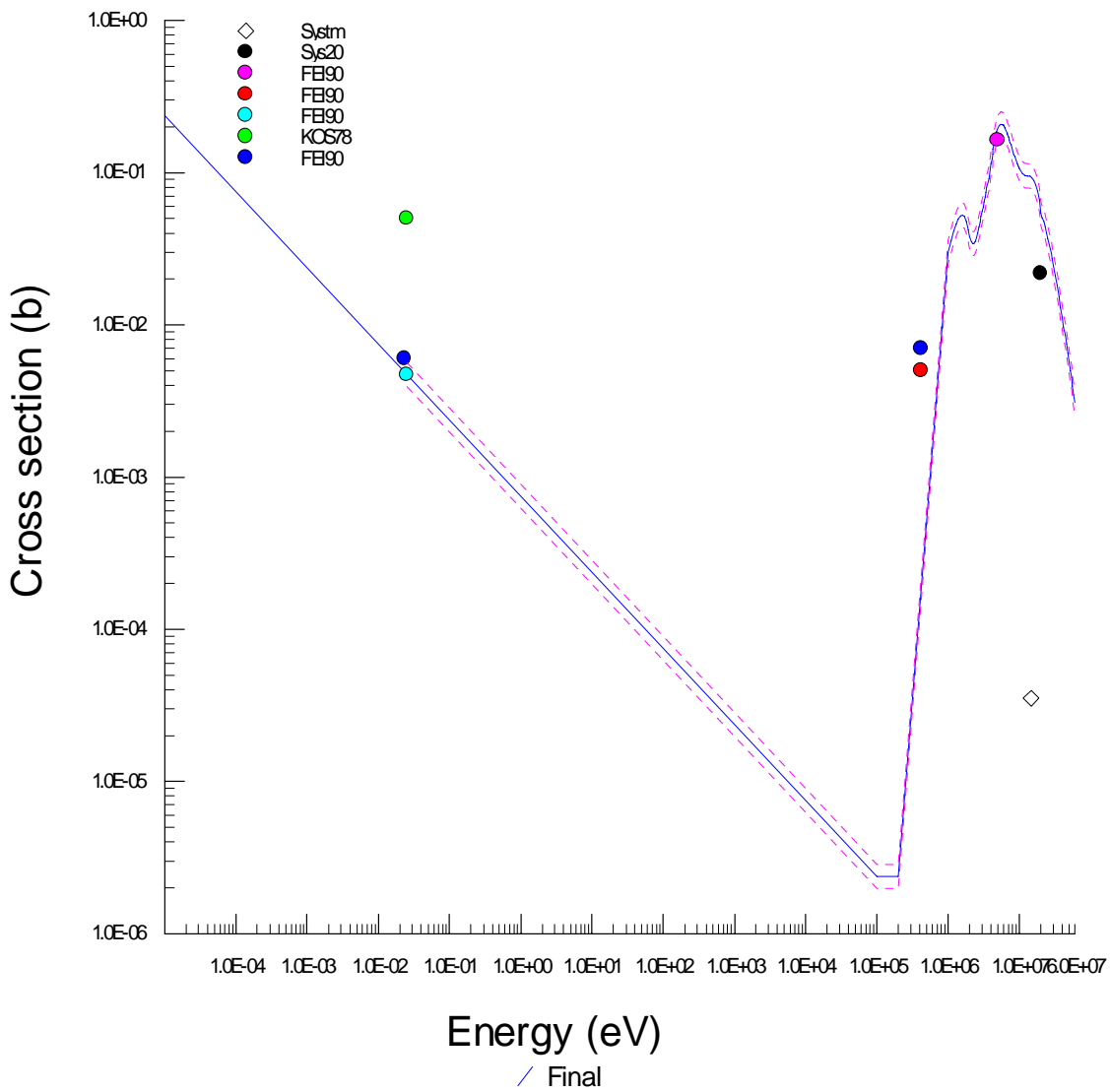


# ${}^9\text{Be}(n,t){}^7\text{Li}$

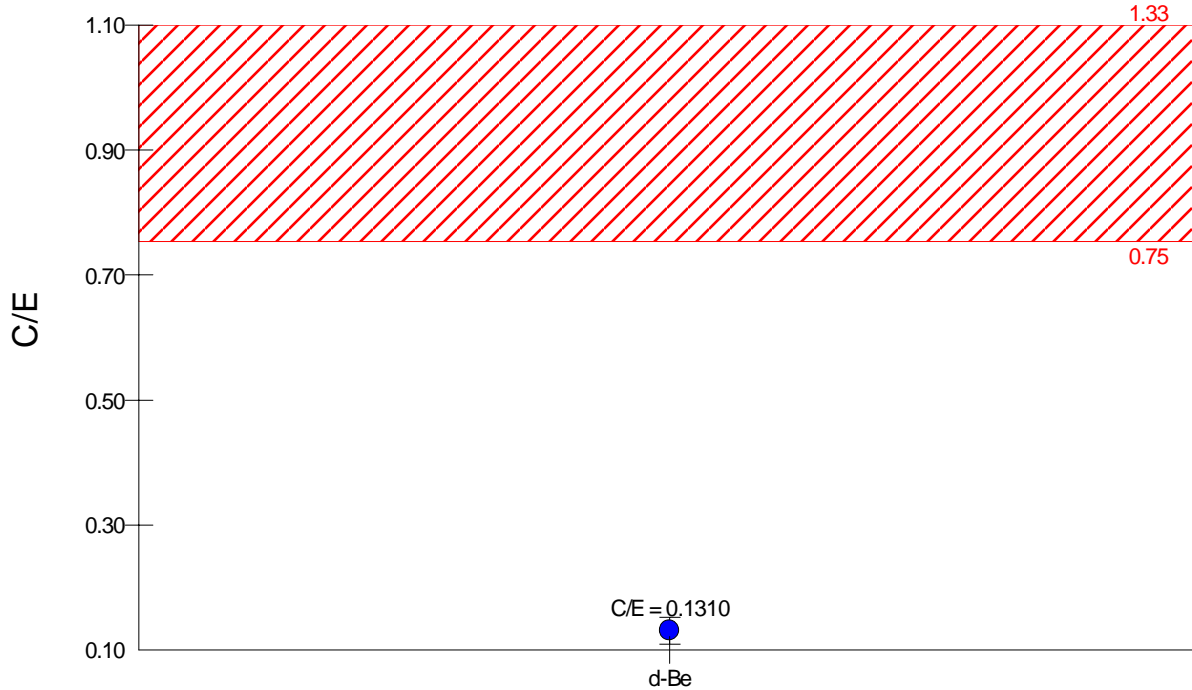




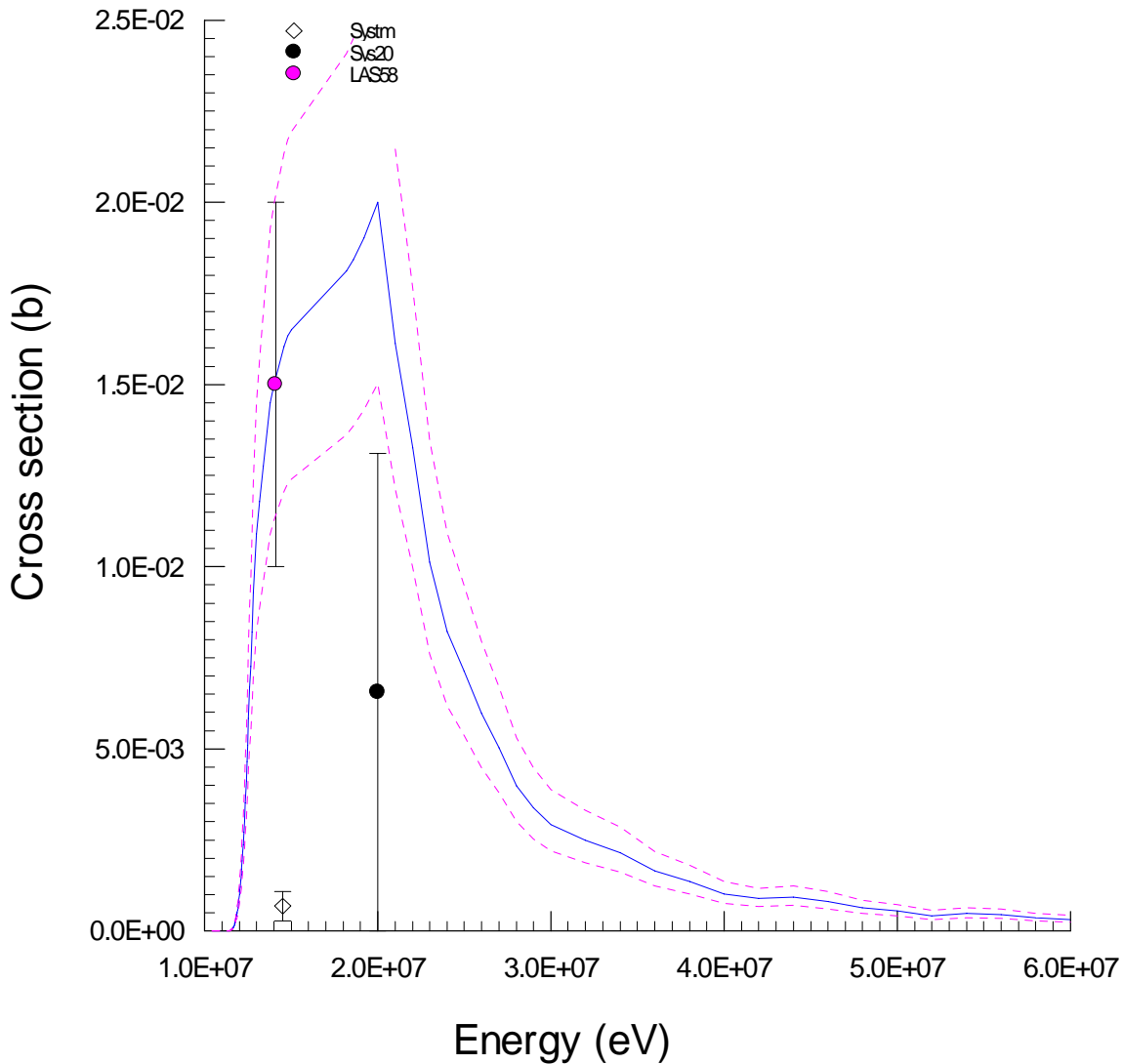
Neutron Spectrum



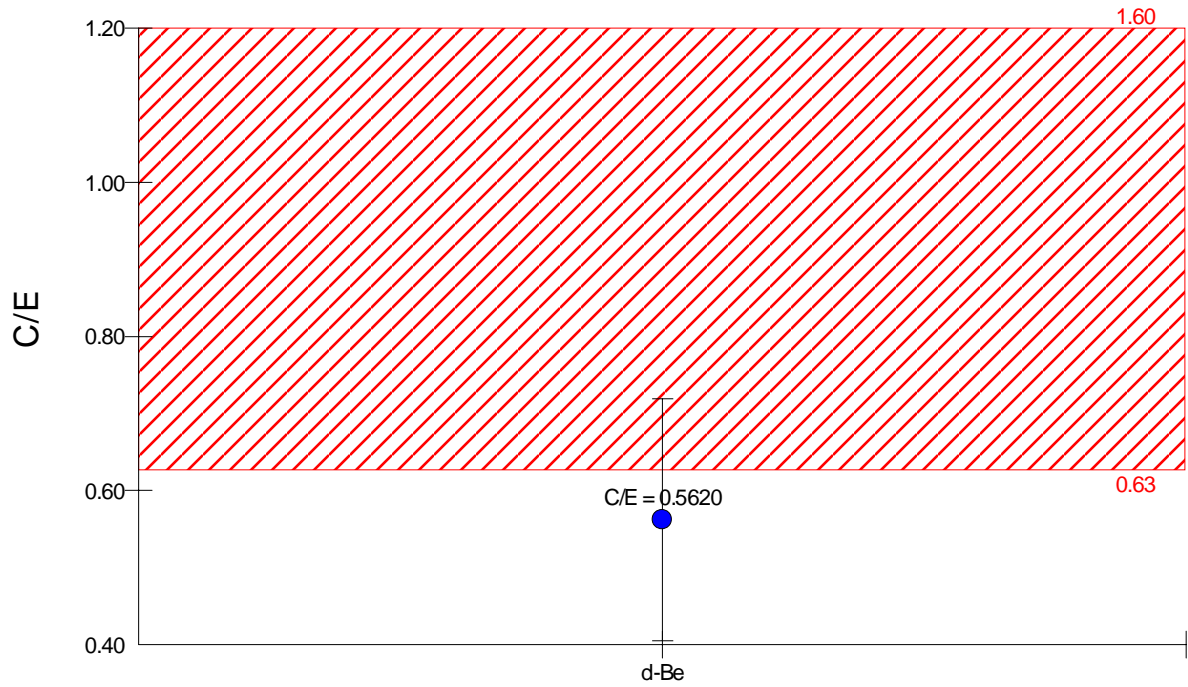
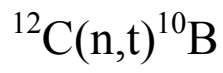
# $^{11}\text{B}(n,t)^9\text{Be}$



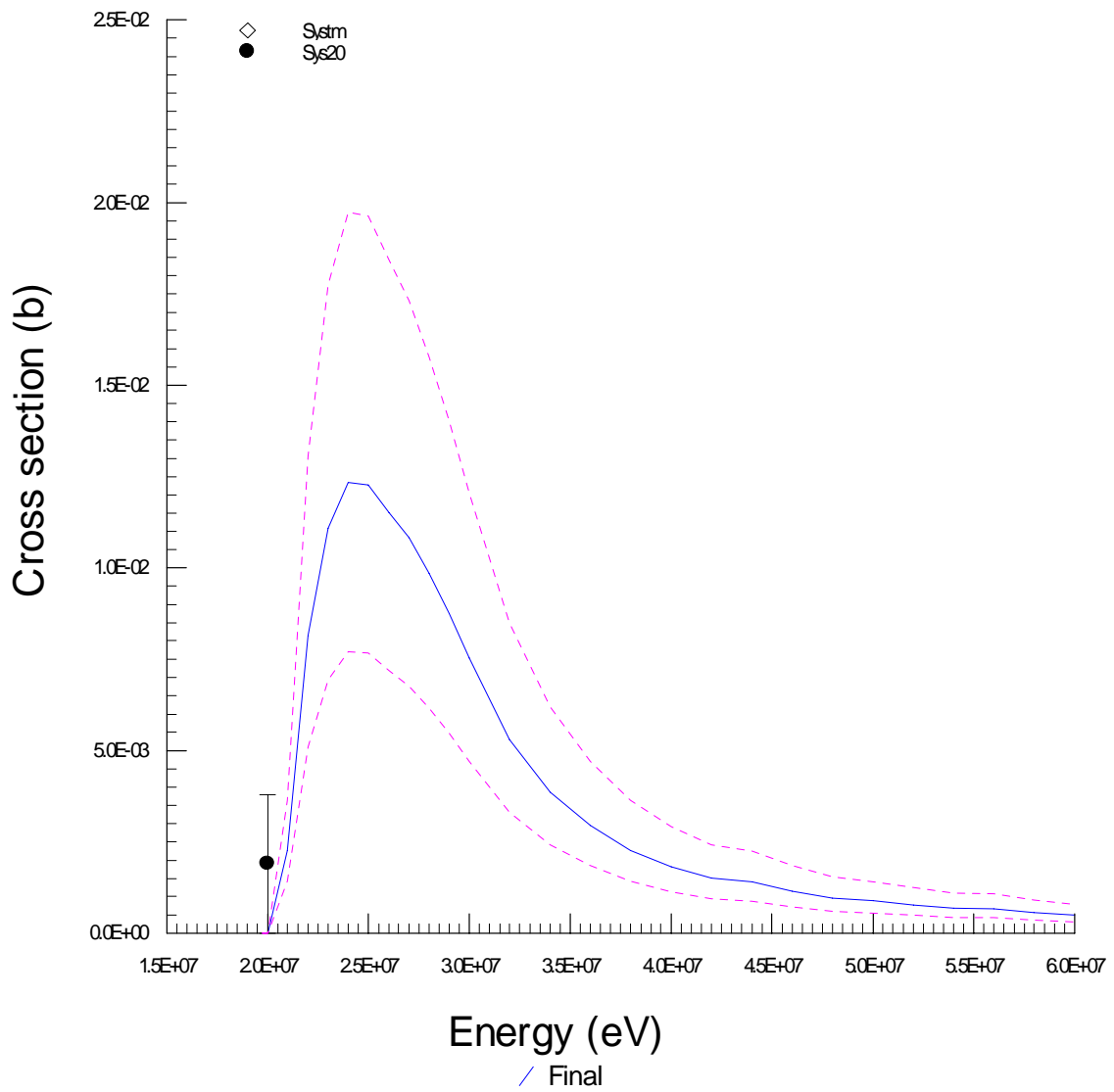
## Neutron Spectrum

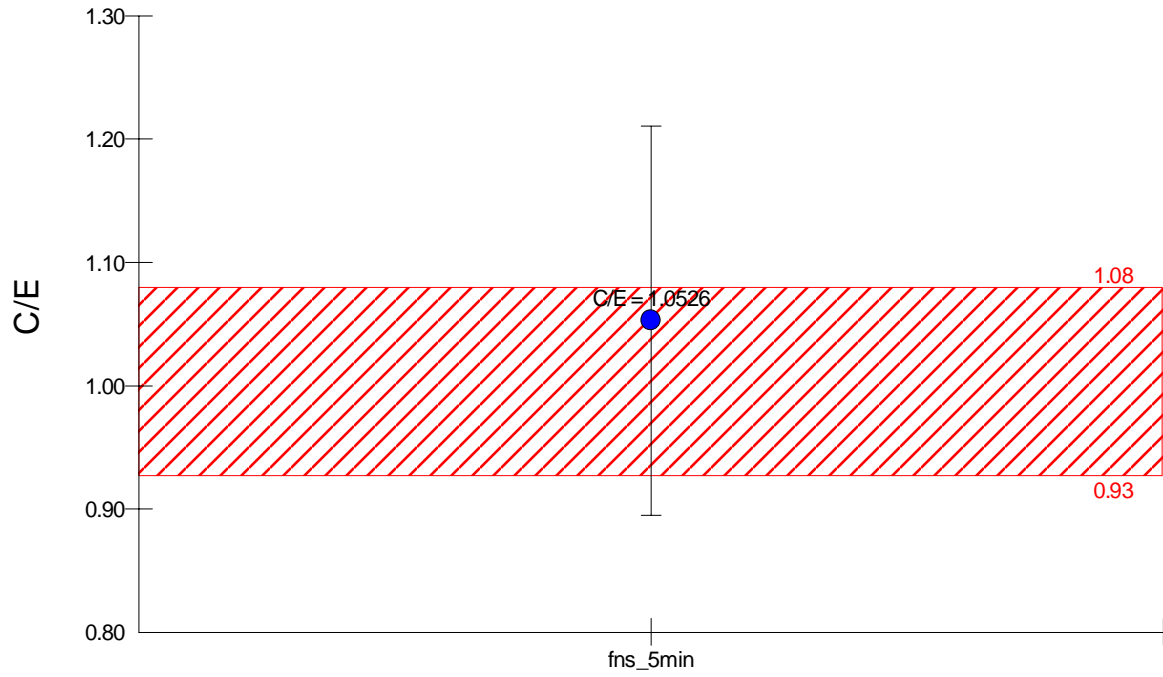
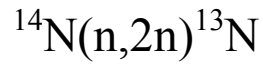


Final

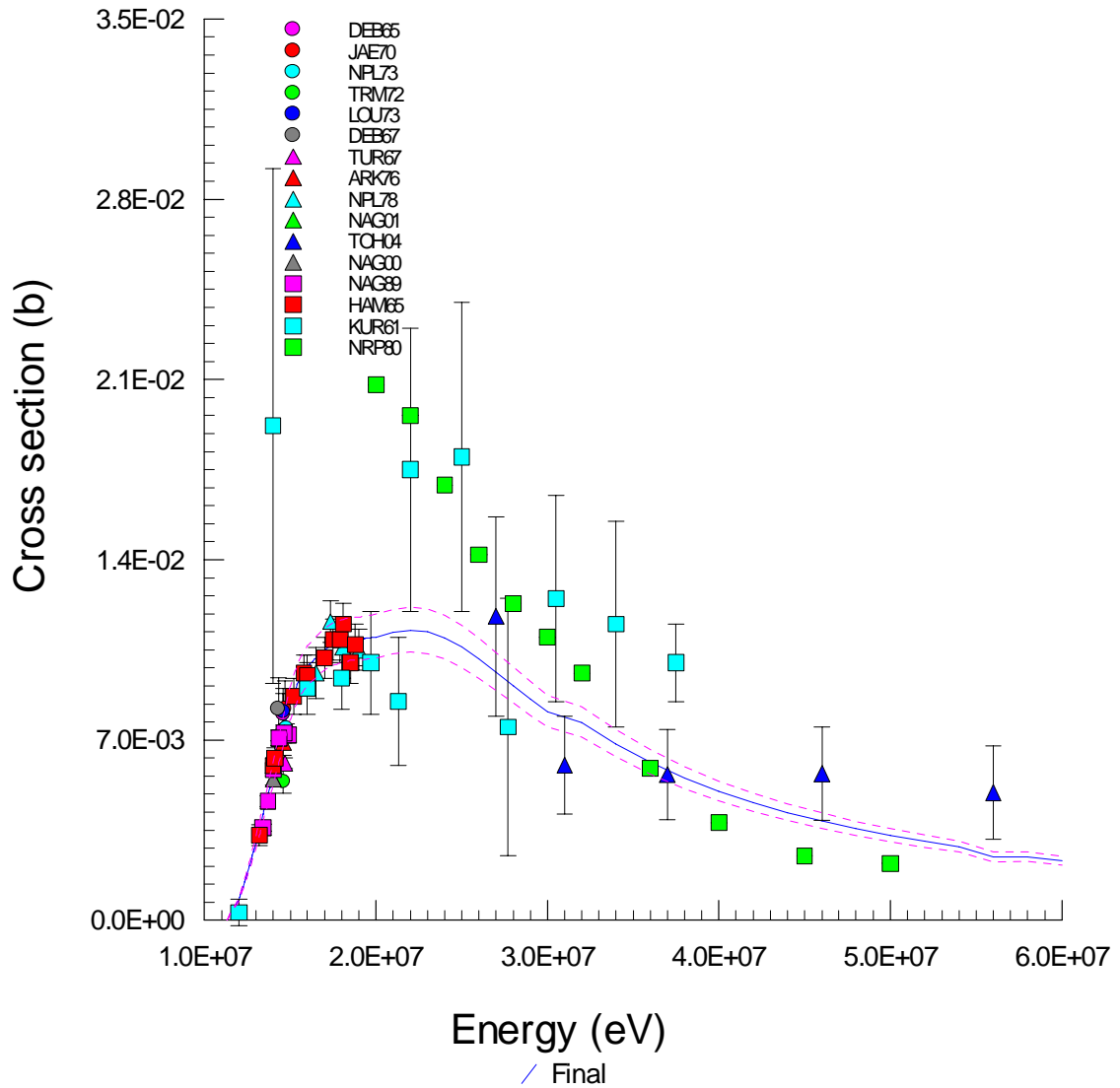


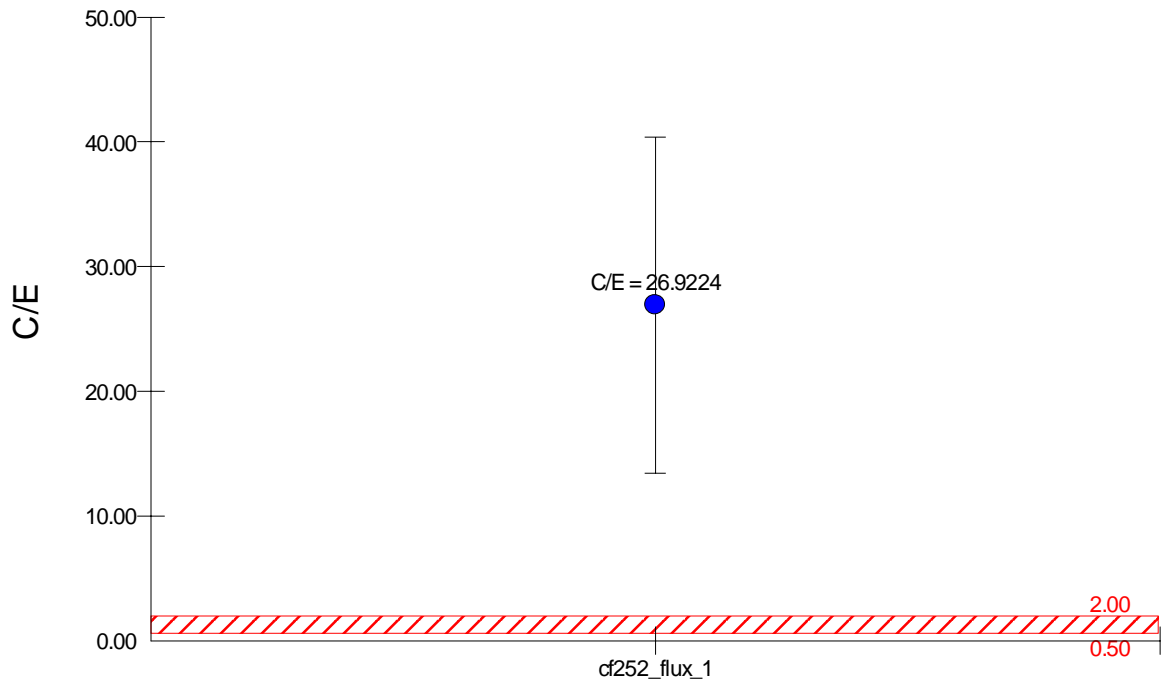
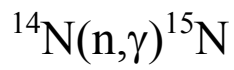
Neutron Spectrum



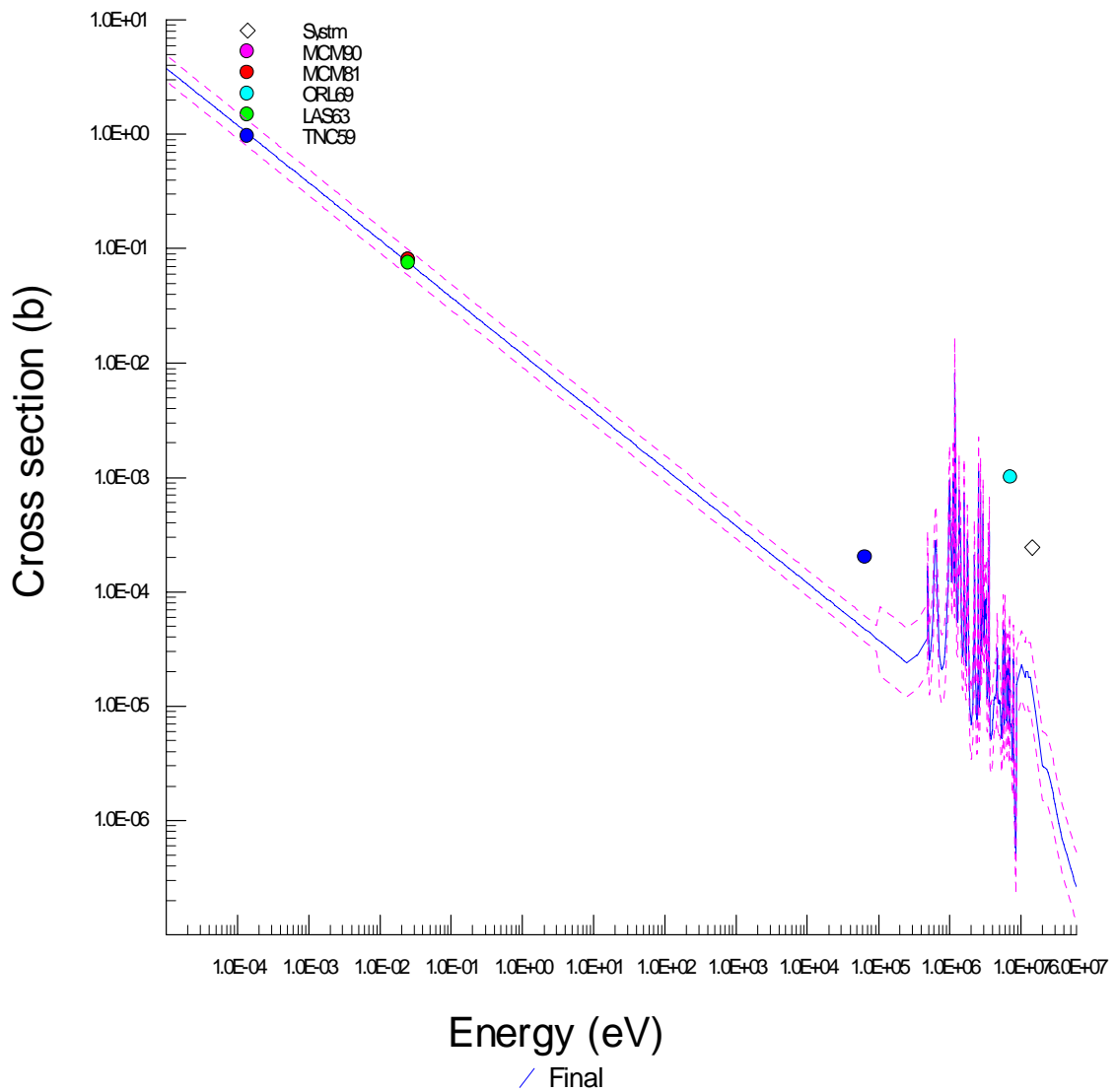


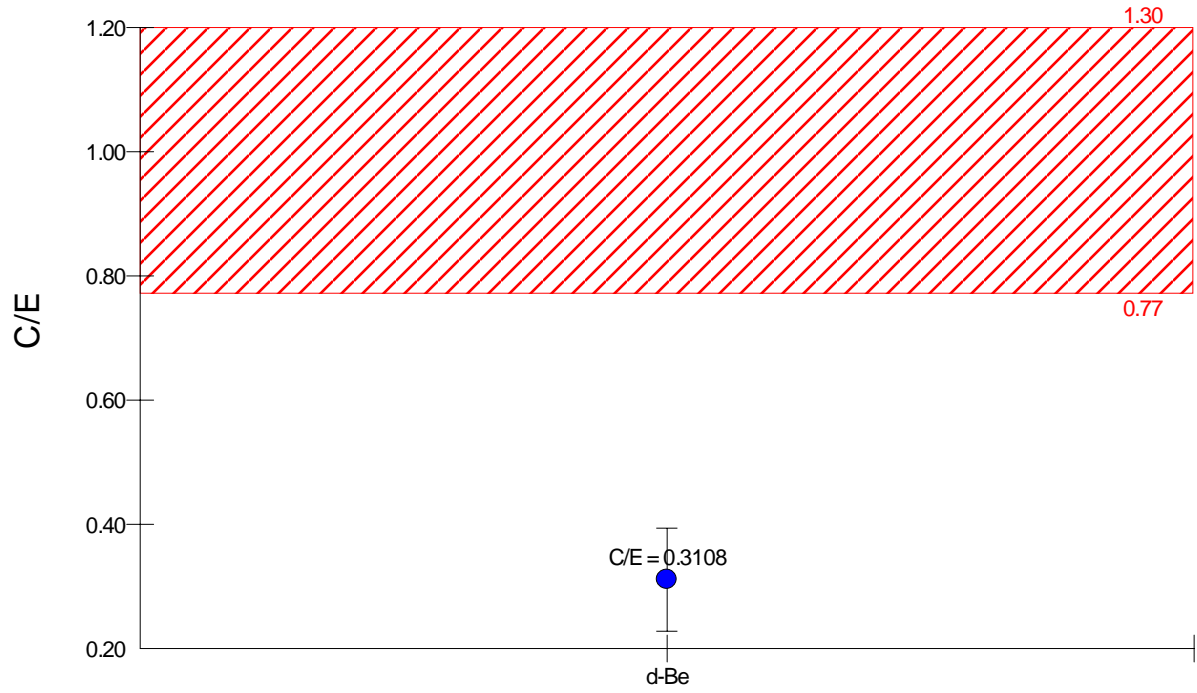
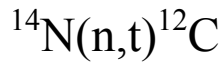
Neutron Spectrum



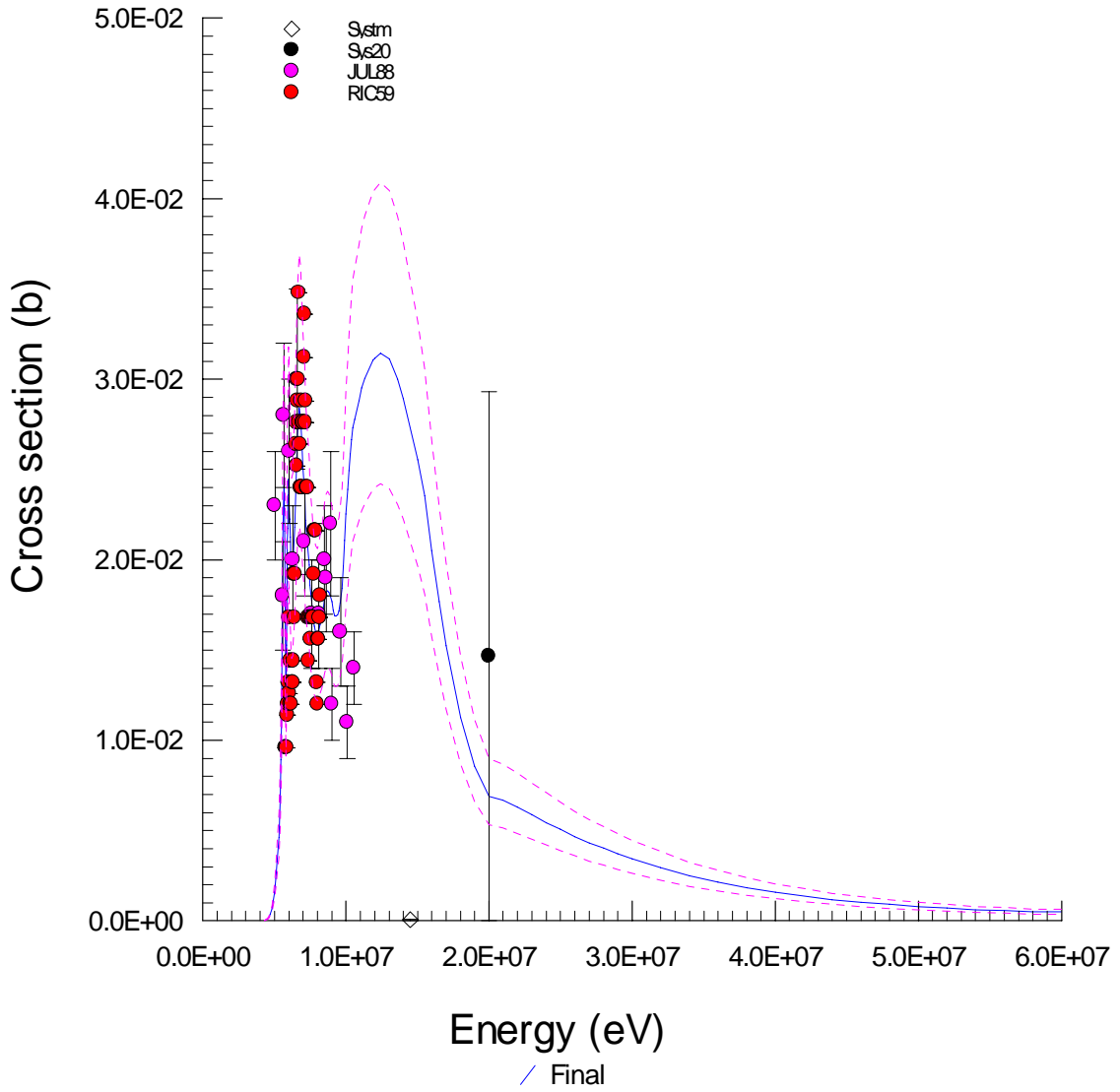


Neutron Spectrum



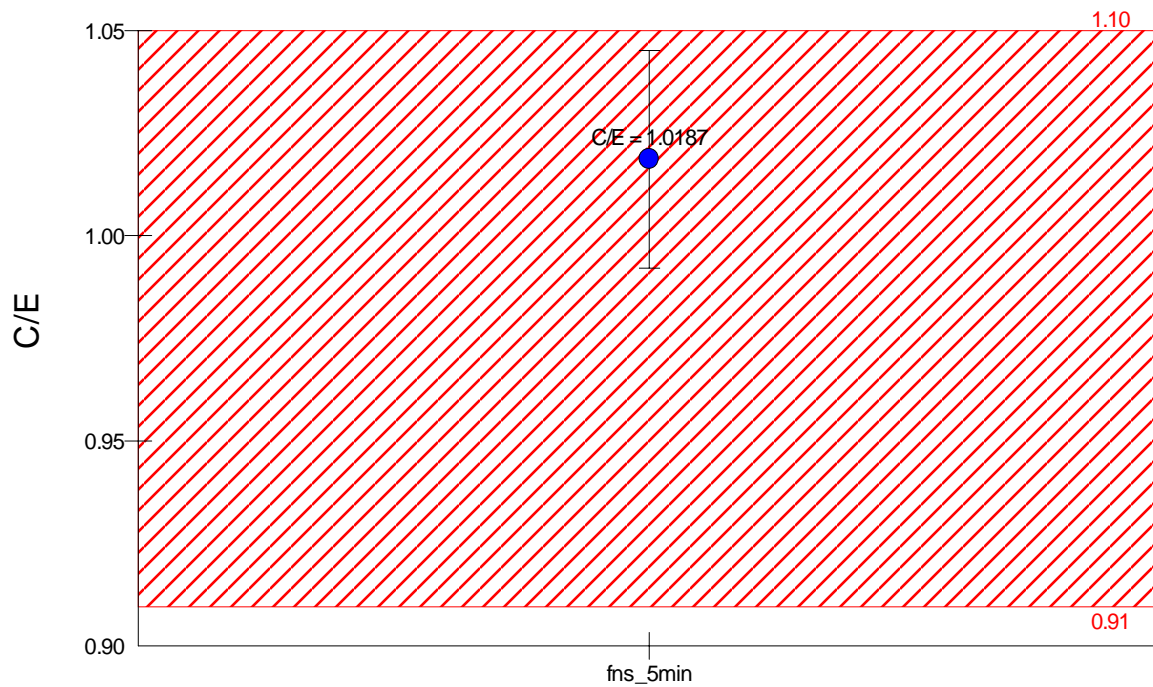


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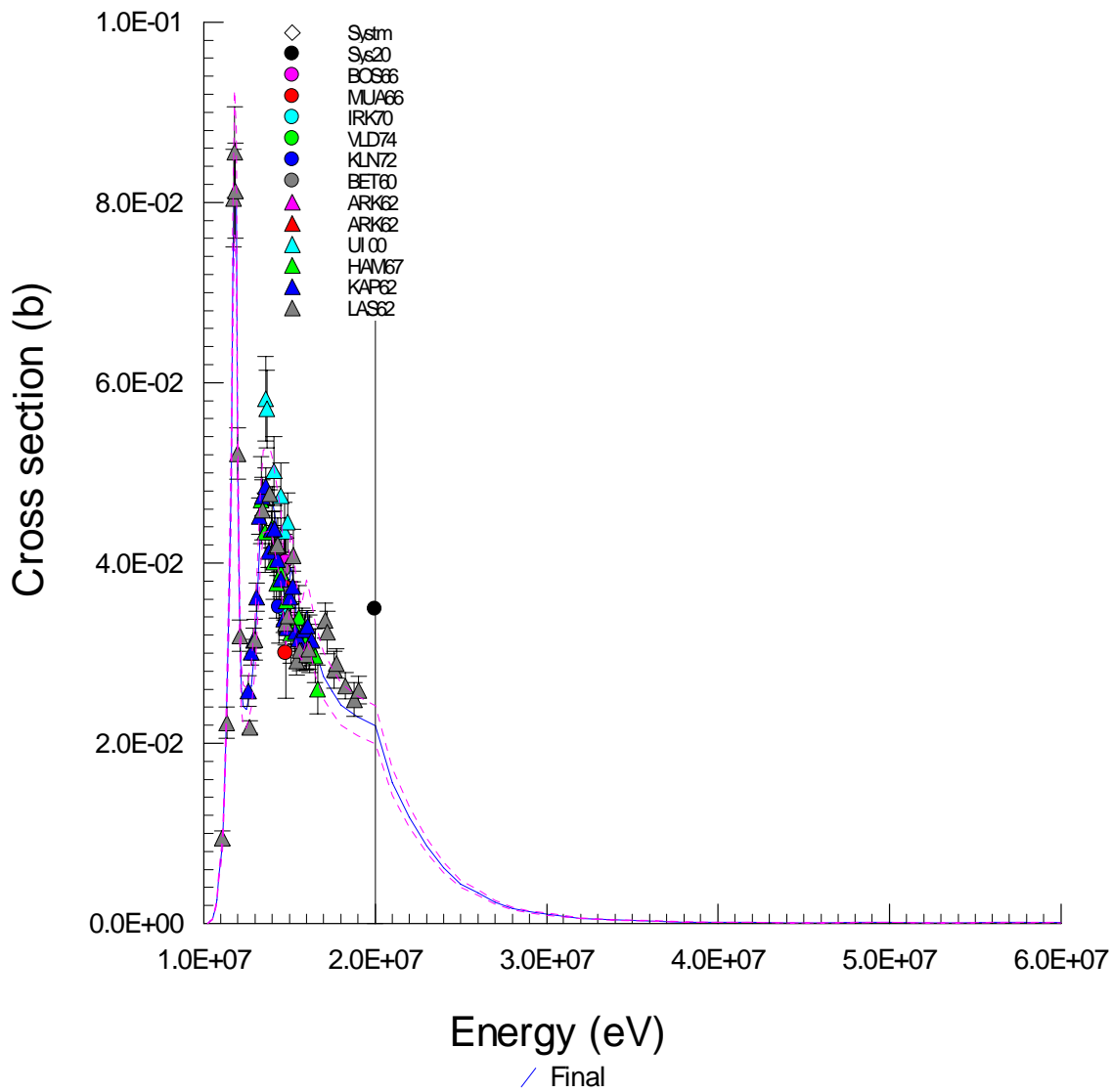


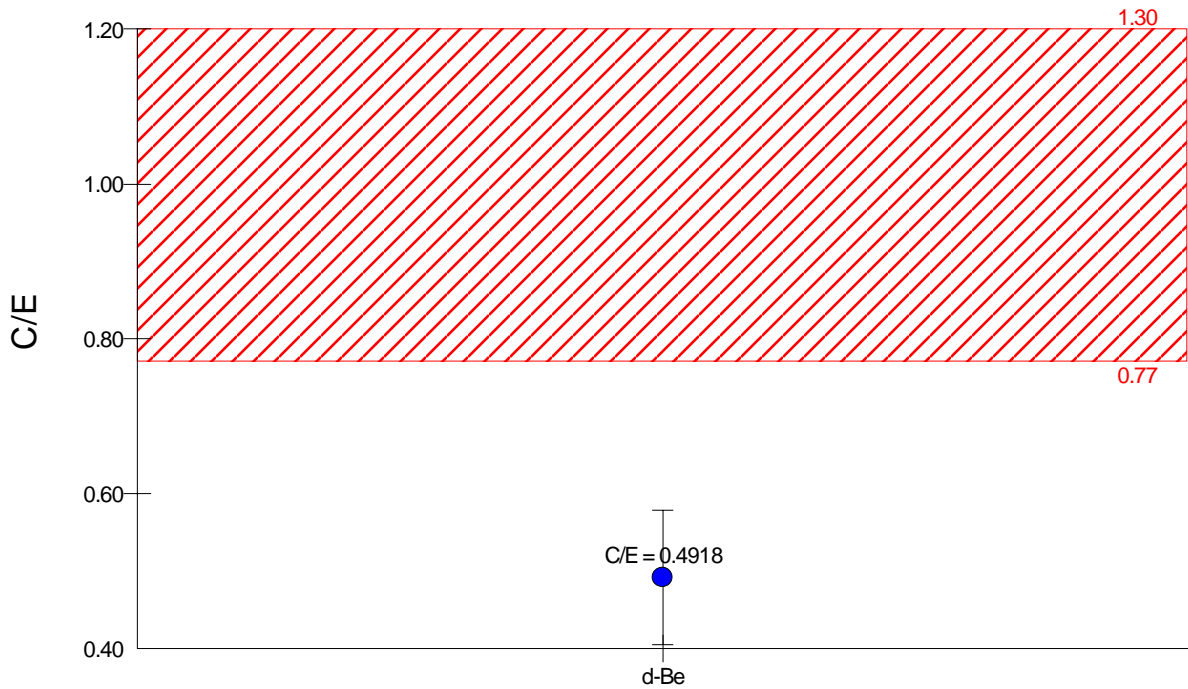
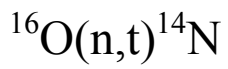


# $^{16}\text{O}(n,p)^{16}\text{N}$

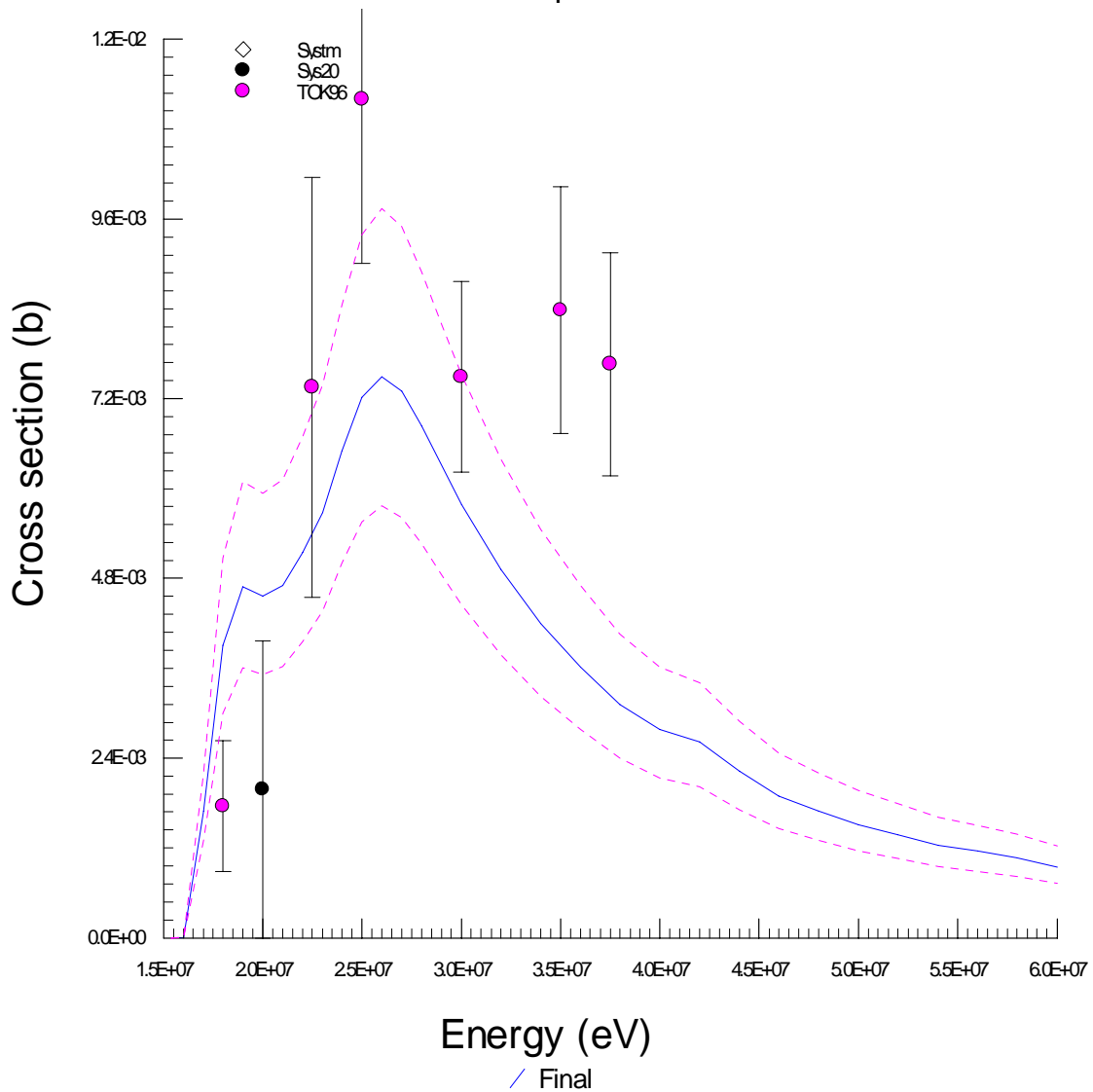


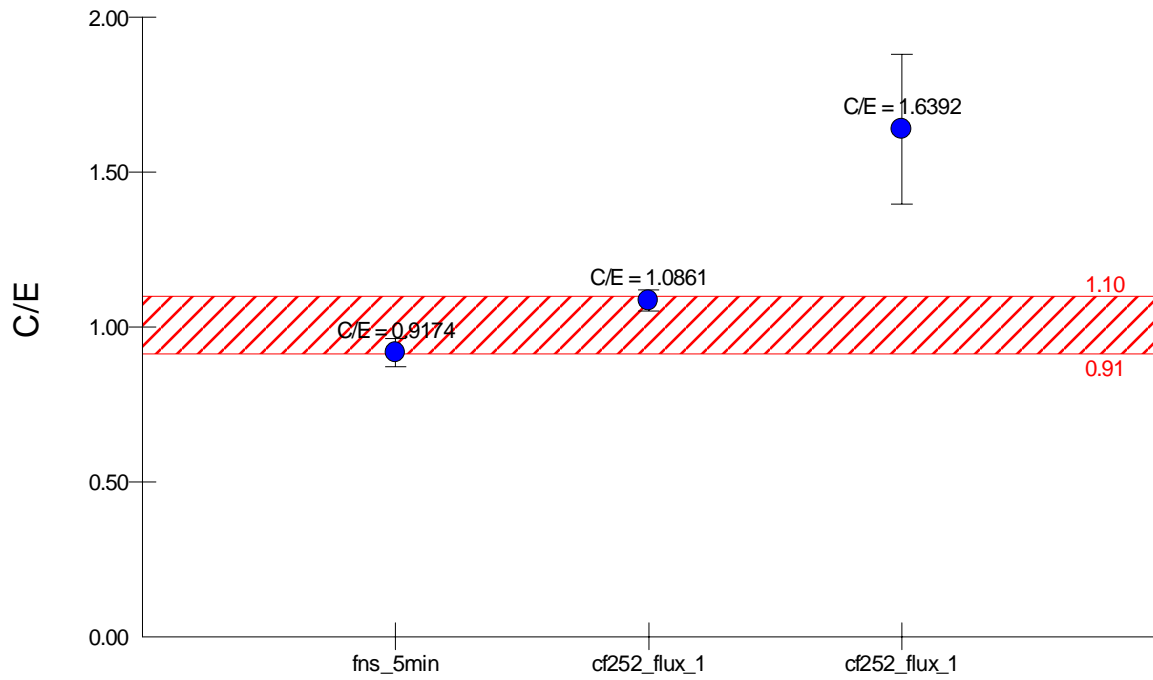
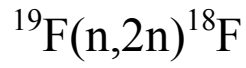
## Neutron Spectrum



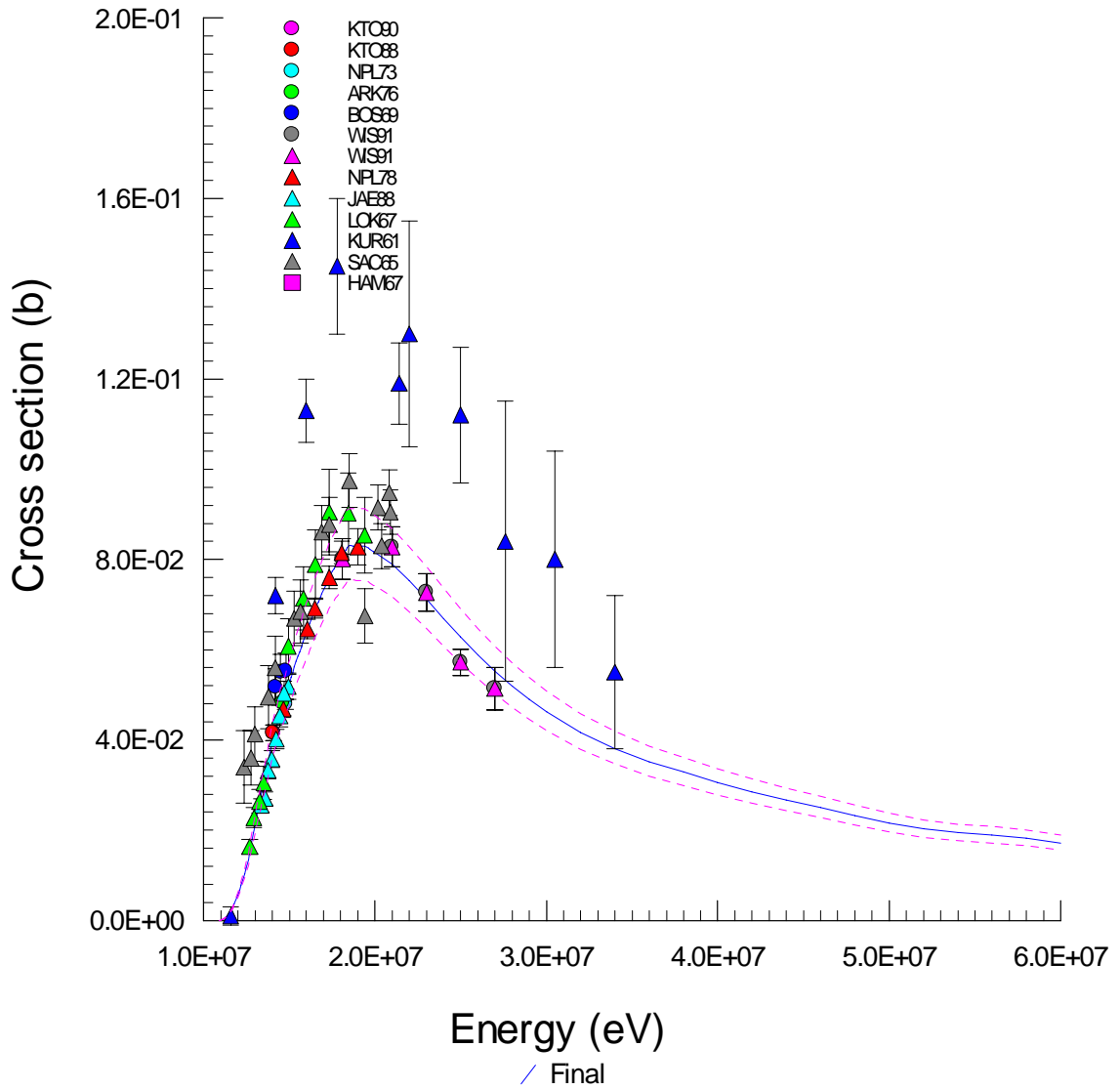


Neutron Spectrum

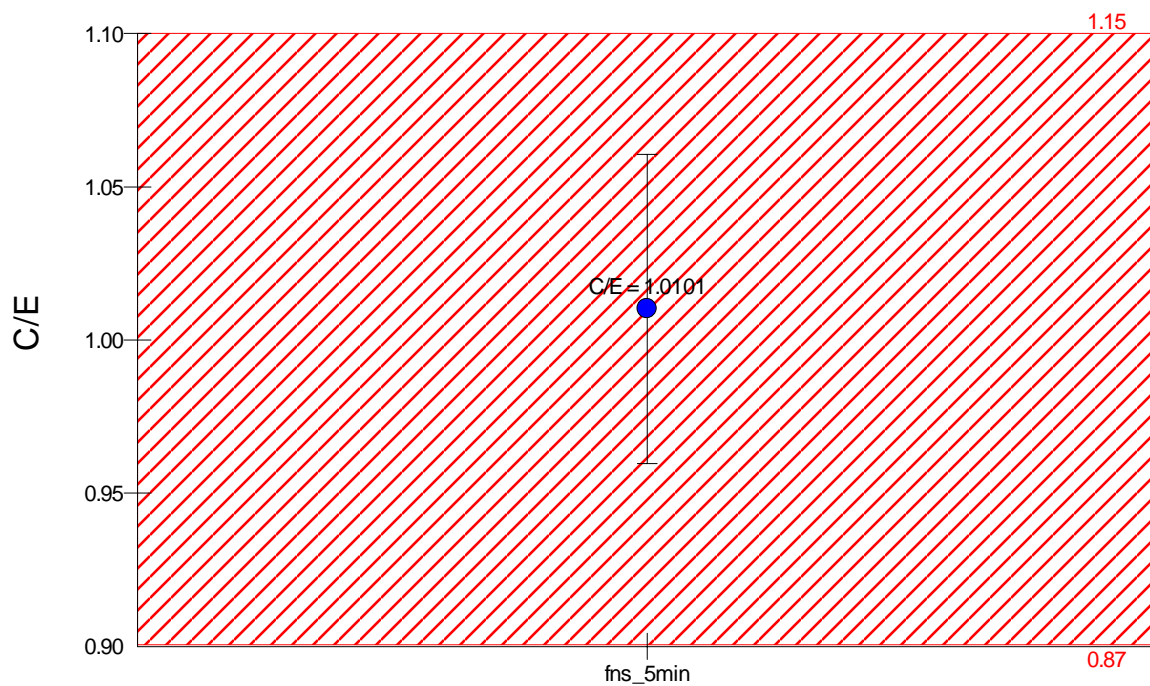




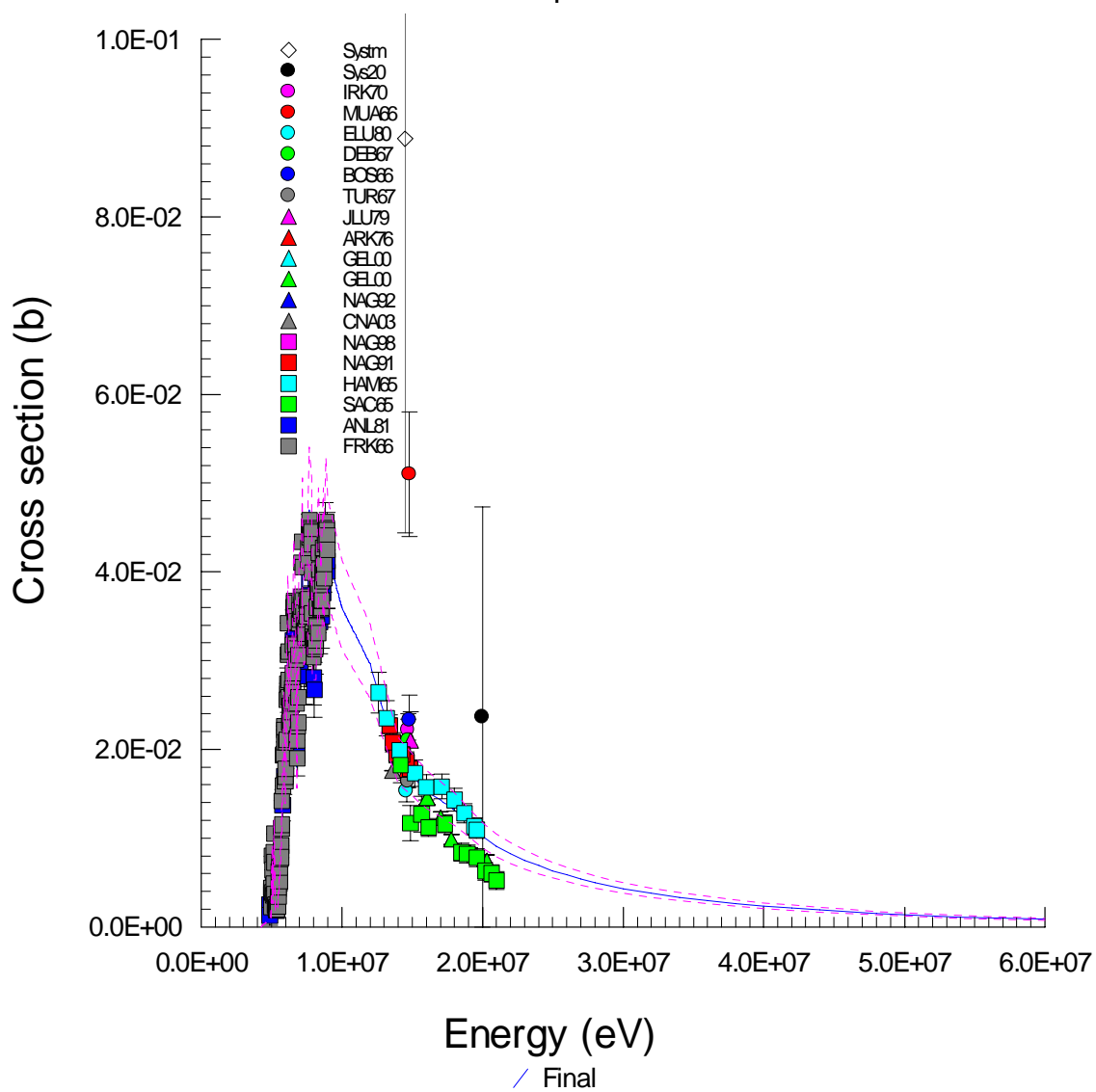
Neutron Spectrum

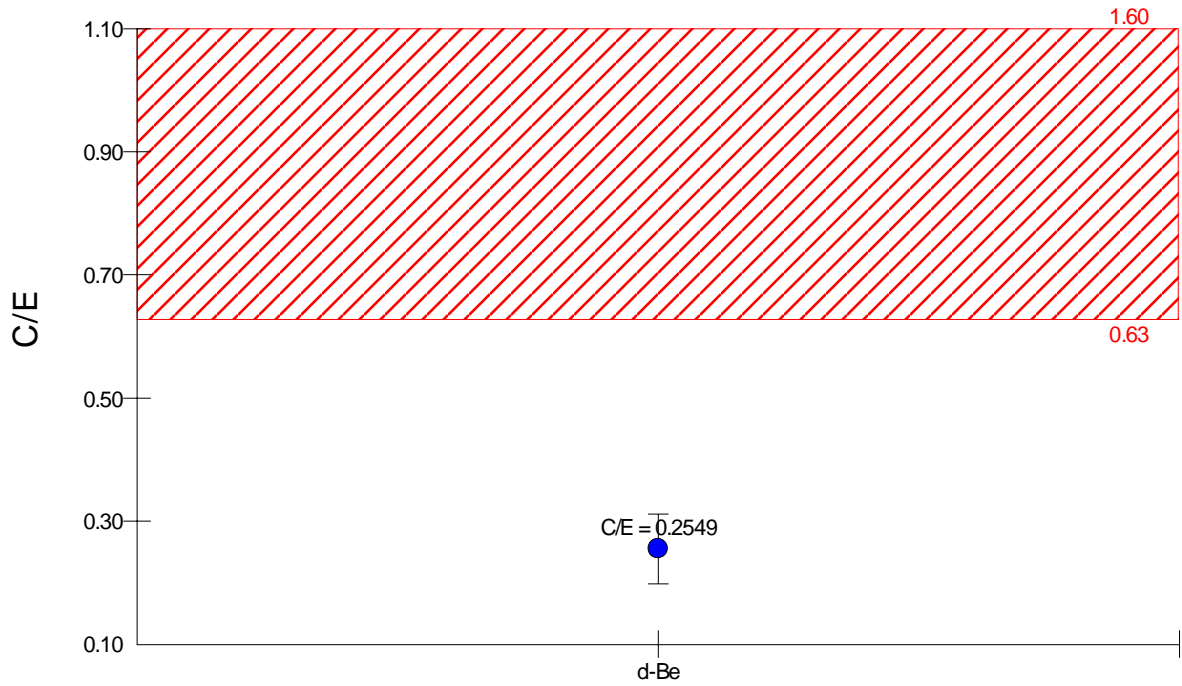
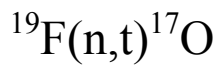


# $^{19}\text{F}(n,p)^{19}\text{O}$

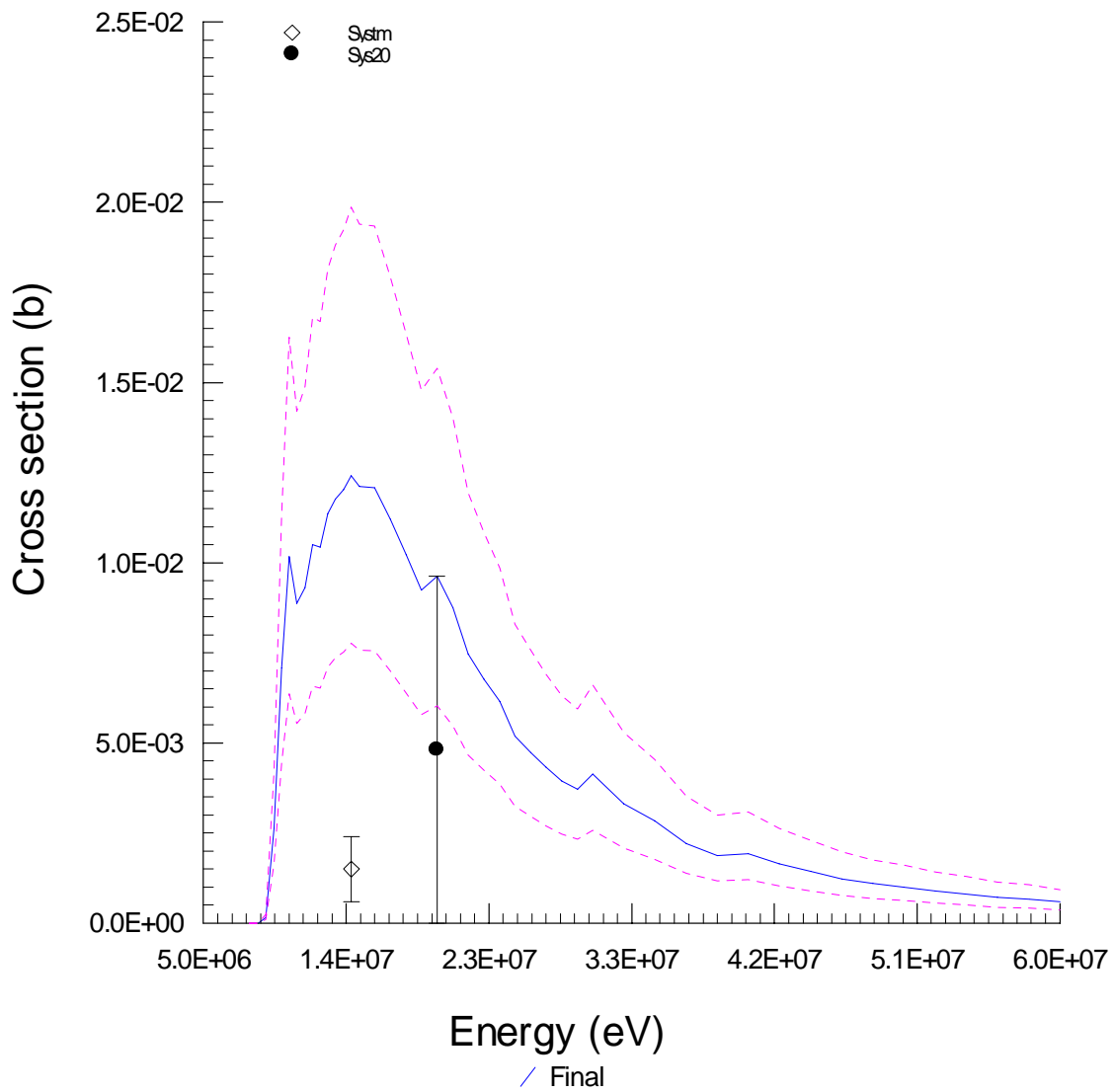


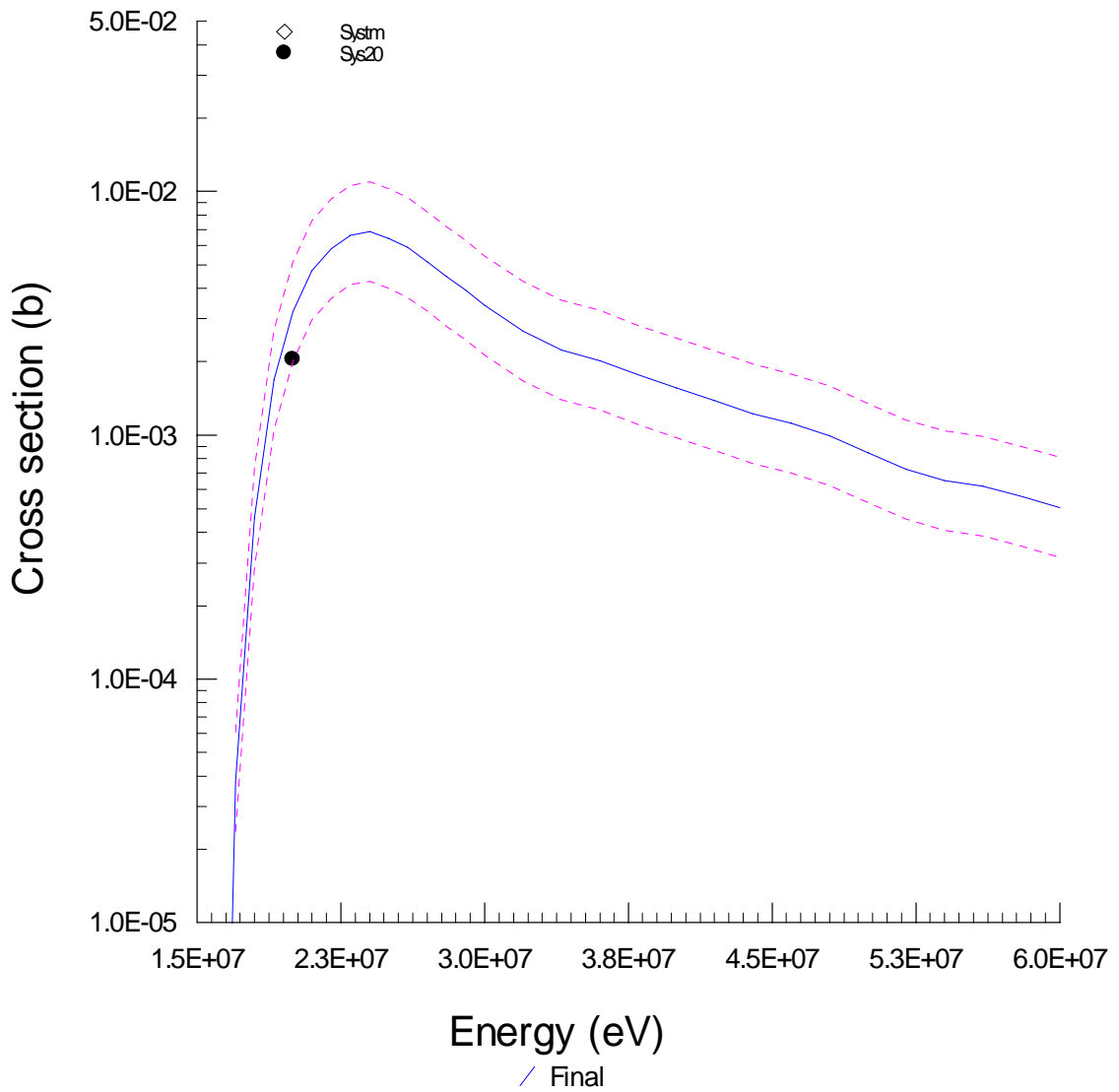
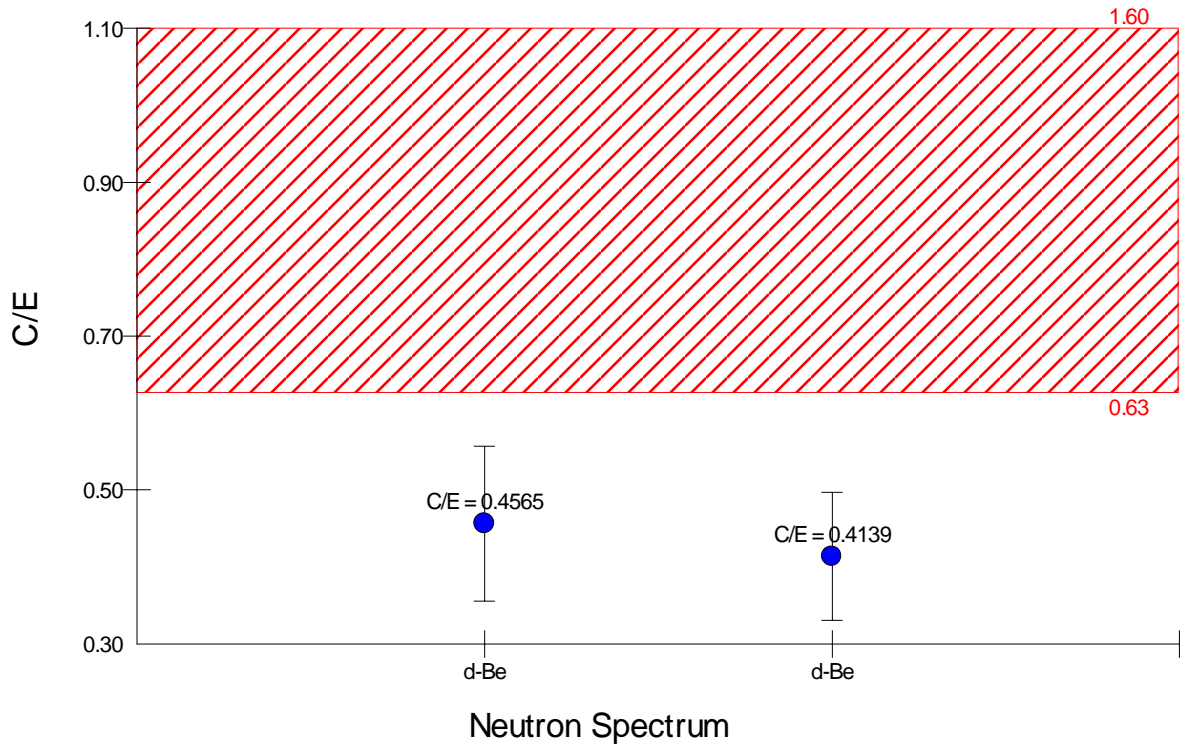
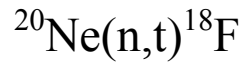
## Neutron Spectrum

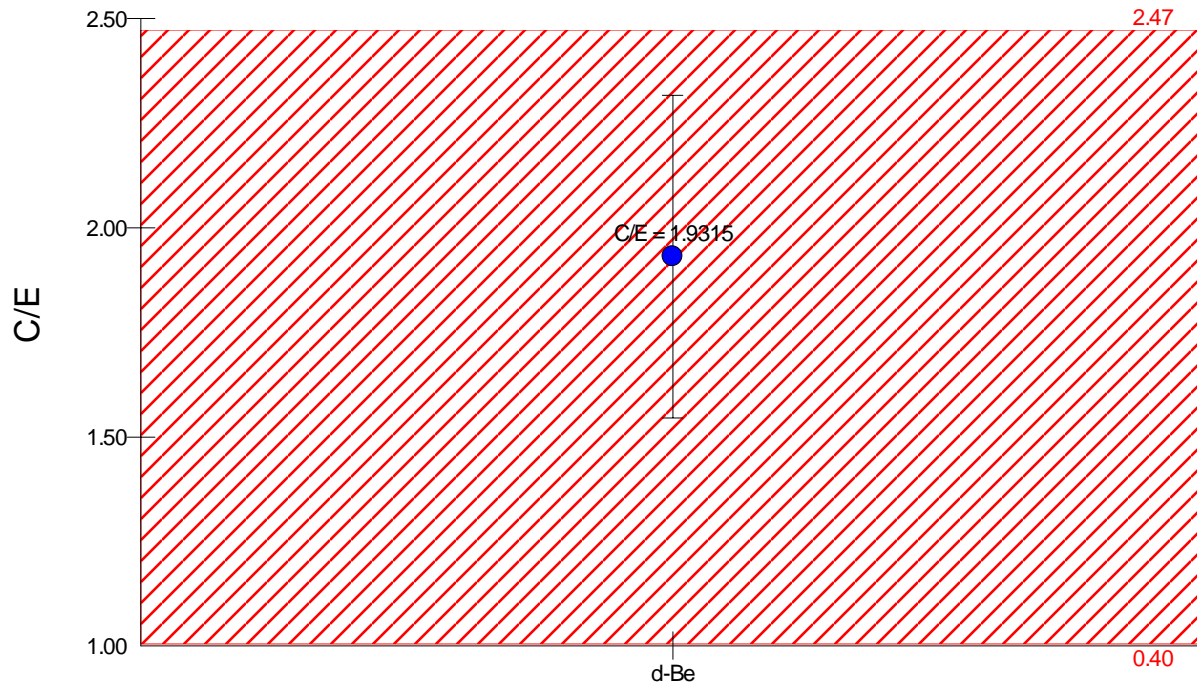
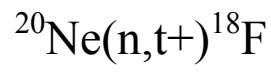




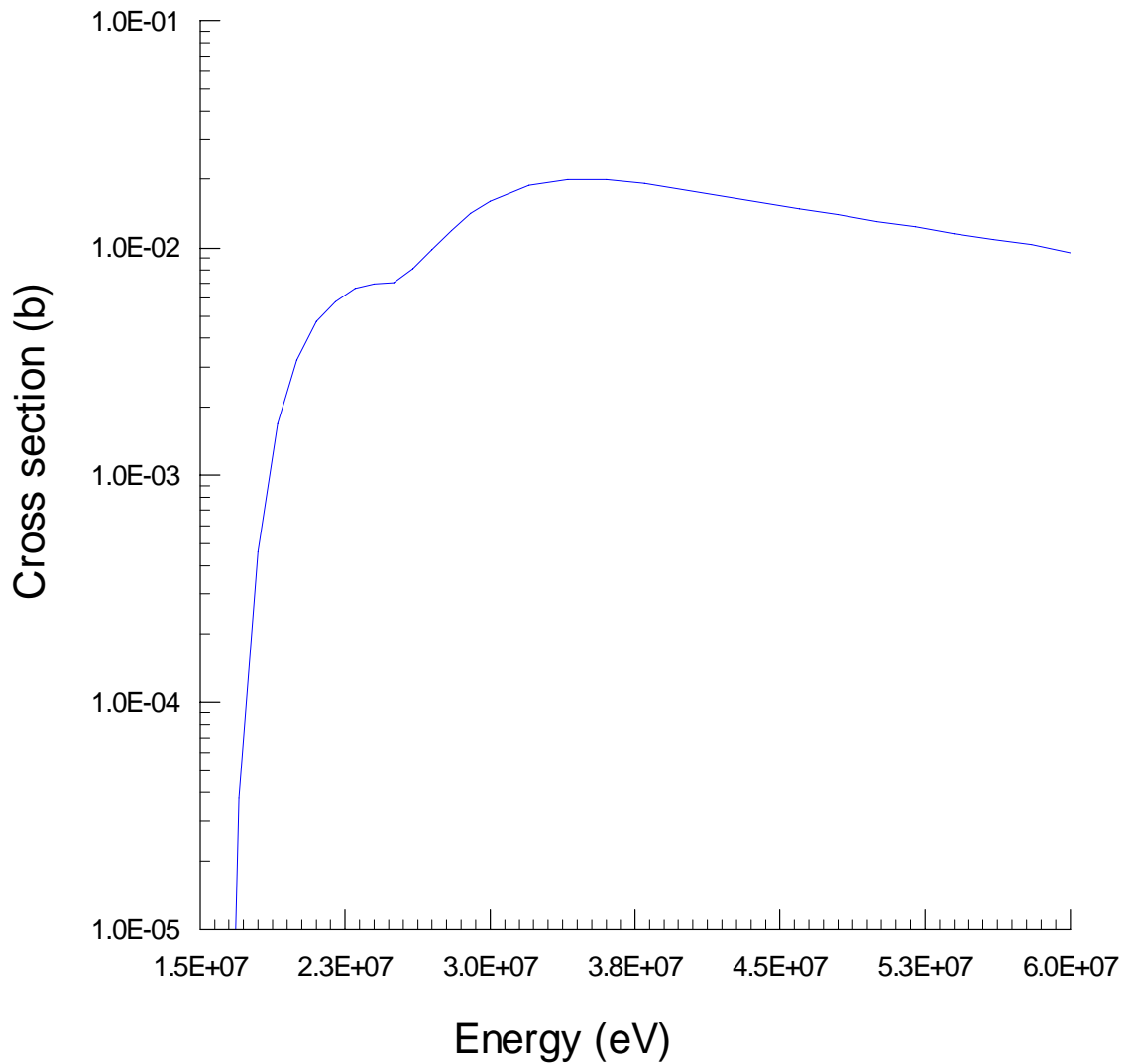
Neutron Spectrum

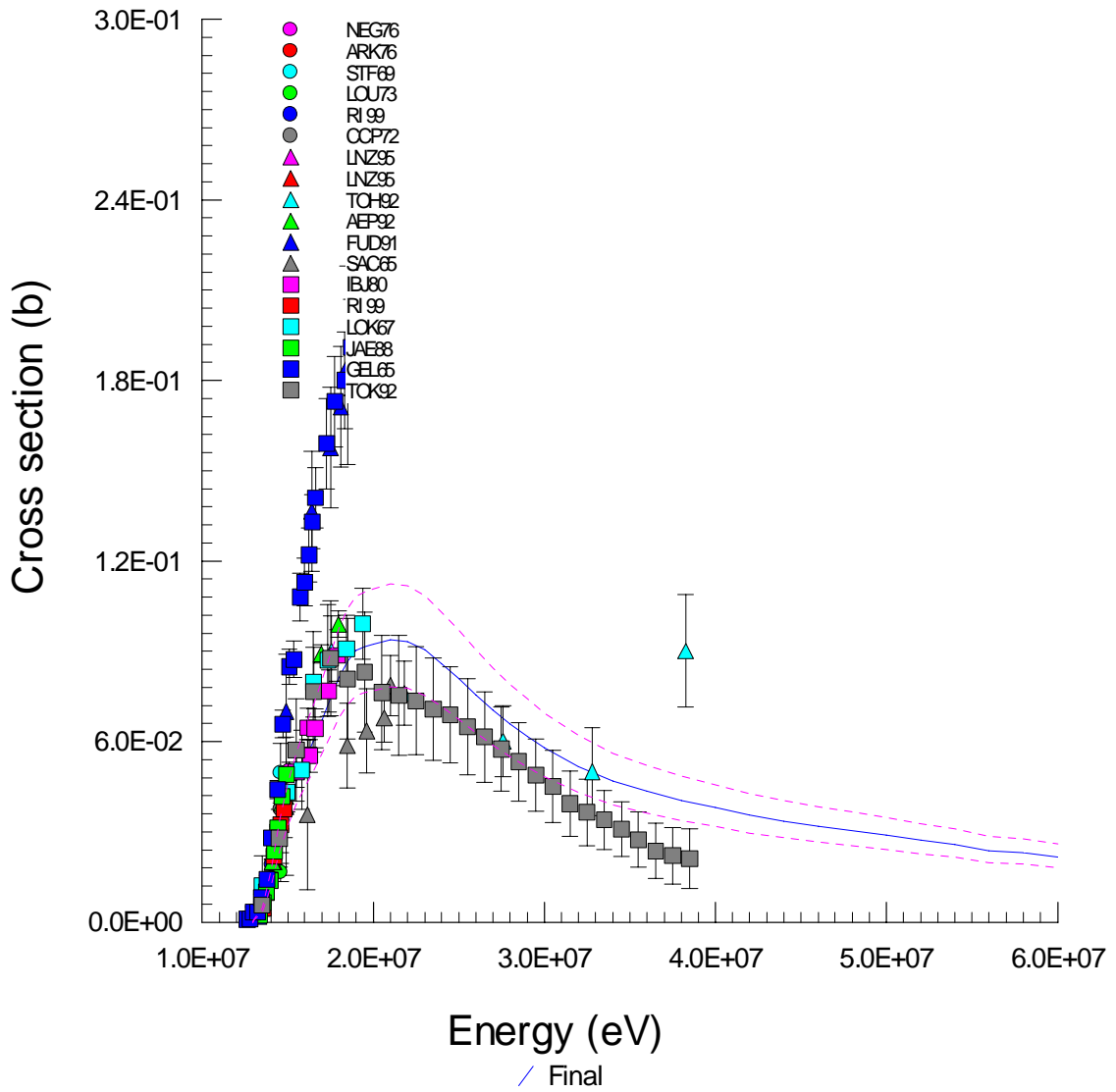
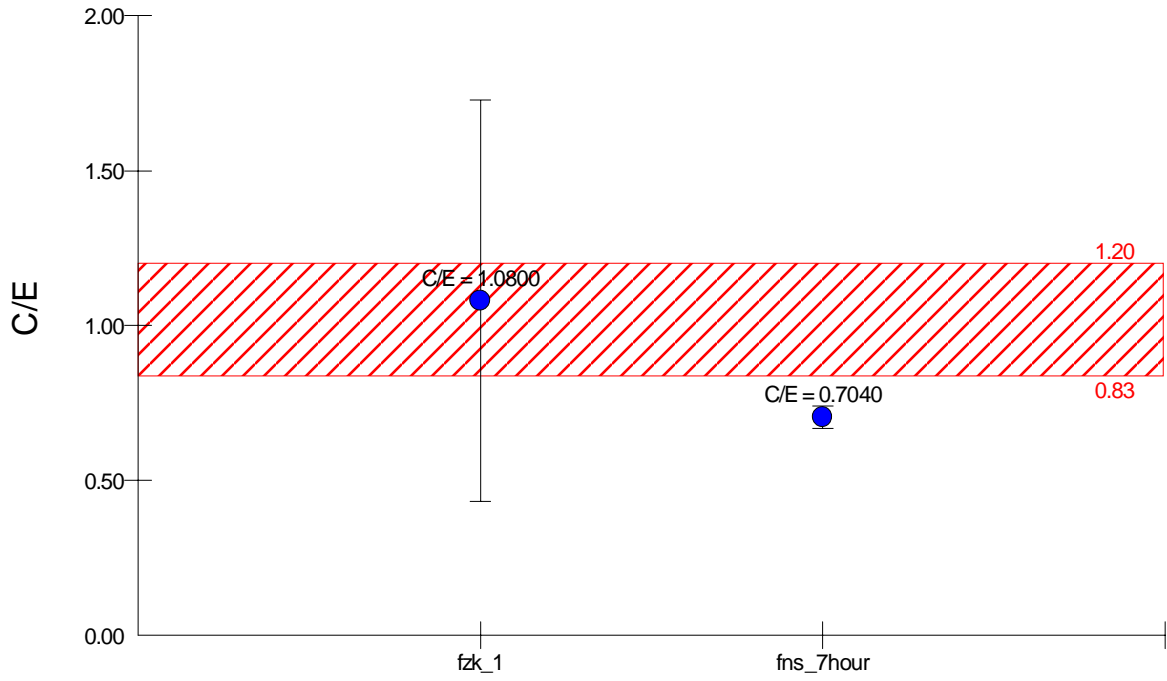
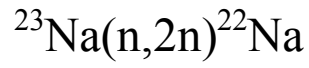




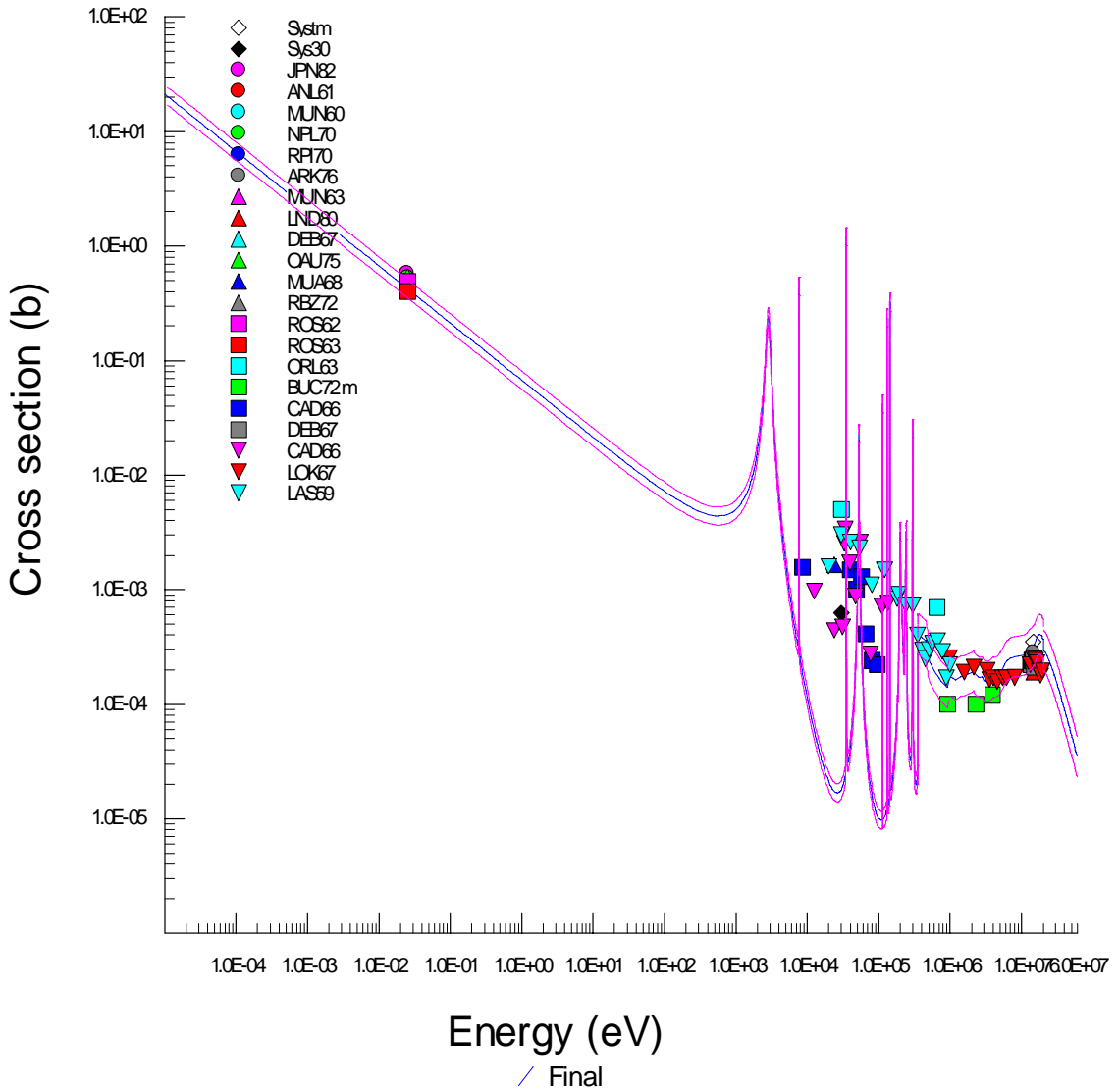
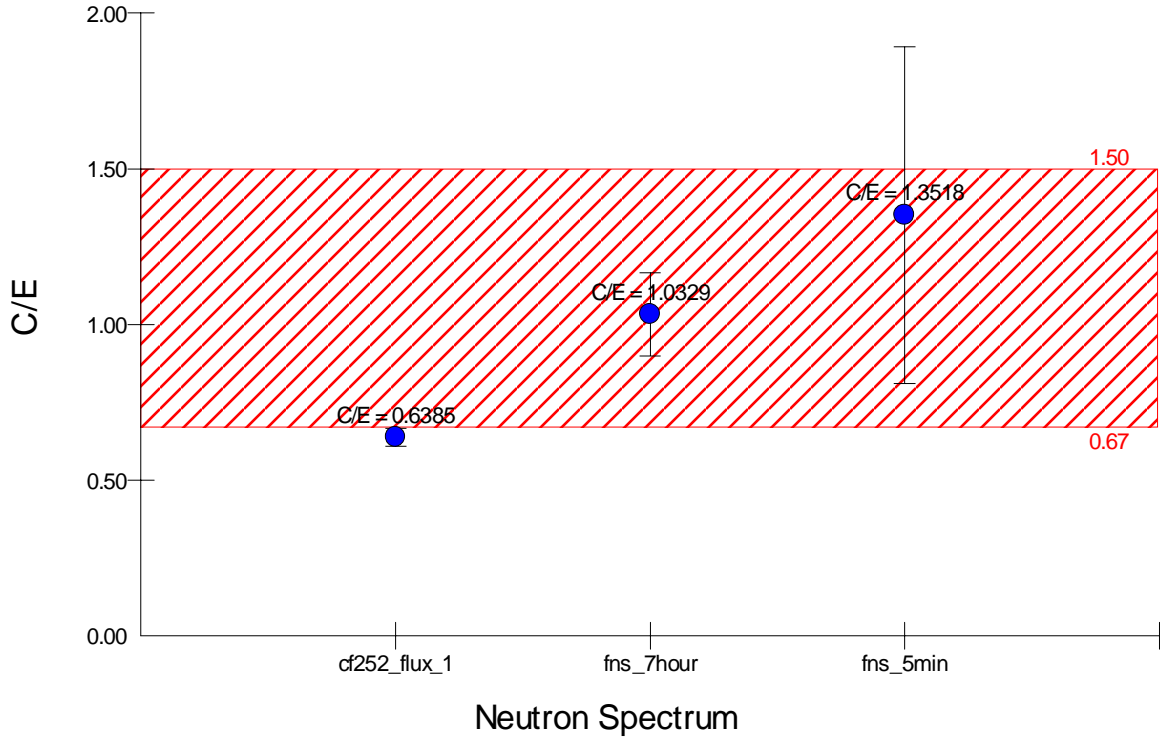
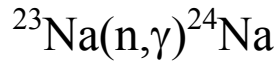


Neutron Spectrum

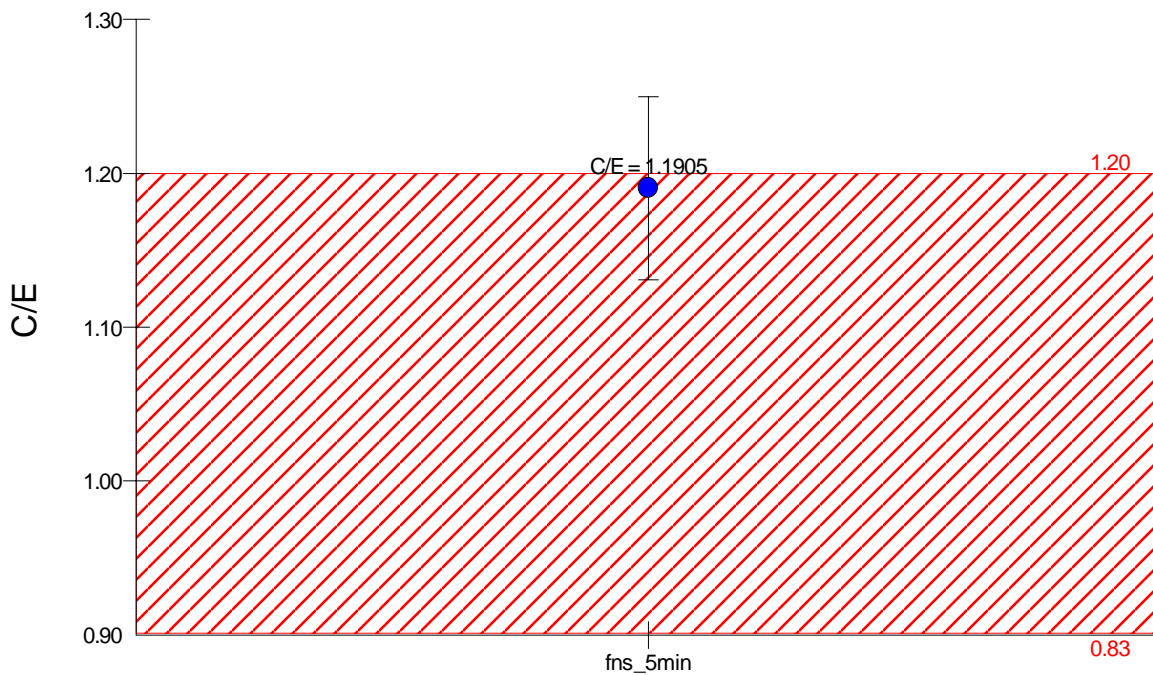




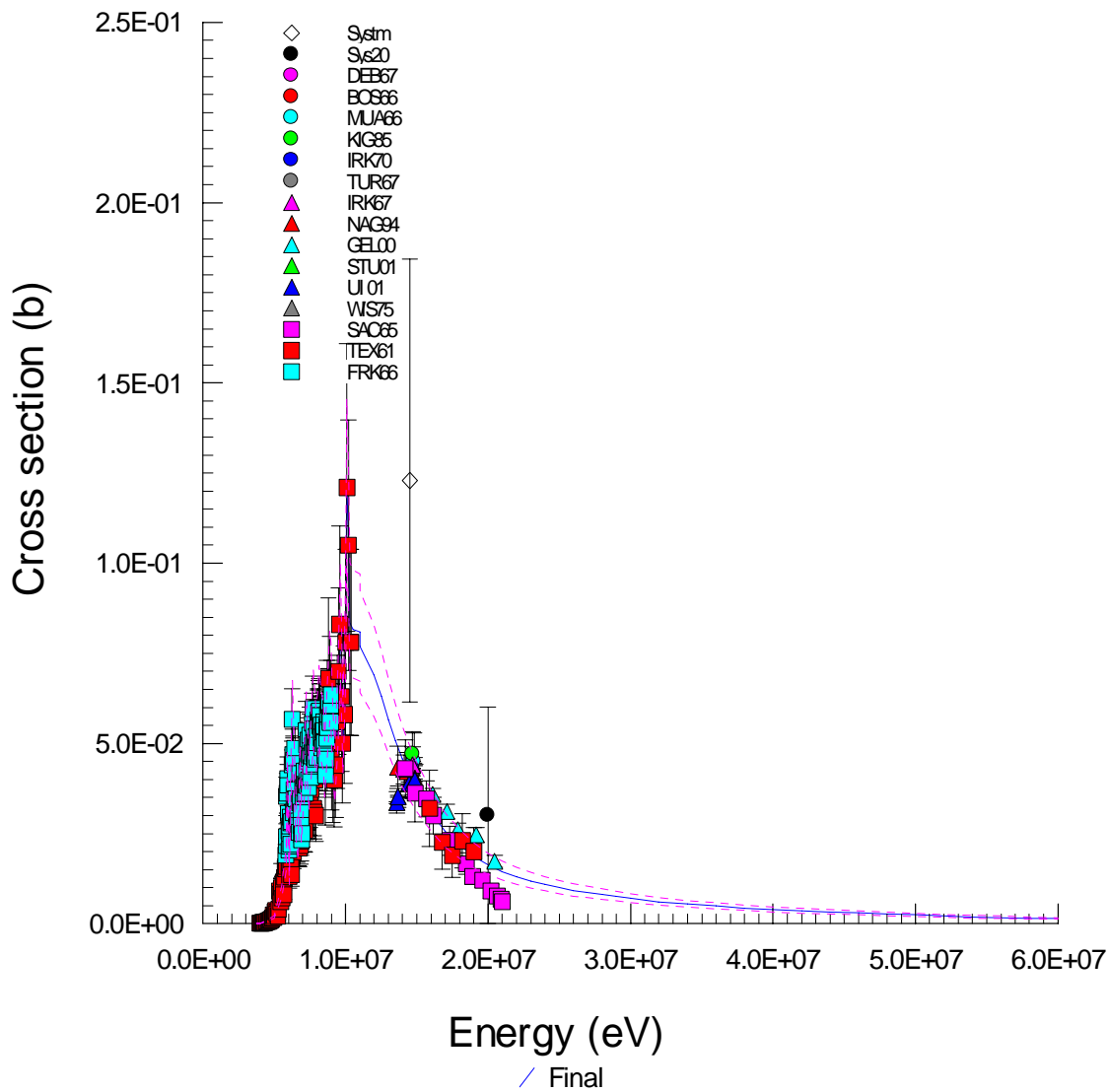


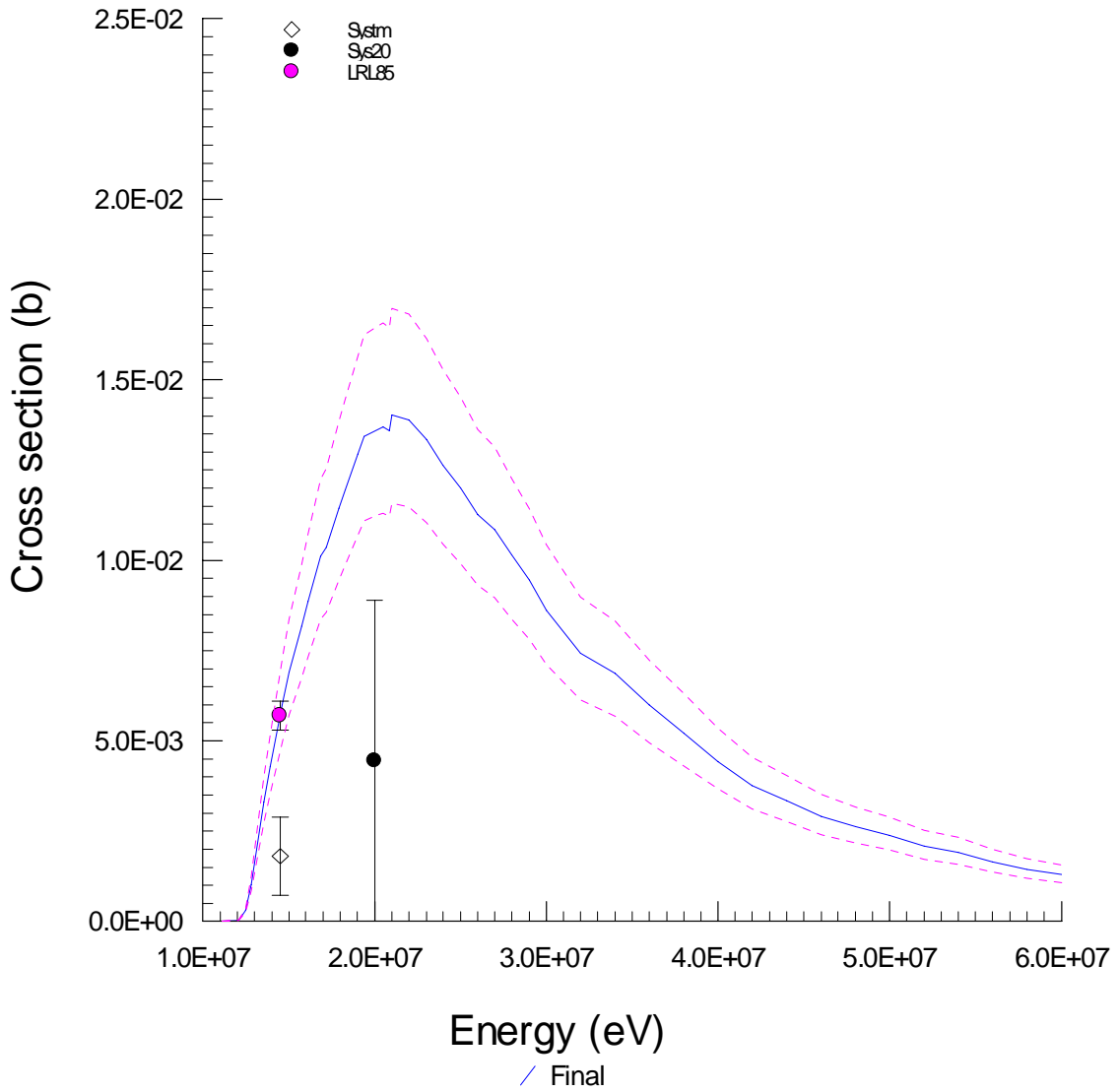
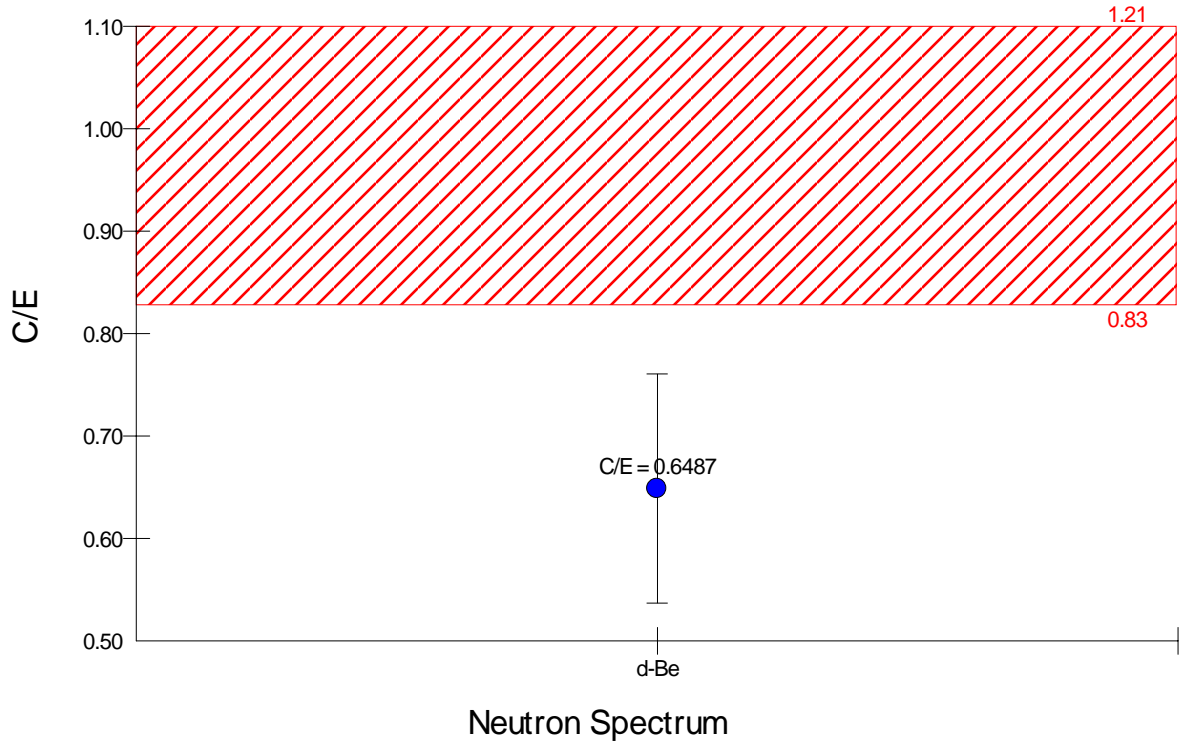
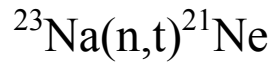


$^{23}\text{Na}(n,p)^{23}\text{Ne}$

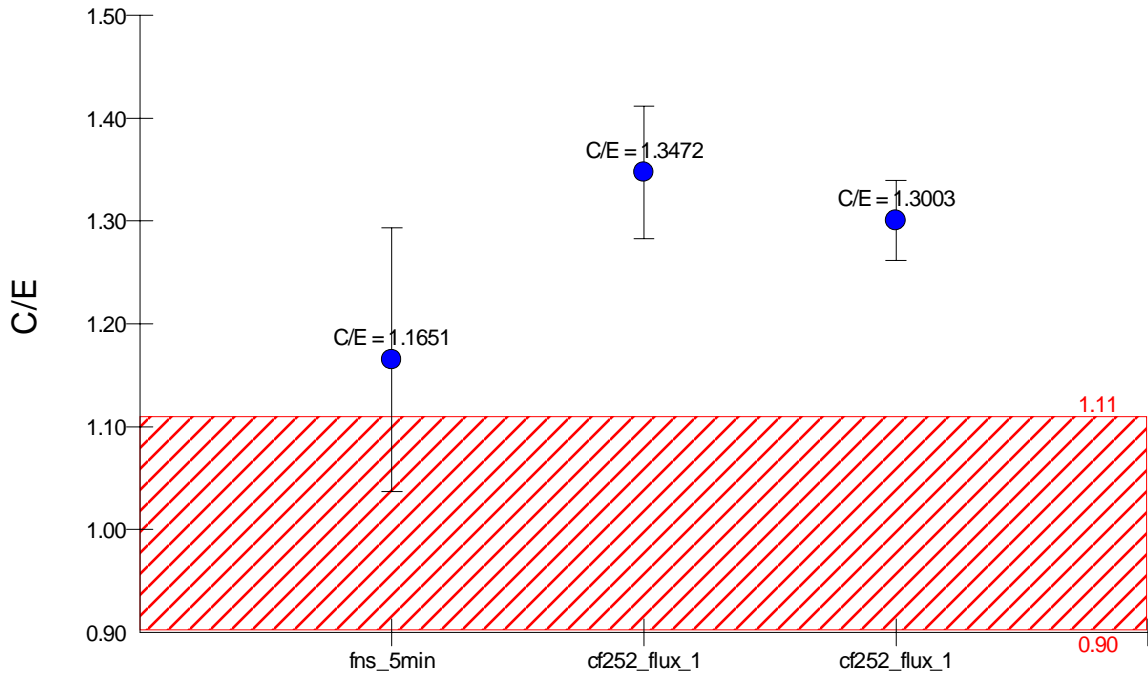


Neutron Spectrum

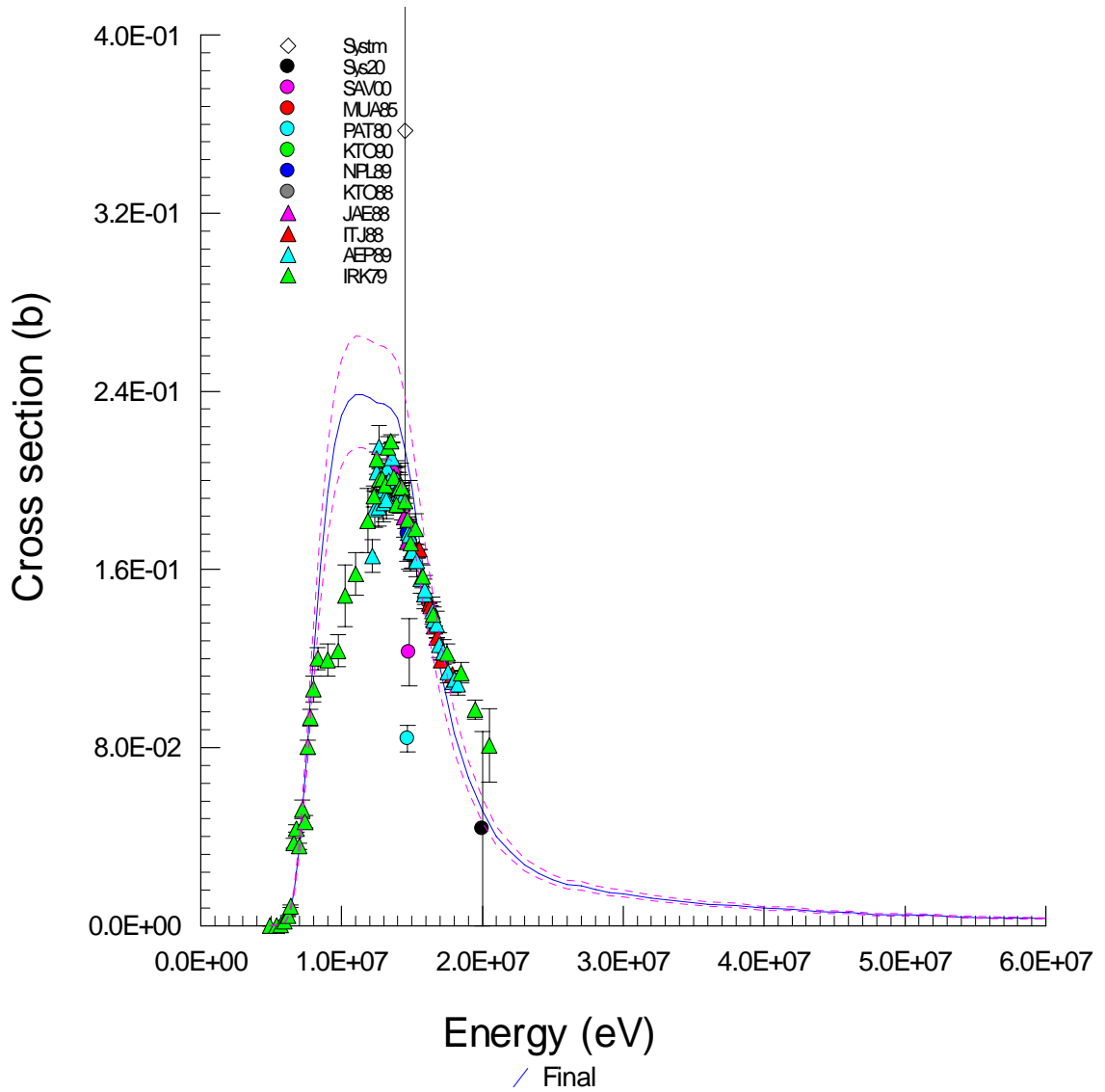


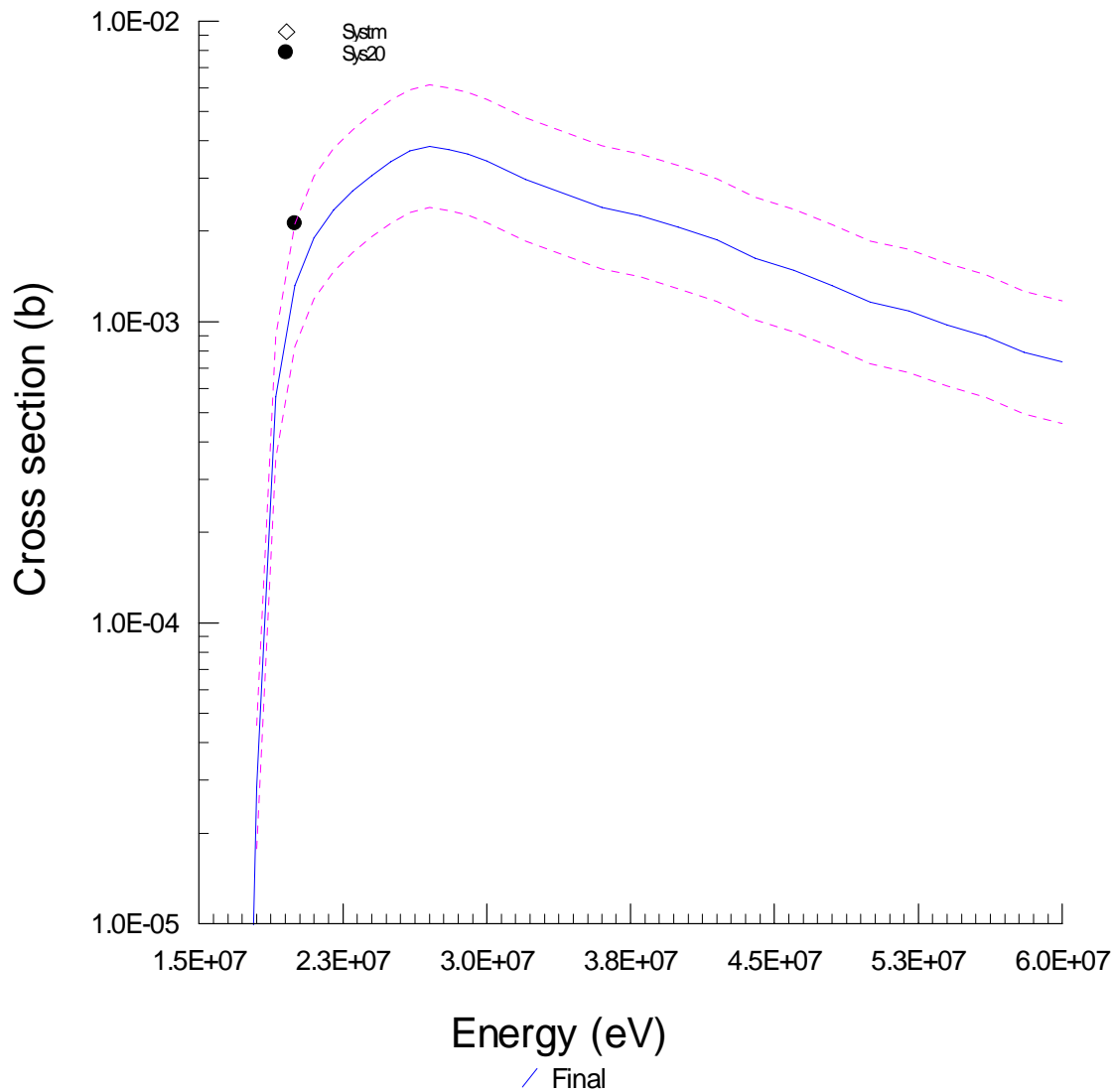
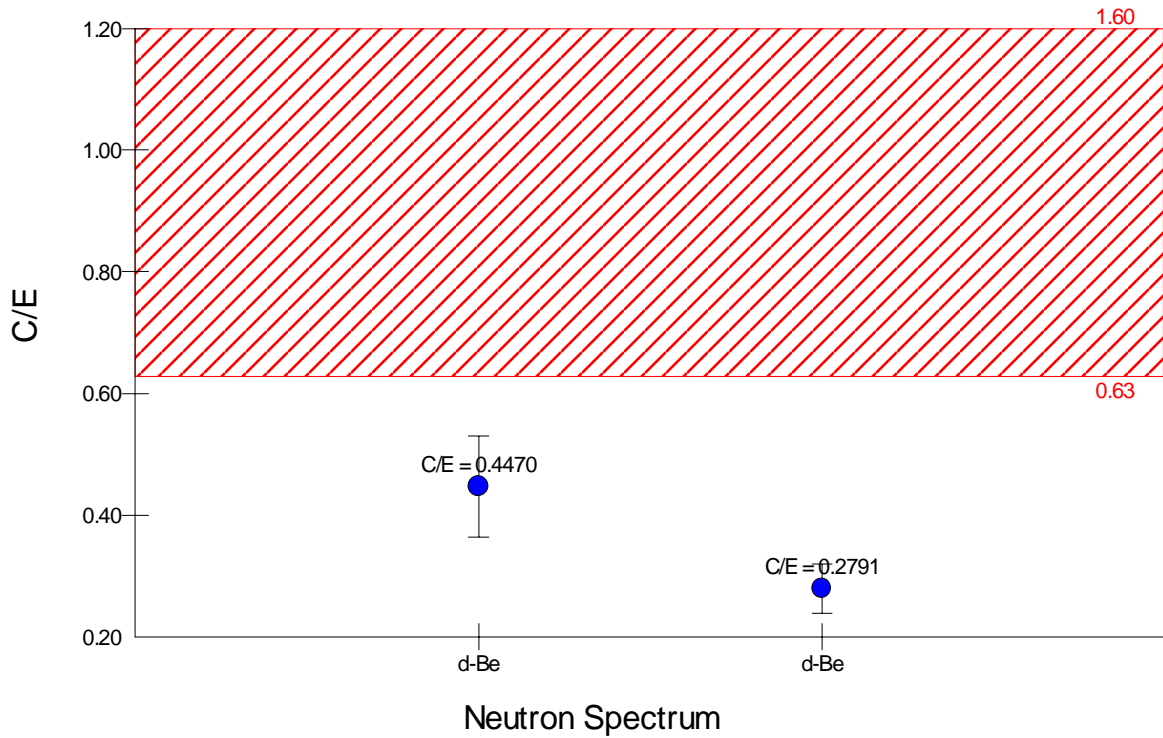
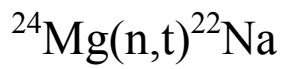


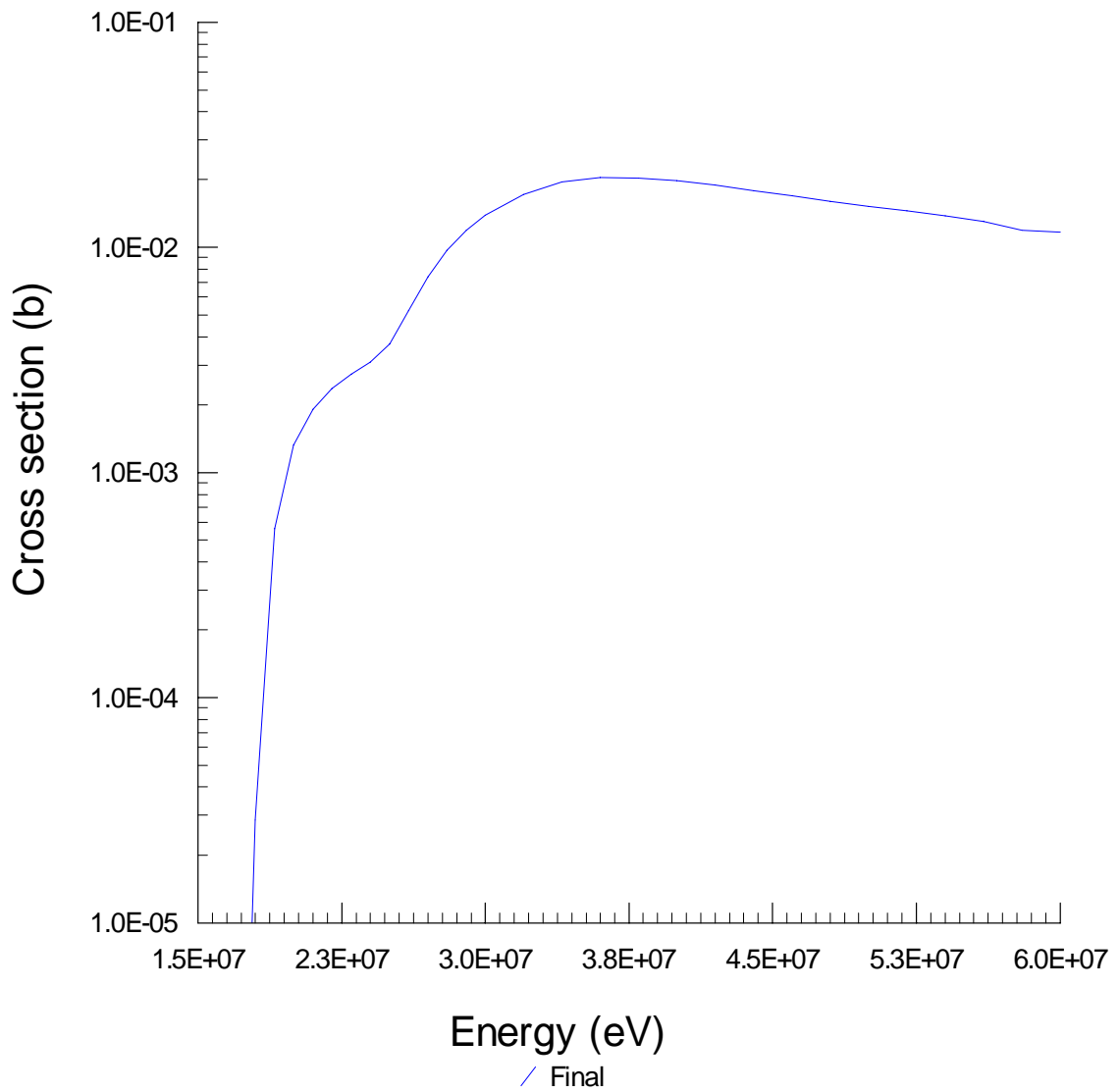
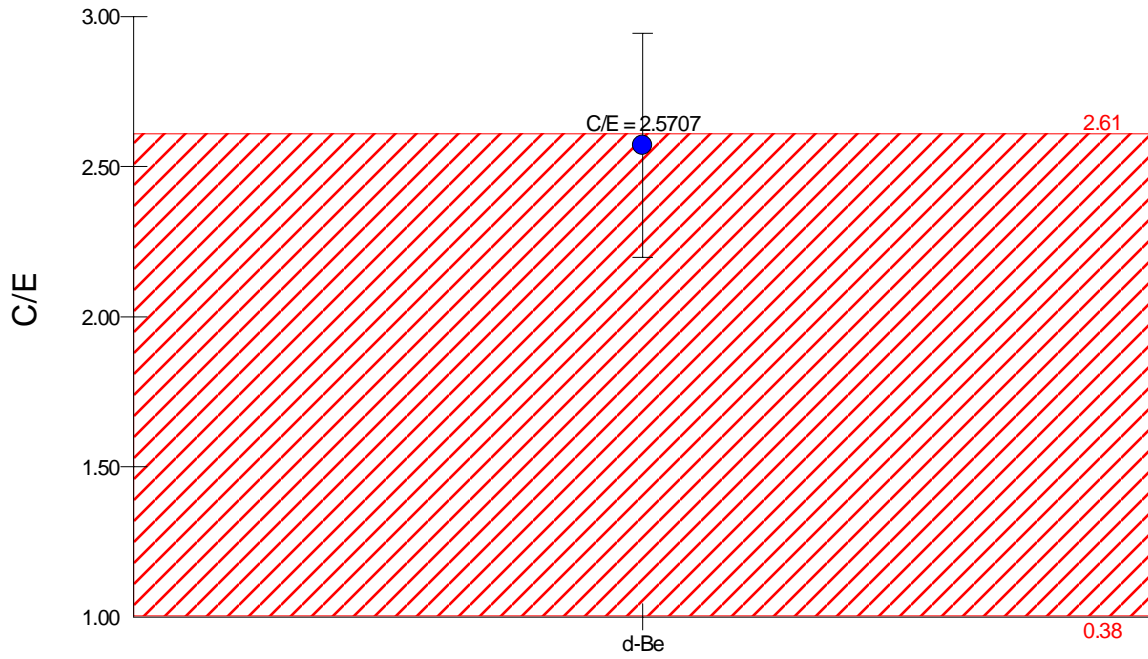
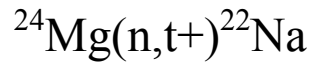
# $^{24}\text{Mg}(n,p)^{24}\text{Na}$

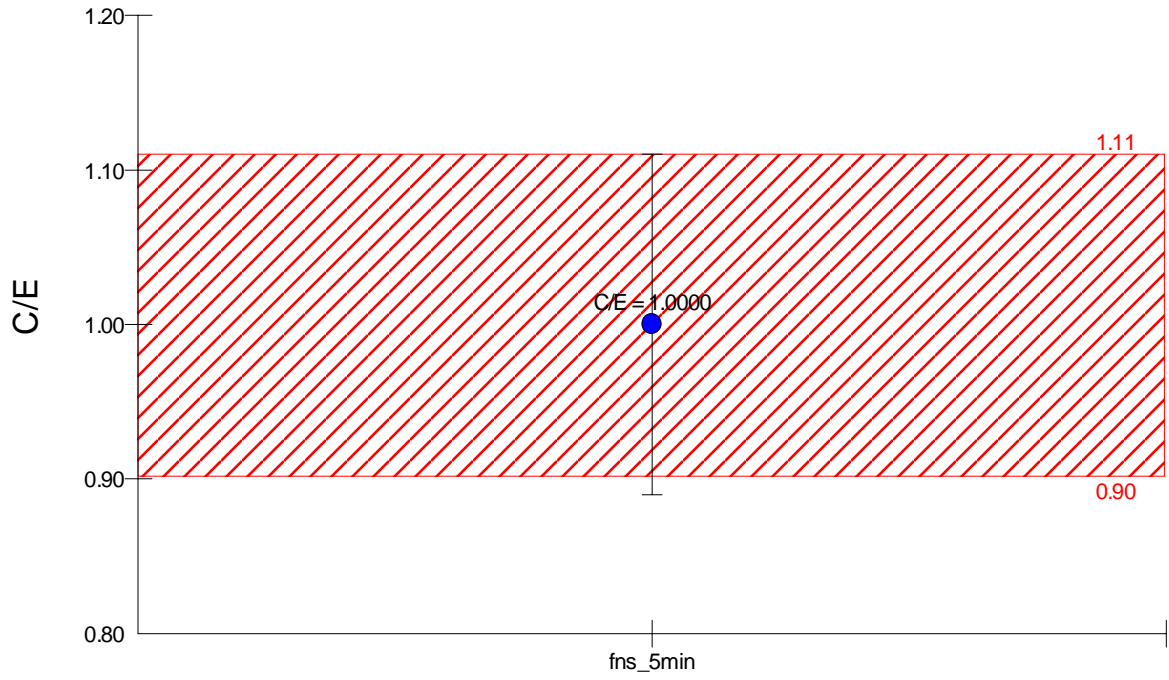
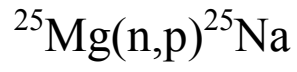


## Neutron Spectrum

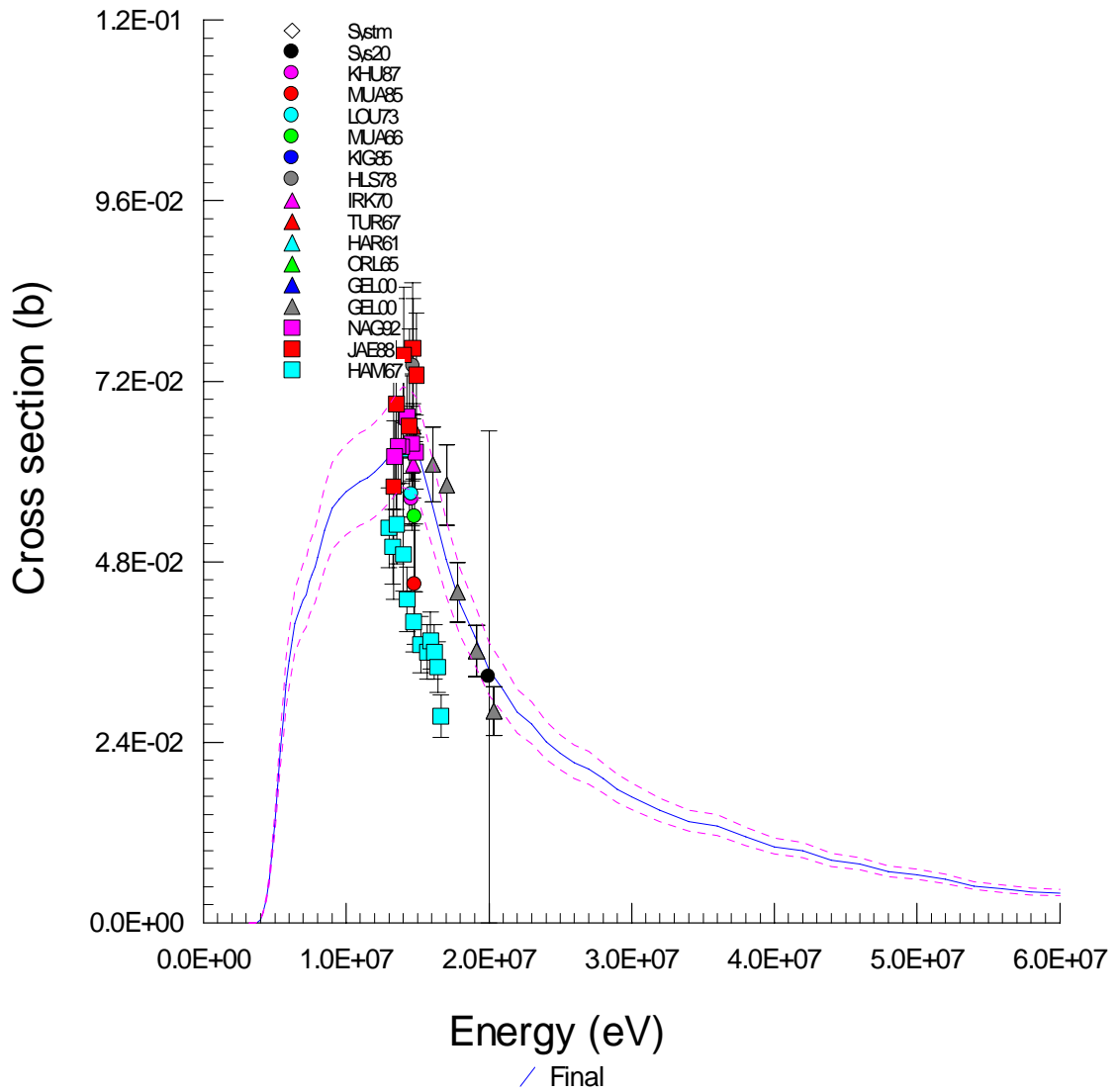


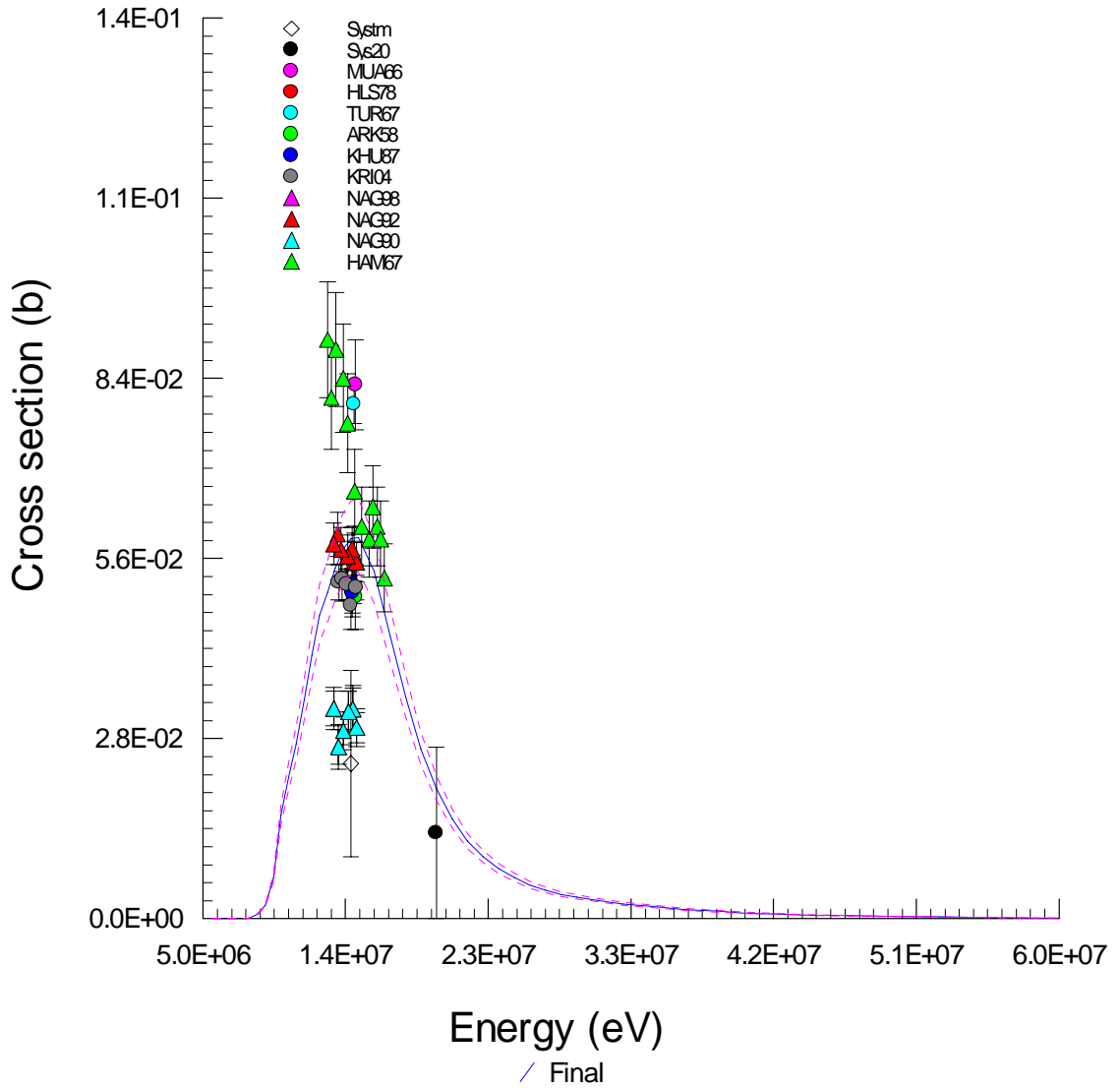
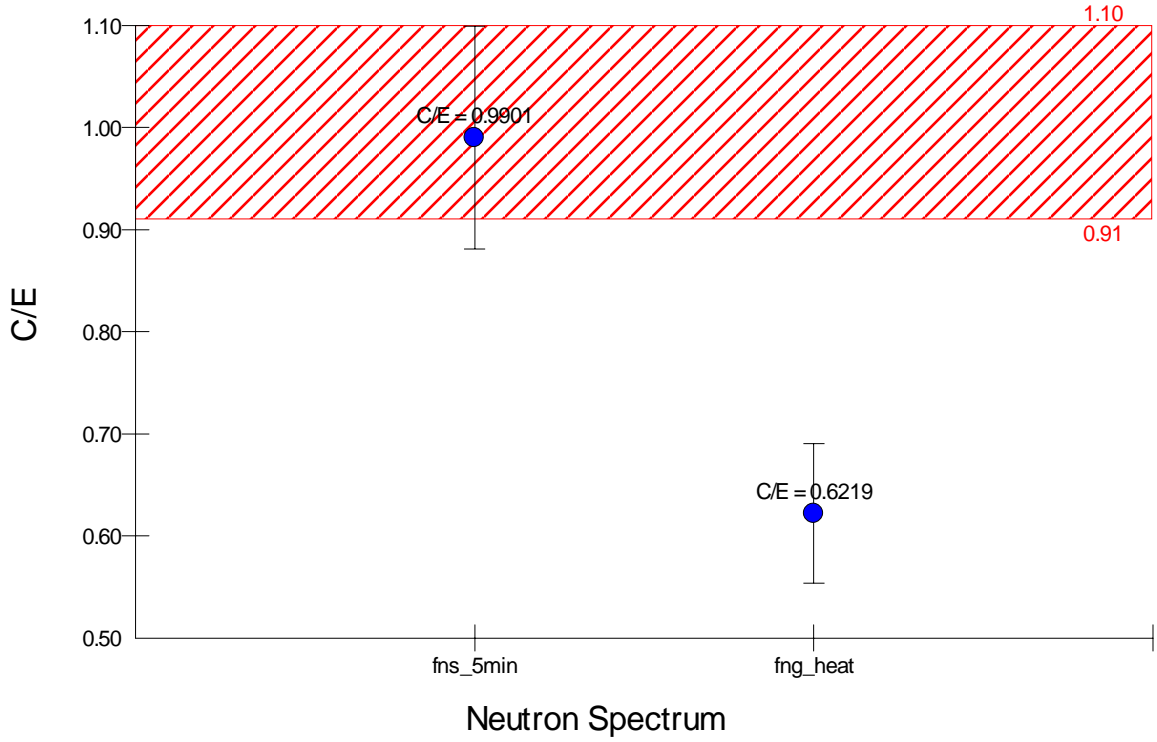
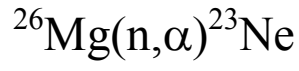






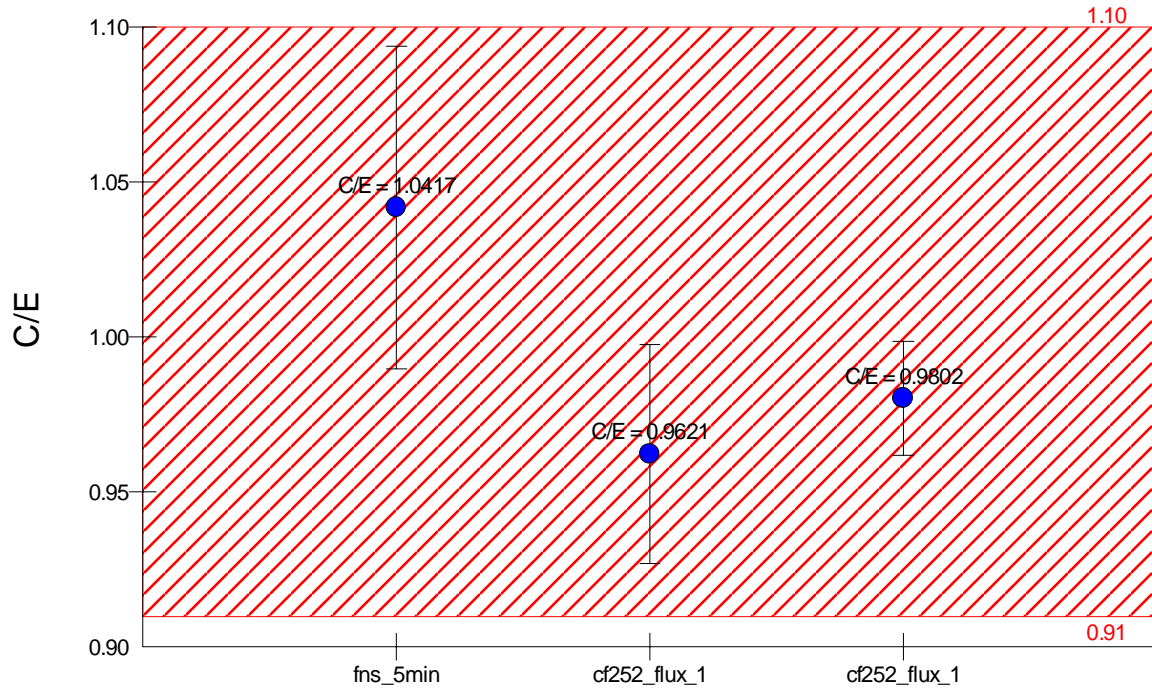
Neutron Spectrum



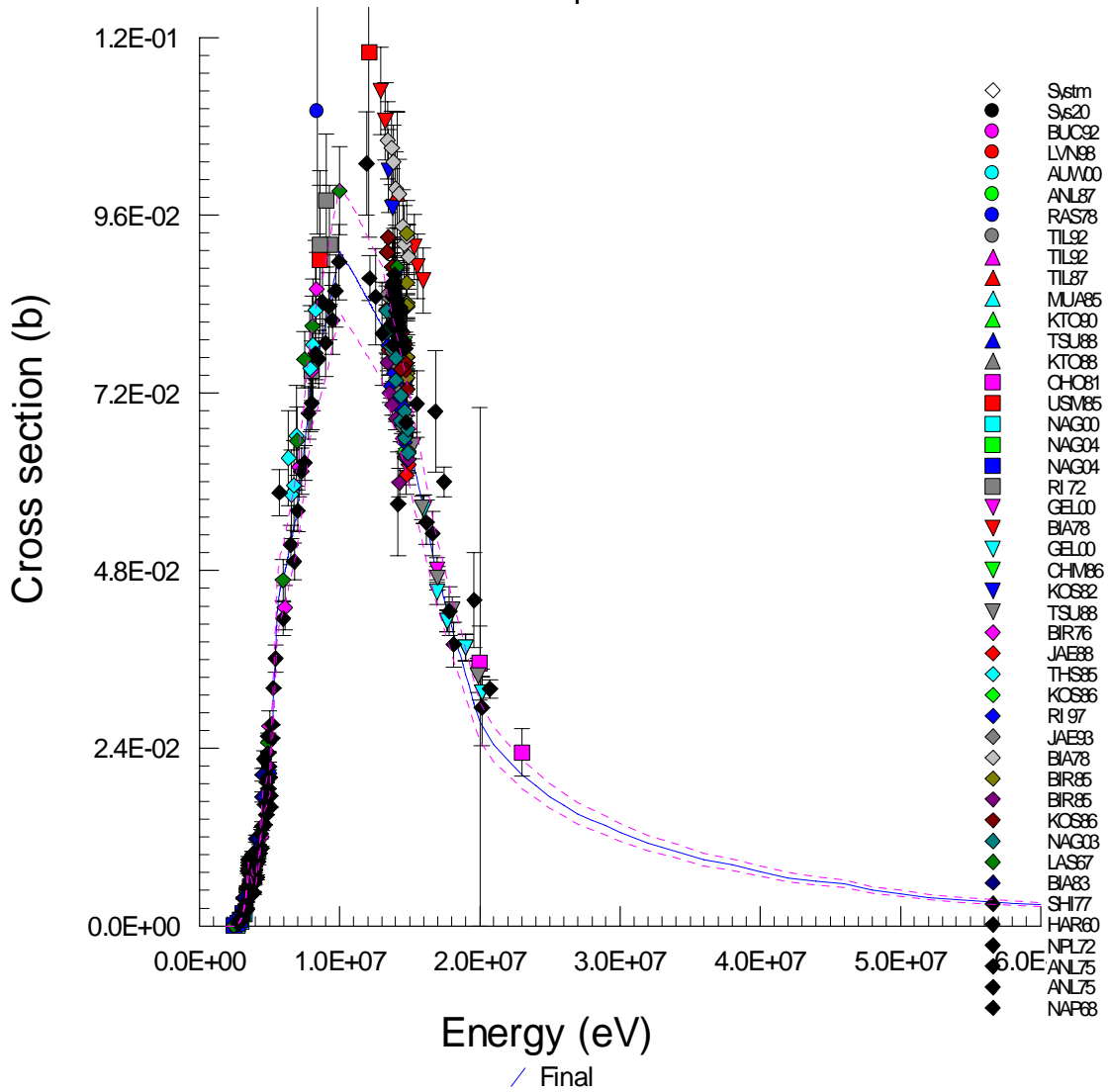


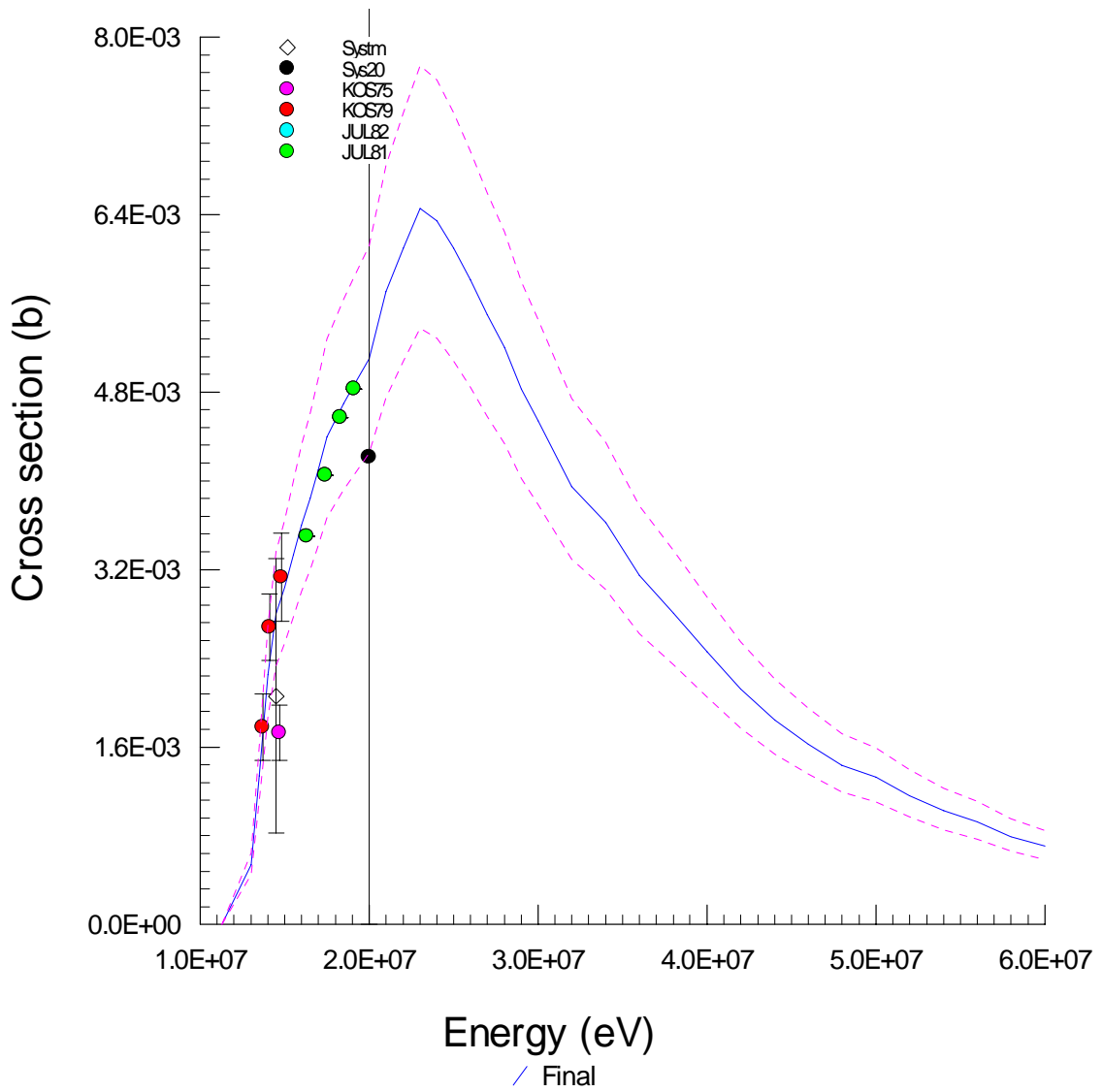
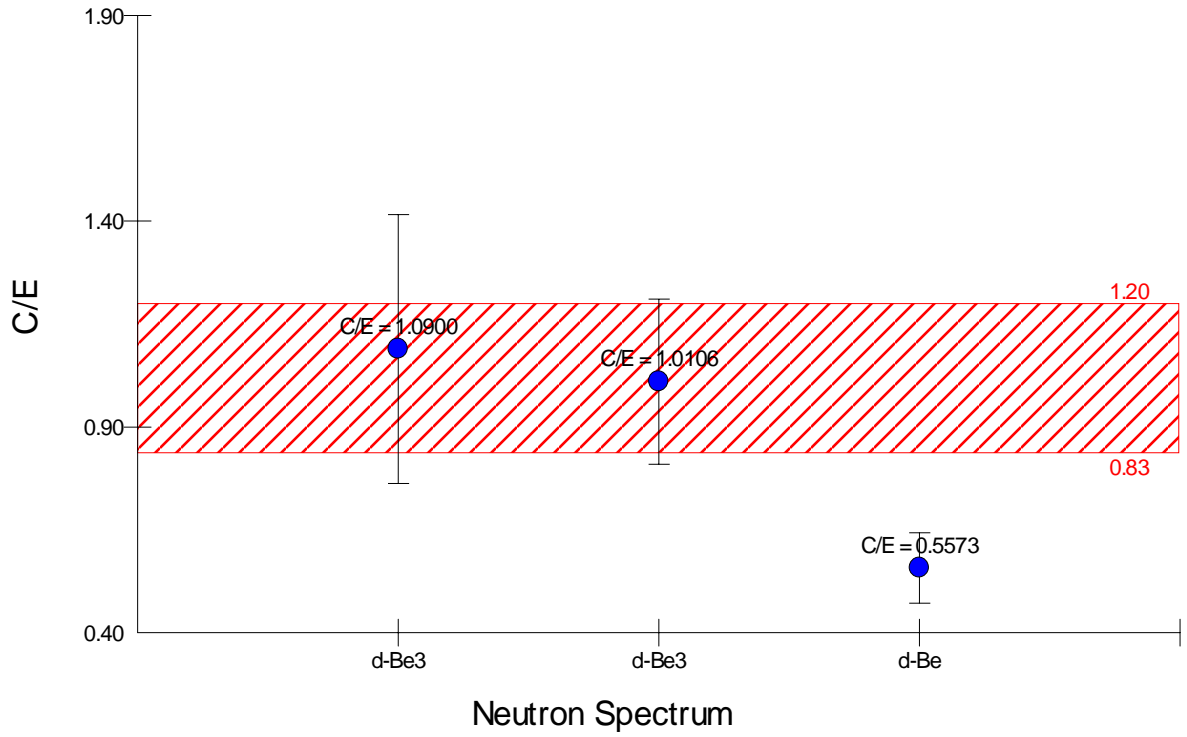
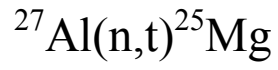


# $^{27}\text{Al}(n,p)^{27}\text{Mg}$

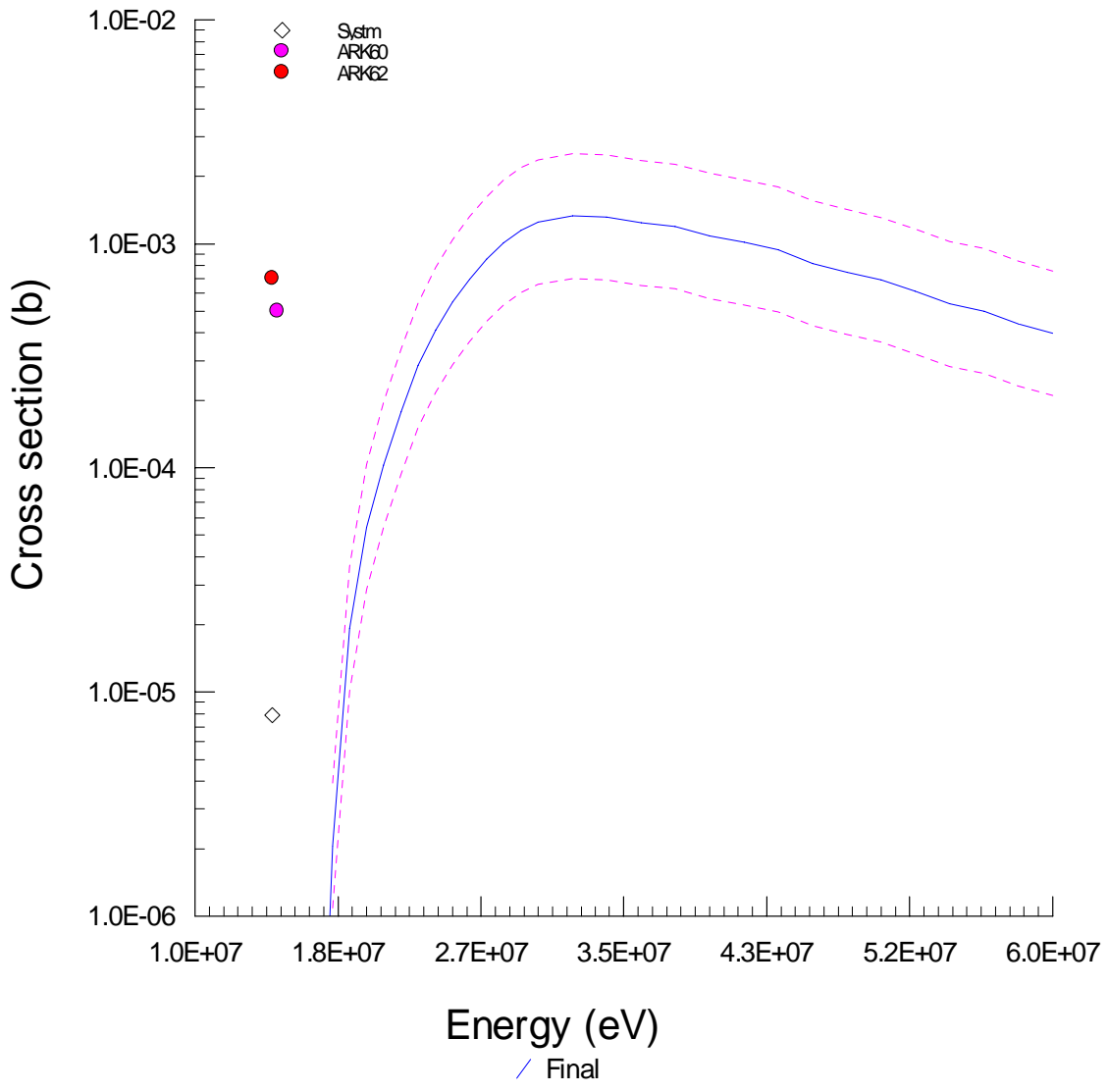
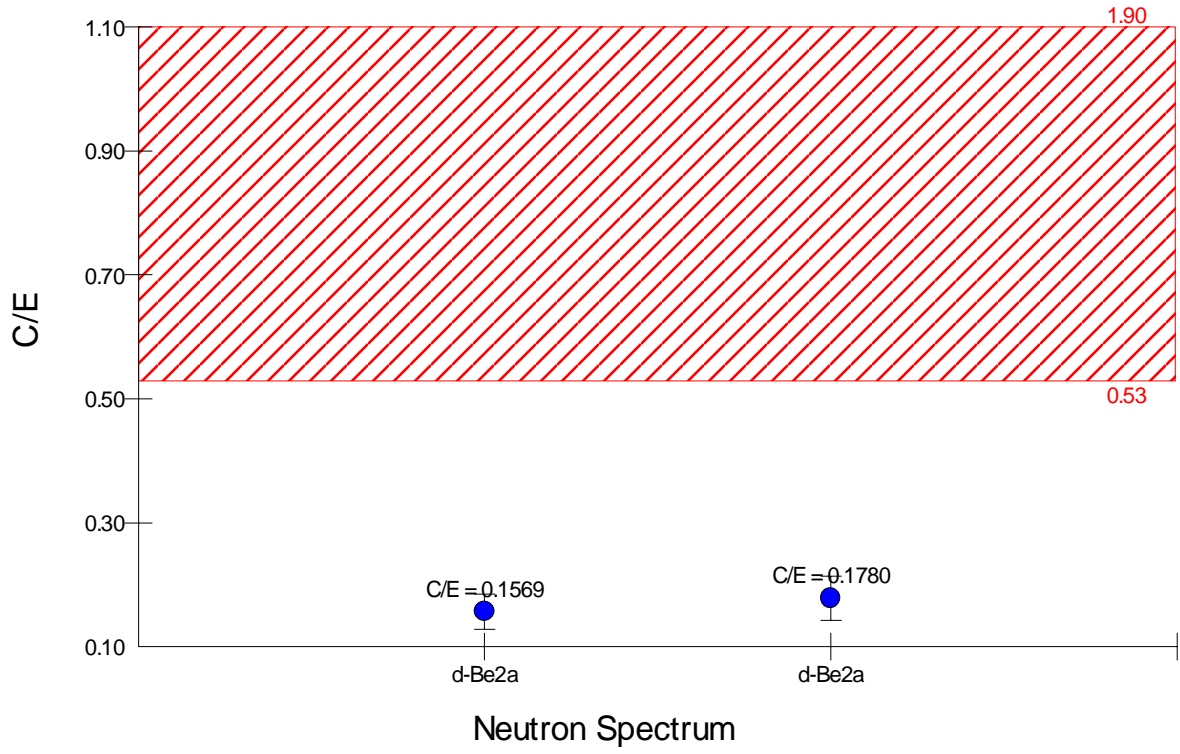


## Neutron Spectrum

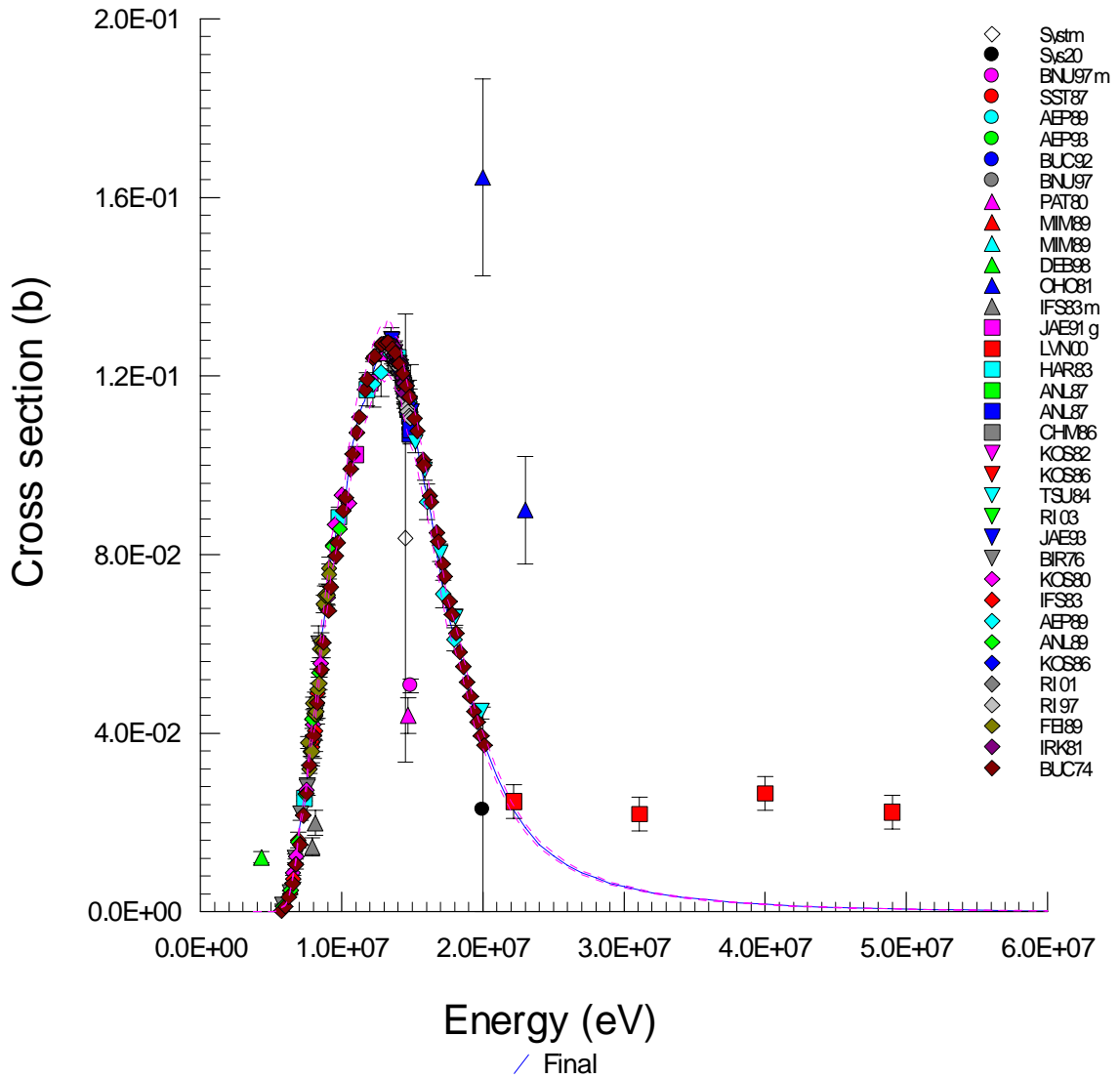
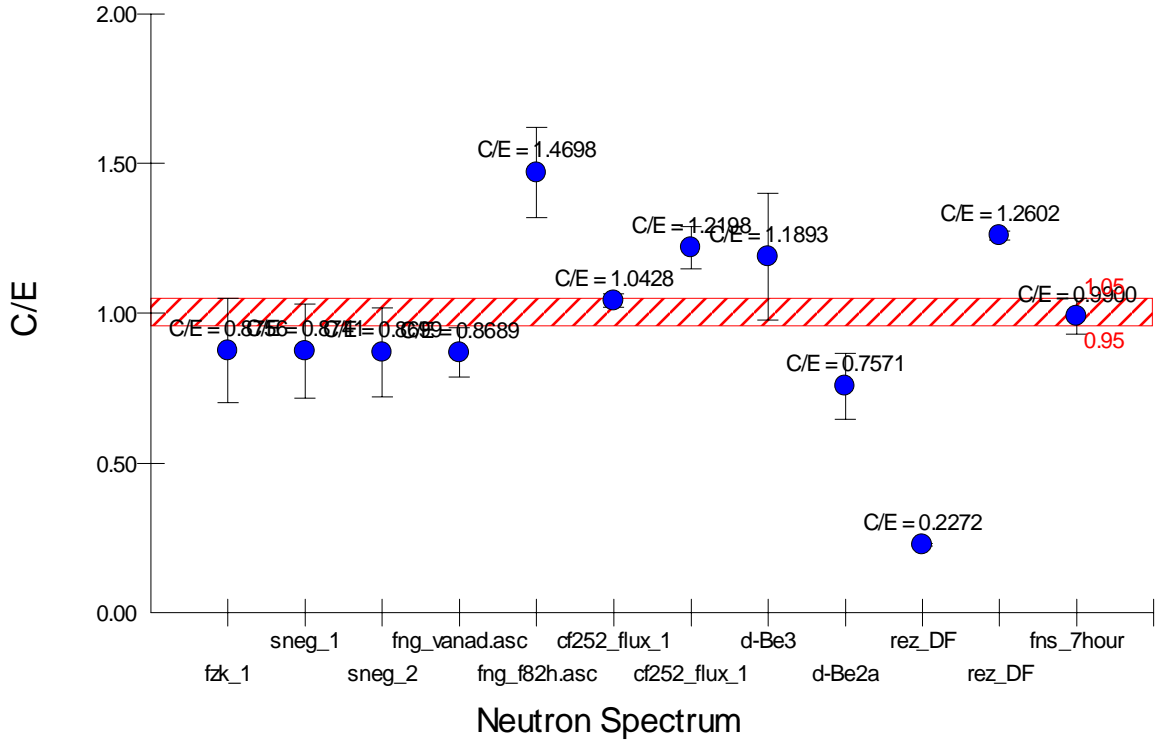


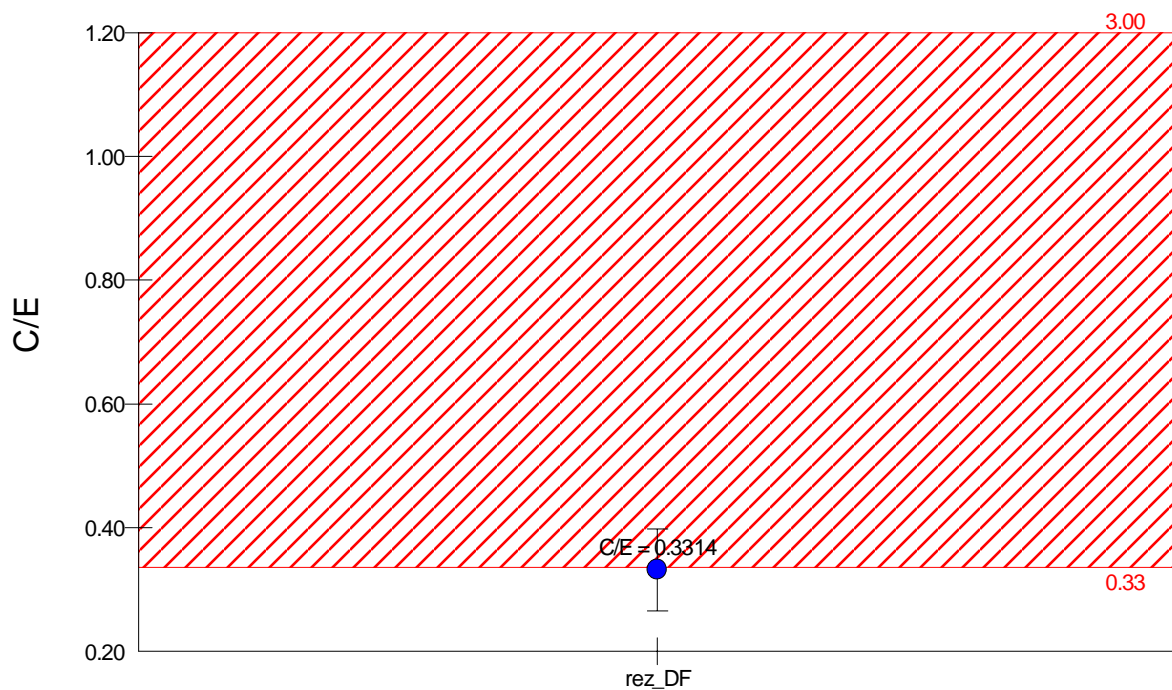
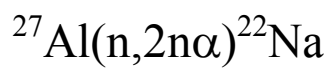


# $^{27}\text{Al}(n,h)^{25}\text{Na}$

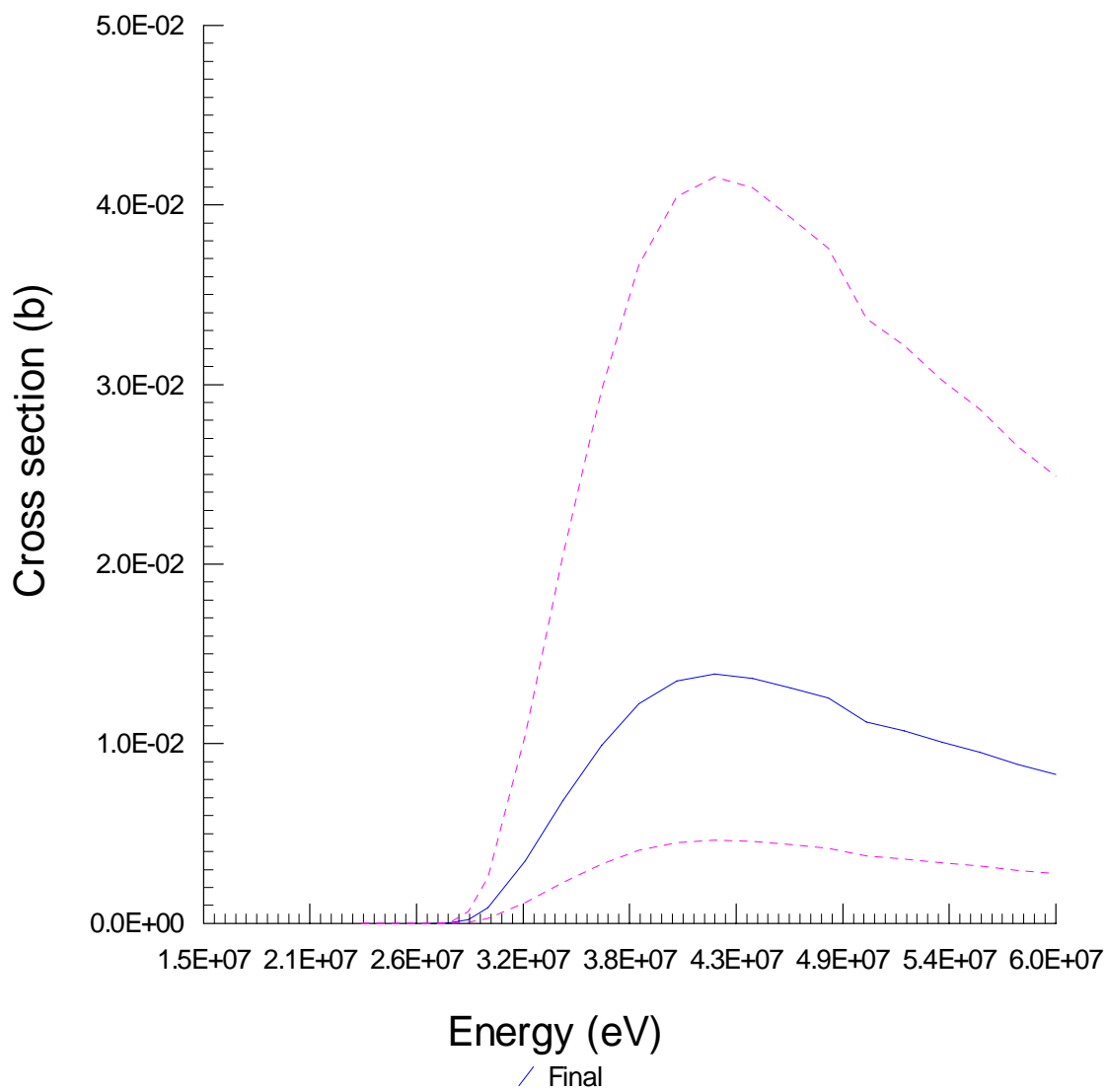


$^{27}\text{Al}(n,\alpha)^{24}\text{Na} \blacktriangleright 543$

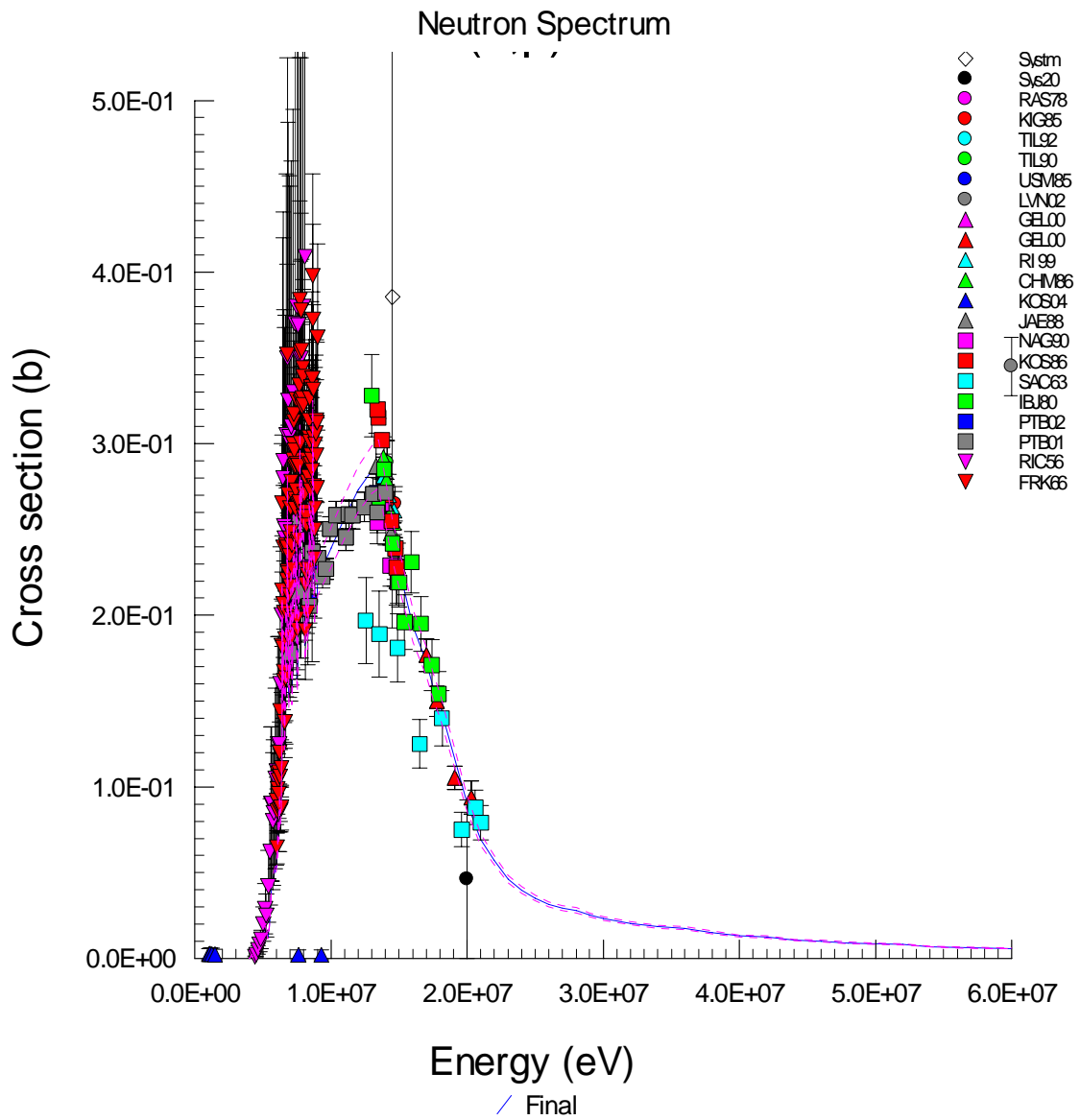
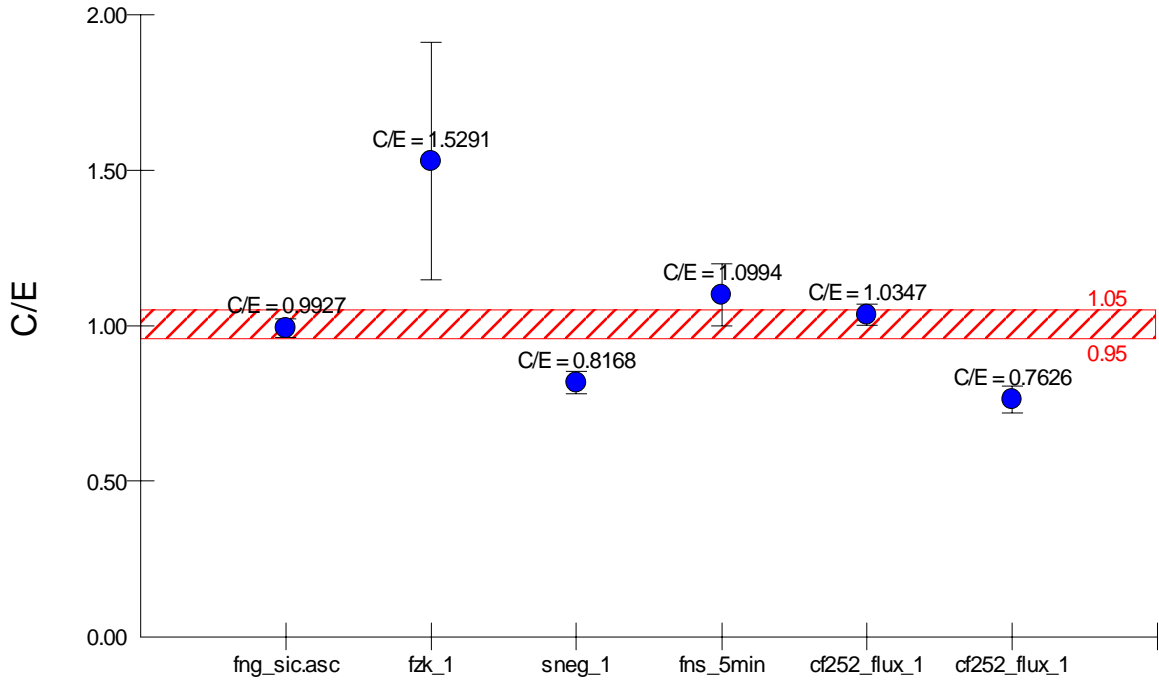




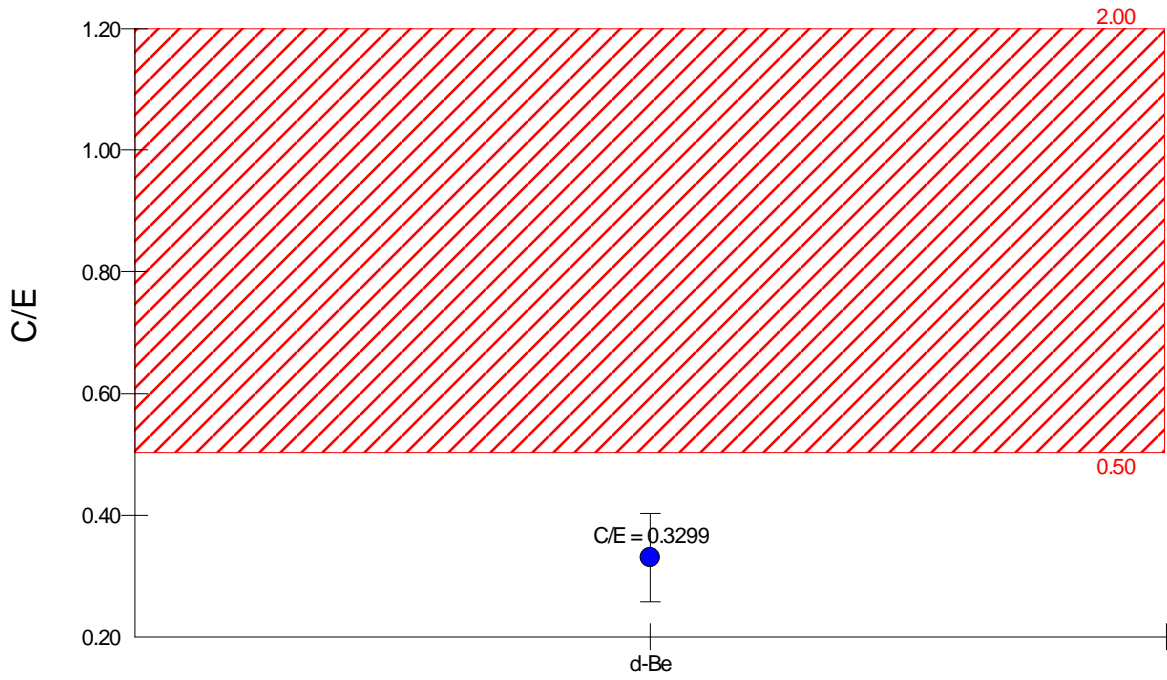
Neutron Spectrum



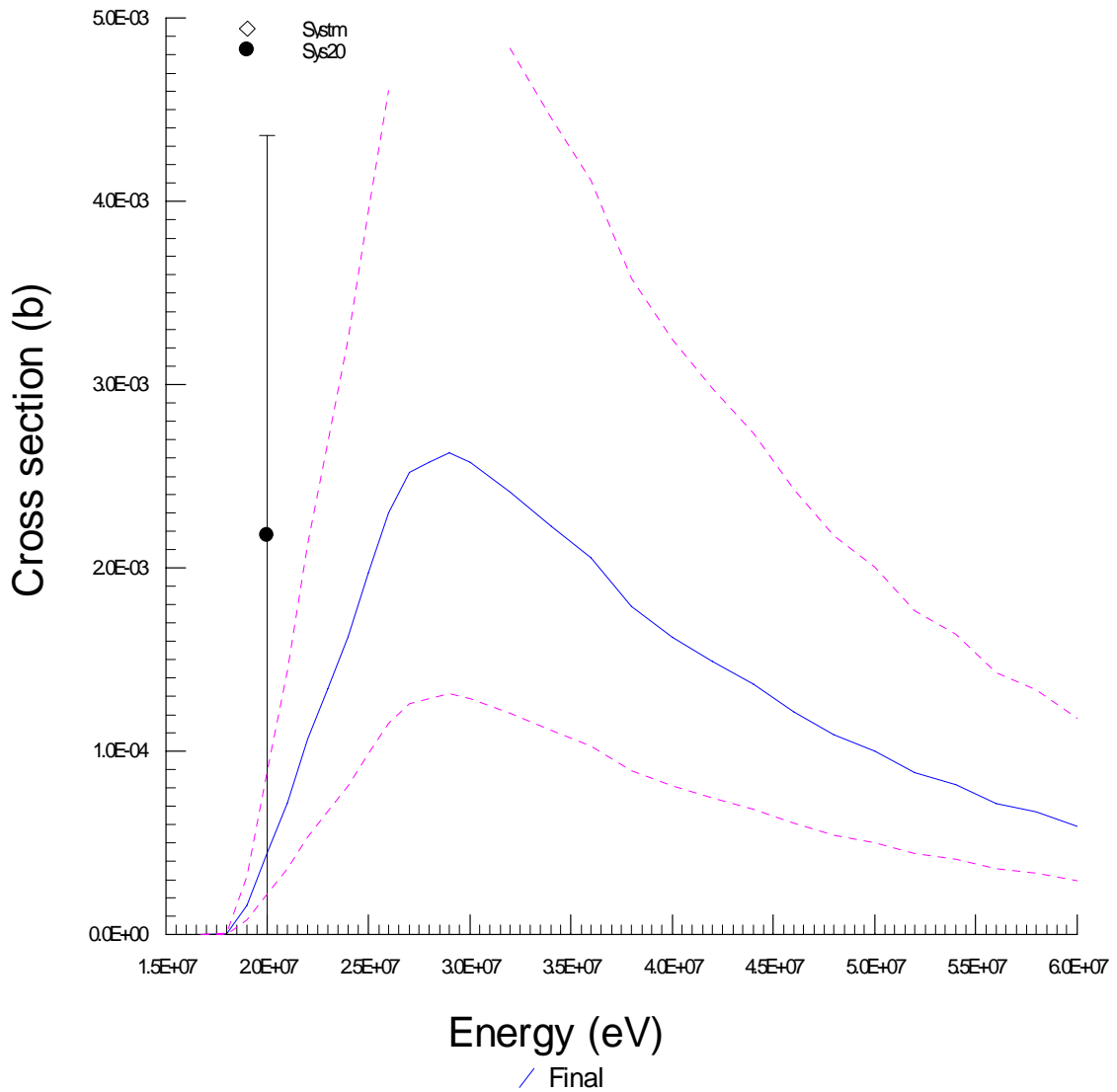
$^{28}\text{Si}(n,p)^{28}\text{Al} \blacktriangleright 543$



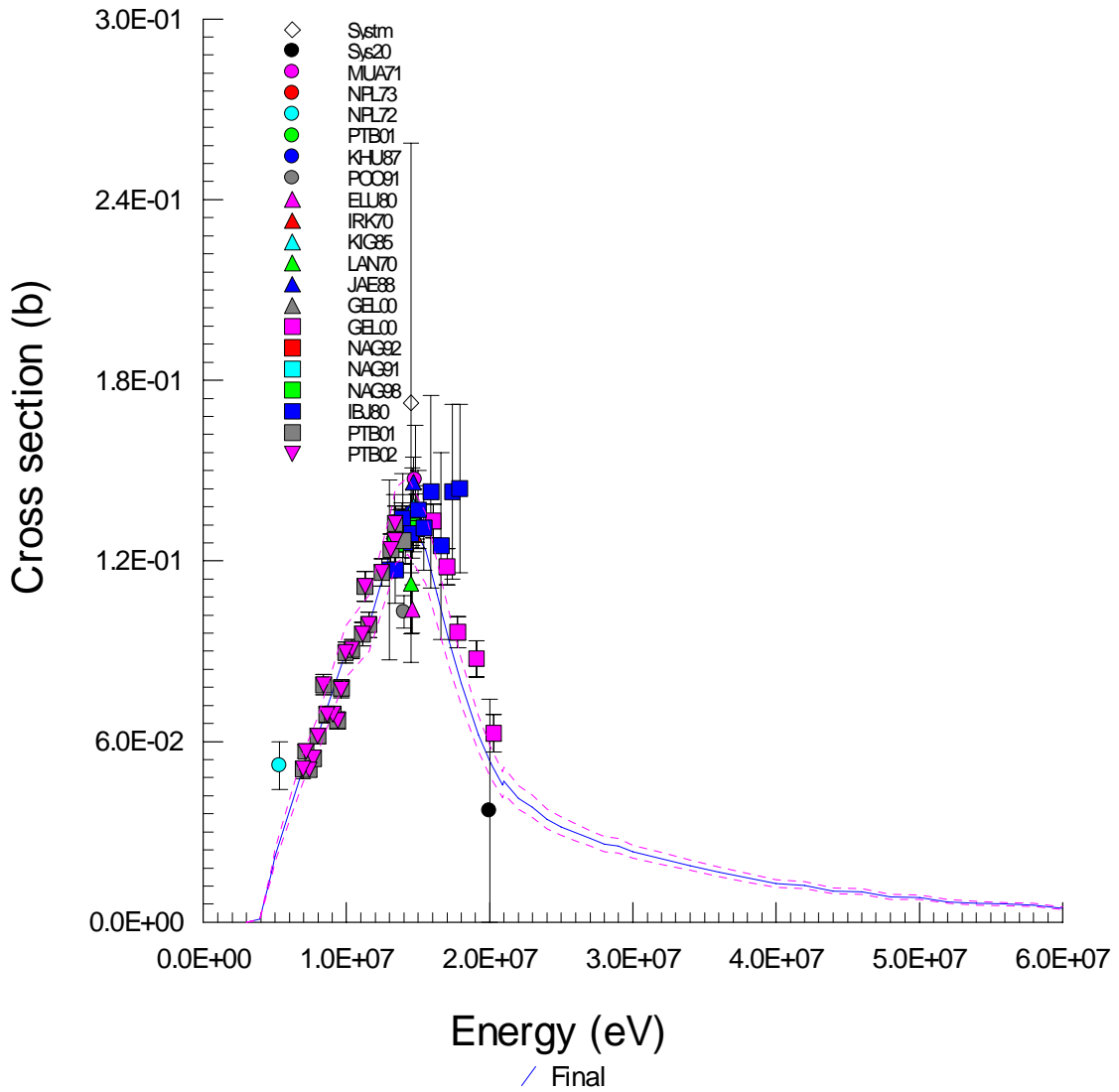
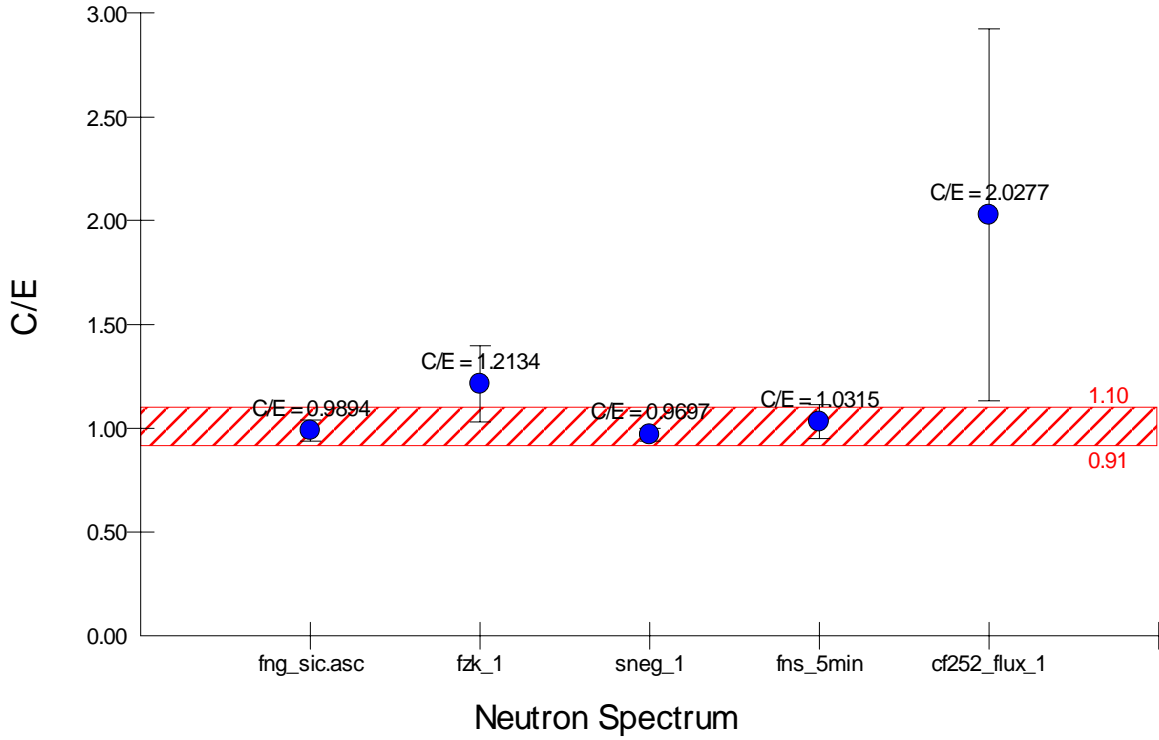
$^{28}\text{Si}(n,t)^{26}\text{Al}$



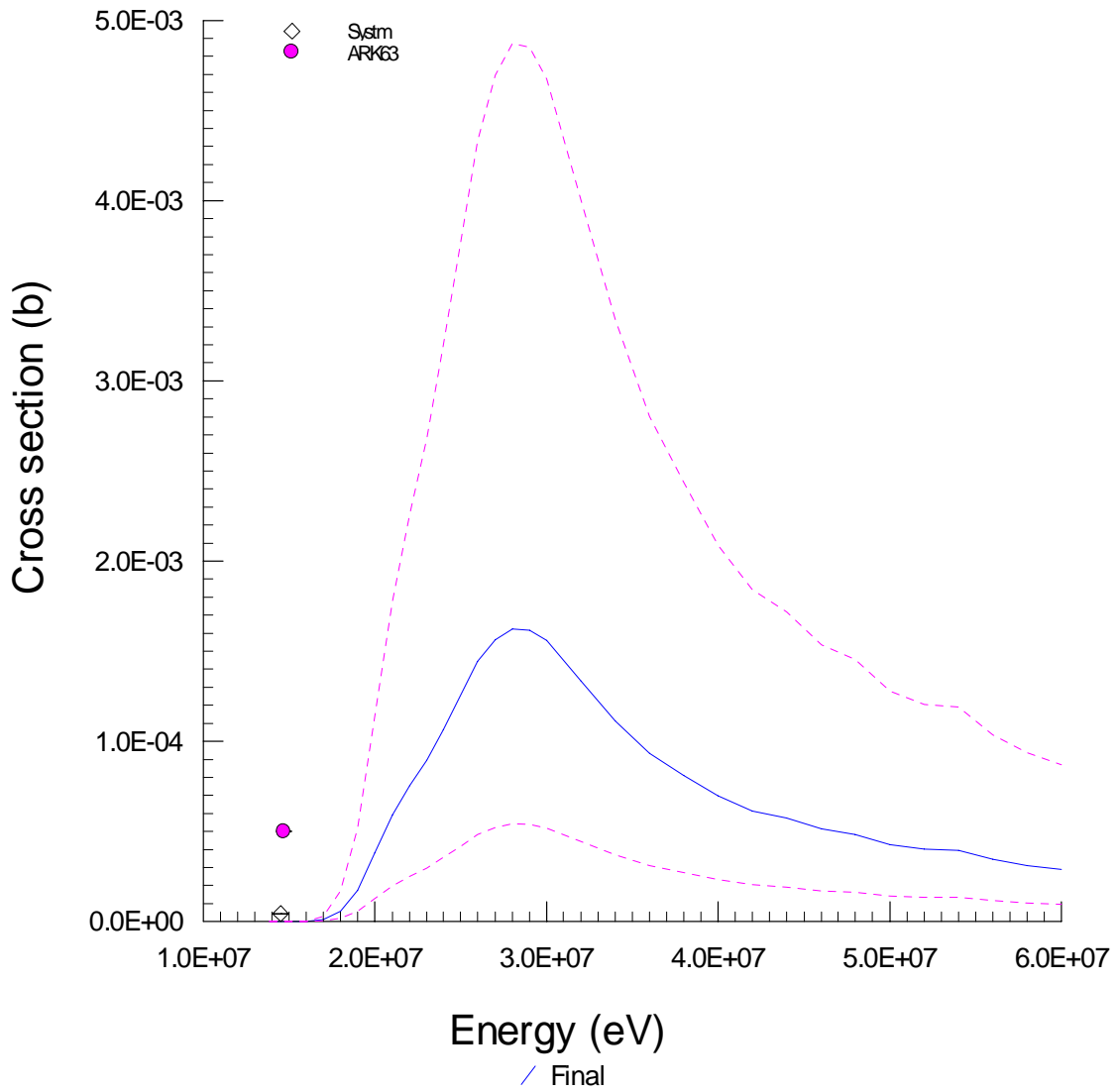
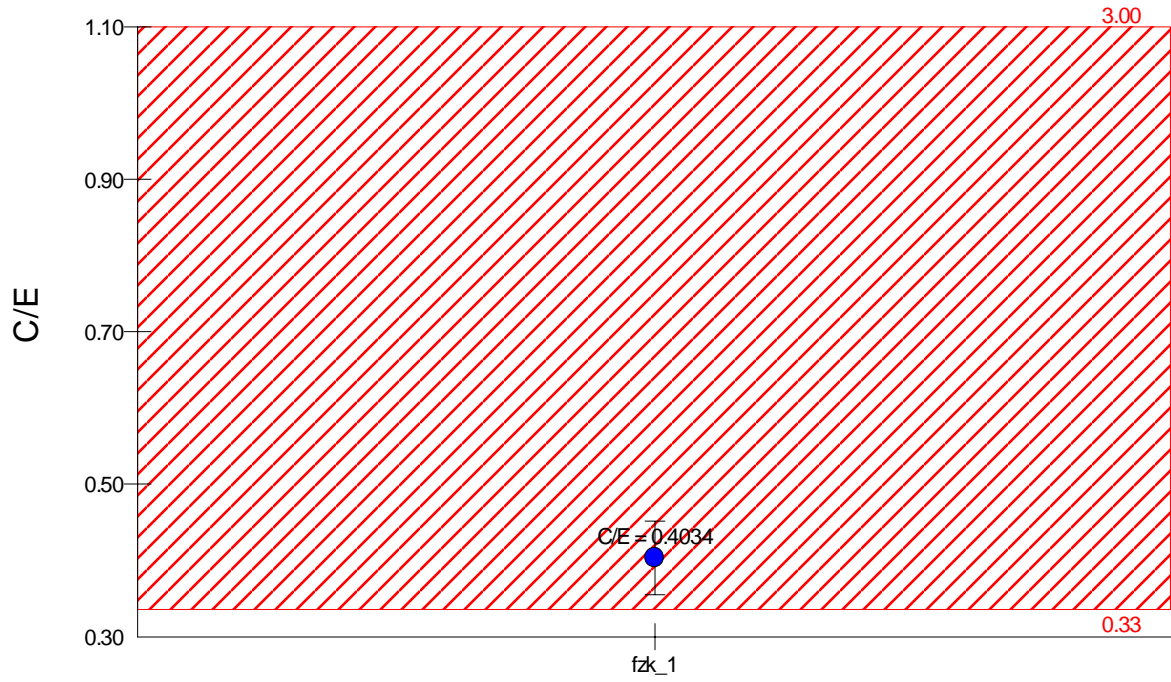
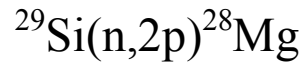
Neutron Spectrum



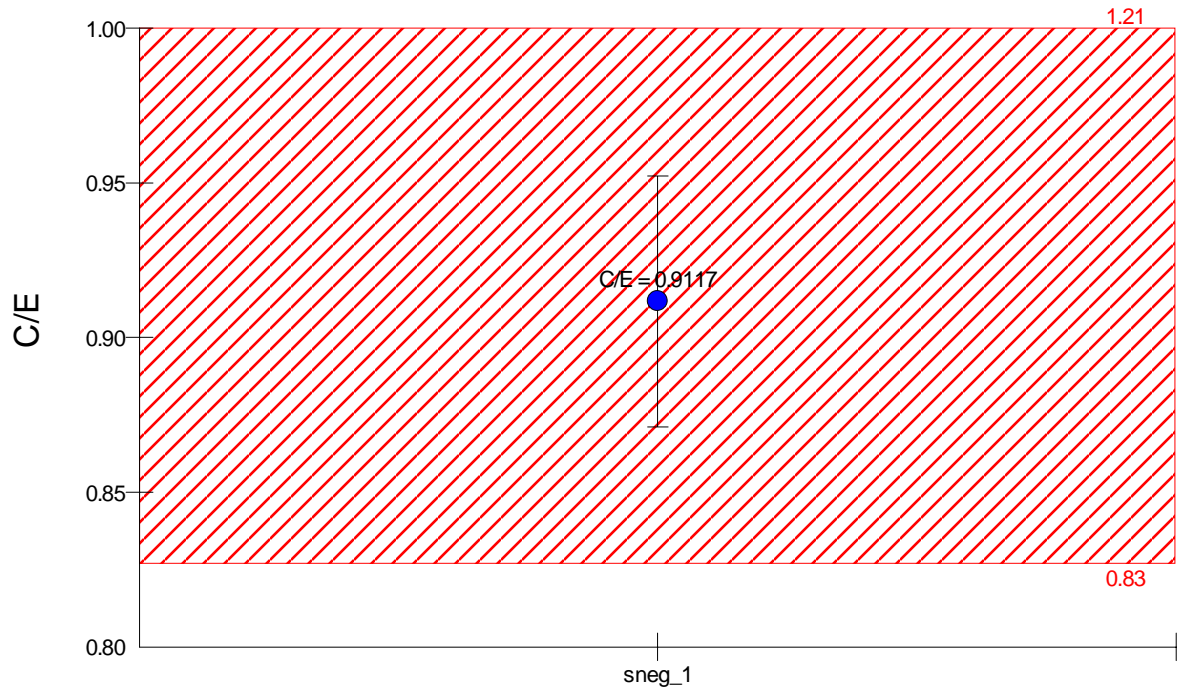
$^{29}\text{Si}(n,p)^{29}\text{Al} \blacktriangleright 544$



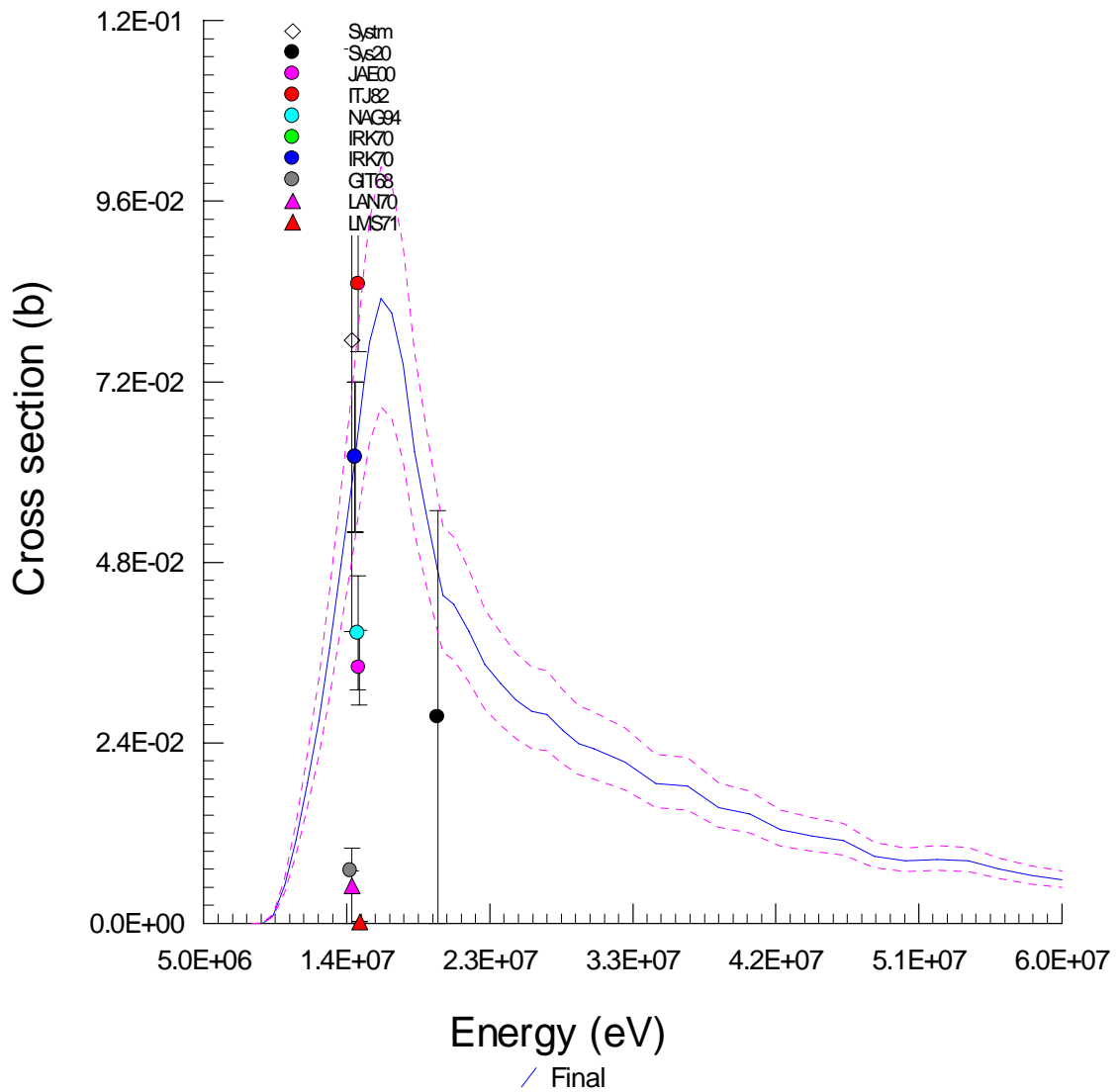


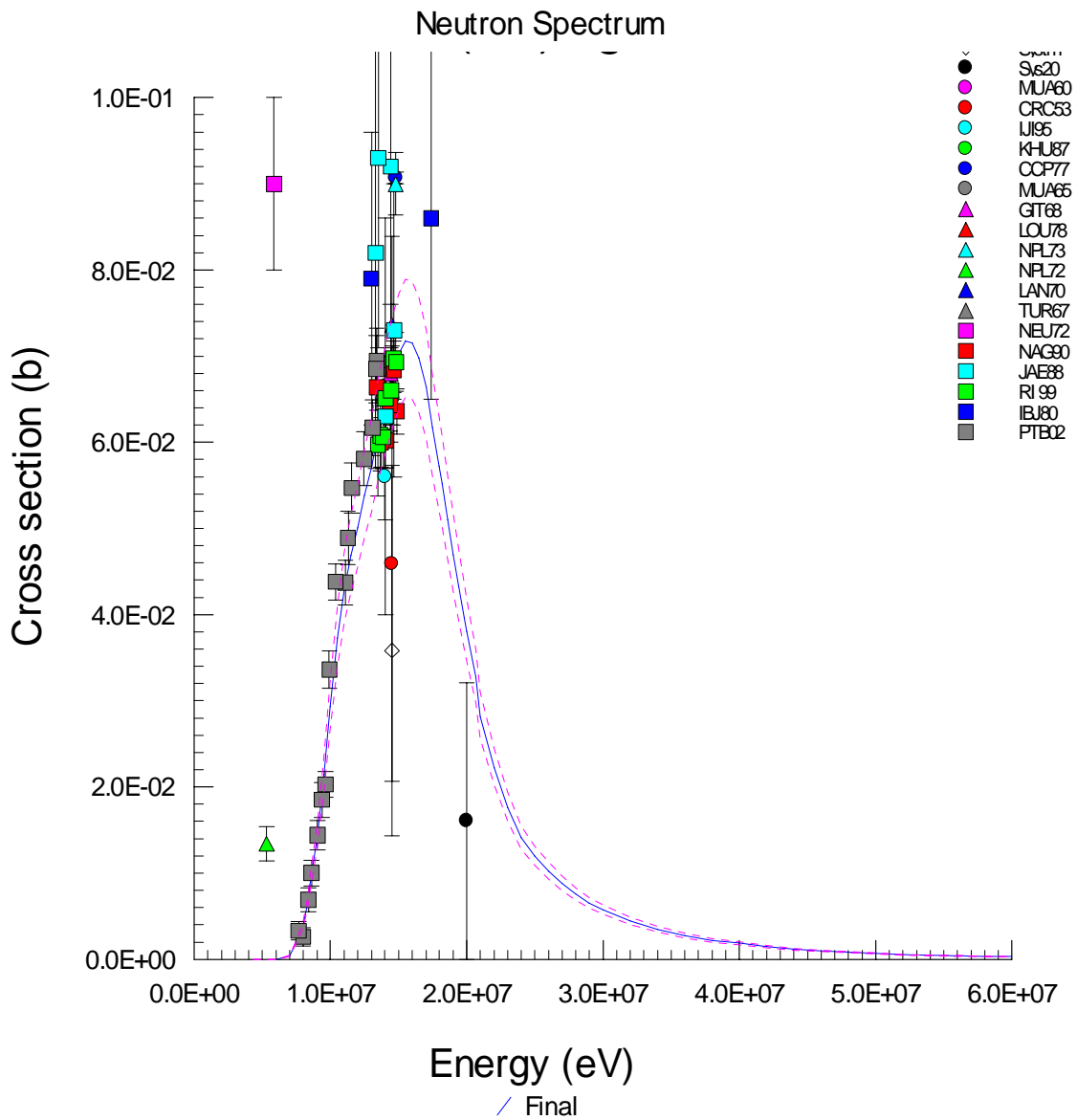
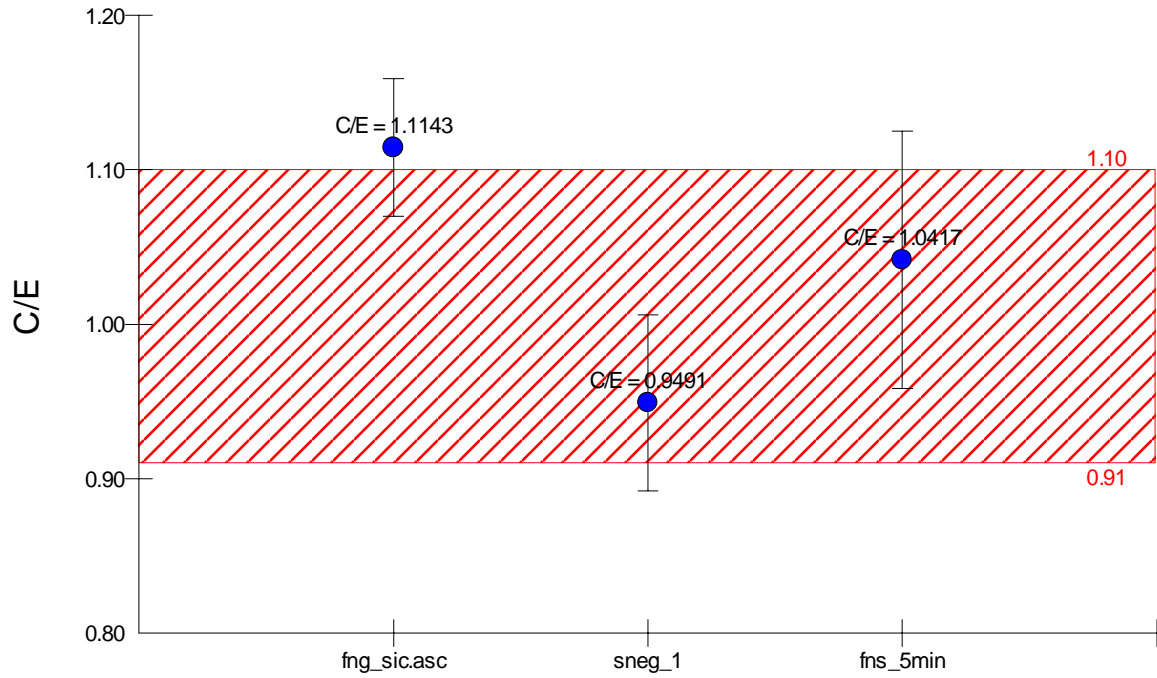
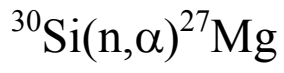


# $^{30}\text{Si}(n,p)^{30}\text{Al}$

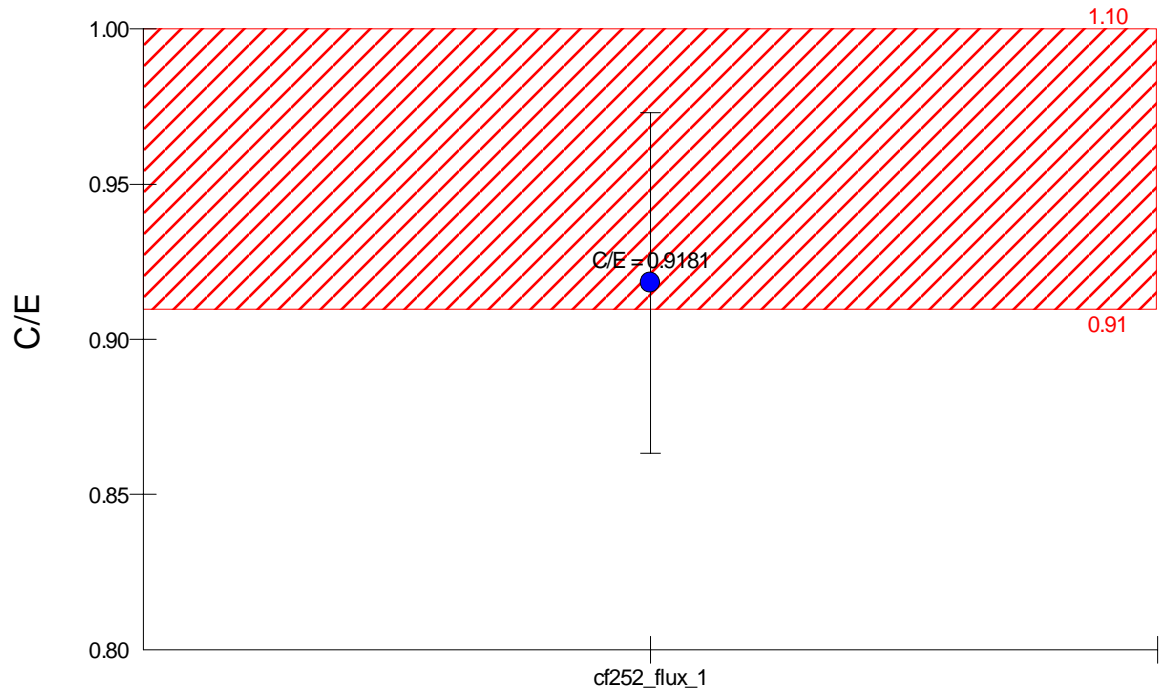


## Neutron Spectrum

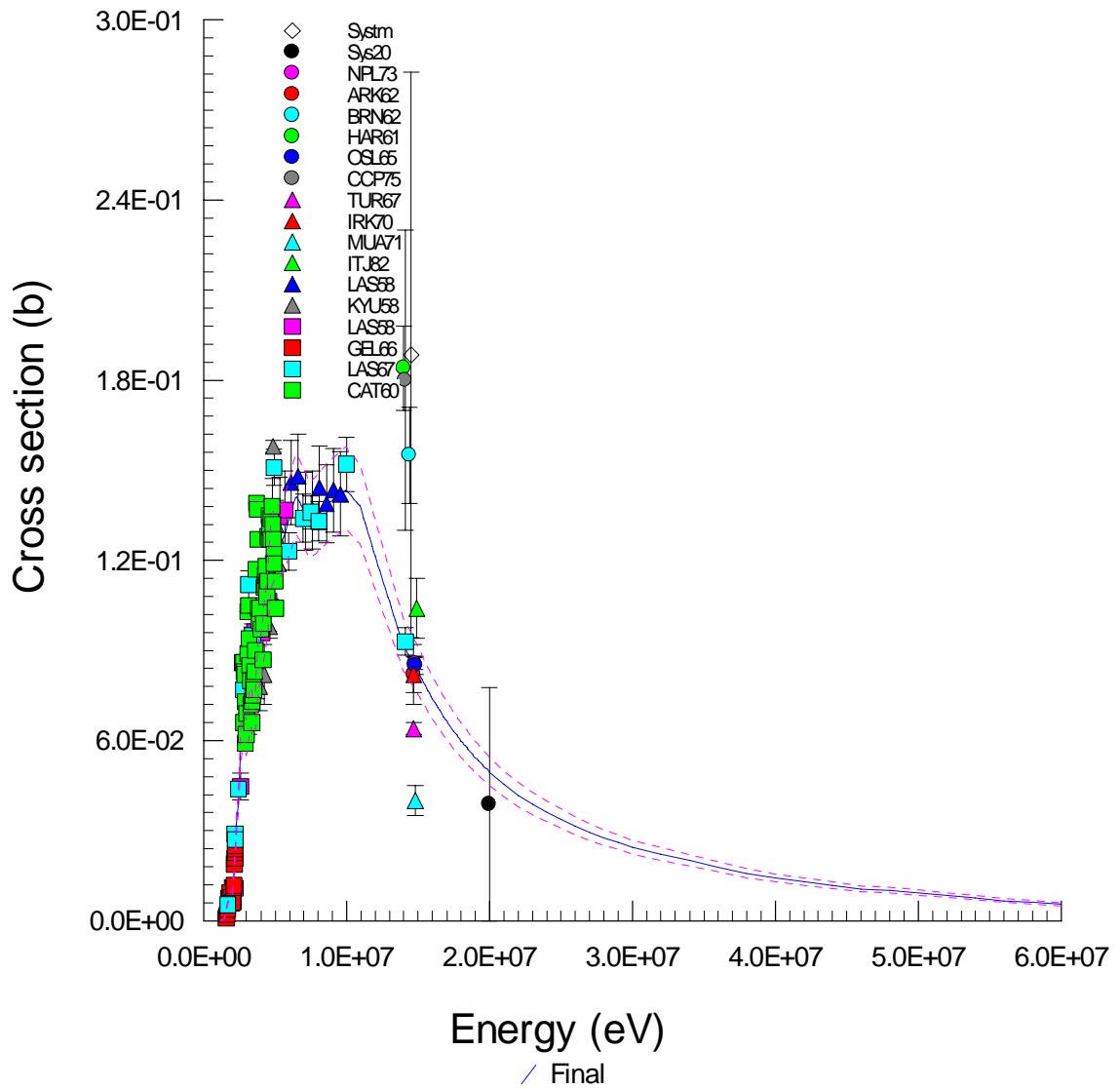


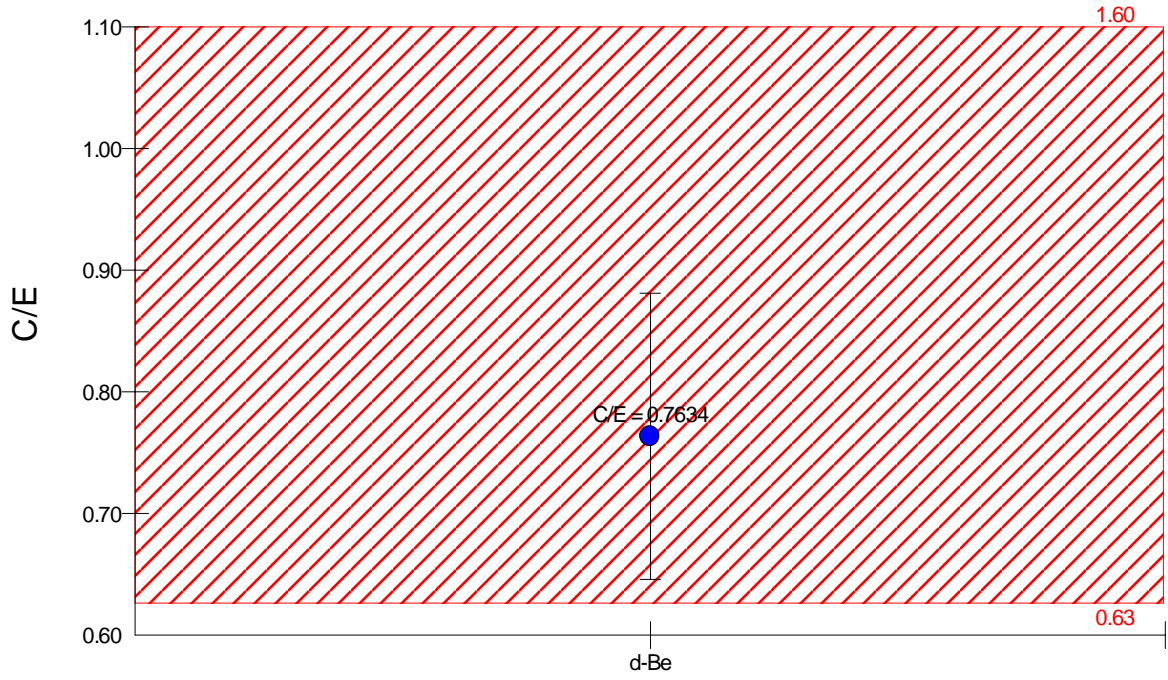
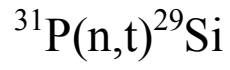


# $^{31}\text{P}(n,p)^{31}\text{Si}$

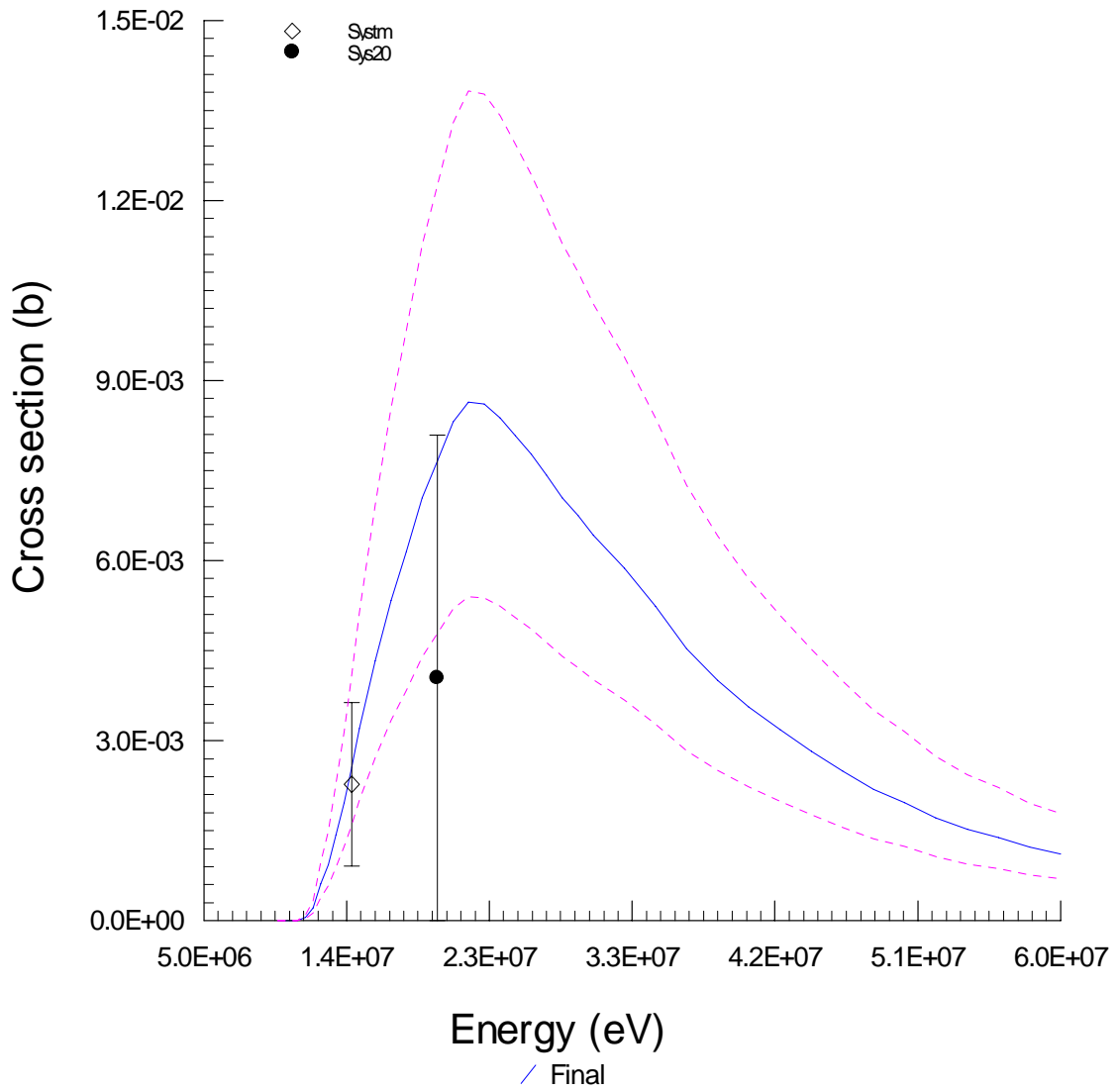


## Neutron Spectrum

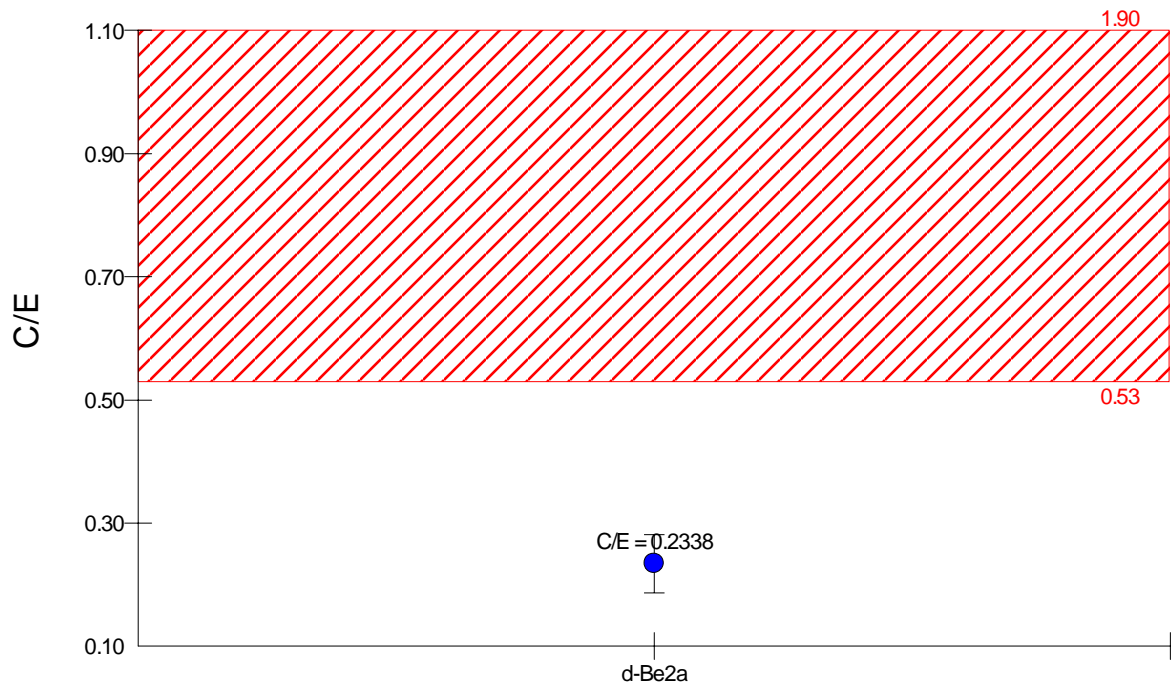




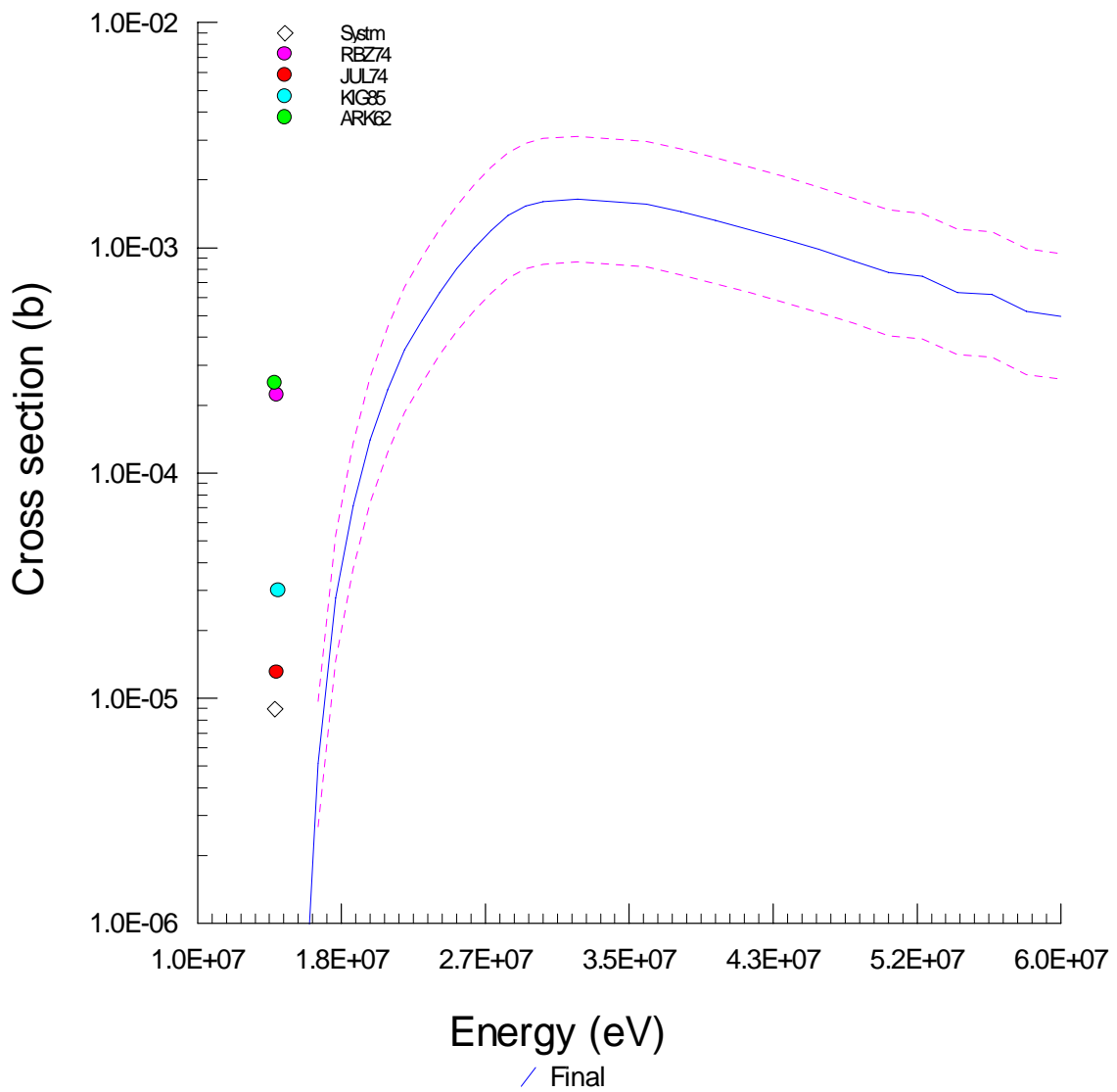
Neutron Spectrum



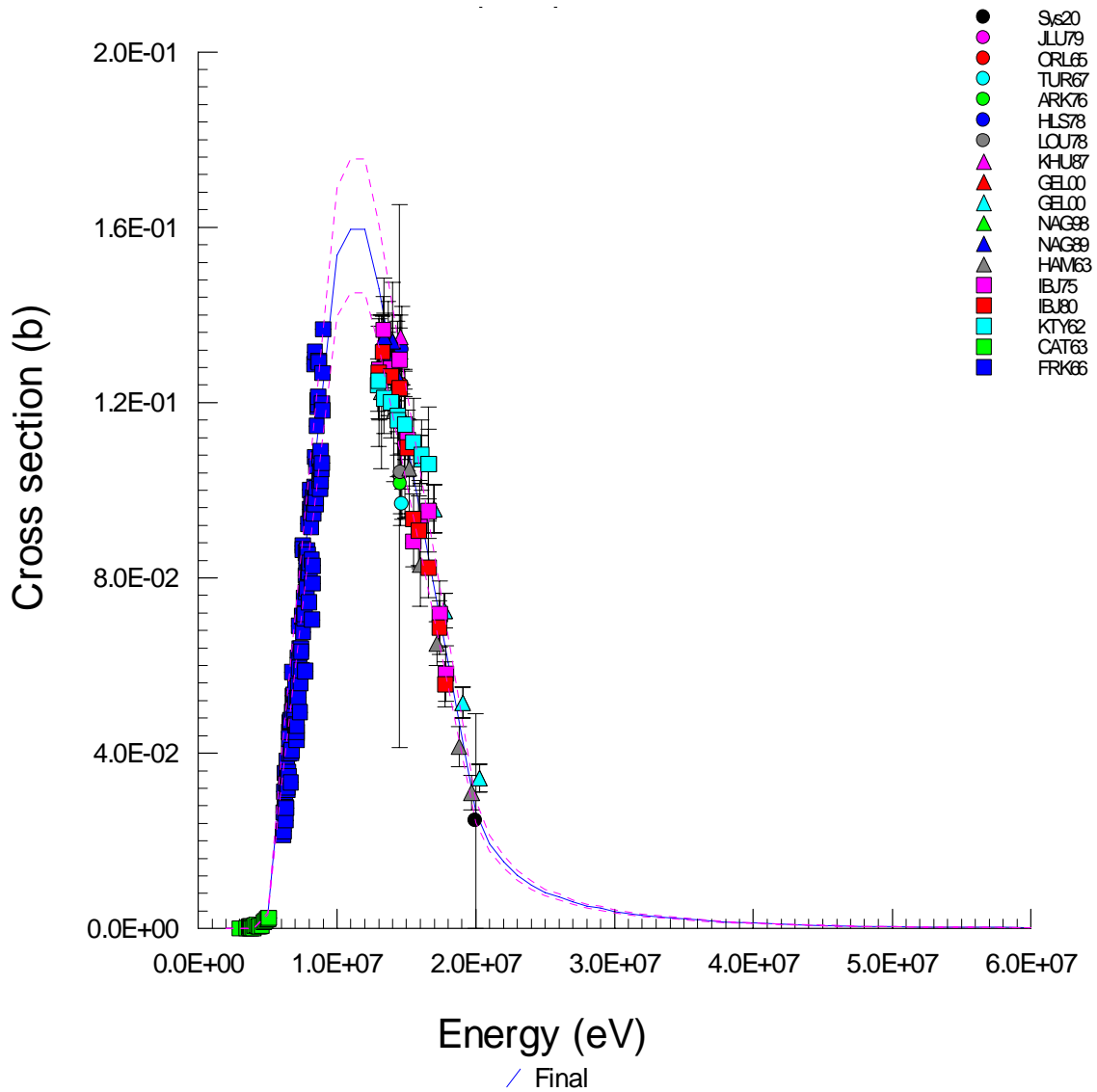
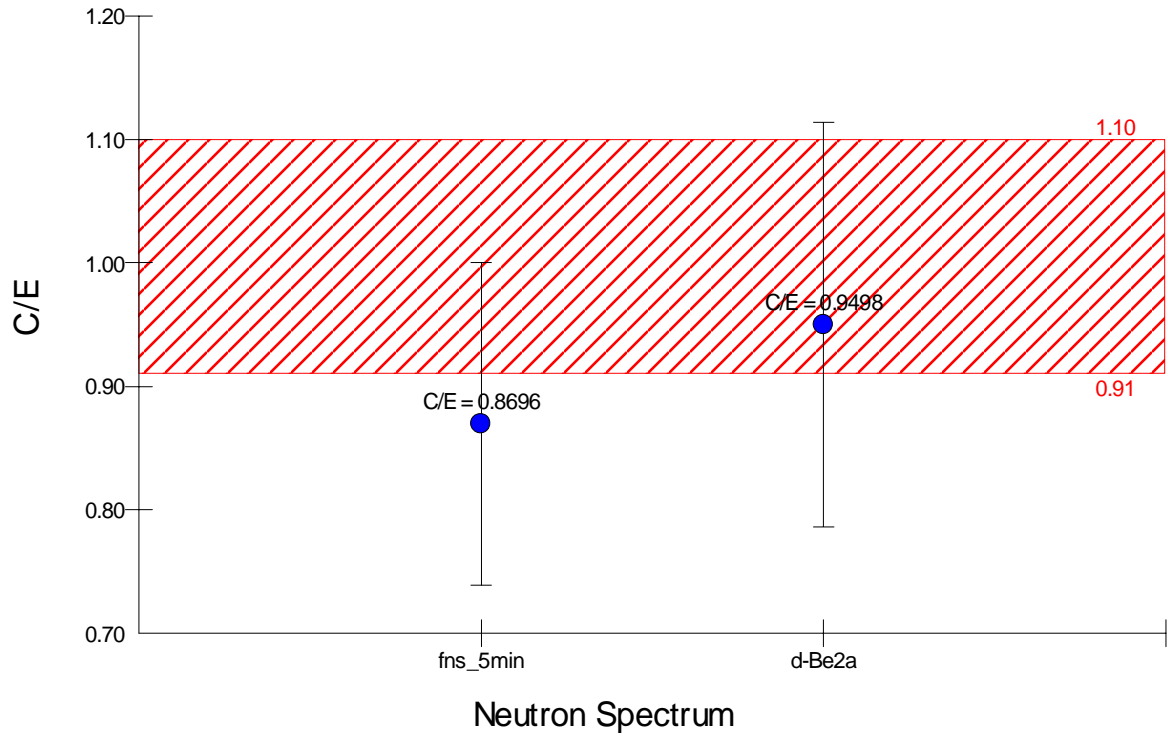
# $^{31}\text{P}(n,h)^{29}\text{Al}$

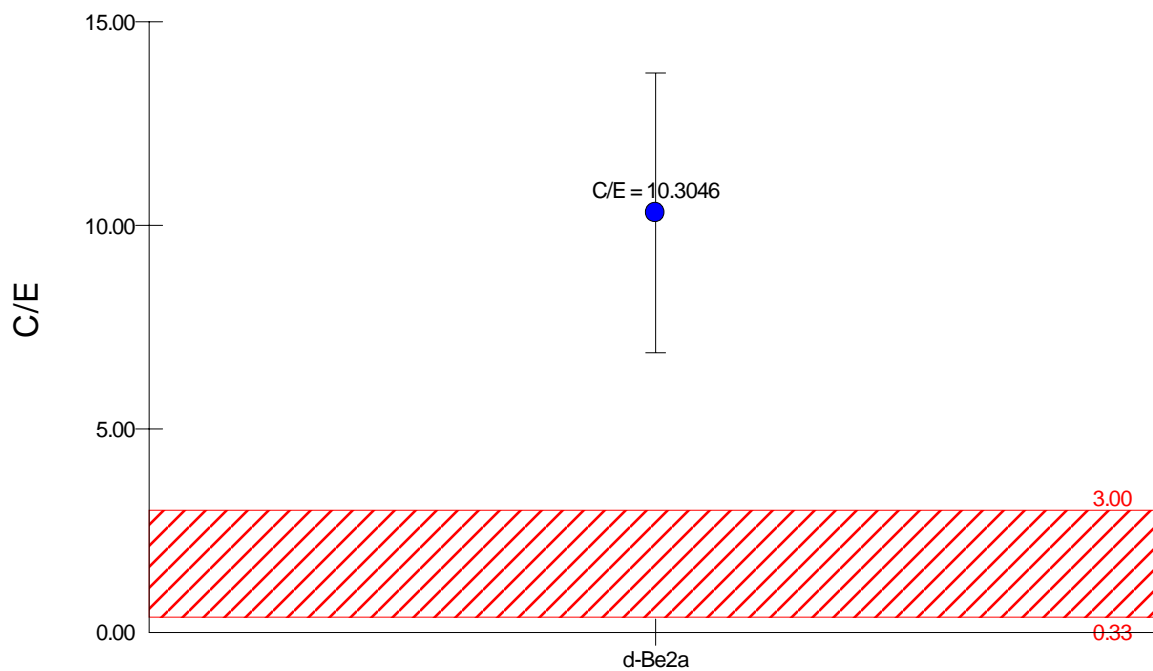
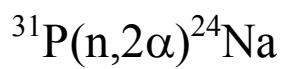


Neutron Spectrum

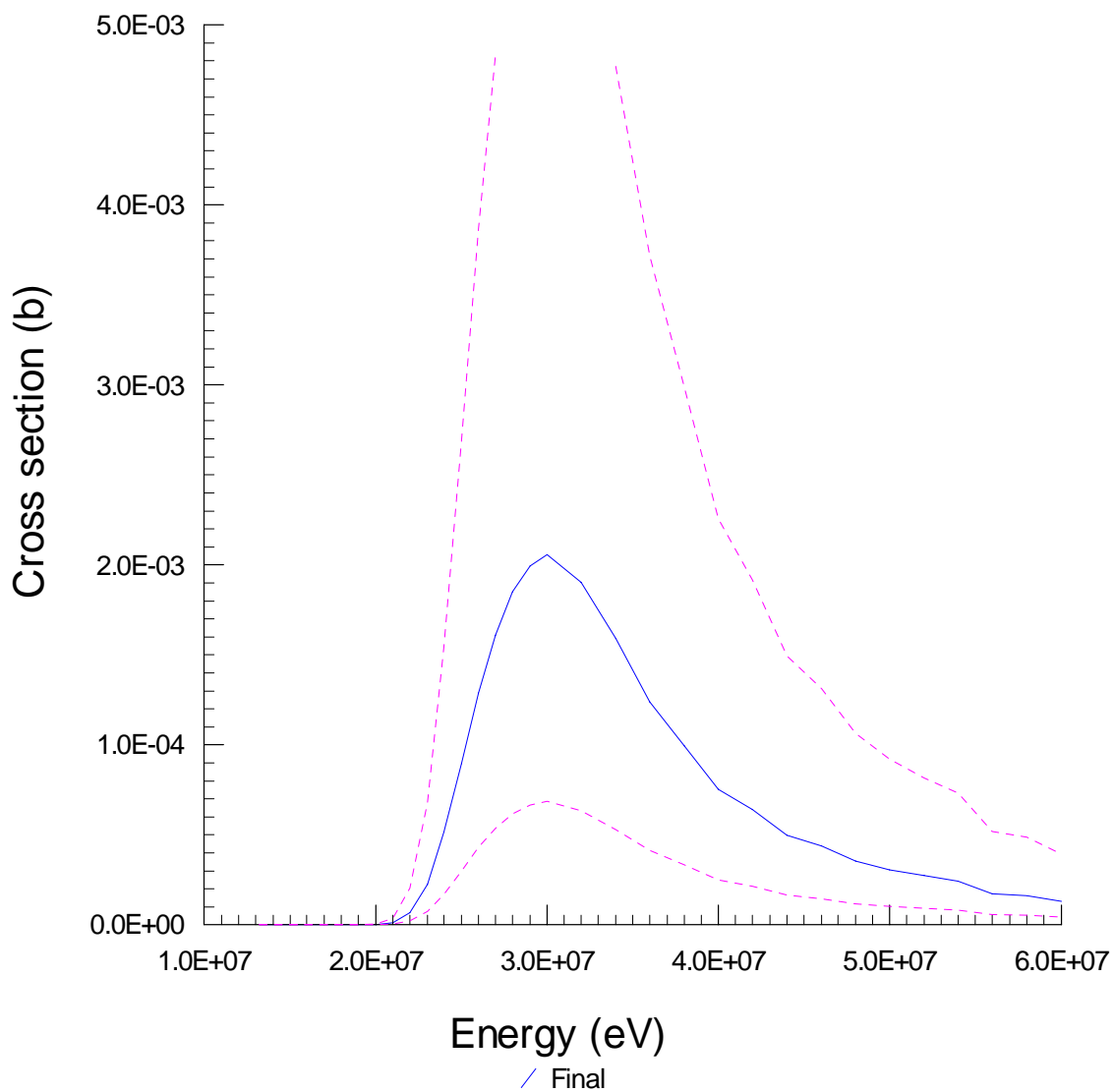


# $^{31}\text{P}(n,\alpha)^{28}\text{Al}$



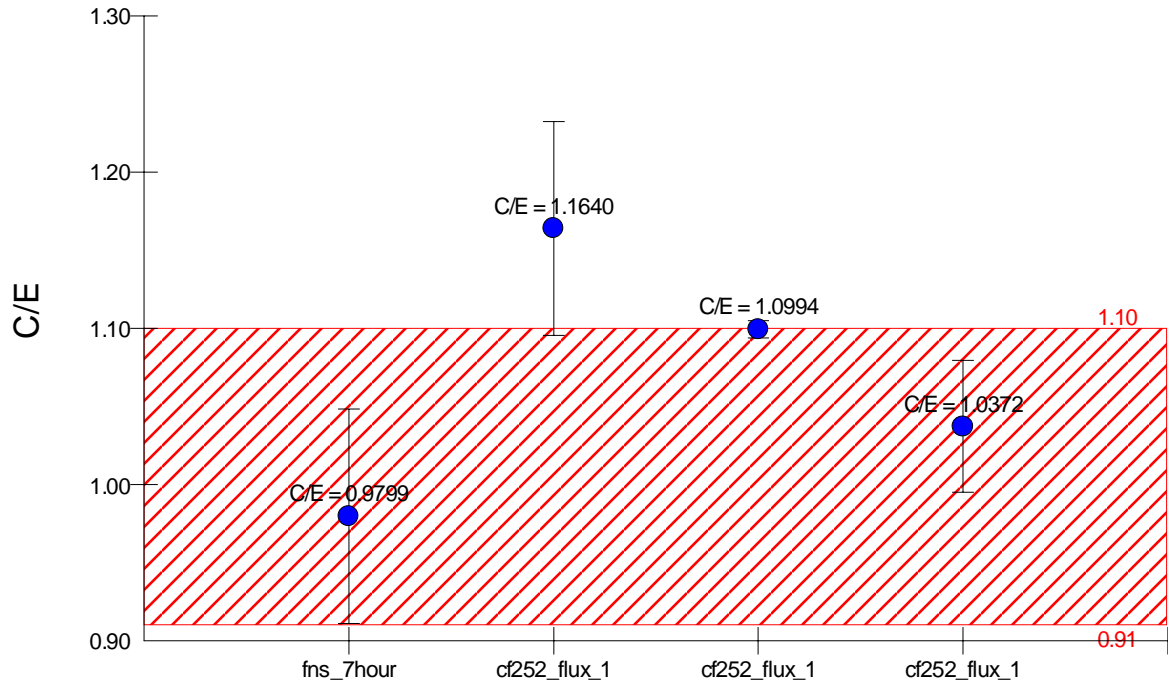


Neutron Spectrum

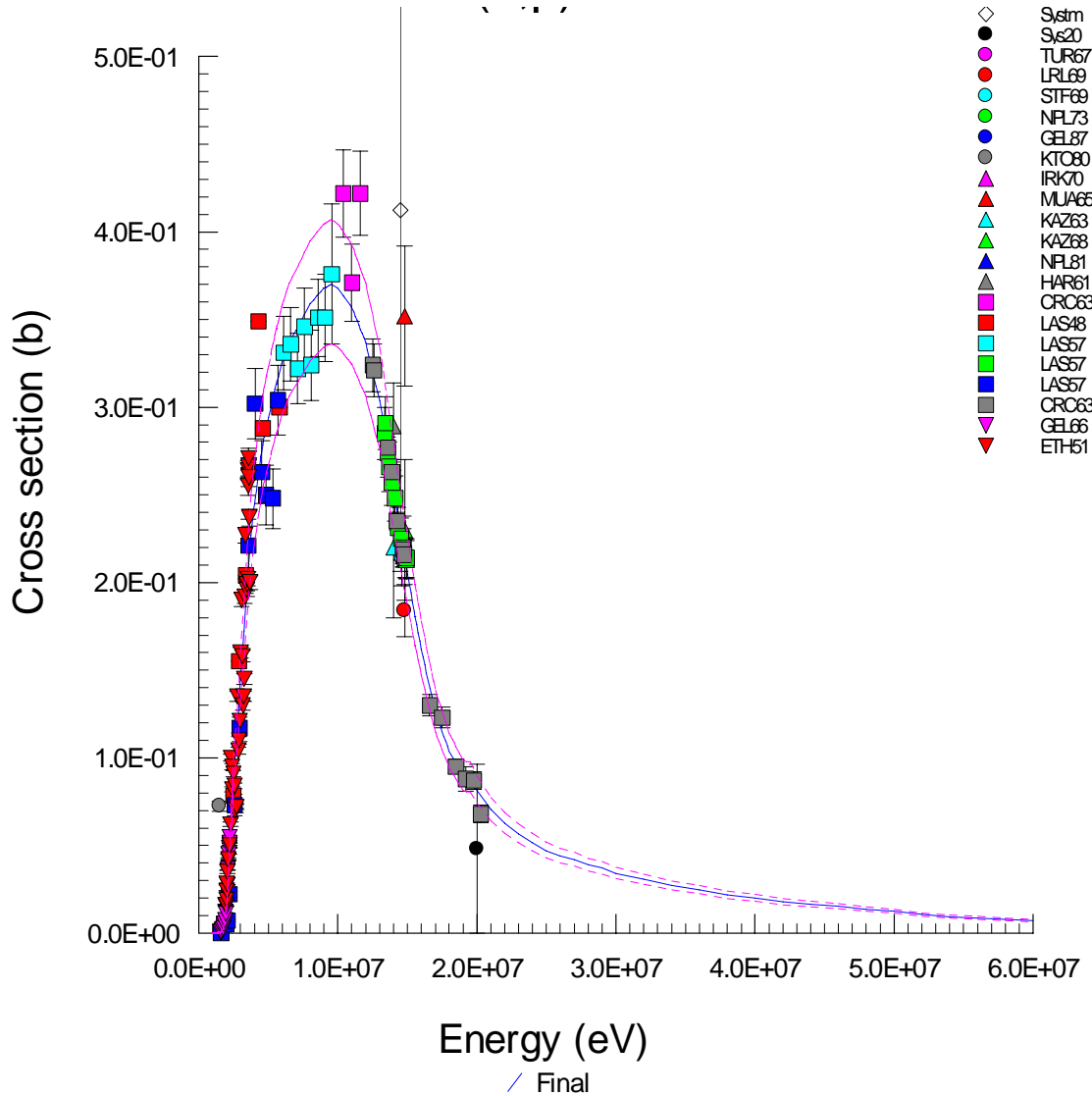


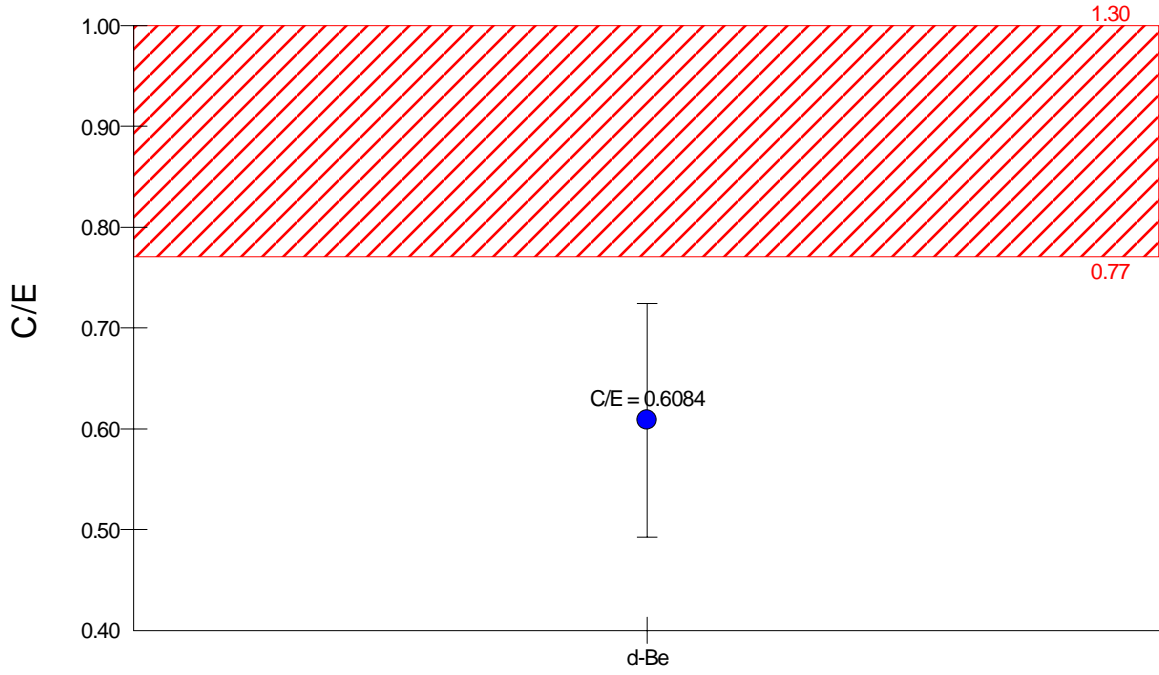
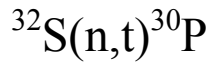


# $^{32}\text{S}(n,p)^{32}\text{P}$

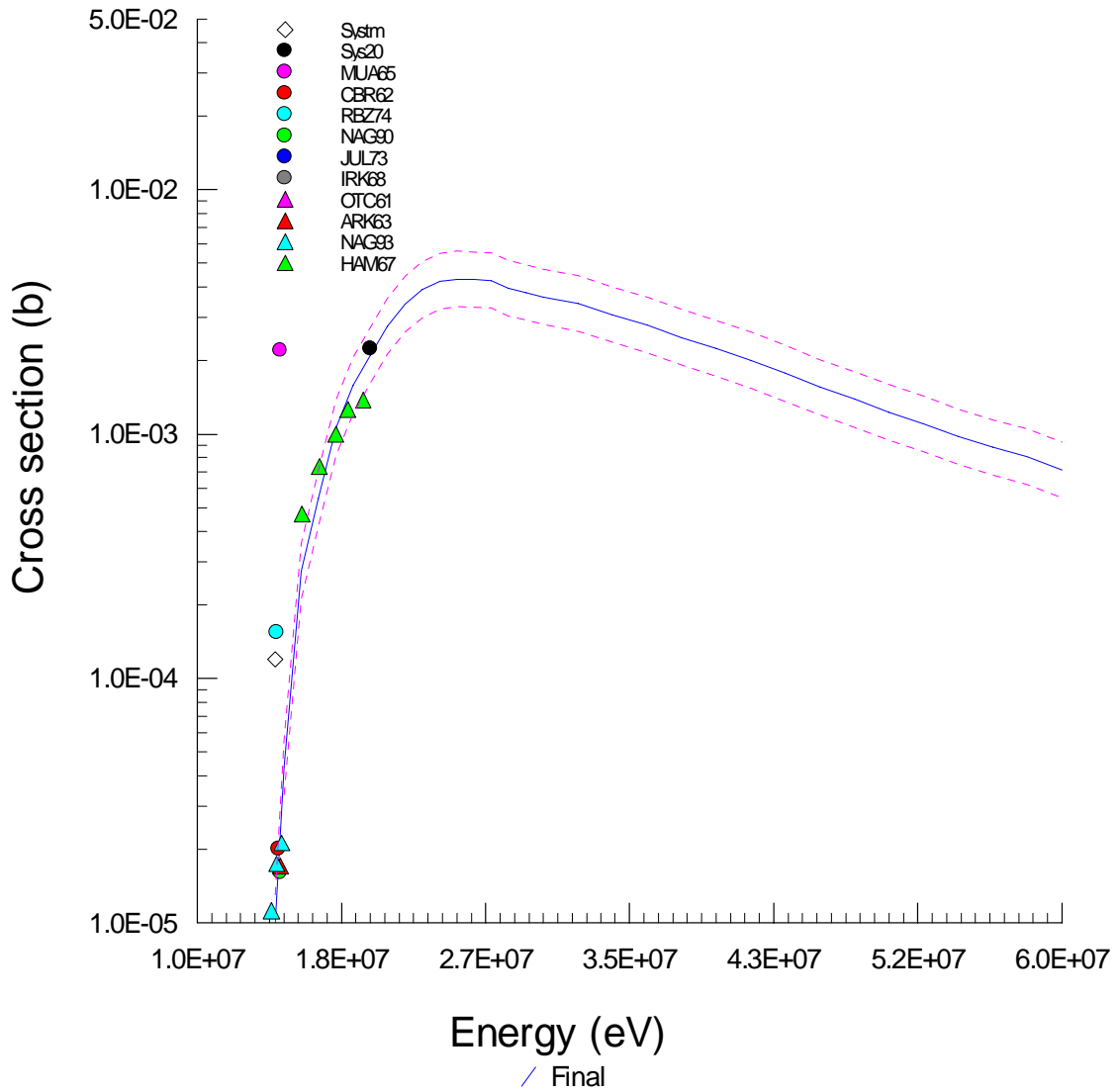


## Neutron Spectrum

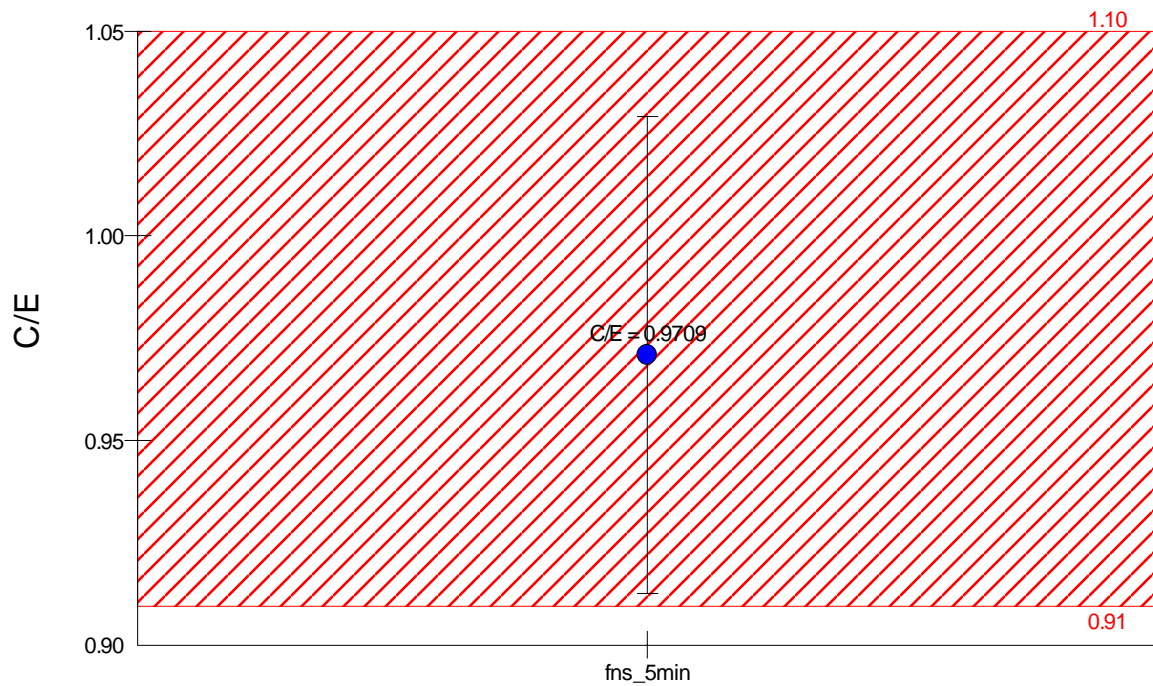




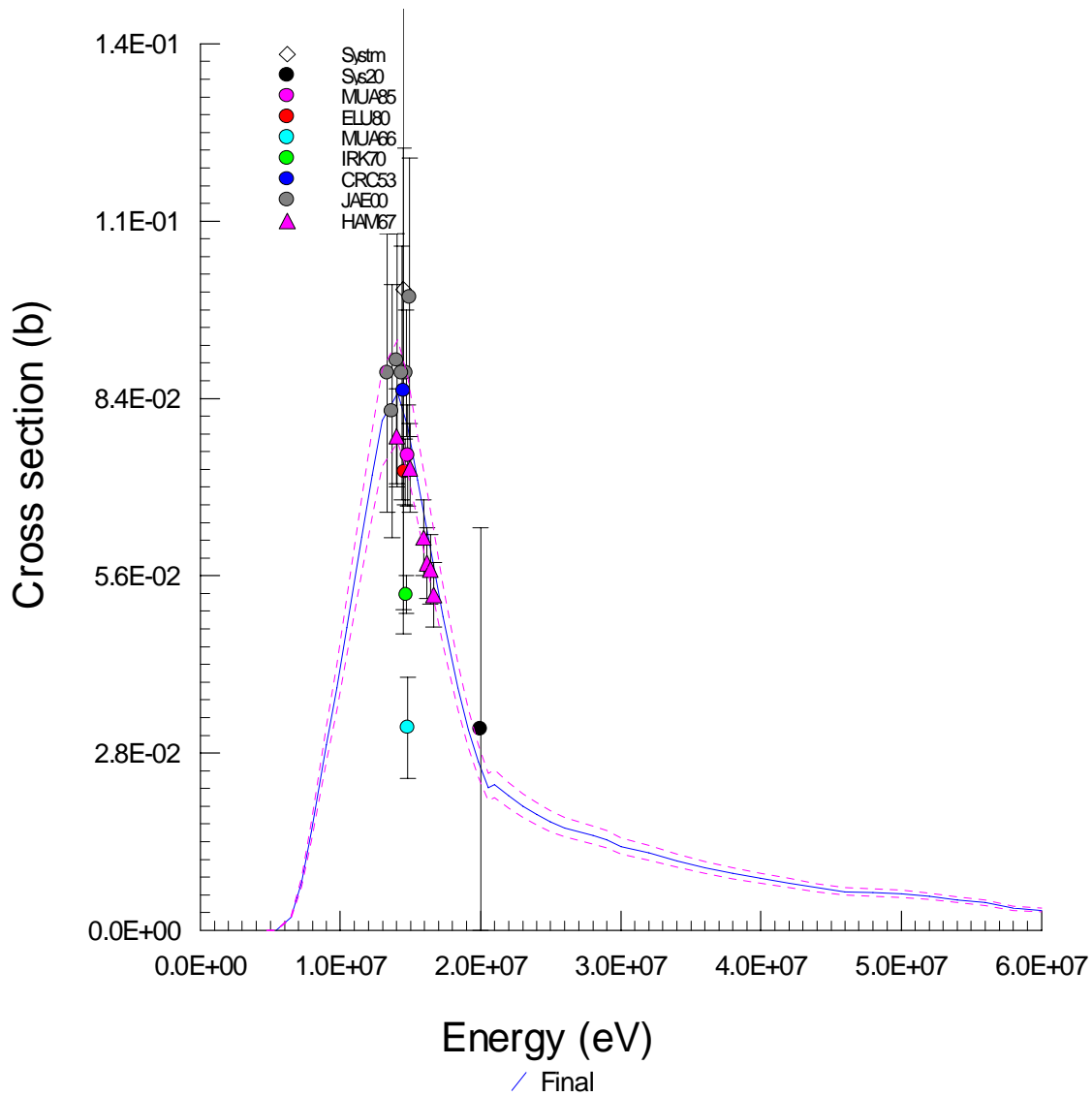
Neutron Spectrum

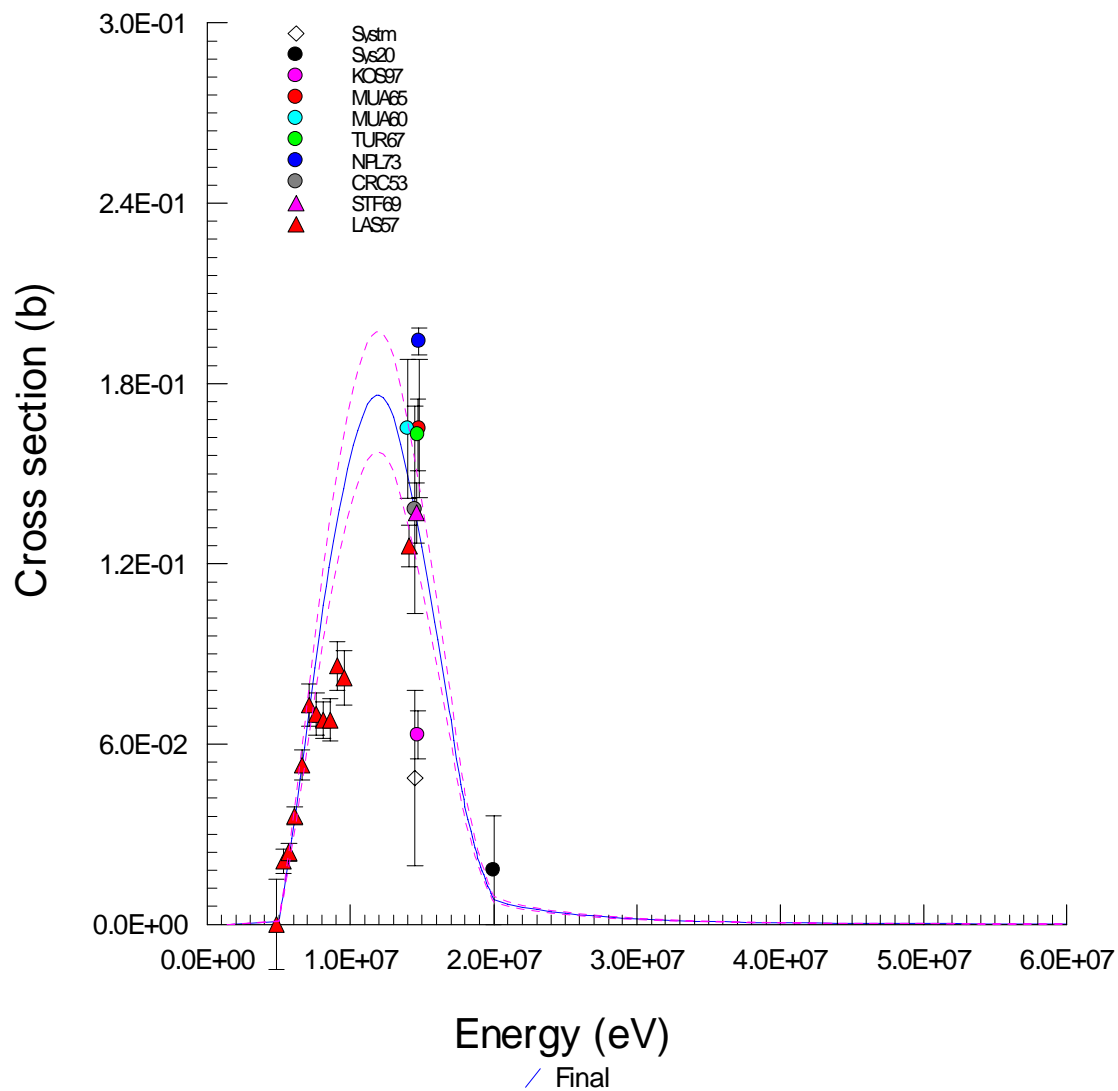
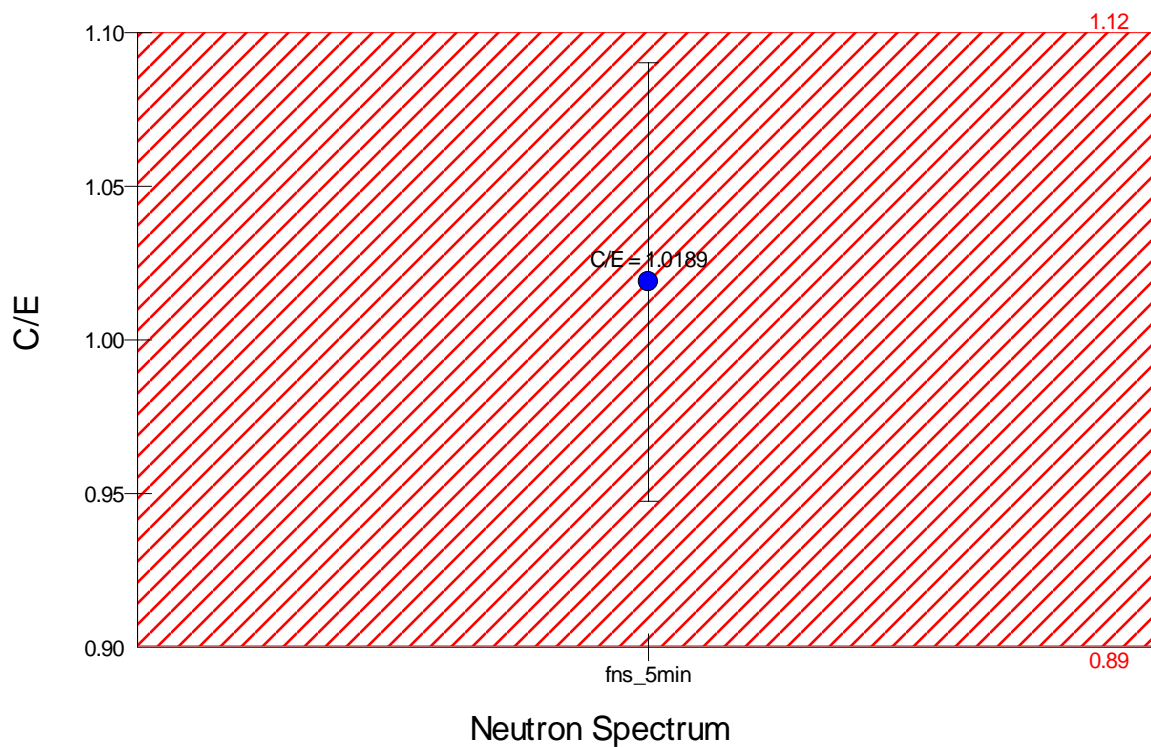
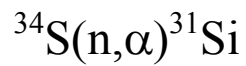


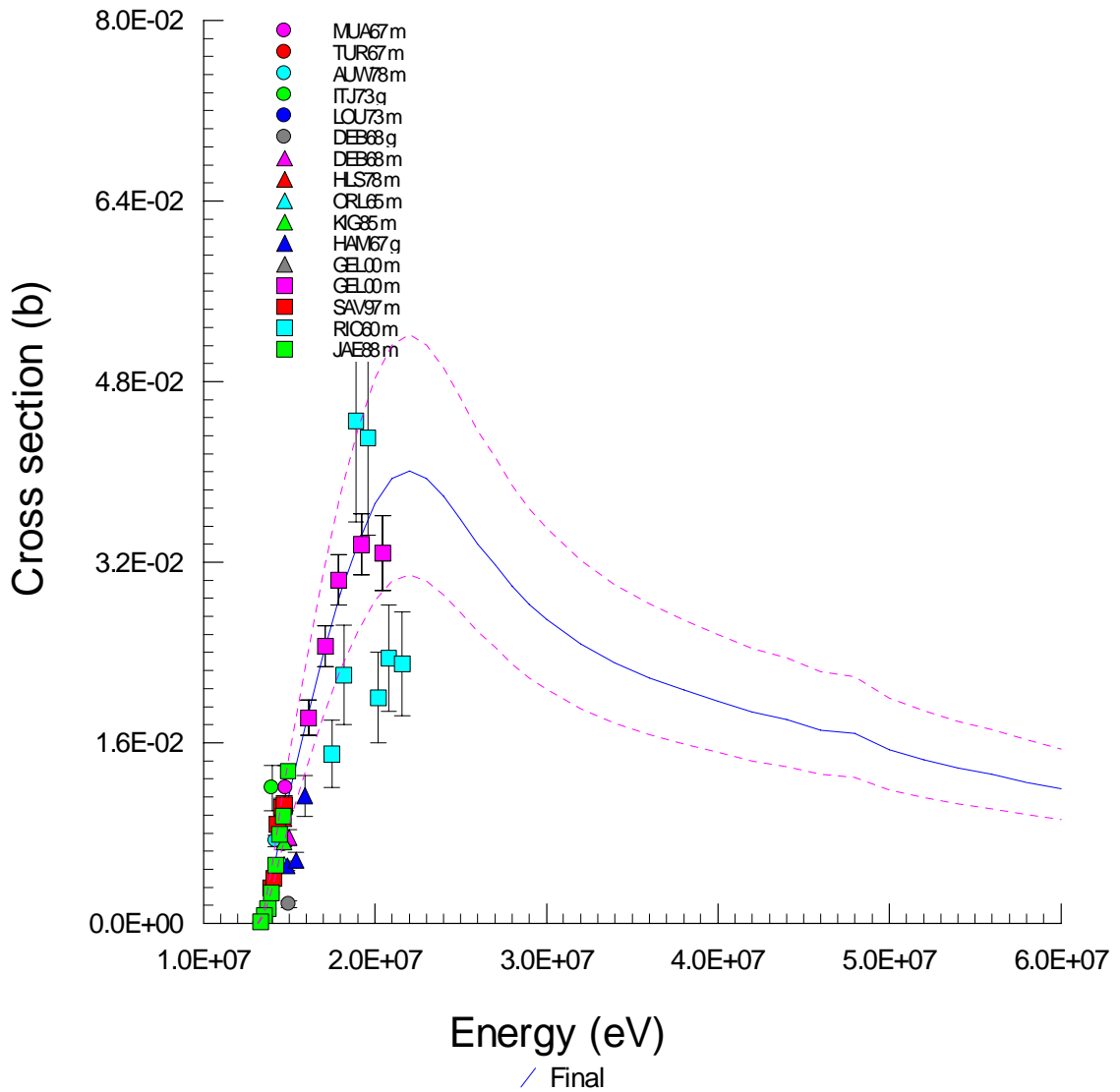
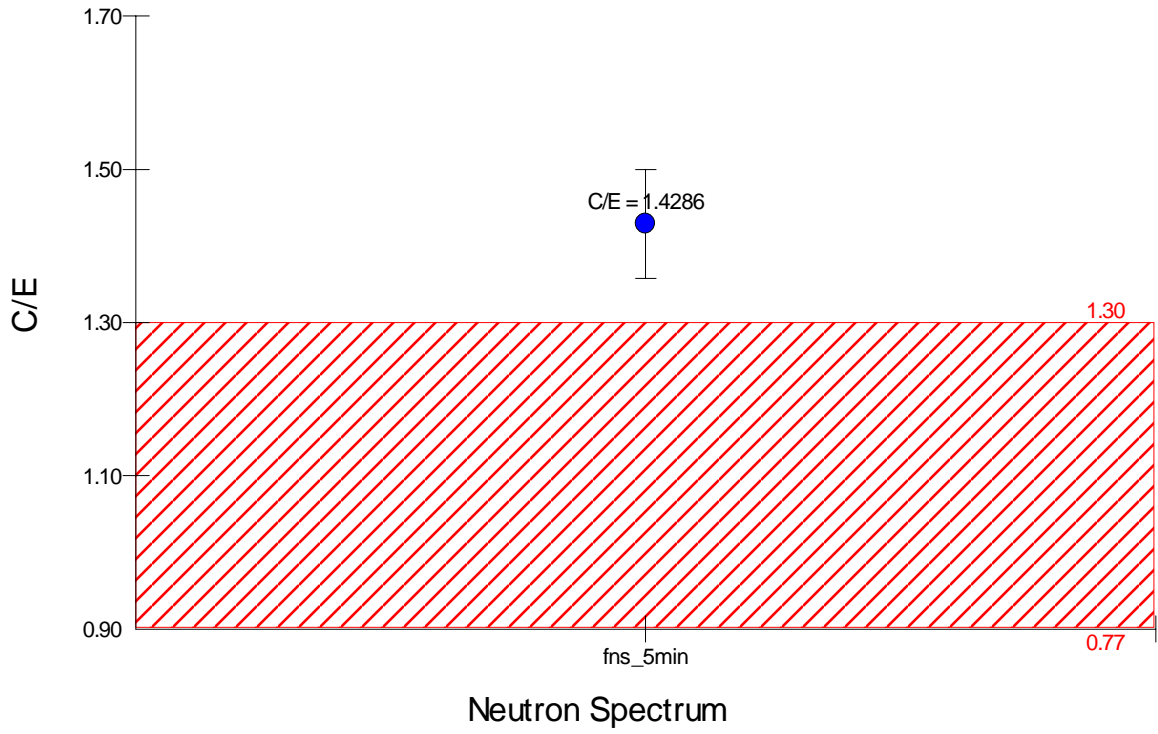
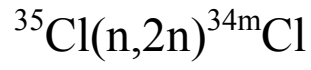
# $^{34}\text{S}(n,p)^{34}\text{P}$



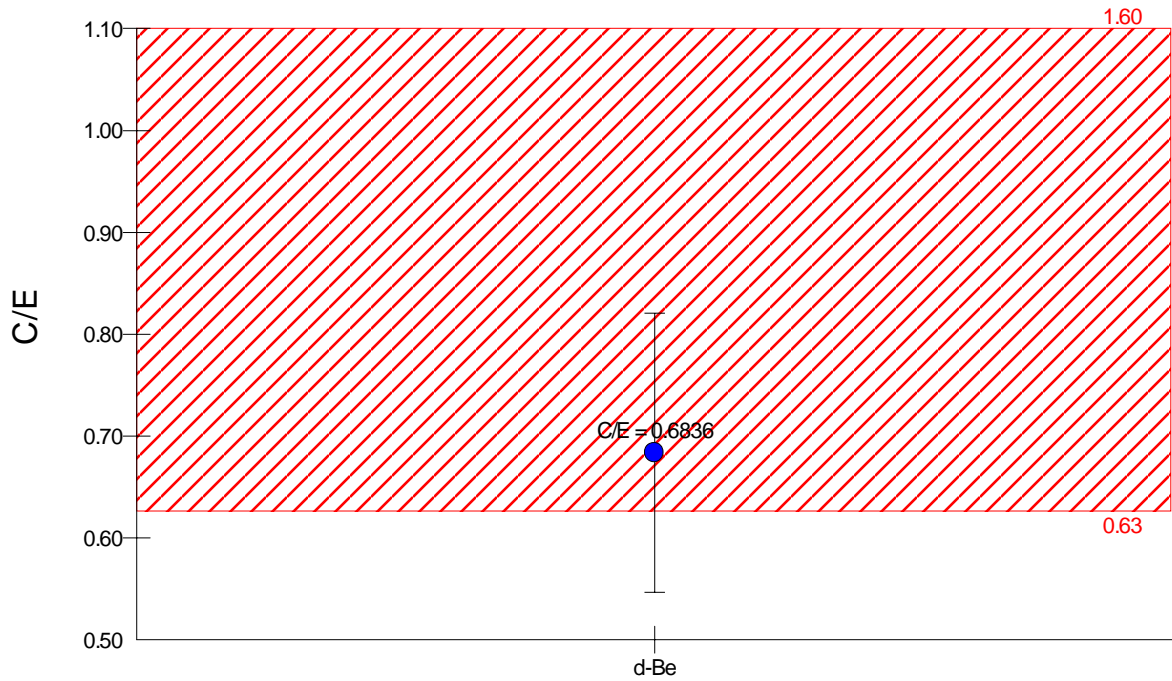
## Neutron Spectrum



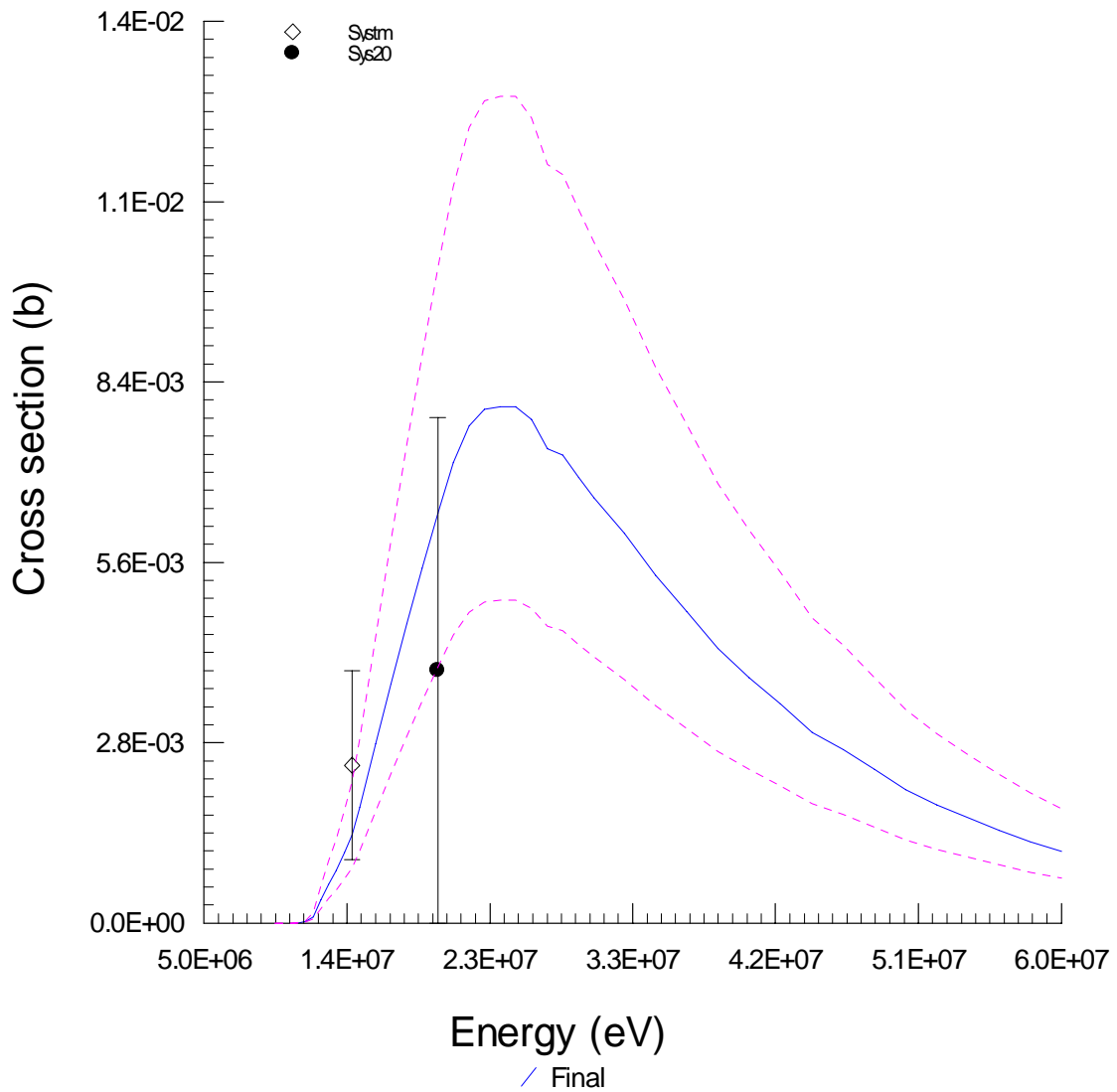




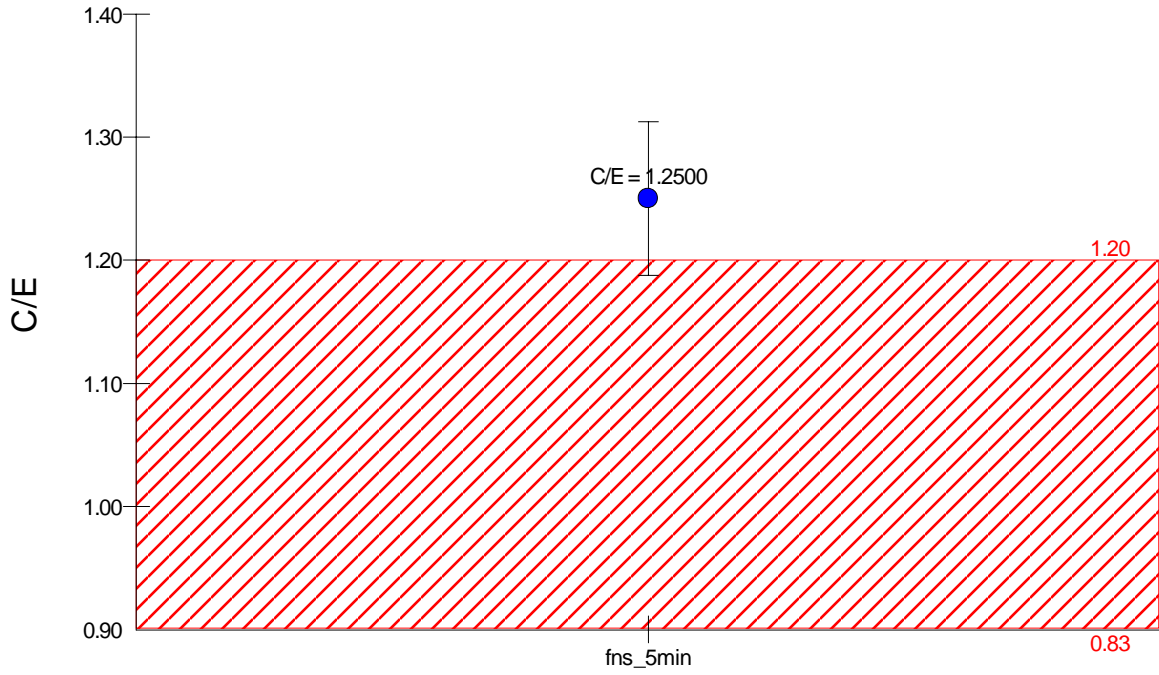
# $^{35}\text{Cl}(n,t)^{33}\text{S}$



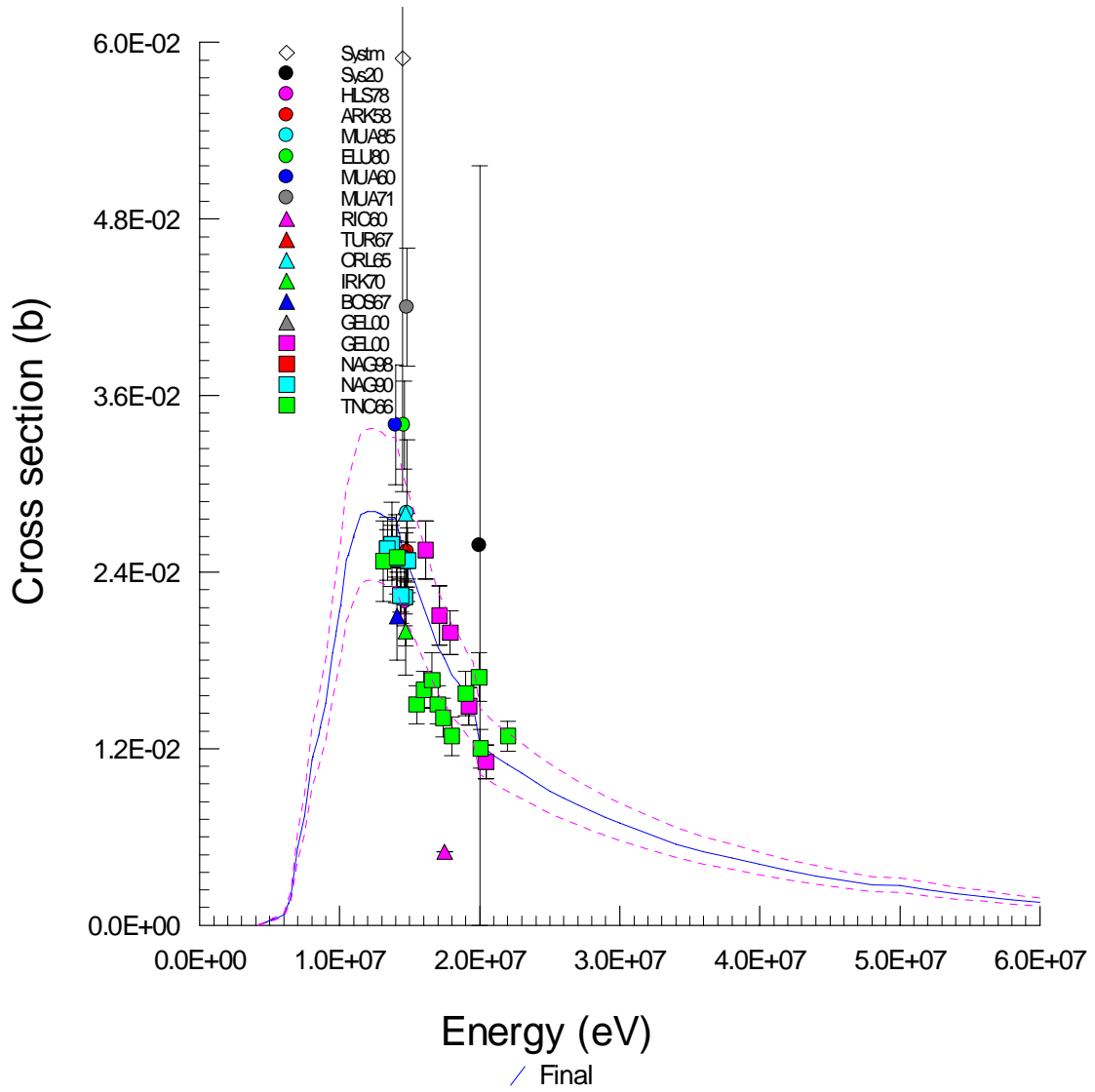
Neutron Spectrum

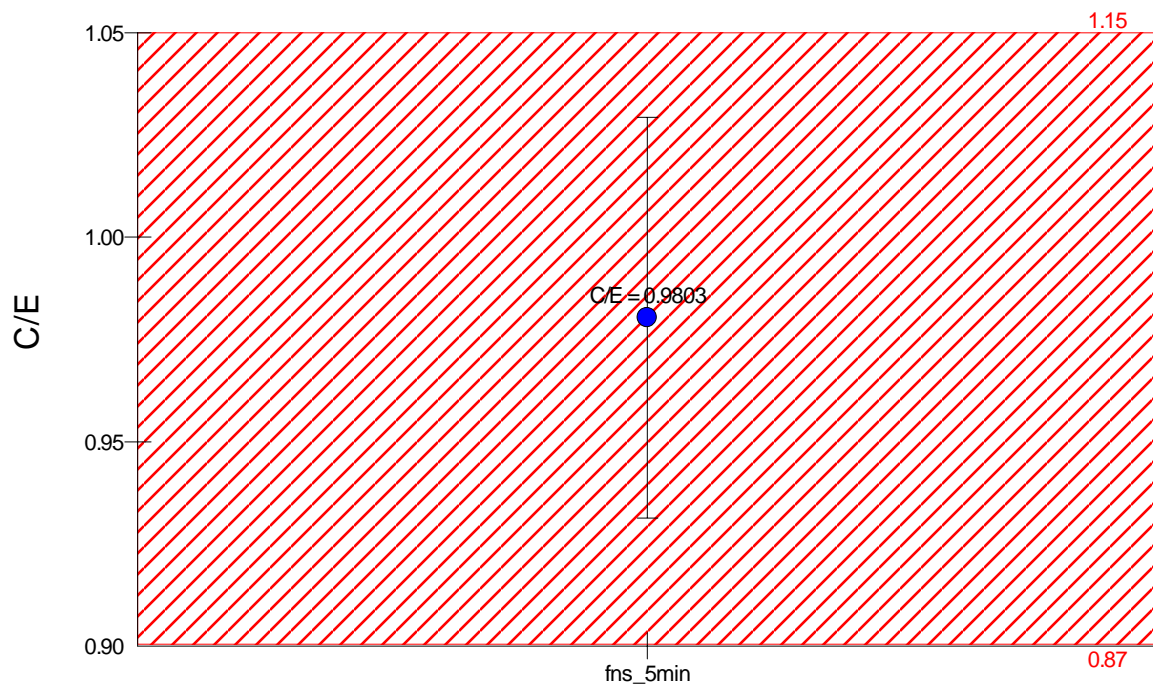
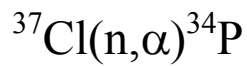


# $^{37}\text{Cl}(n,p)^{37}\text{S}$

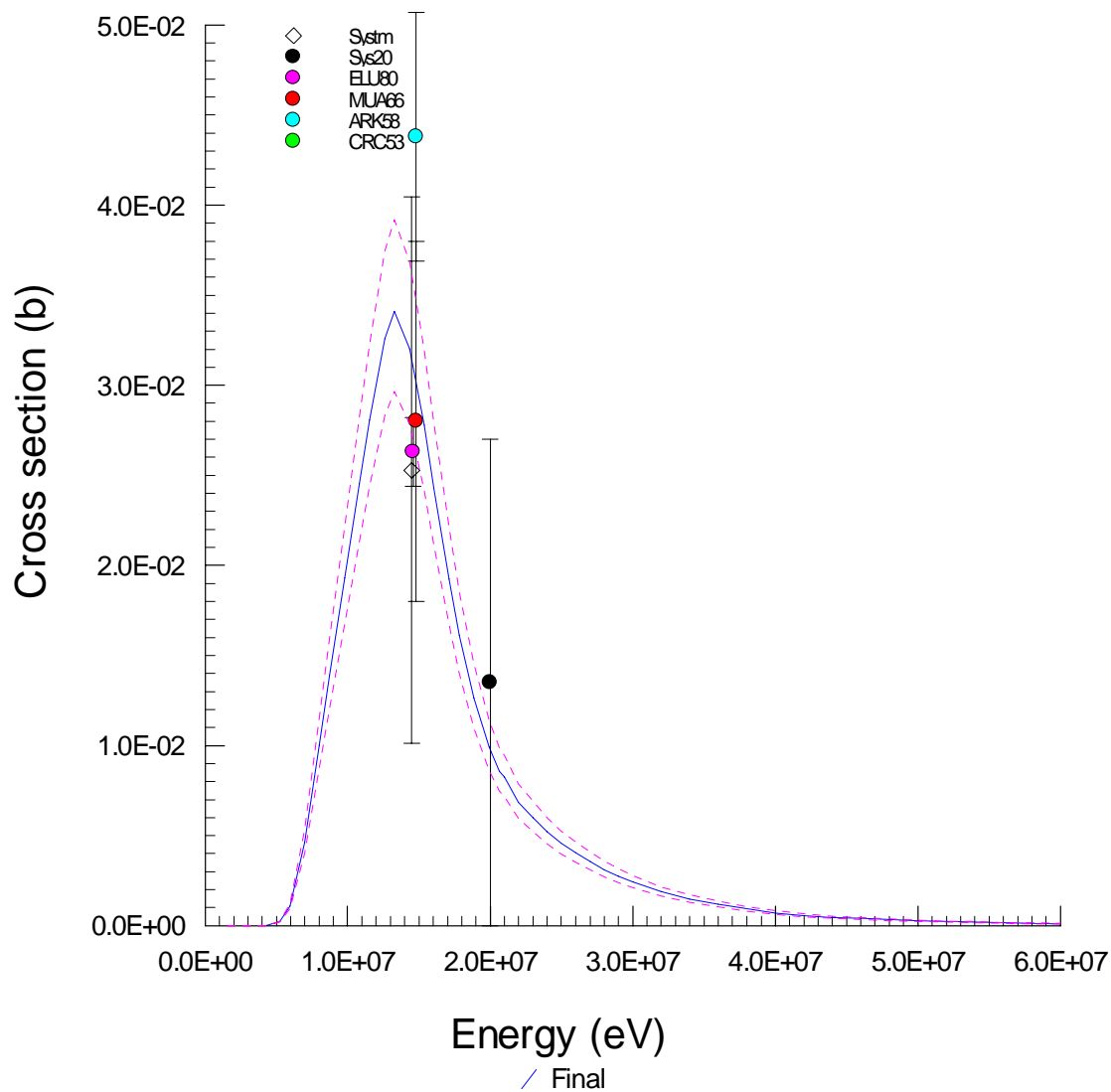


## Neutron Spectrum



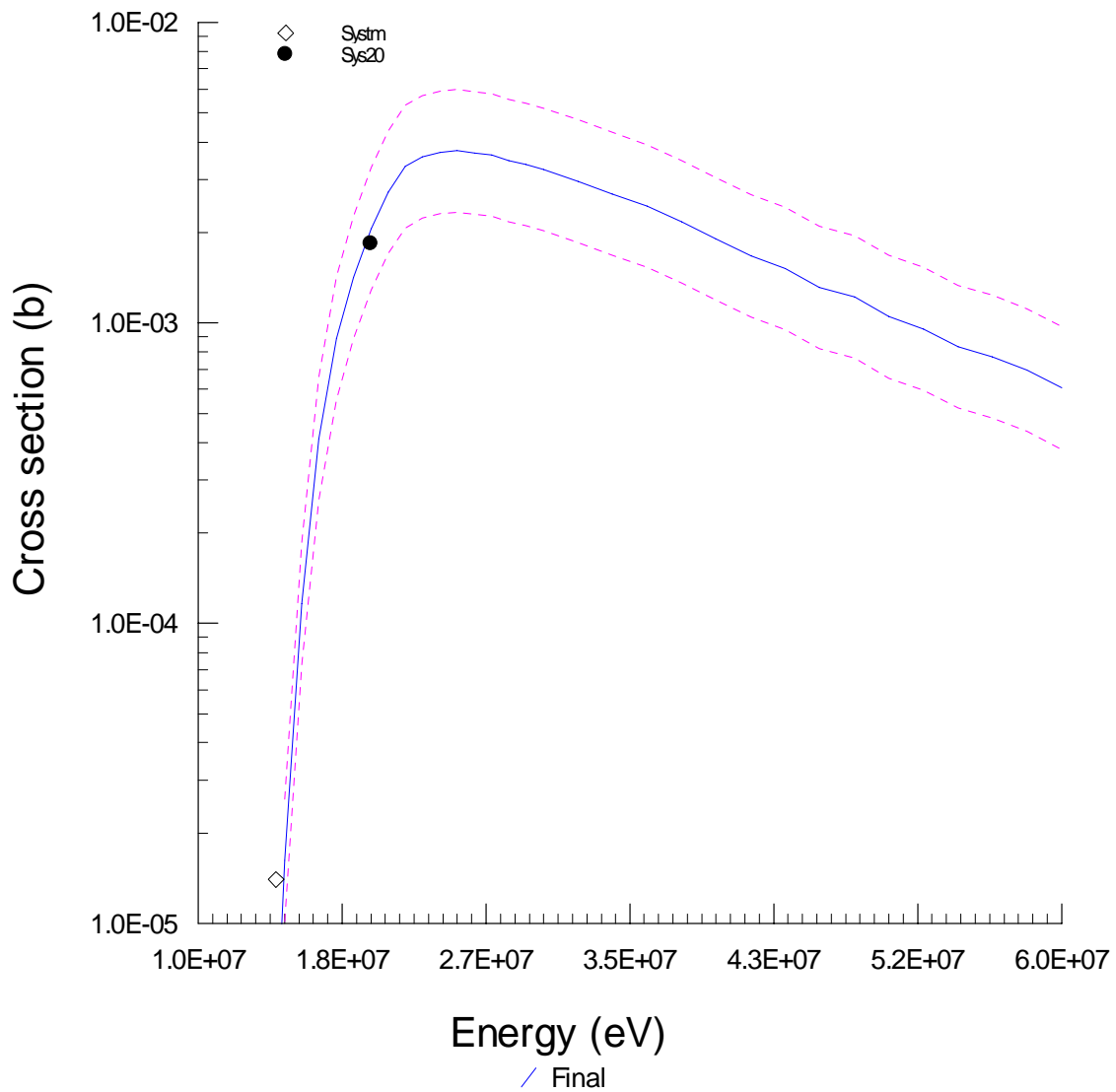
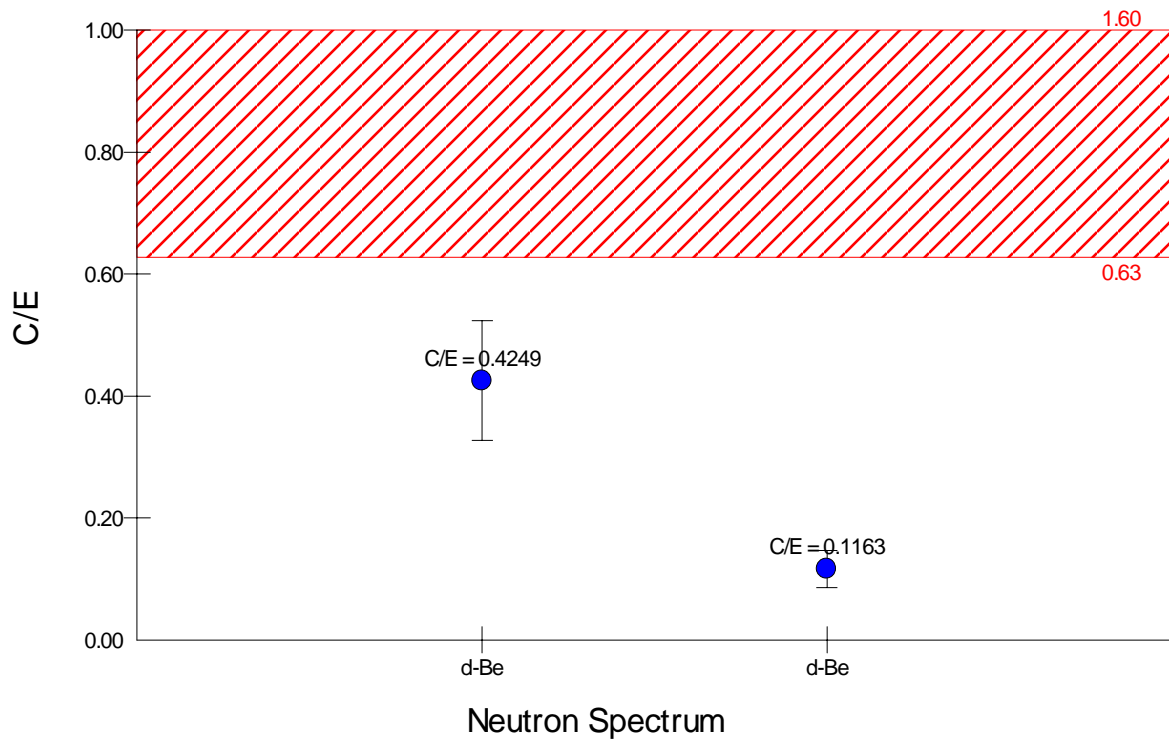


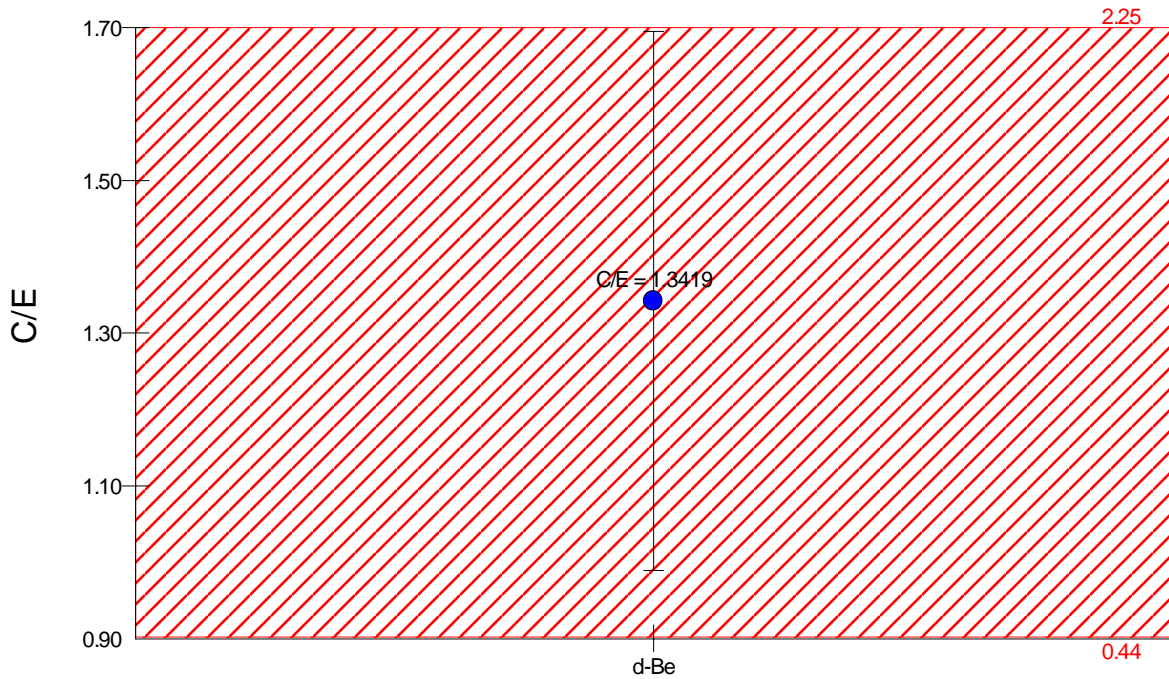
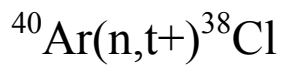
Neutron Spectrum



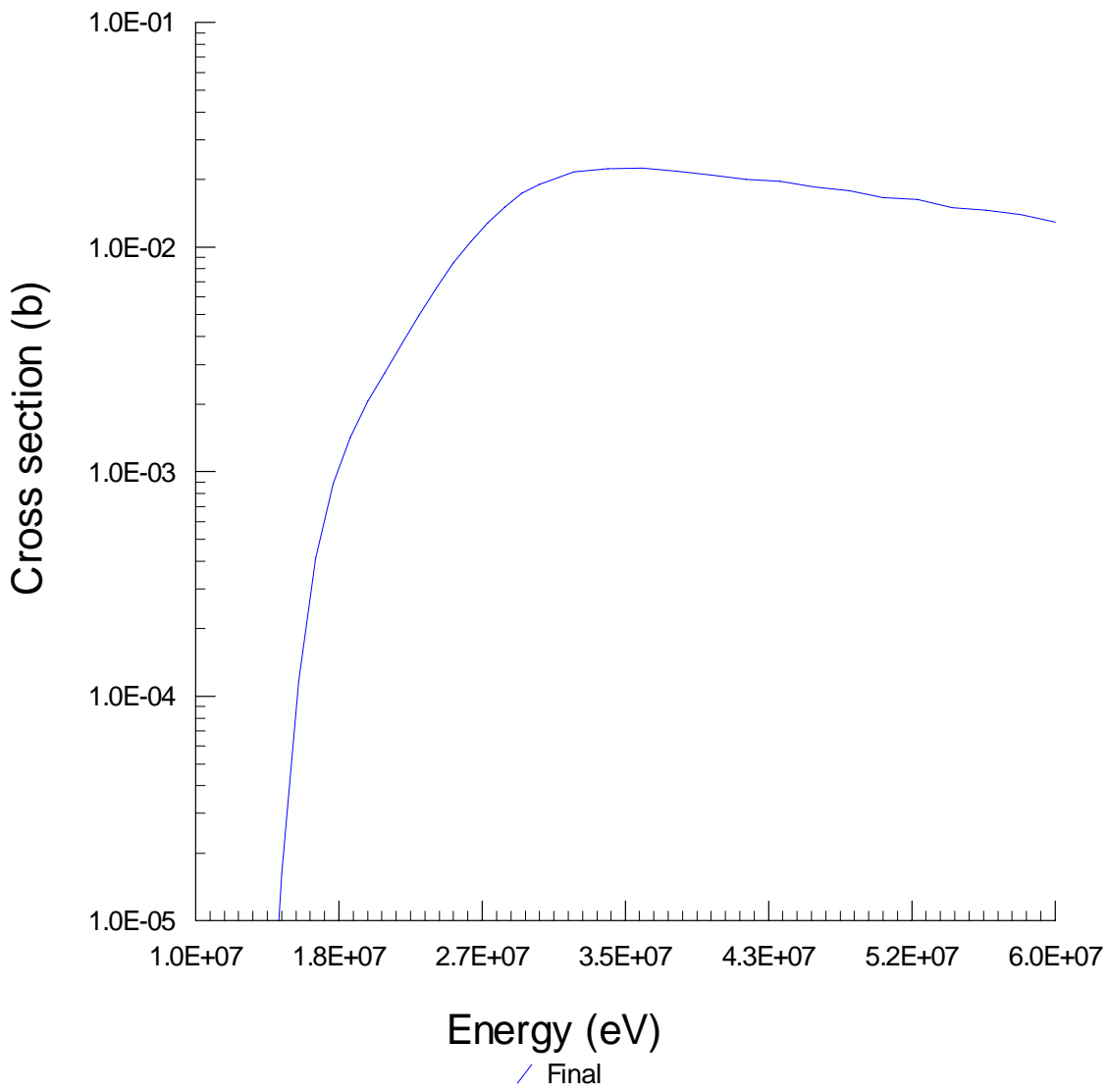


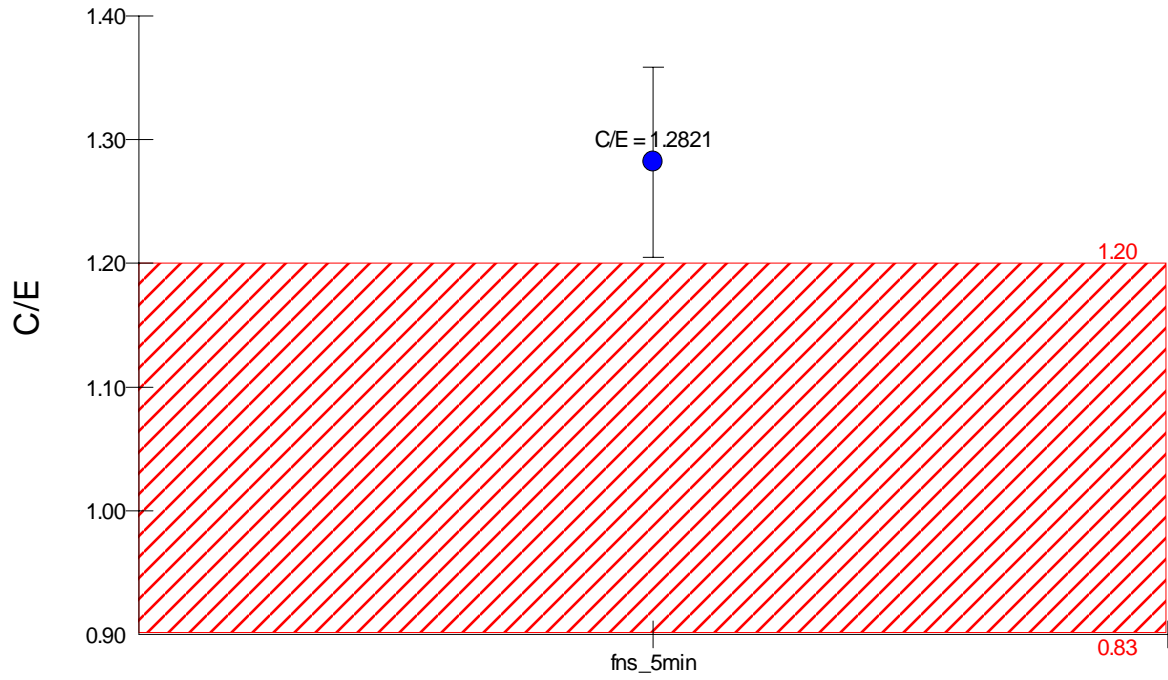
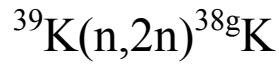
$^{40}\text{Ar}(n,t)^{38}\text{Cl}$



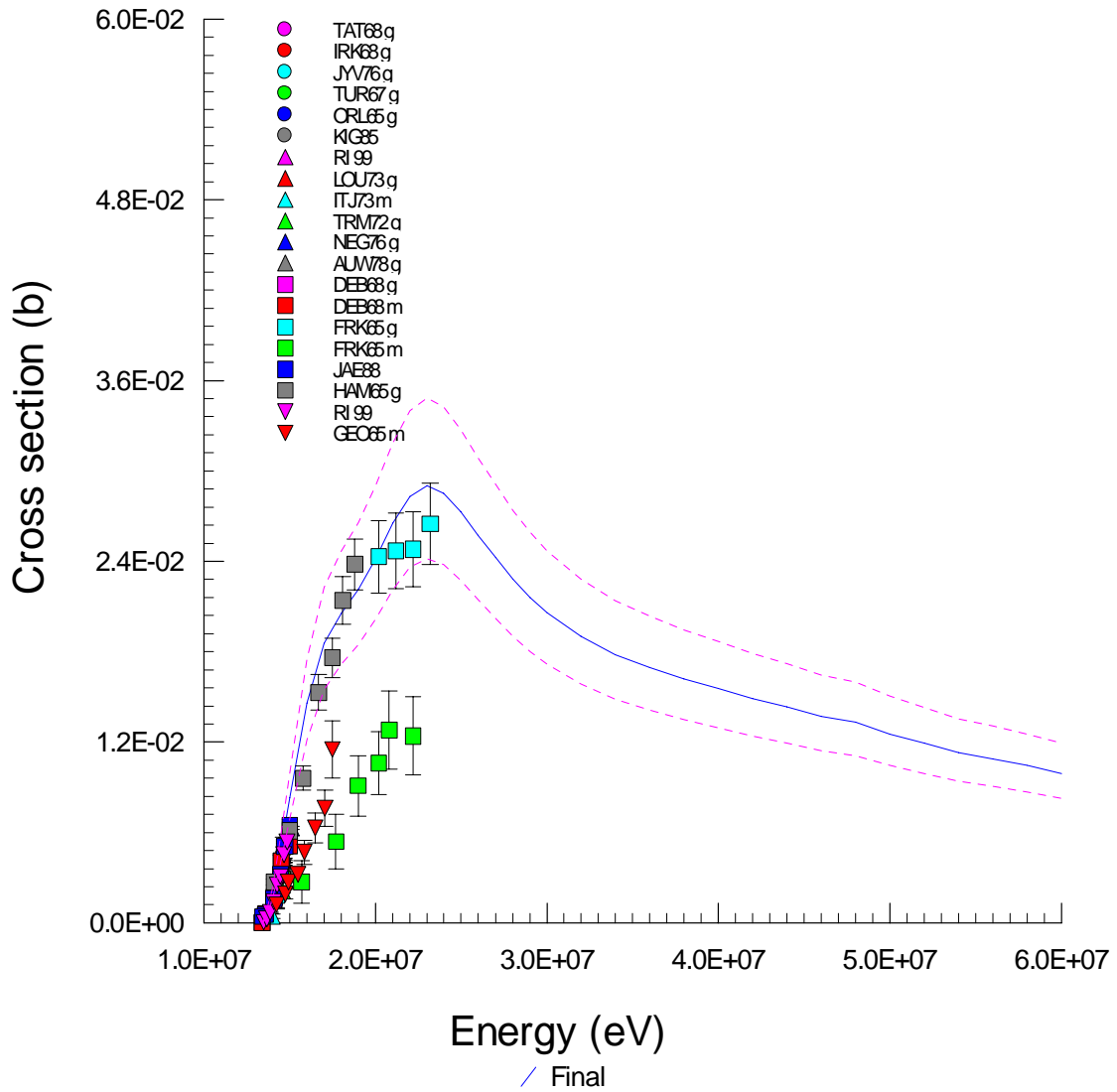


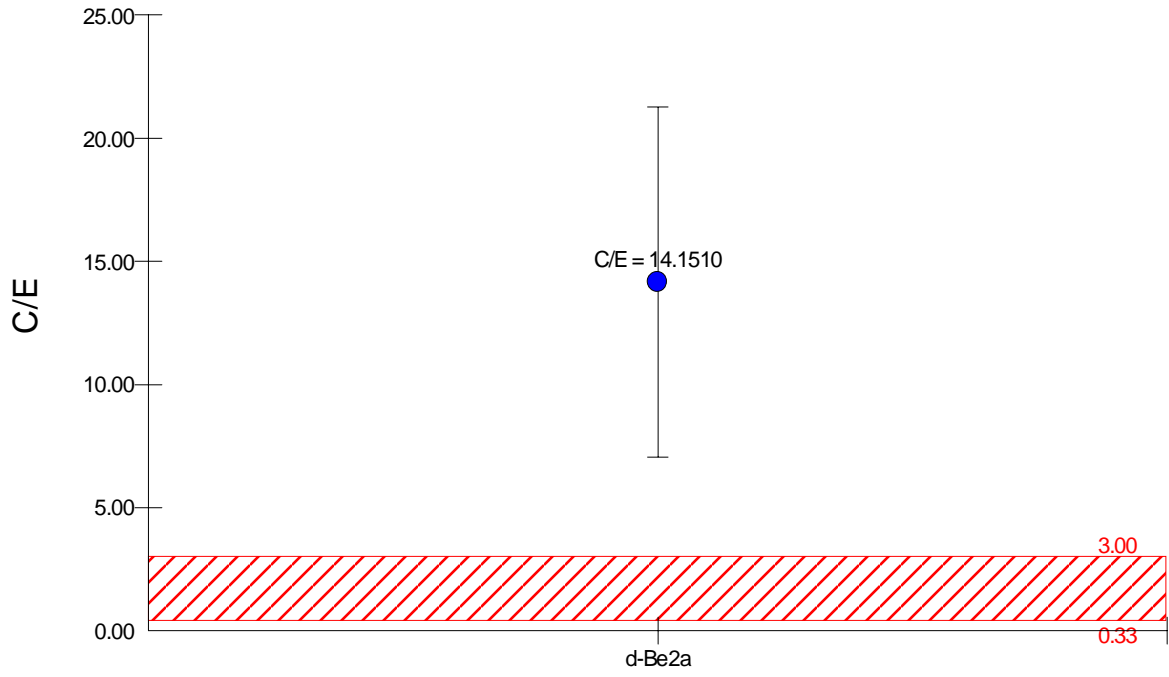
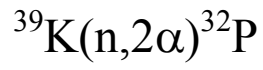
Neutron Spectrum



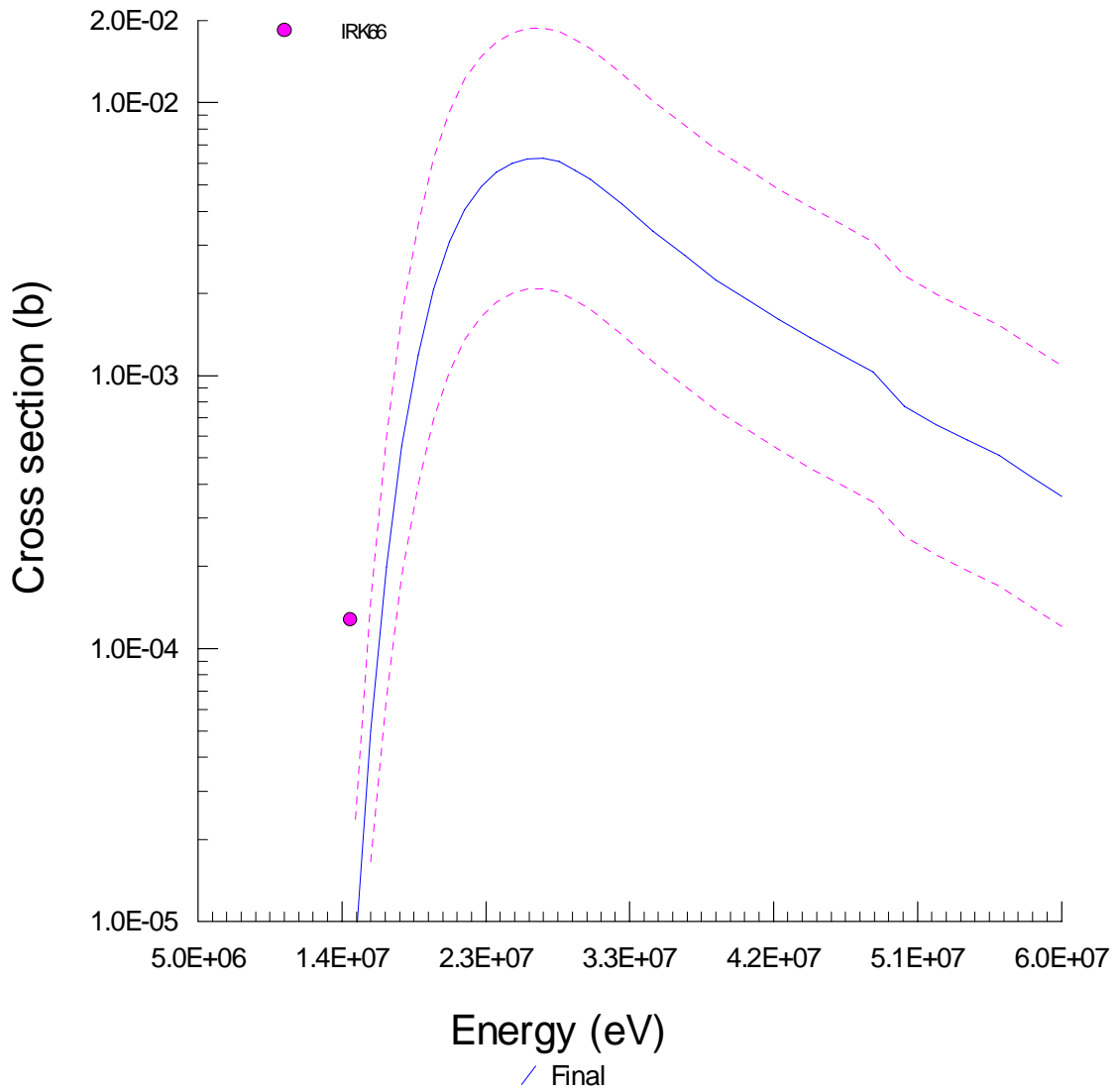


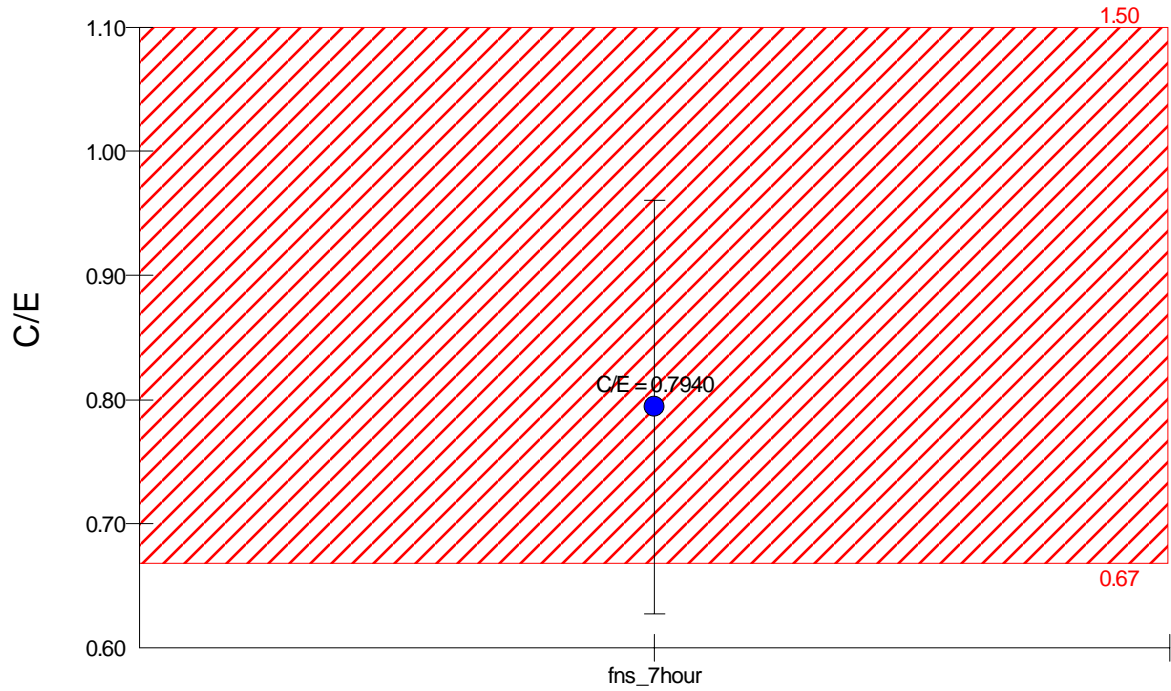
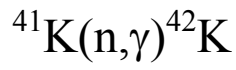
Neutron Spectrum



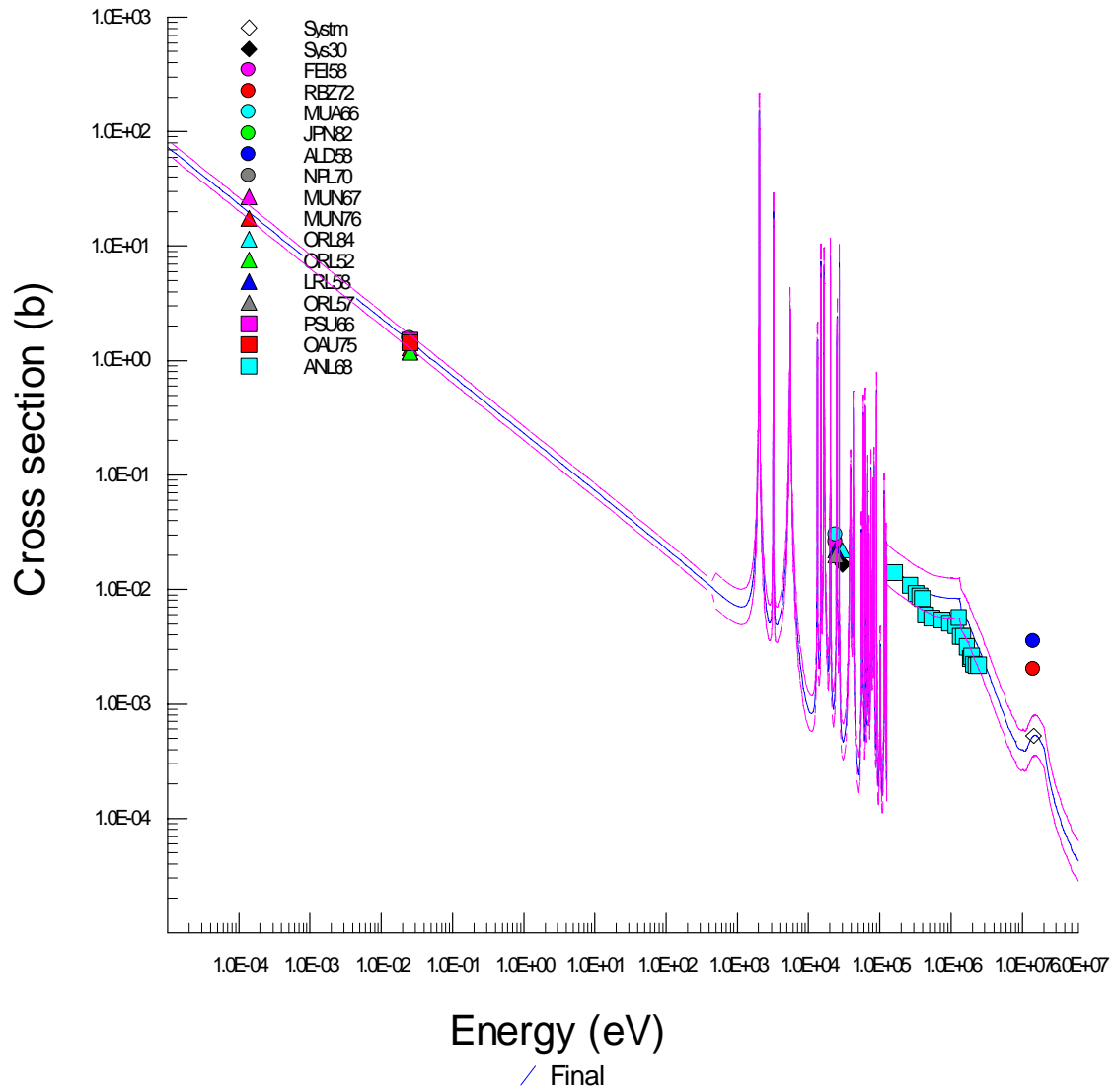


Neutron Spectrum

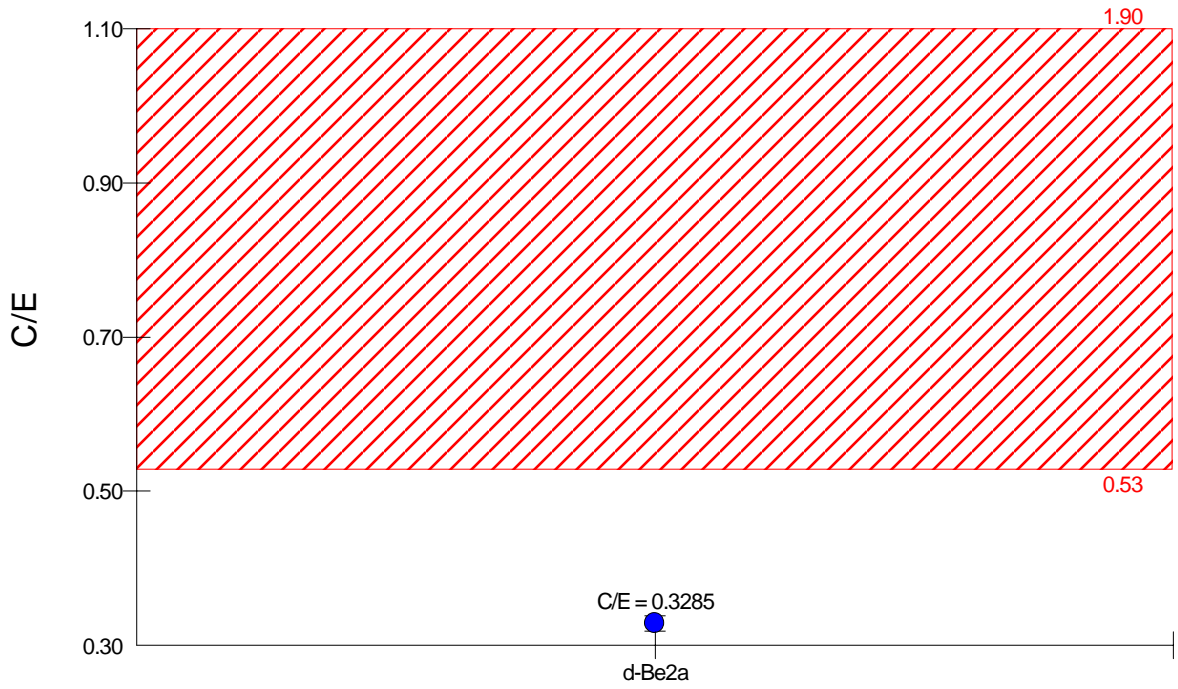




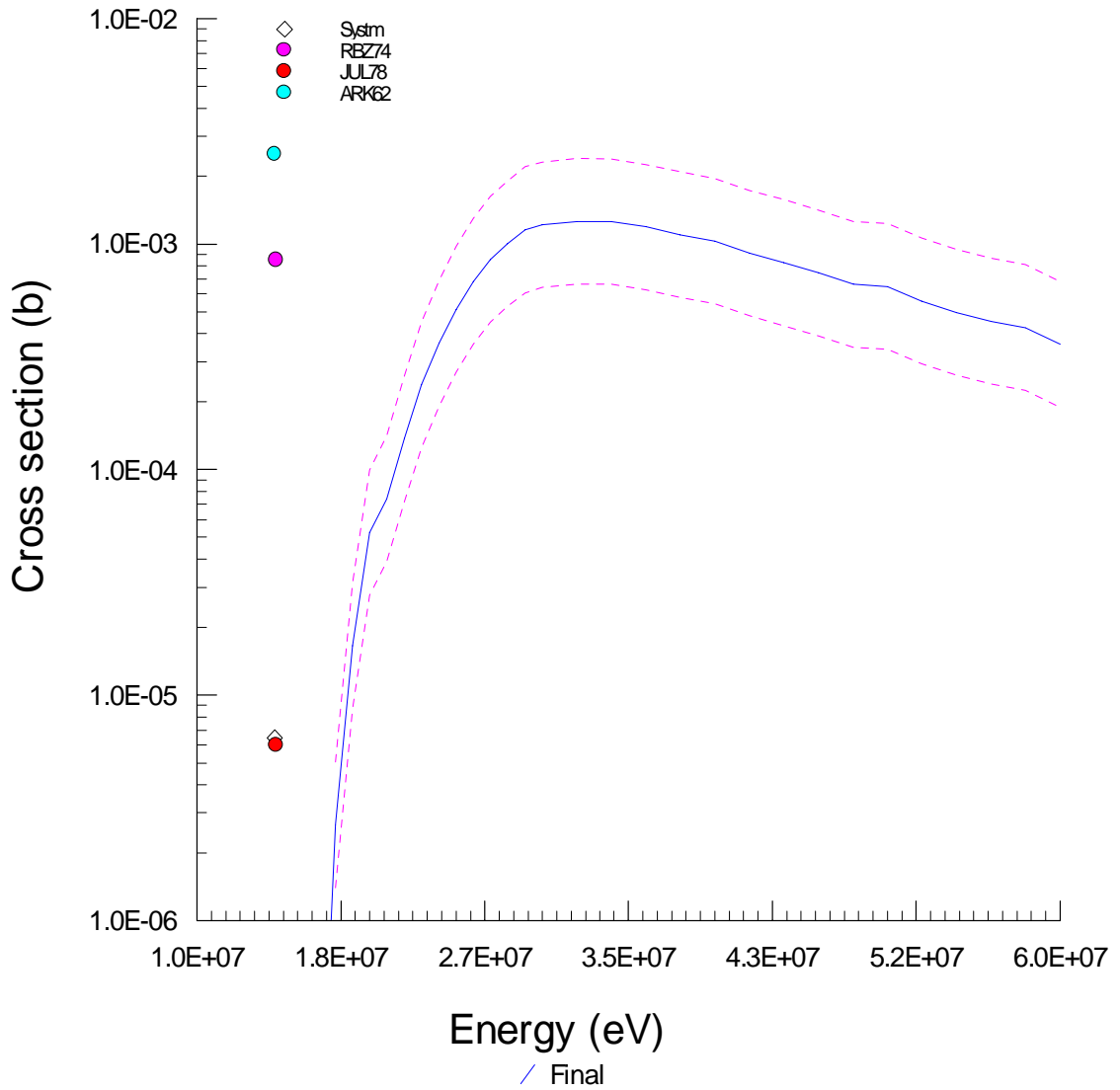
Neutron Spectrum

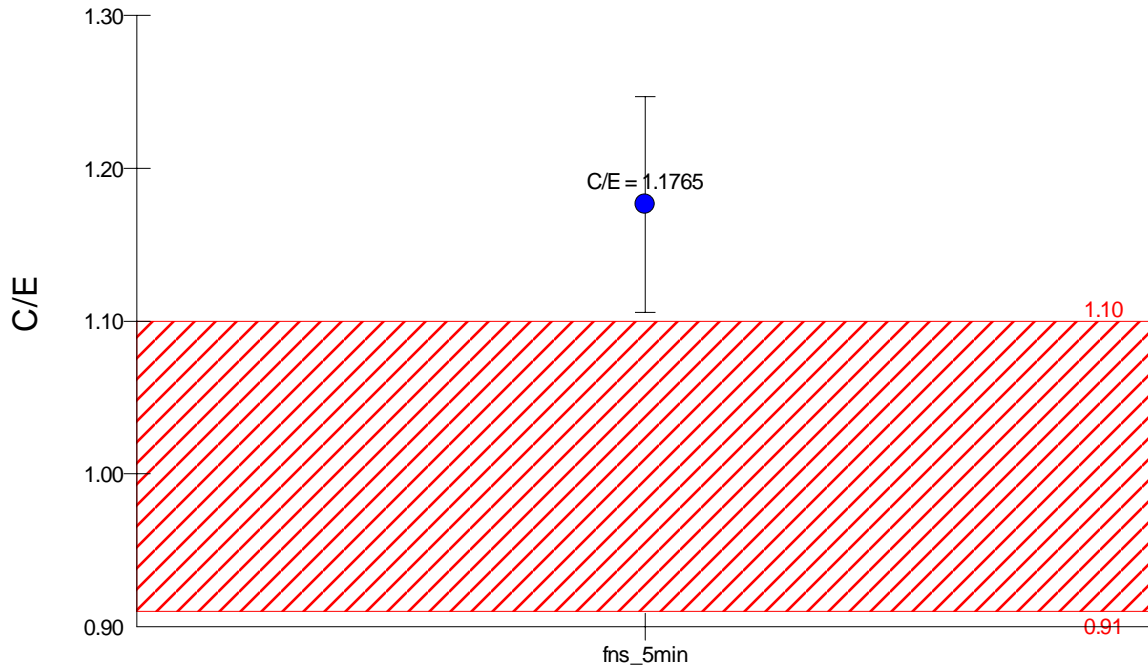
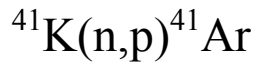


# $^{41}\text{K}(n,h)^{39}\text{Cl}$

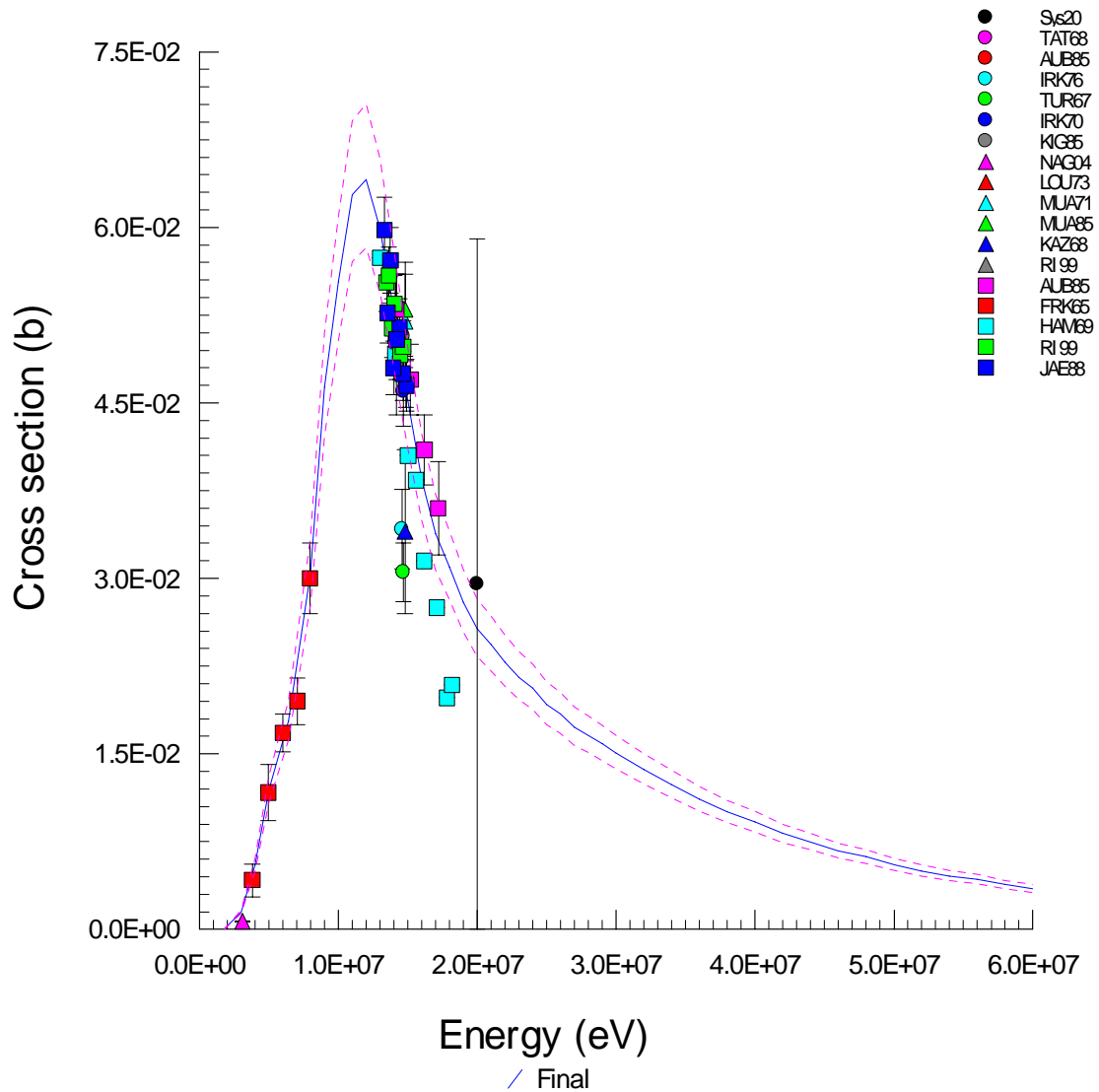


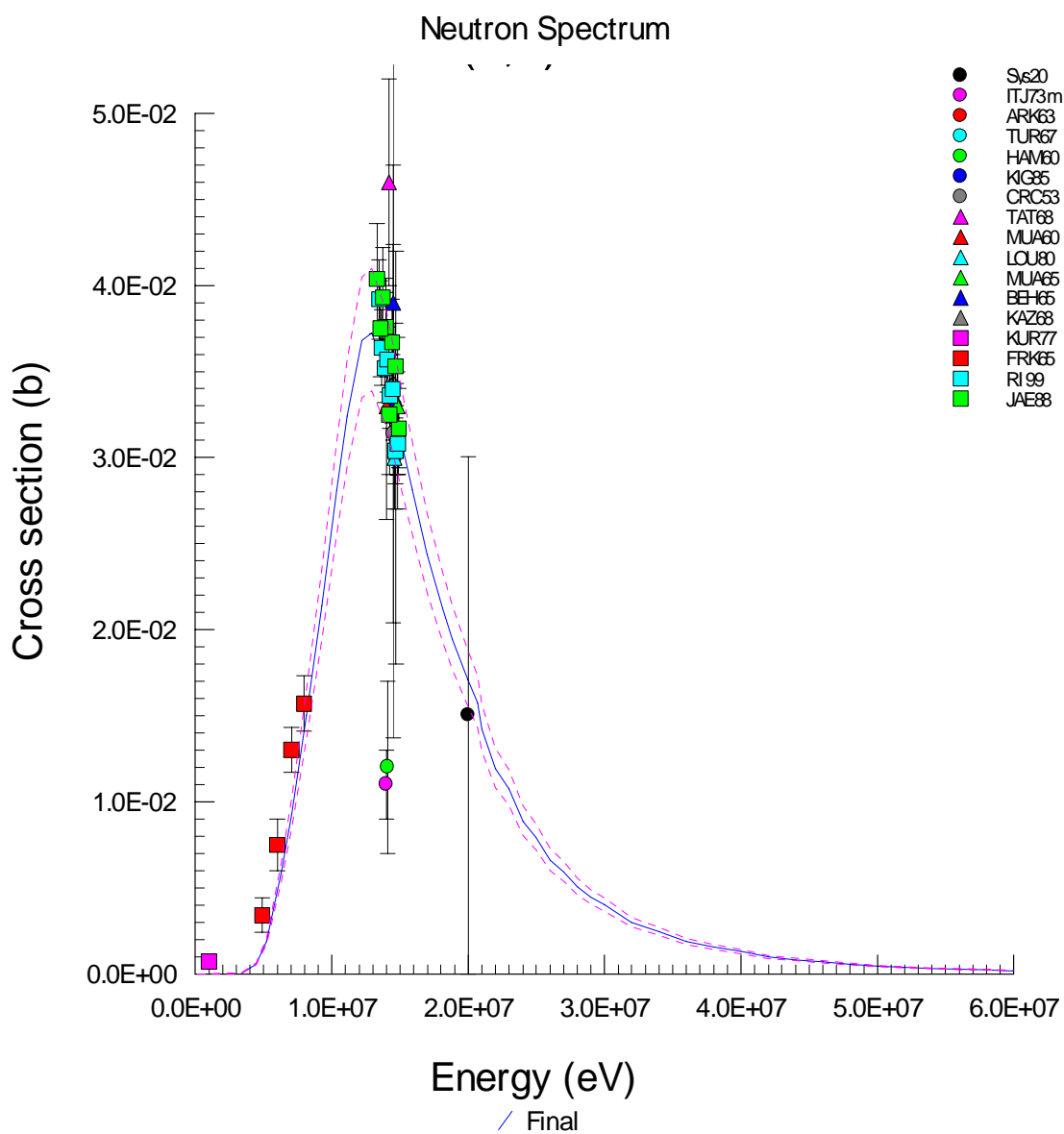
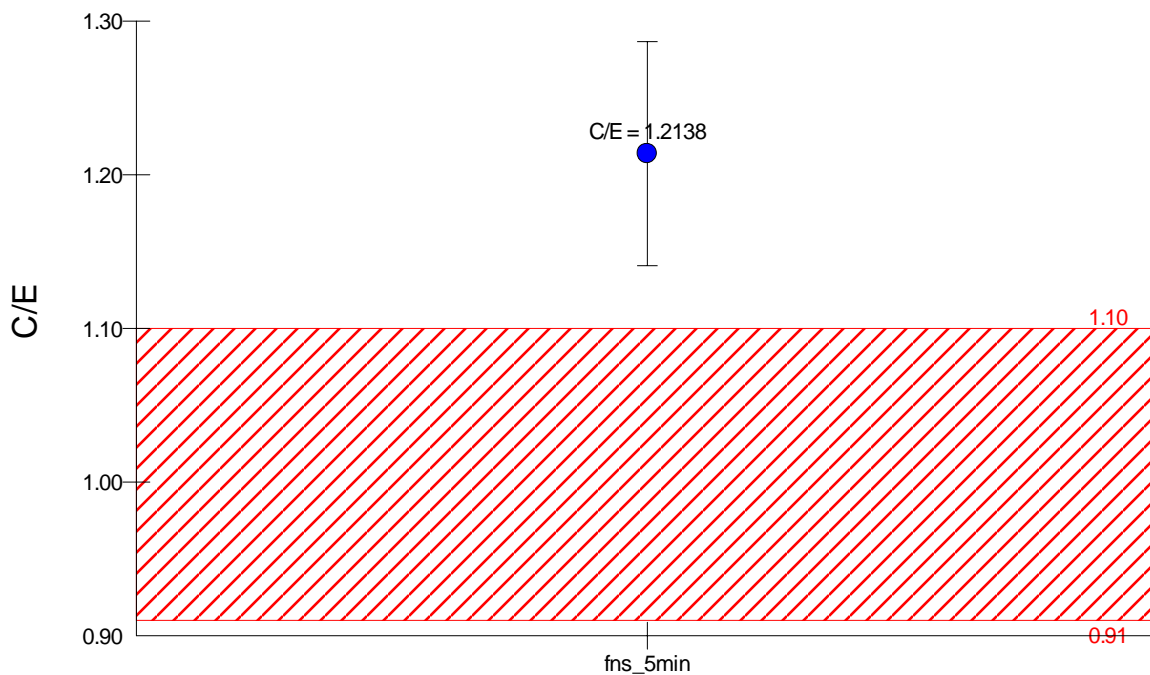
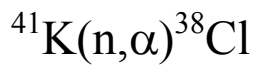
## Neutron Spectrum



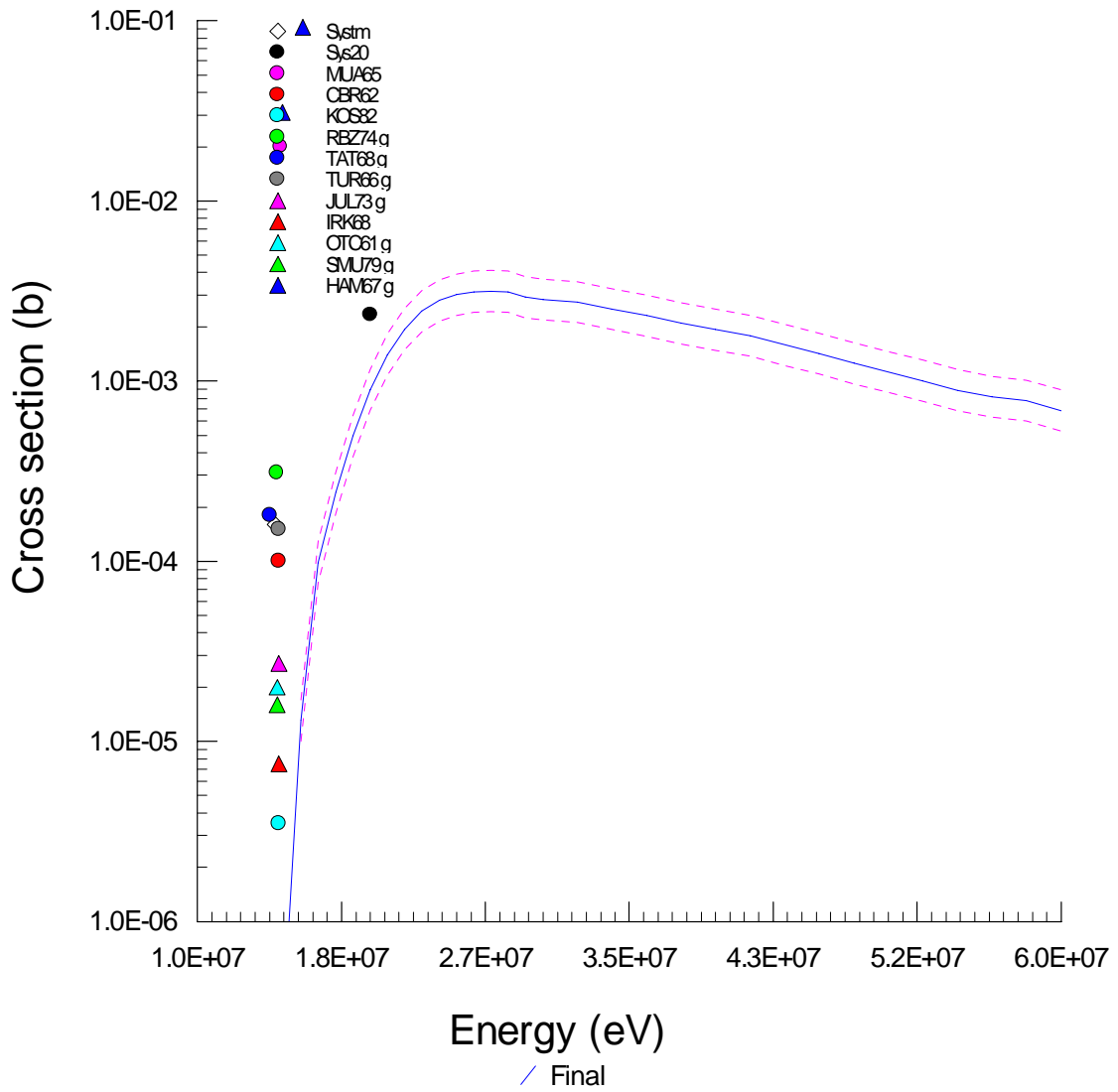
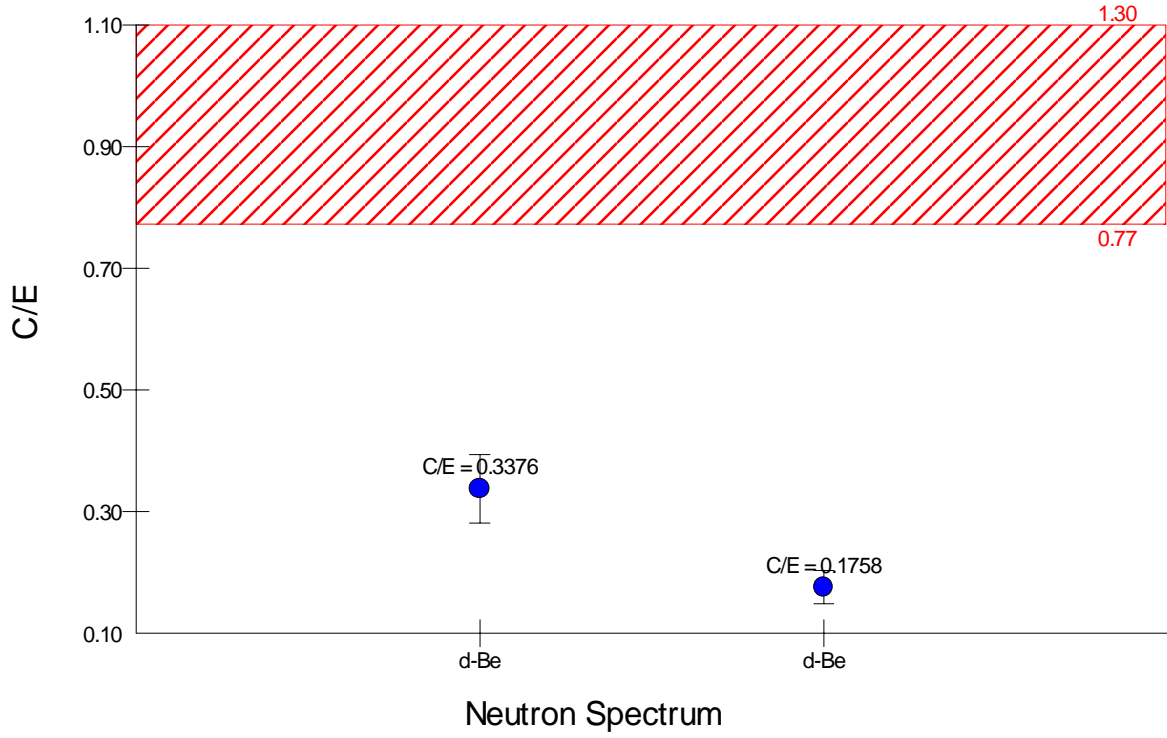
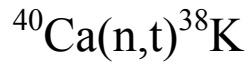


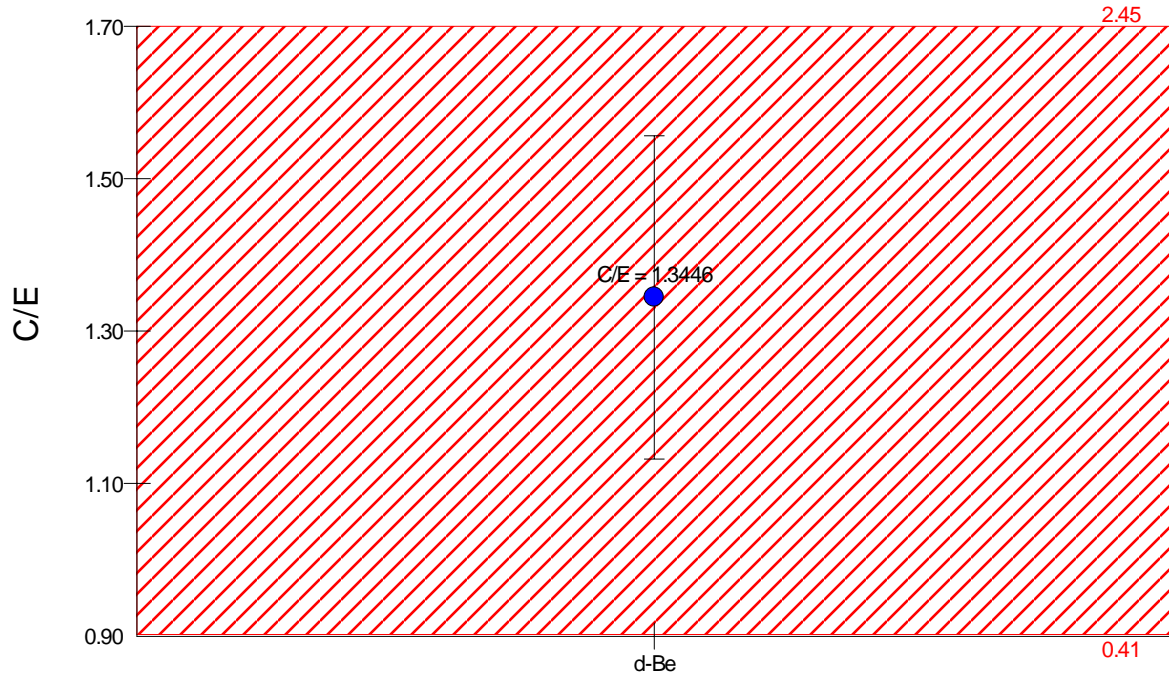
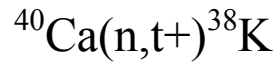
Neutron Spectrum



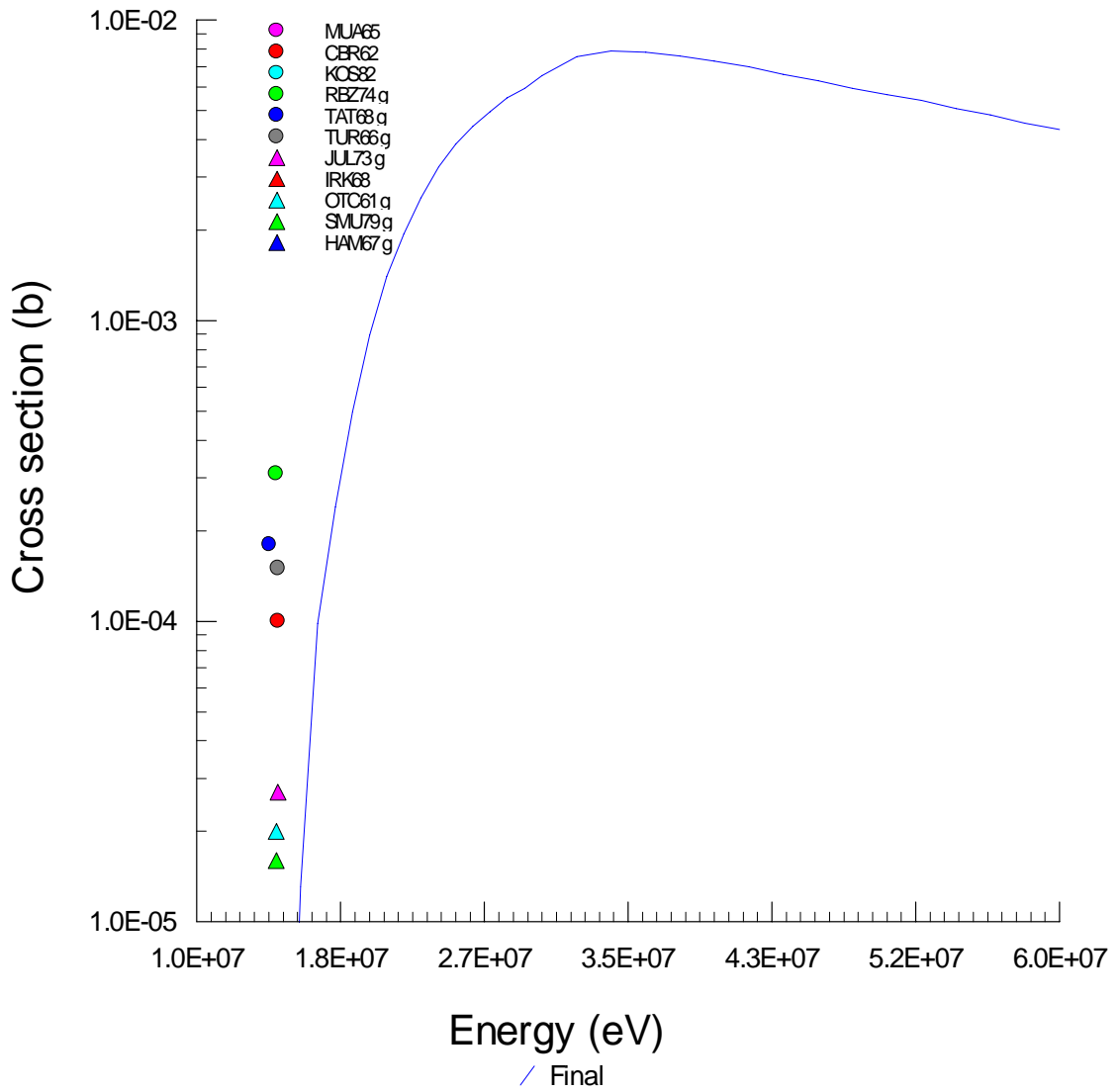


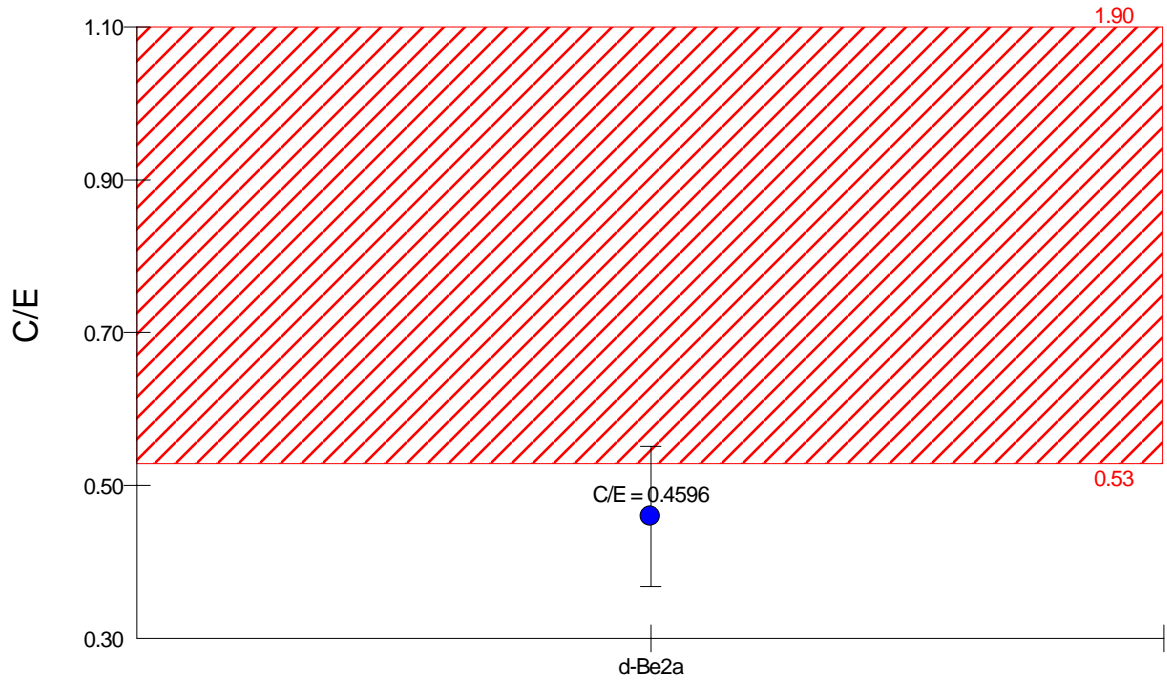
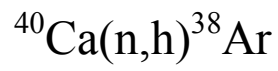




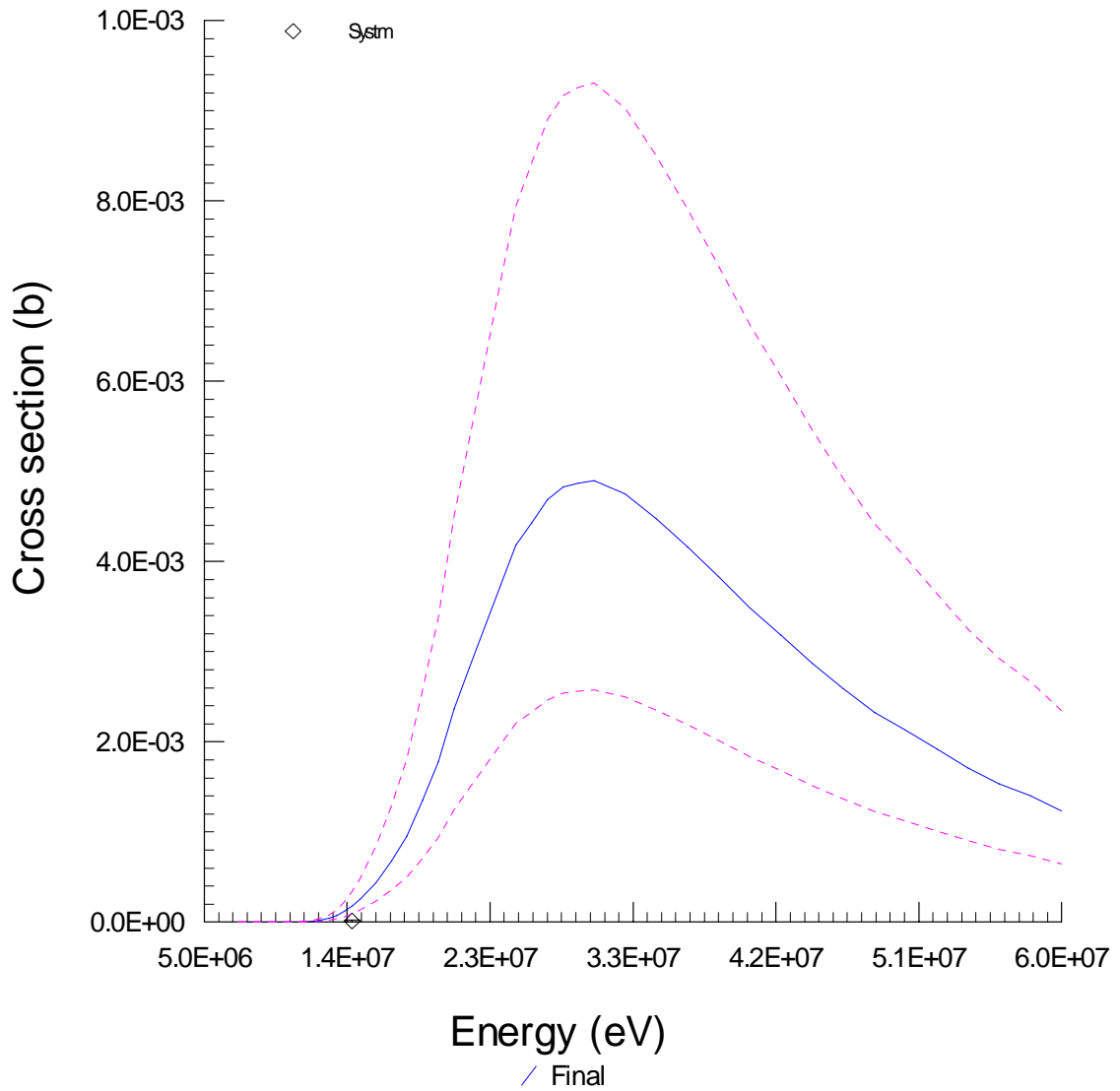


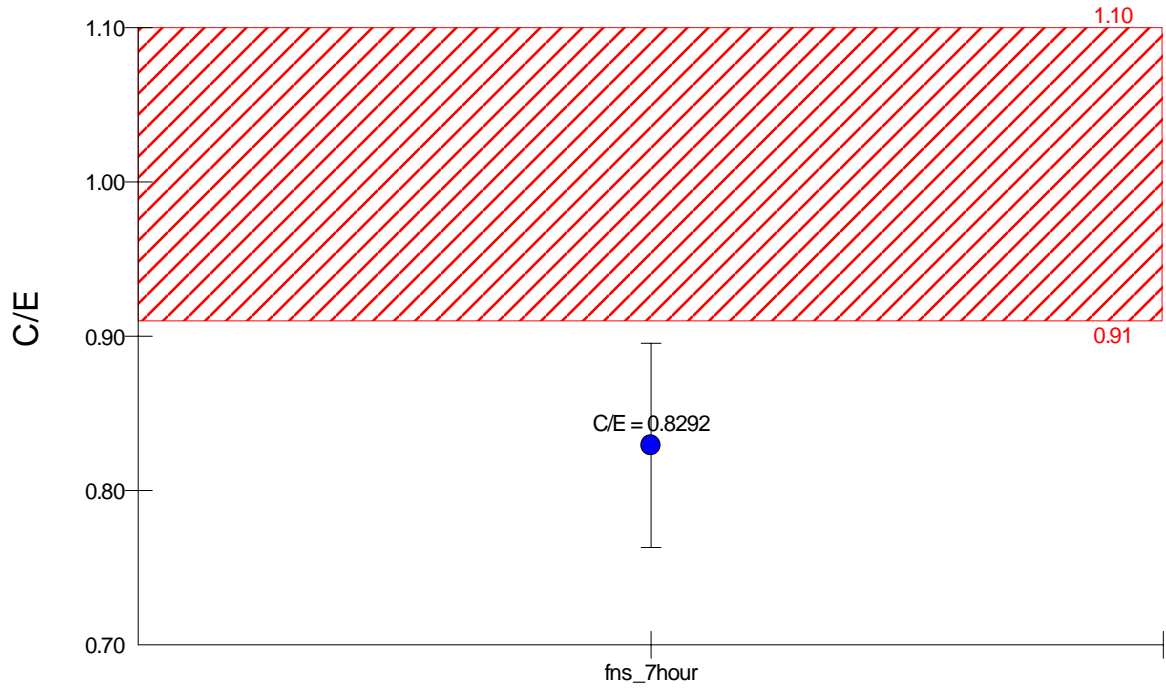
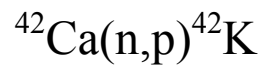
Neutron Spectrum



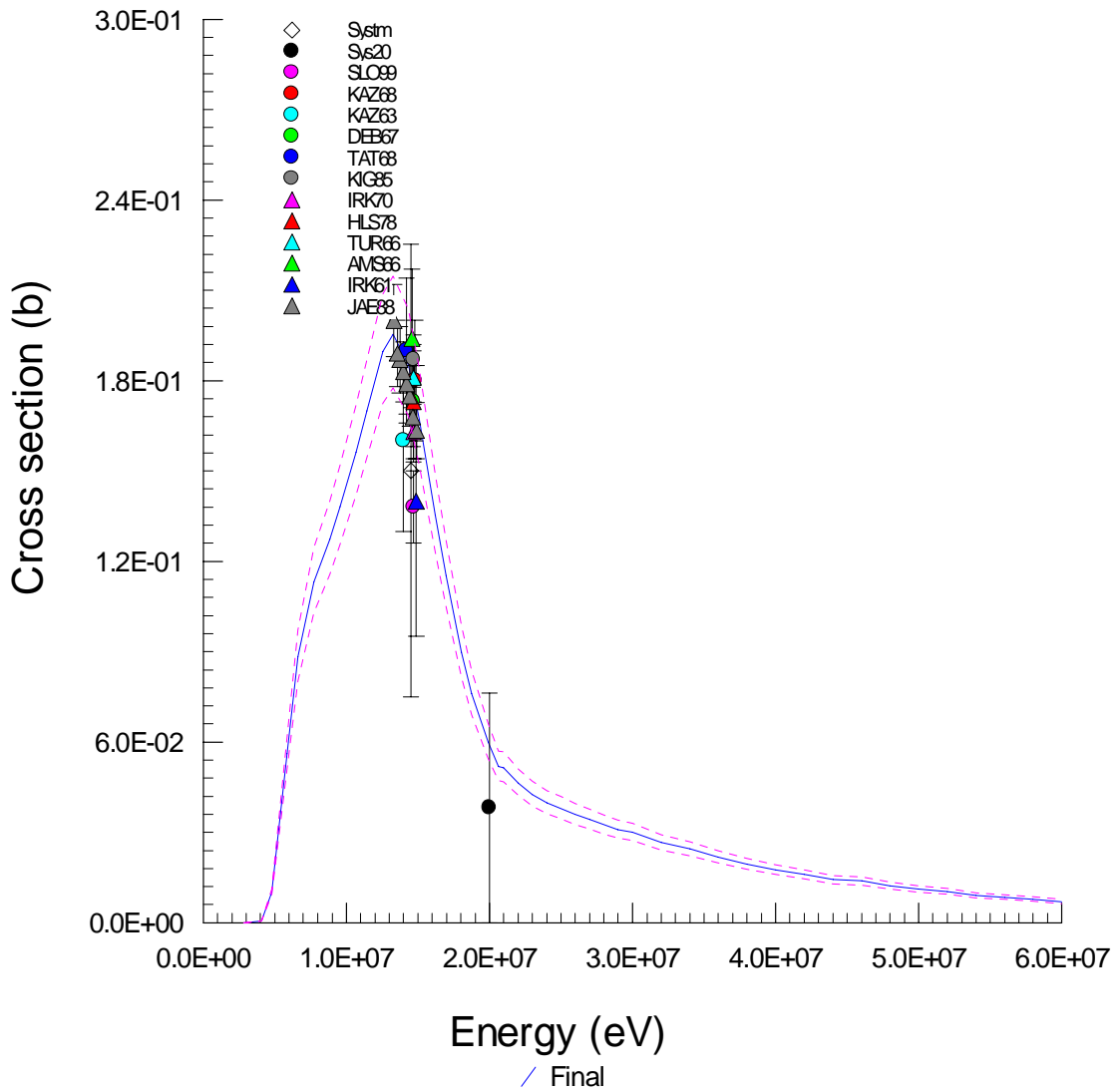


Neutron Spectrum

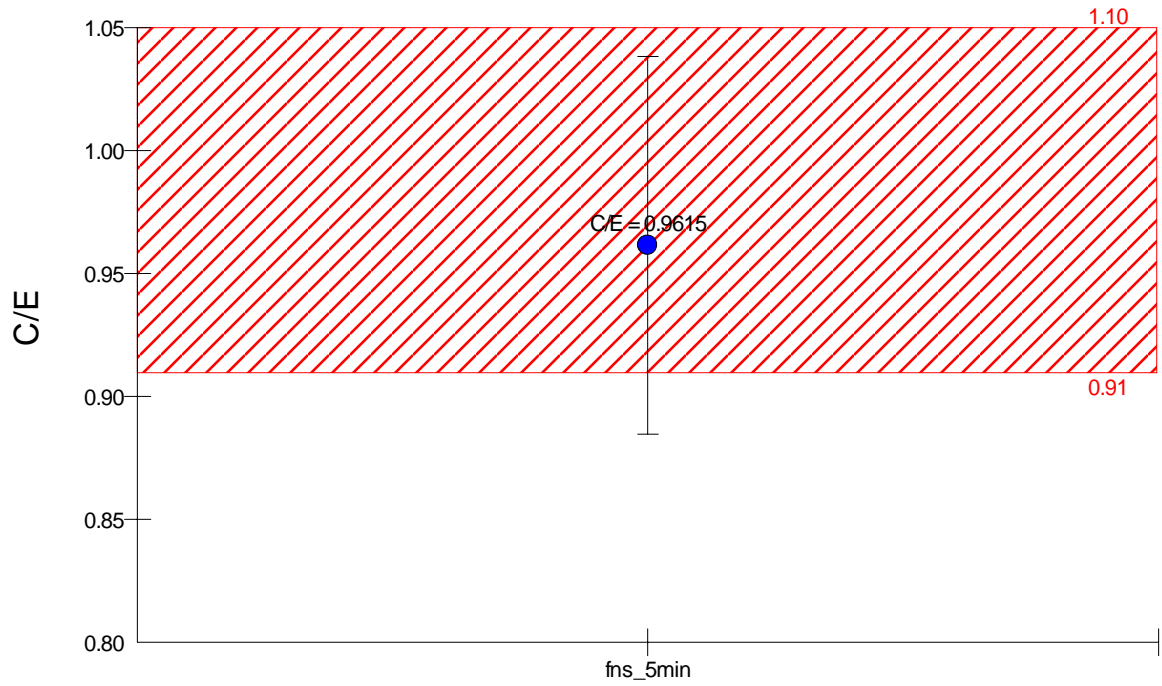




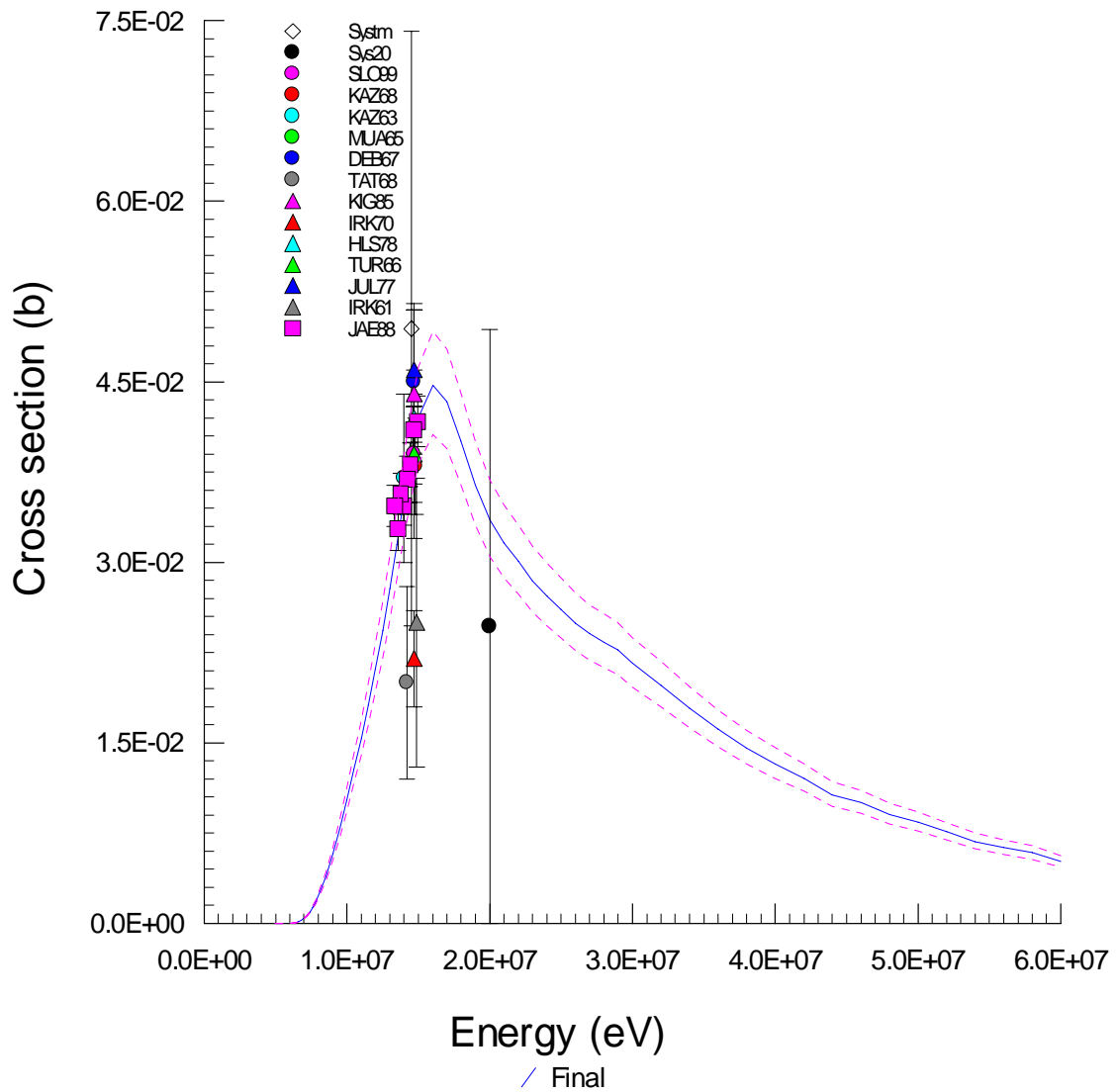
Neutron Spectrum

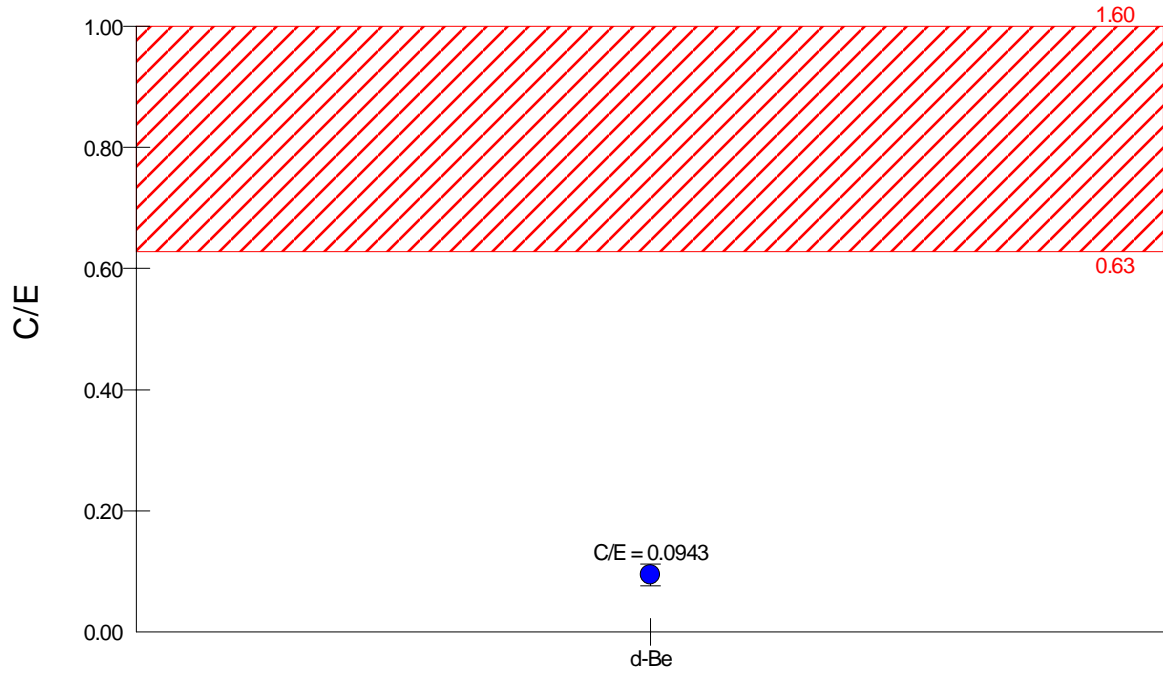
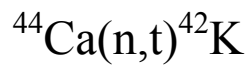


# $^{44}\text{Ca}(n,p)^{44}\text{K}$

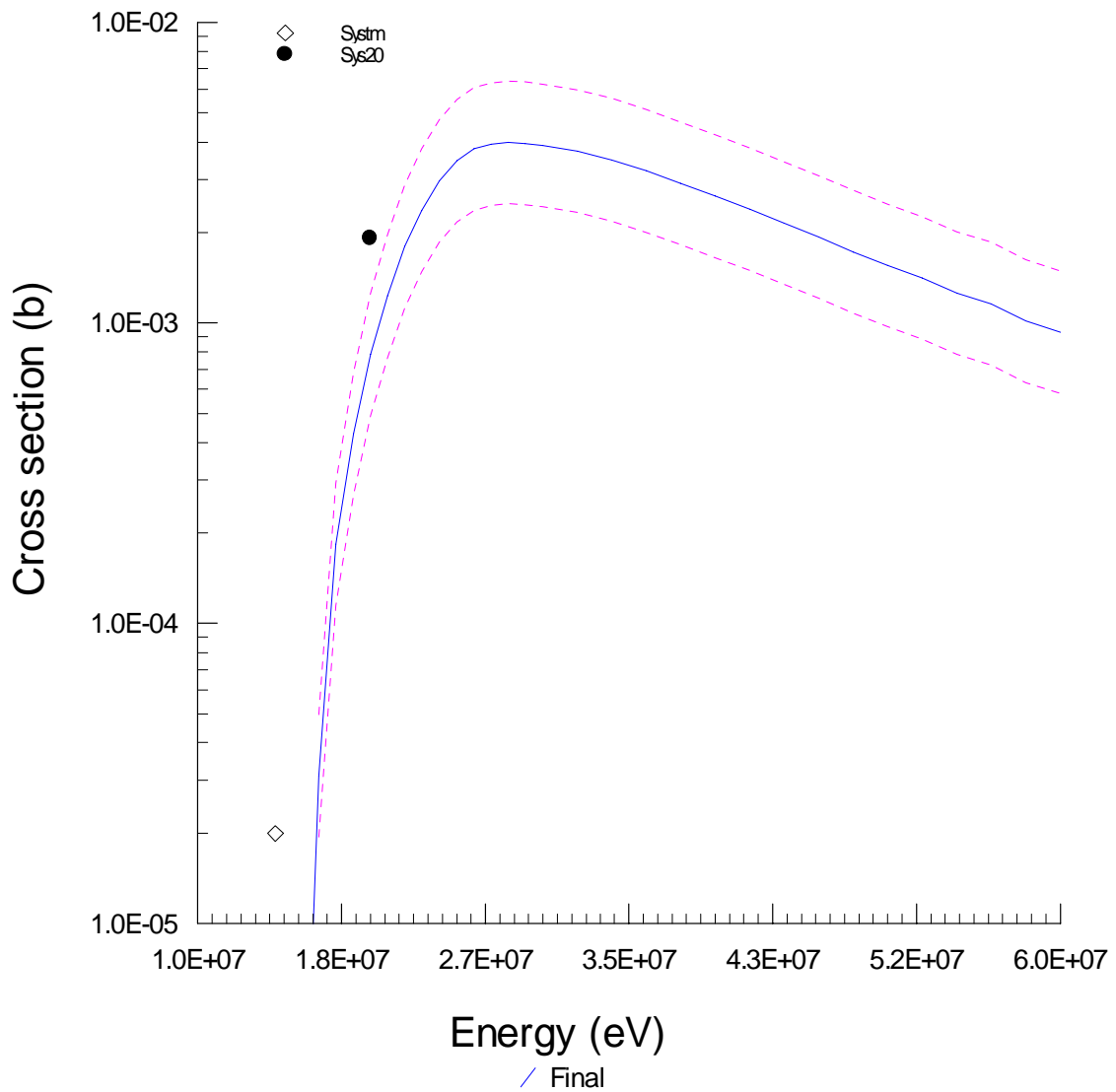


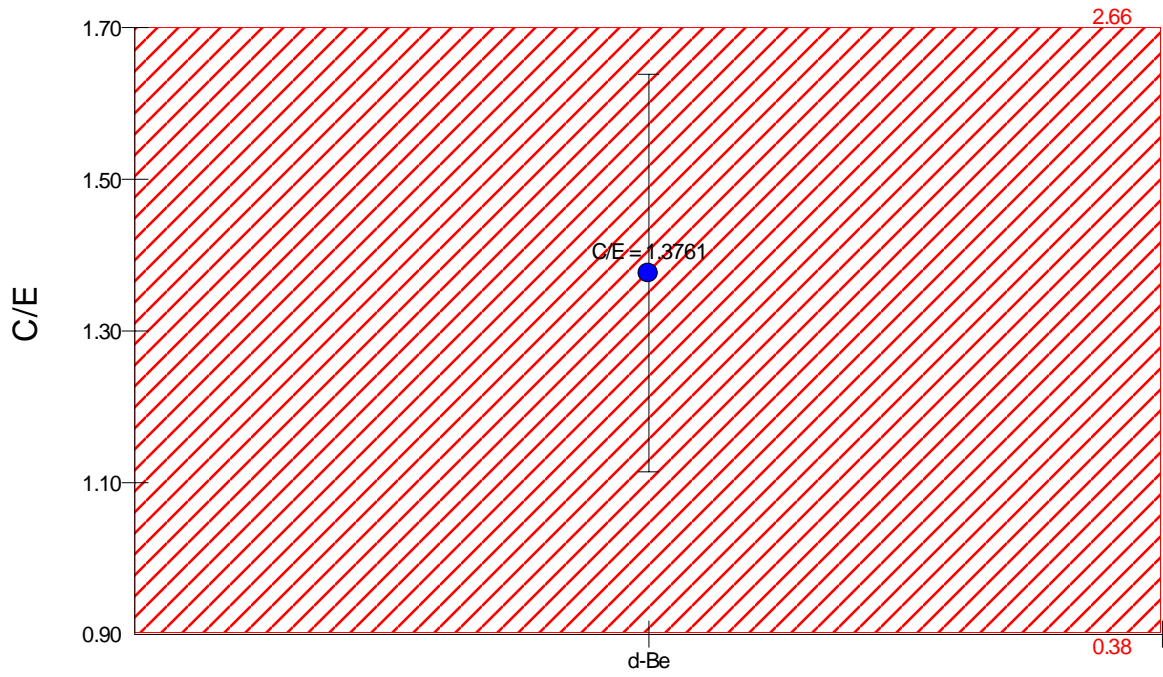
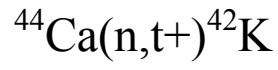
## Neutron Spectrum



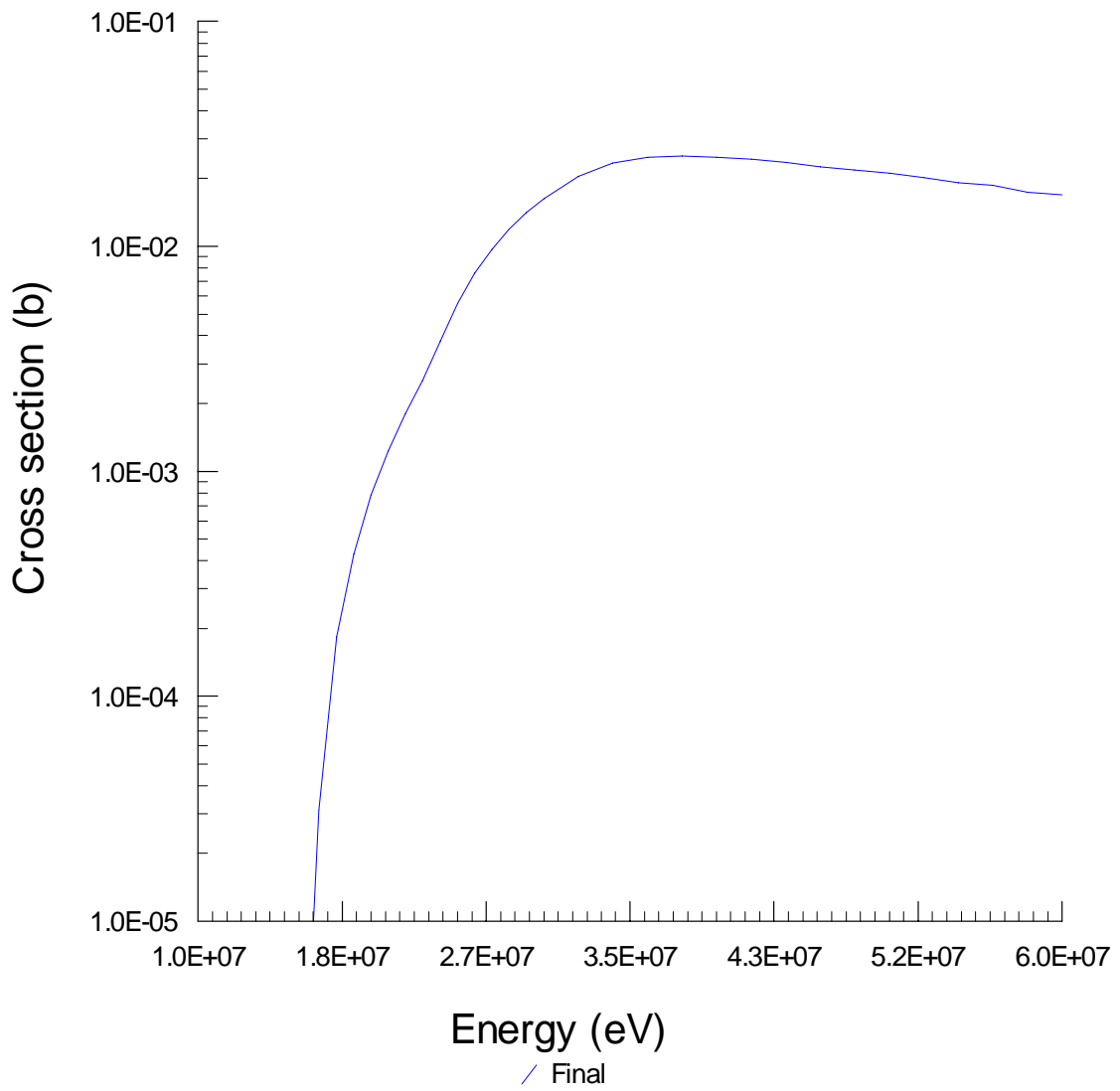


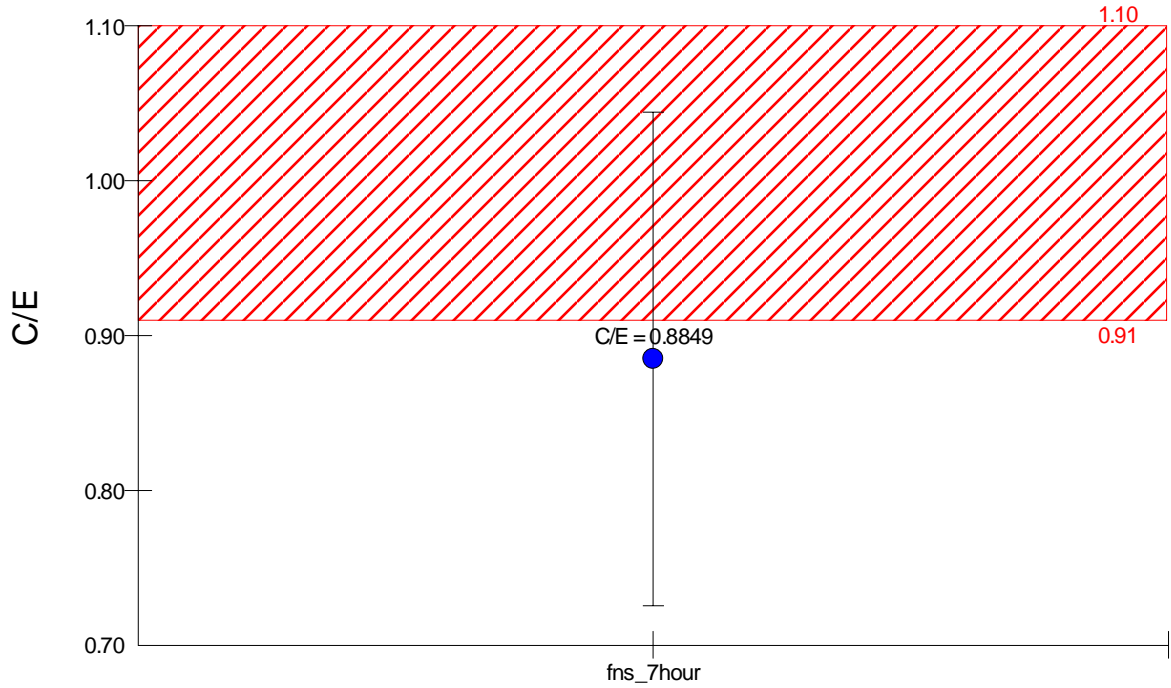
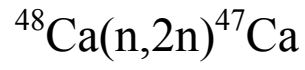
Neutron Spectrum



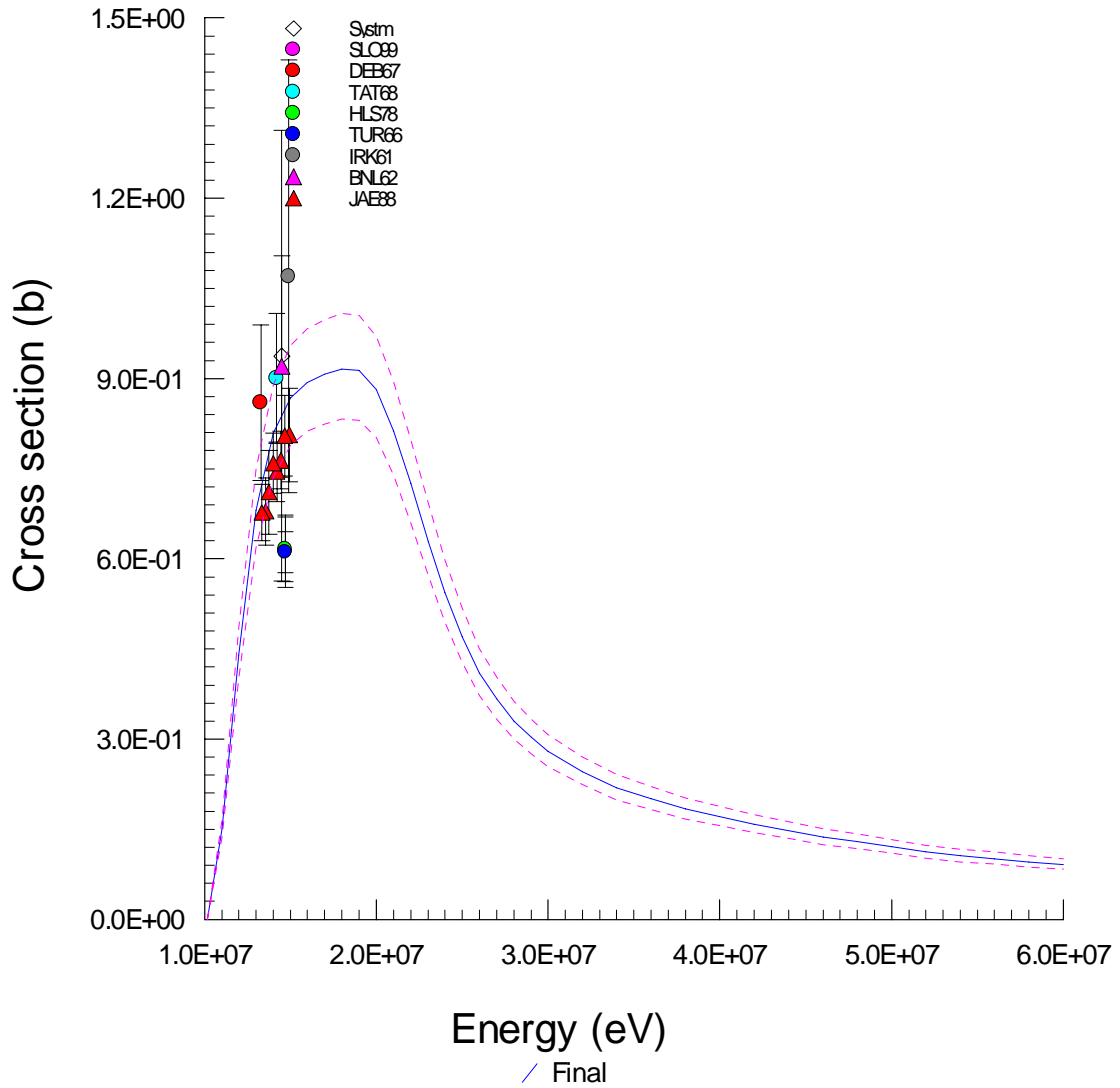


Neutron Spectrum

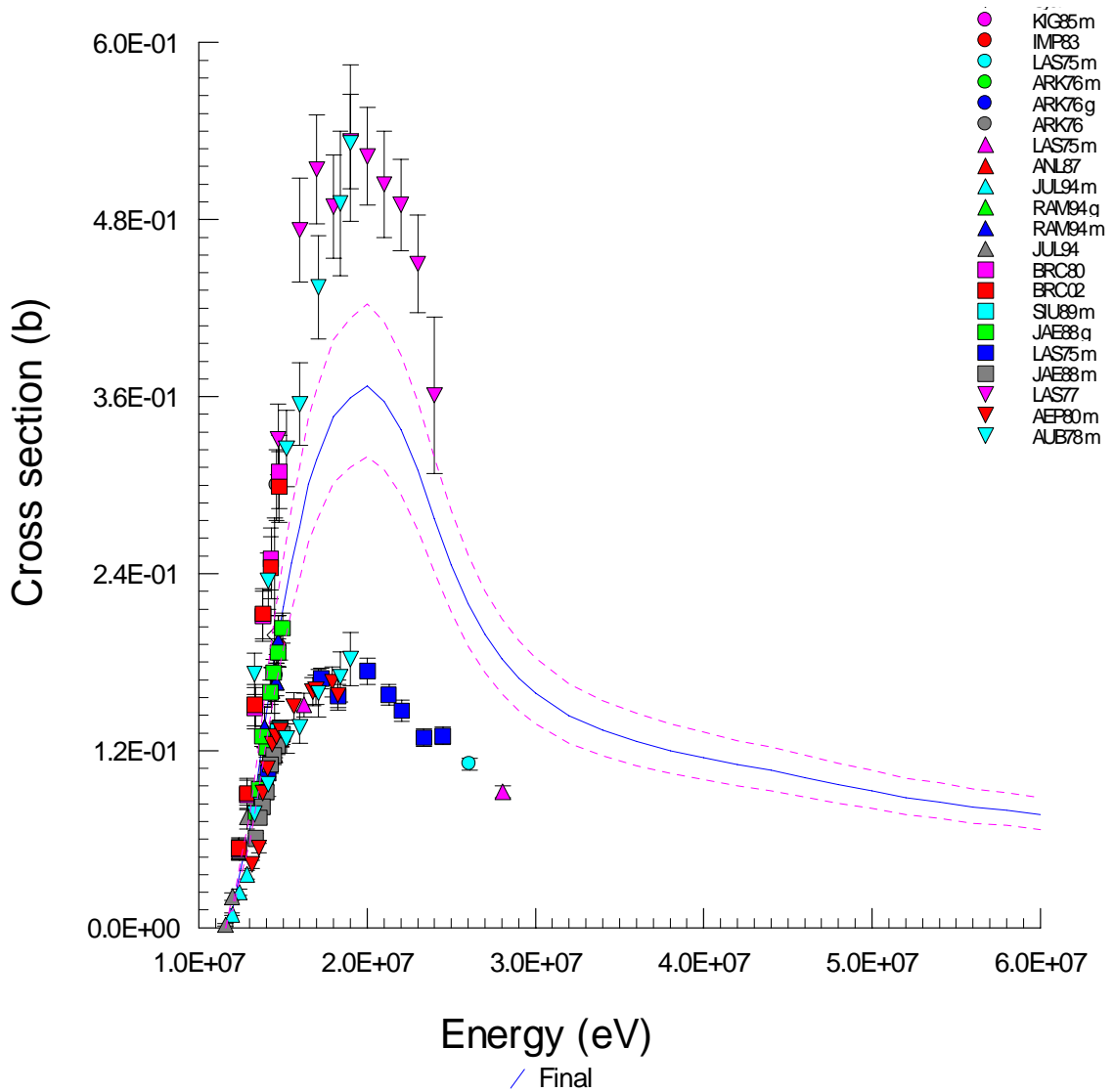
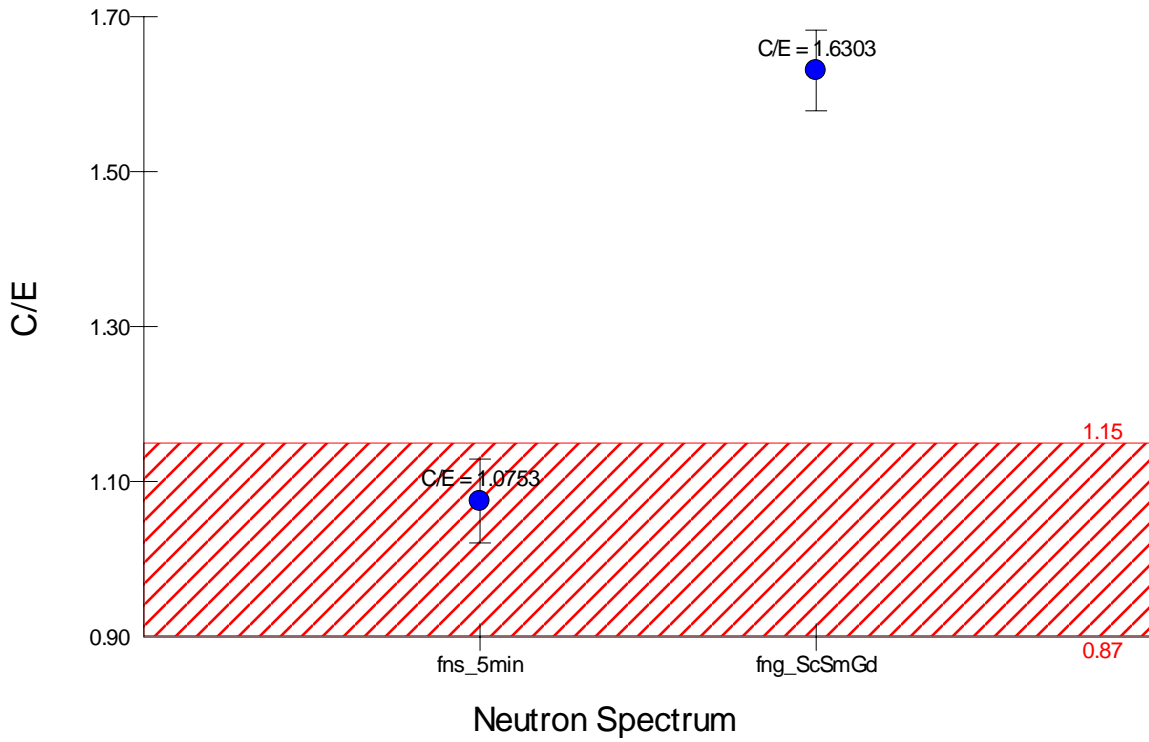
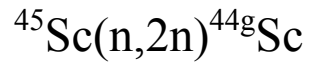


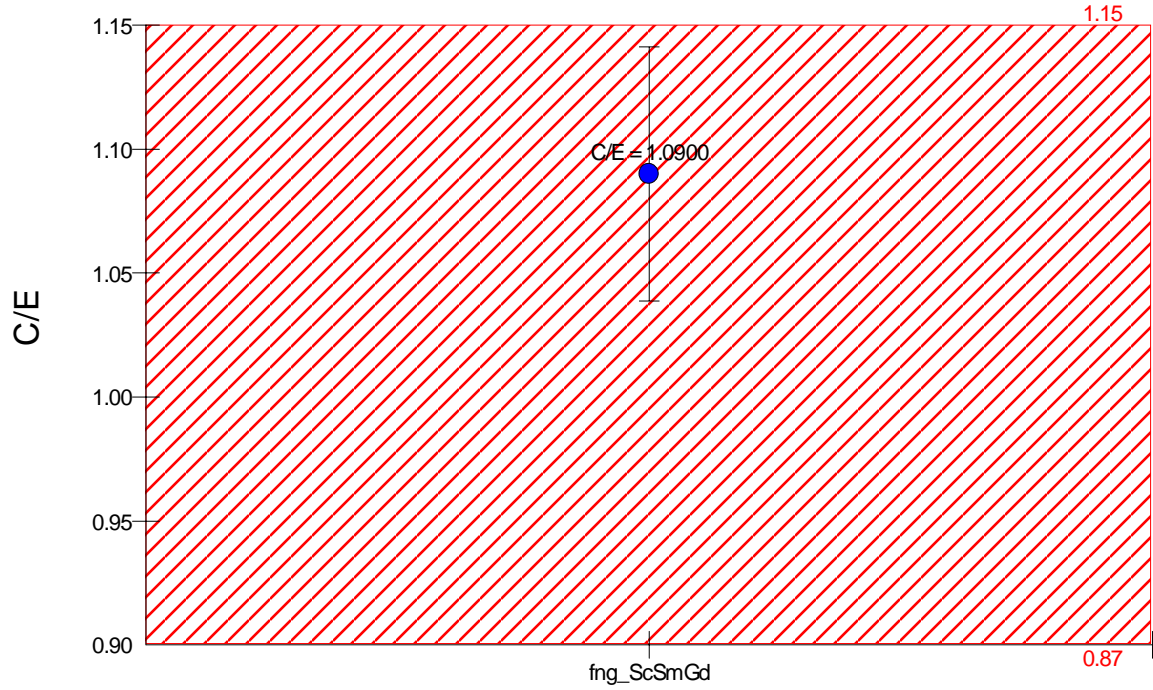
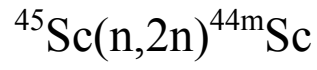


Neutron Spectrum

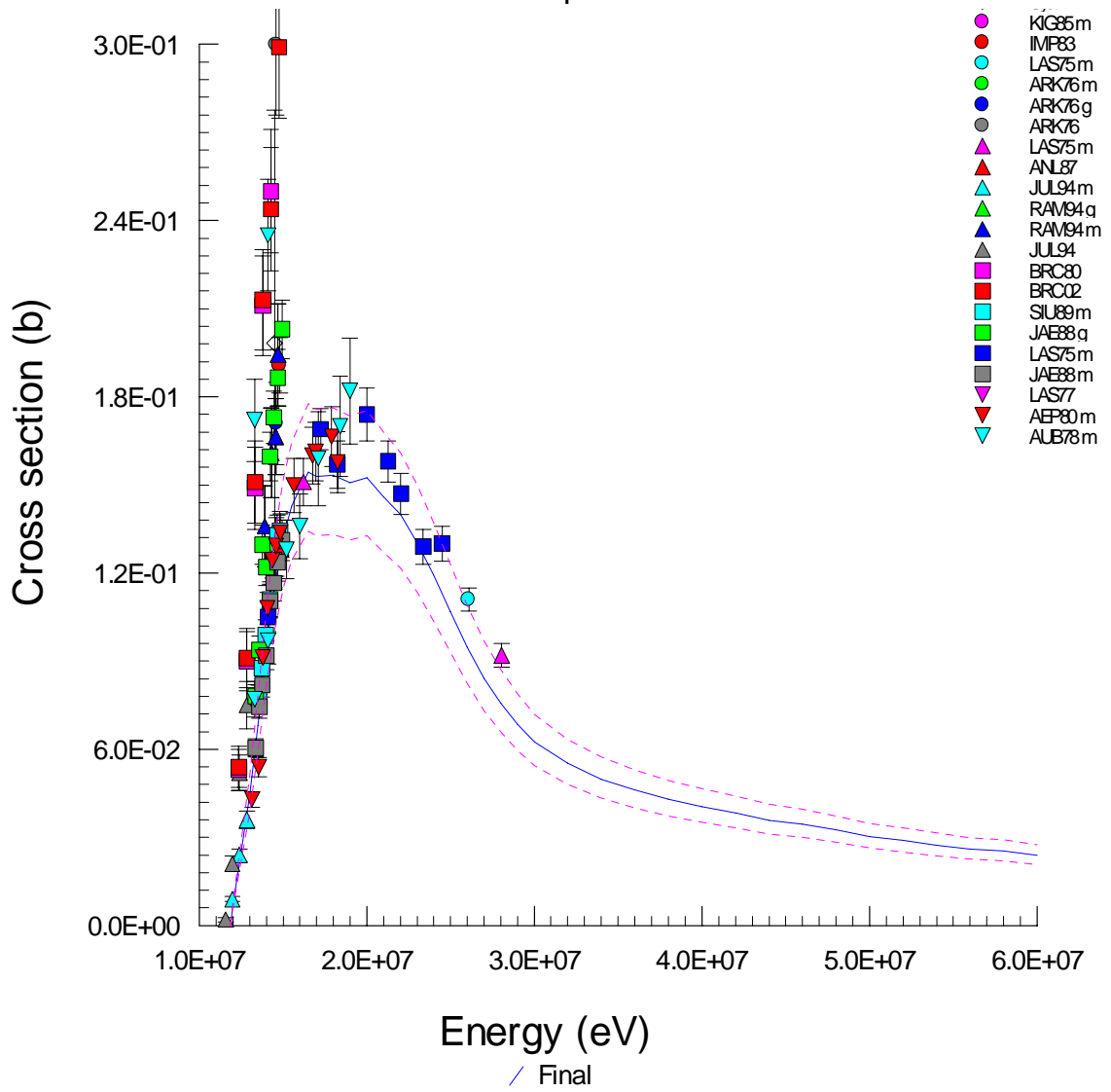




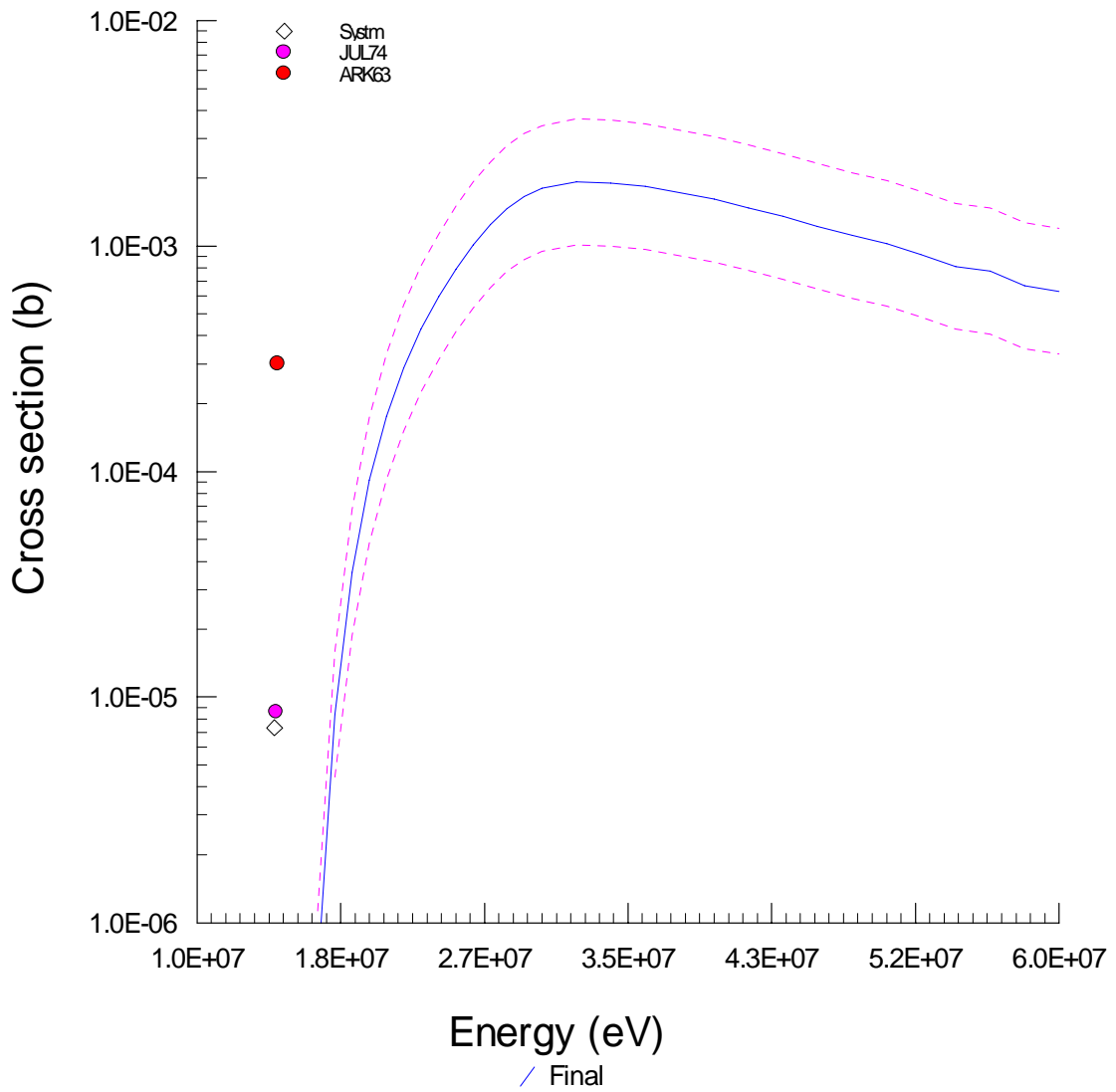
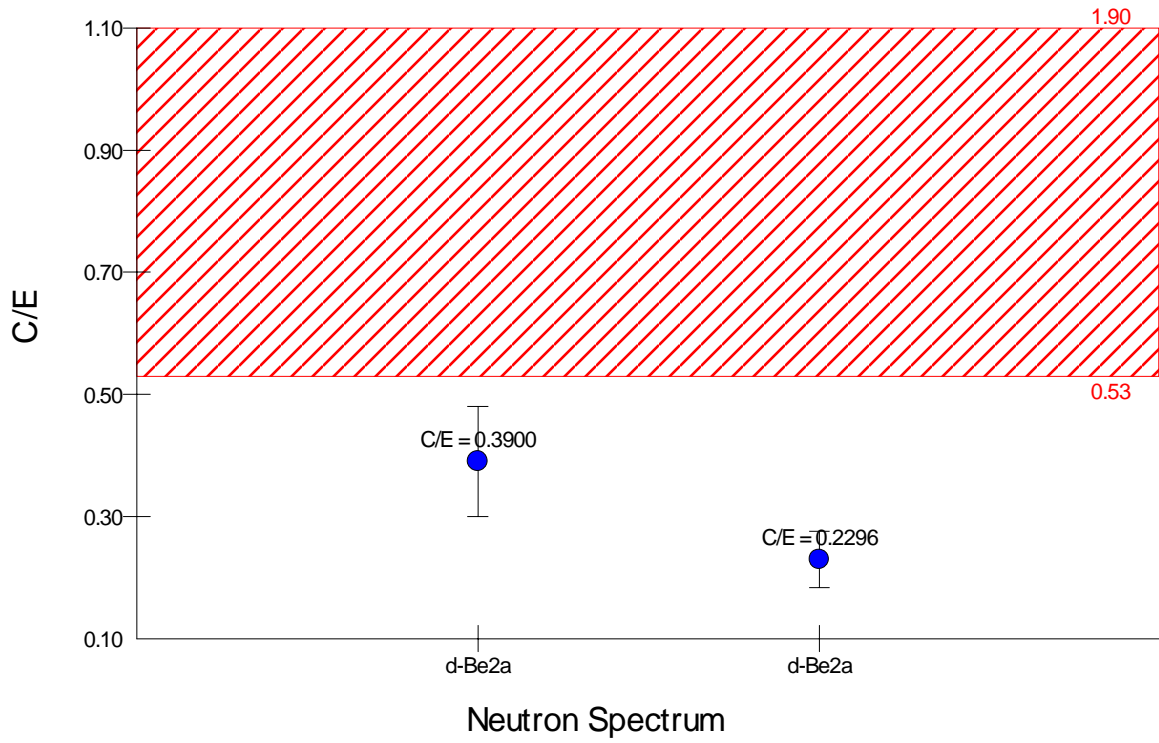


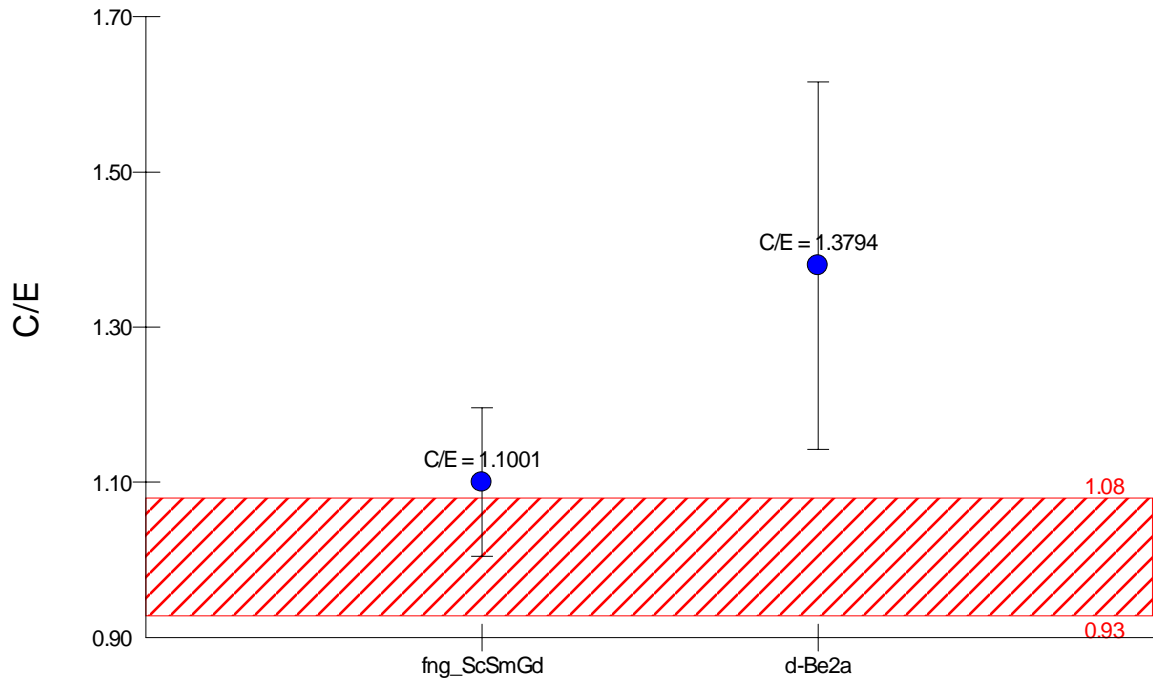
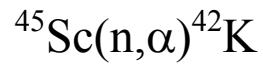


Neutron Spectrum

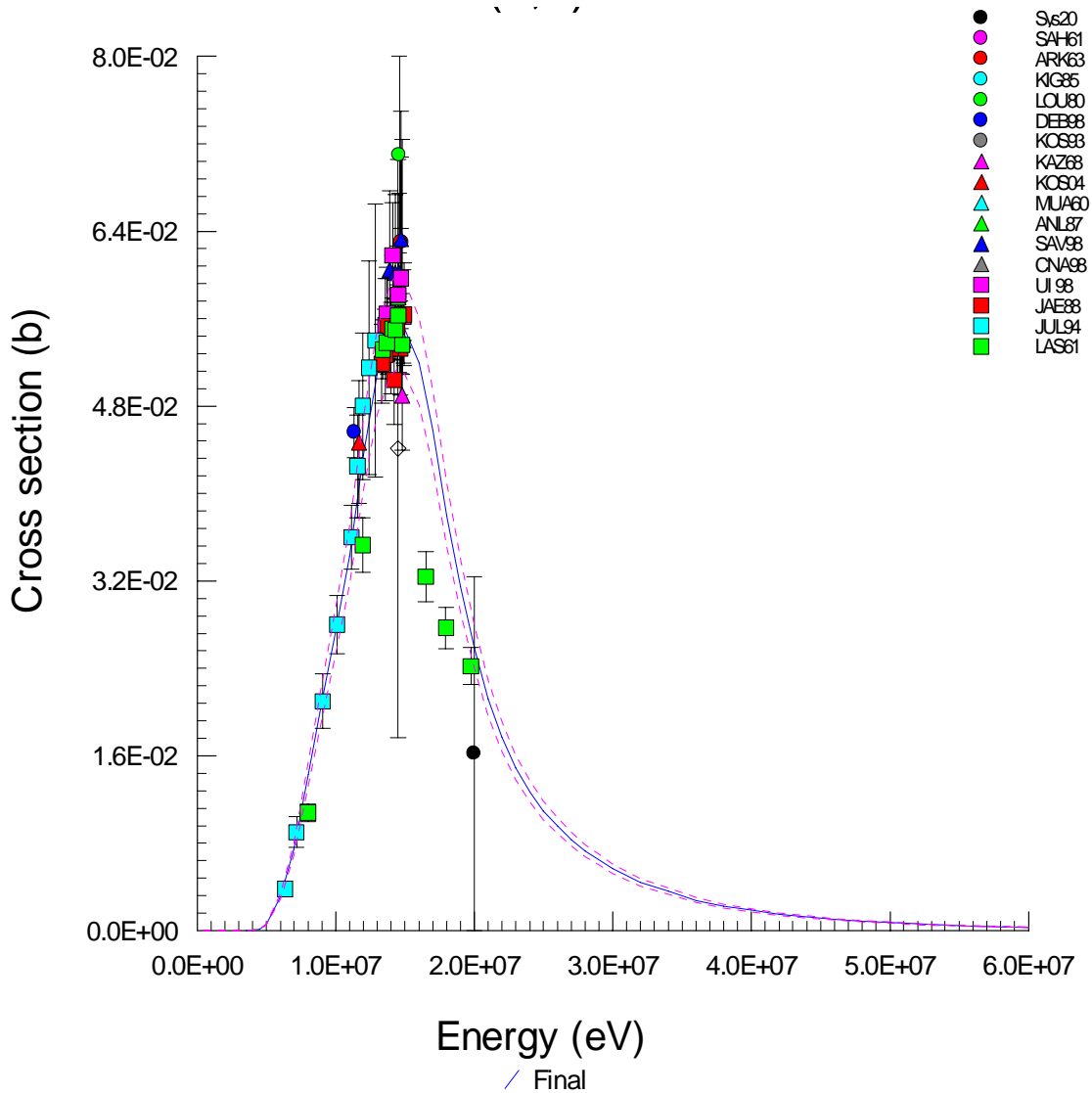


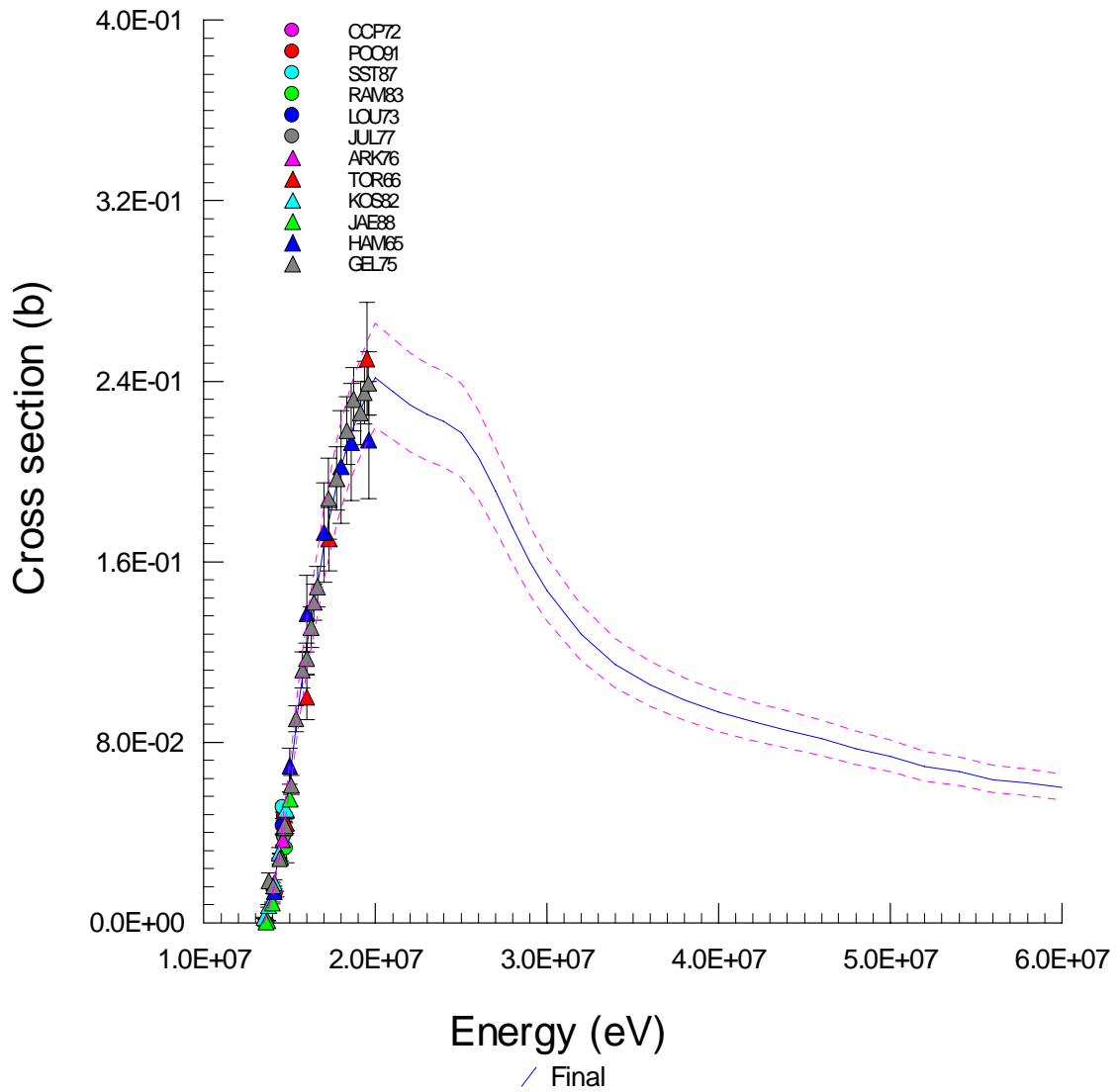
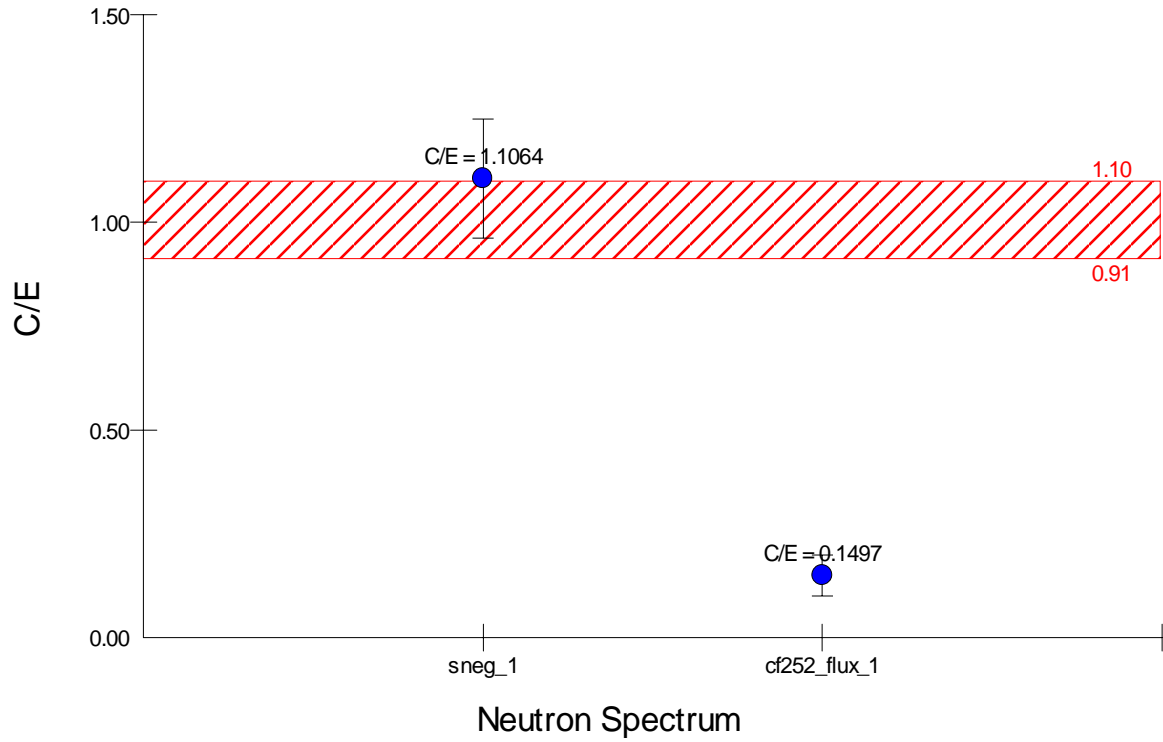
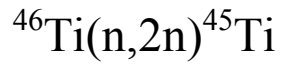
# $^{45}\text{Sc}(n,h)^{43}\text{K}$

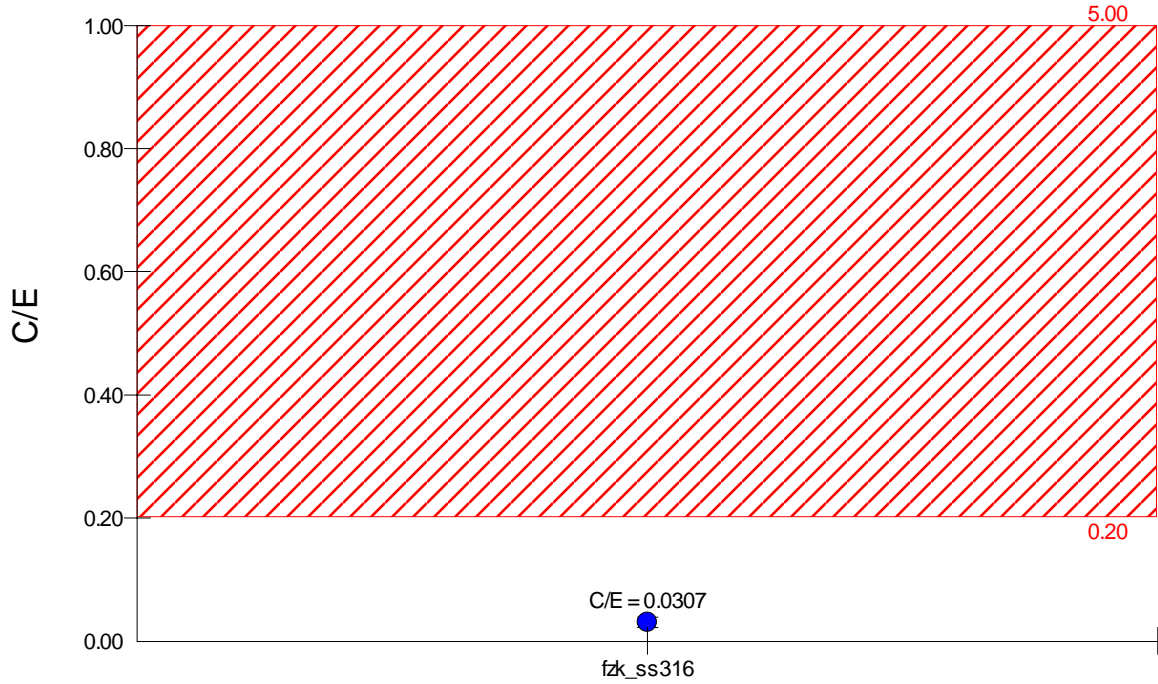
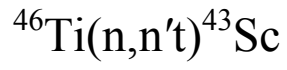




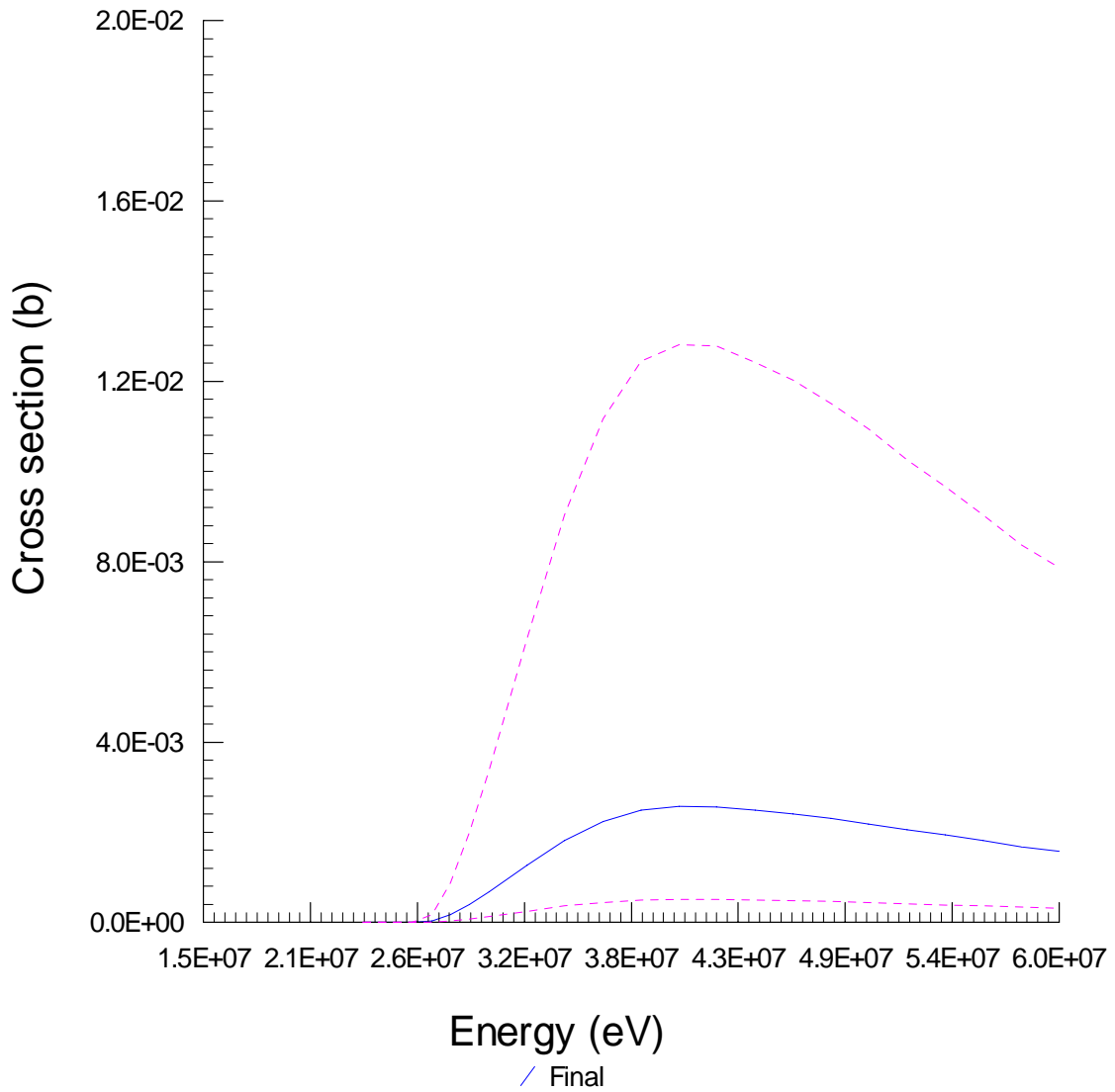
Neutron Spectrum

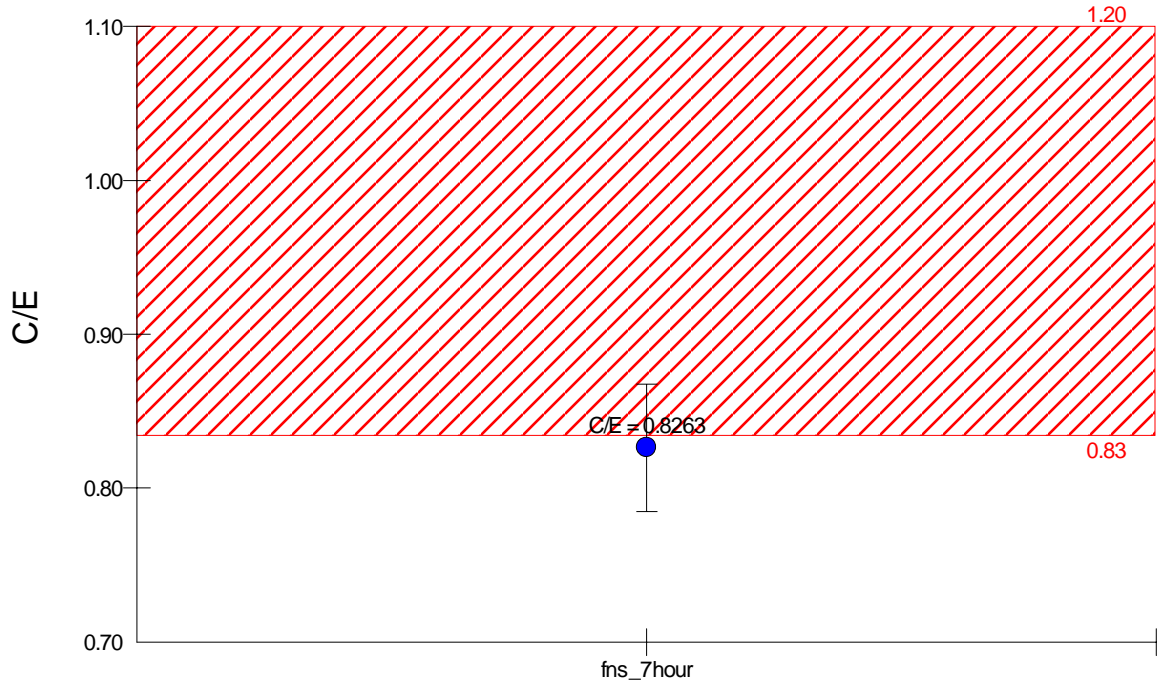
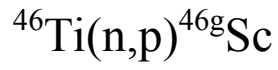




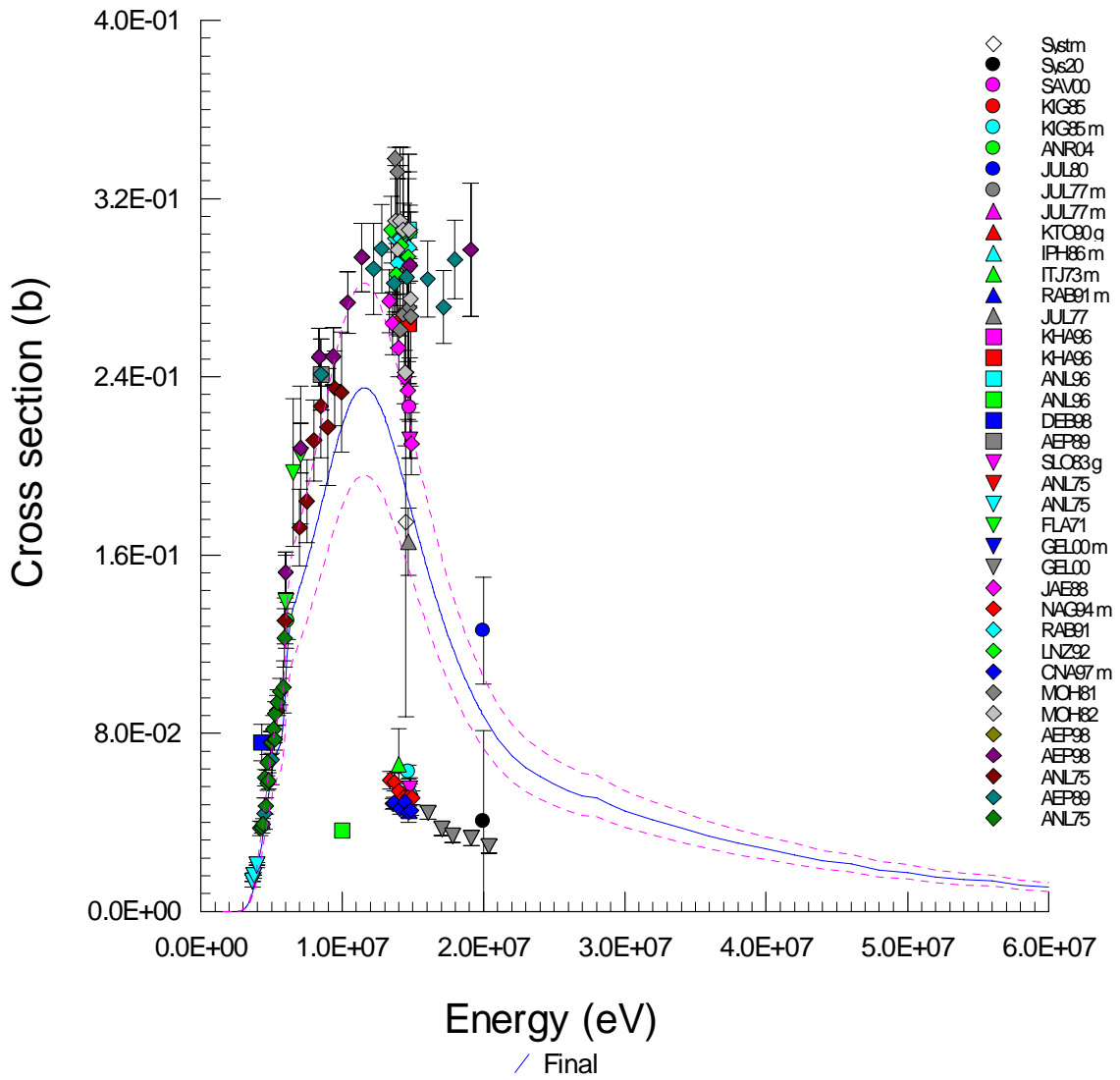


Neutron Spectrum

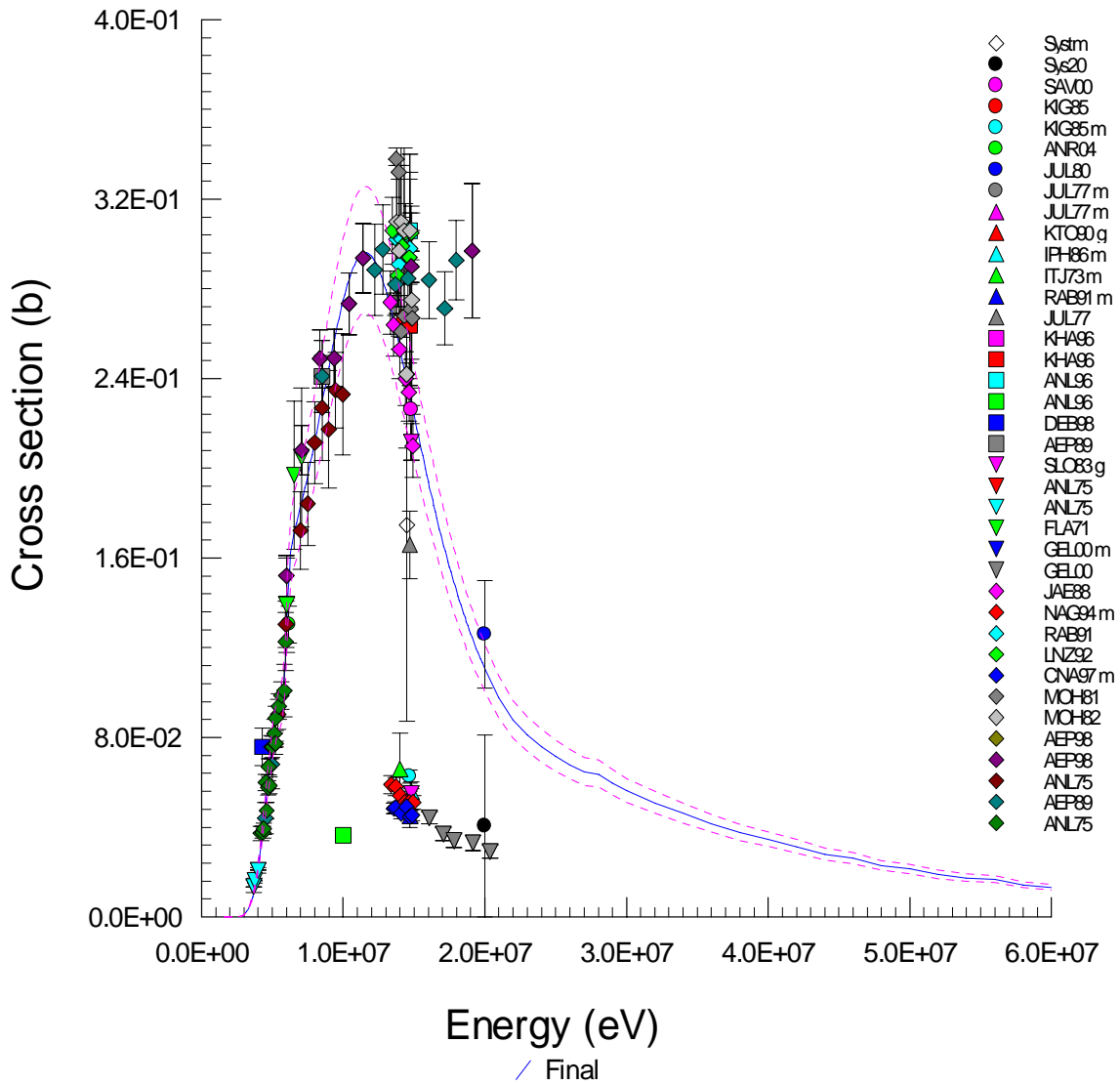
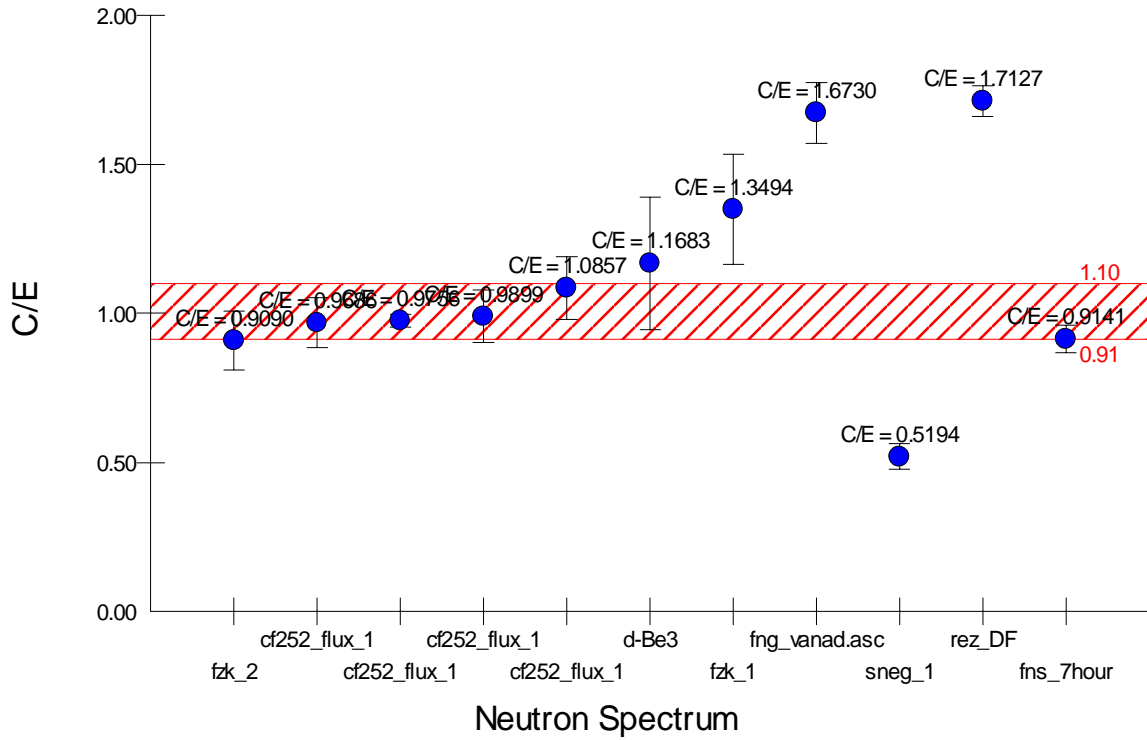




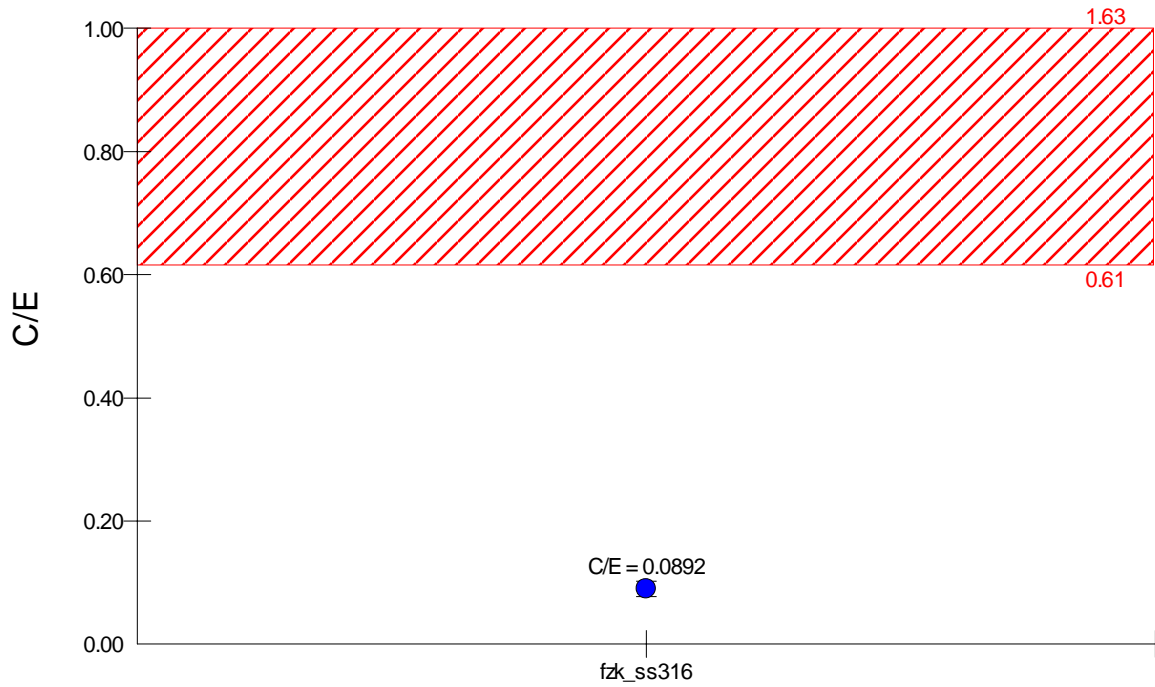
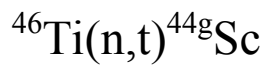
Neutron Spectrum



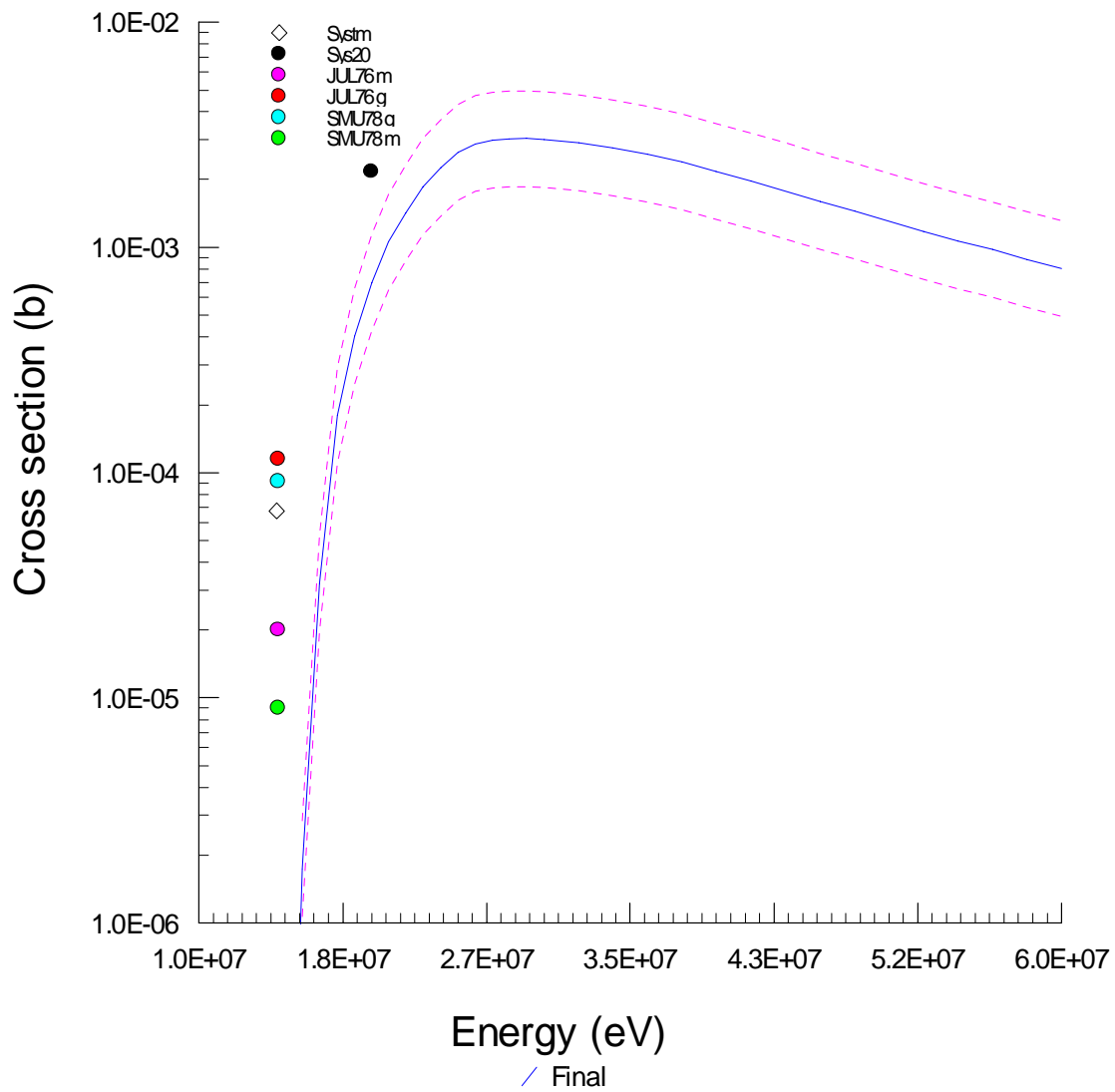
# $^{46}\text{Ti}(n,p)^{46}\text{Sc} \blacktriangleright 544$

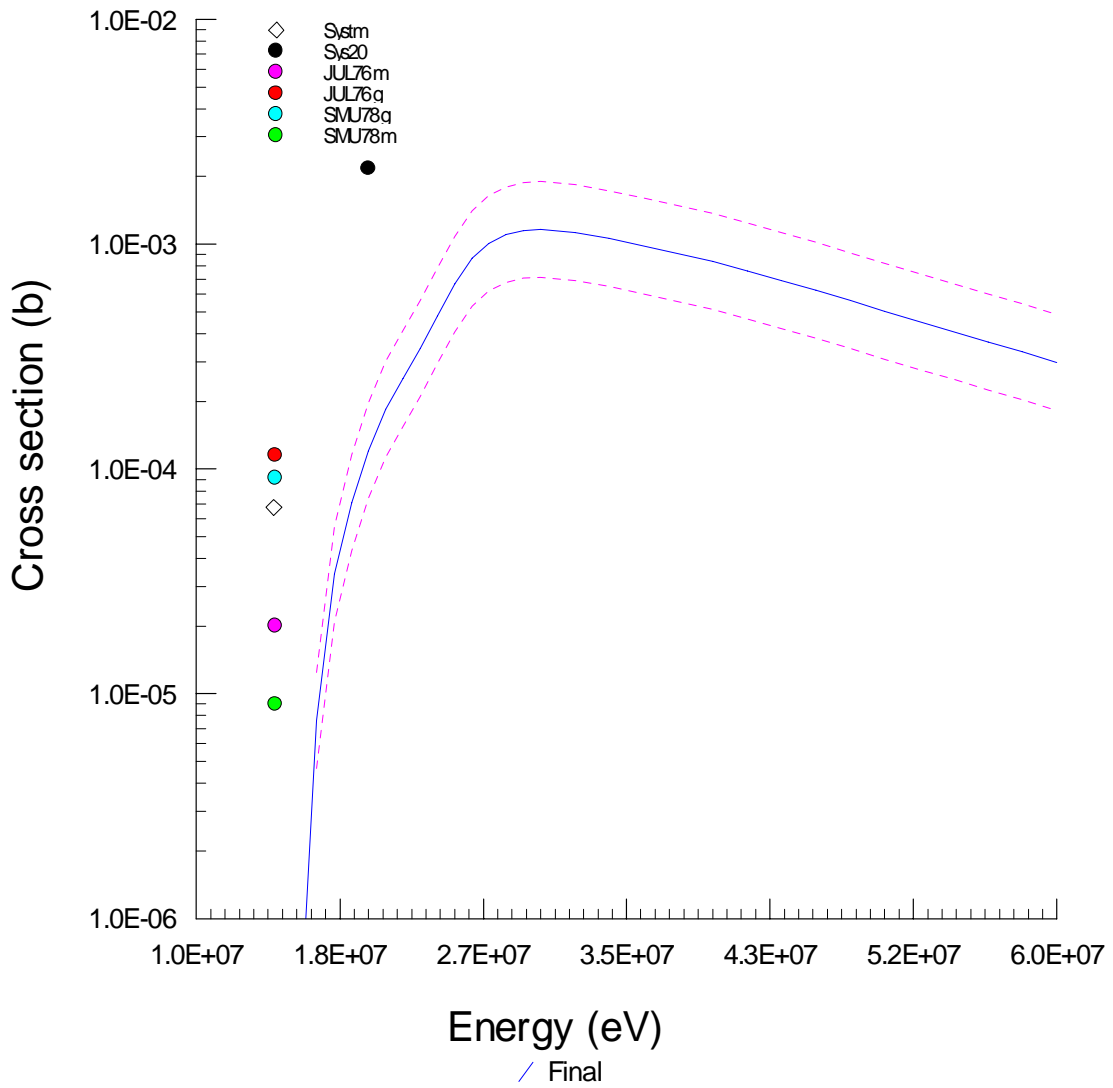
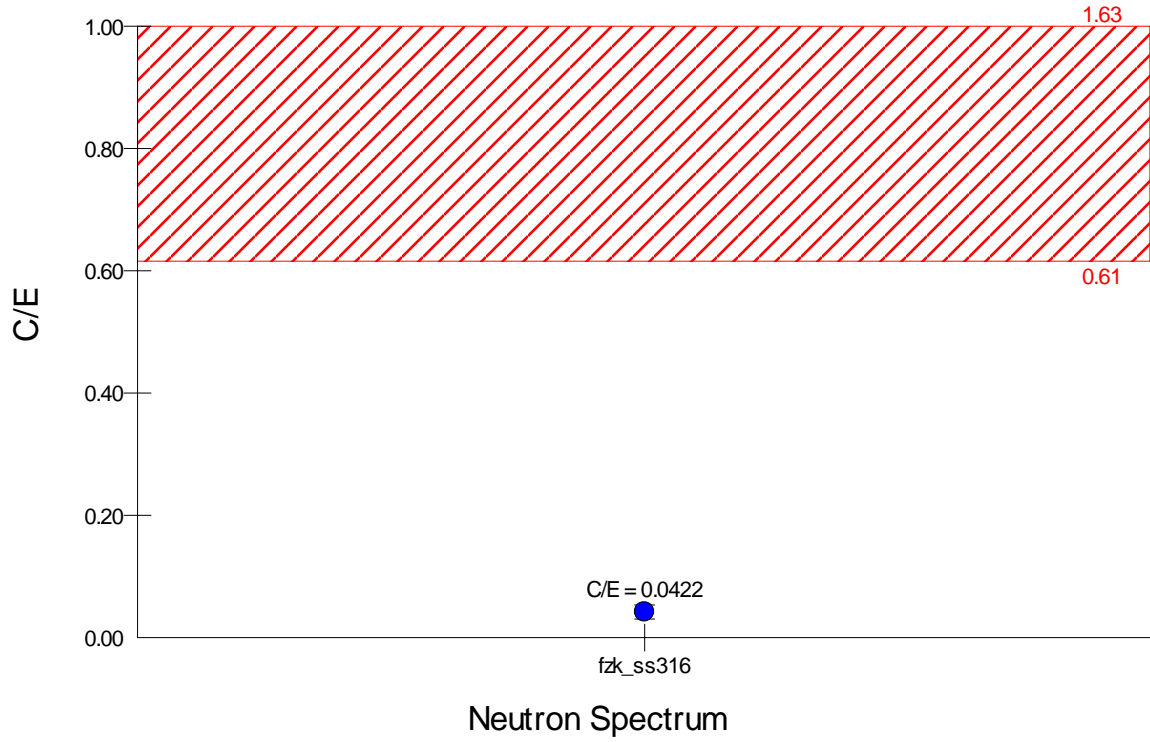
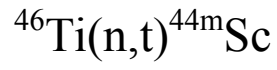


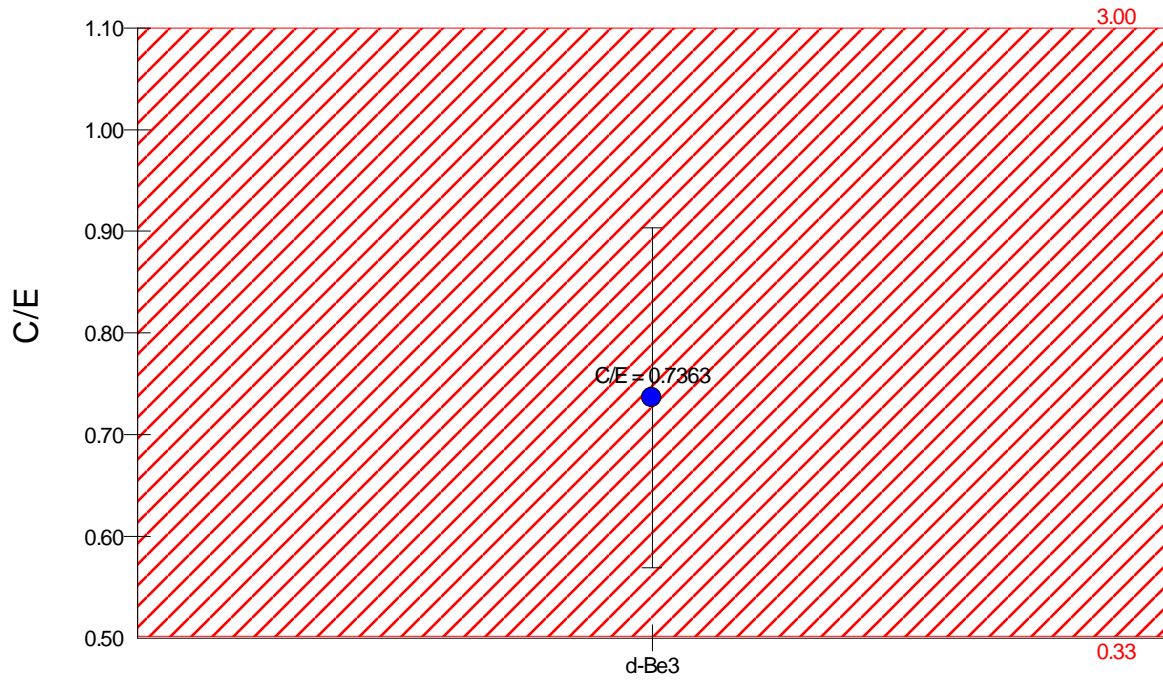
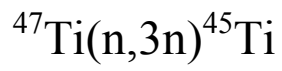




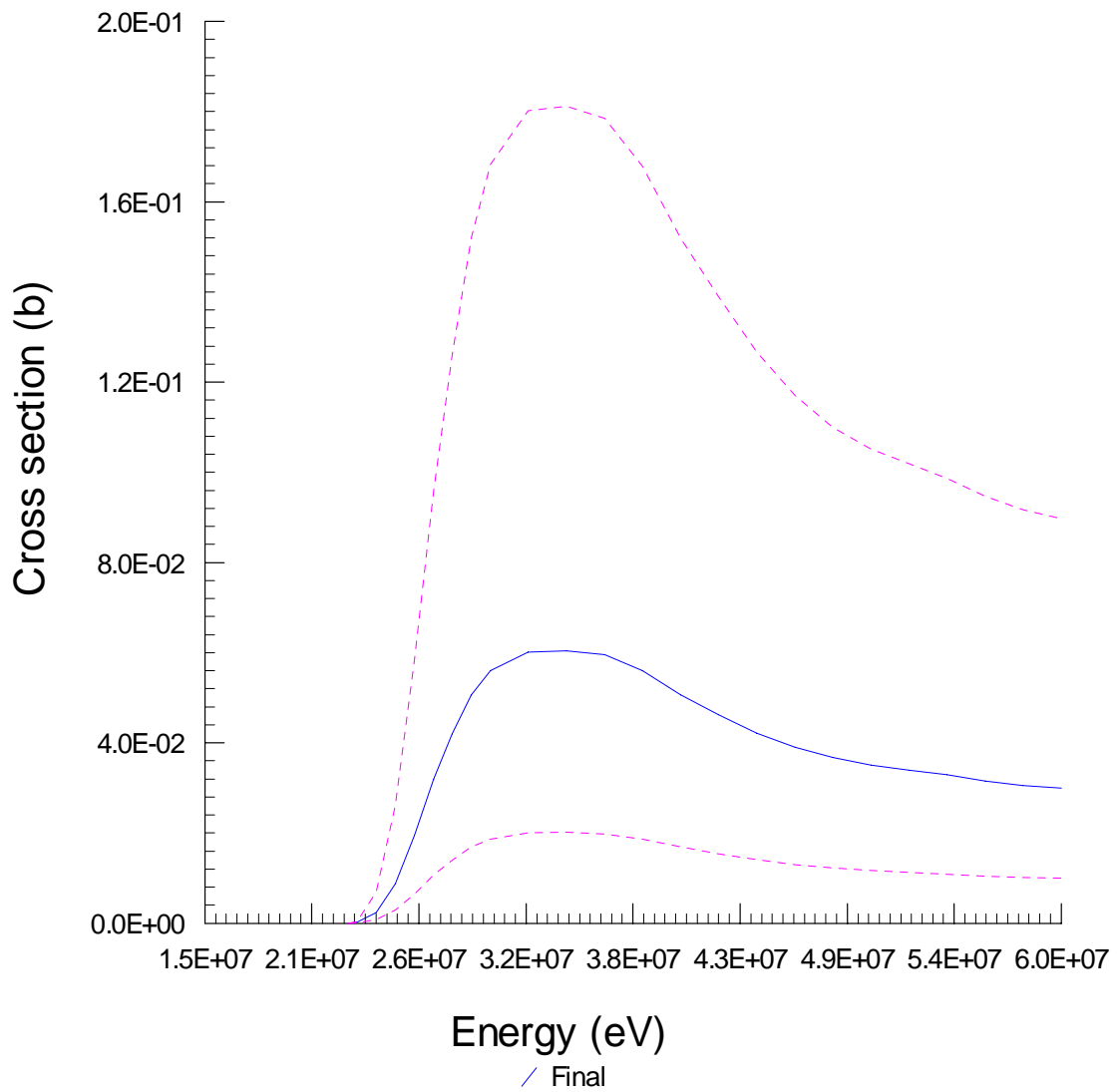
Neutron Spectrum



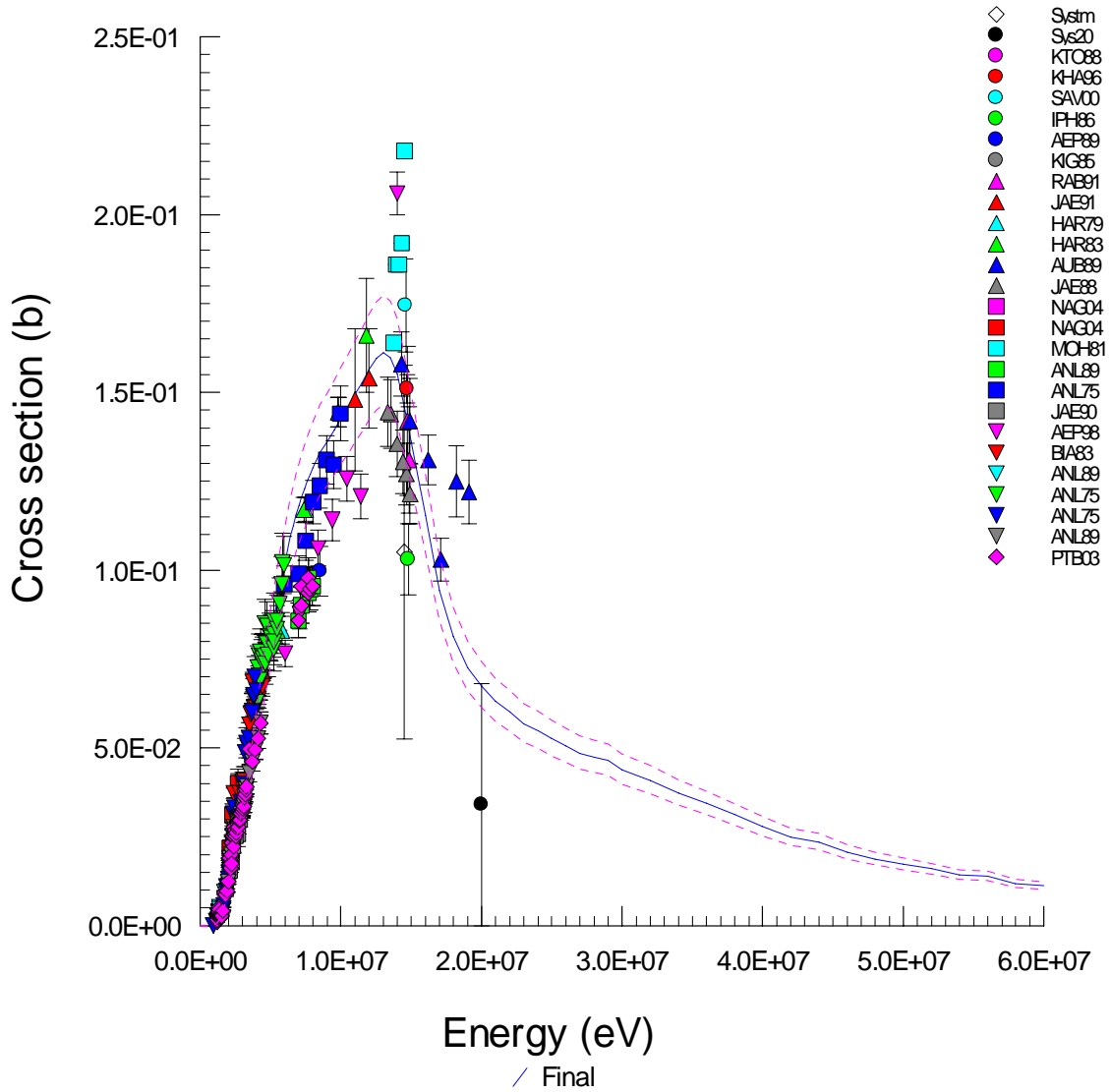
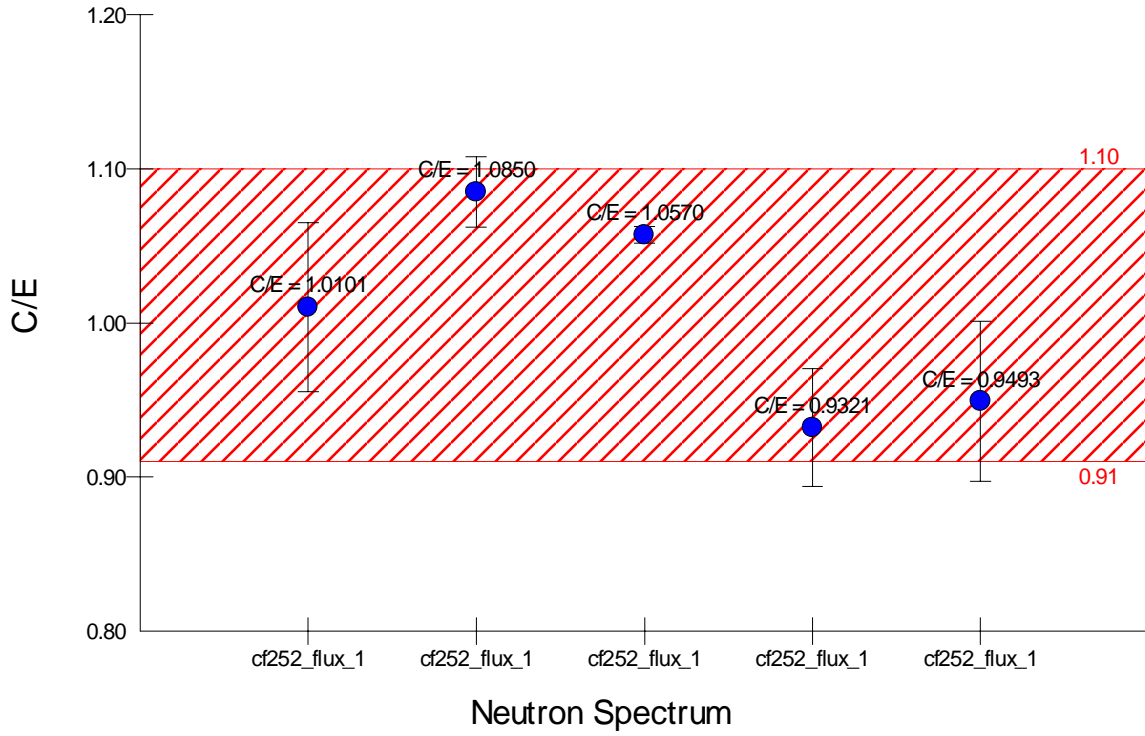




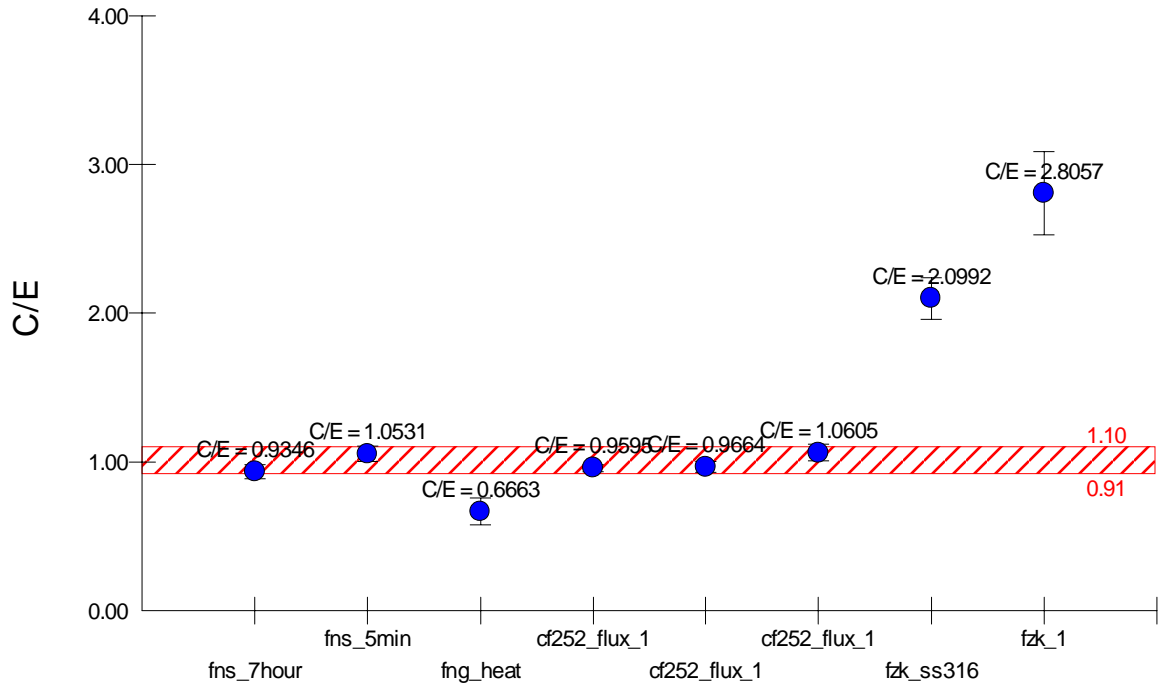
Neutron Spectrum



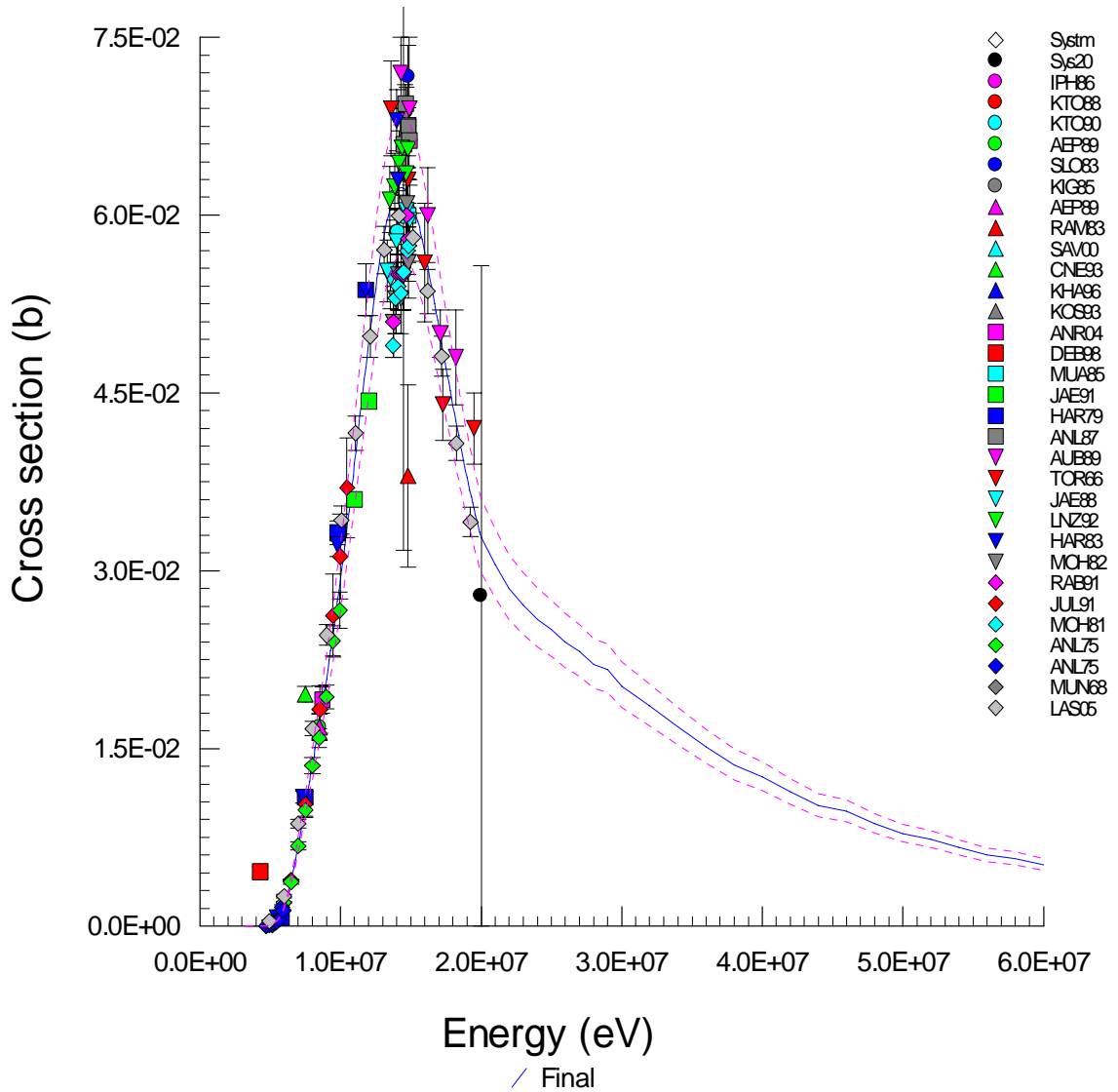
# $^{47}\text{Ti}(n,p)^{47}\text{Sc}$

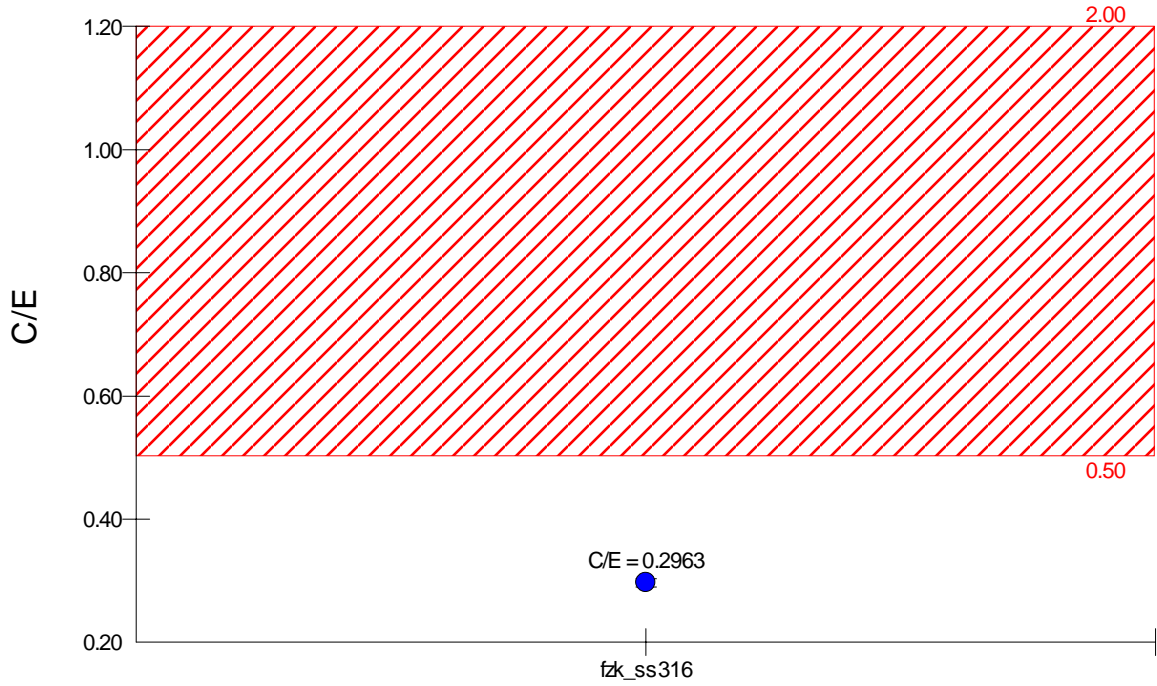
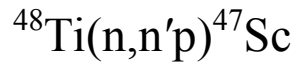


# $^{48}\text{Ti}(n,p)^{48}\text{Sc} \blacktriangleright 545$

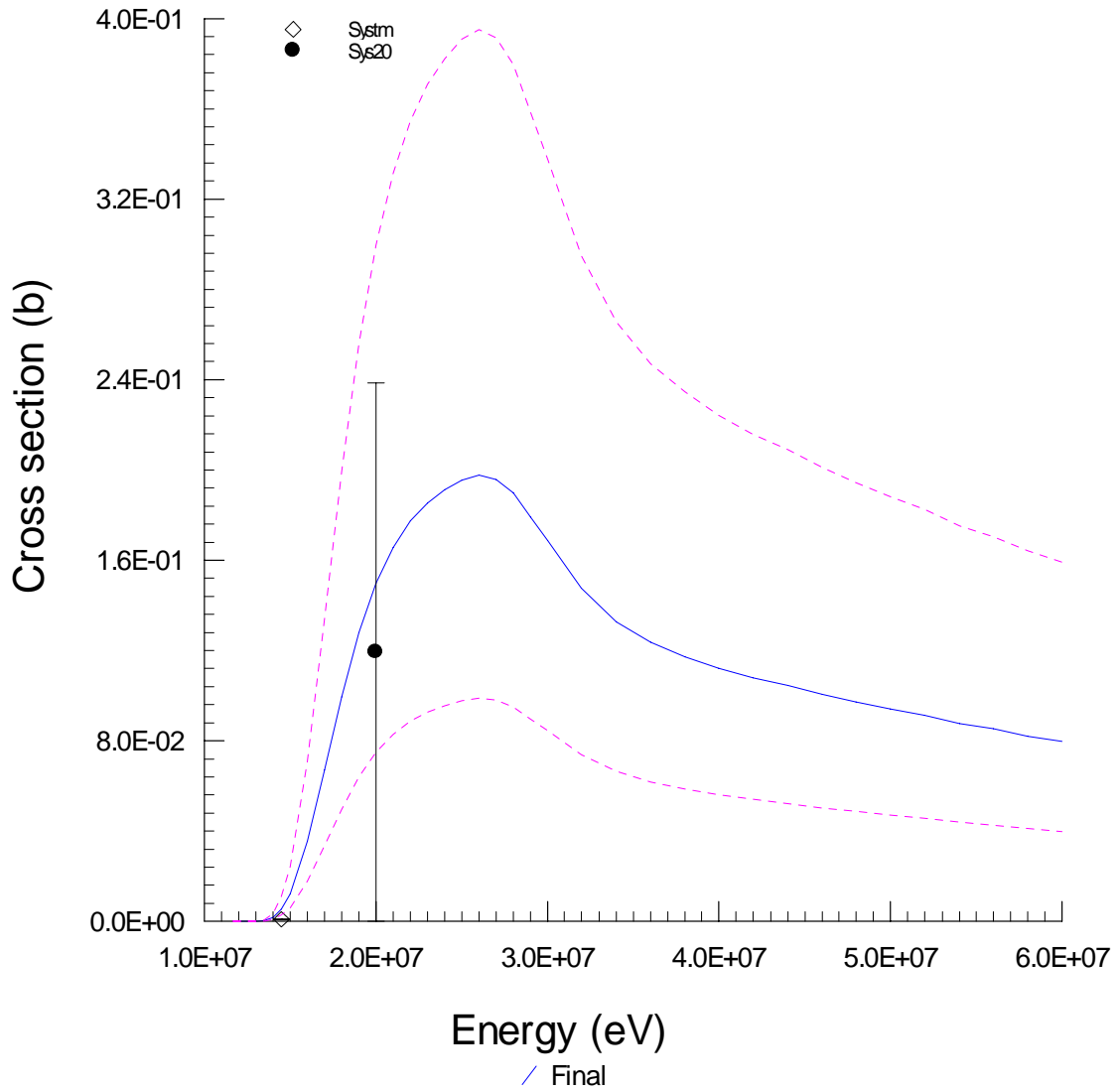


## Neutron Spectrum

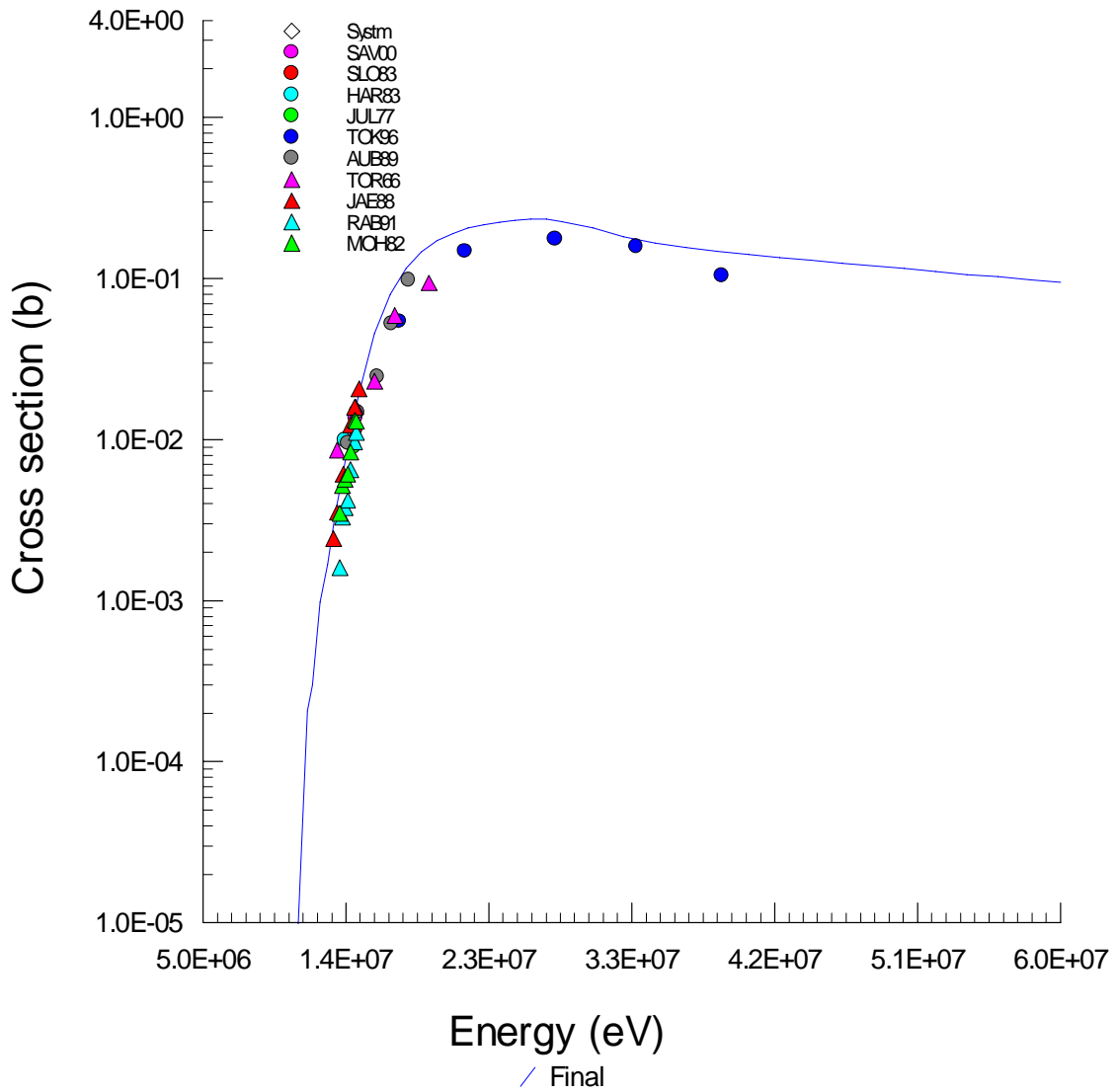
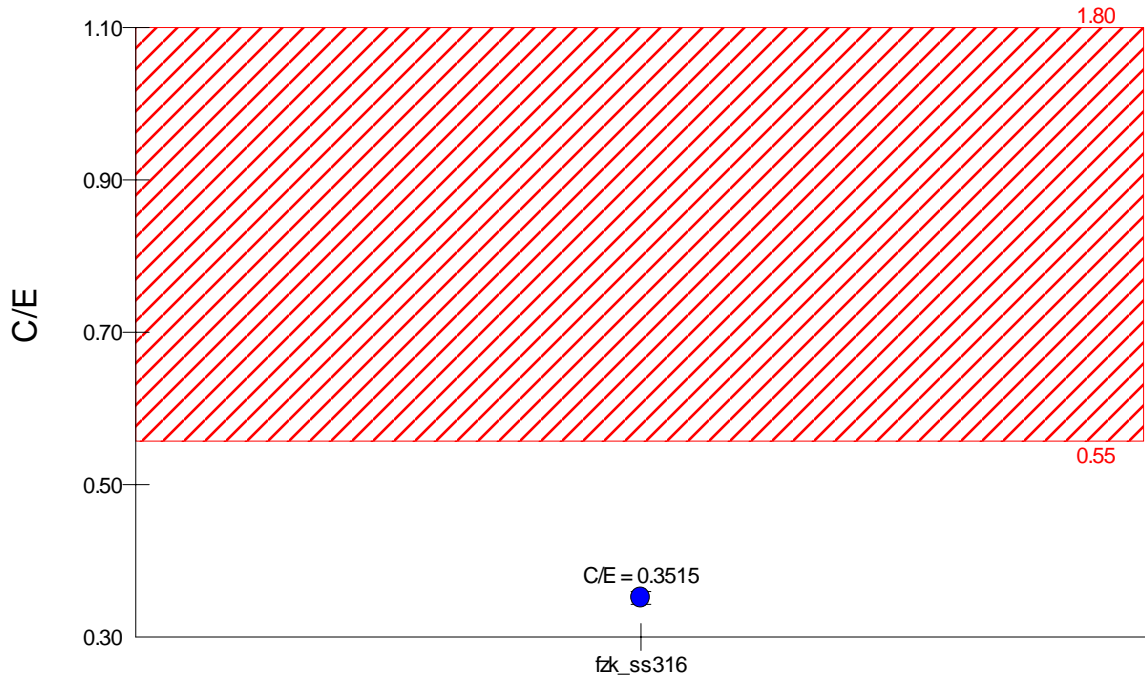


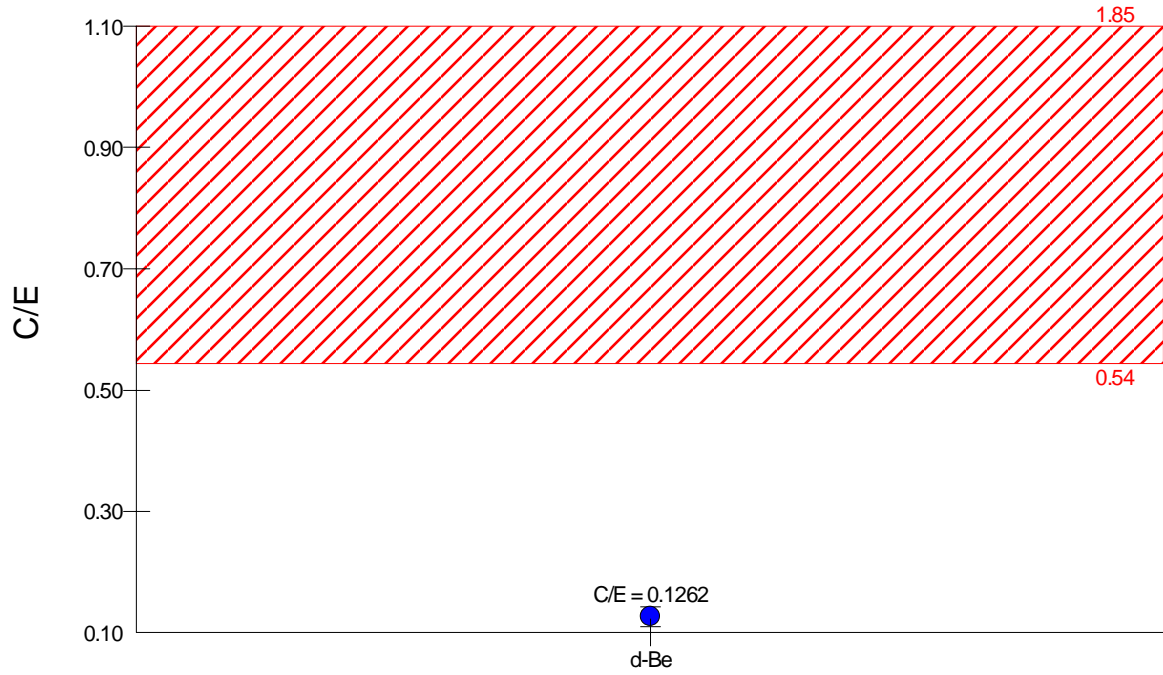
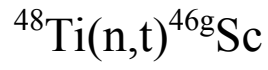


Neutron Spectrum

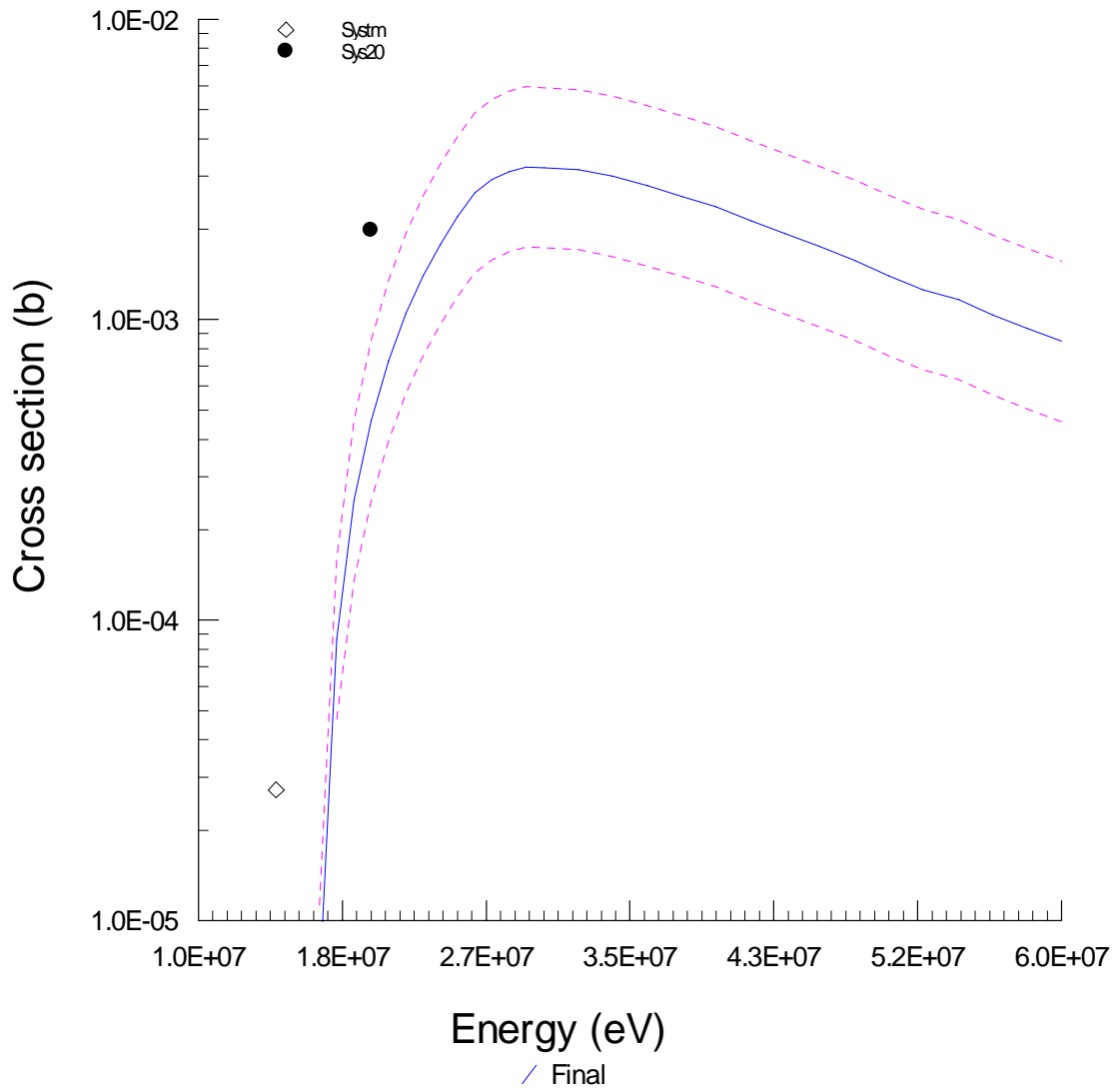


# $^{48}\text{Ti}(n,d)^{47}\text{Sc}$

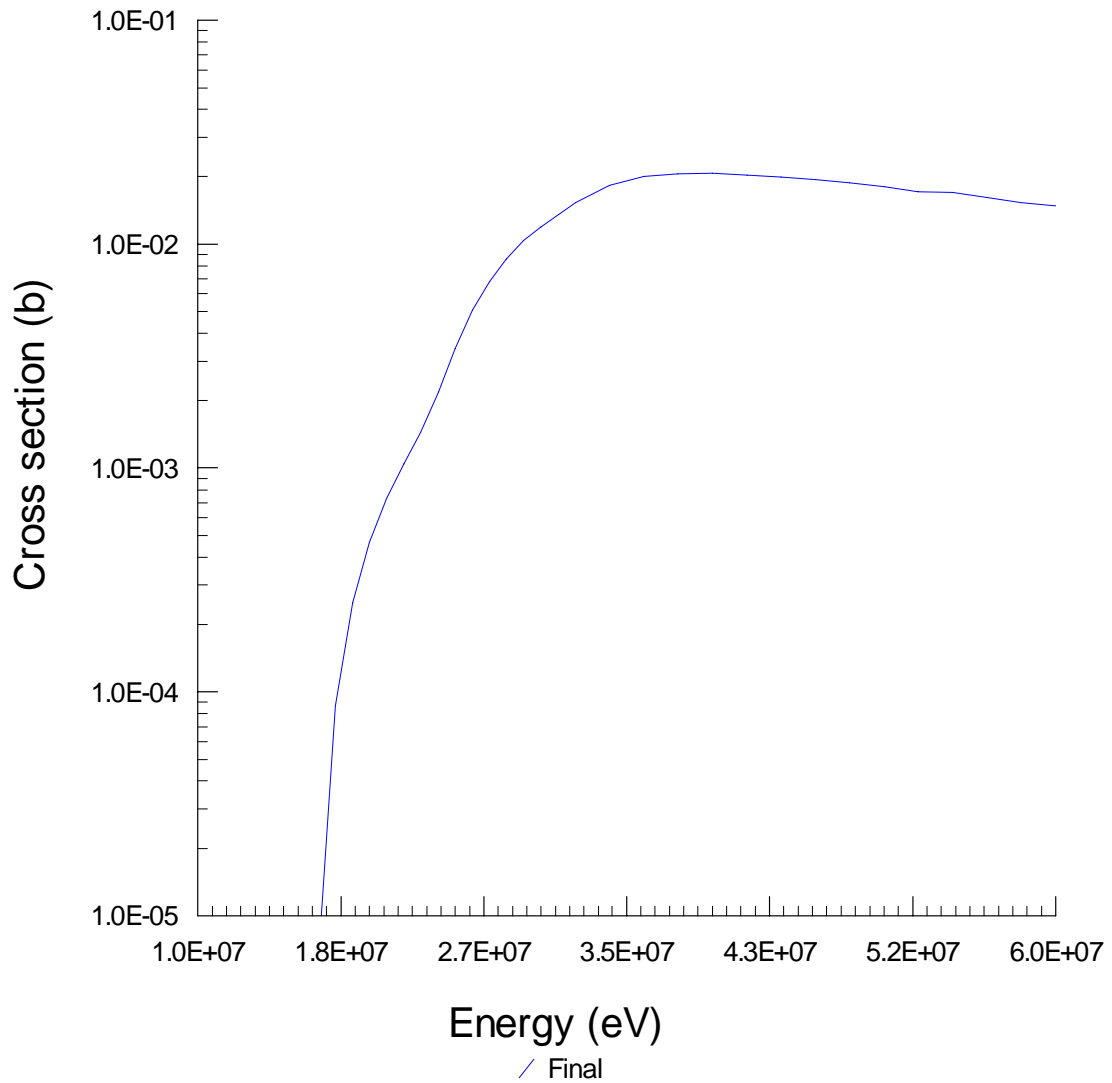
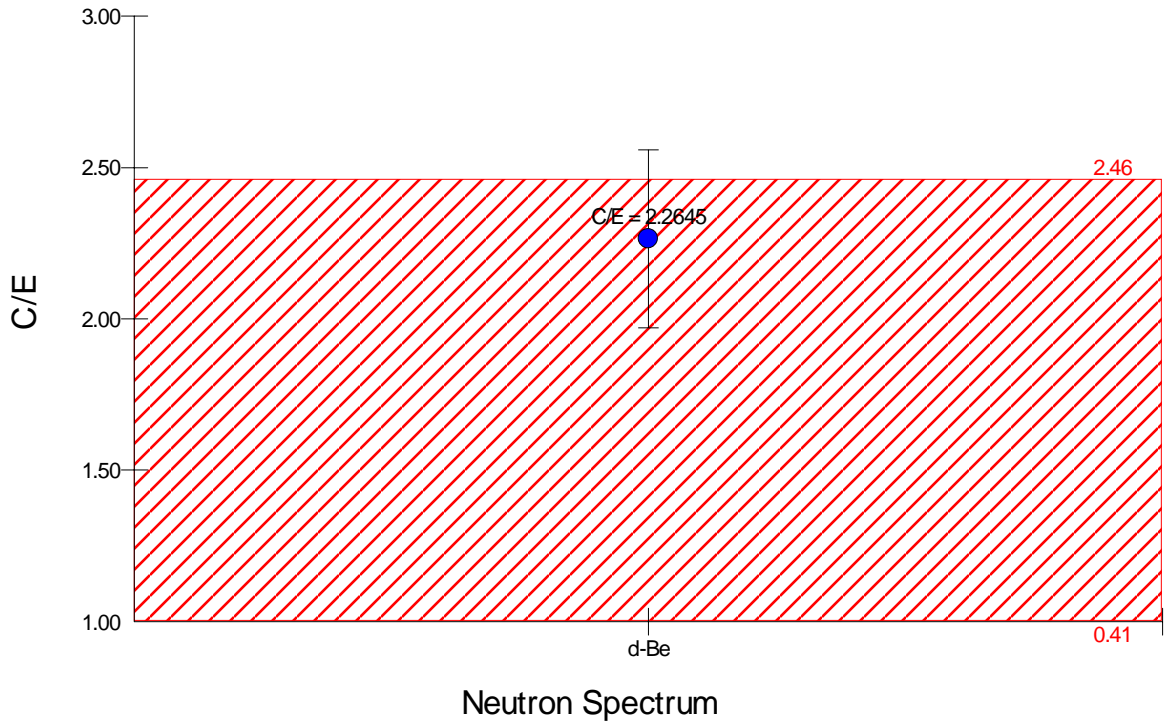
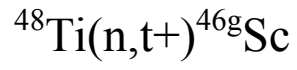


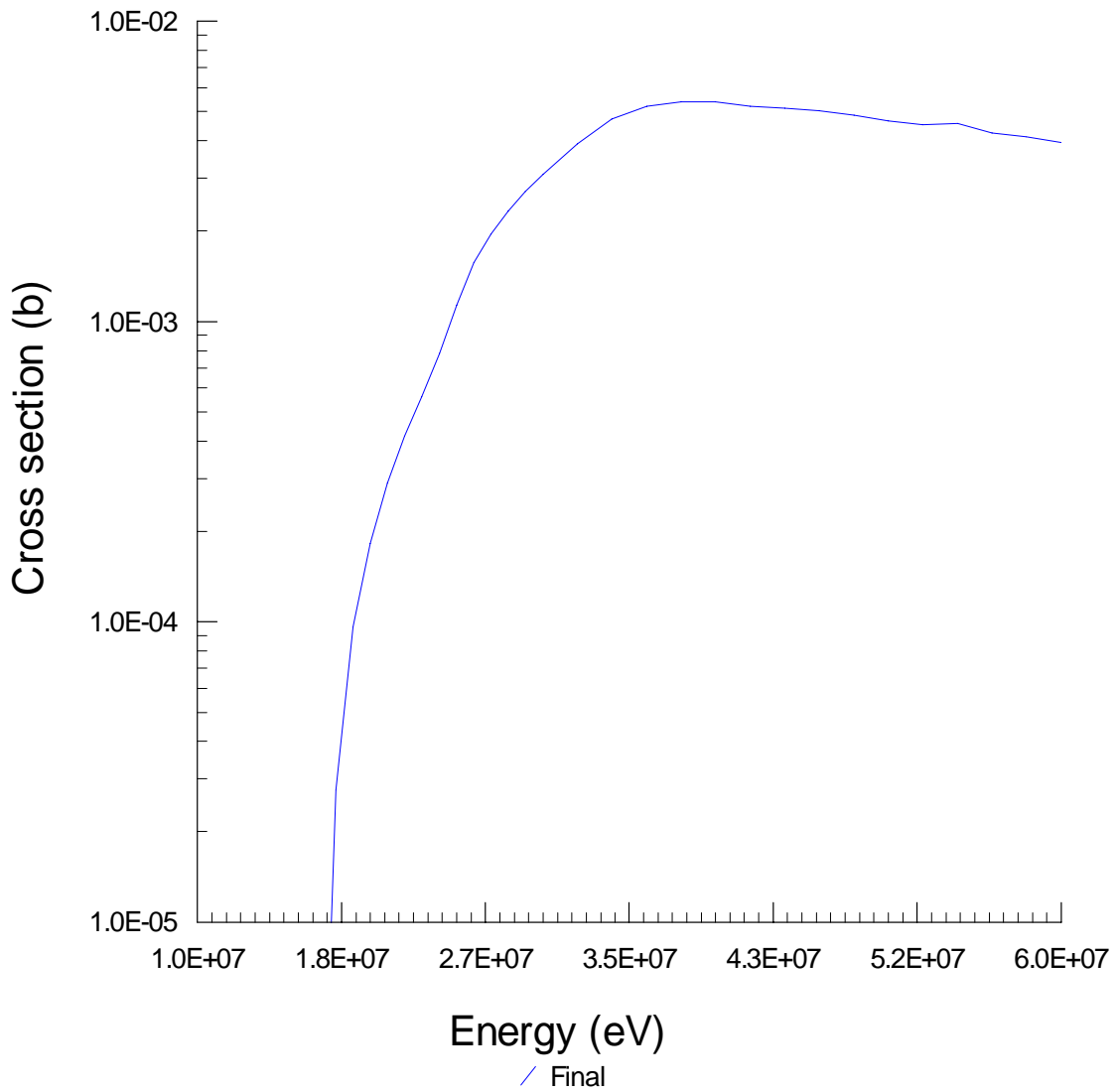
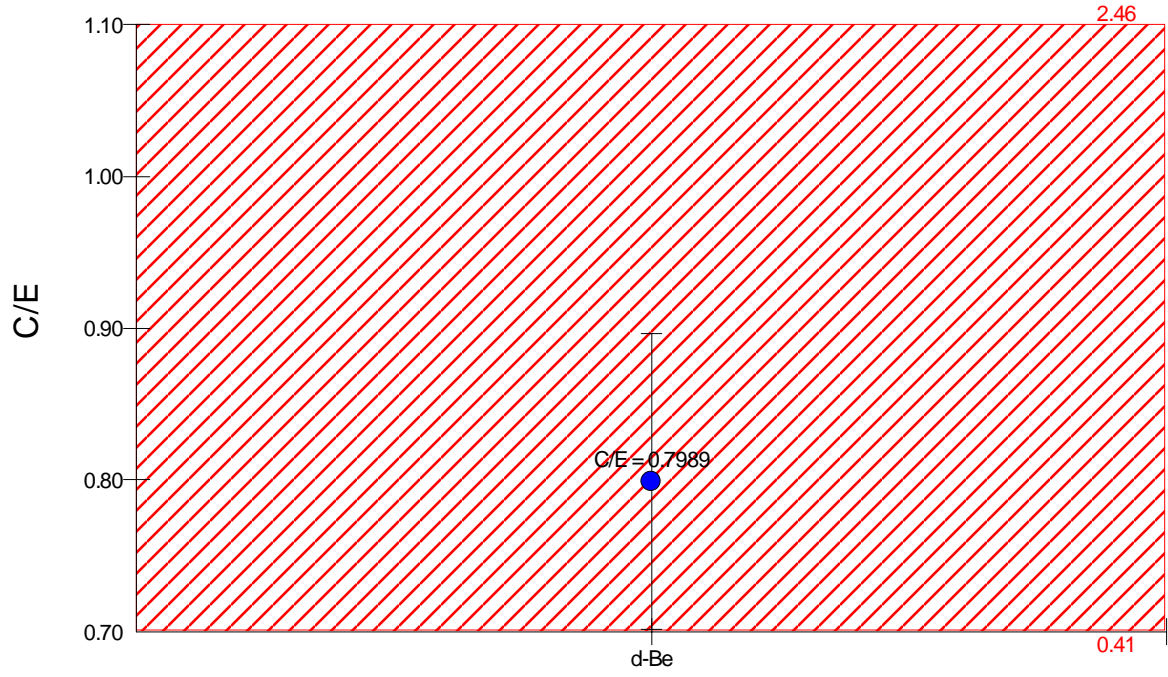
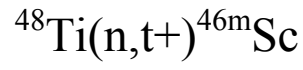


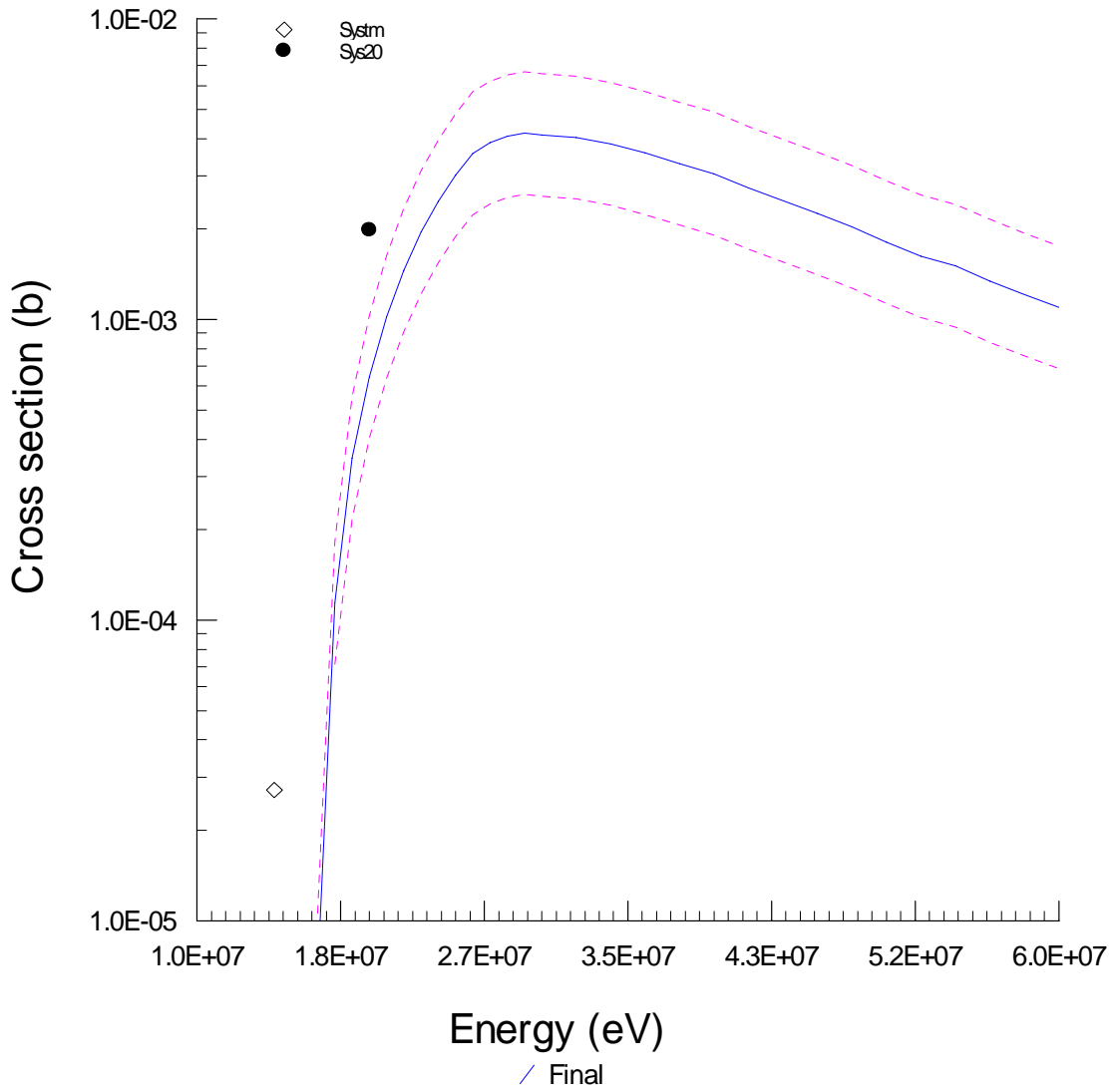
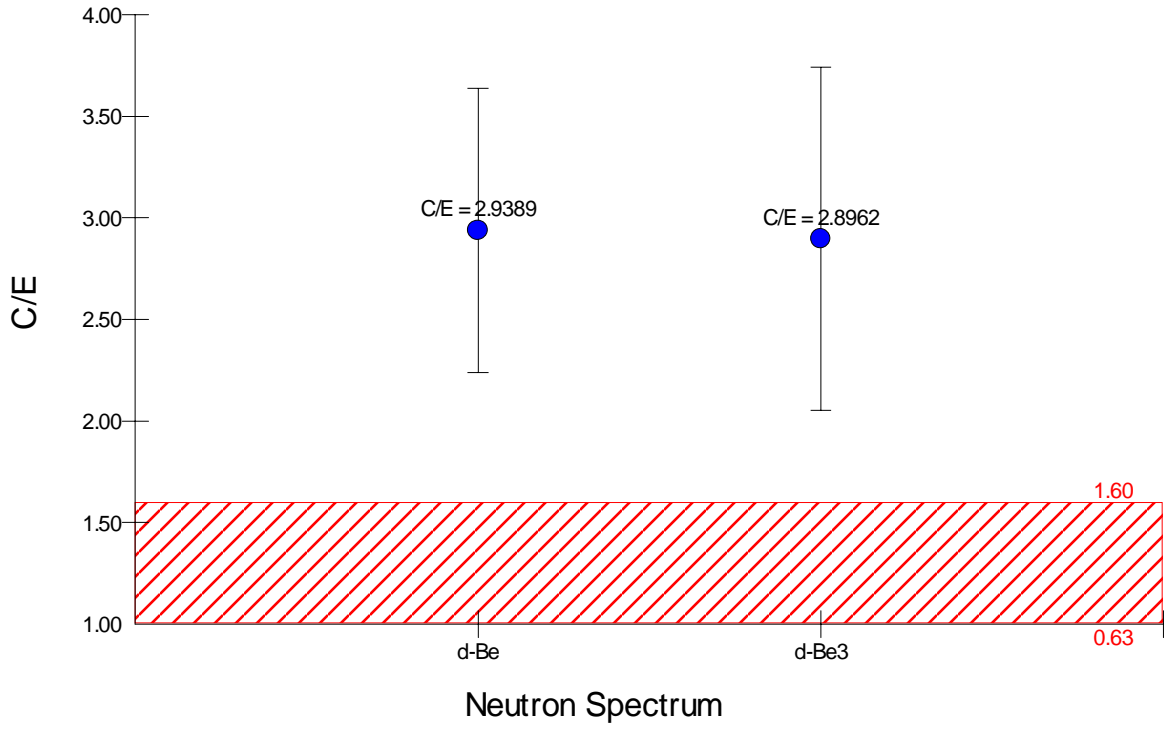
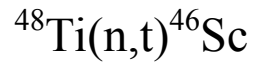
Neutron Spectrum



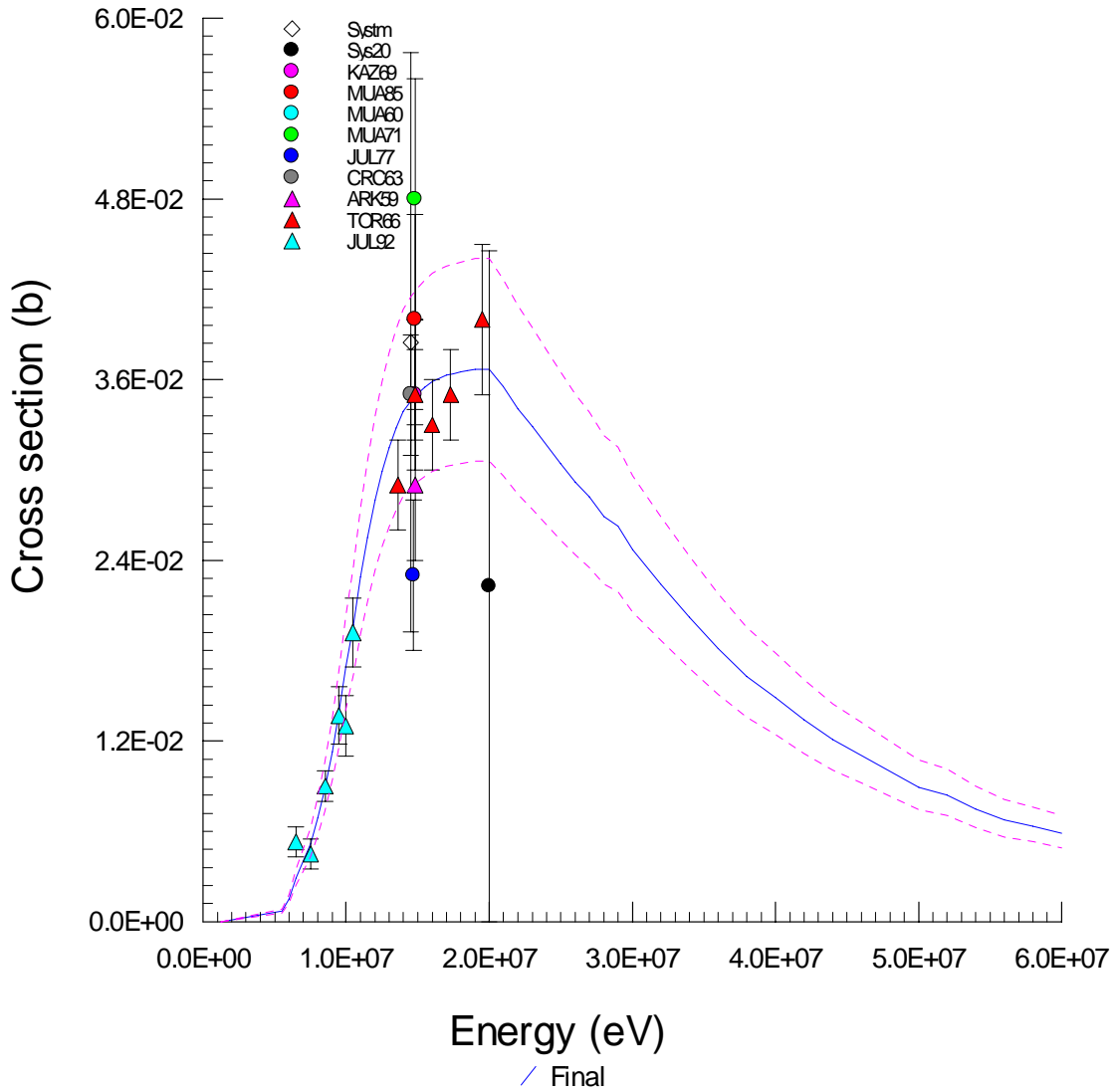
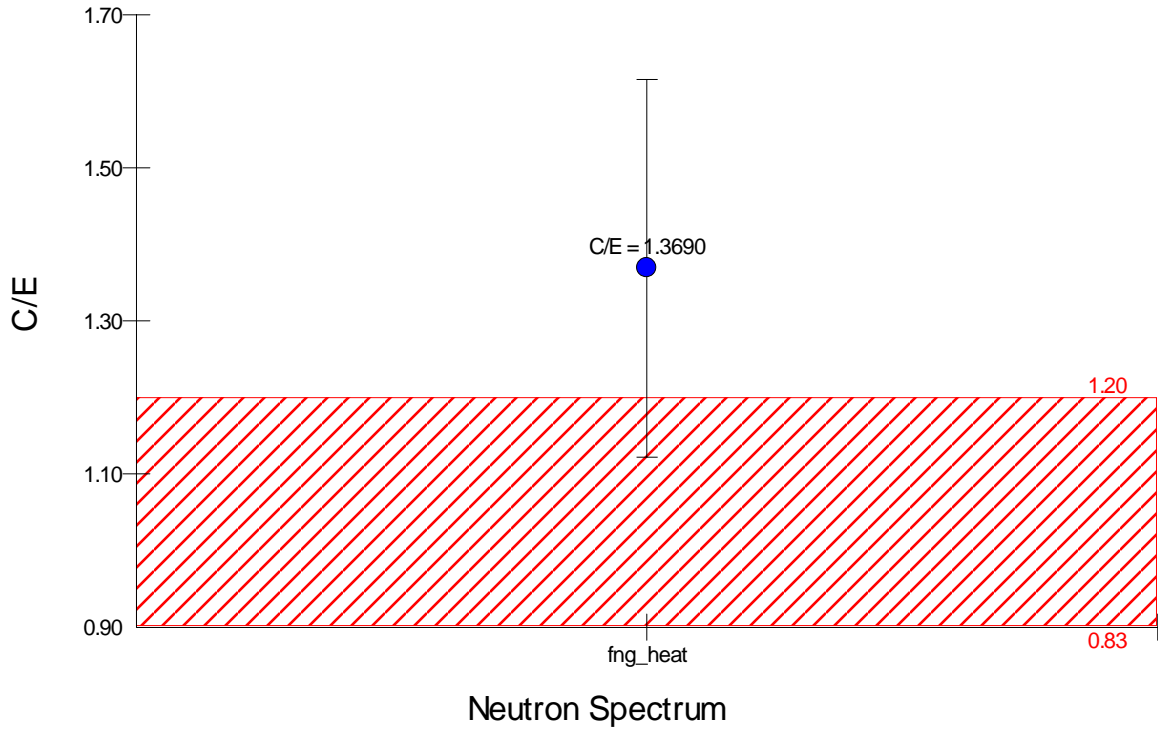




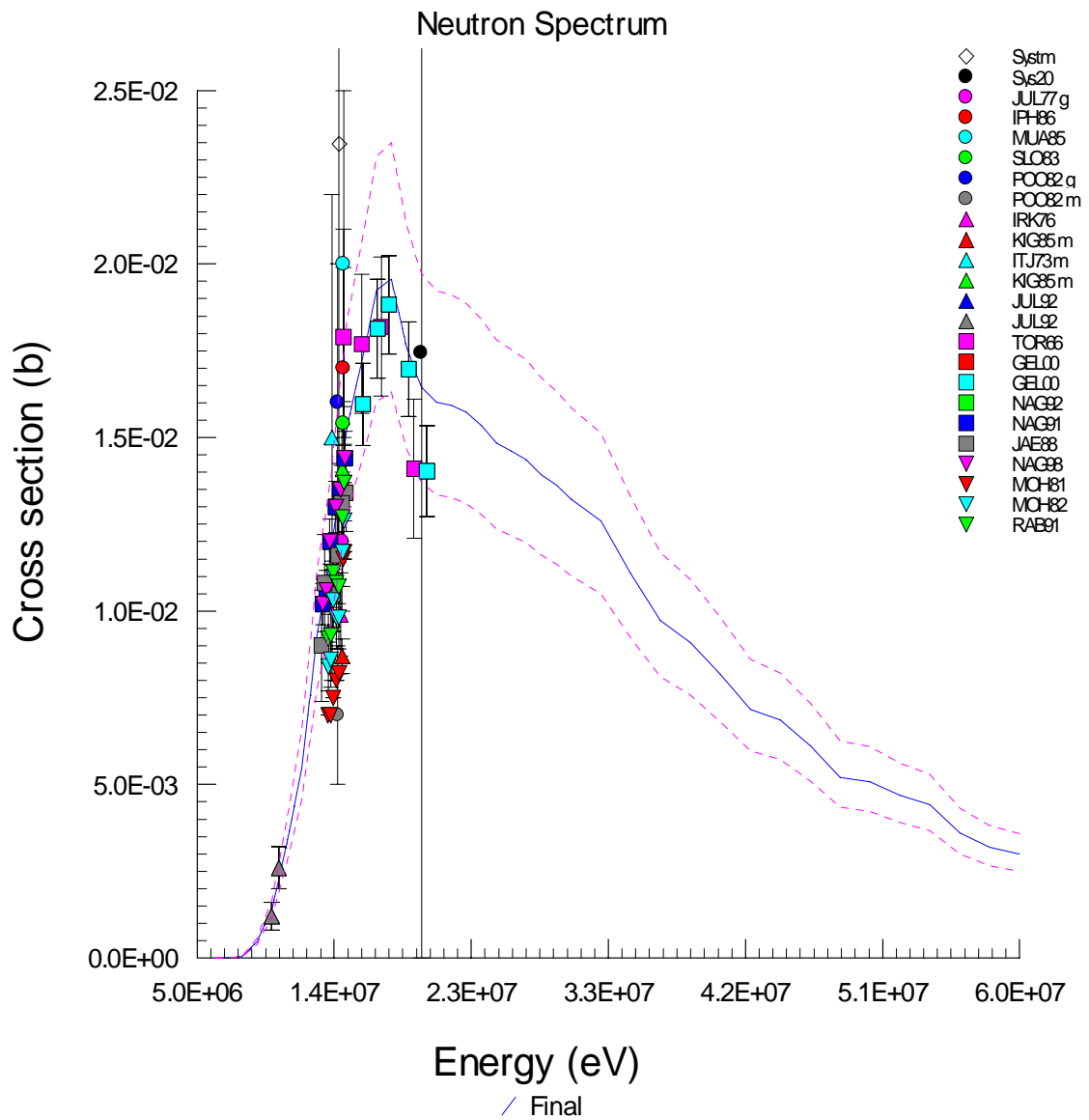
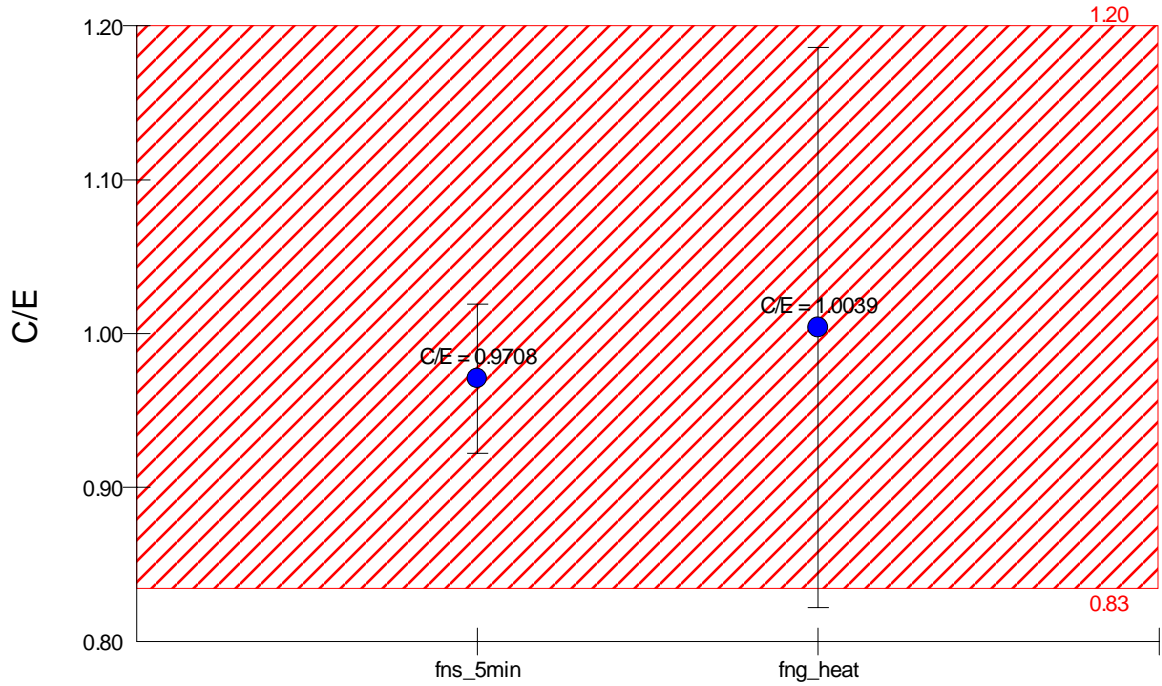




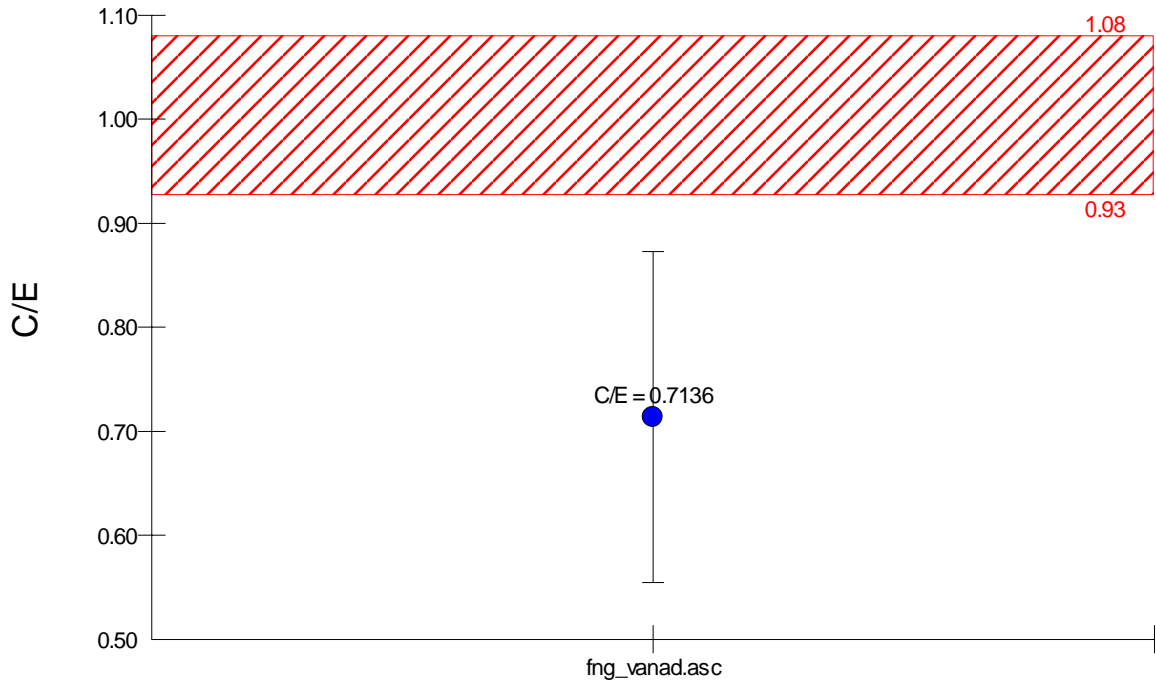
# $^{49}\text{Ti}(n,p)^{49}\text{Sc}$



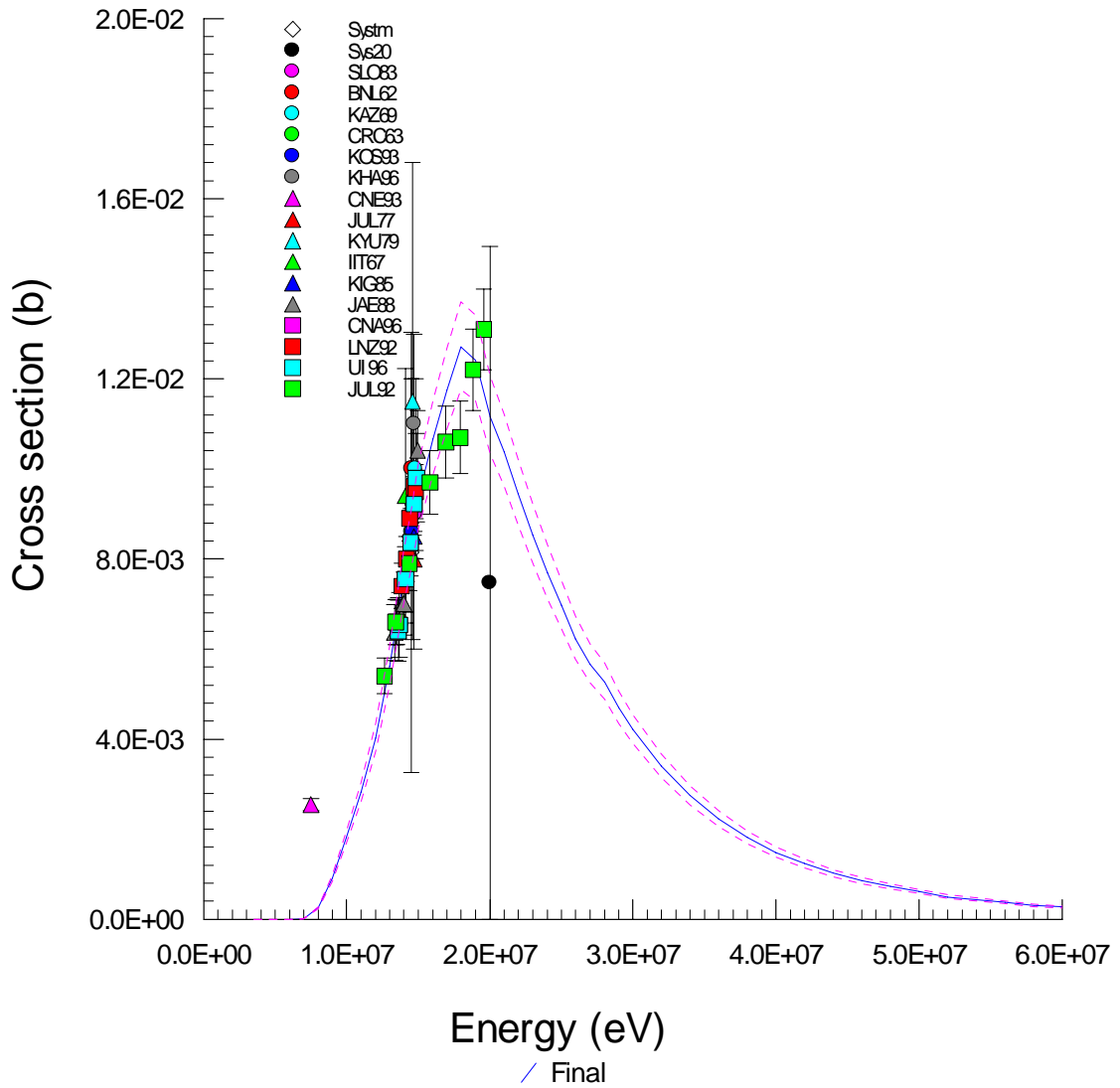
# $^{50}\text{Ti}(n,p)^{50}\text{Sc}$

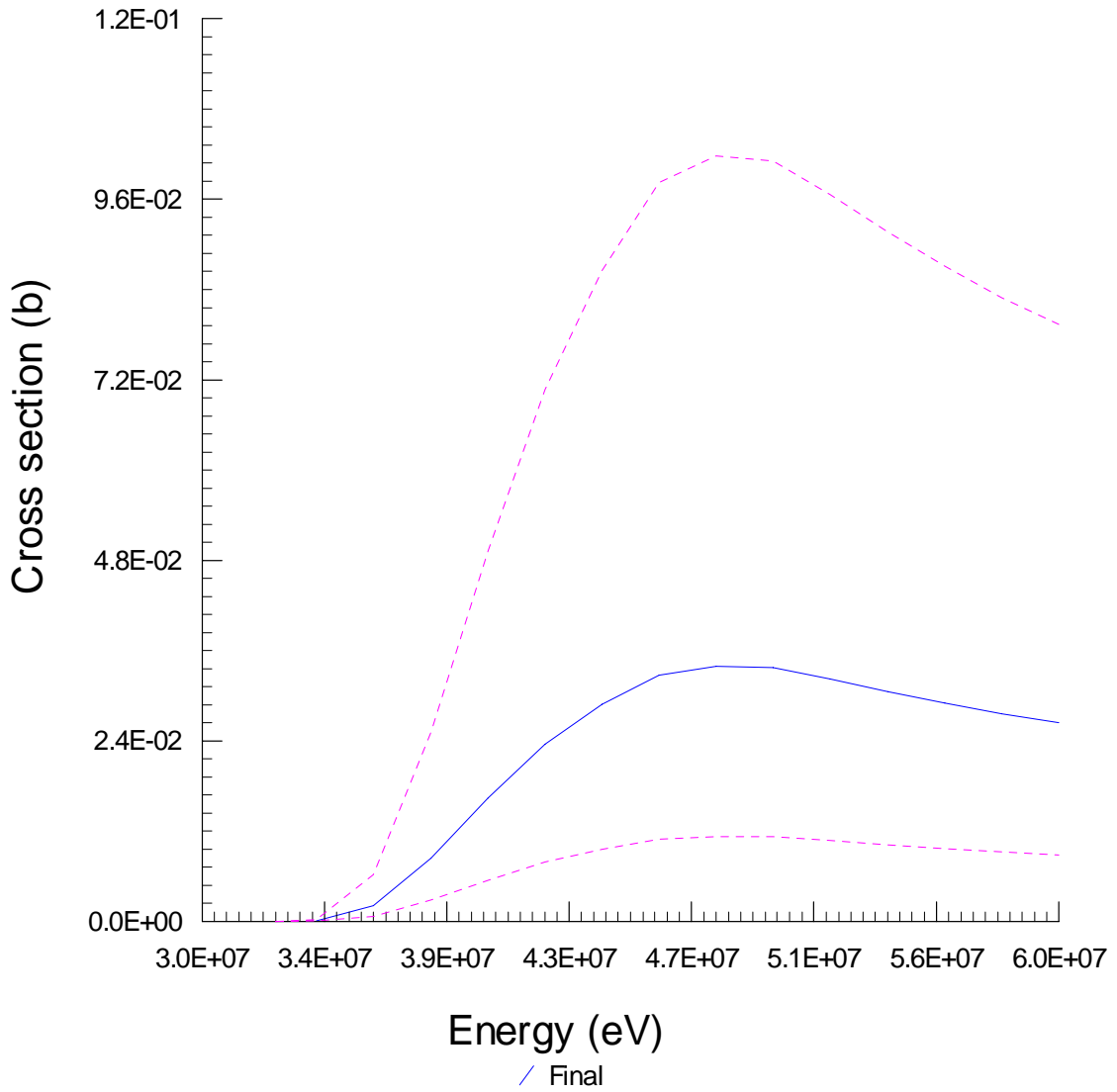
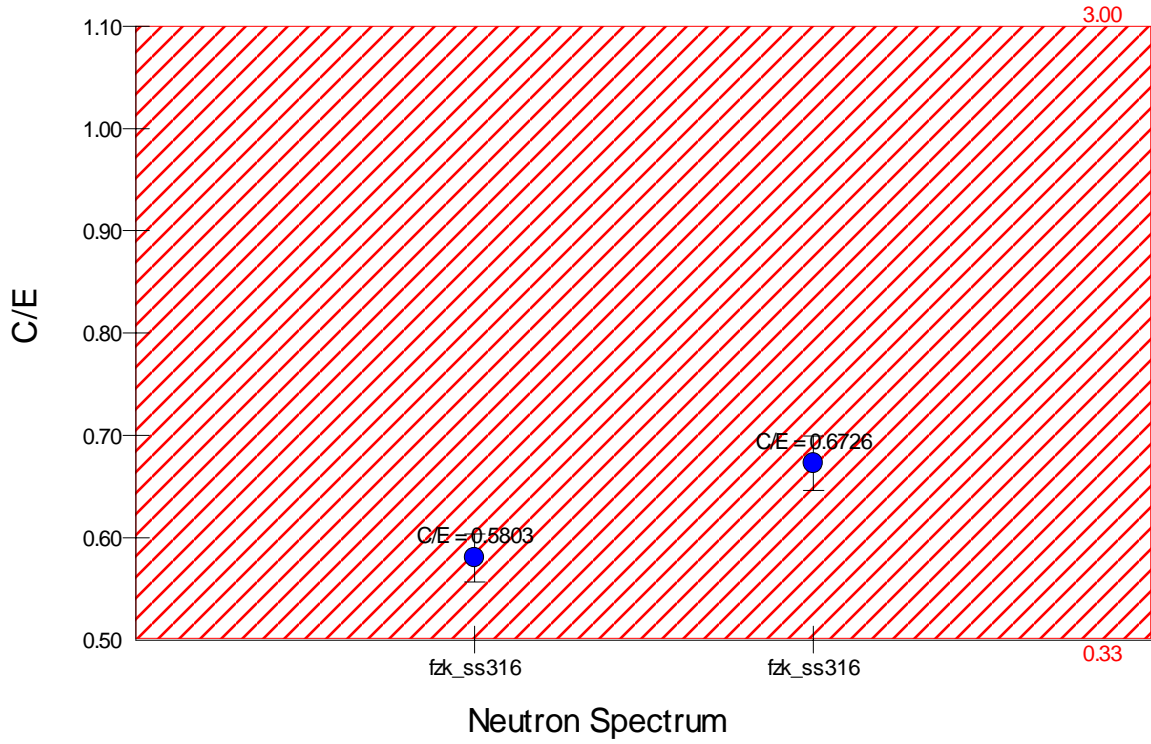
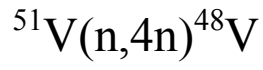


# $^{50}\text{Ti}(n,\alpha)^{47}\text{Ca}$

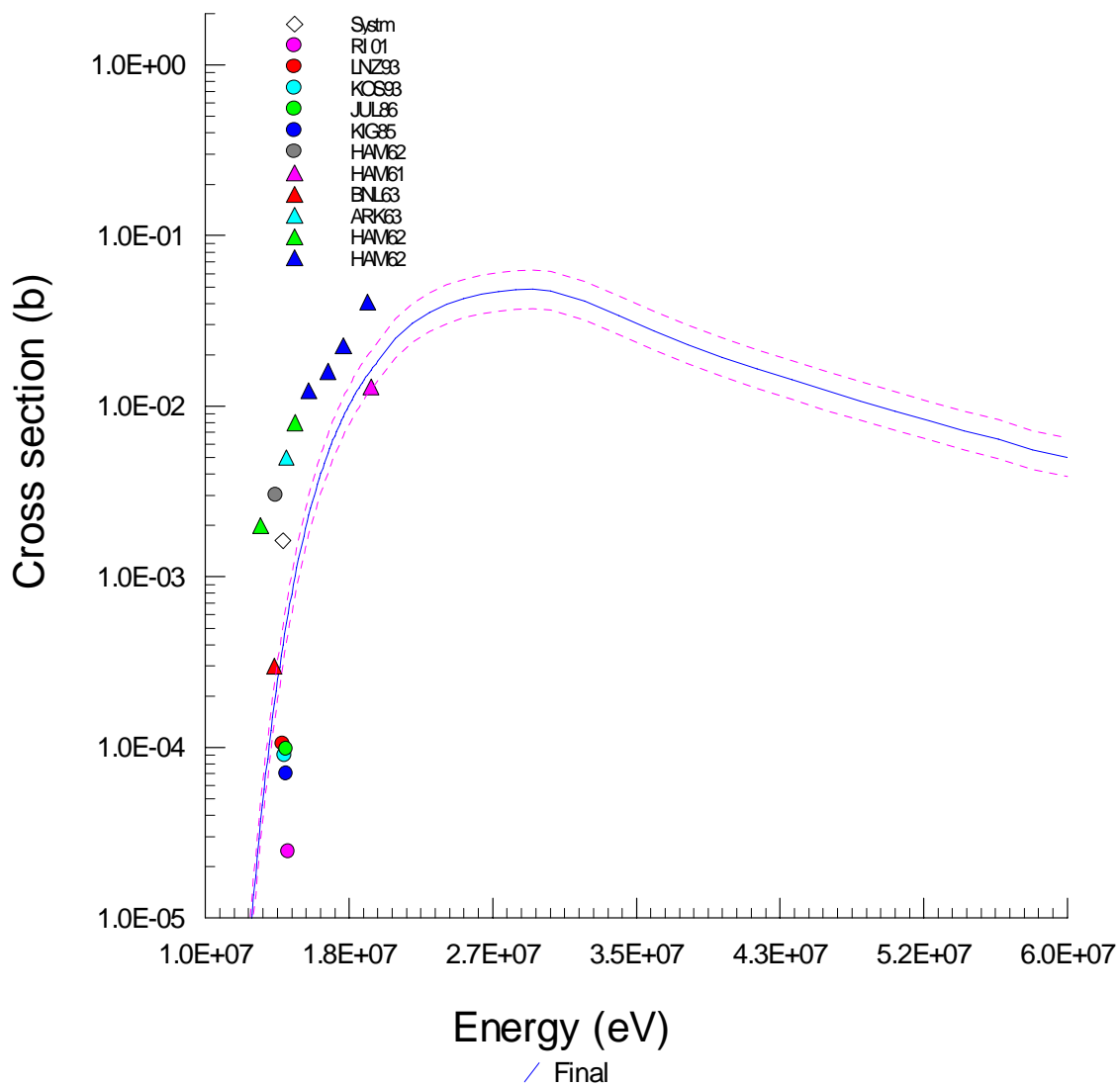
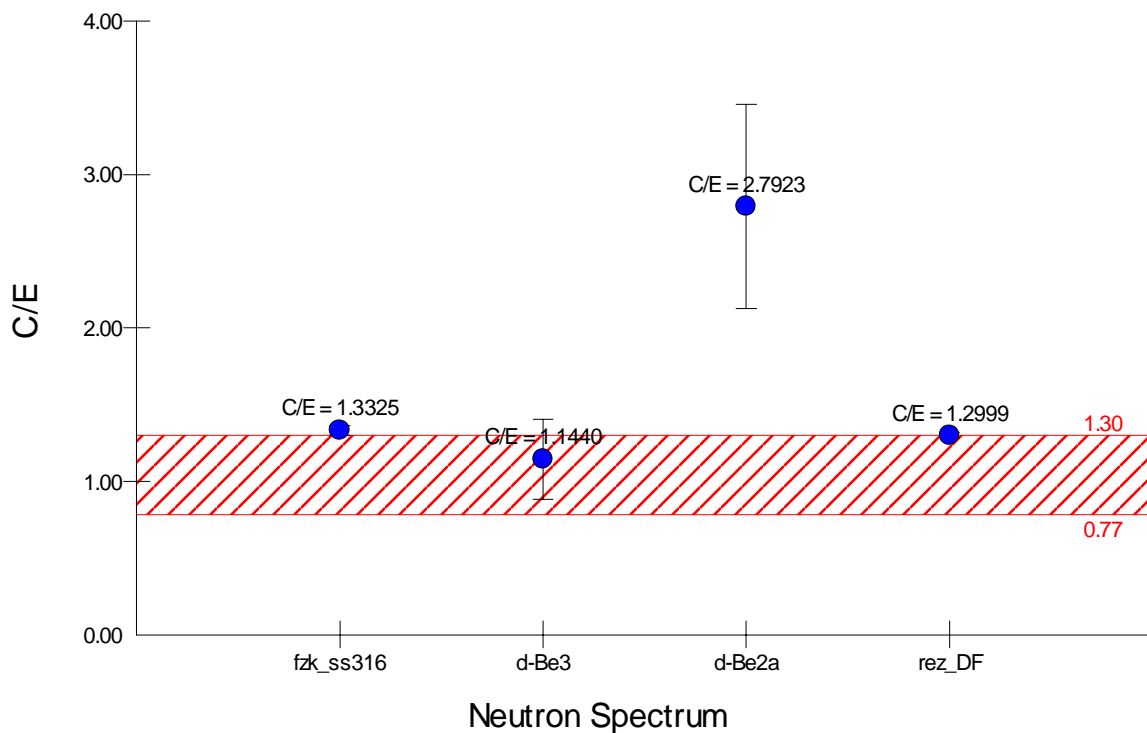


## Neutron Spectrum

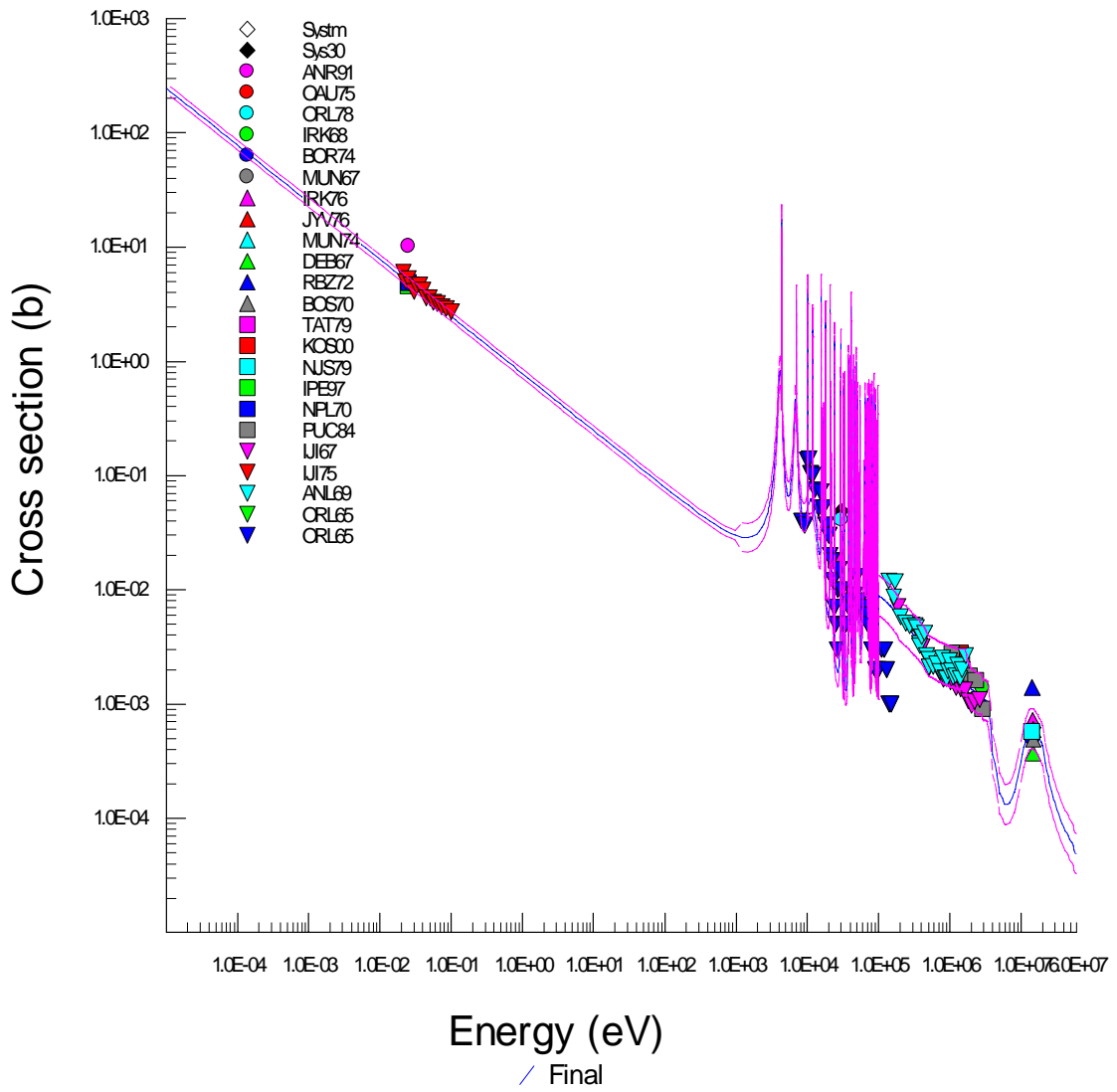
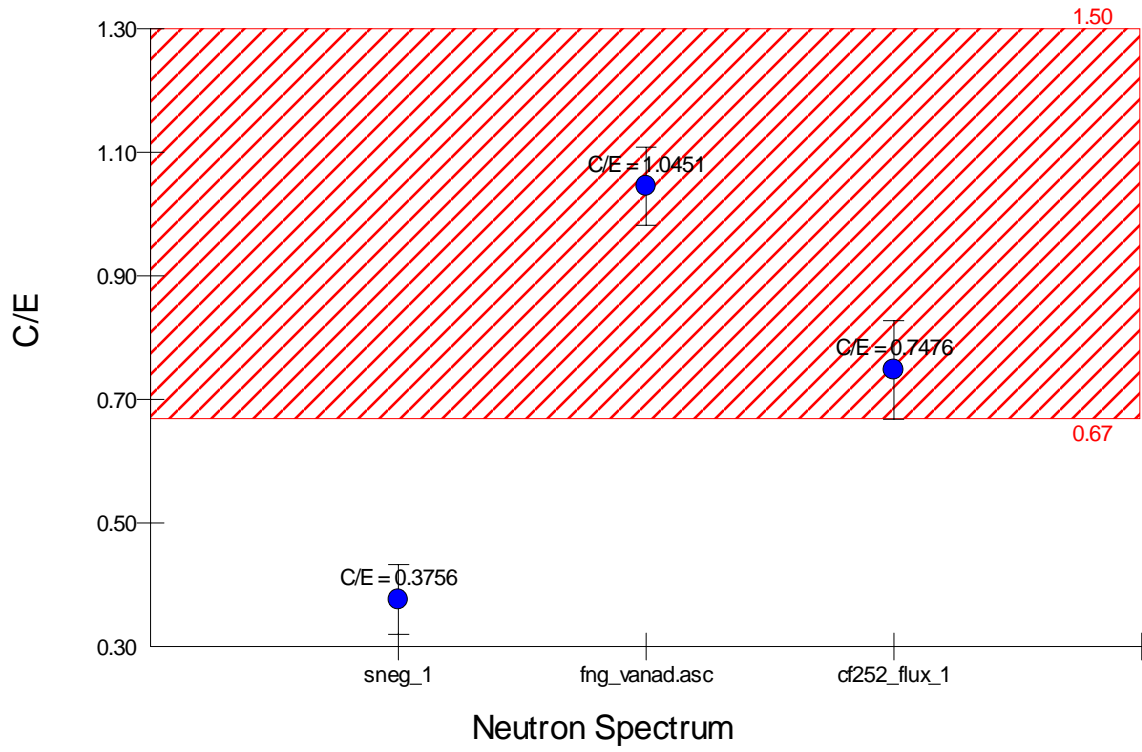
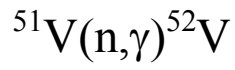




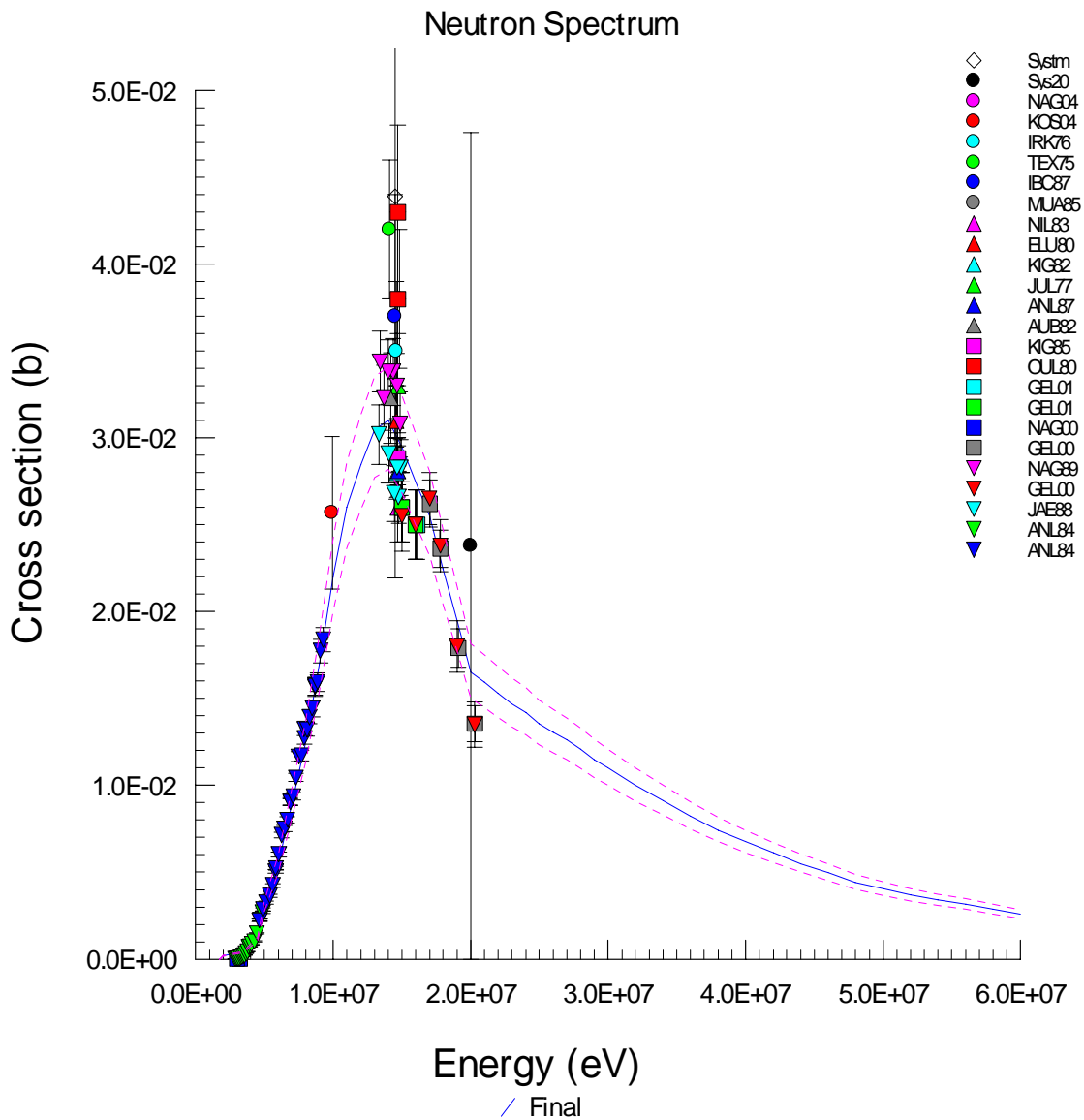
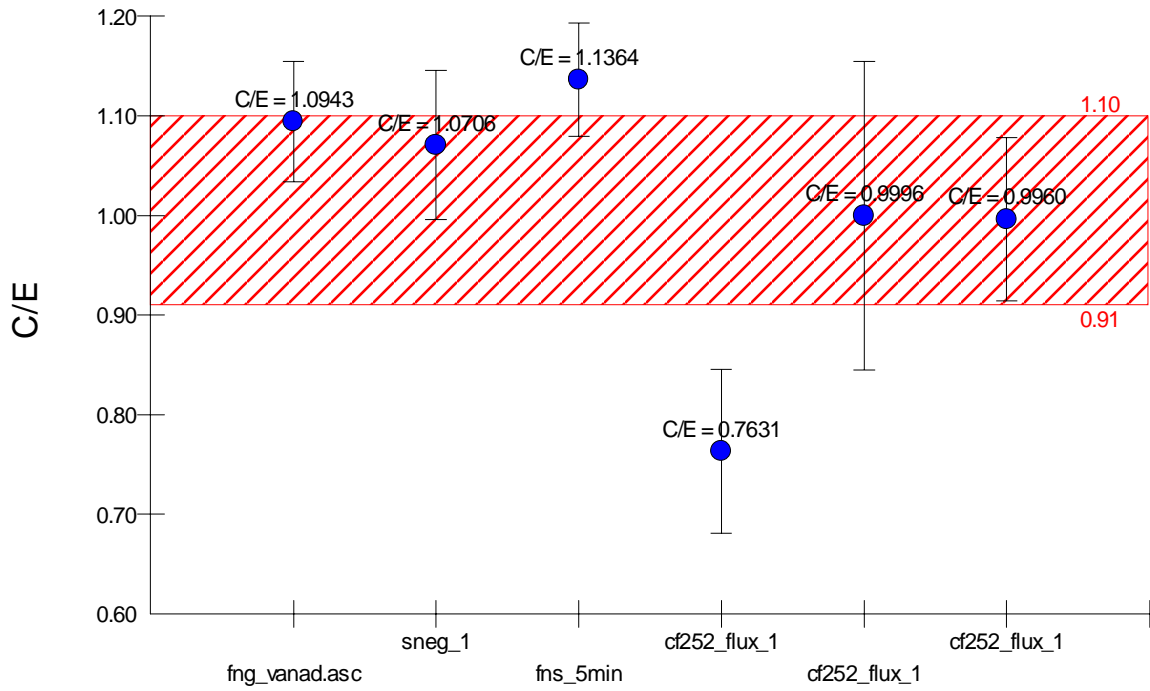
# $^{51}\text{V}(n,n'\alpha)^{47}\text{Sc}$

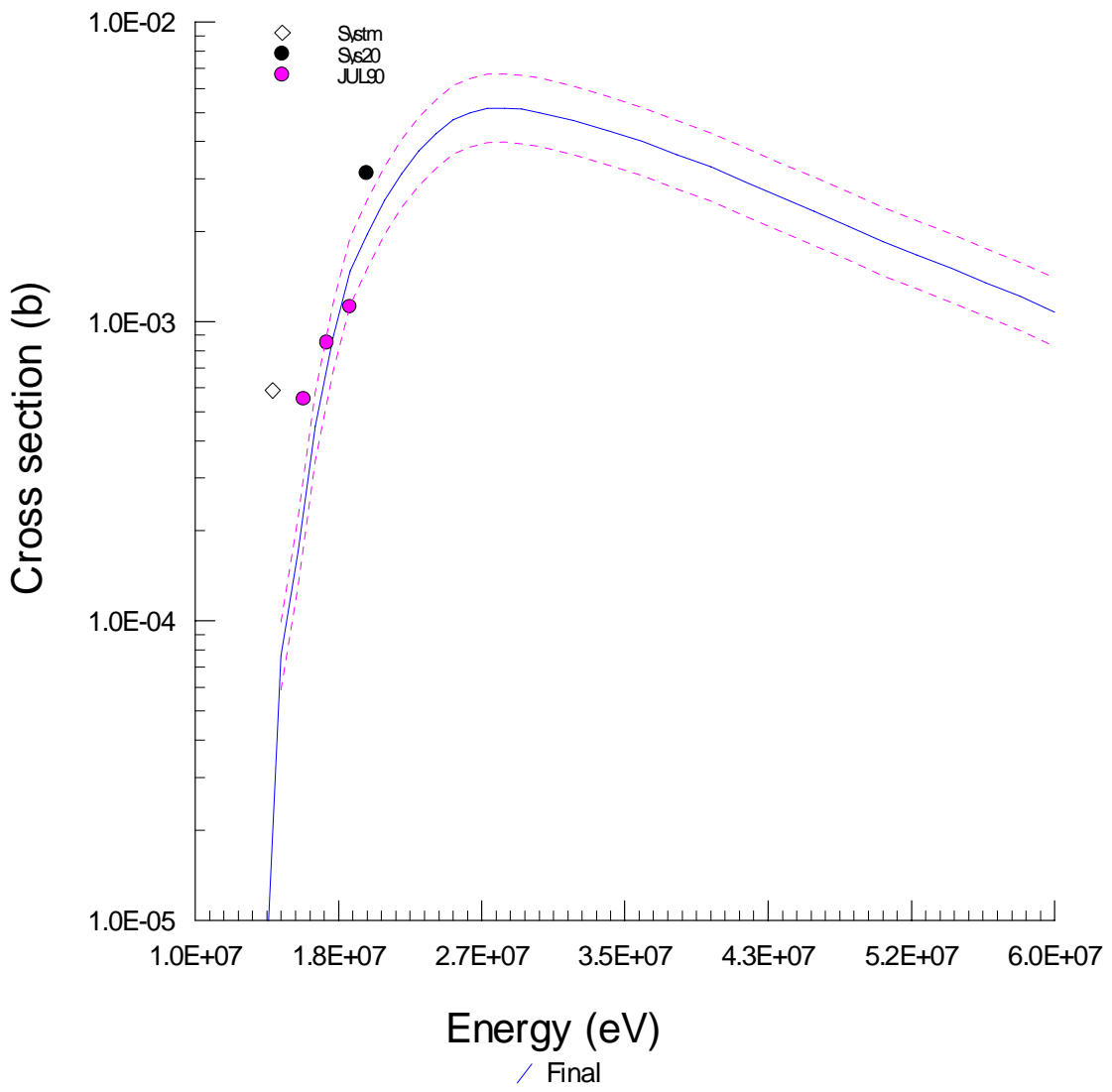
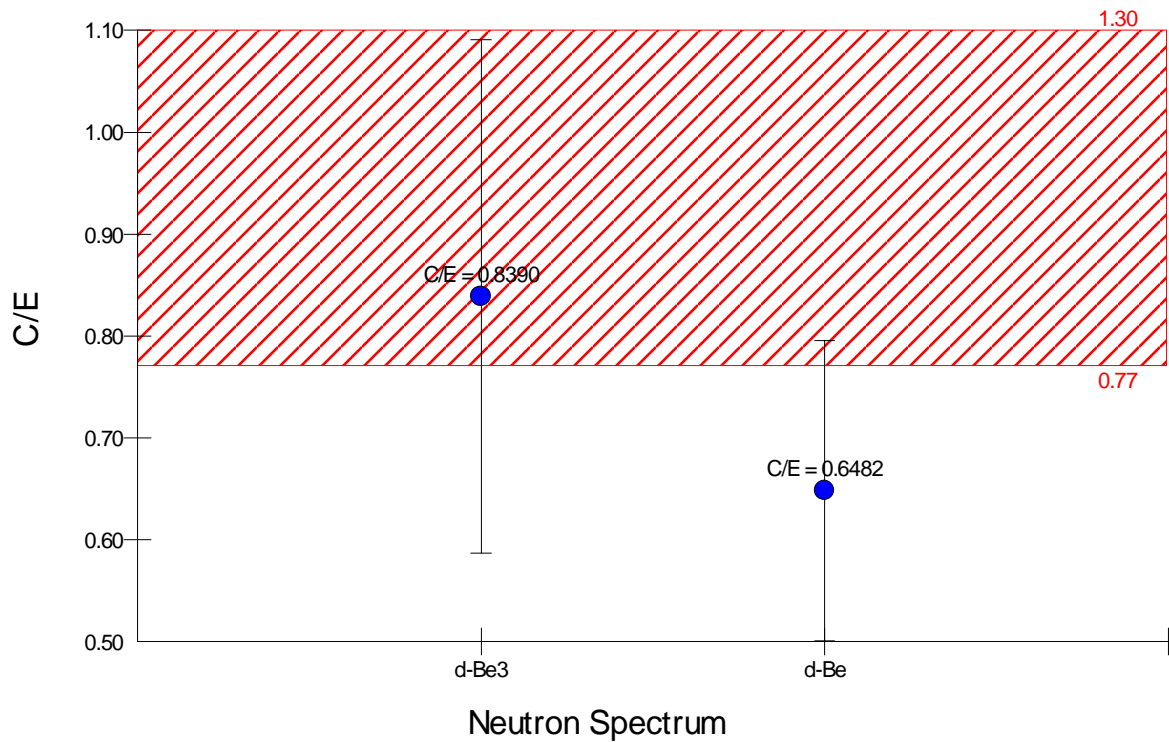
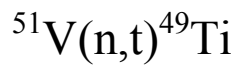




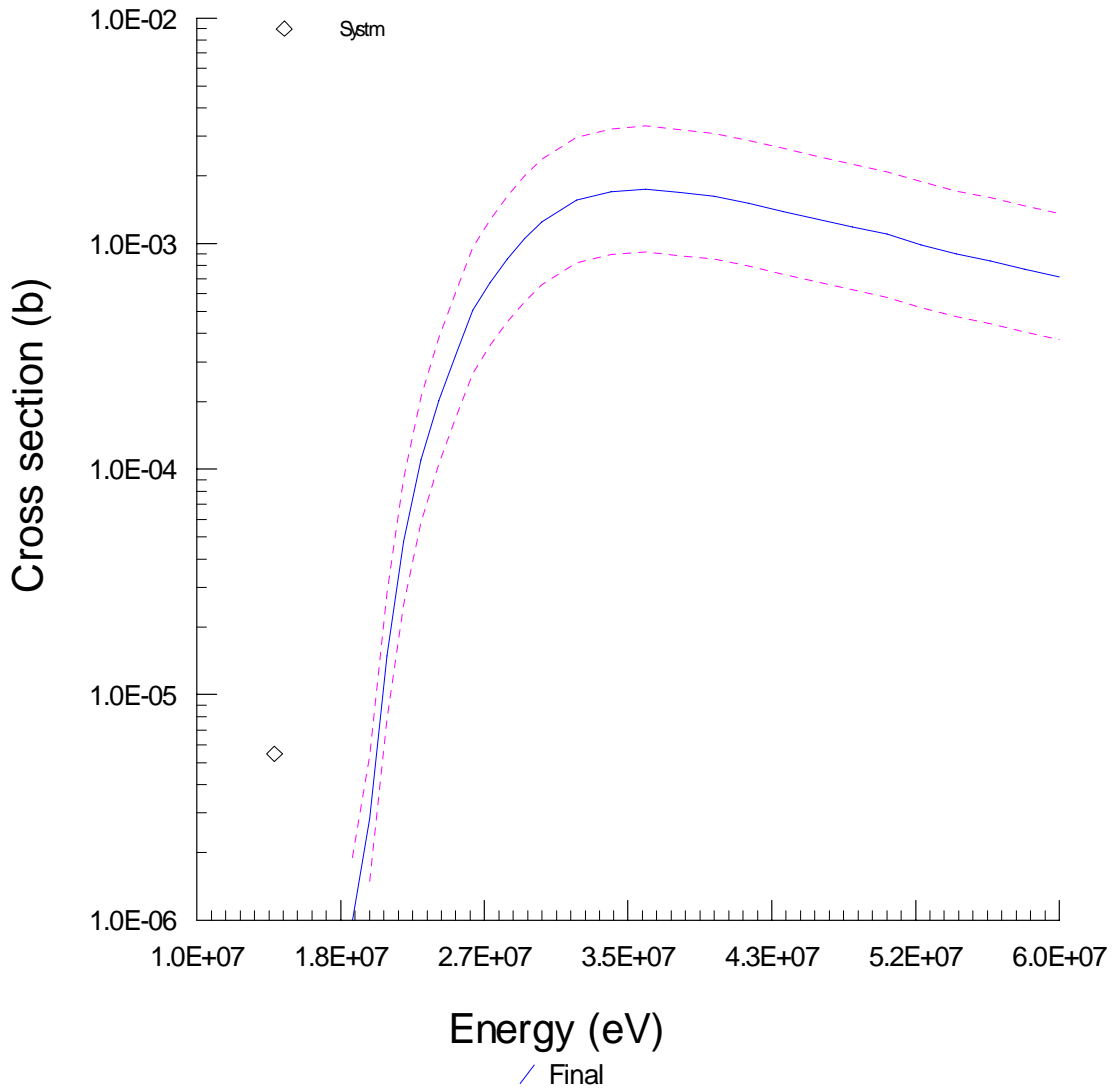
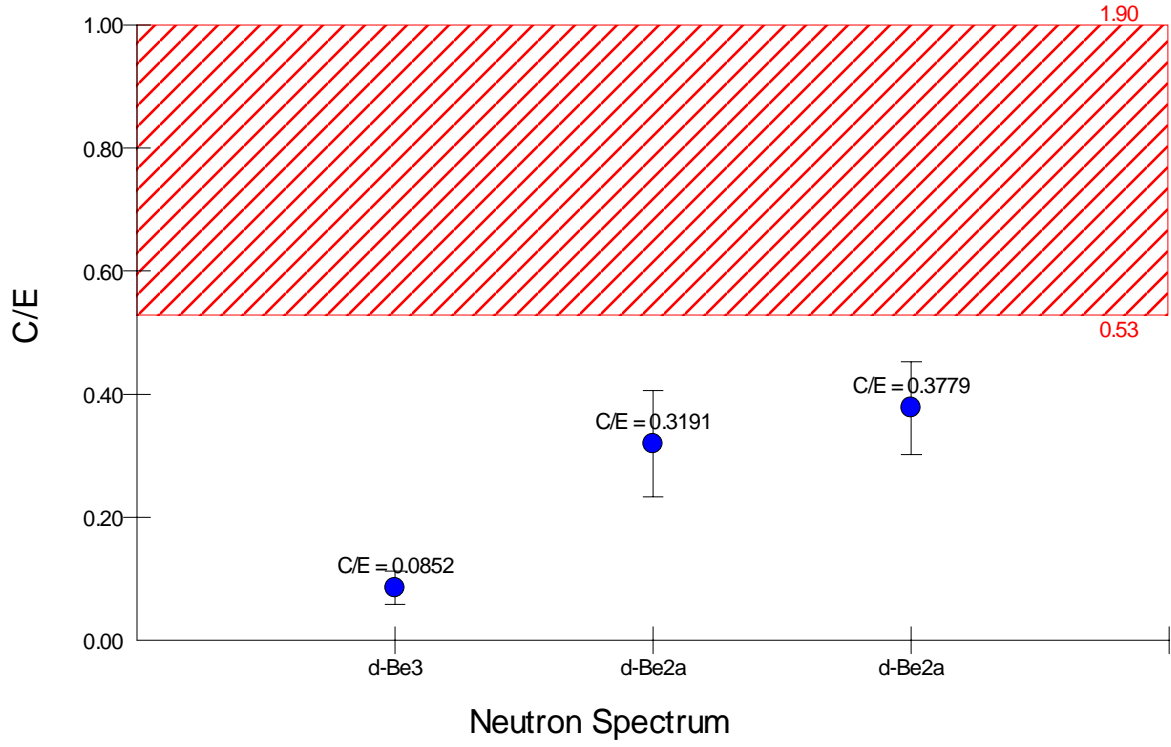


# $^{51}\text{V}(n,p)^{51}\text{Ti}$

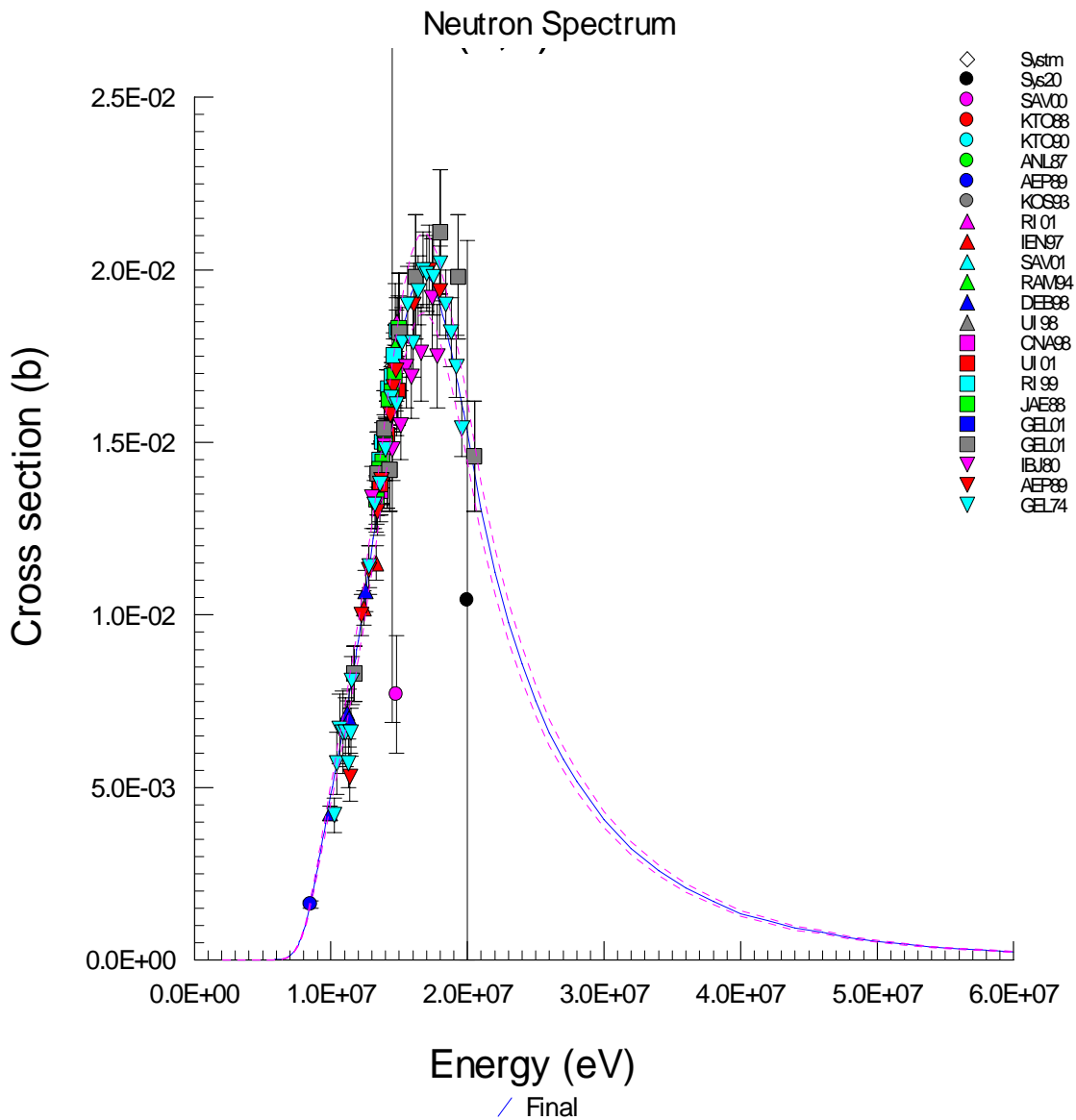
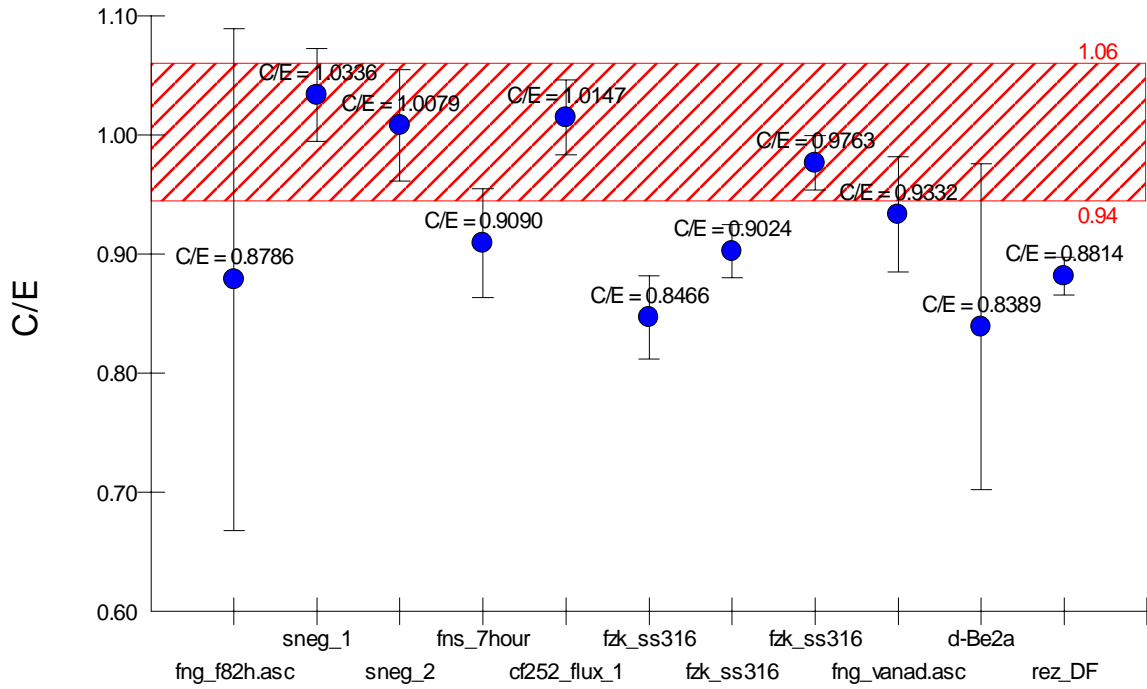




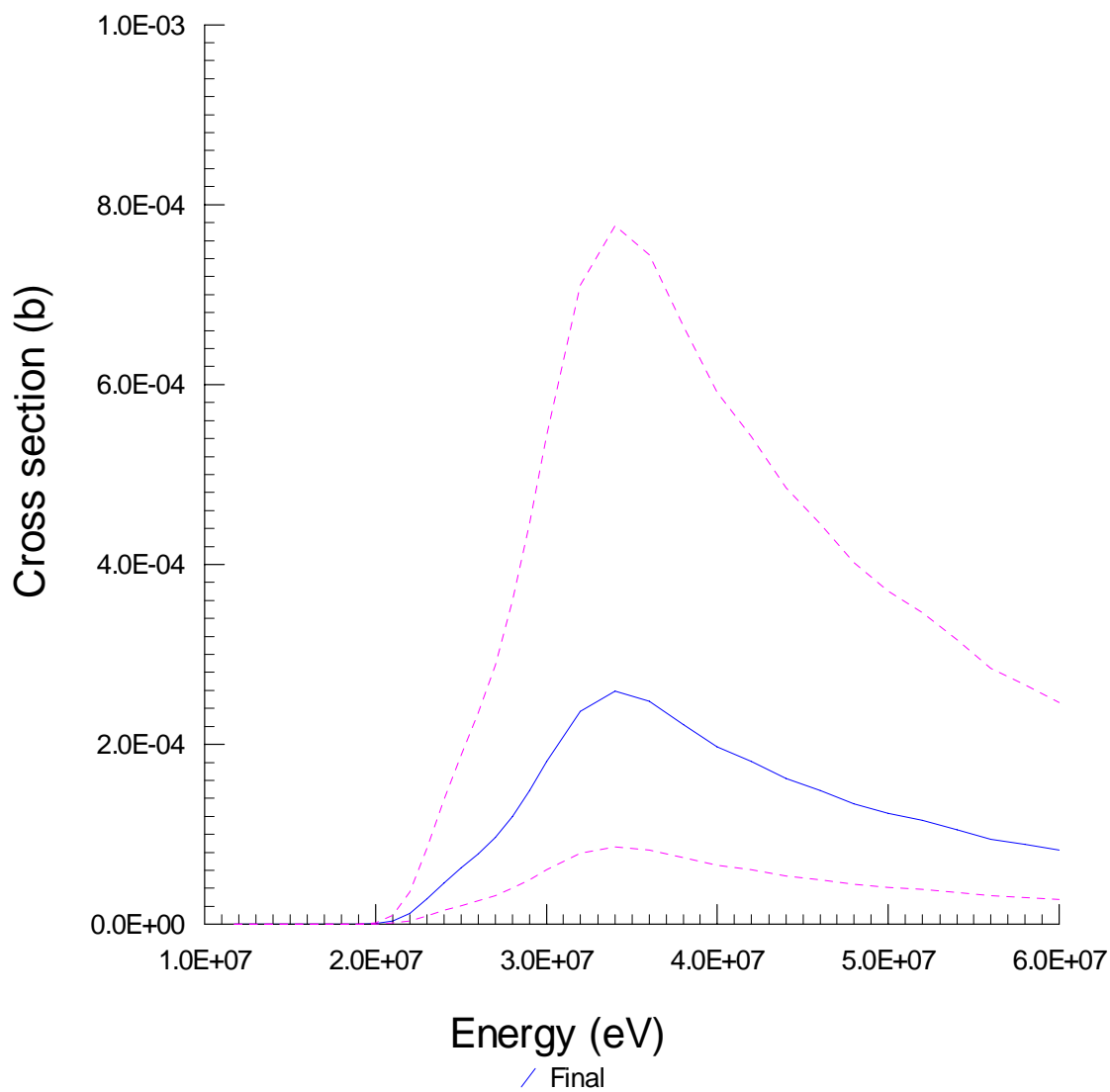
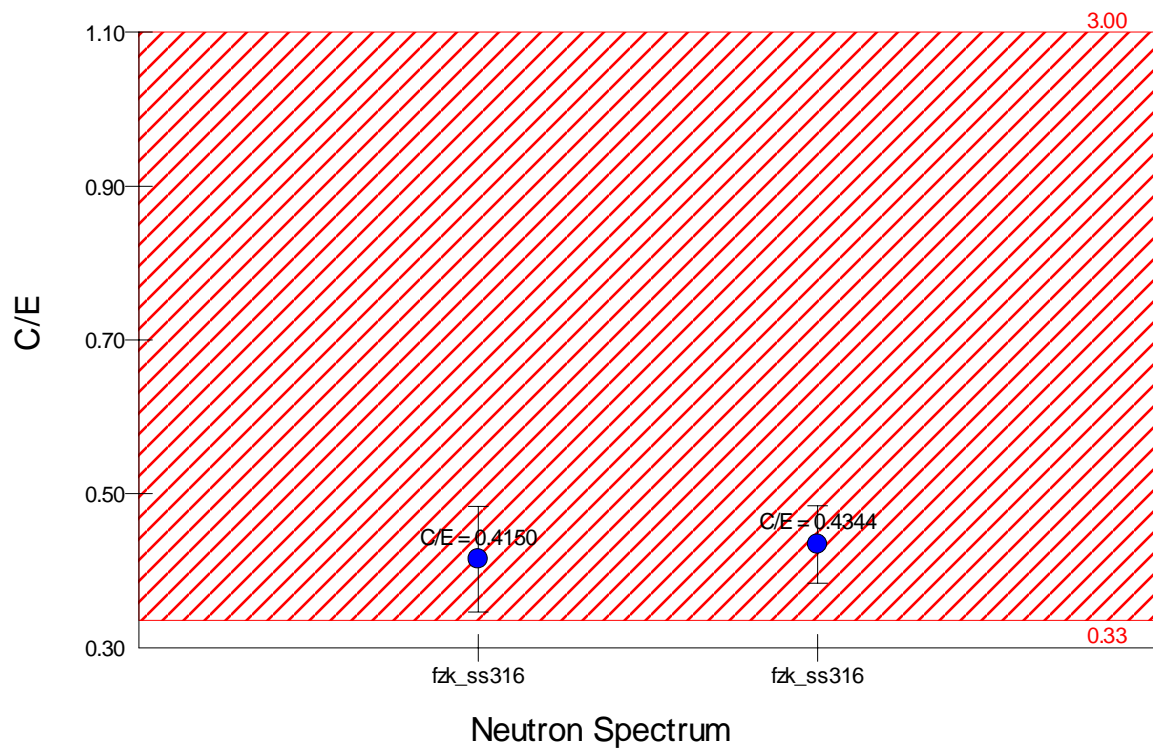
$^{51}\text{V}(n,h)^{49}\text{Sc}$

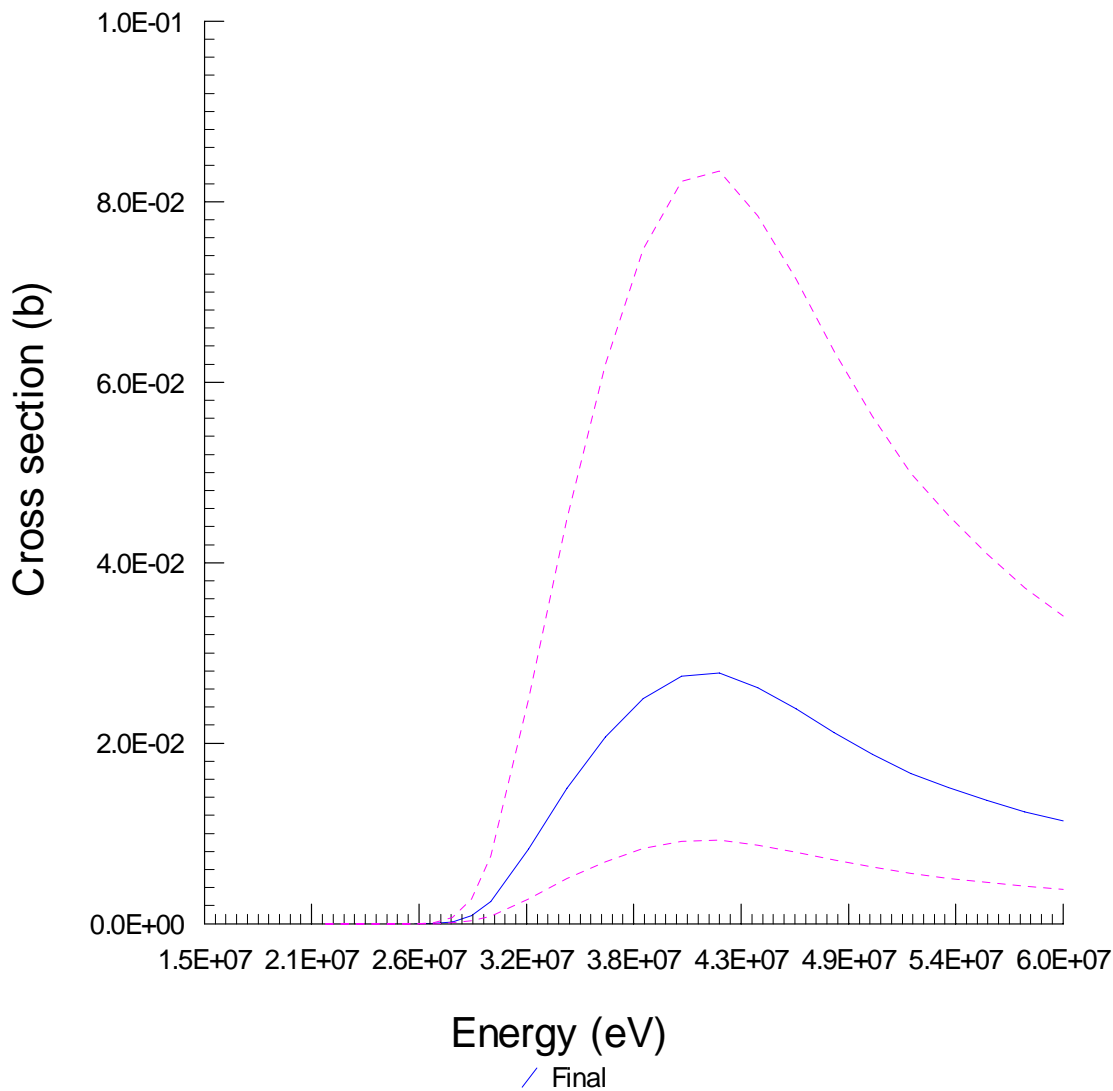
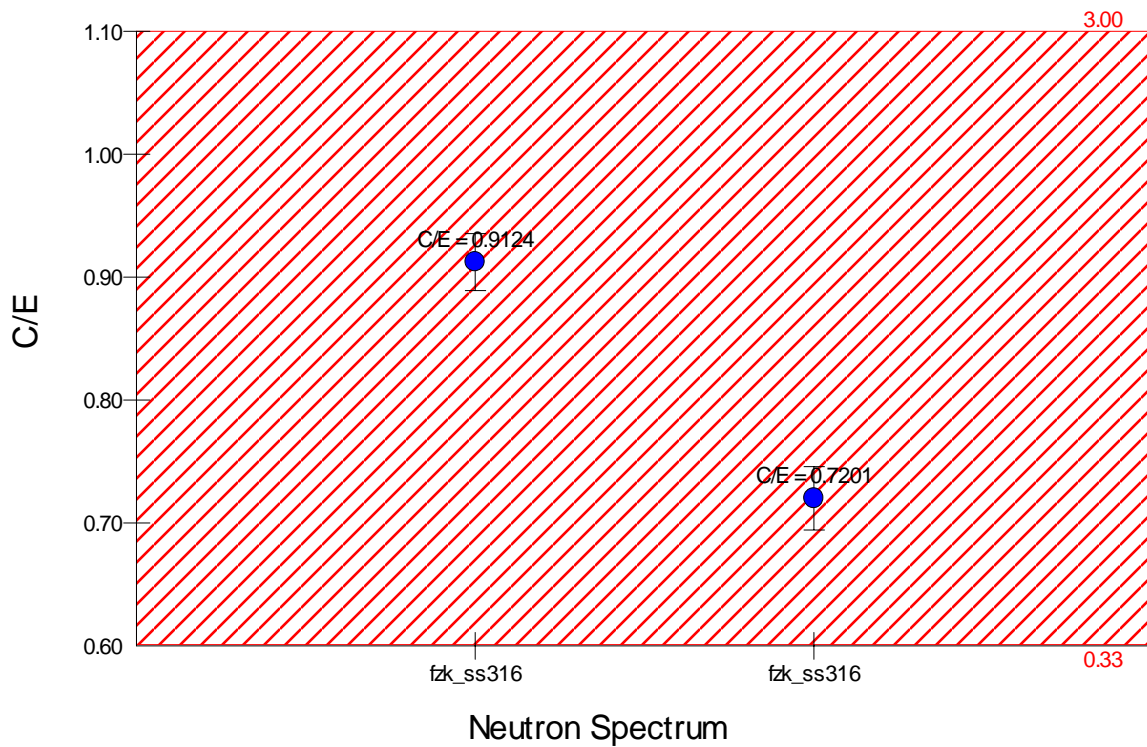
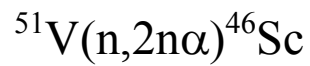


# $^{51}\text{V}(n,\alpha)^{48}\text{Sc} \blacktriangleright 545$

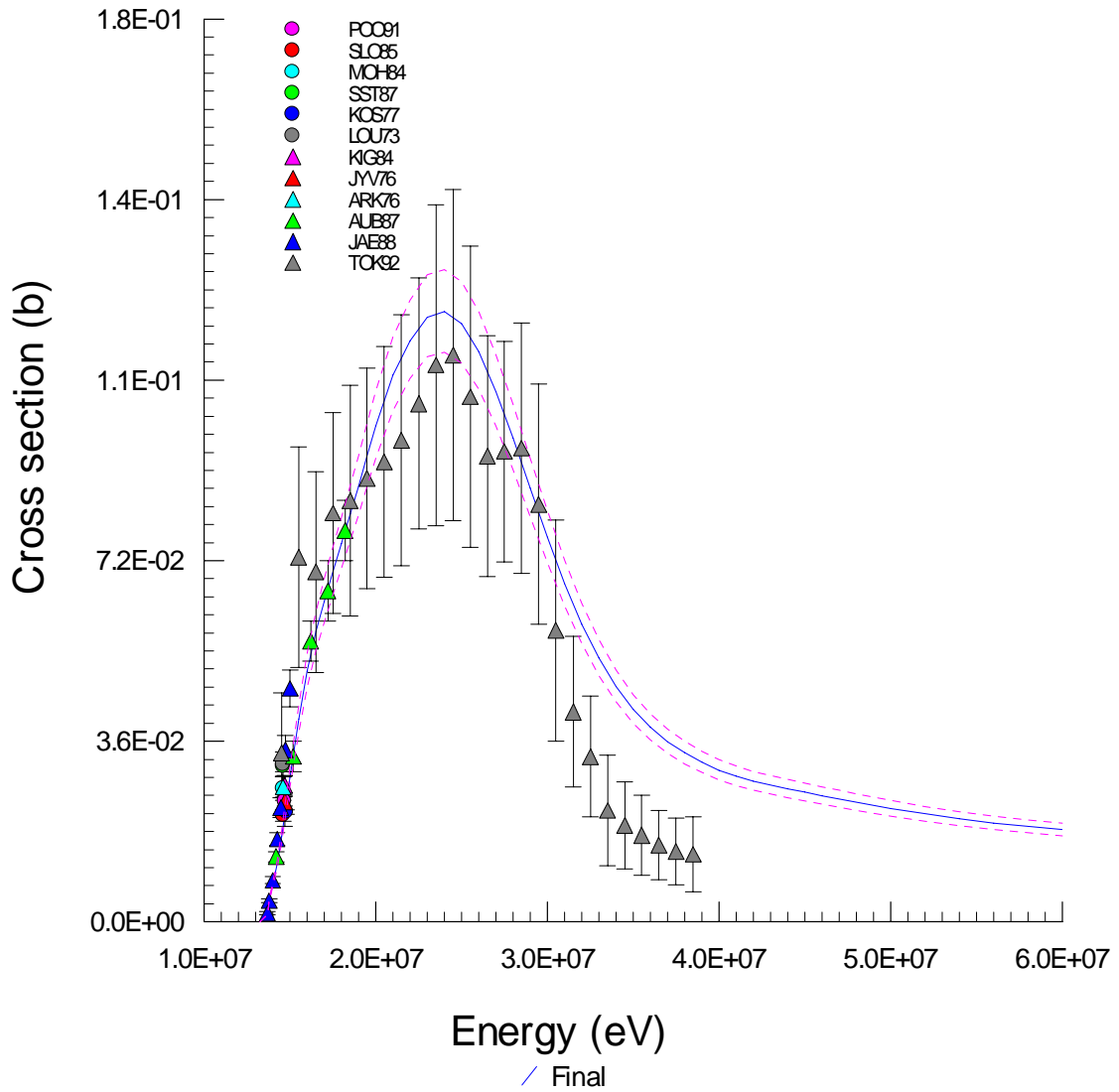
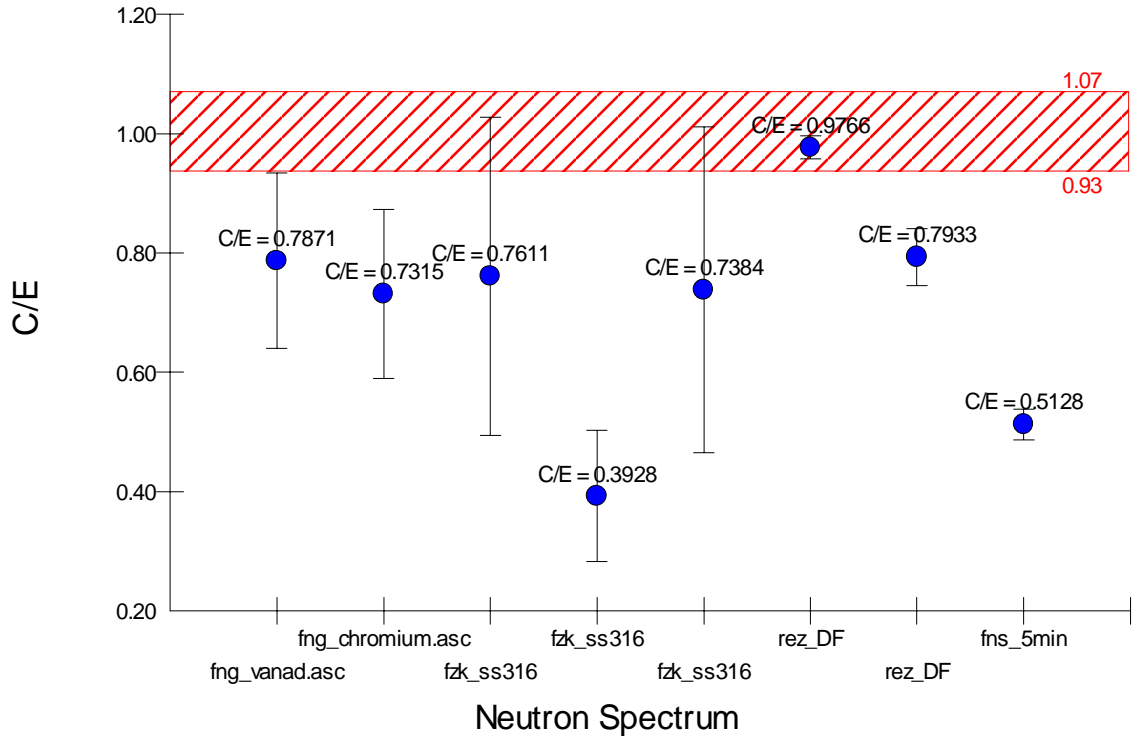


# $^{51}\text{V}(n,p\alpha)^{47}\text{Ca}$



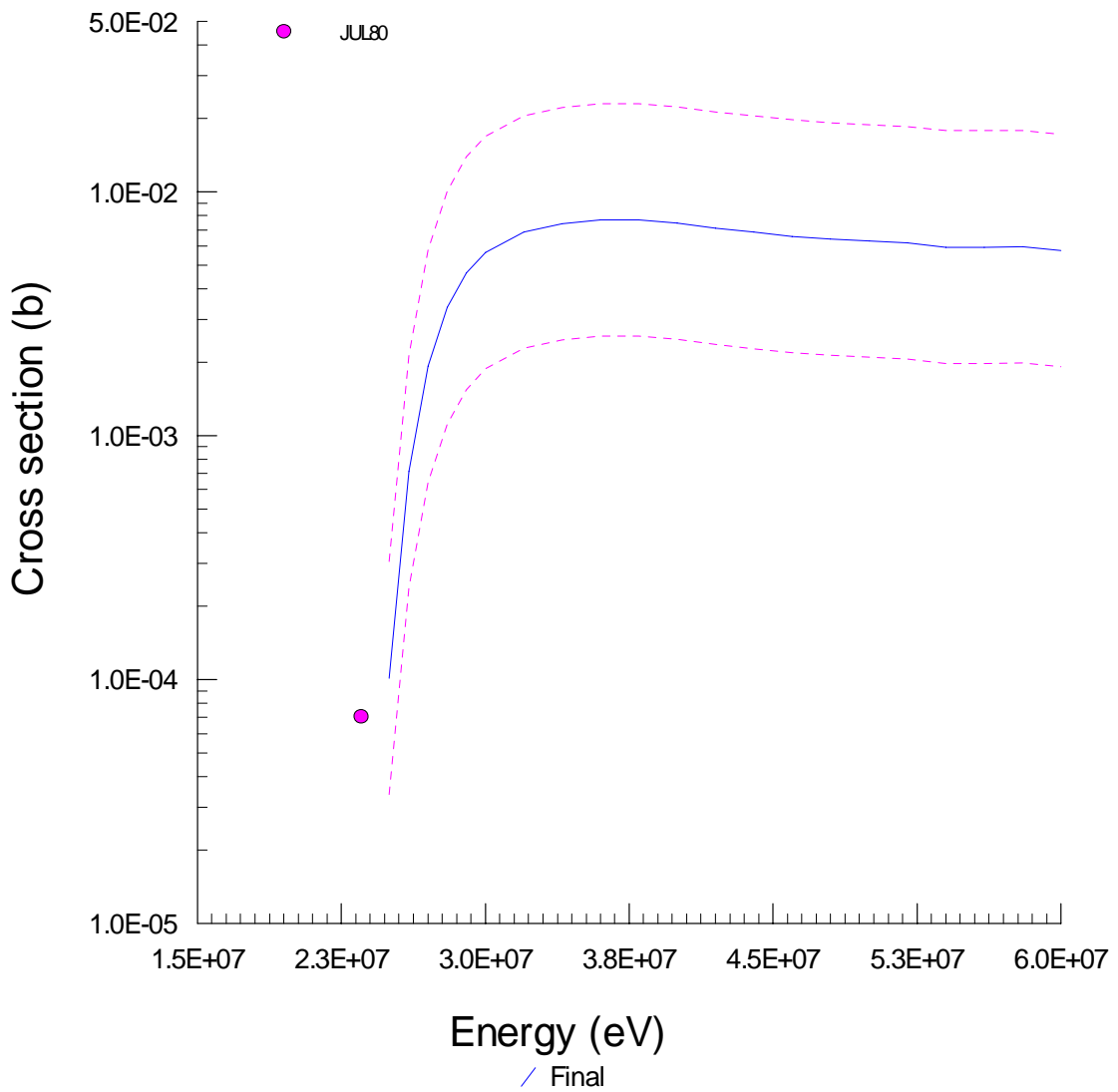
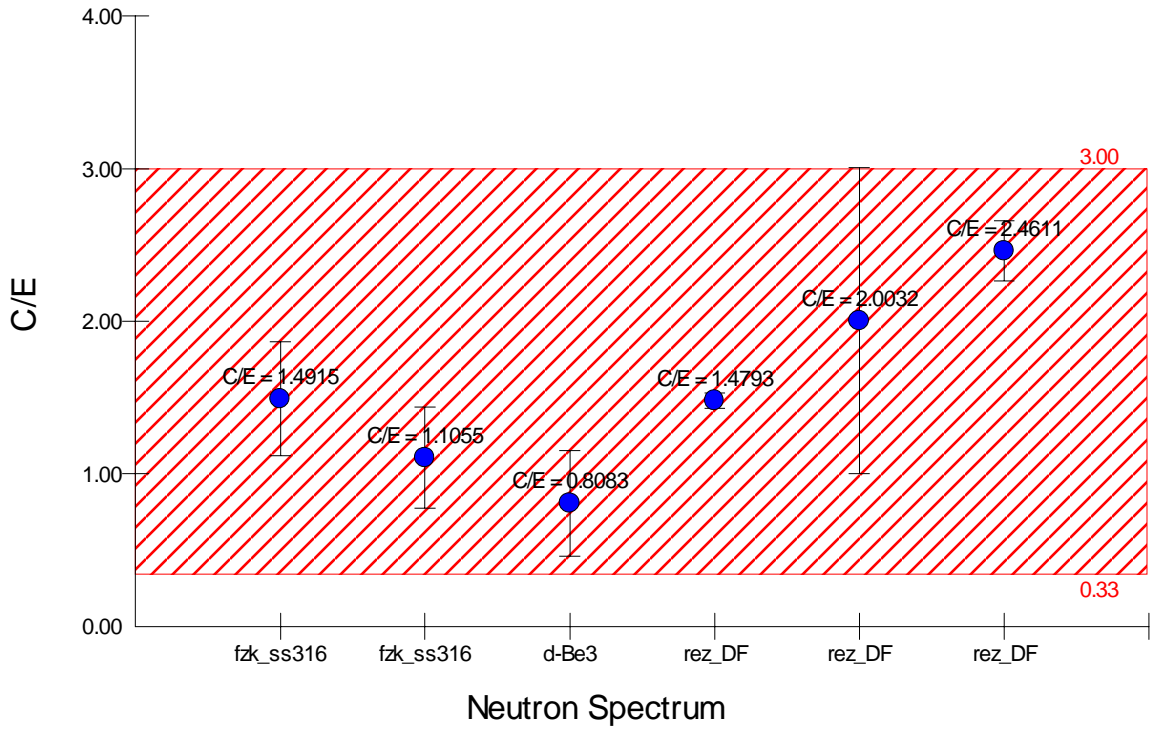


$^{50}\text{Cr}(n,2n)^{49}\text{Cr} \blacktriangleright 546$

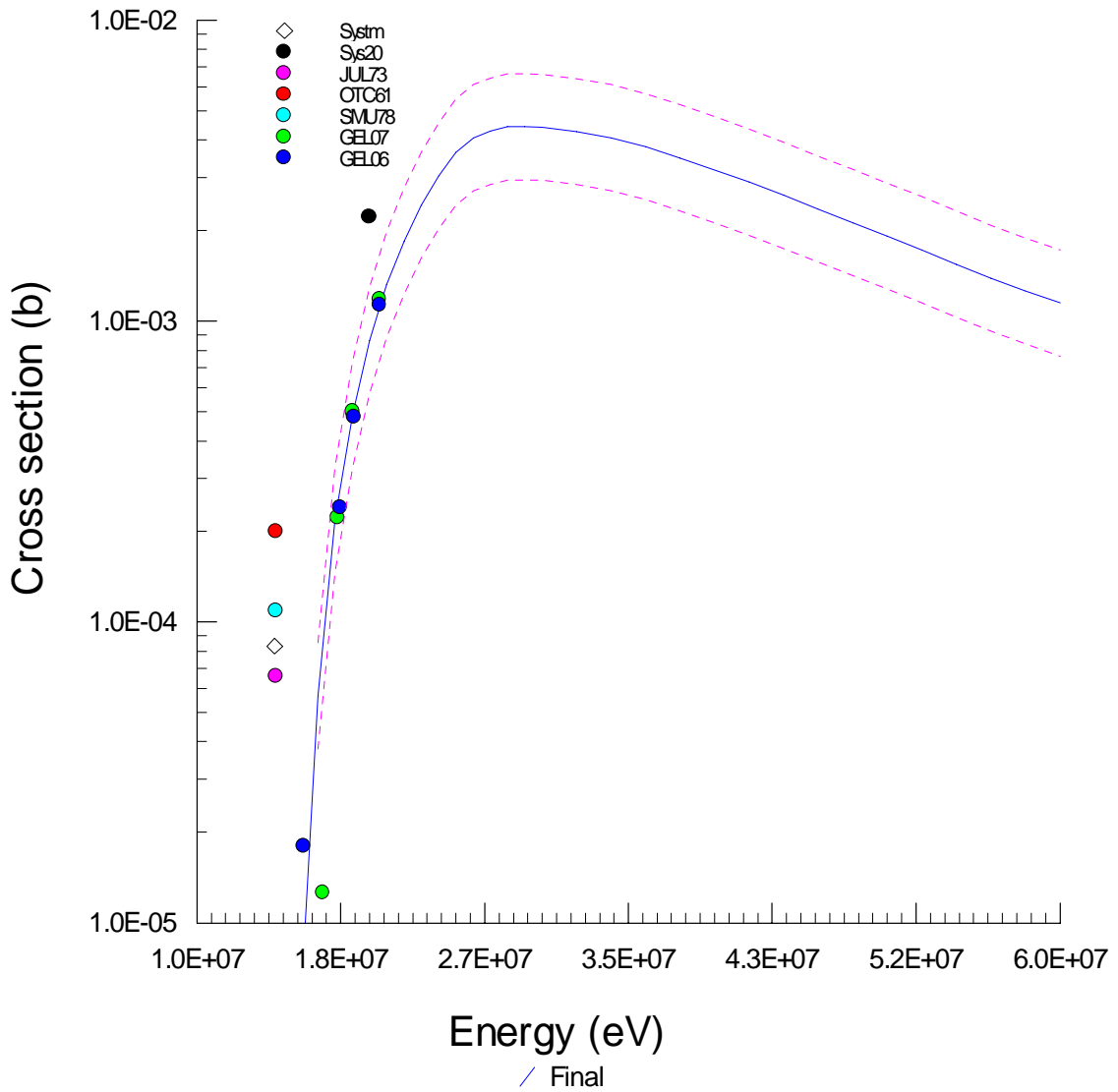
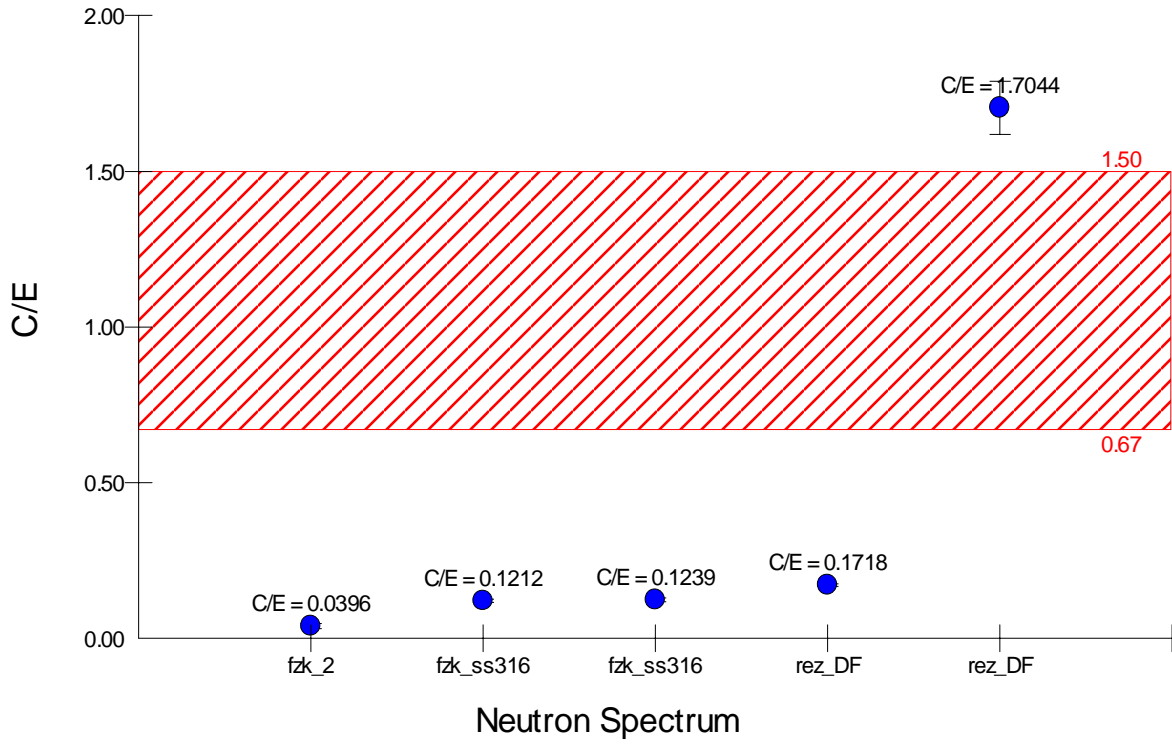


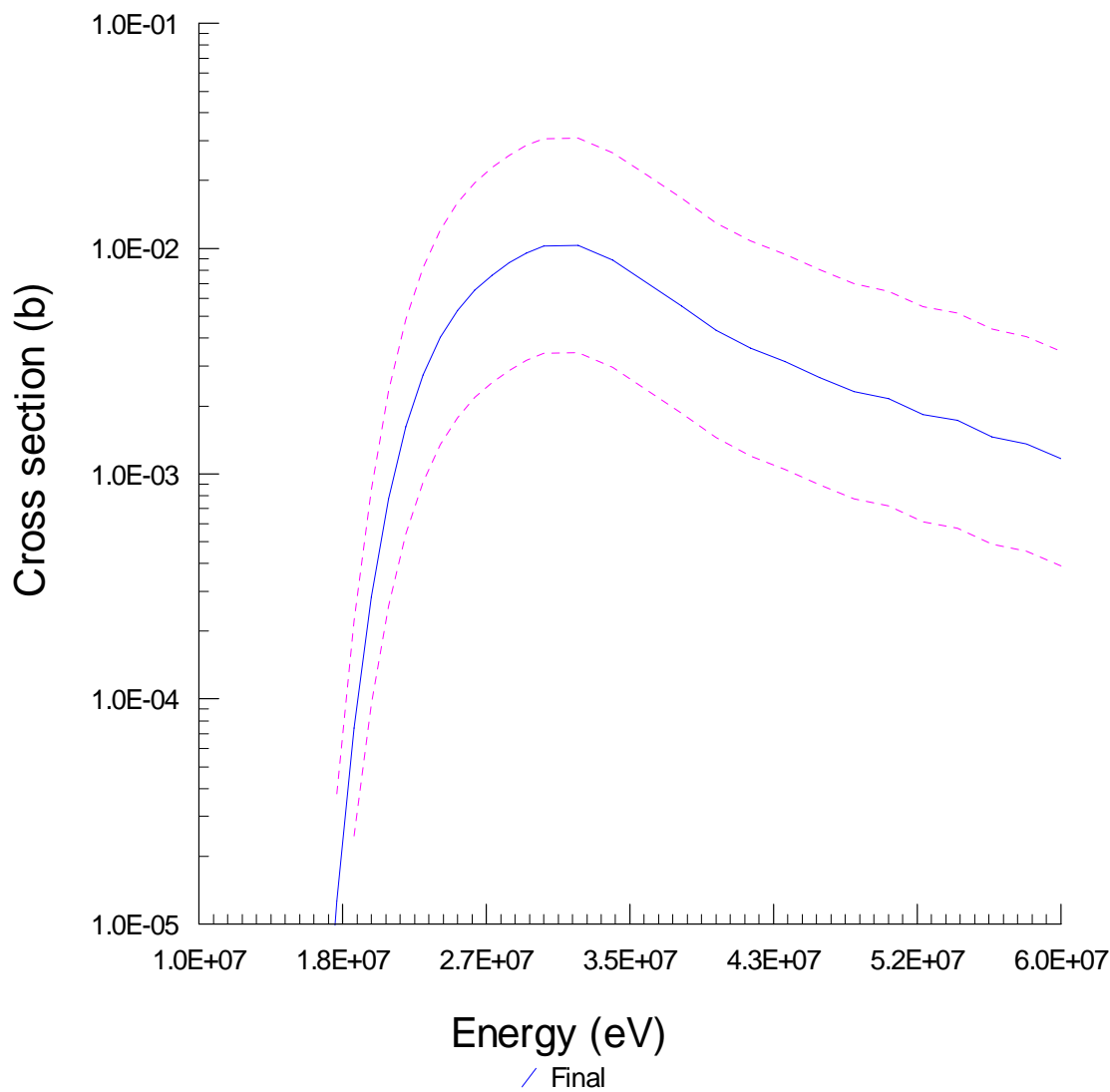
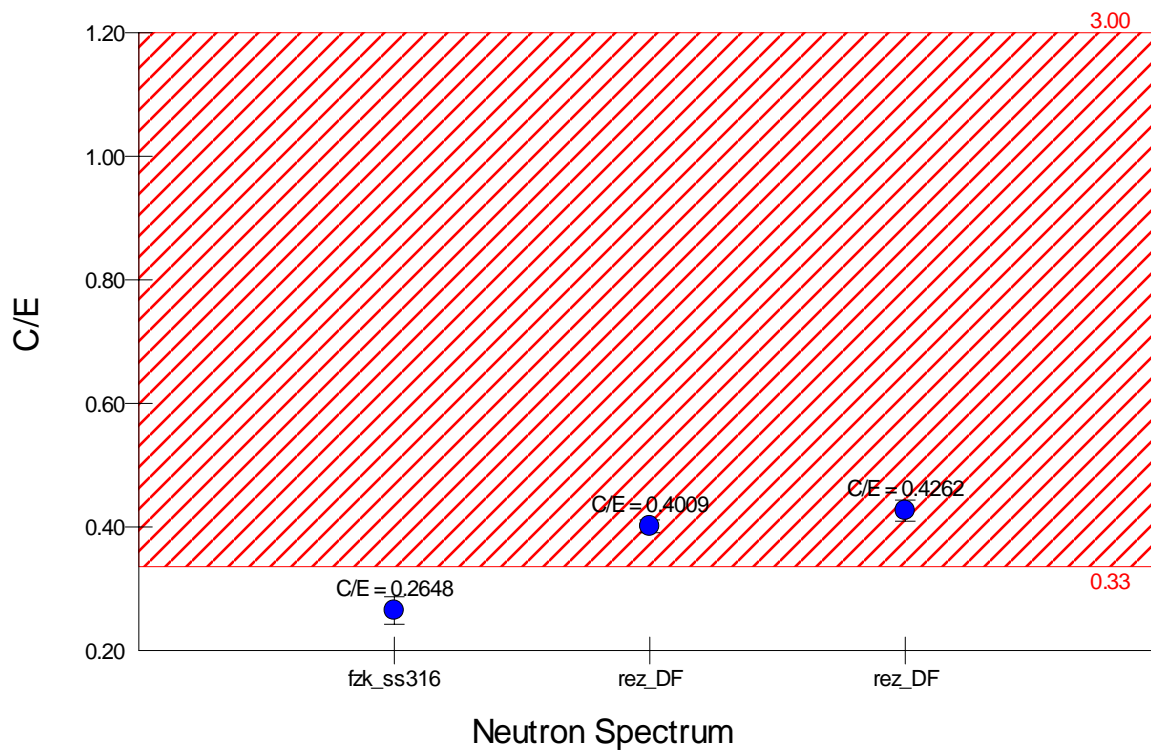


$^{50}\text{Cr}(n,3n)^{48}\text{Cr} \blacktriangleright 546$

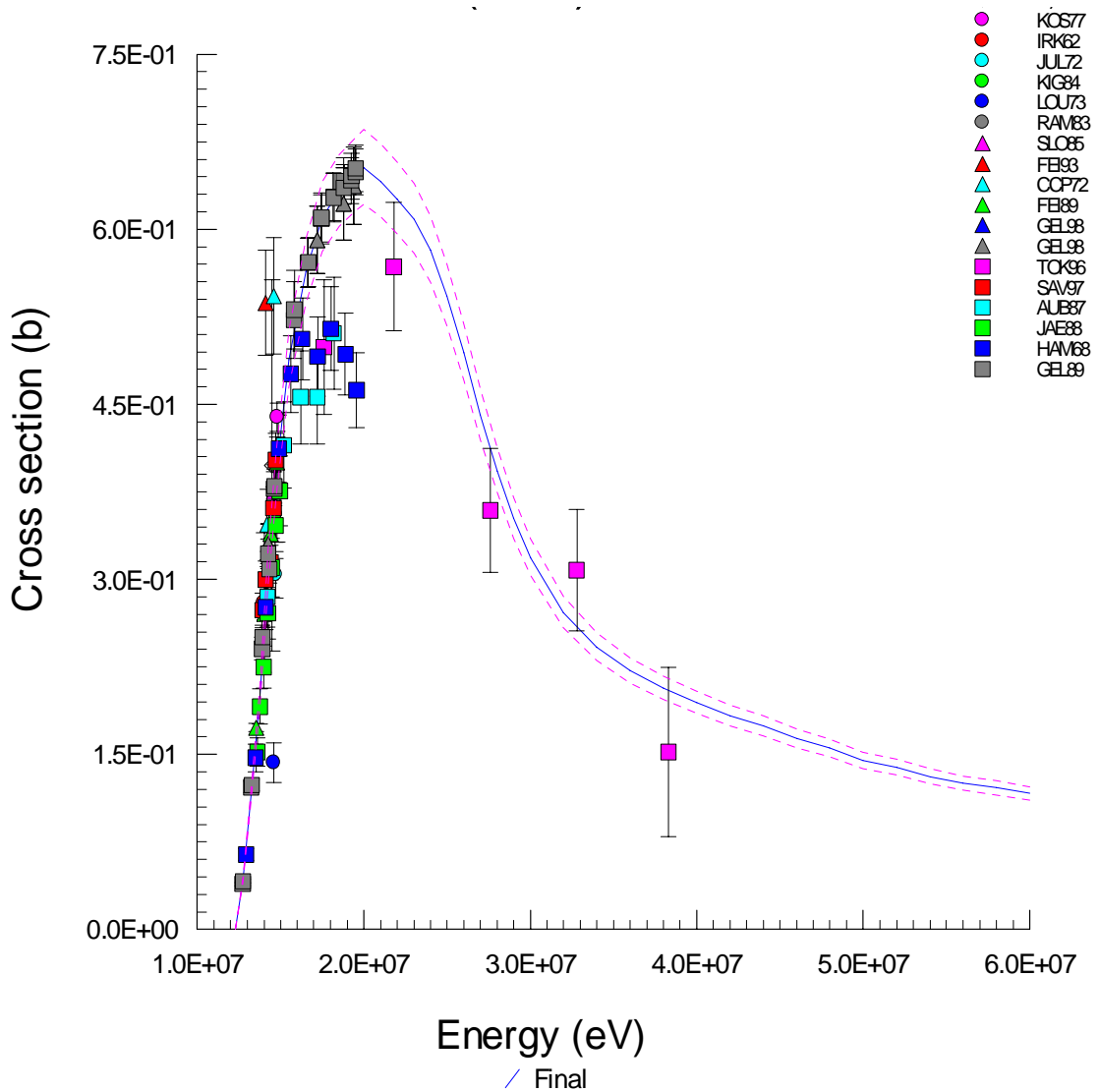
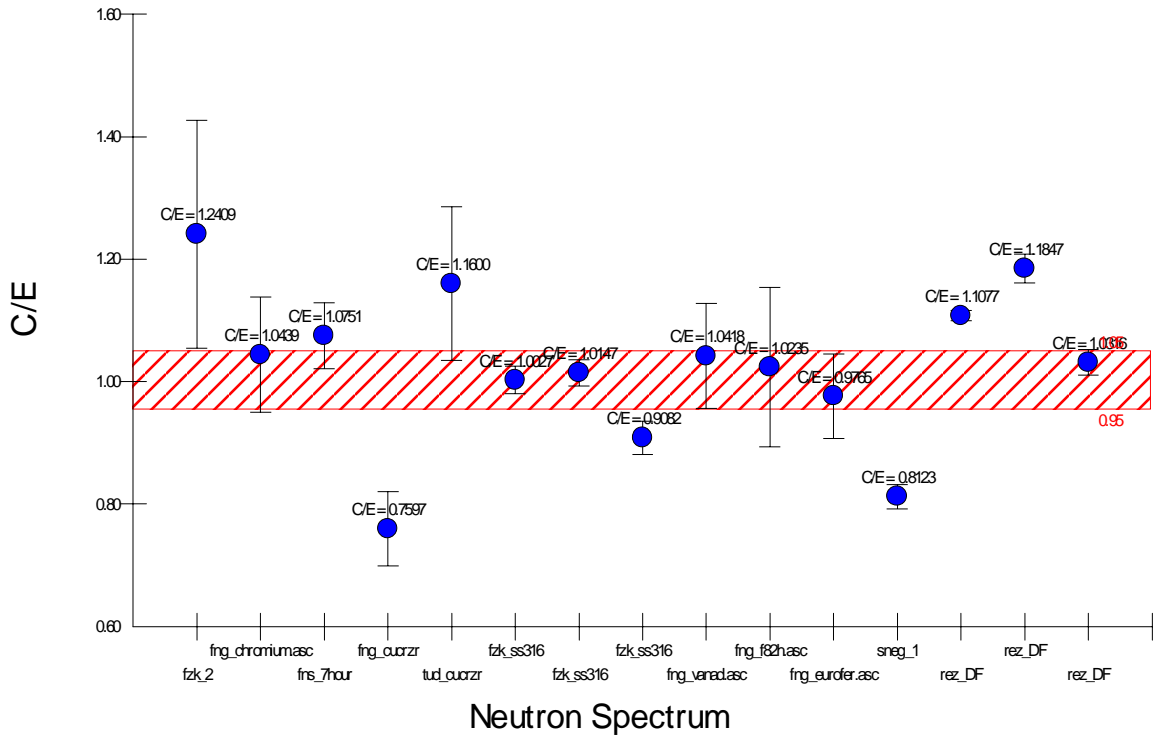


$^{50}\text{Cr}(n,t)^{48}\text{V}$

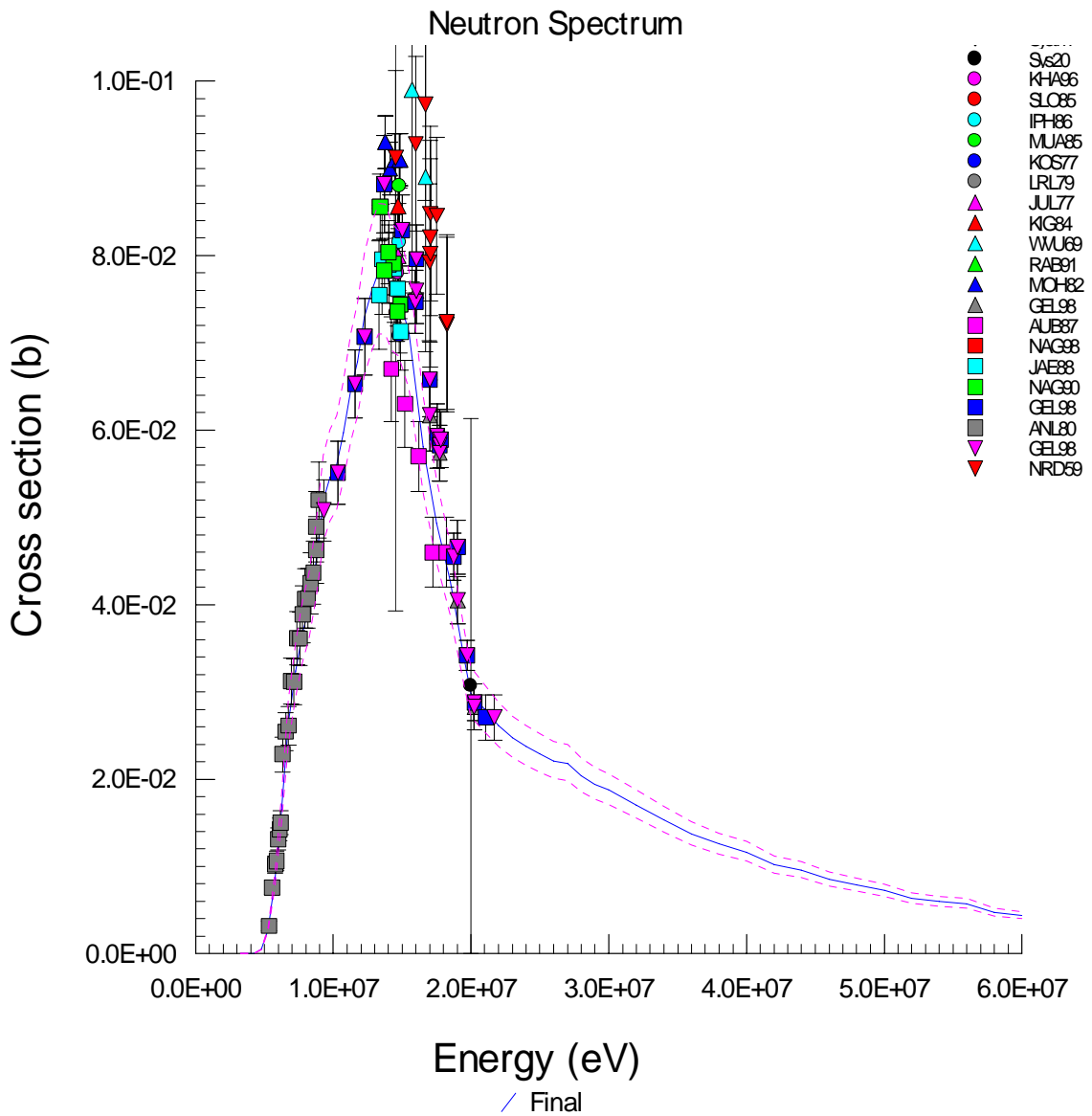
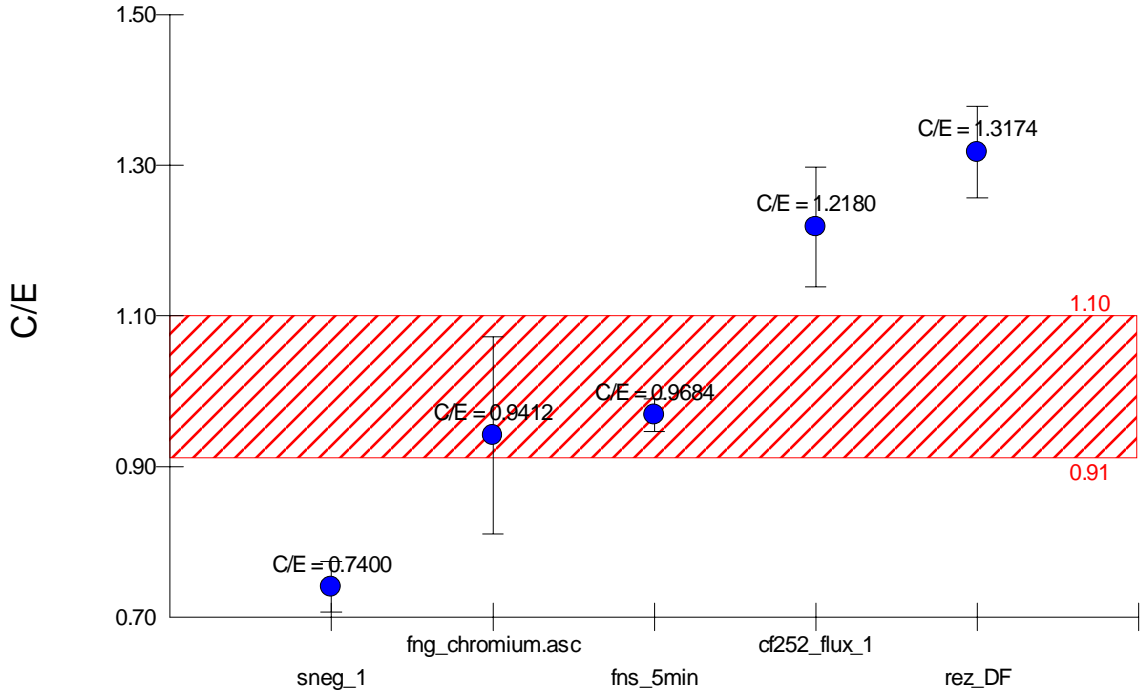


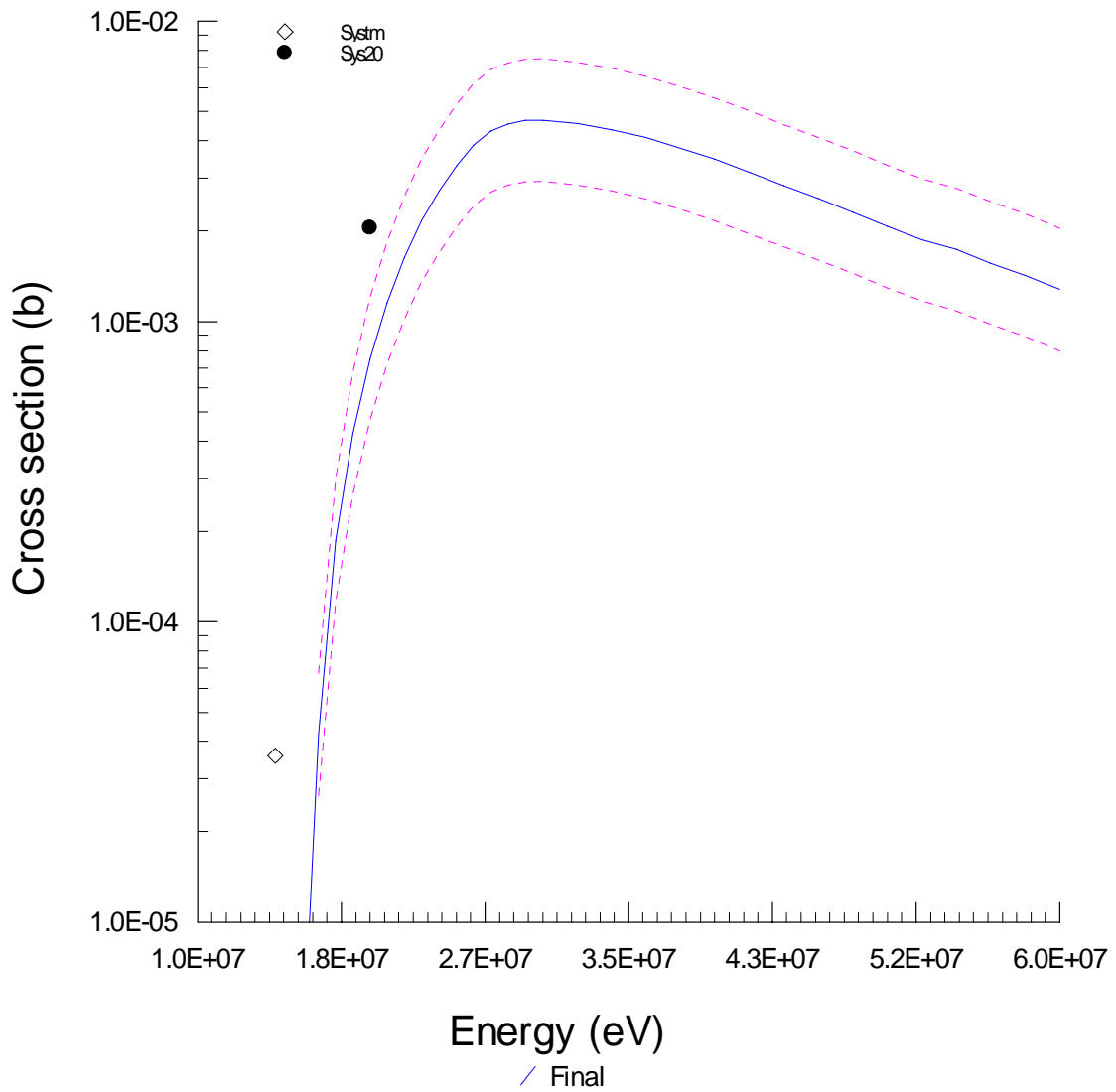
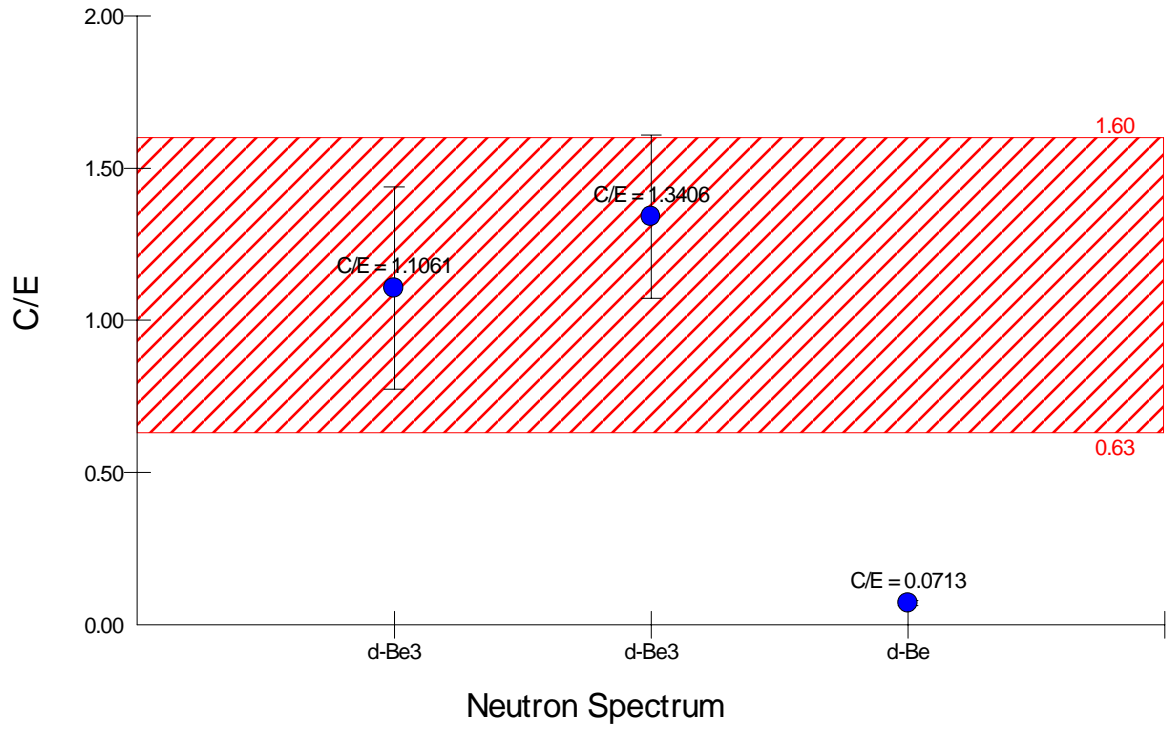
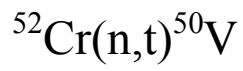


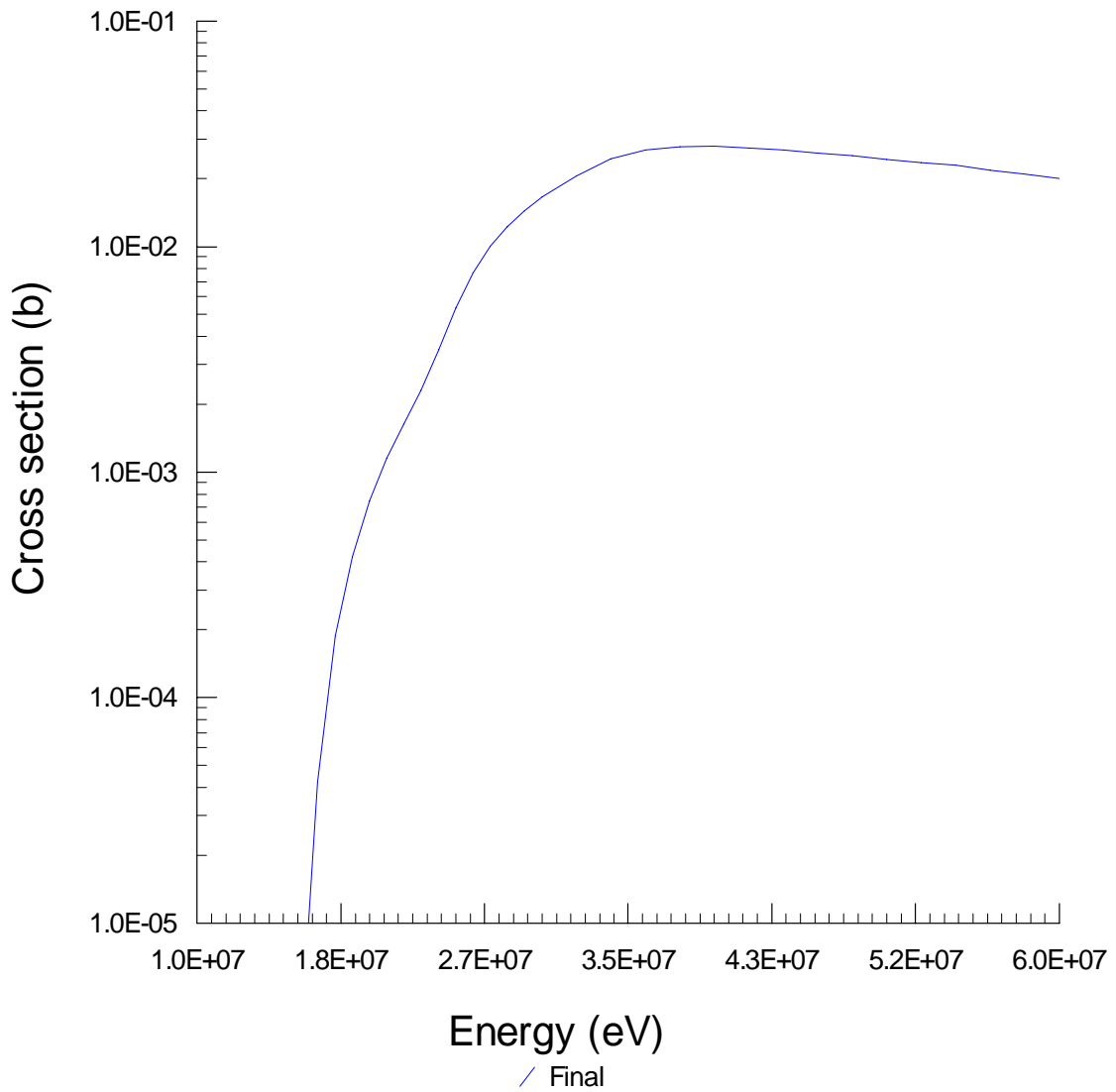
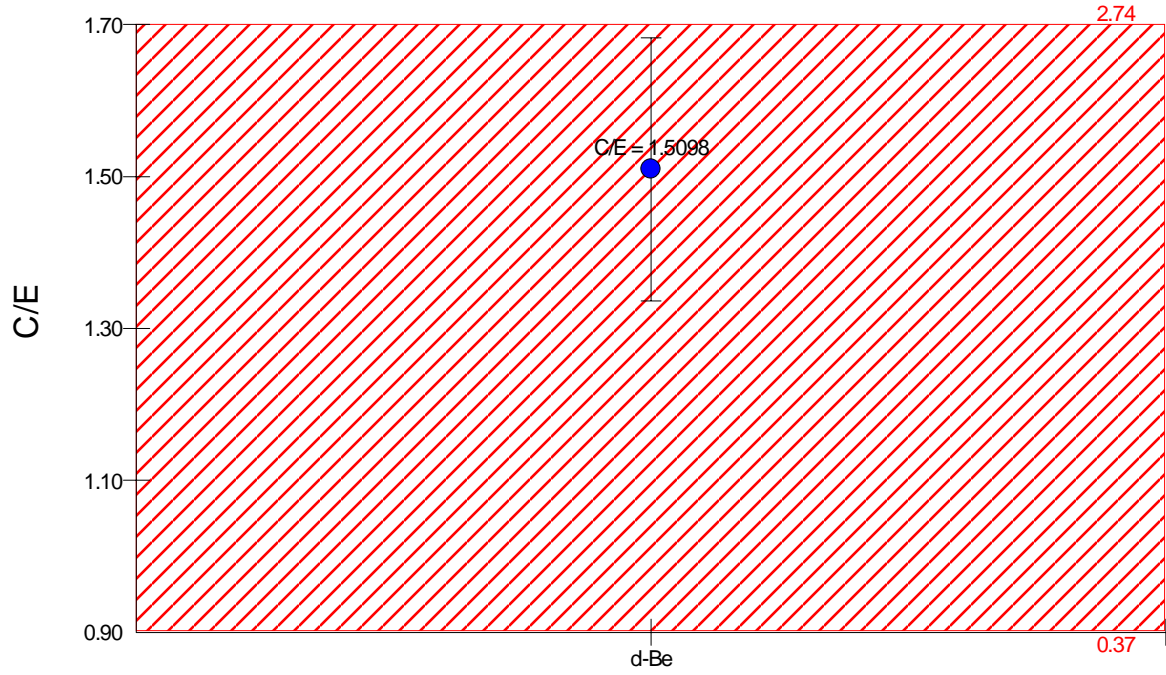
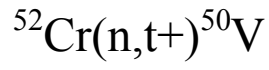
# $^{52}\text{Cr}(n,2n)^{51}\text{Cr} \blacktriangleright 547$

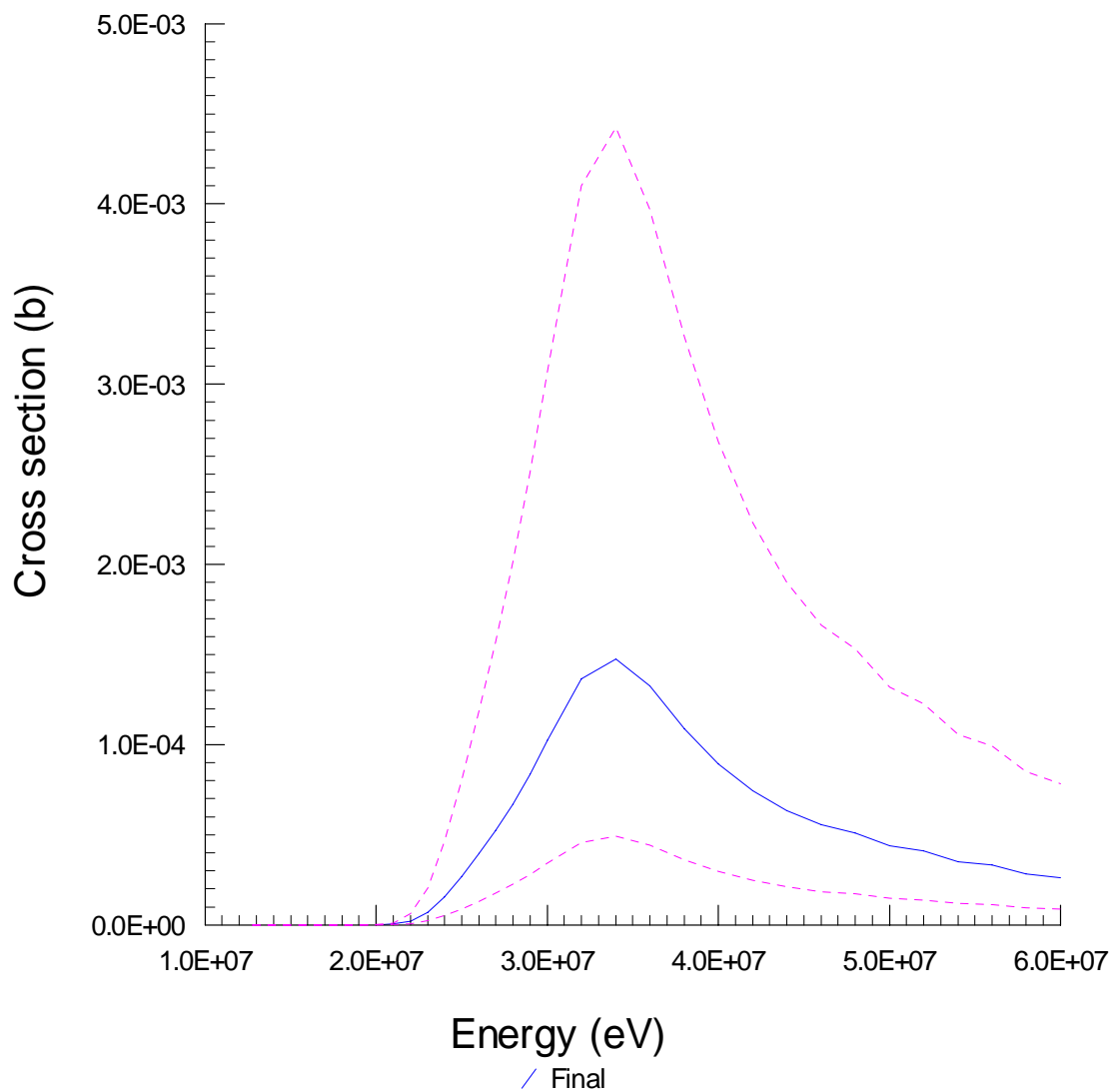
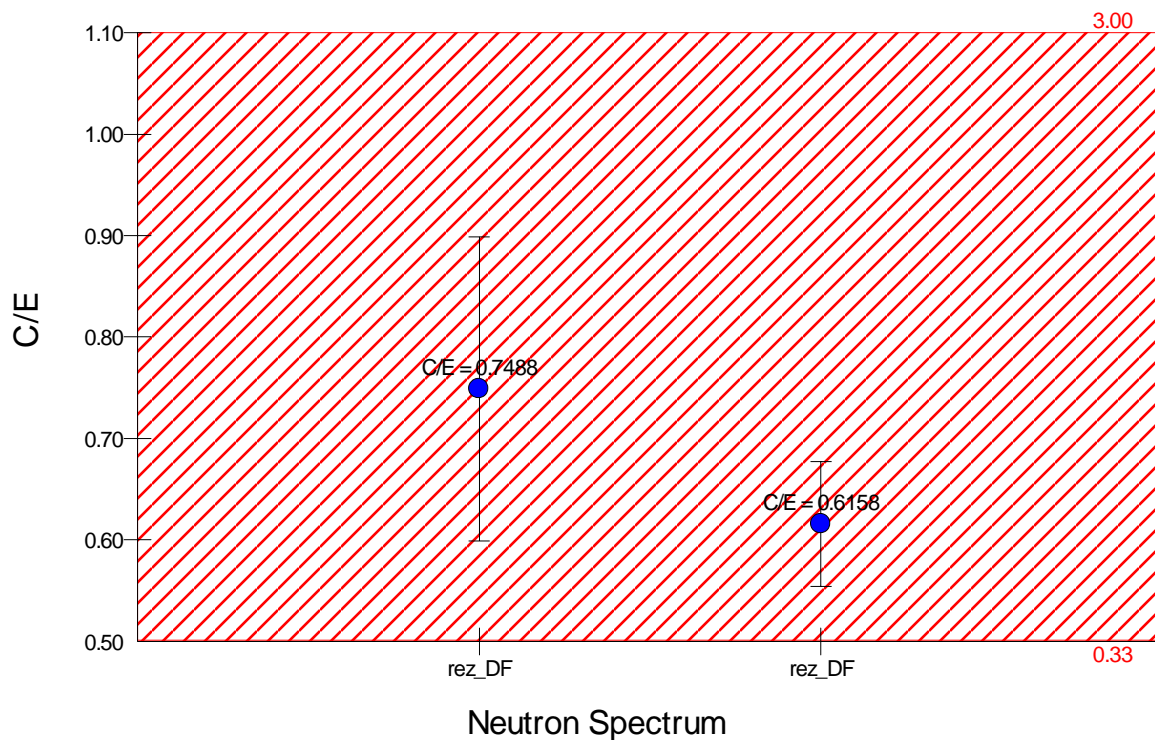


$^{52}\text{Cr}(n,p)^{52}\text{V} \blacktriangleright 547$

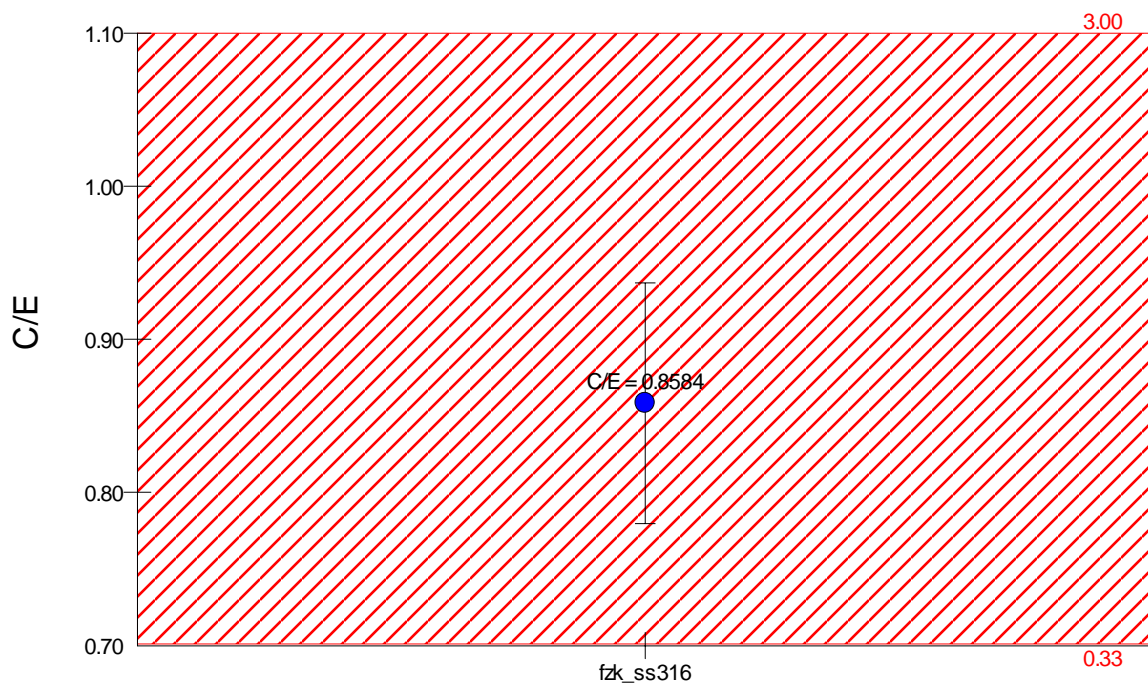
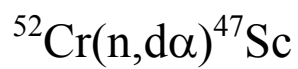




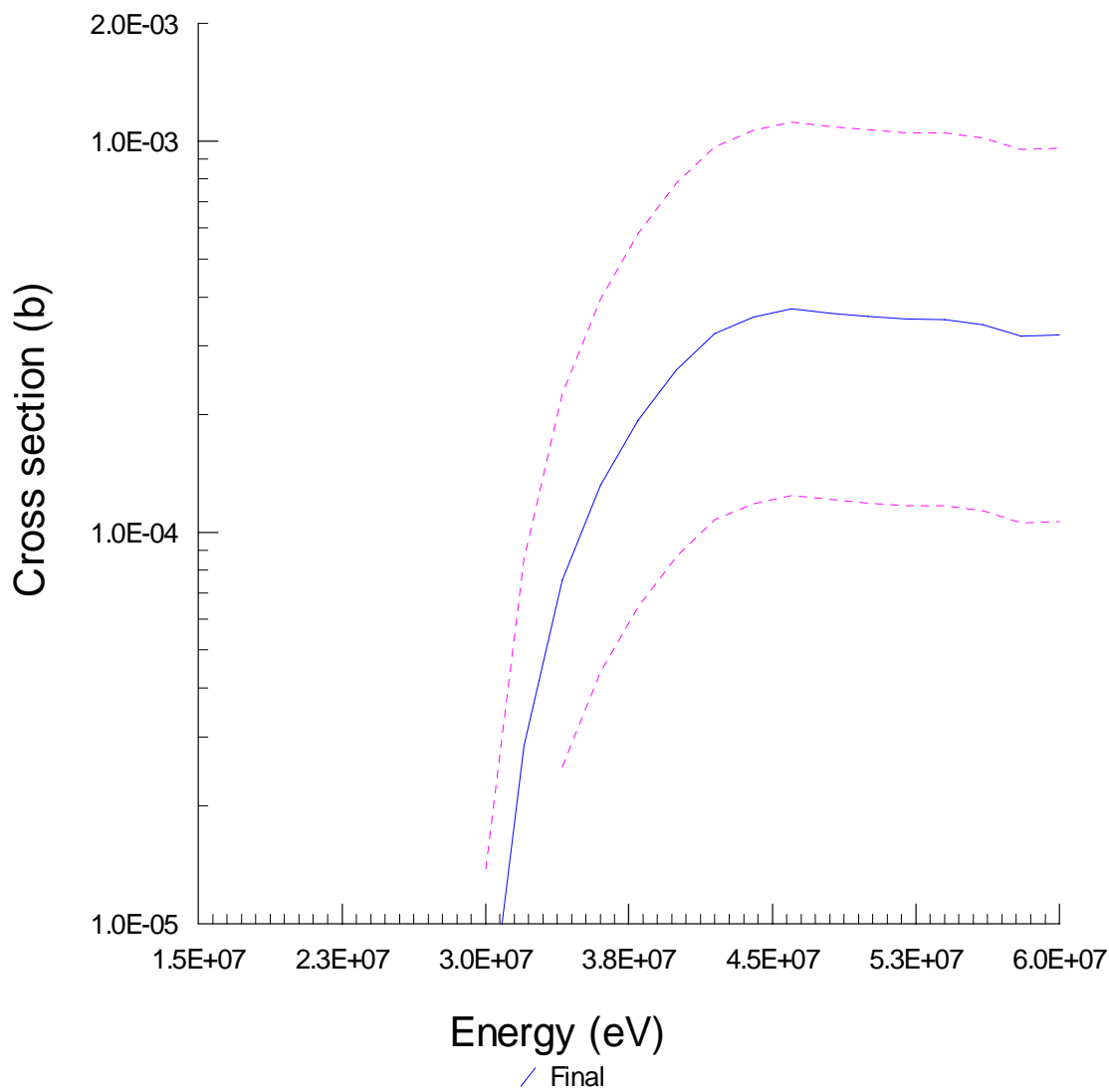


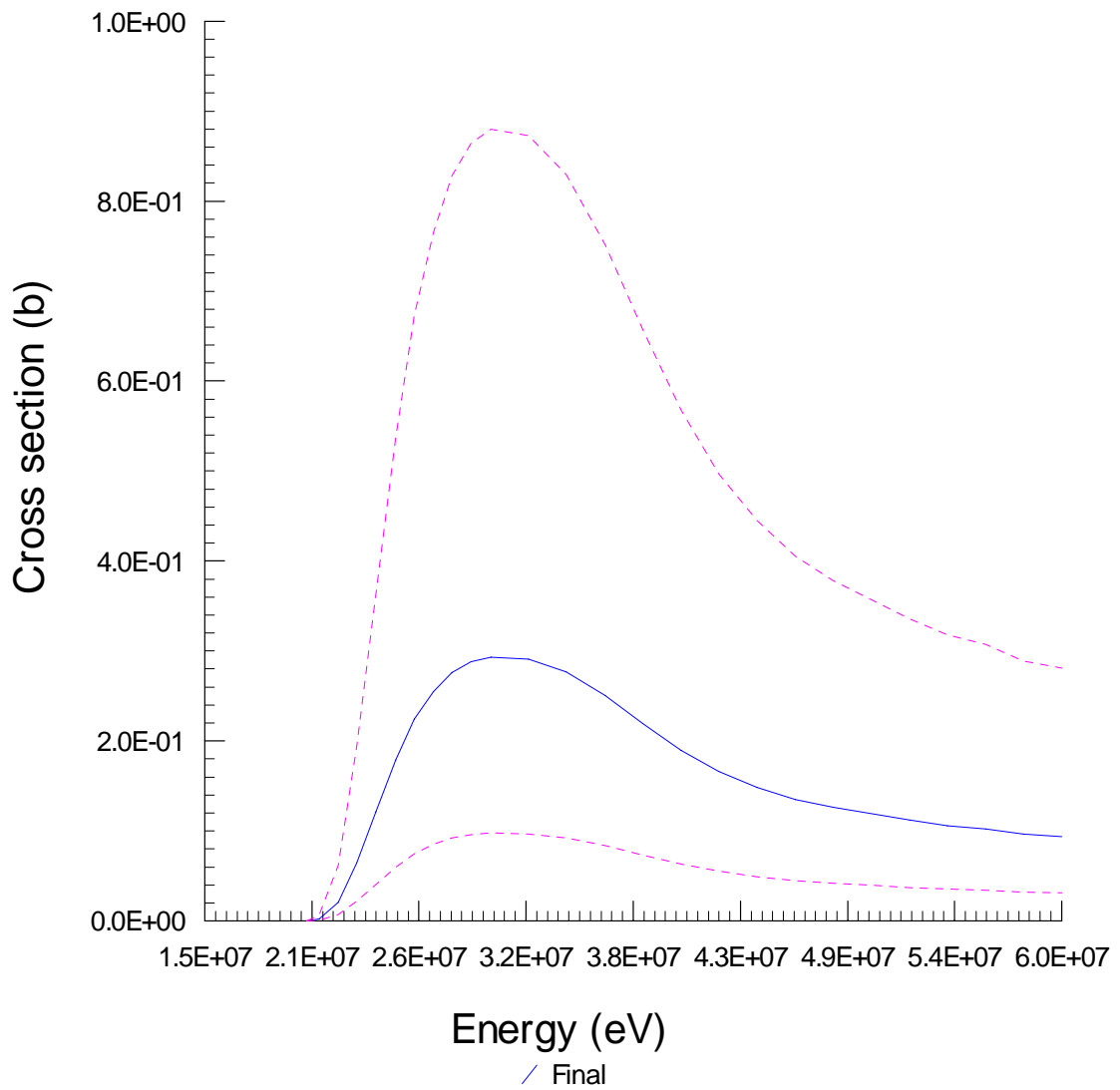
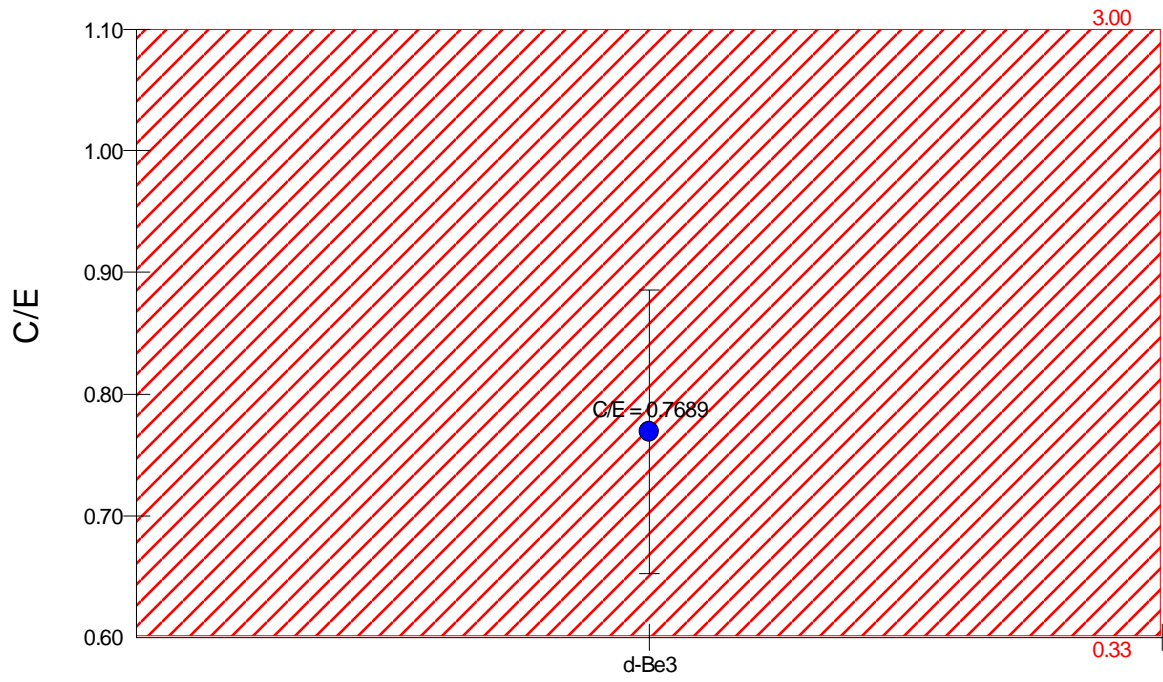
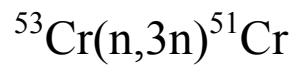




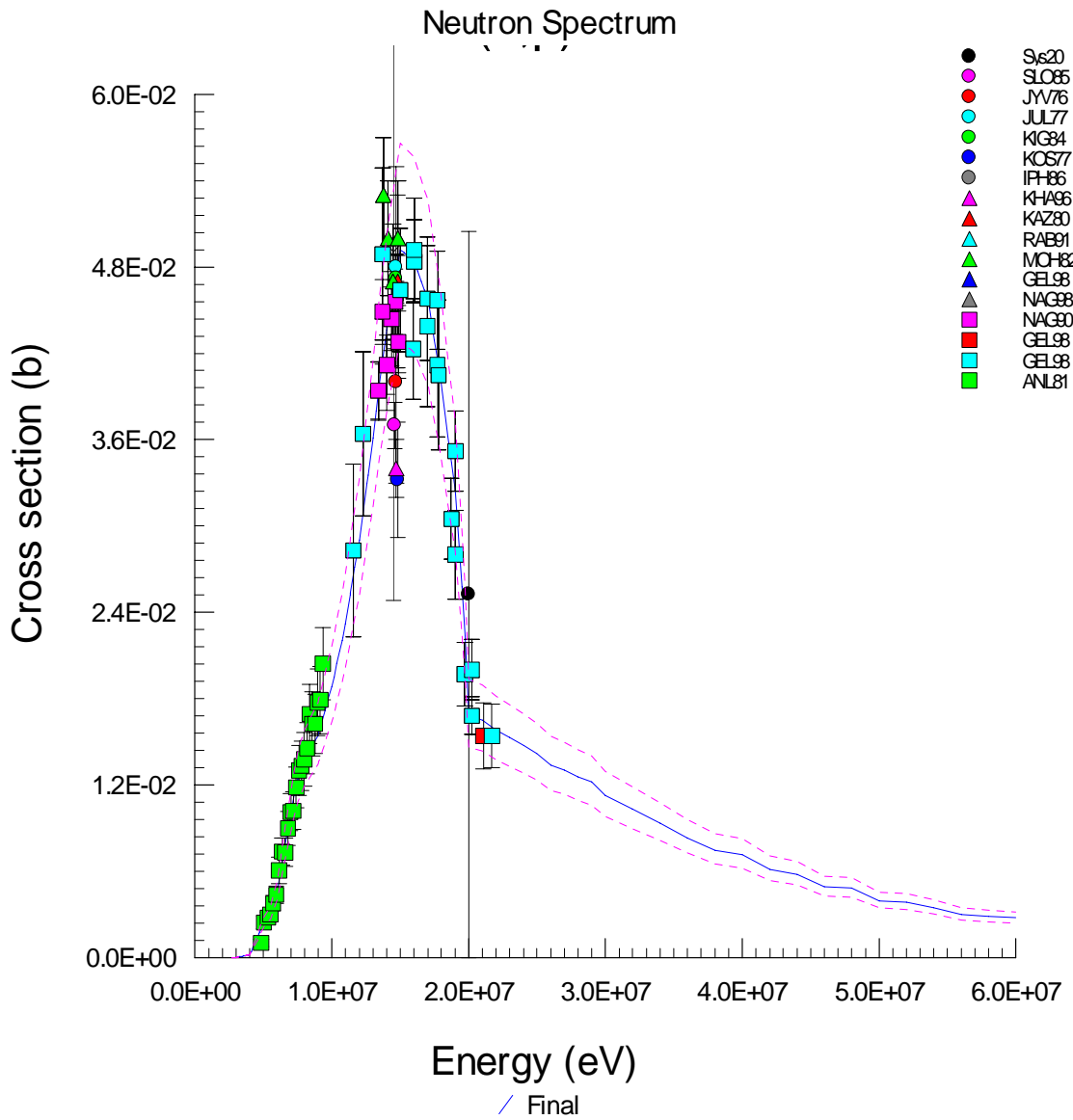
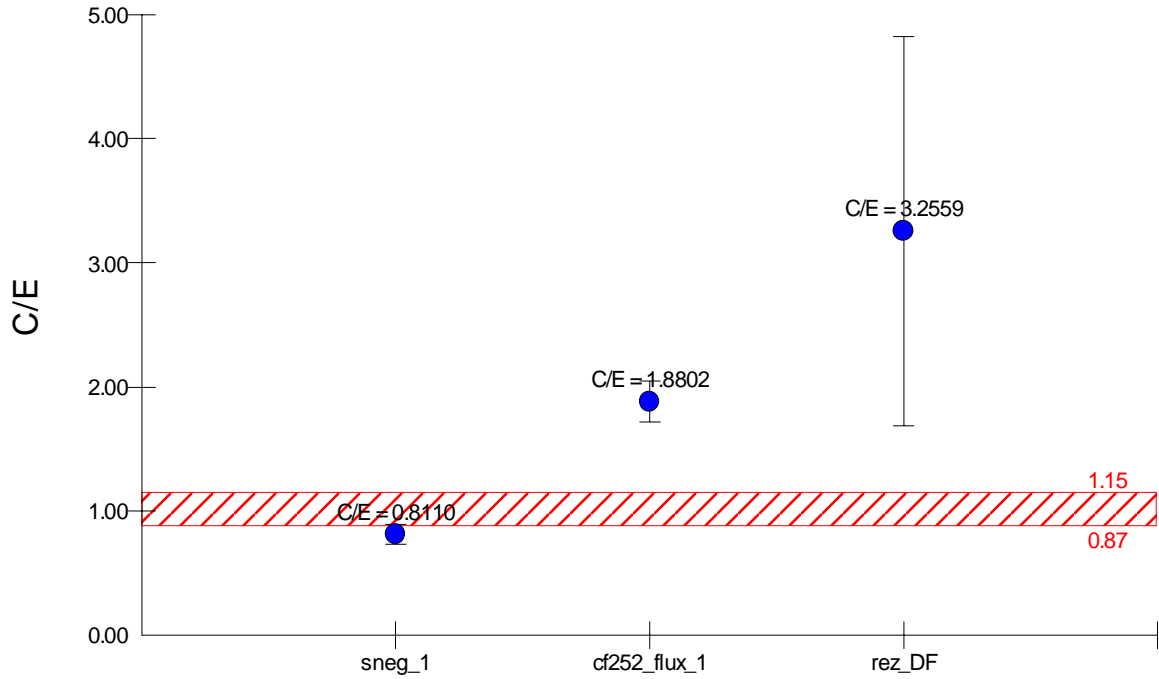


Neutron Spectrum

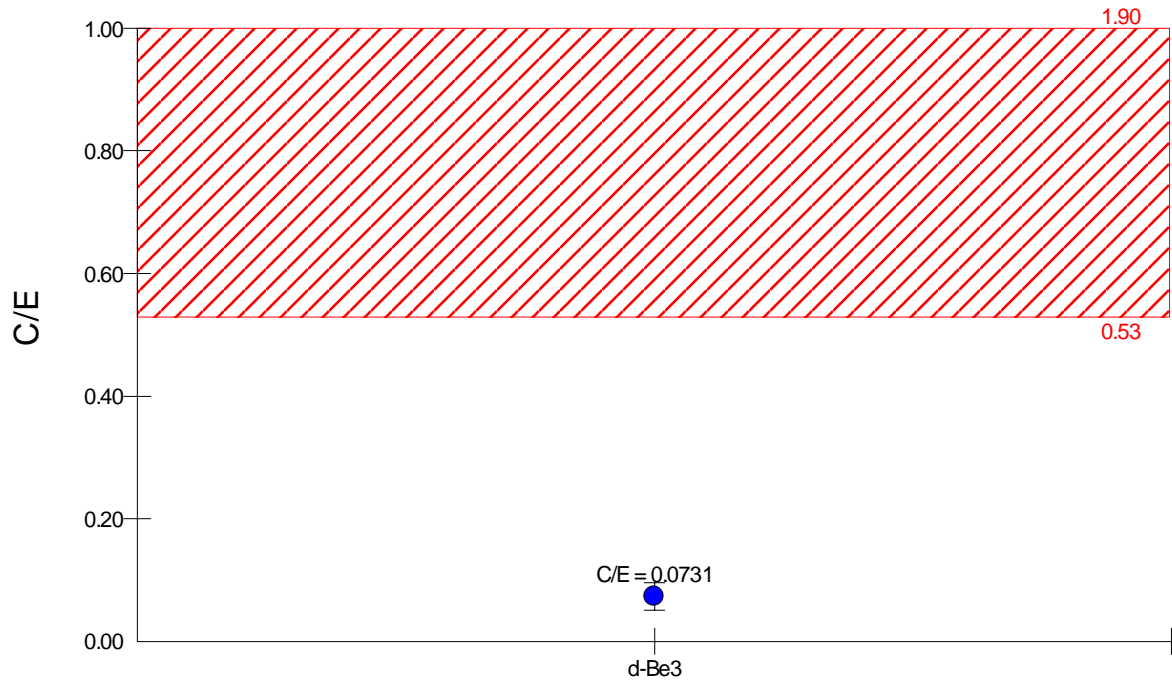




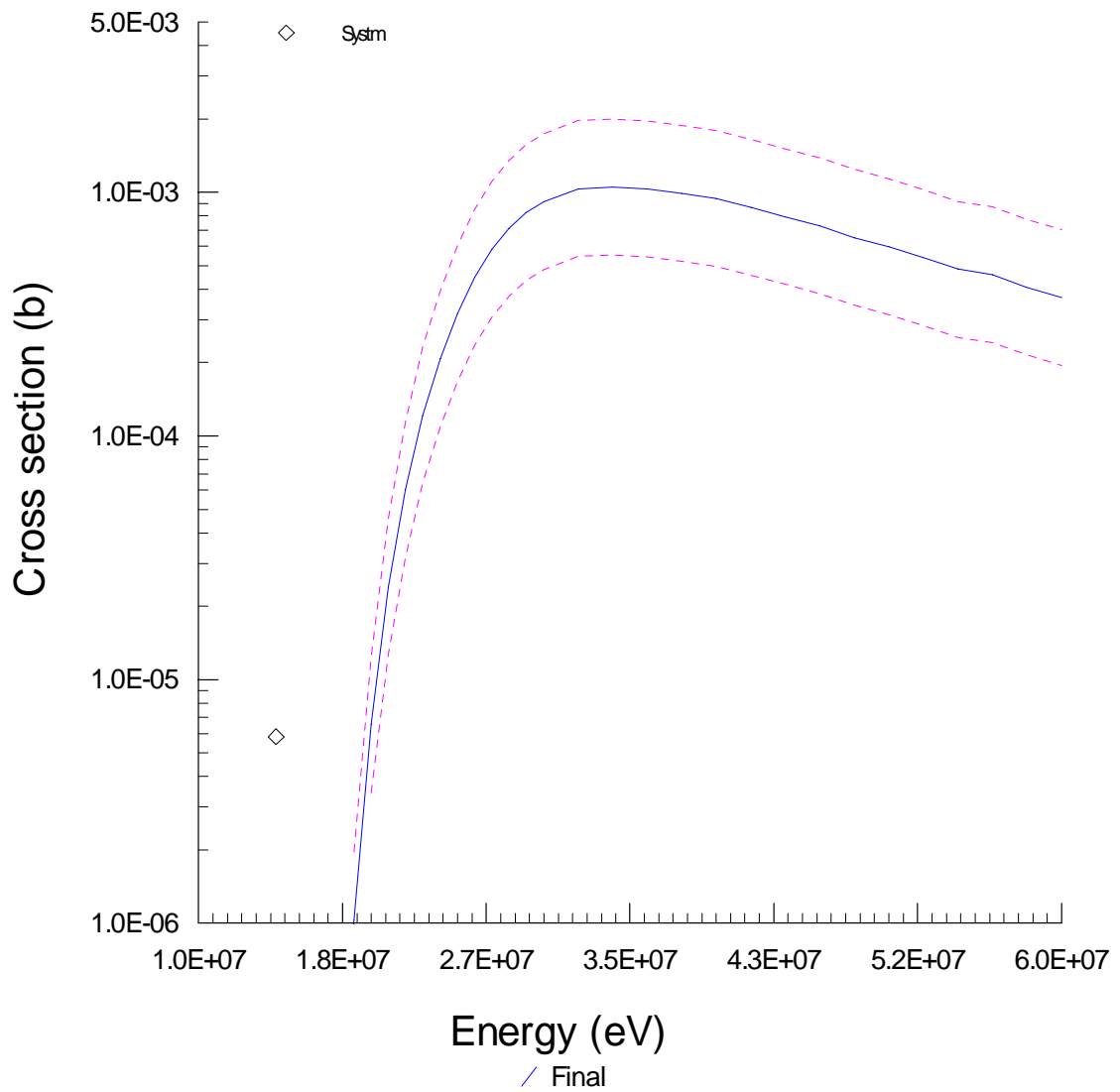
# $^{53}\text{Cr}(n,p)^{53}\text{V}$

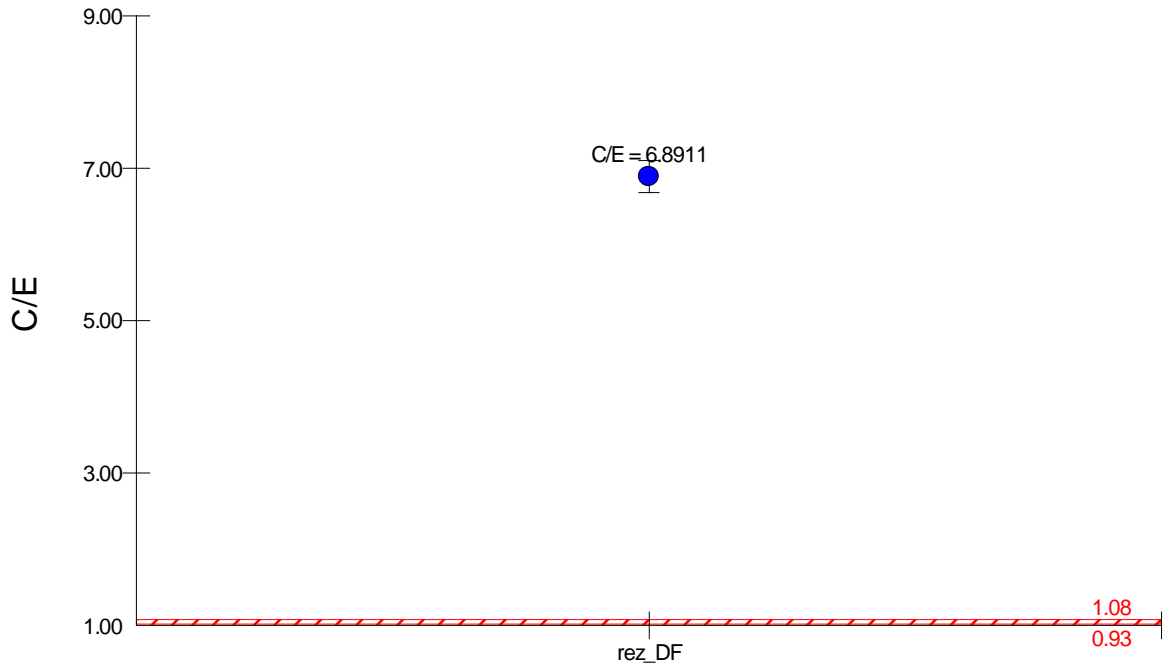
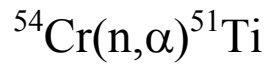


# $^{53}\text{Cr}(n,h)^{51}\text{Ti}$

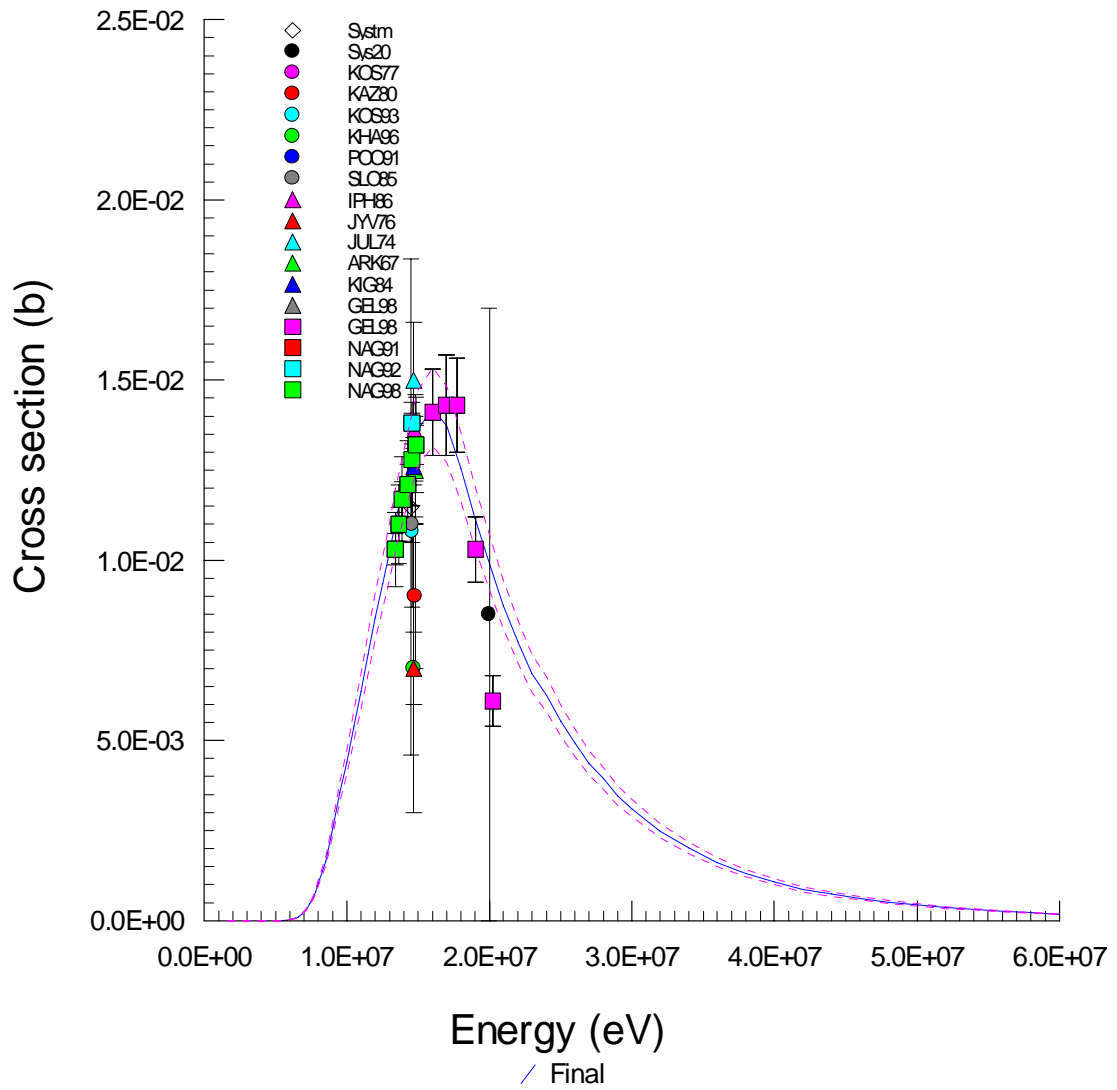


## Neutron Spectrum

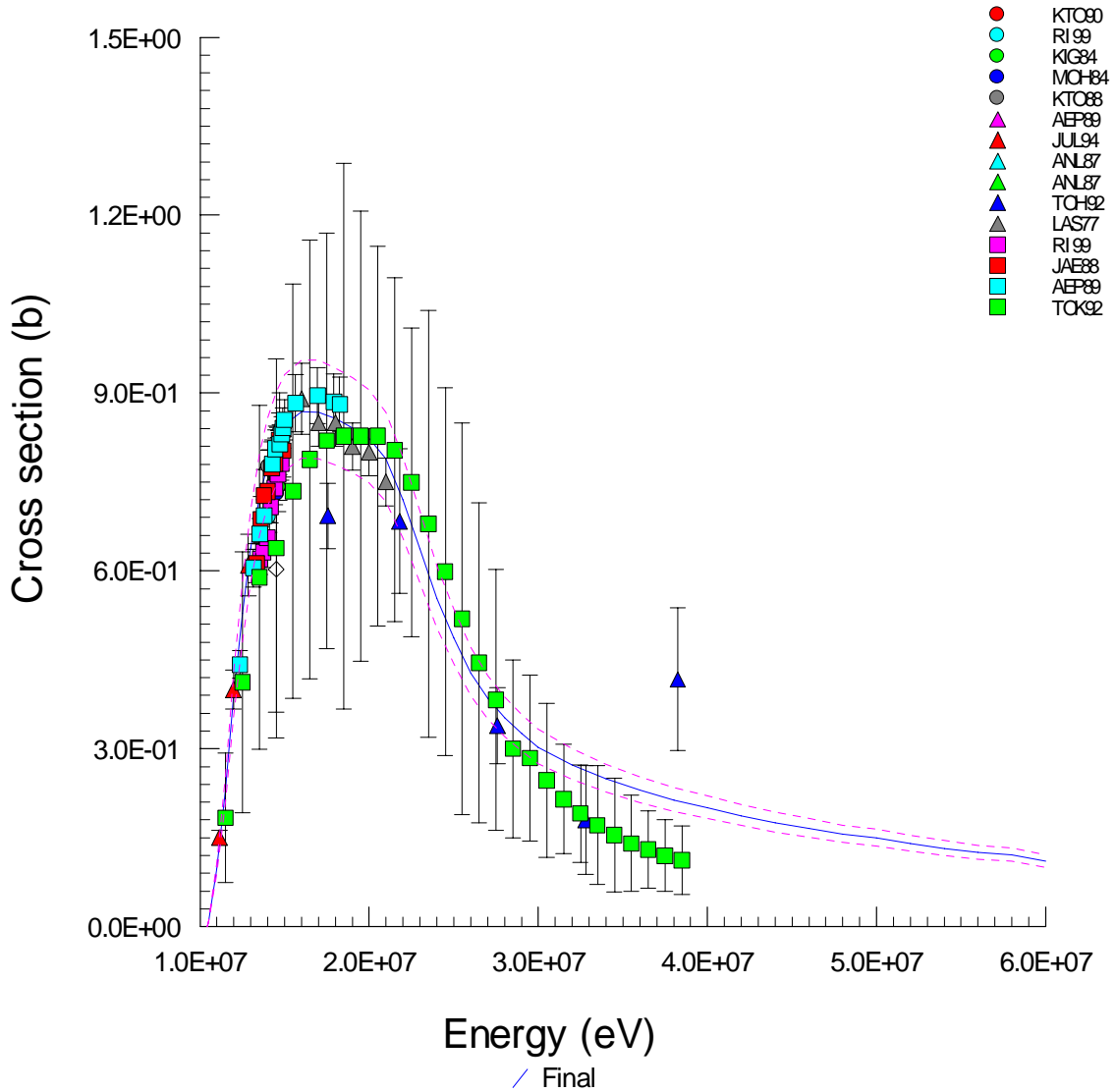
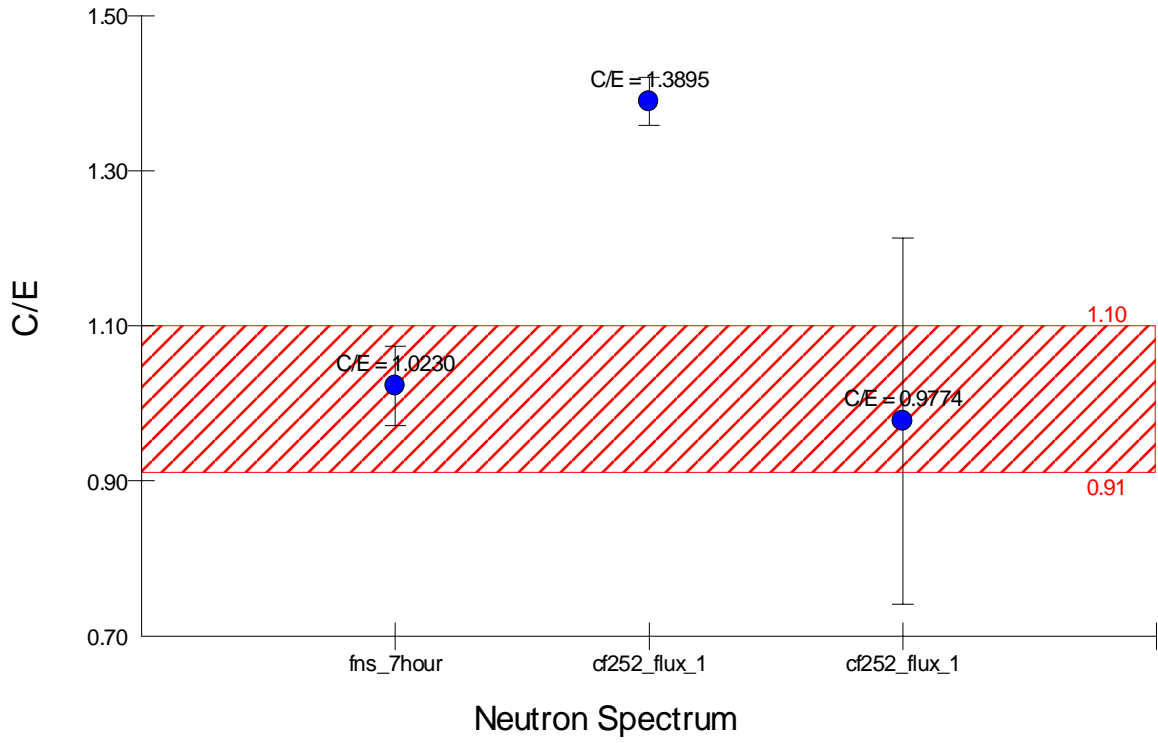




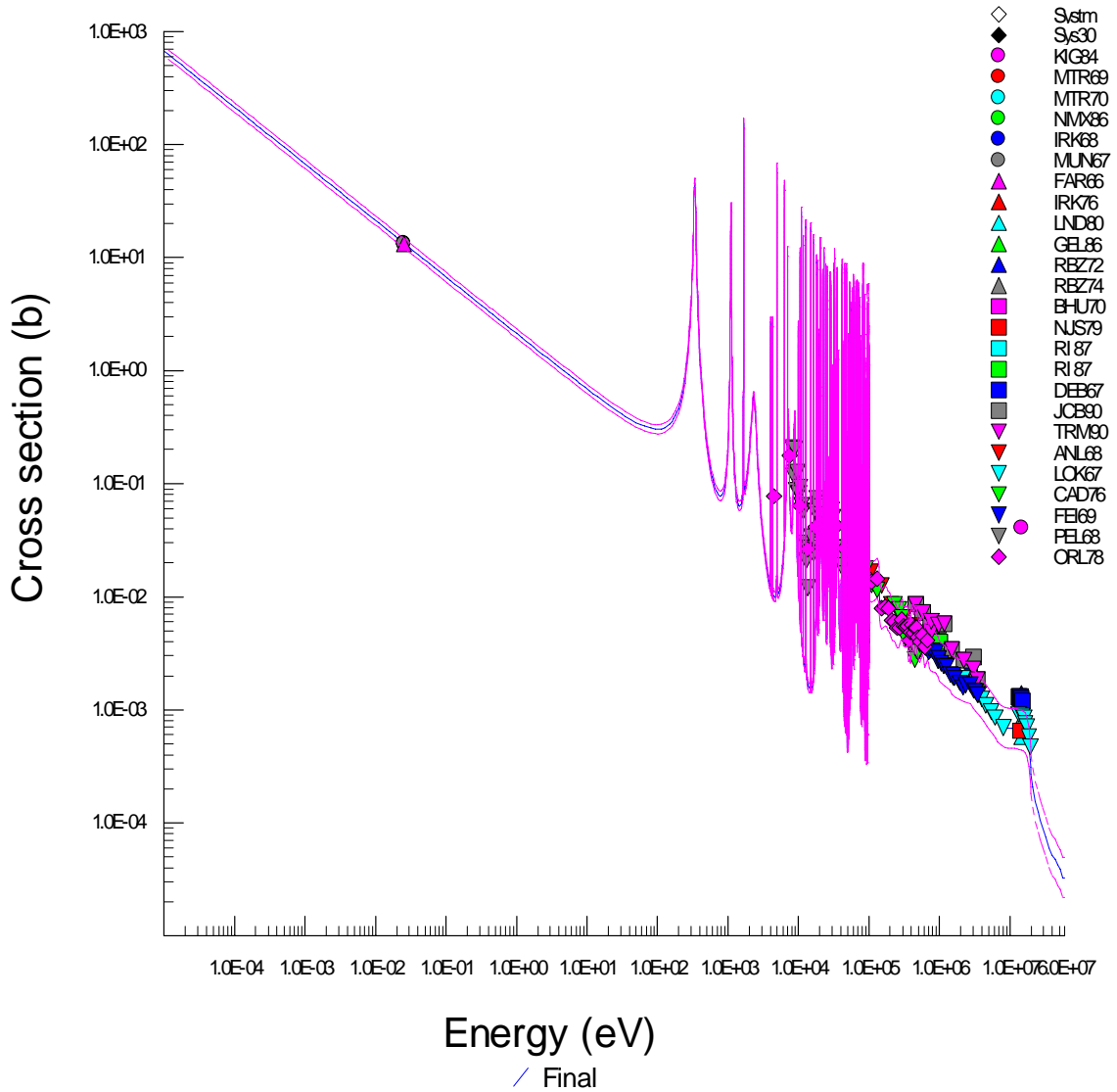
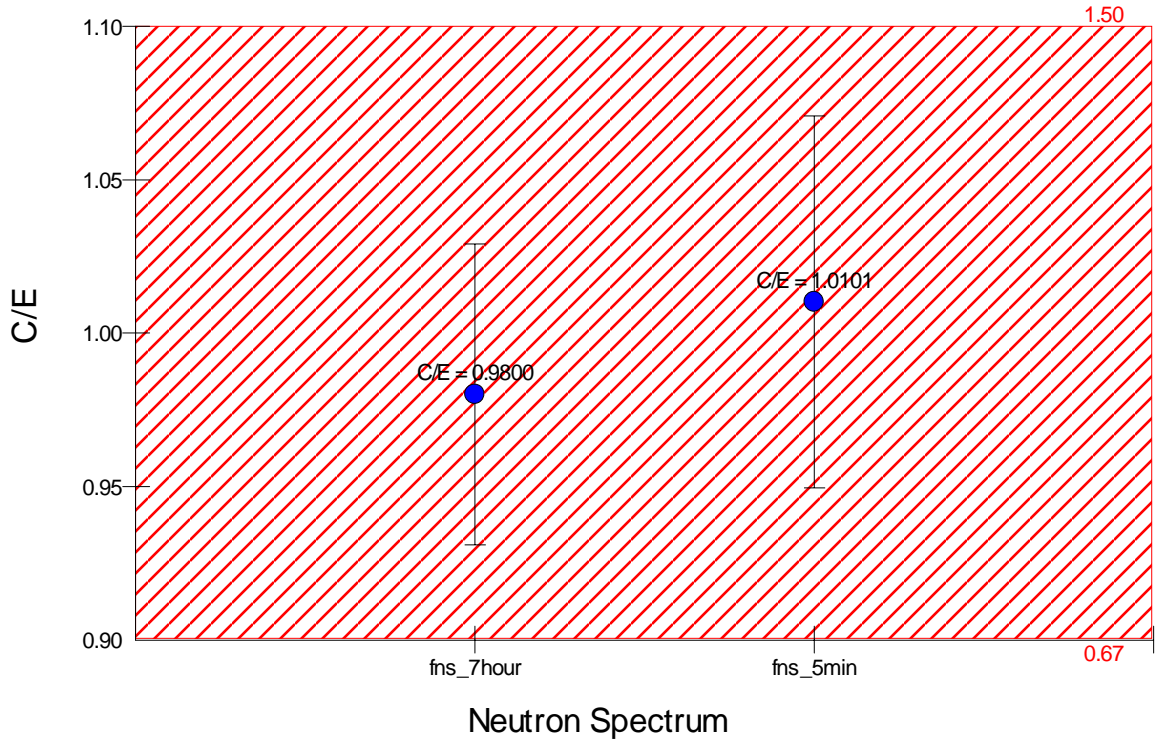
Neutron Spectrum



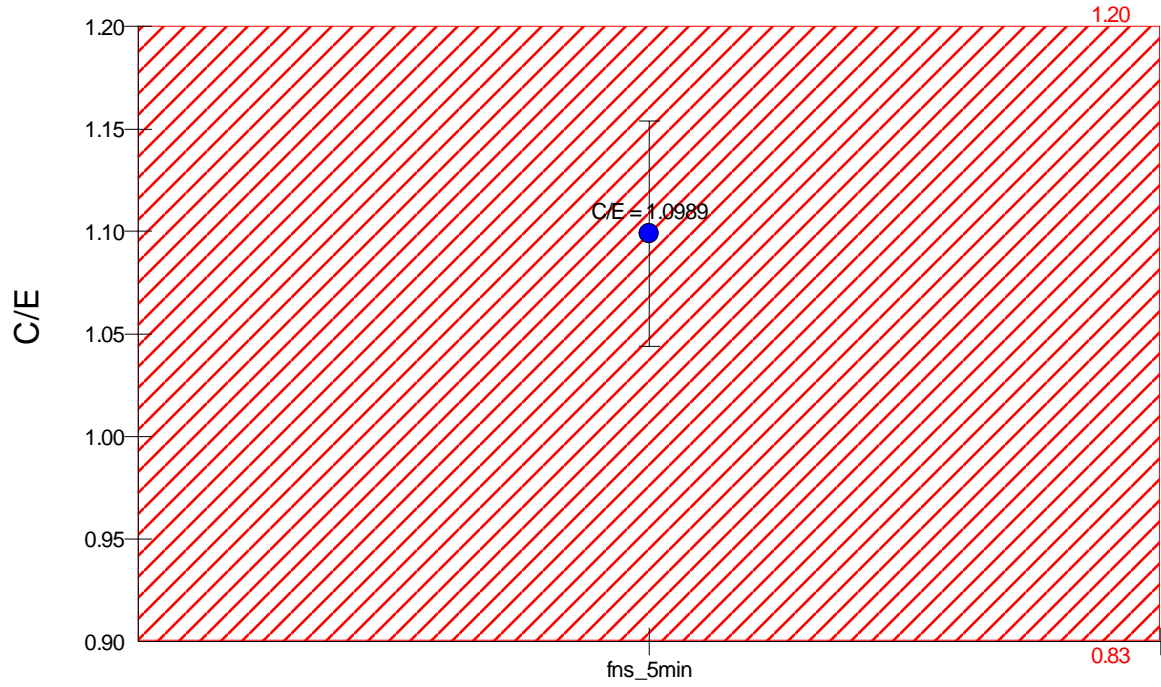
# $^{55}\text{Mn}(n,2n)^{54}\text{Mn}$



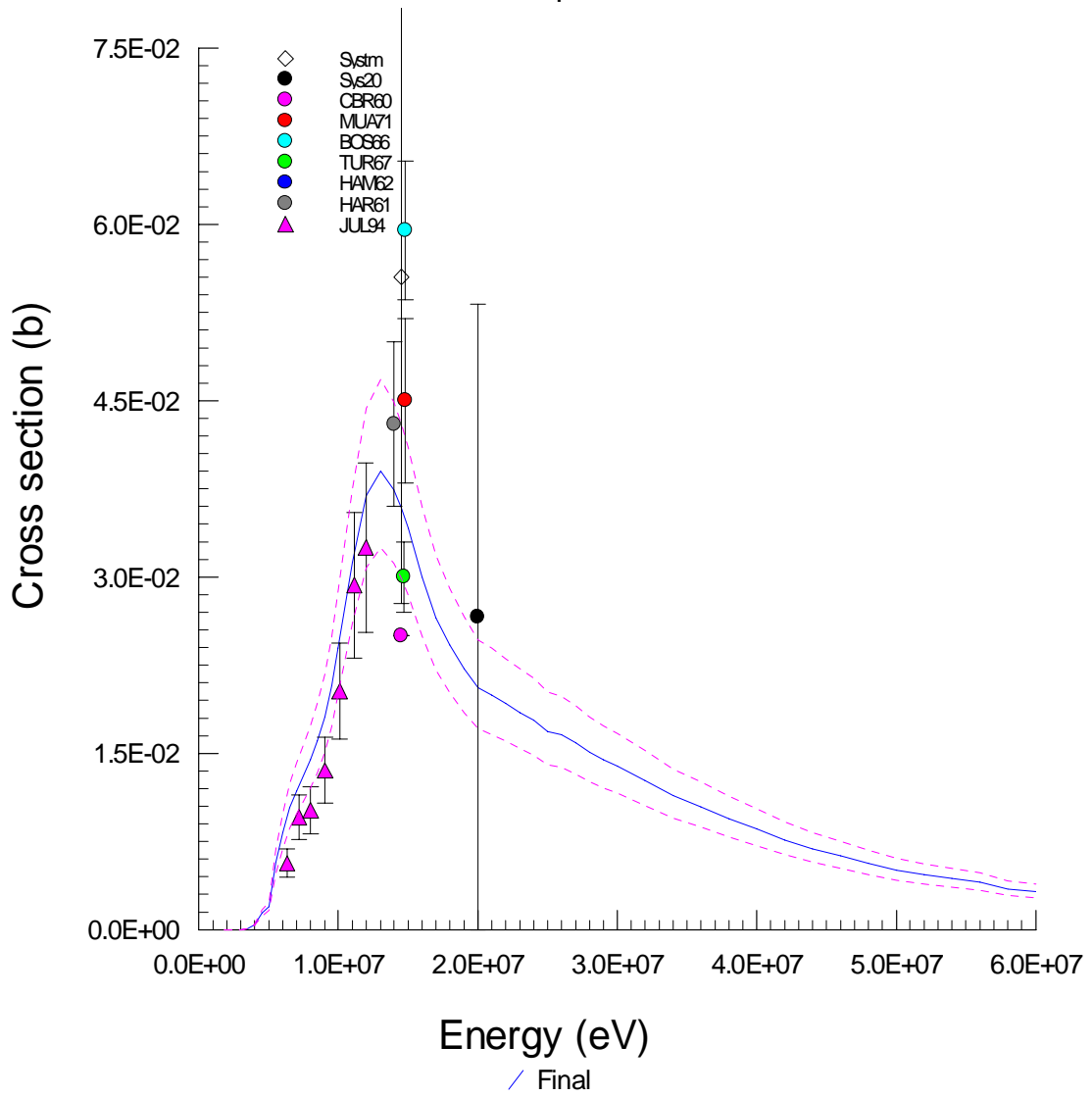
# $^{55}\text{Mn}(n,\gamma)^{56}\text{Mn}$



# $^{55}\text{Mn}(n,p)^{55}\text{Cr}$

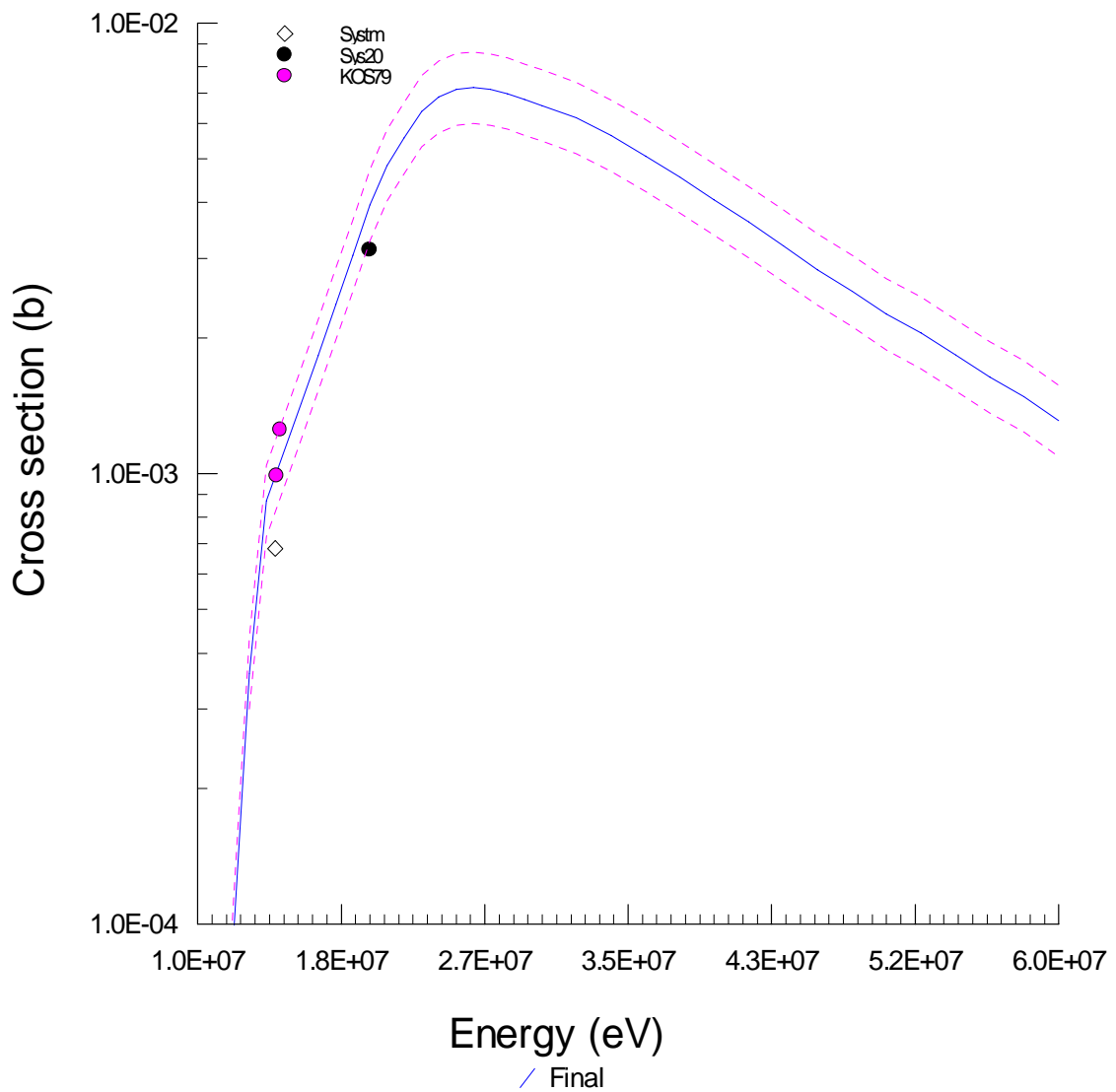
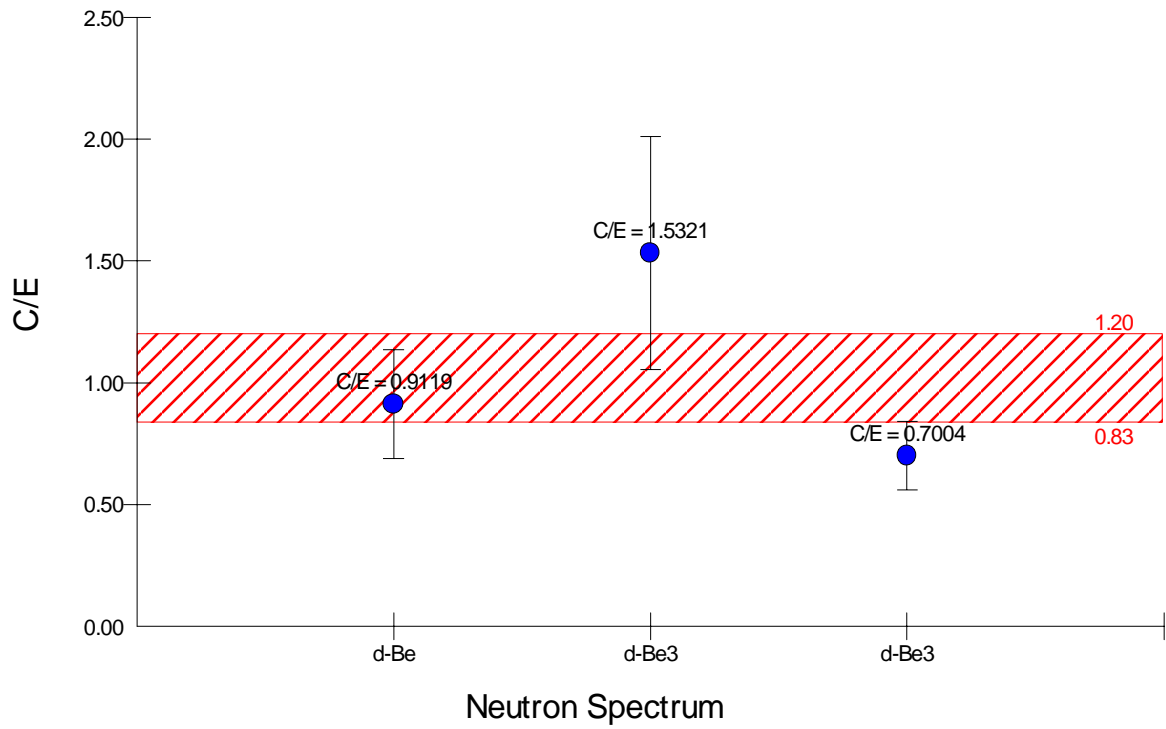


## Neutron Spectrum

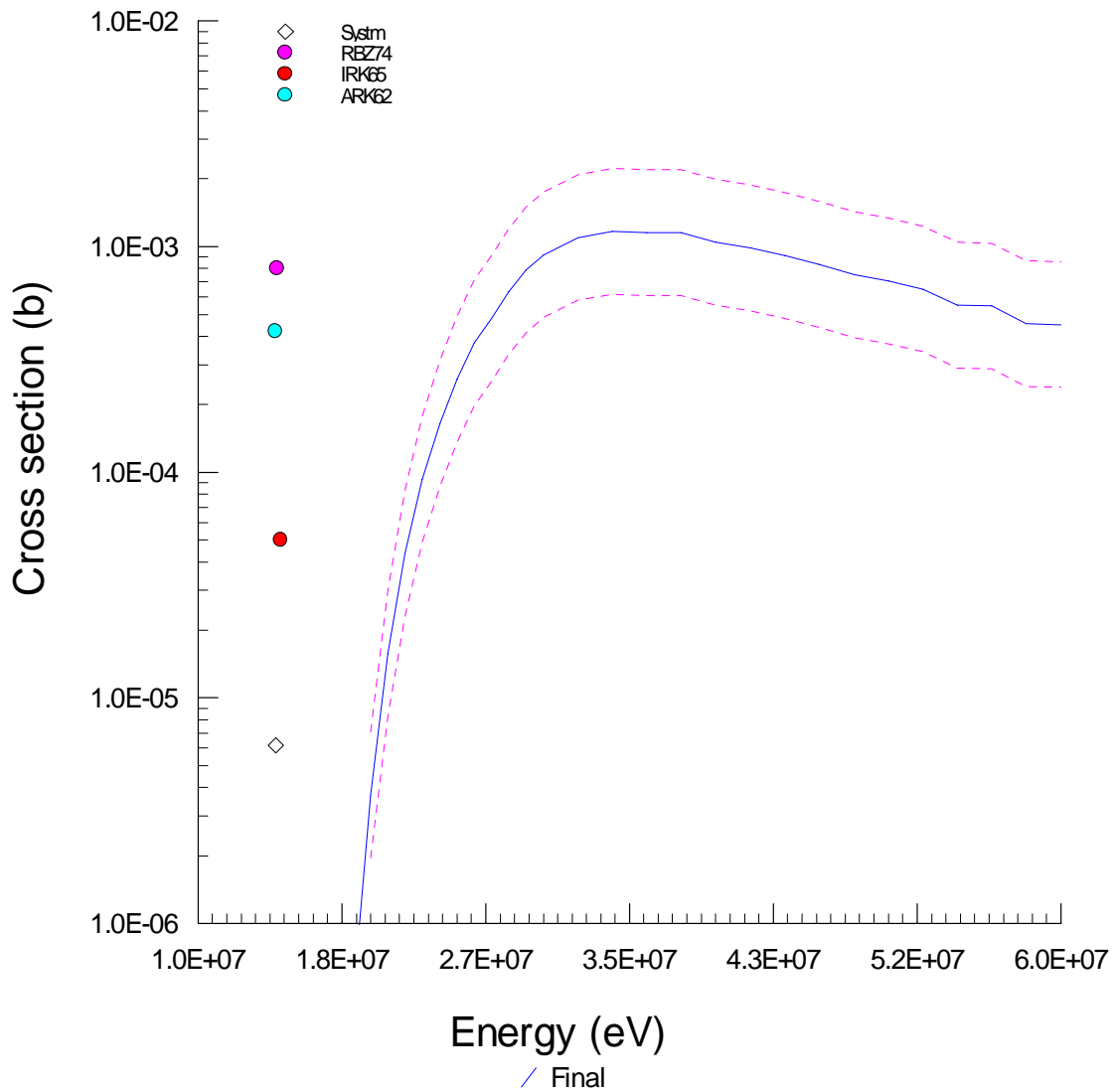
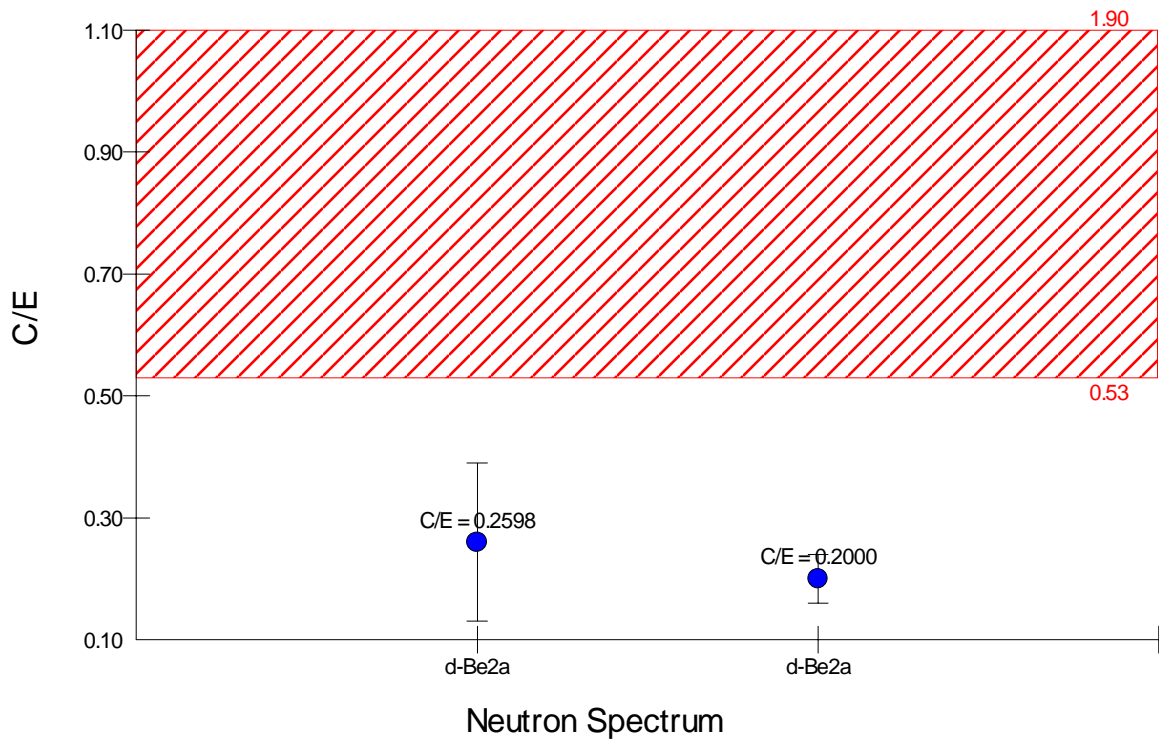




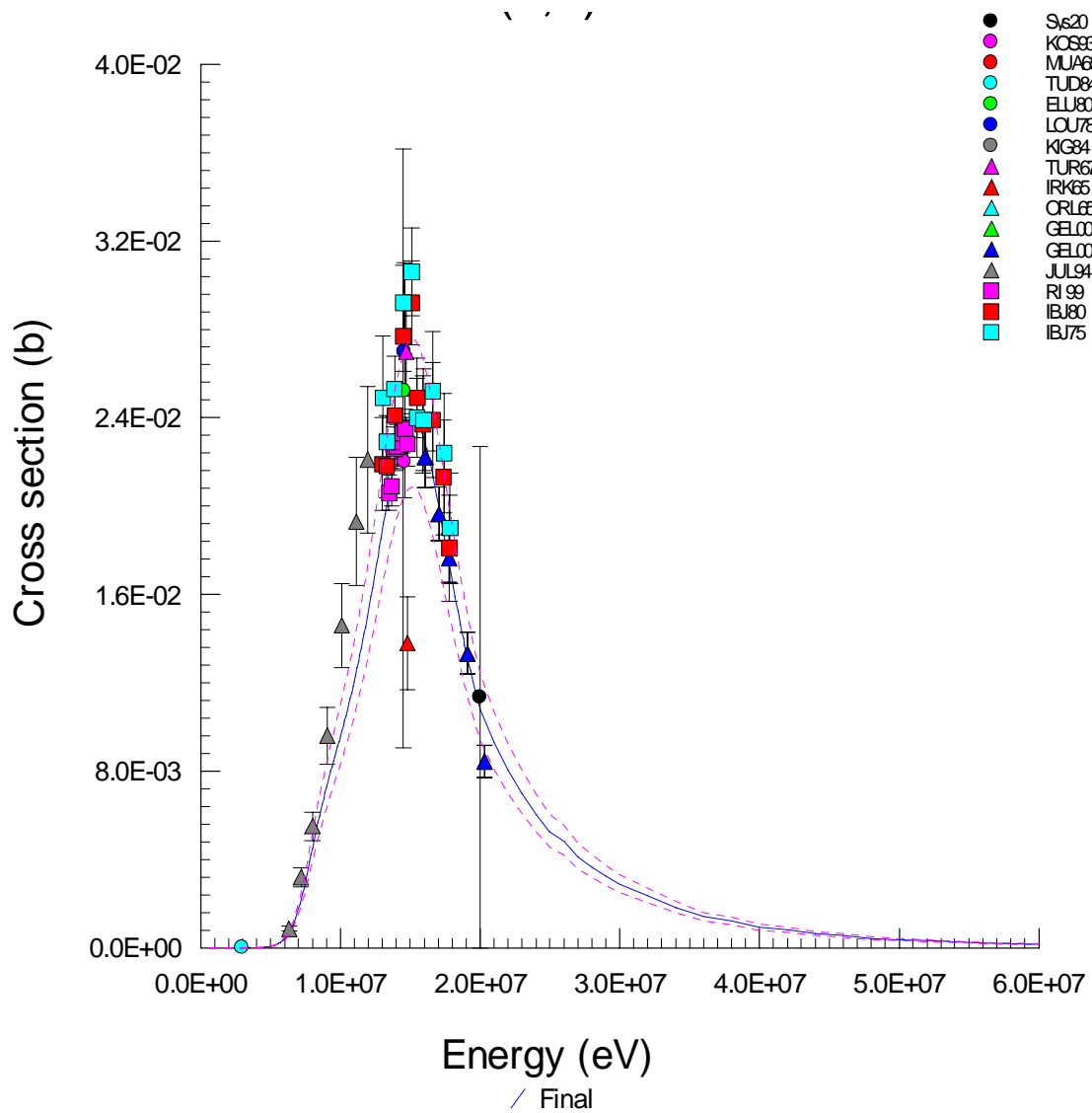
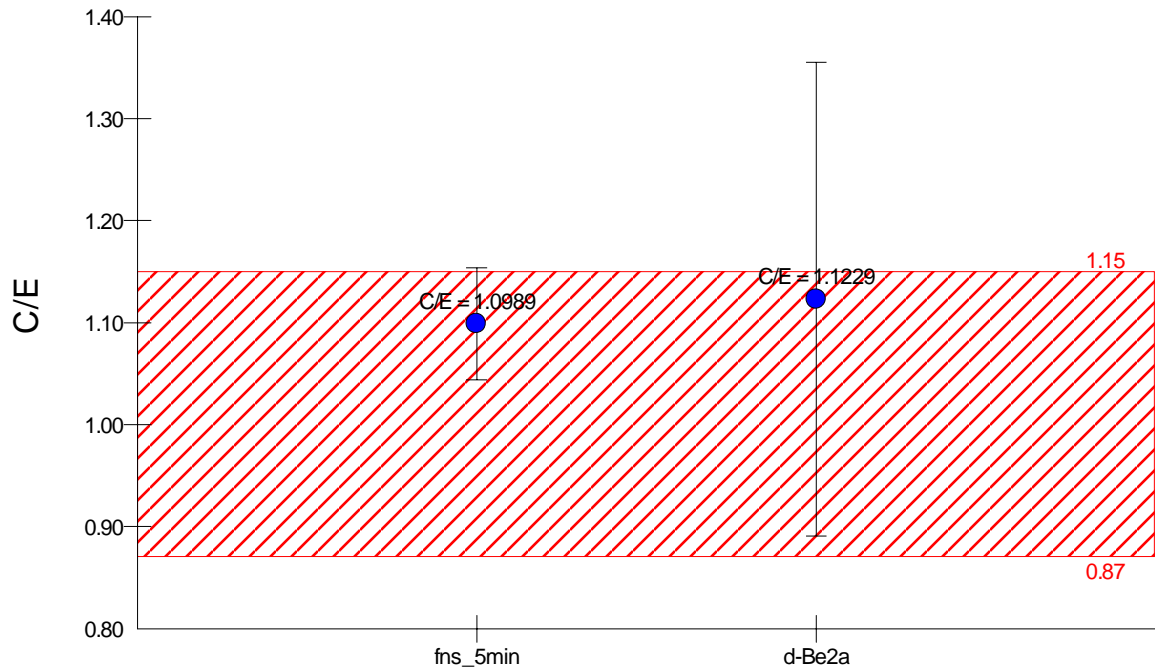
# $^{55}\text{Mn}(n,t)^{53}\text{Cr}$



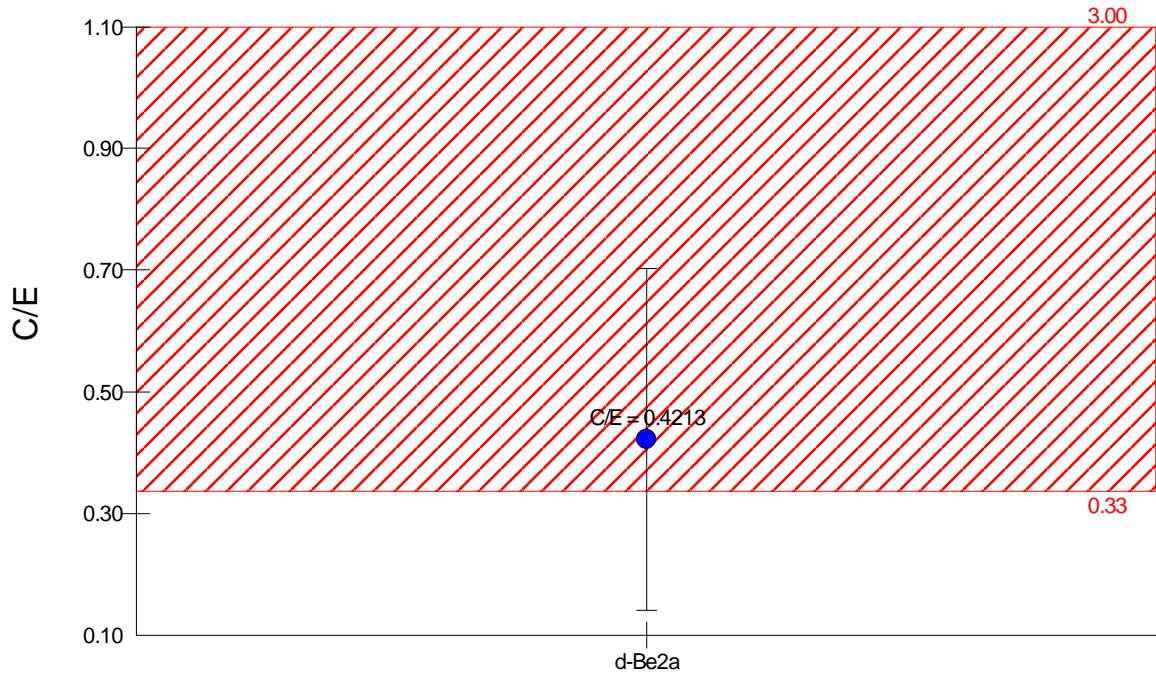
# $^{55}\text{Mn}(n,h)^{53}\text{V}$



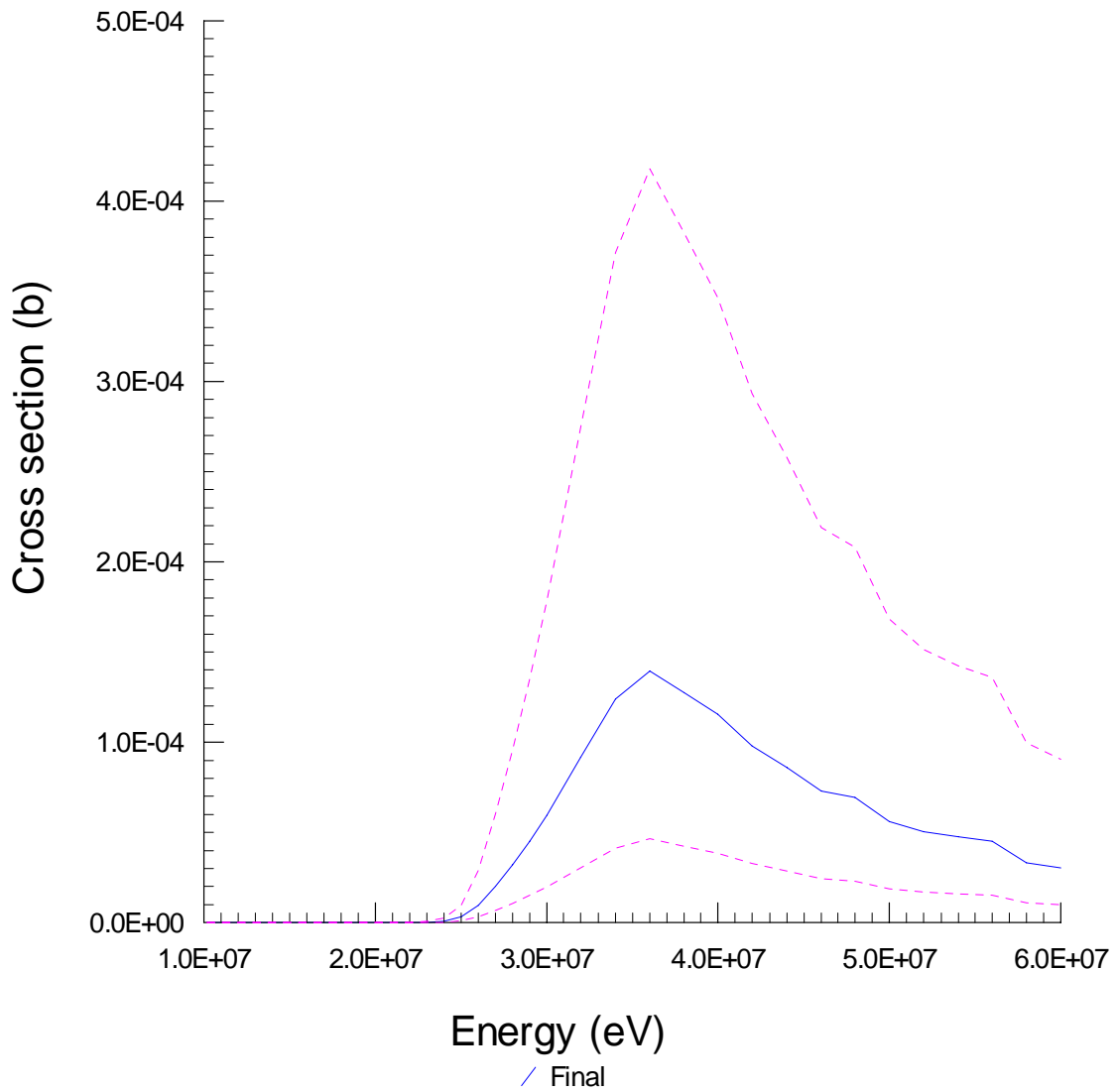
# $^{55}\text{Mn}(n,\alpha)^{52}\text{V}$



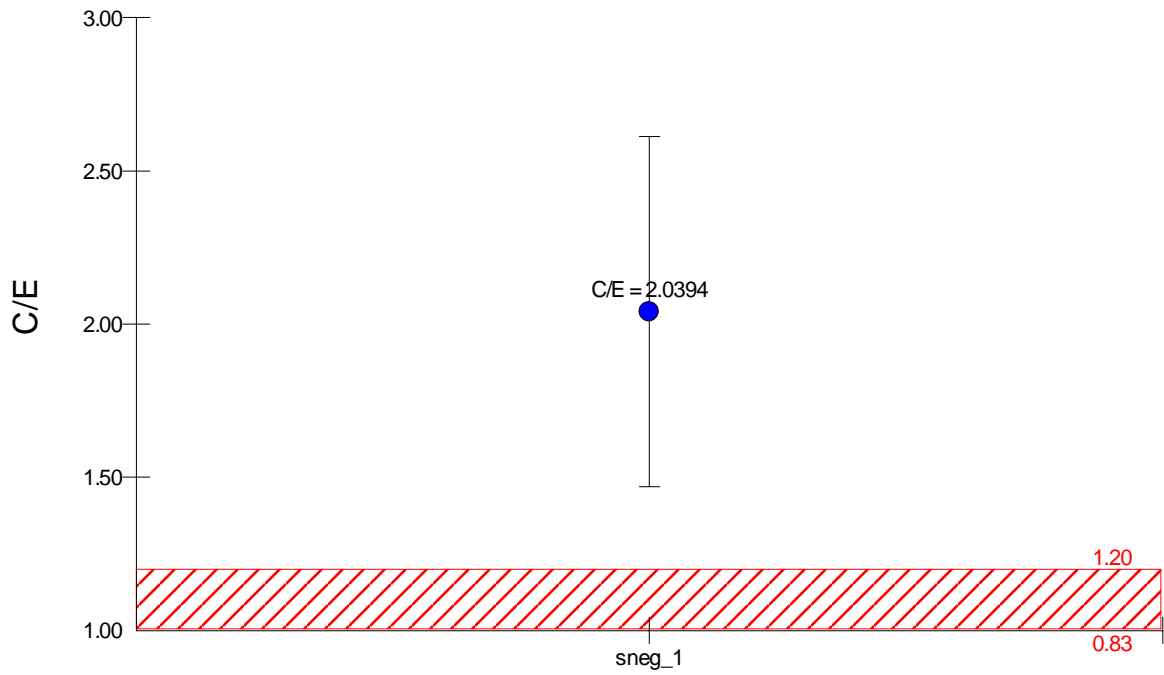
$^{55}\text{Mn}(n,2\alpha)^{48}\text{Sc}$



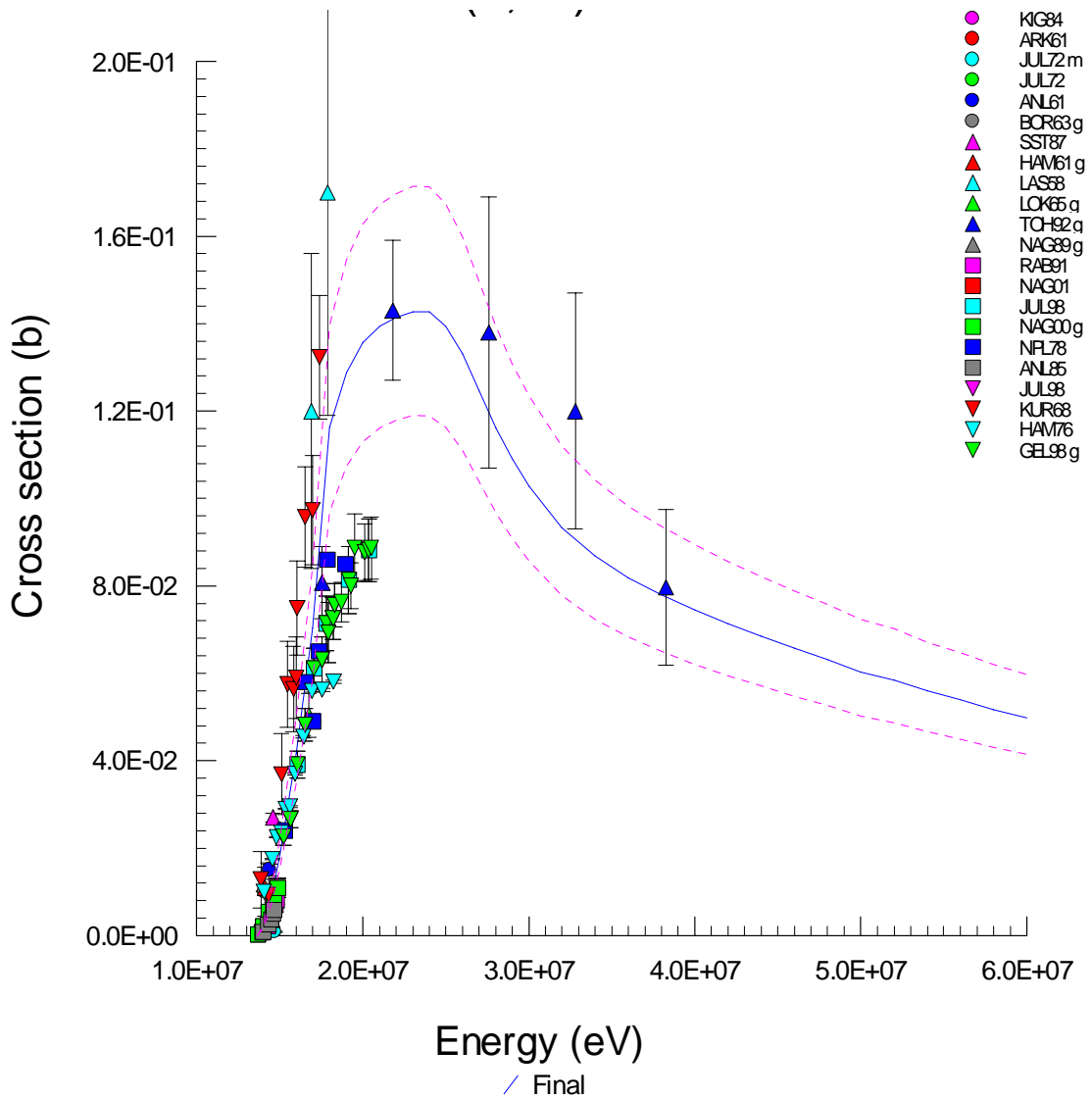
Neutron Spectrum



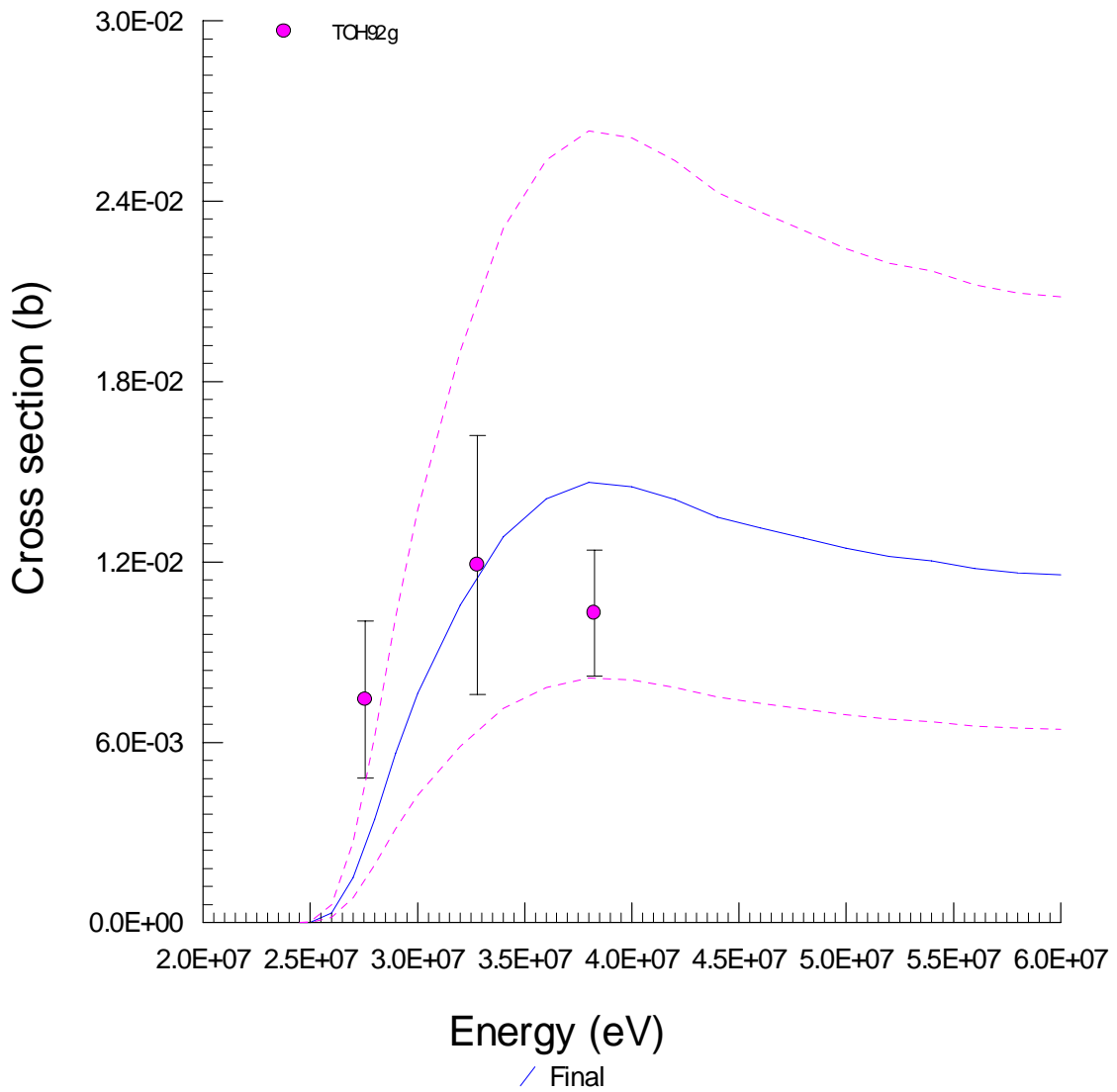
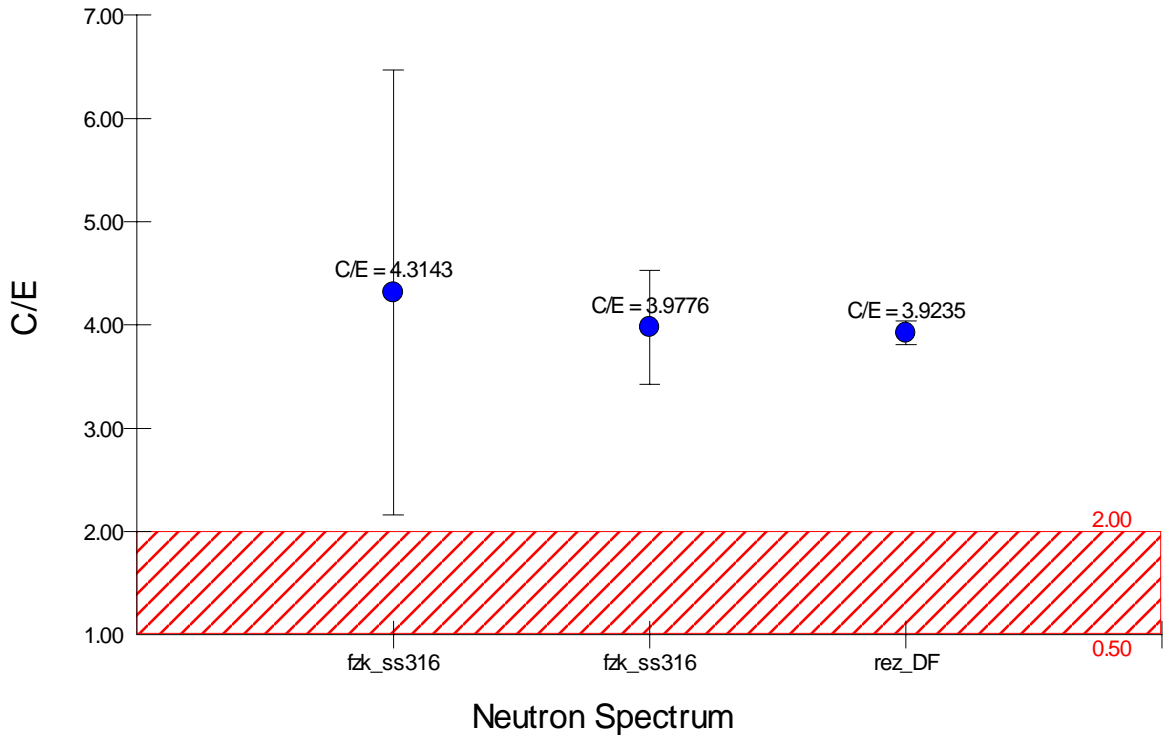
# $^{54}\text{Fe}(n,2n)^{53}\text{Fe}$



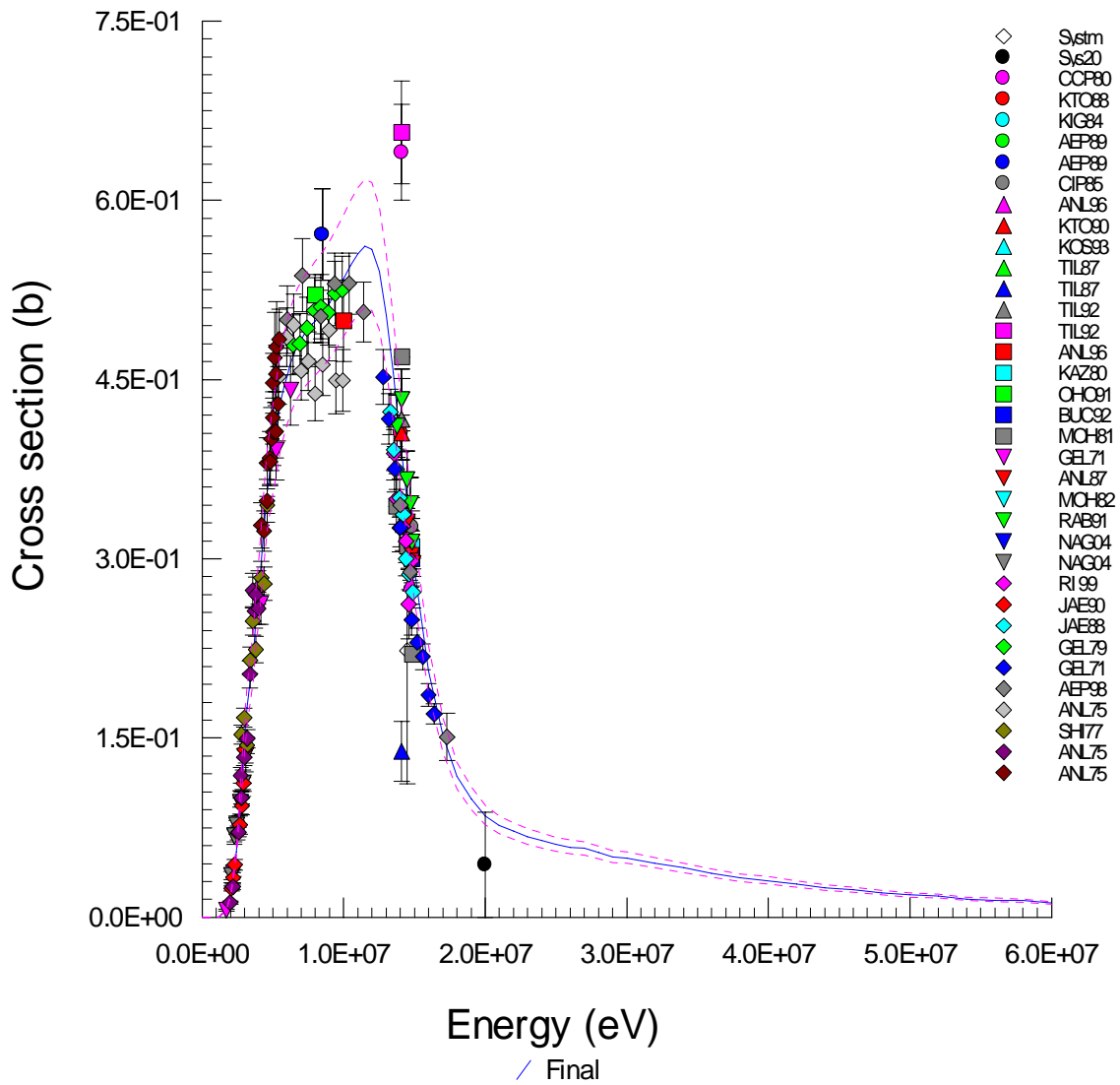
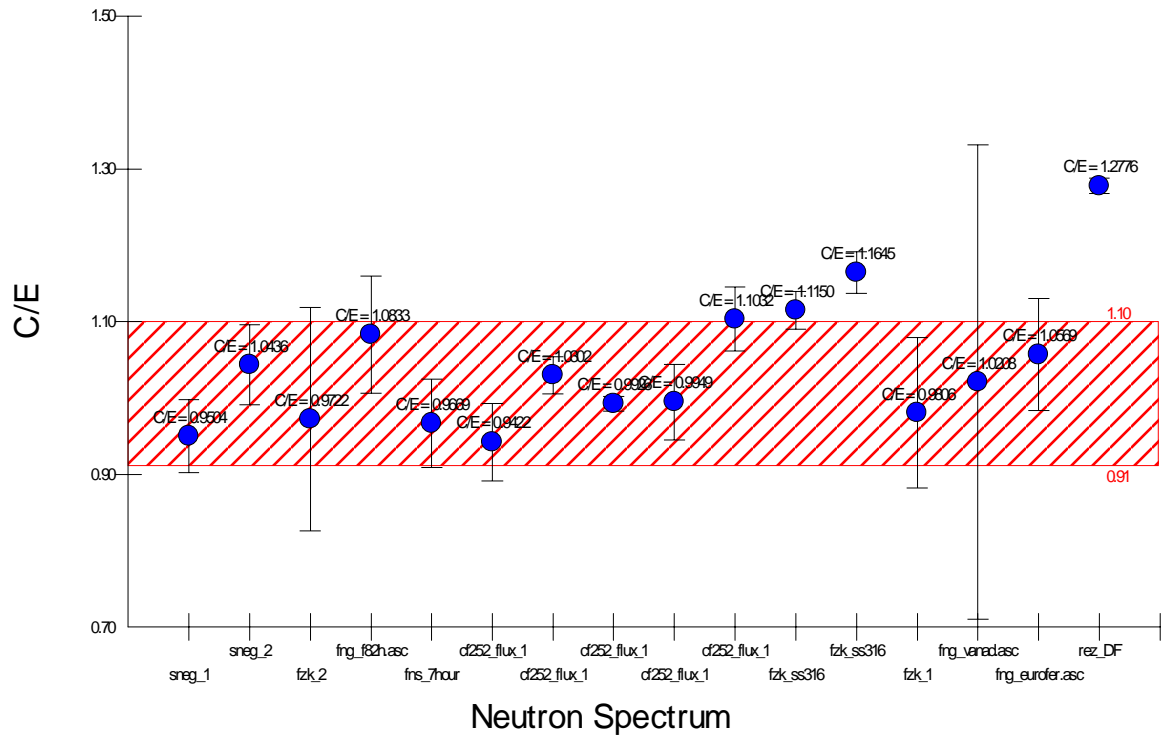
## Neutron Spectrum



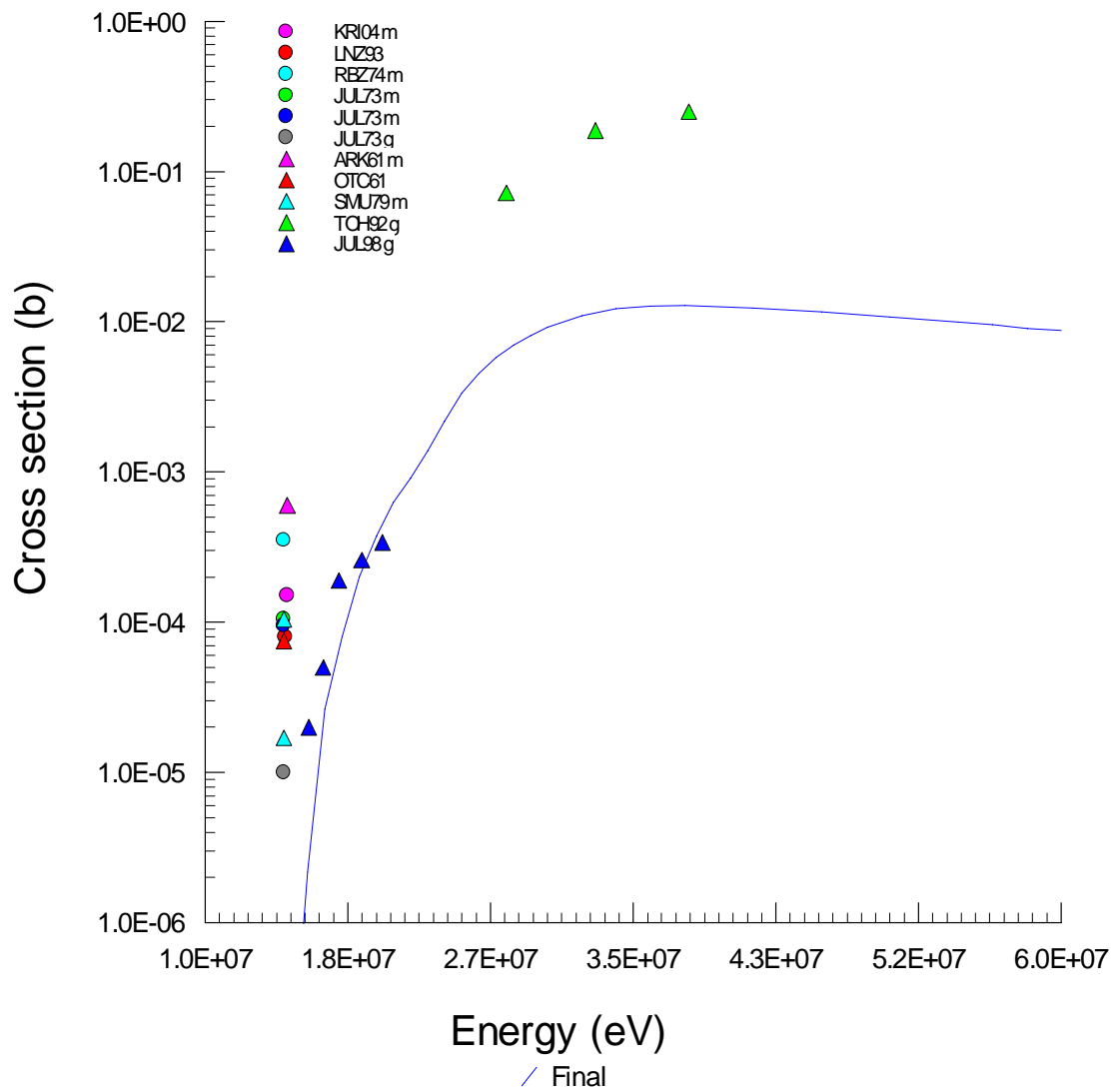
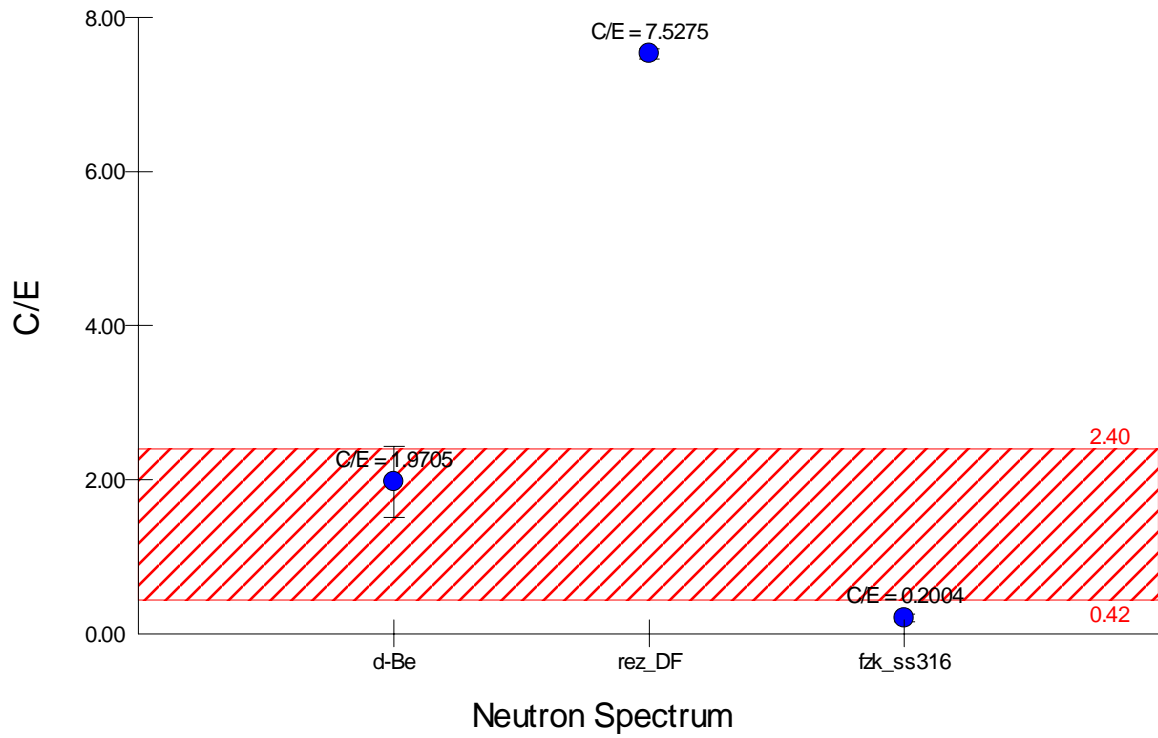
$^{54}\text{Fe}(n,3n)^{52g}\text{Fe}$



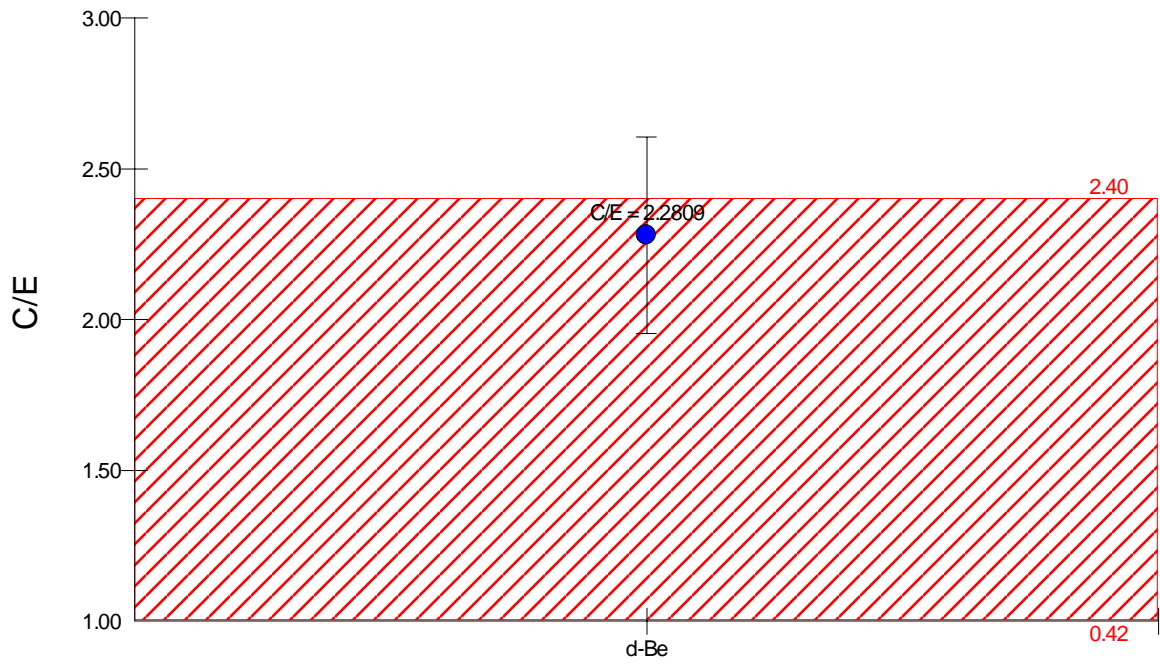
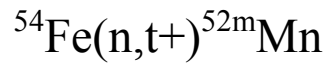
# $^{54}\text{Fe}(n,p)^{54}\text{Mn} \blacktriangleright 548$



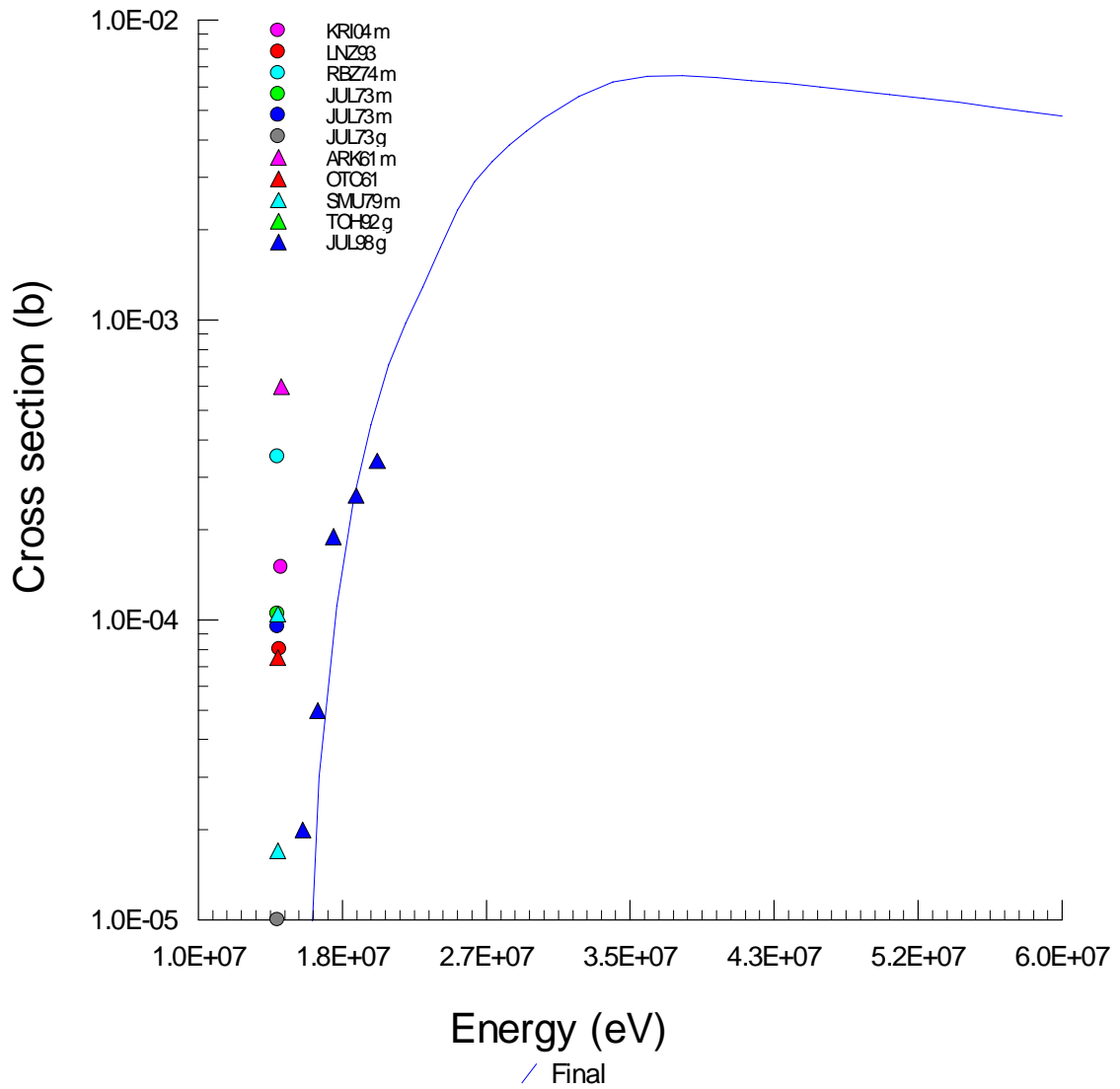
$^{54}\text{Fe}(n,t+)^{52g}\text{Mn}$



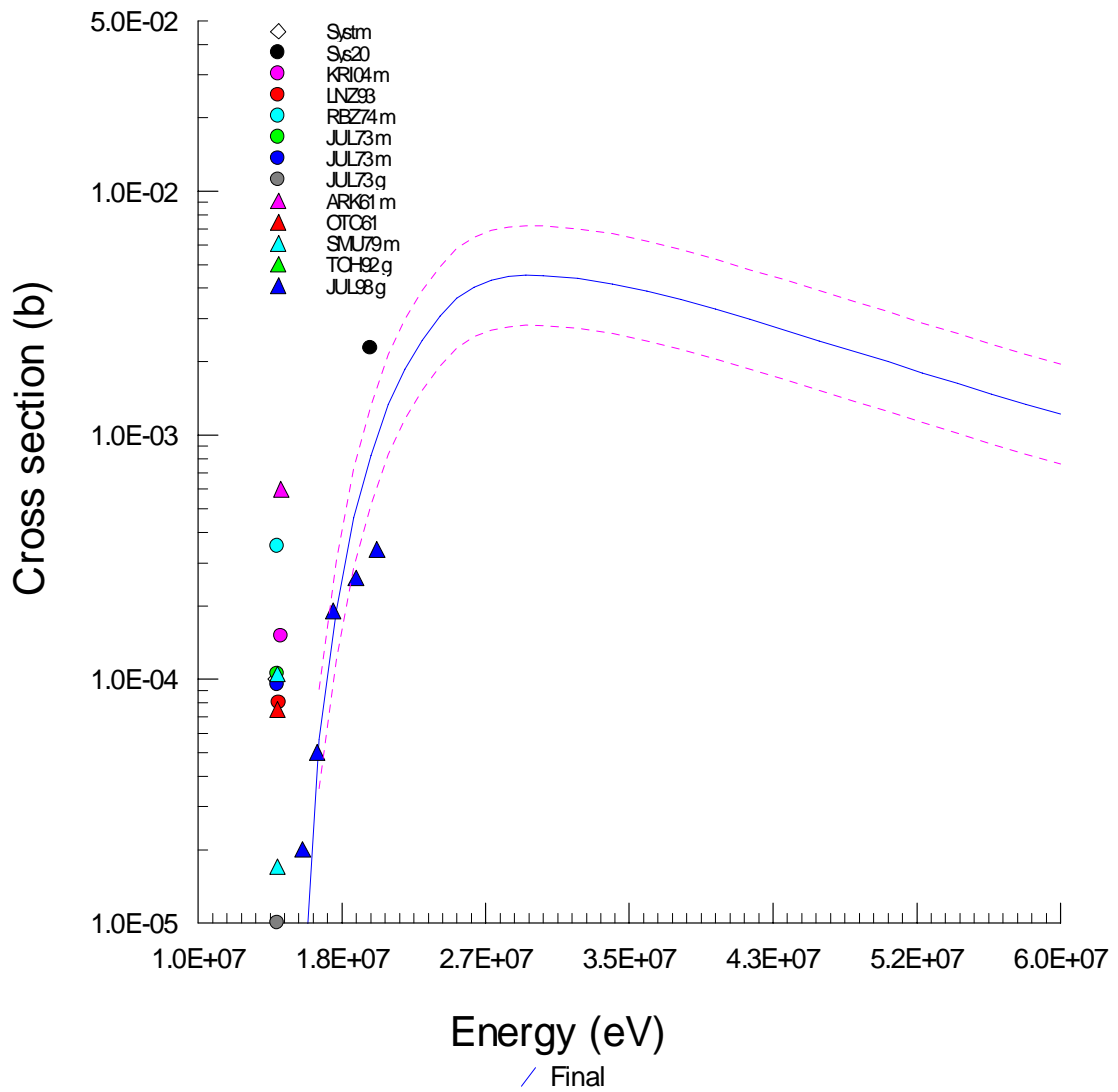
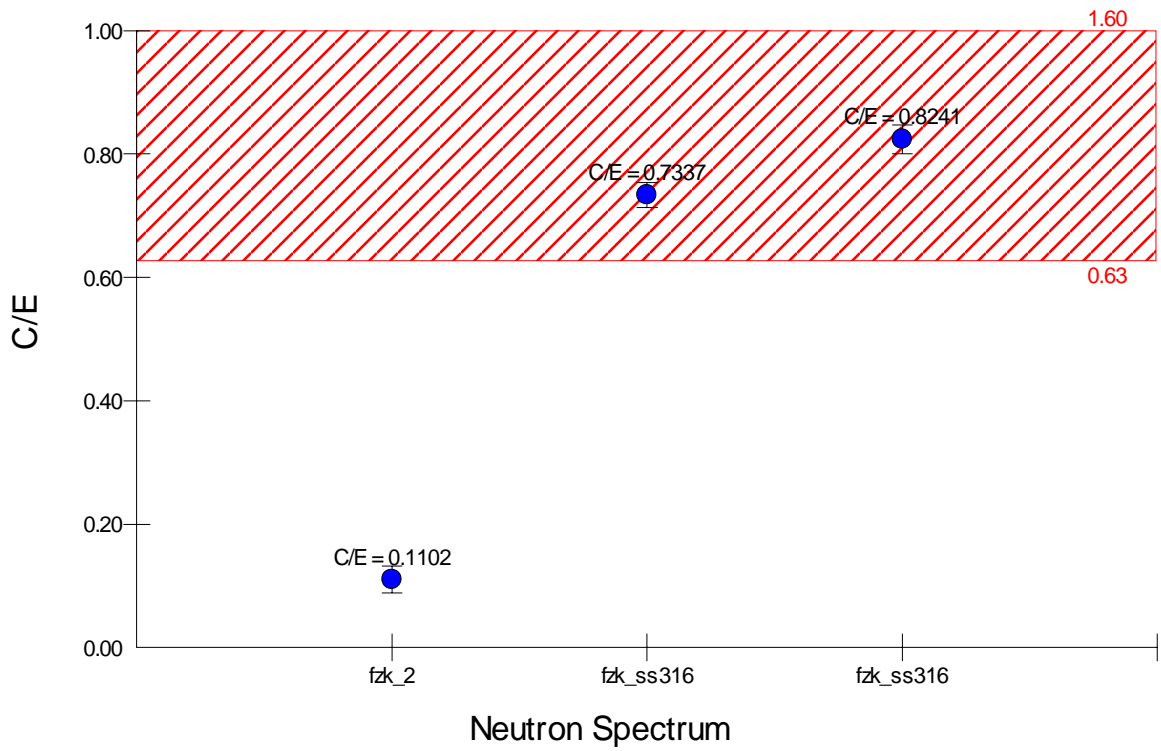




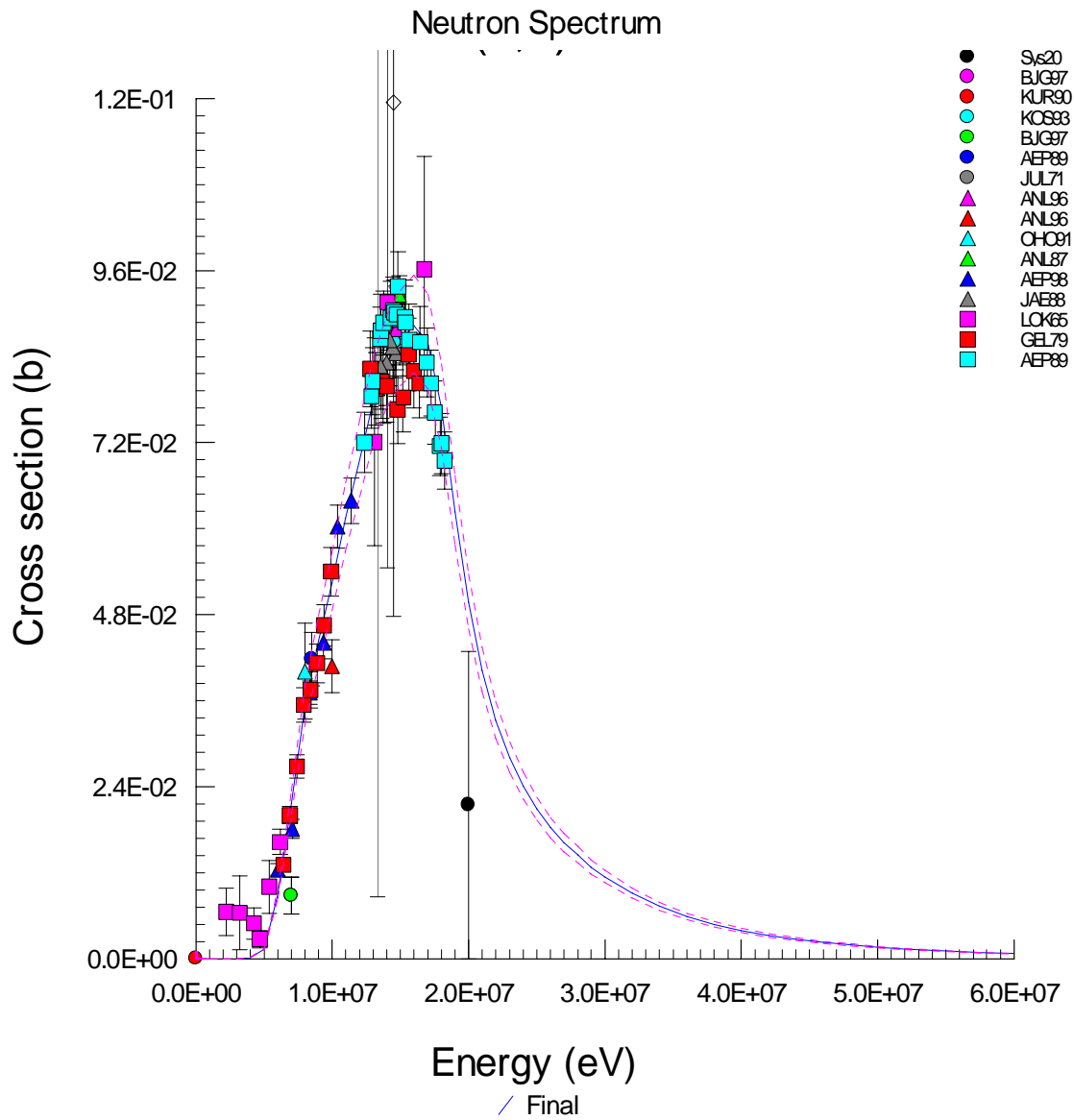
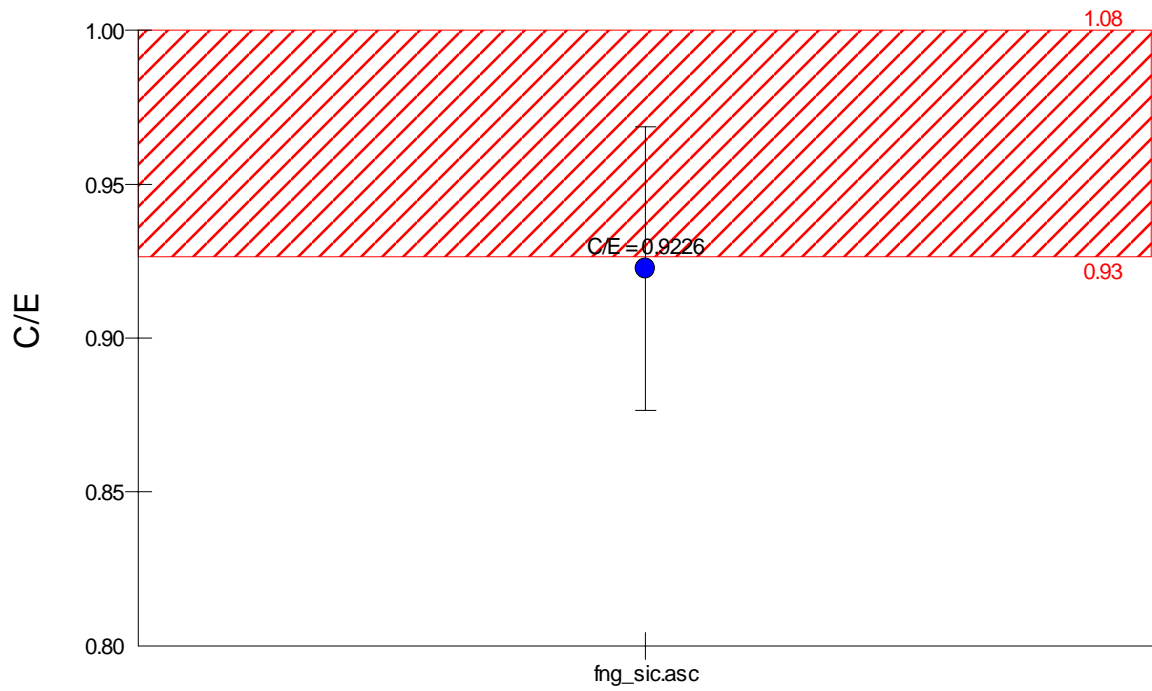
Neutron Spectrum



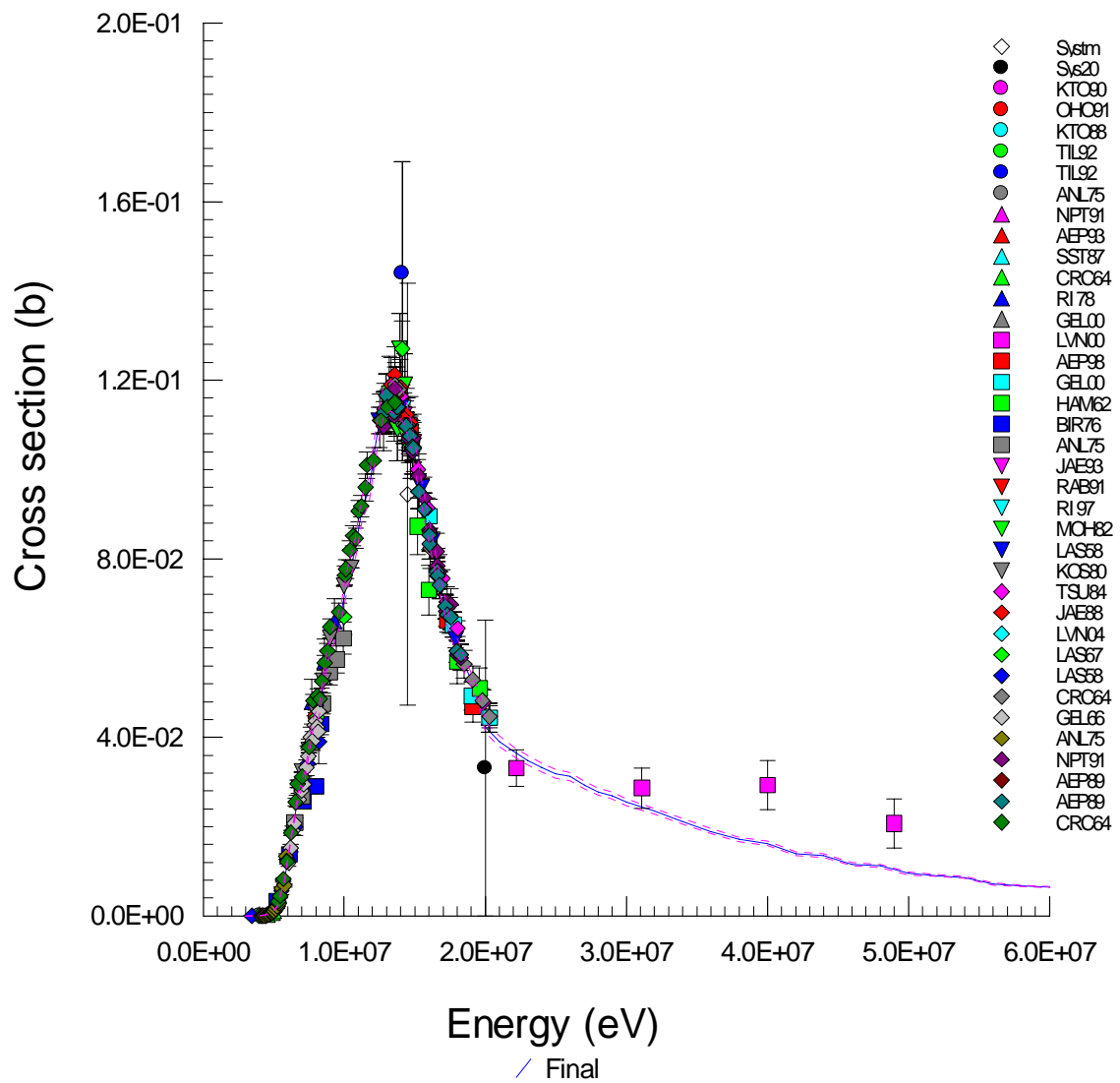
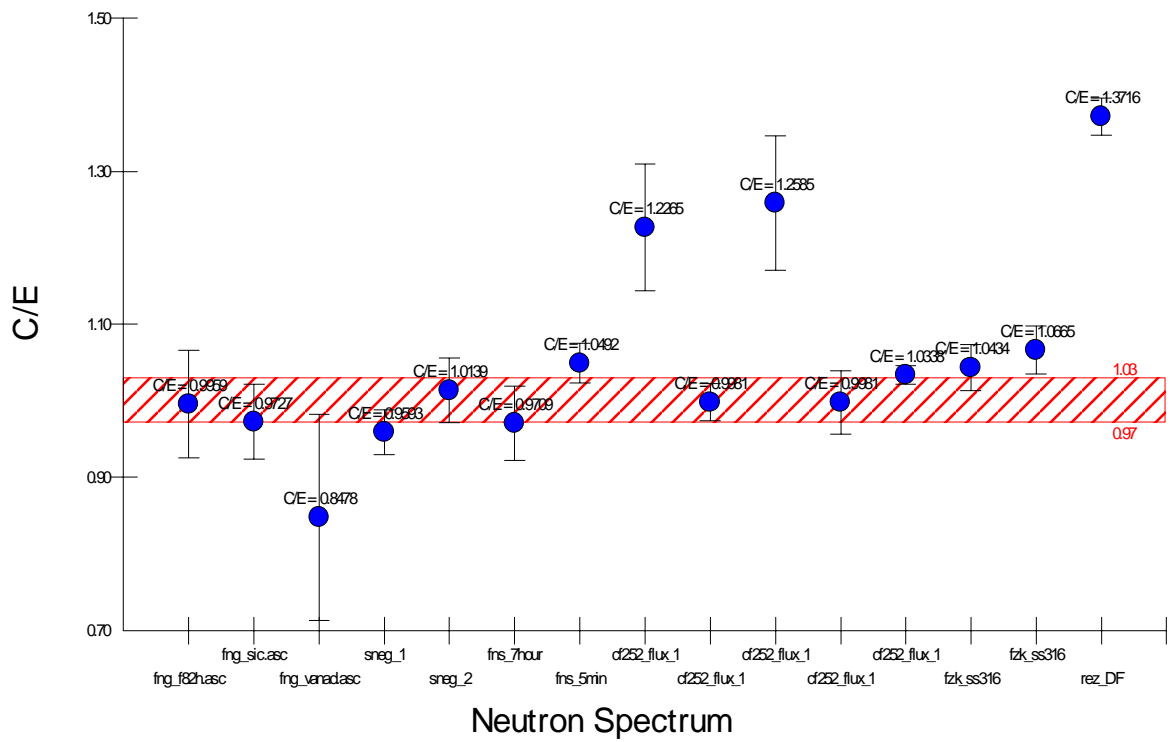
# $^{54}\text{Fe}(n,t)^{52}\text{Mn}$



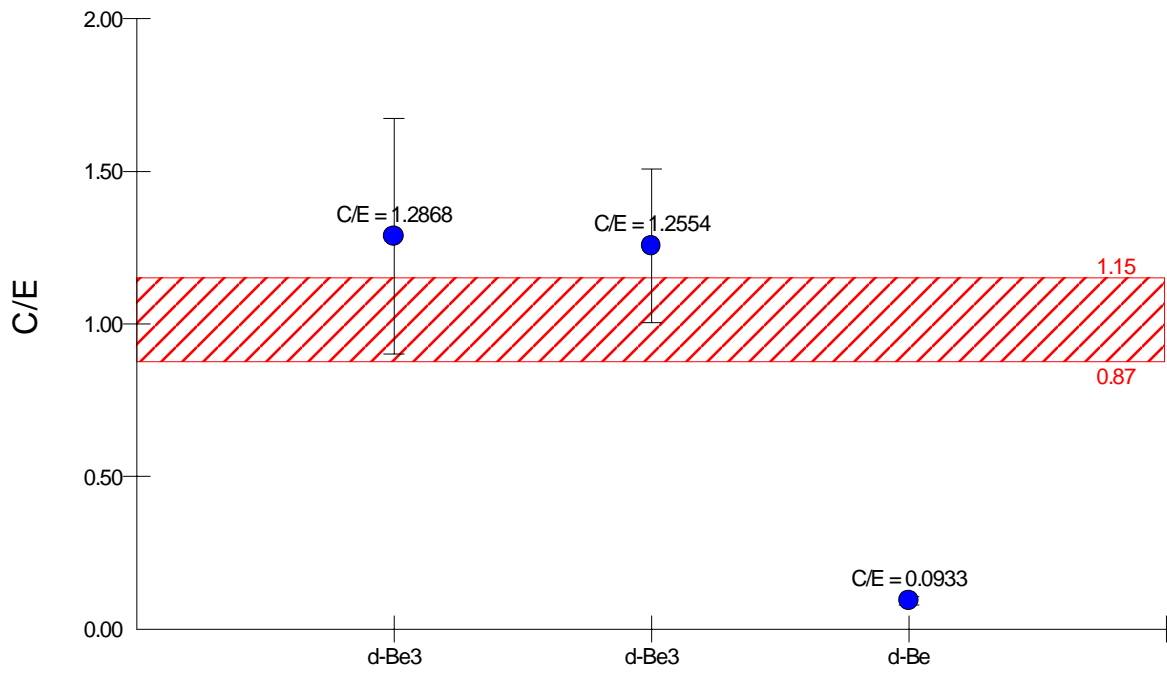
# $^{54}\text{Fe}(n,\alpha)^{51}\text{Cr}$



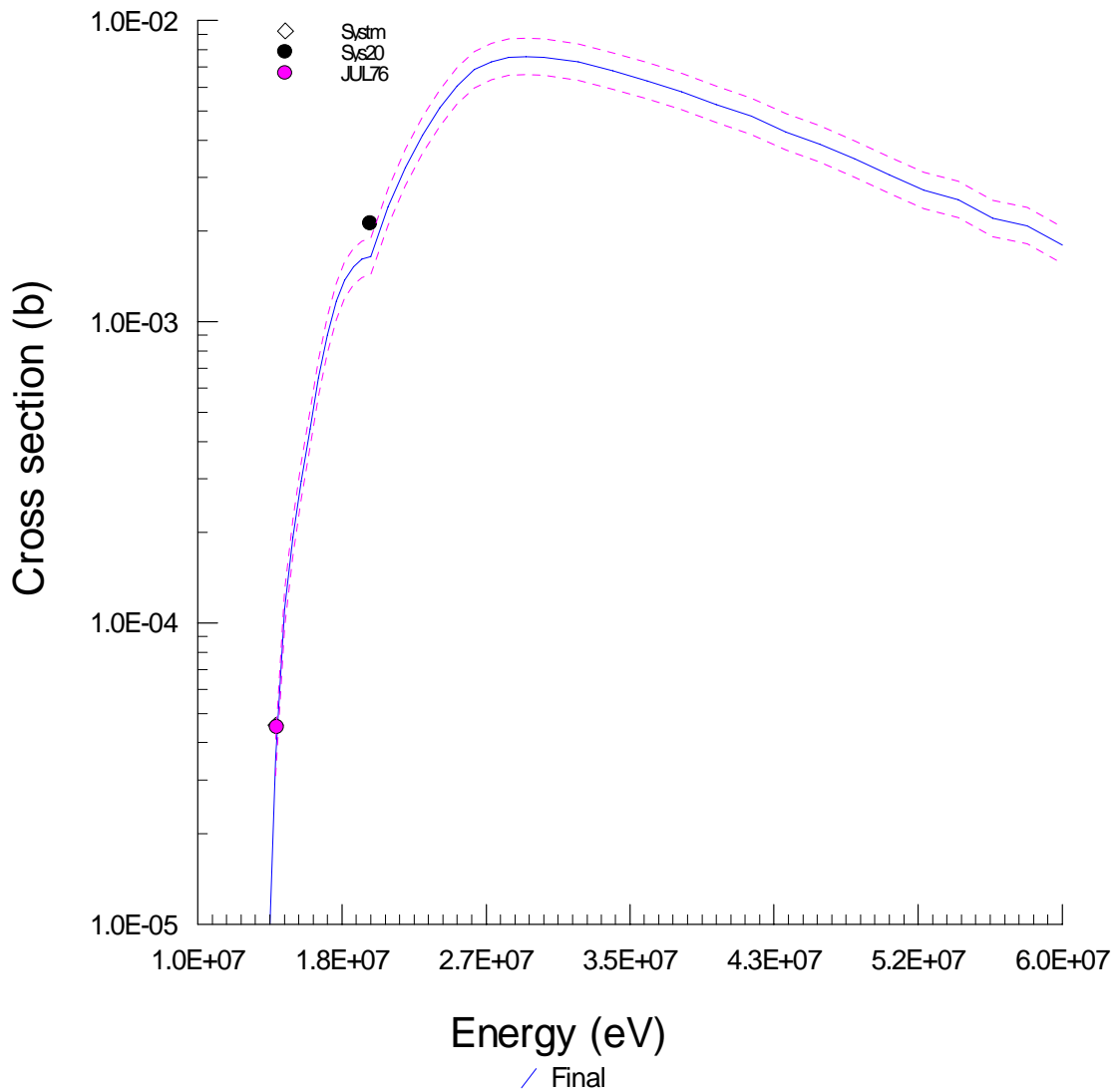
# $^{56}\text{Fe}(n,p)^{56}\text{Mn} \blacktriangleright 548$

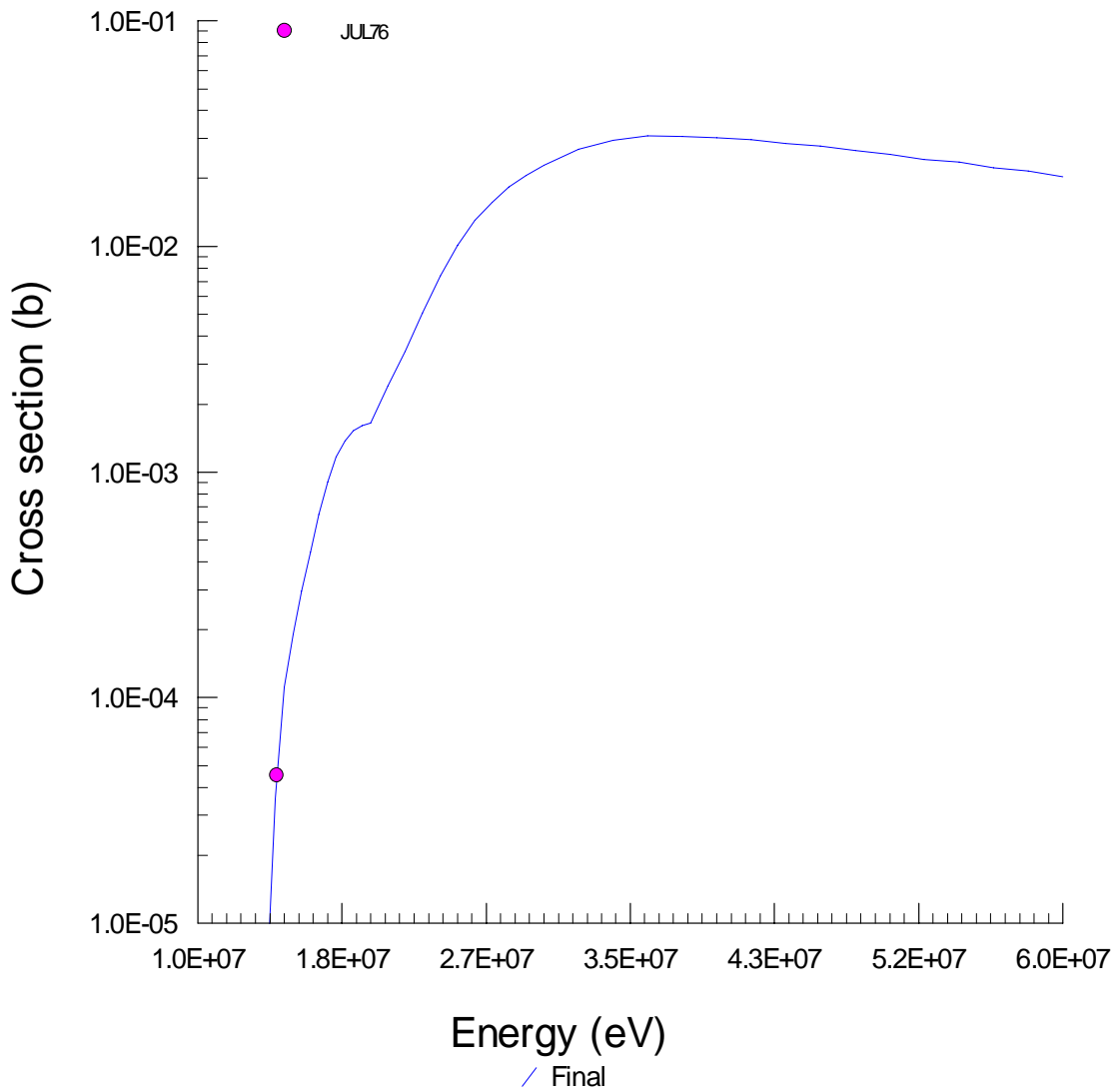
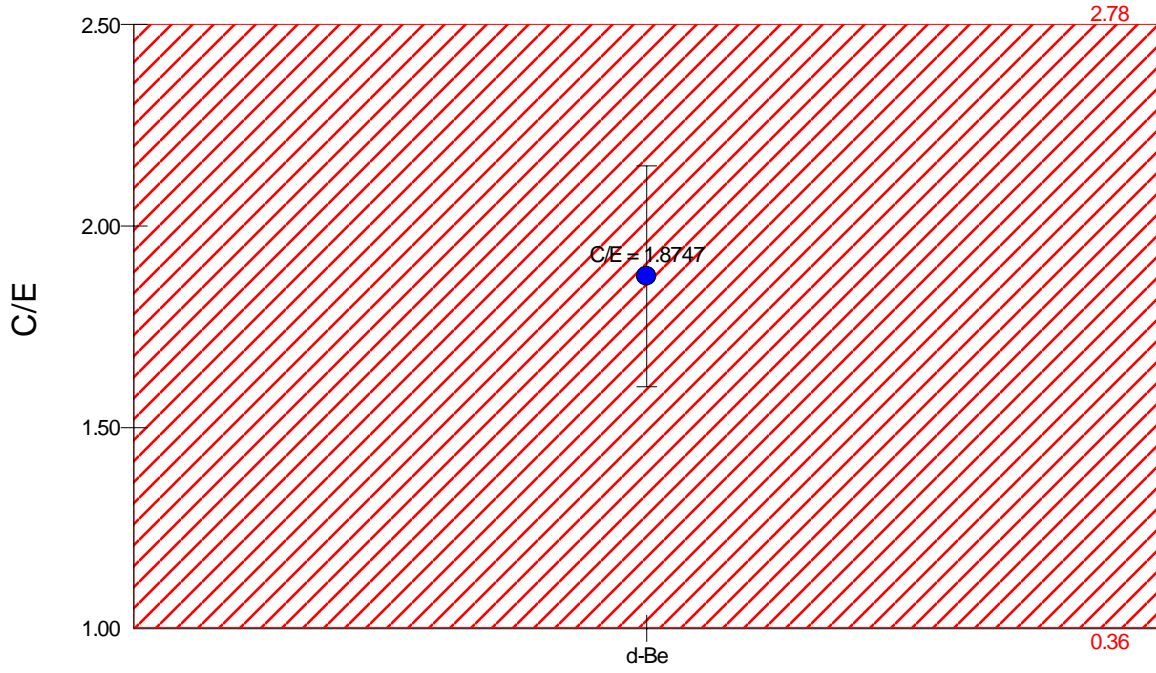
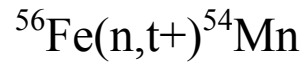


# $^{56}\text{Fe}(n,t)^{54}\text{Mn}$

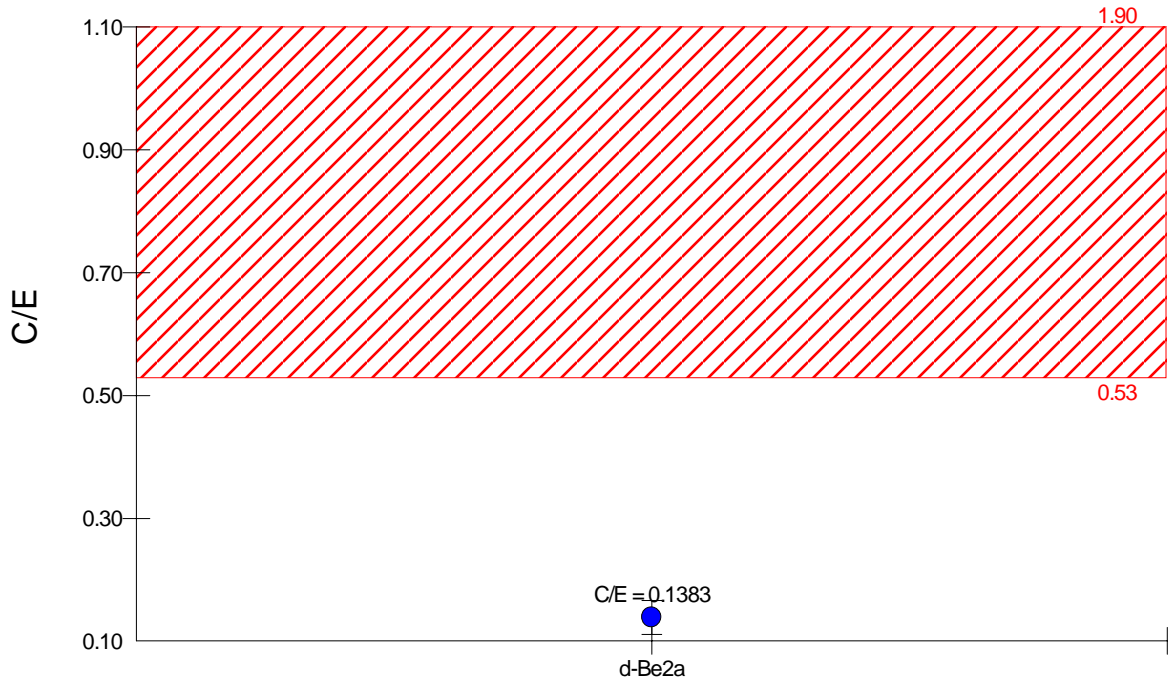


Neutron Spectrum

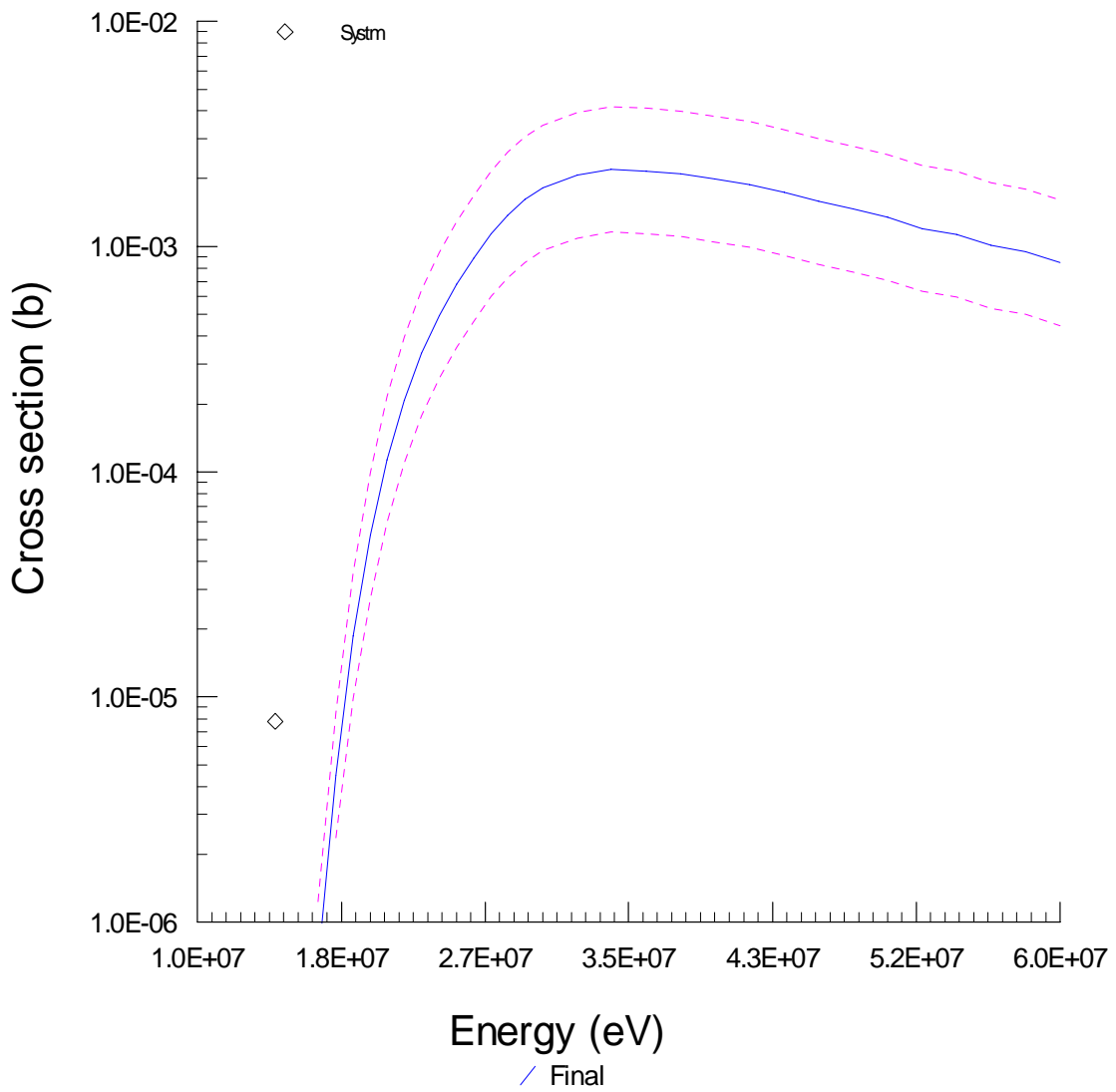




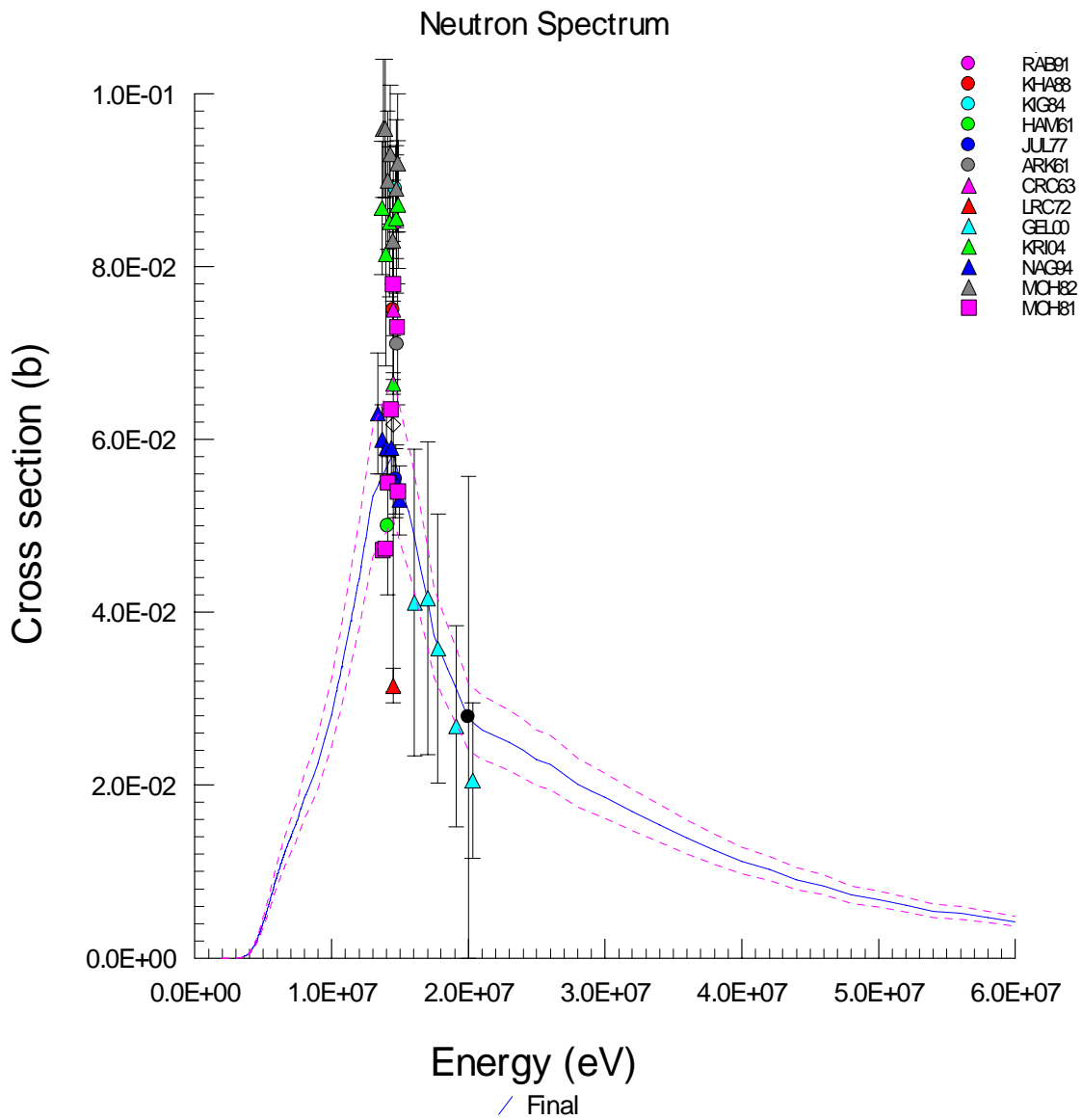
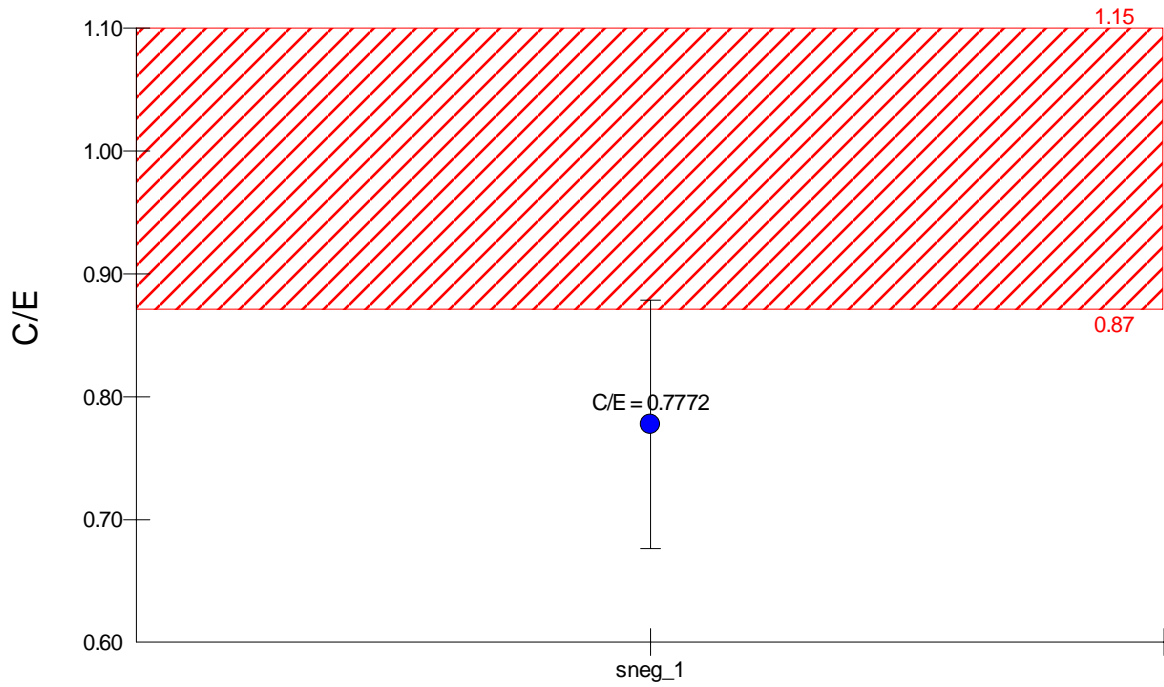
# $^{56}\text{Fe}(n,h)^{54}\text{Cr}$



Neutron Spectrum

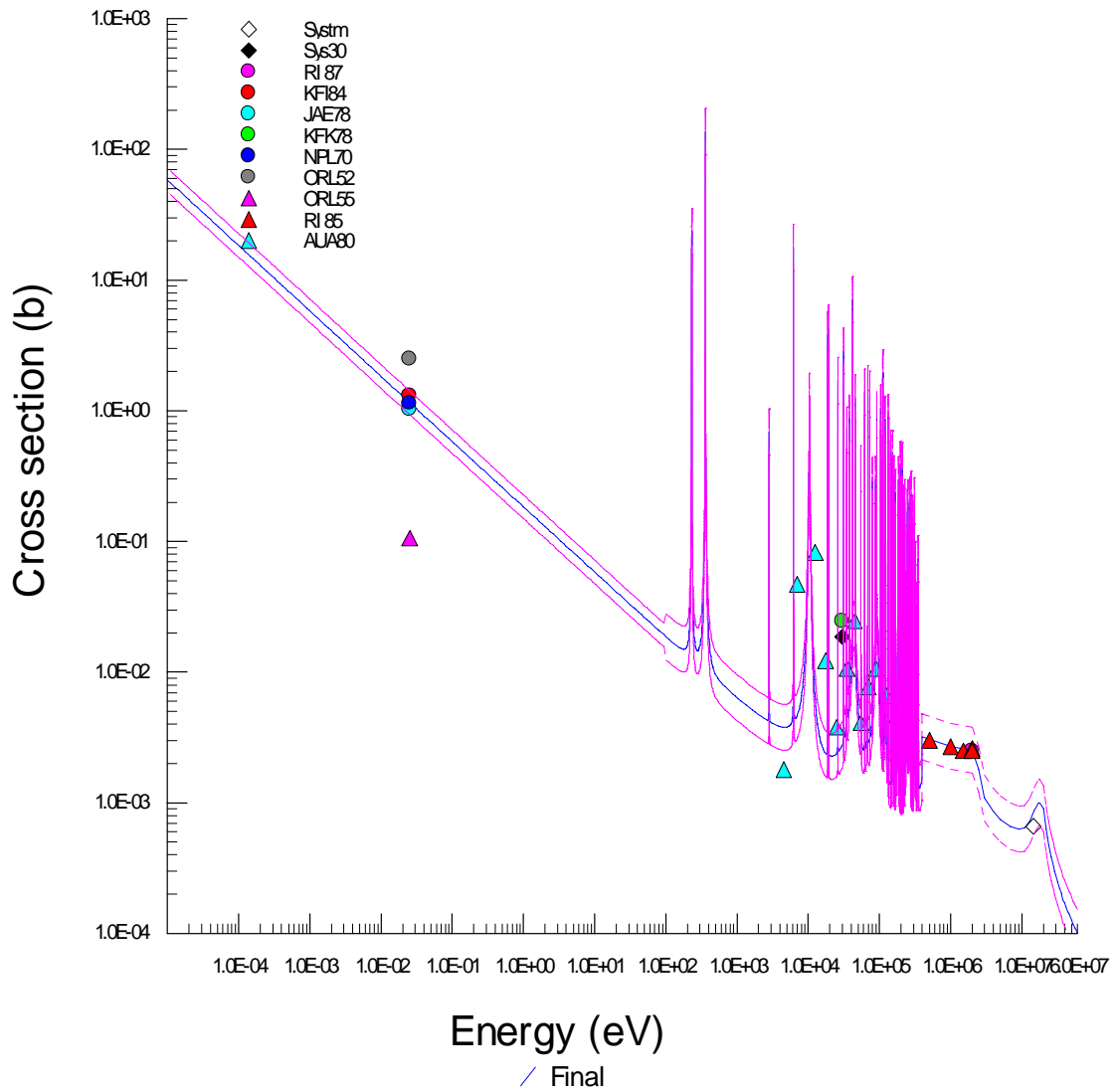
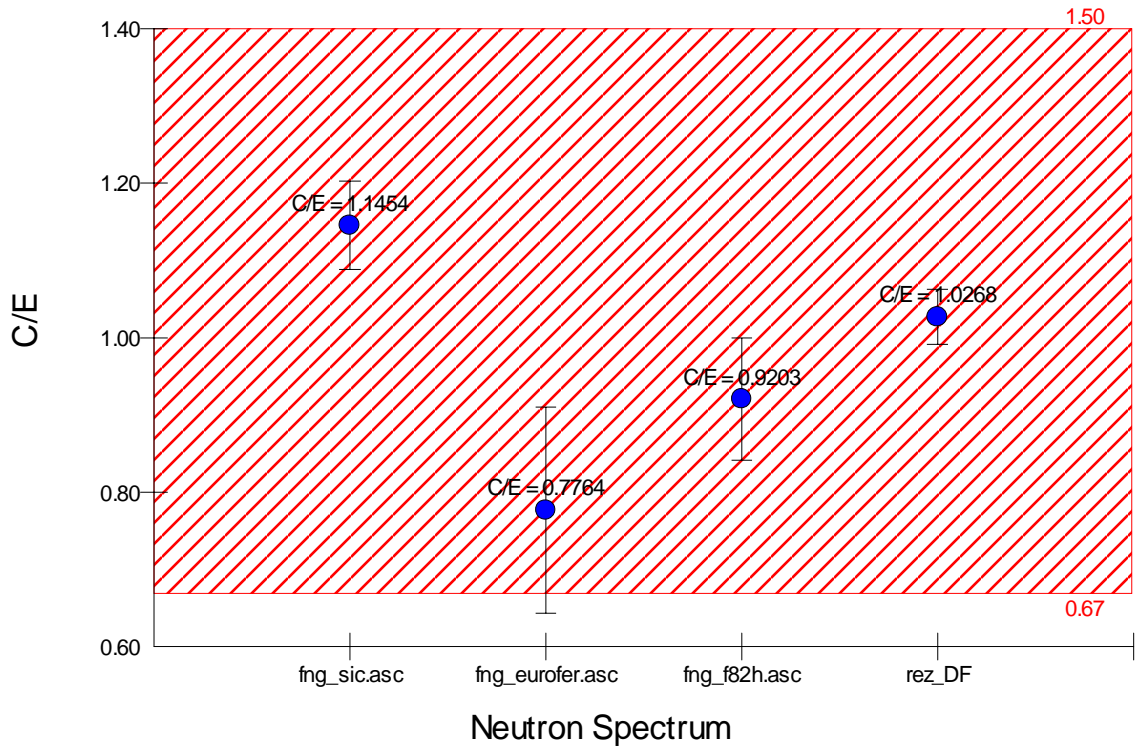


# $^{57}\text{Fe}(n,p)^{57}\text{Mn}$

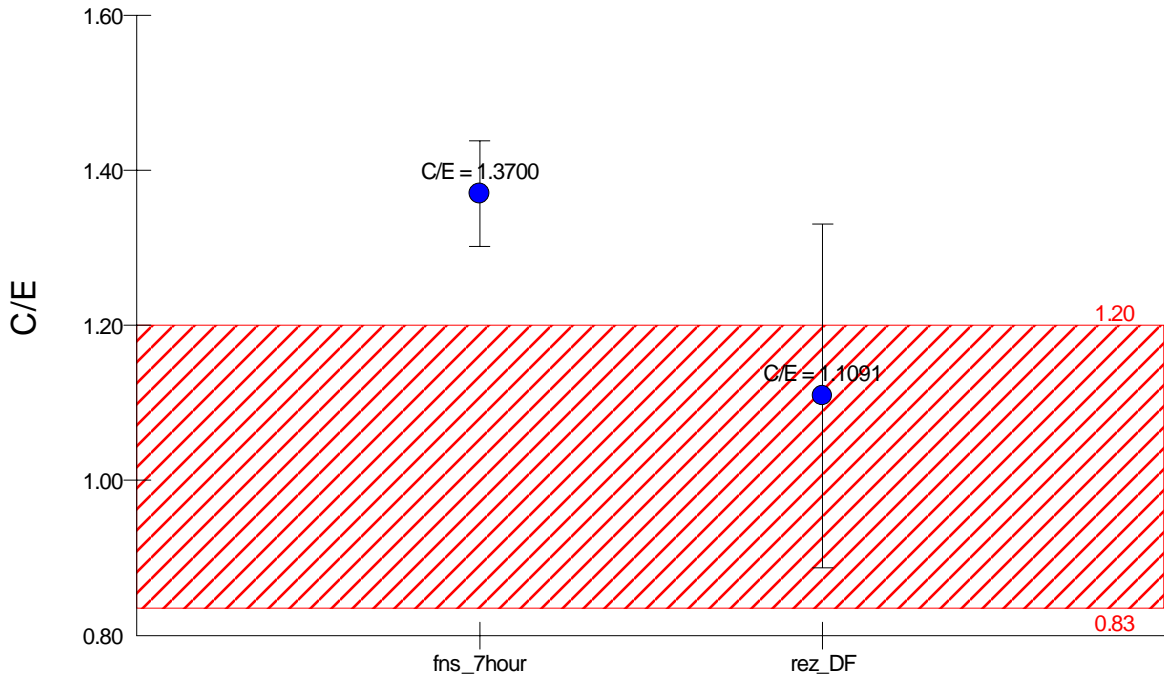




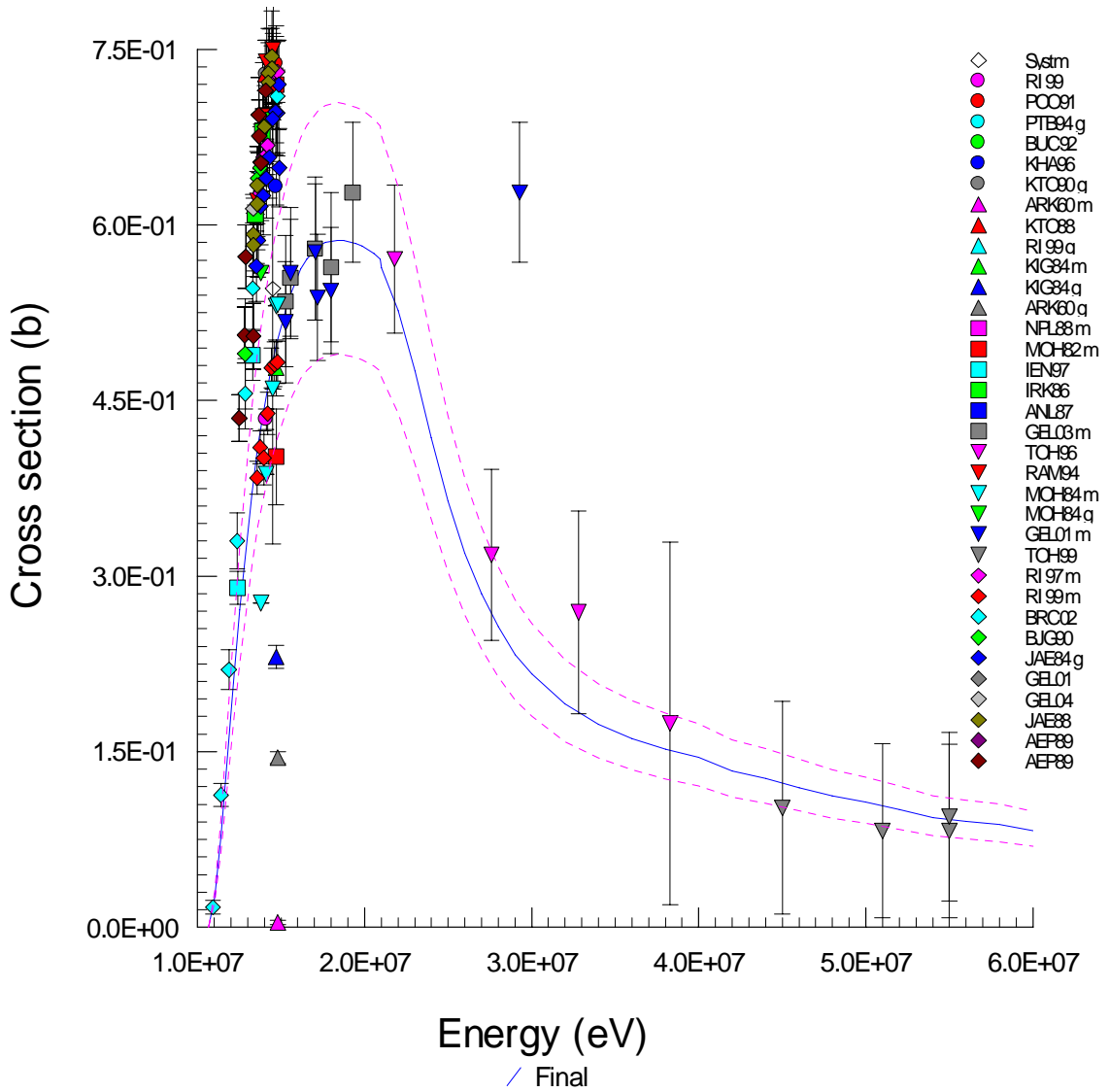
# $^{58}\text{Fe}(n,\gamma)^{59}\text{Fe}$



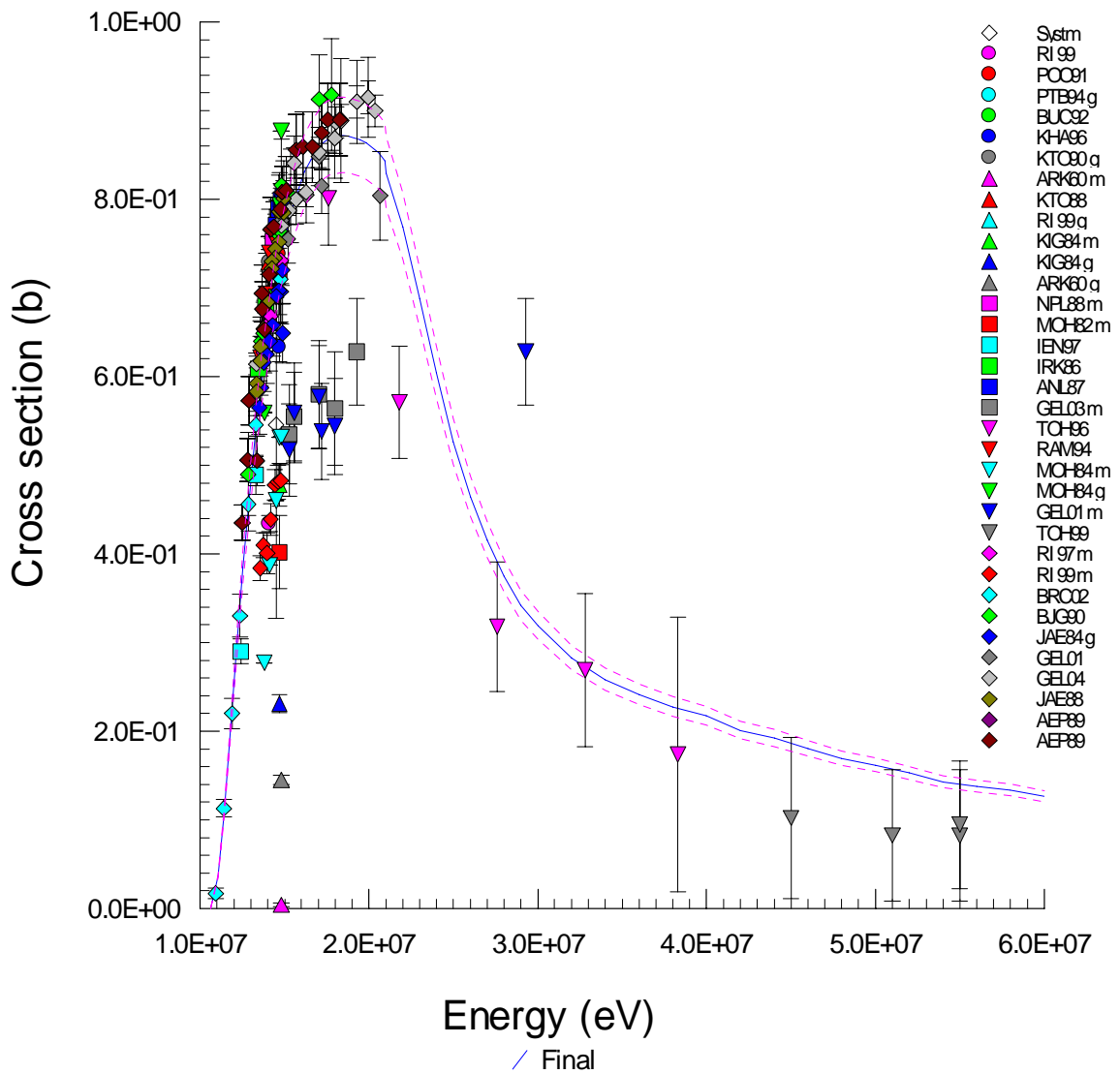
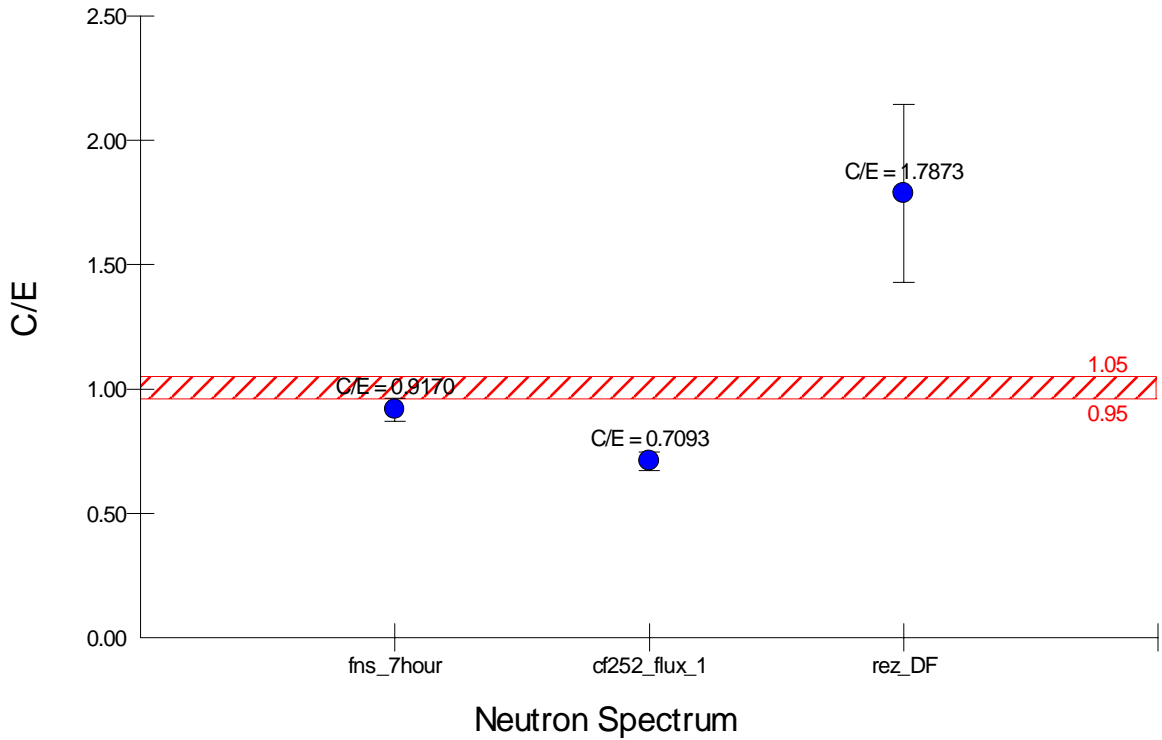
# $^{59}\text{Co}(n,2n)^{58\text{m}}\text{Co}$



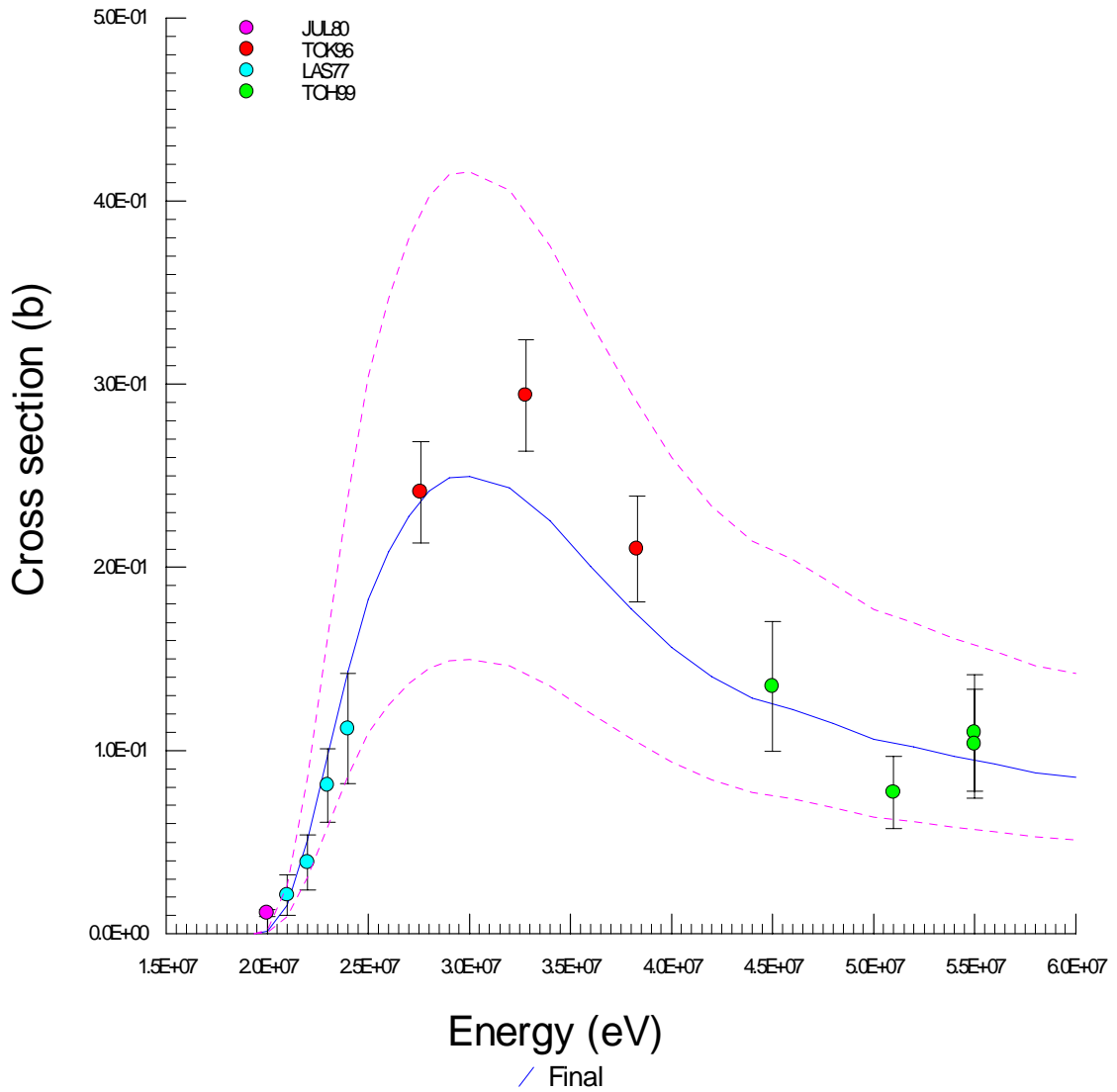
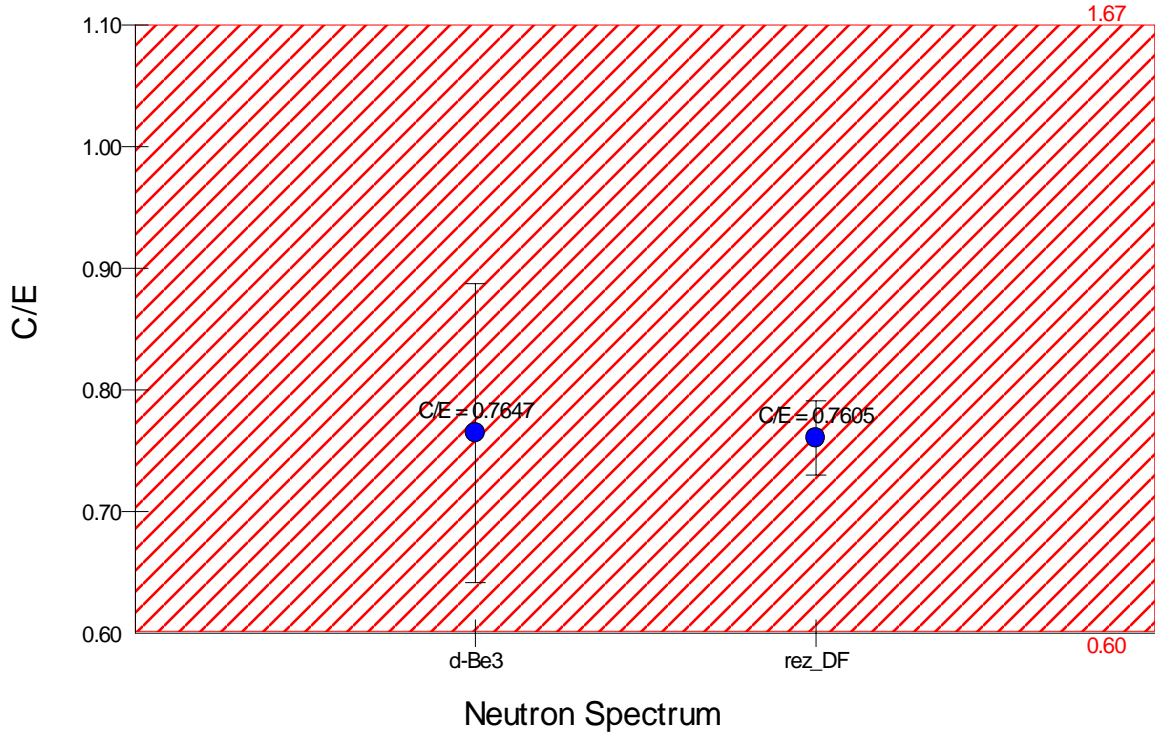
## Neutron Spectrum



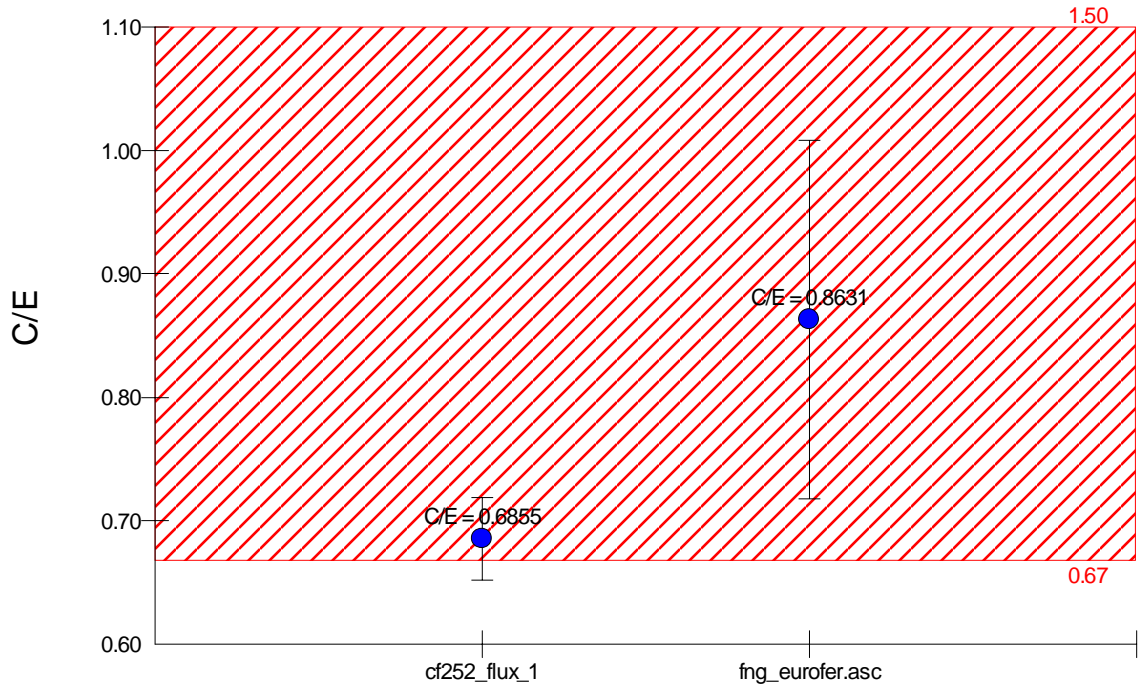
$^{59}\text{Co}(n,2n)^{58}\text{Co}$



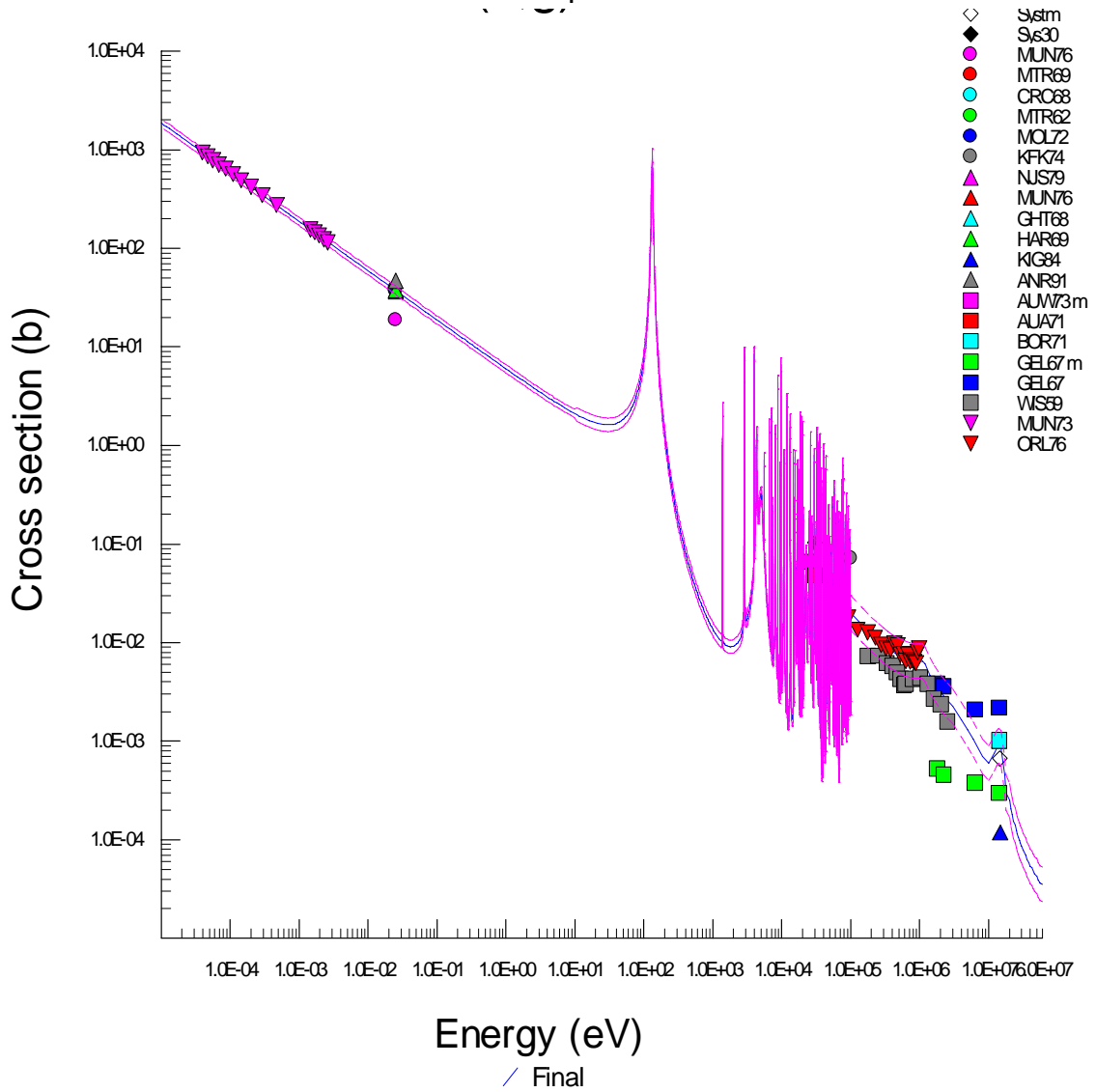
$^{59}\text{Co}(n,3n)^{57}\text{Co}$



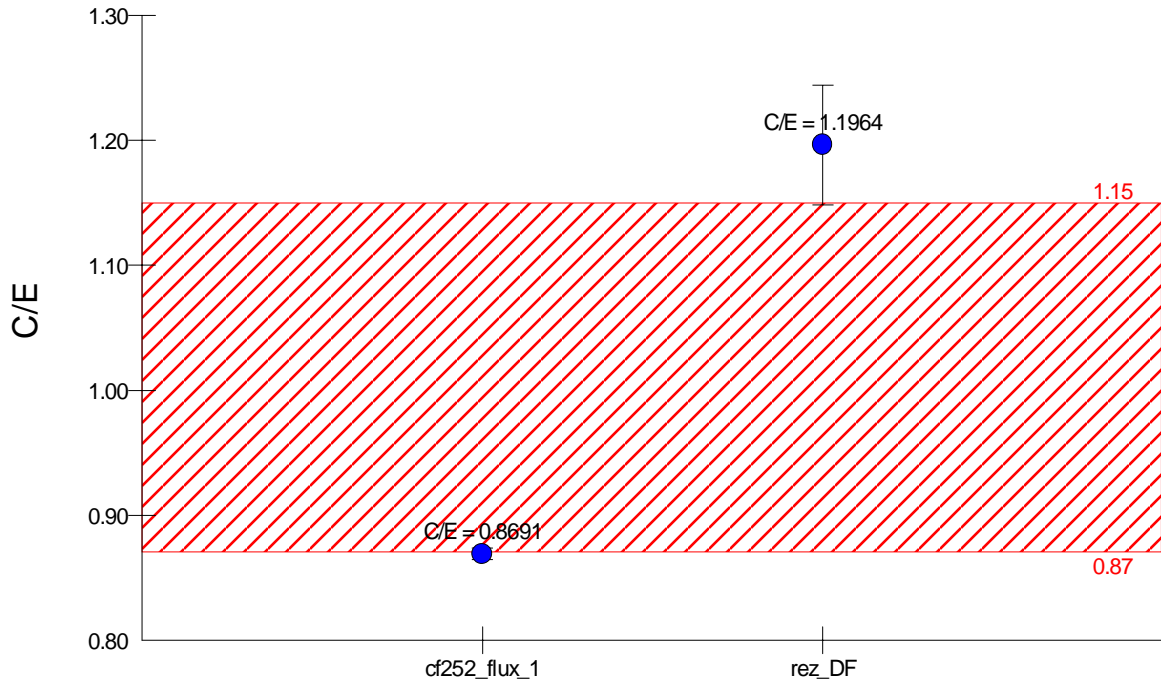
# $^{59}\text{Co}(n,\gamma)^{60}\text{Co}$



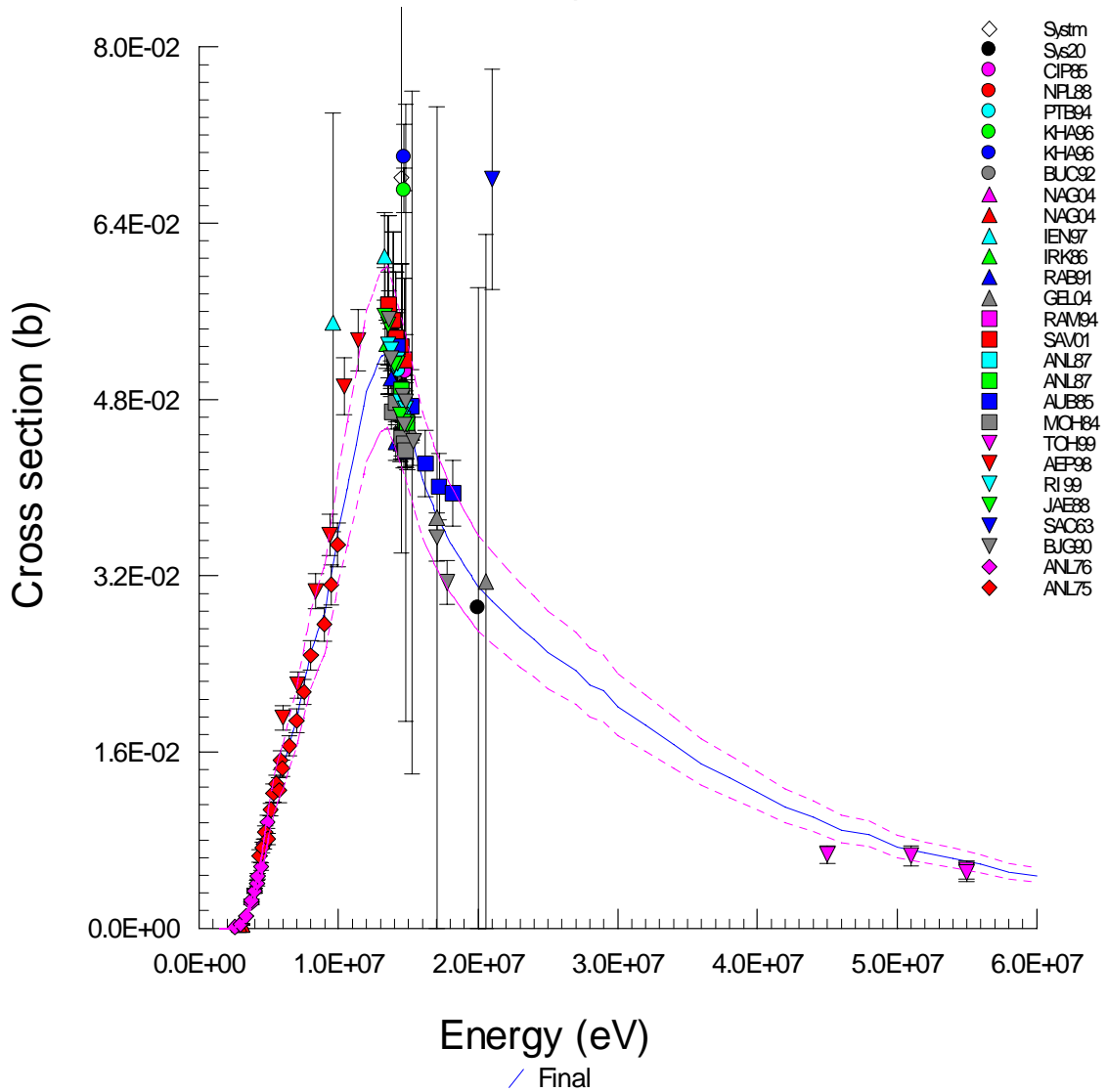
## Neutron Spectrum



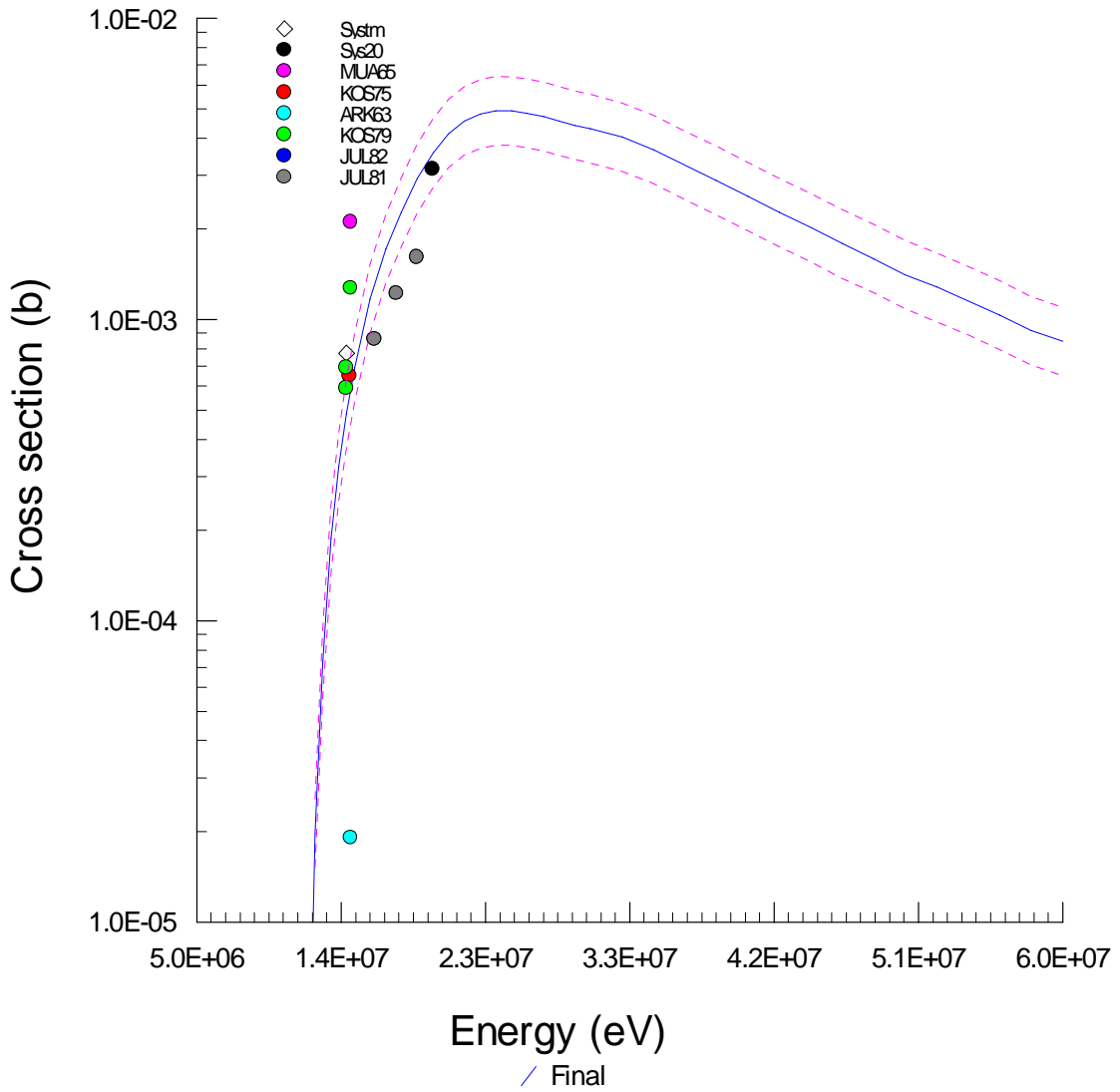
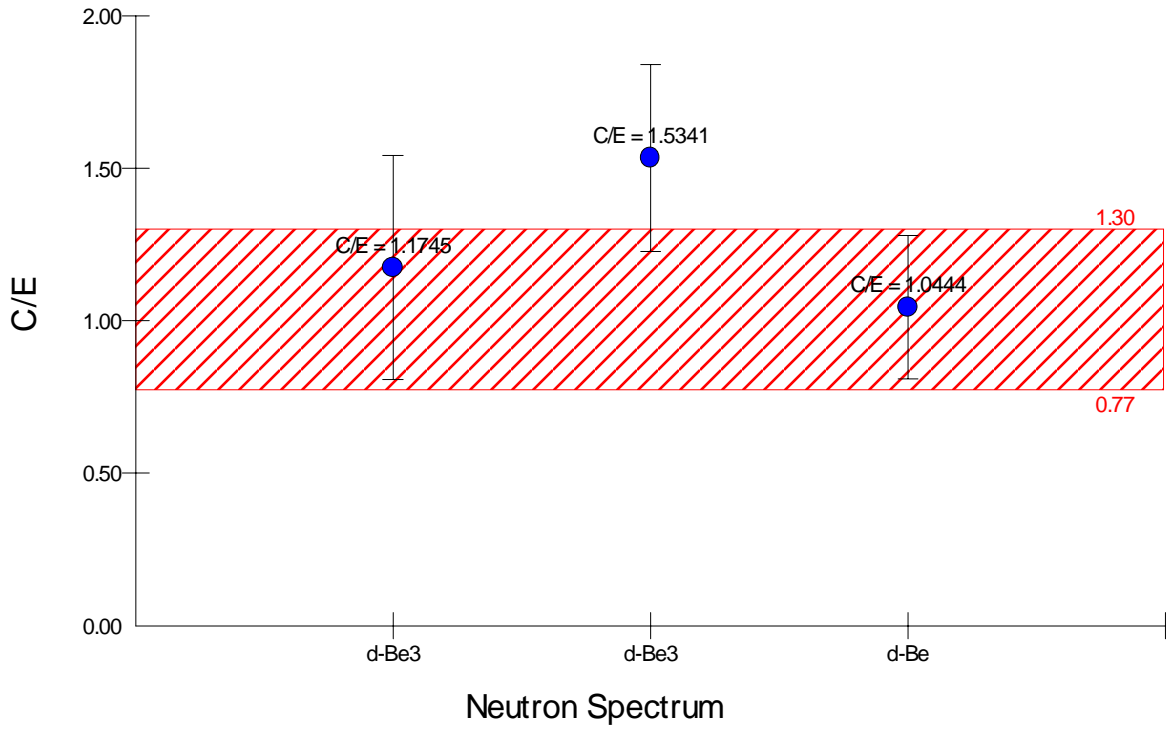
# $^{59}\text{Co}(n,p)^{59}\text{Fe}$



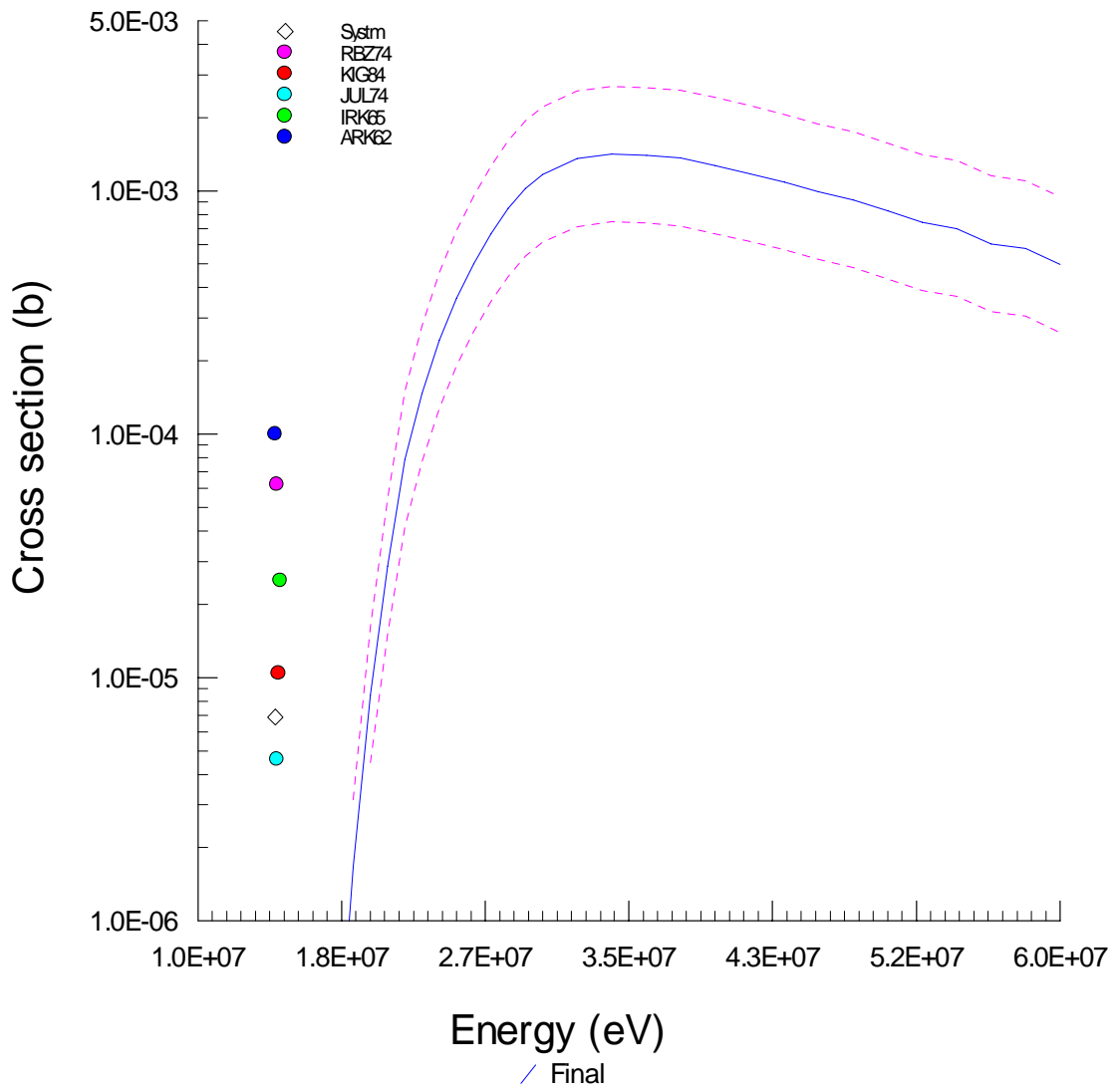
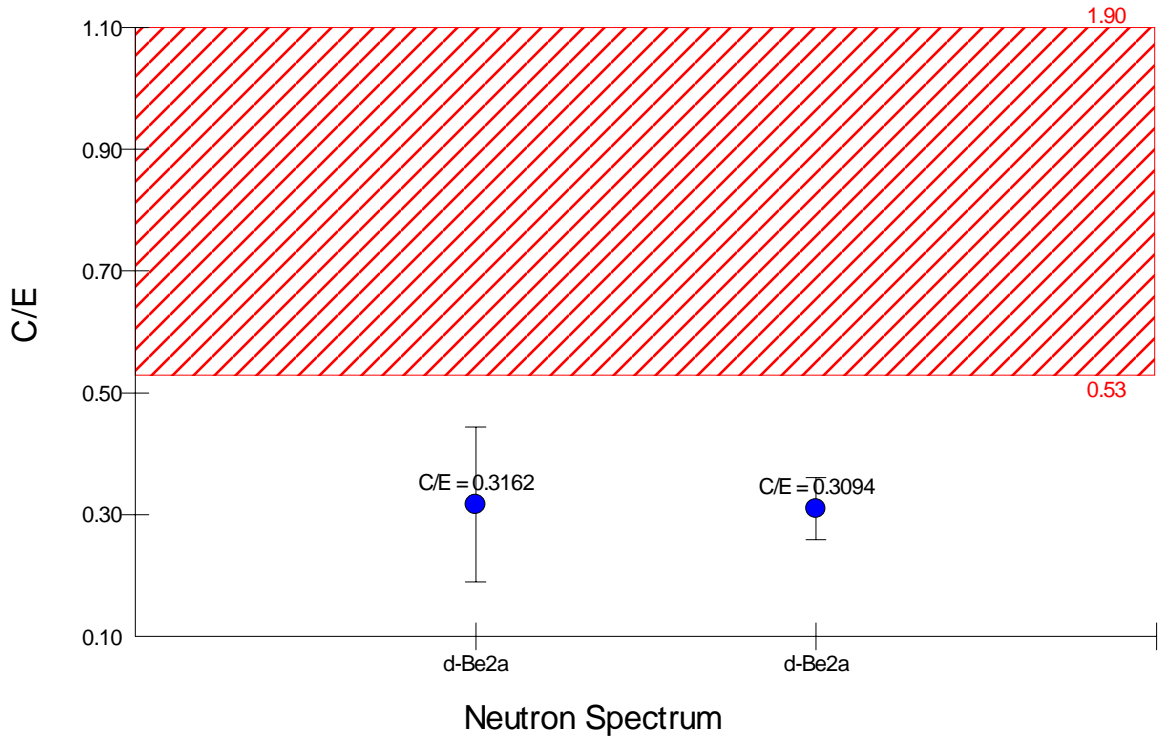
## Neutron Spectrum



# $^{59}\text{Co}(n,t)^{57}\text{Fe}$

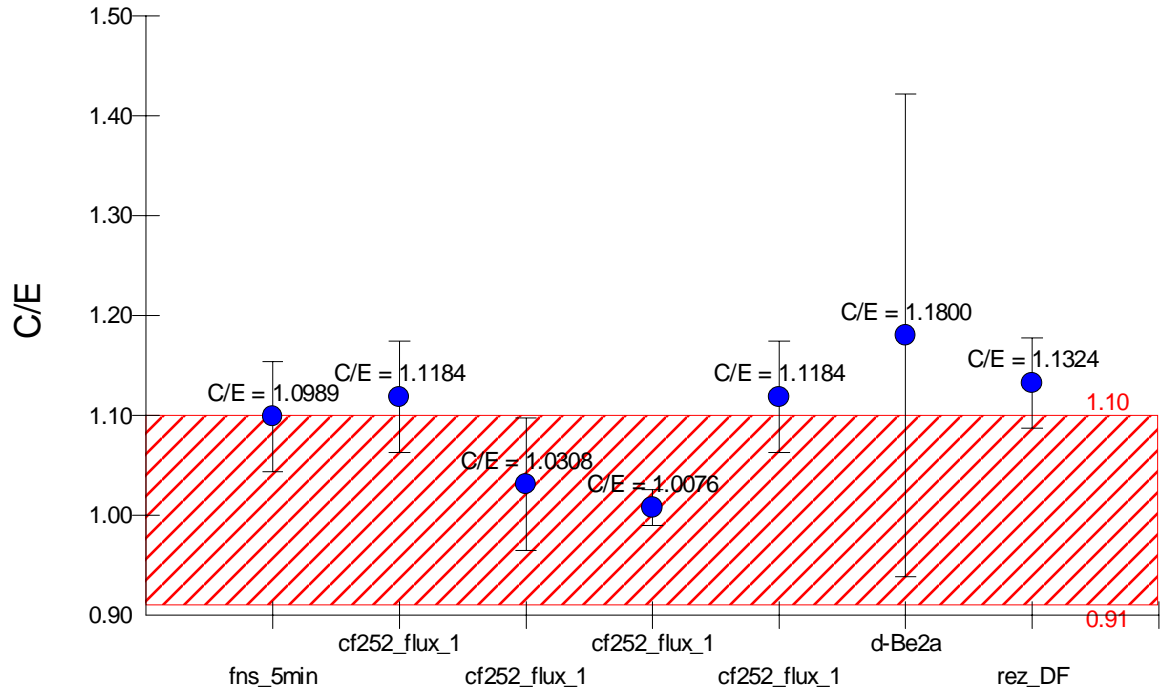


# $^{59}\text{Co}(n,h)^{57}\text{Mn}$

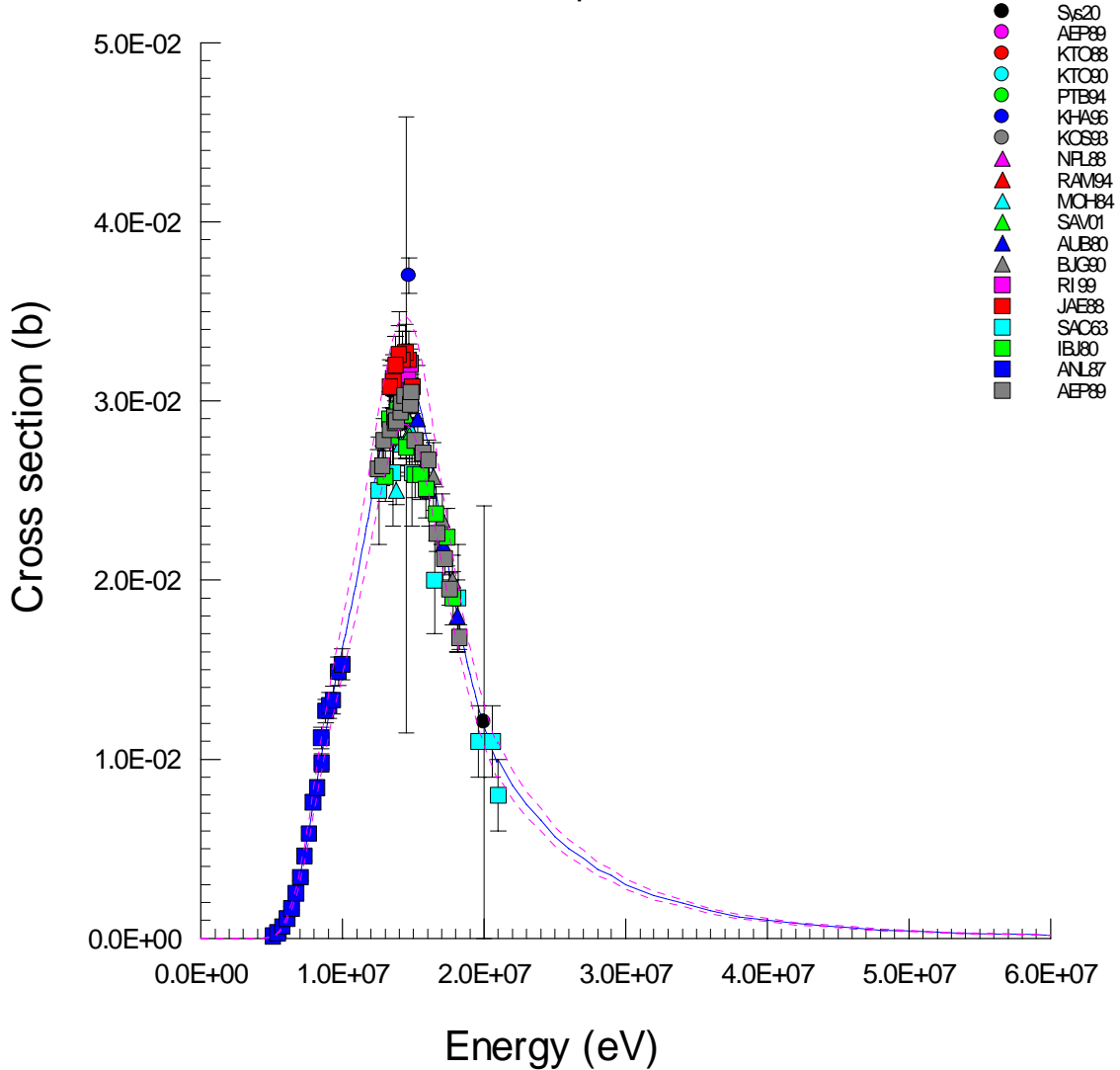


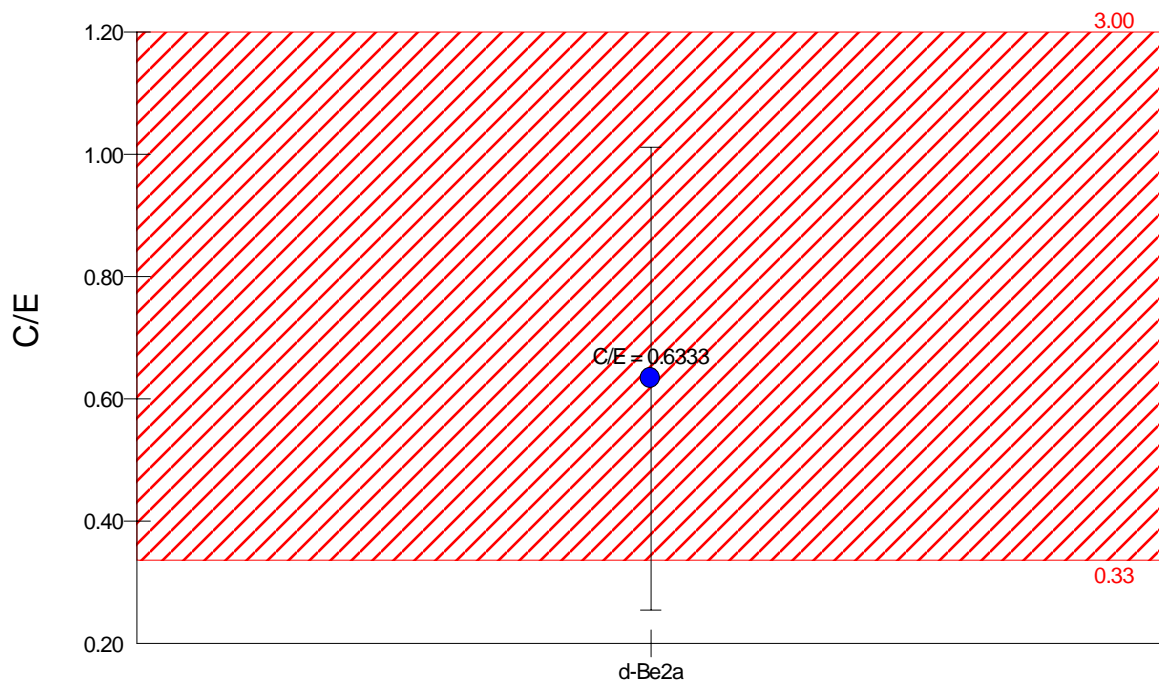
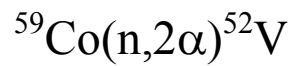


$^{59}\text{Co}(n,\alpha)^{56}\text{Mn} \blacktriangleright 549$

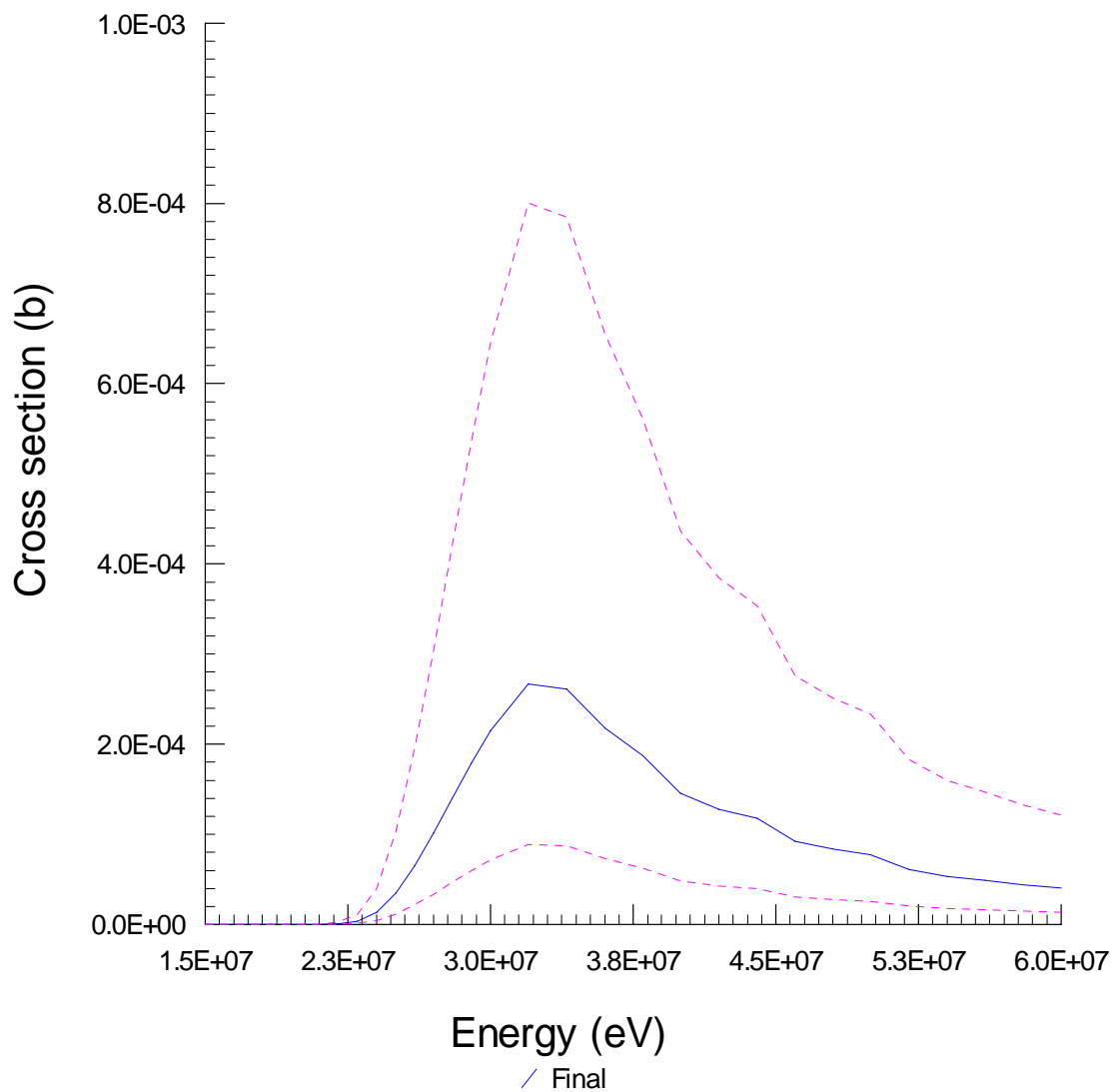


Neutron Spectrum

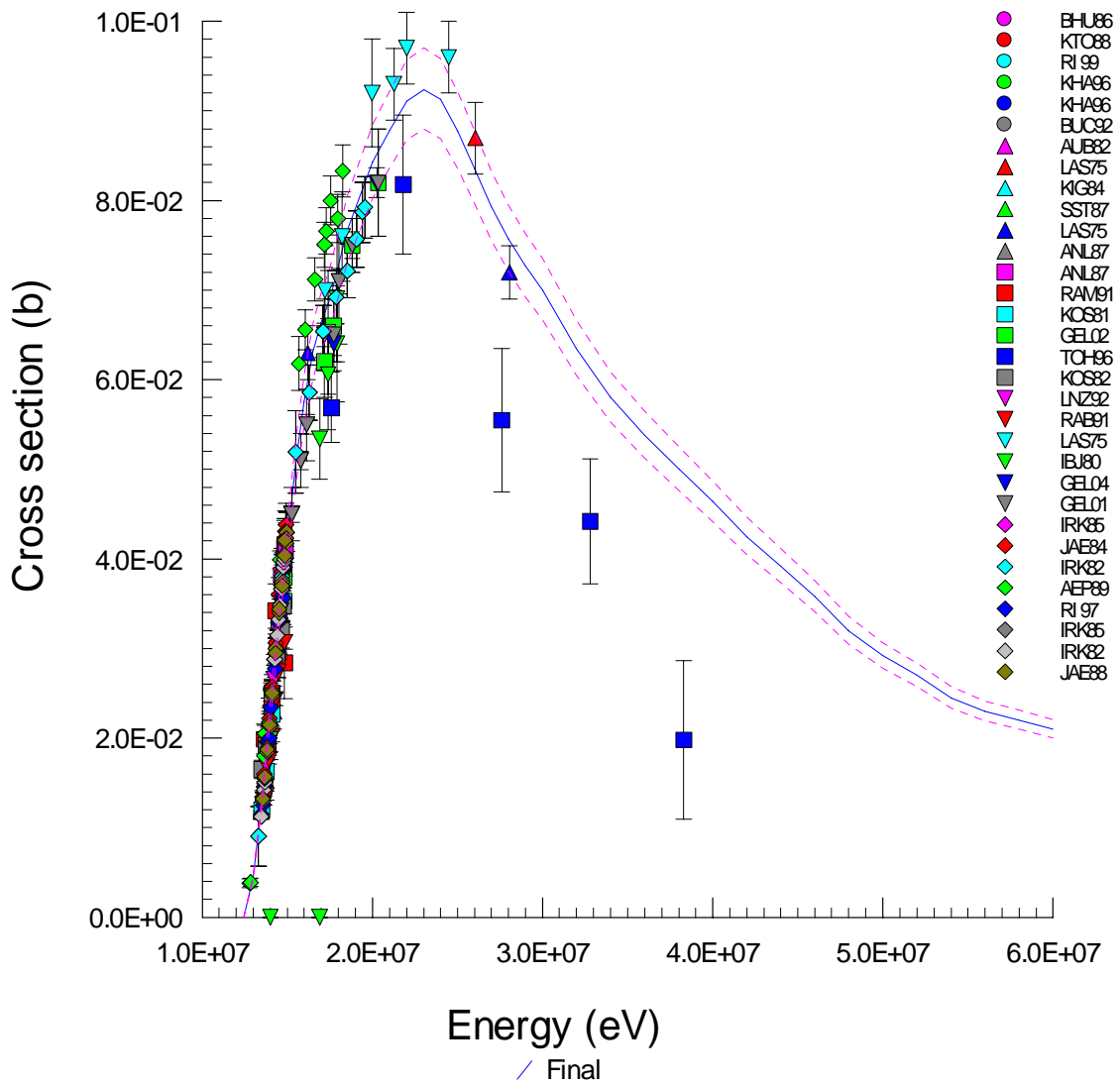
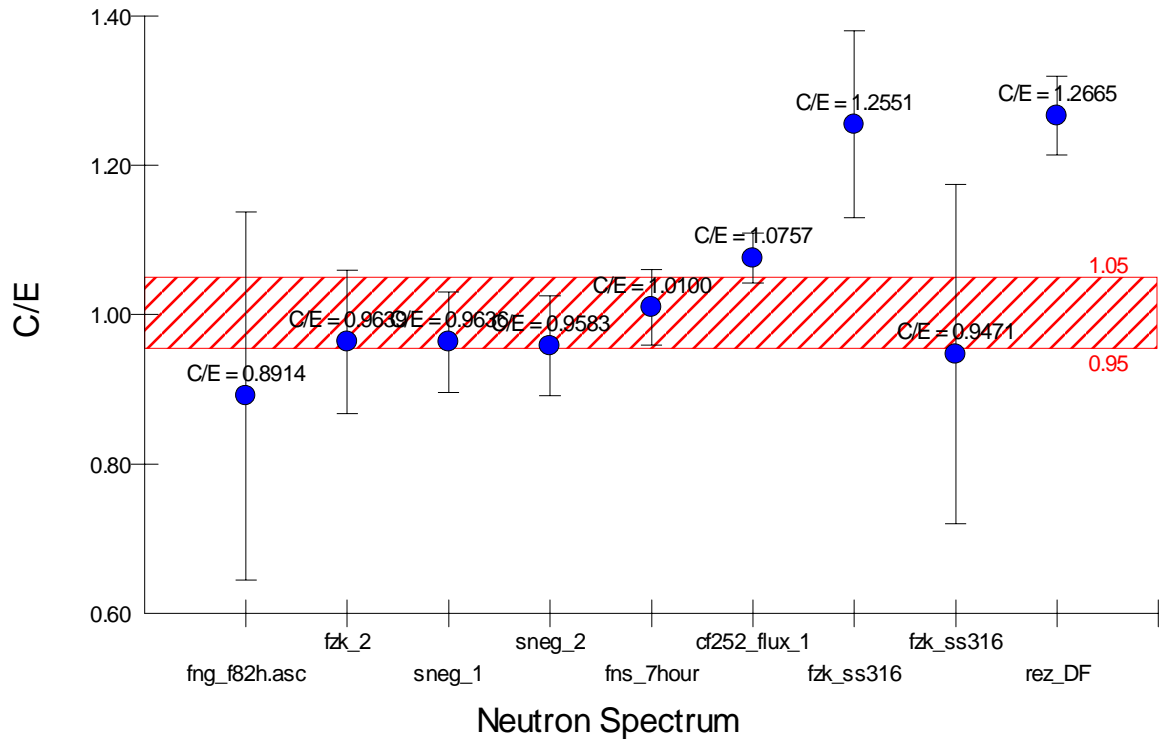


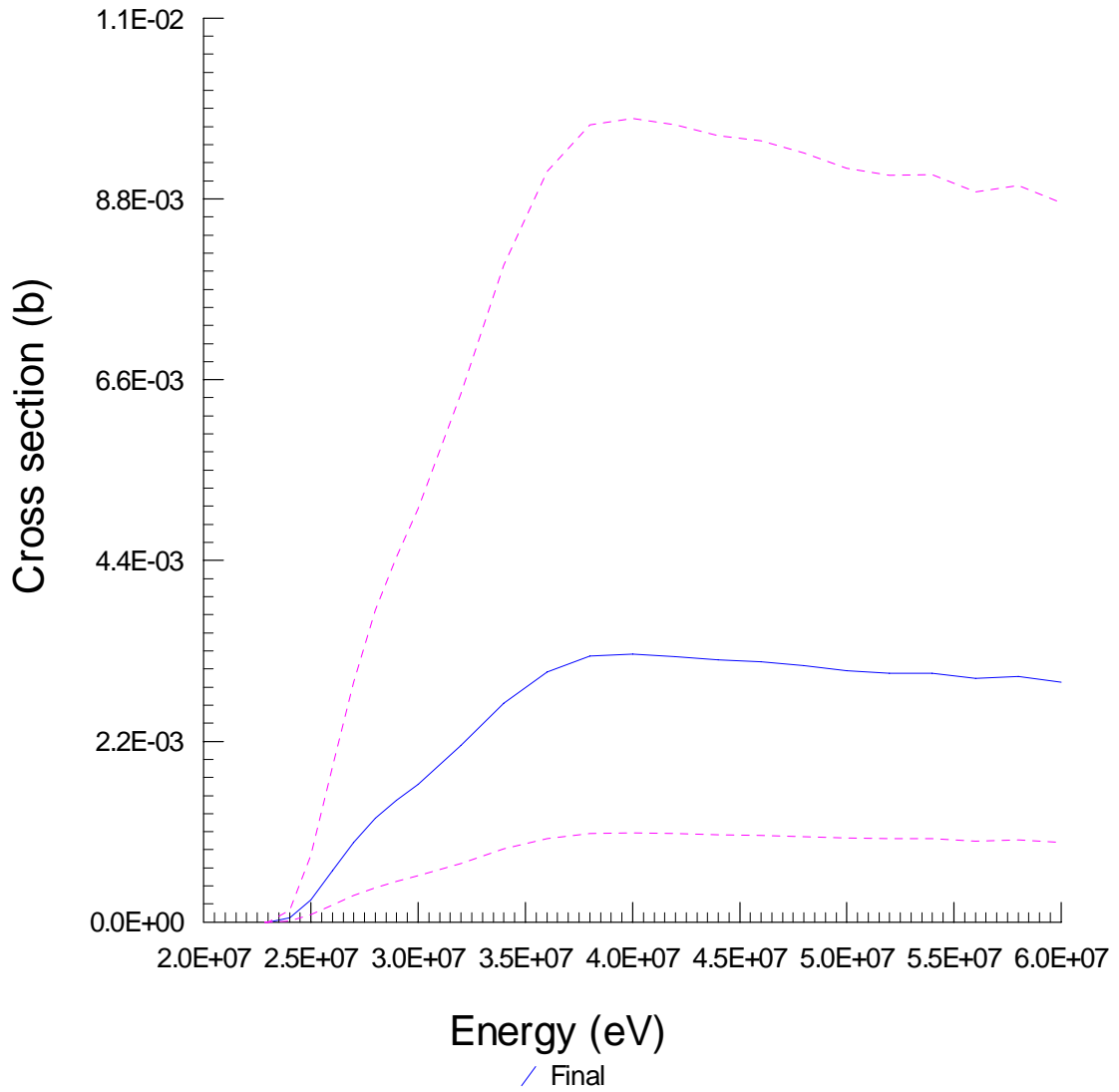
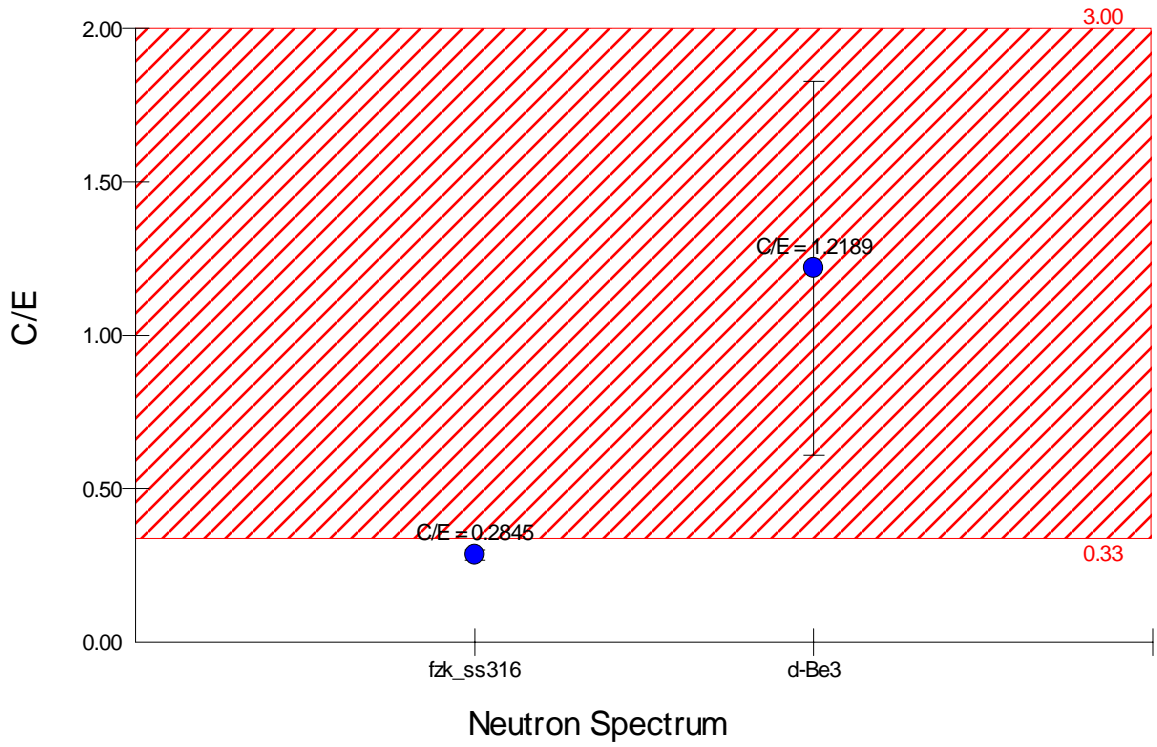
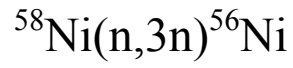


Neutron Spectrum

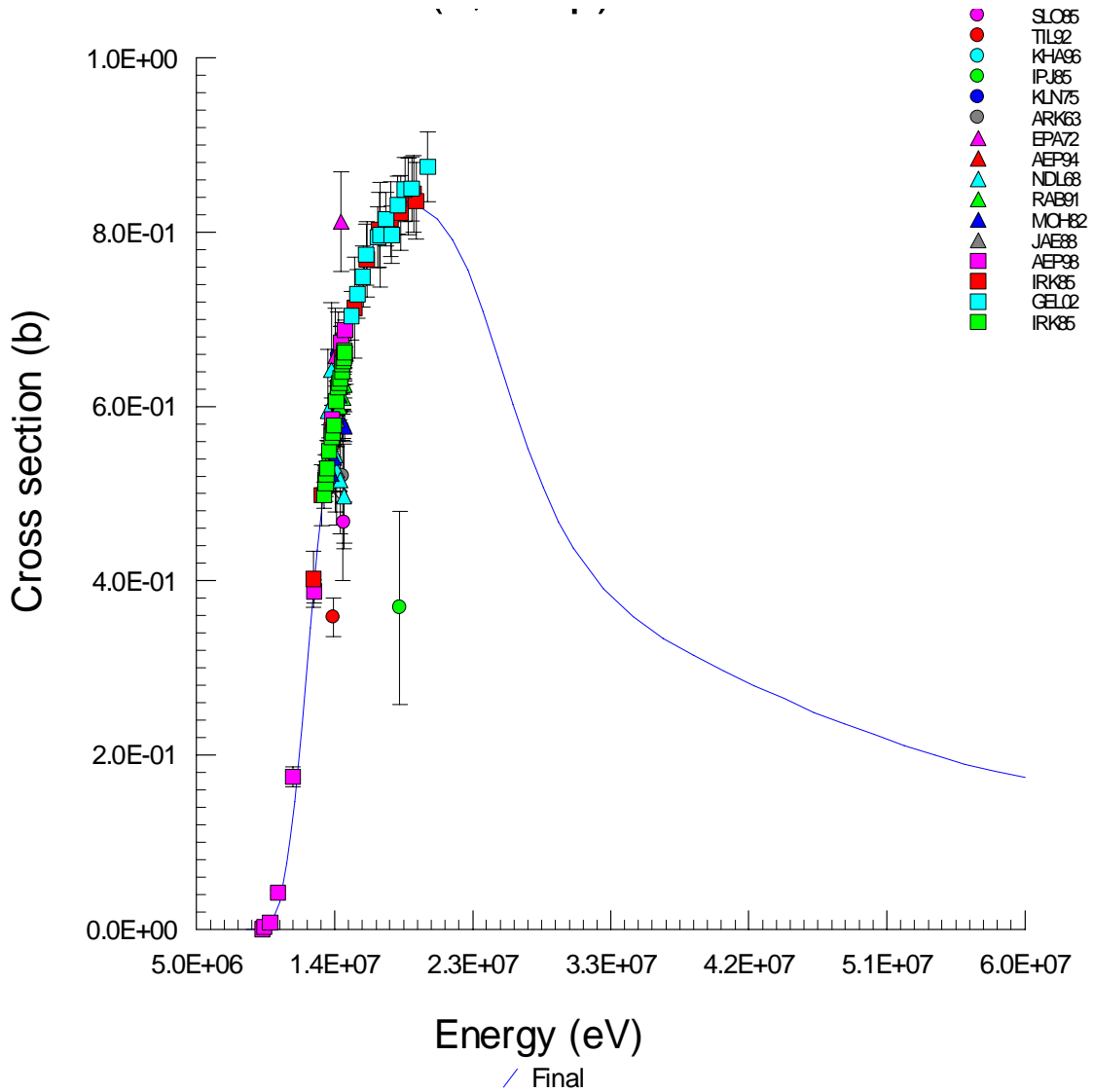
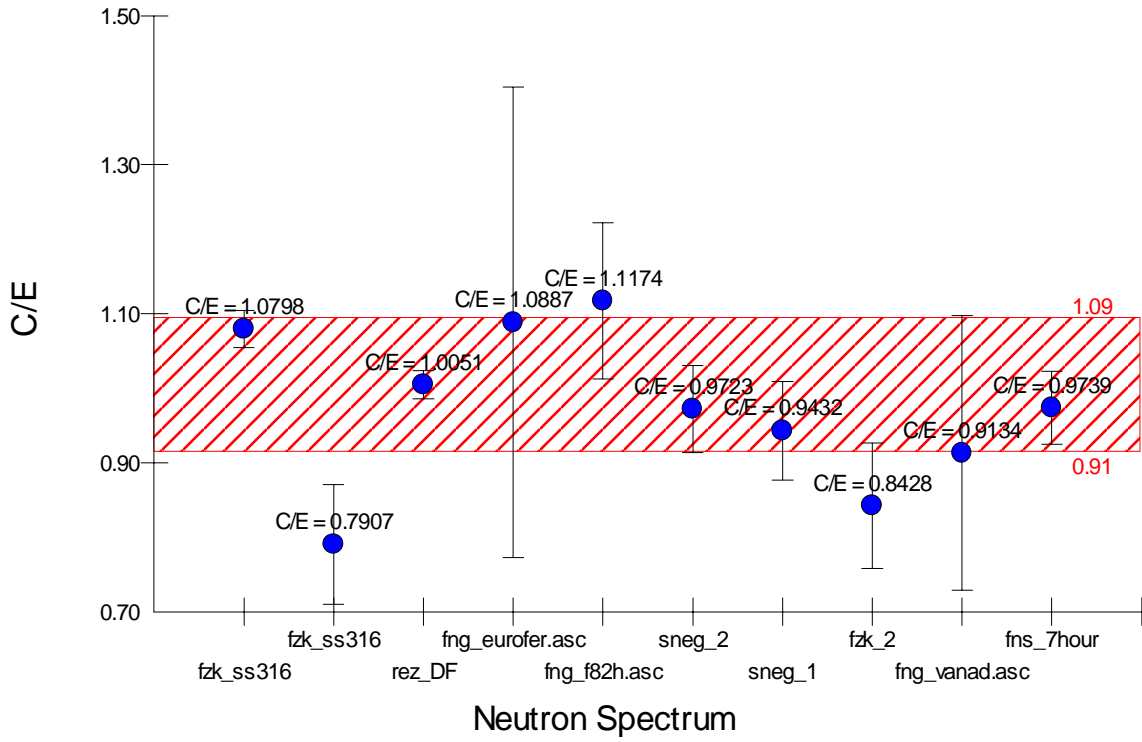


# $^{58}\text{Ni}(n,2n)^{57}\text{Ni} \blacktriangleright 549$

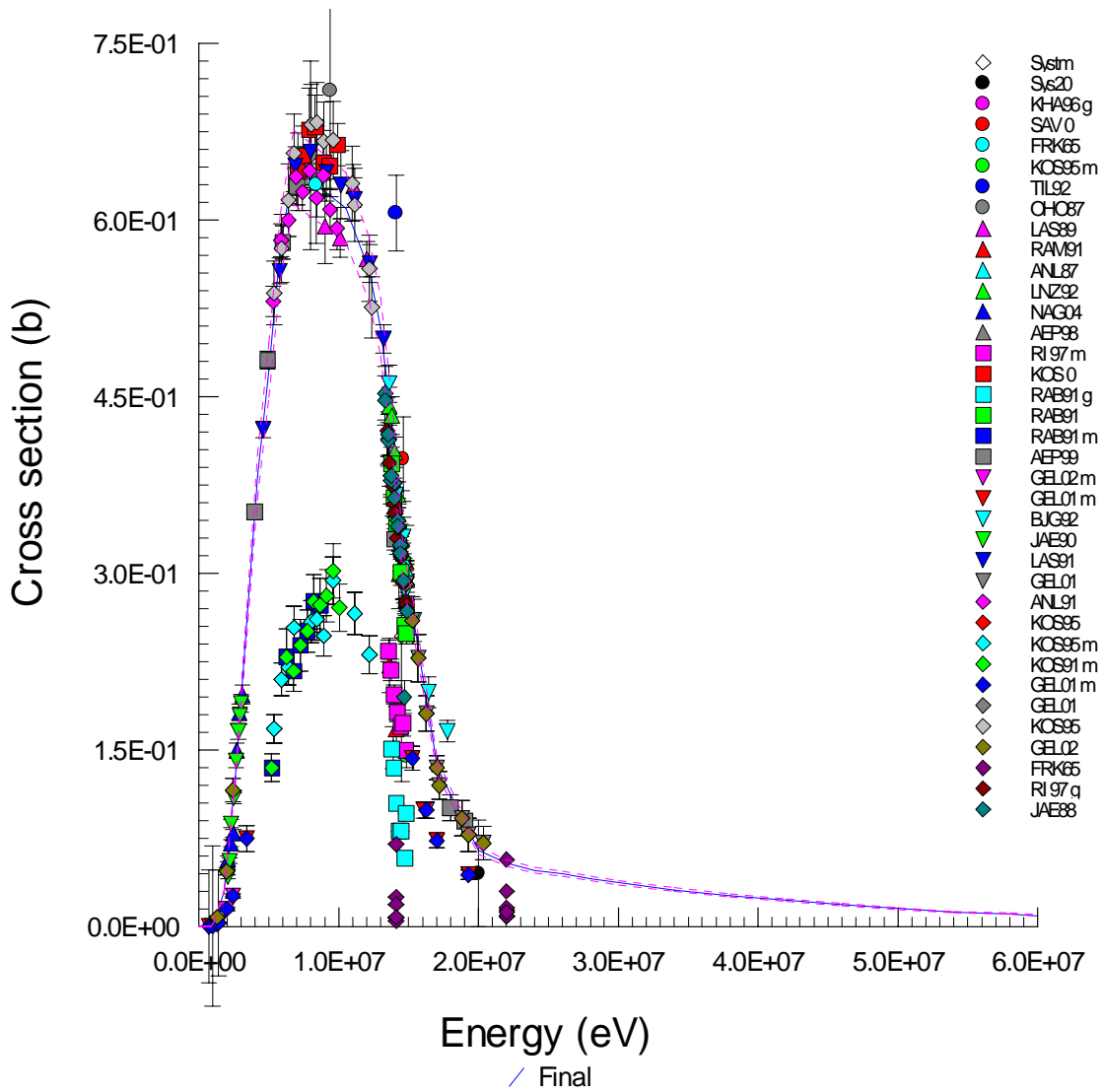
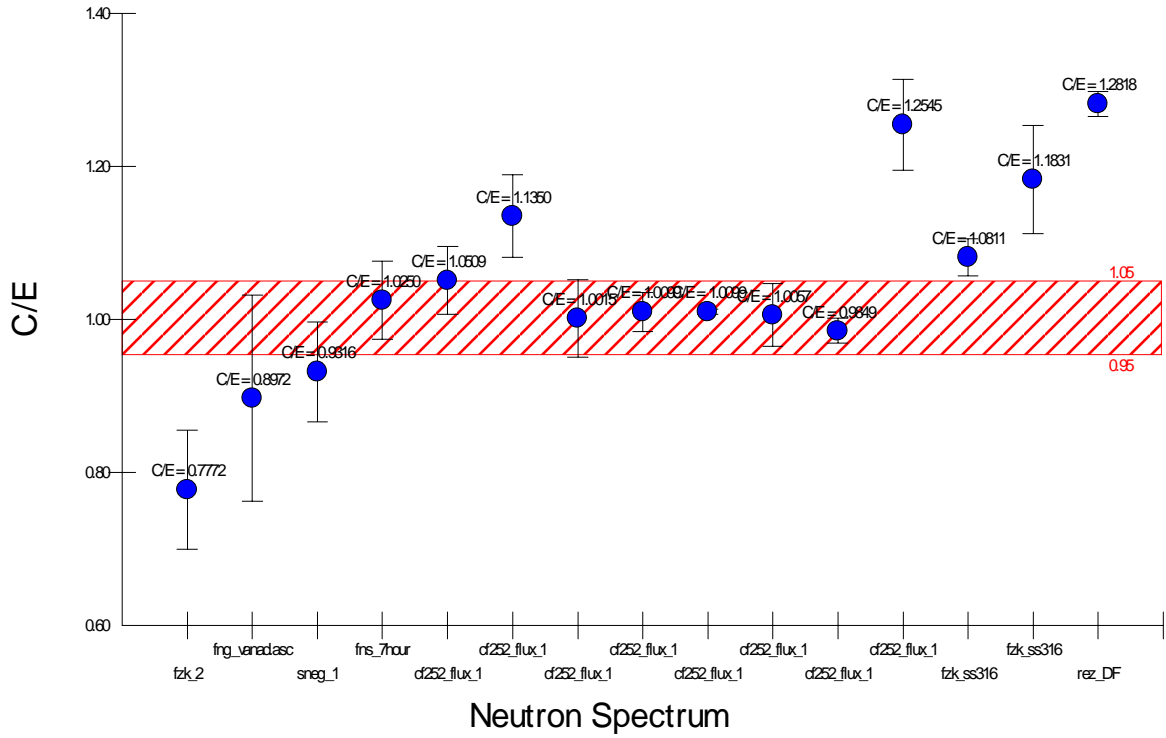




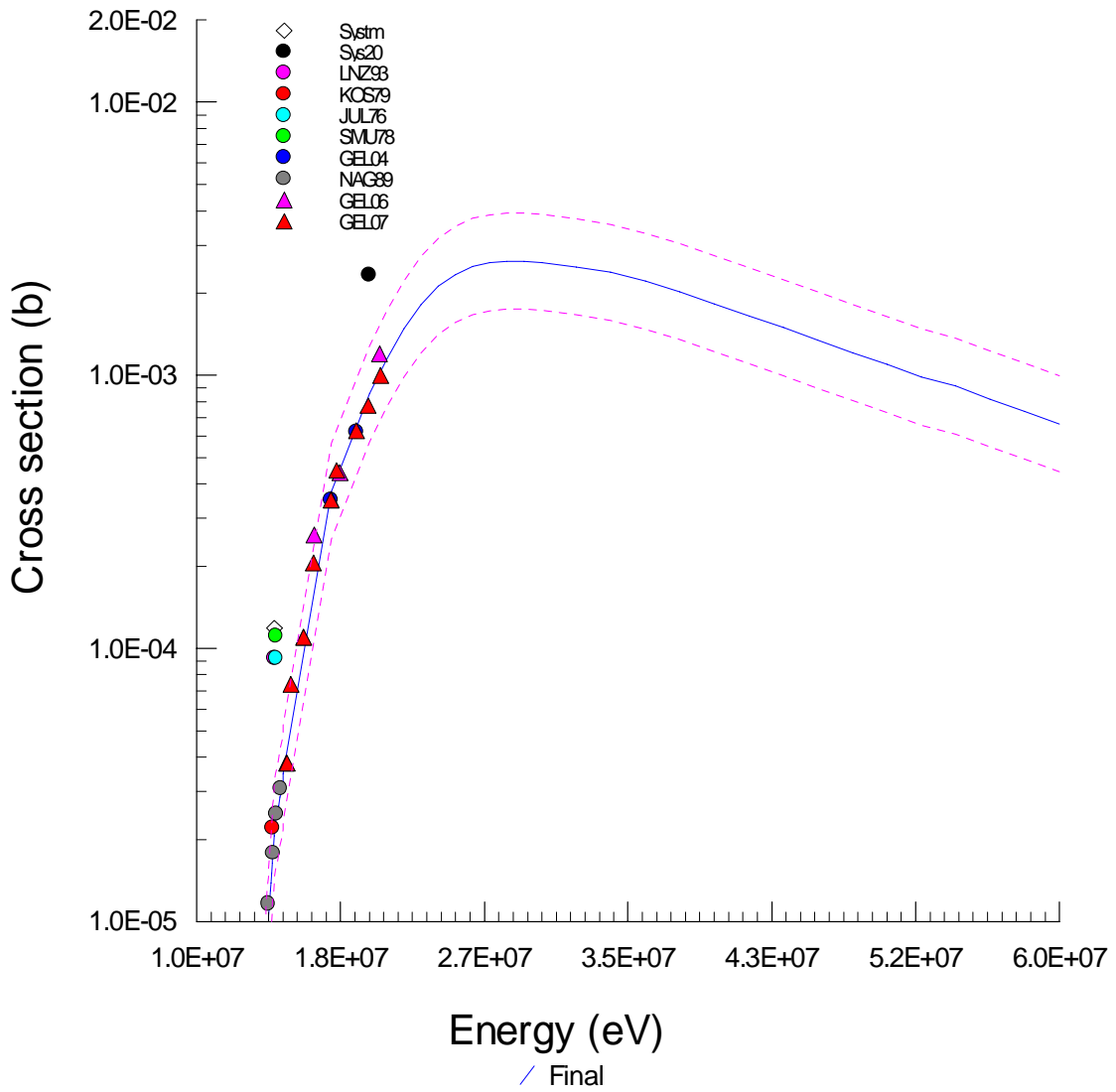
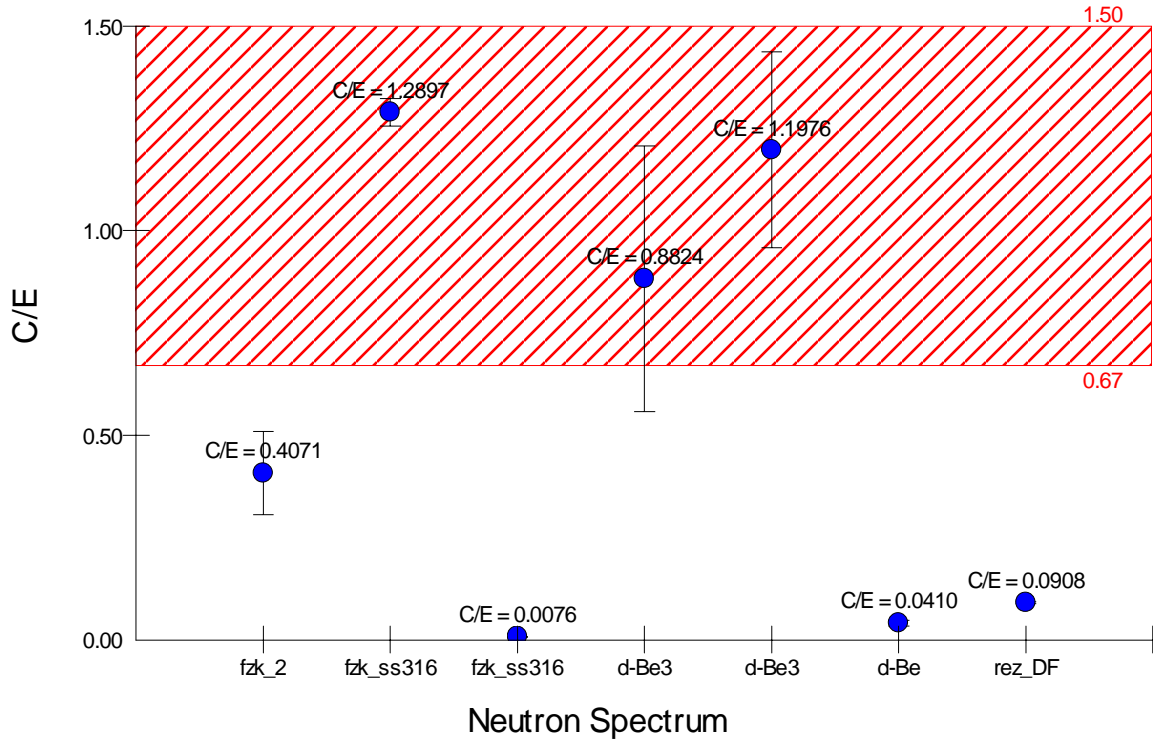
$^{58}\text{Ni}(n,d+n'p)^{57}\text{Co} \blacktriangleright 550$

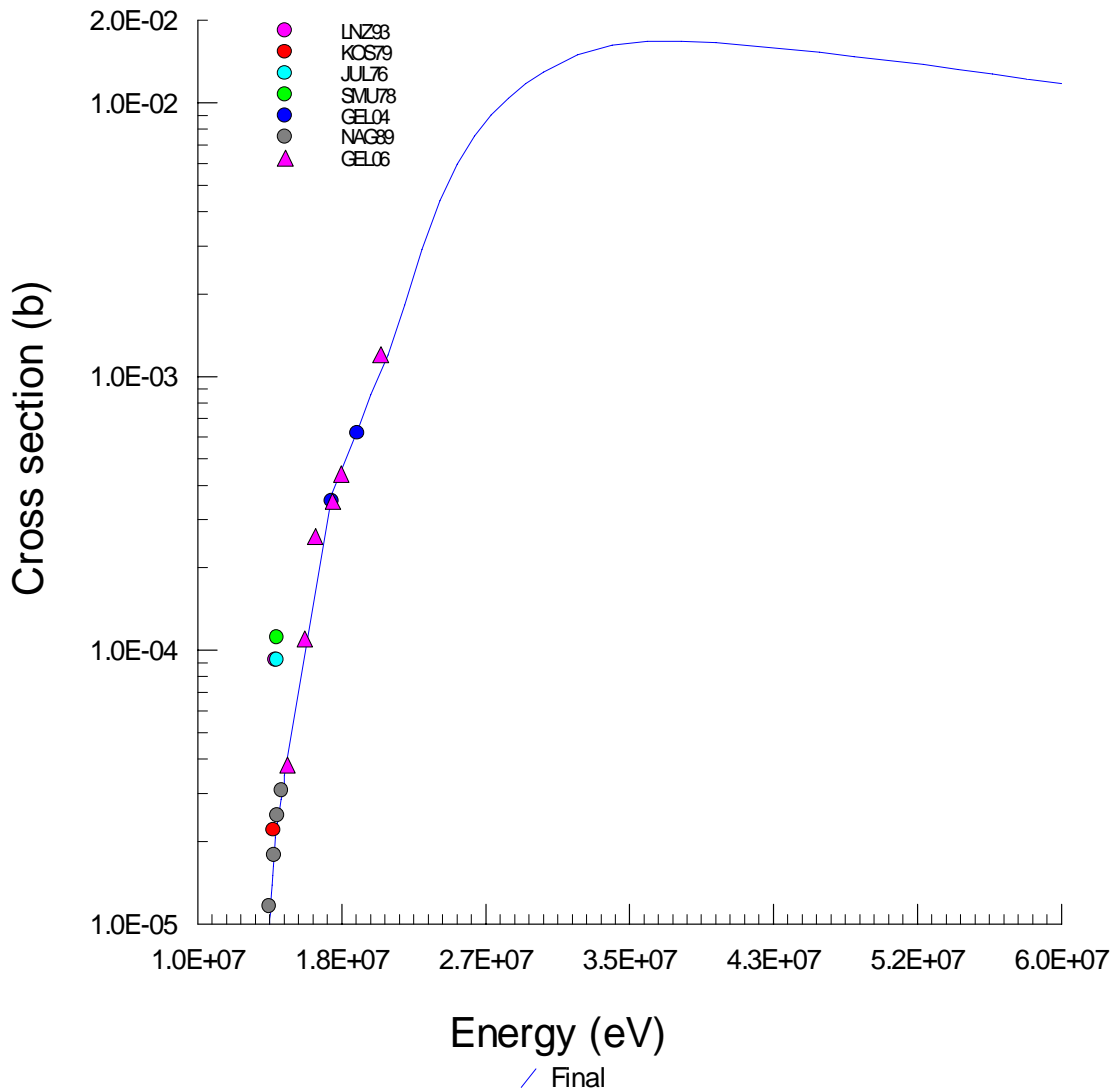
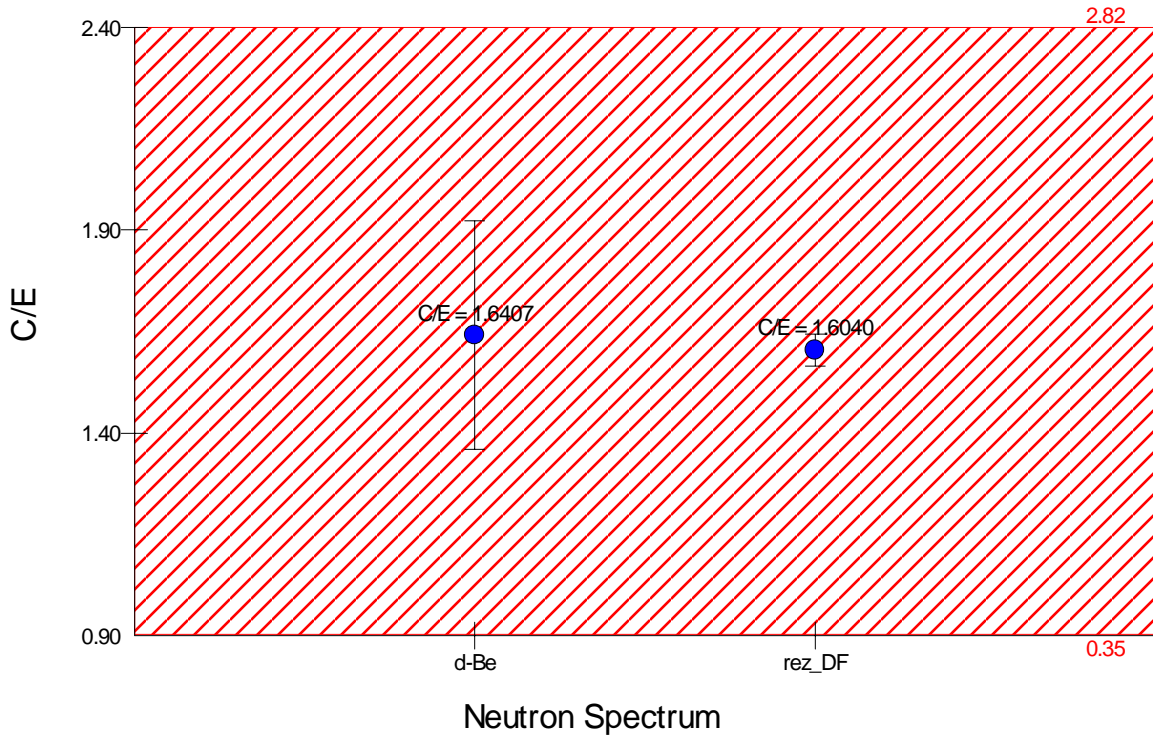
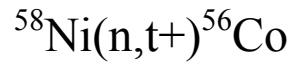


# $^{58}\text{Ni}(n,p)^{58}\text{Co} \blacktriangleright 550$



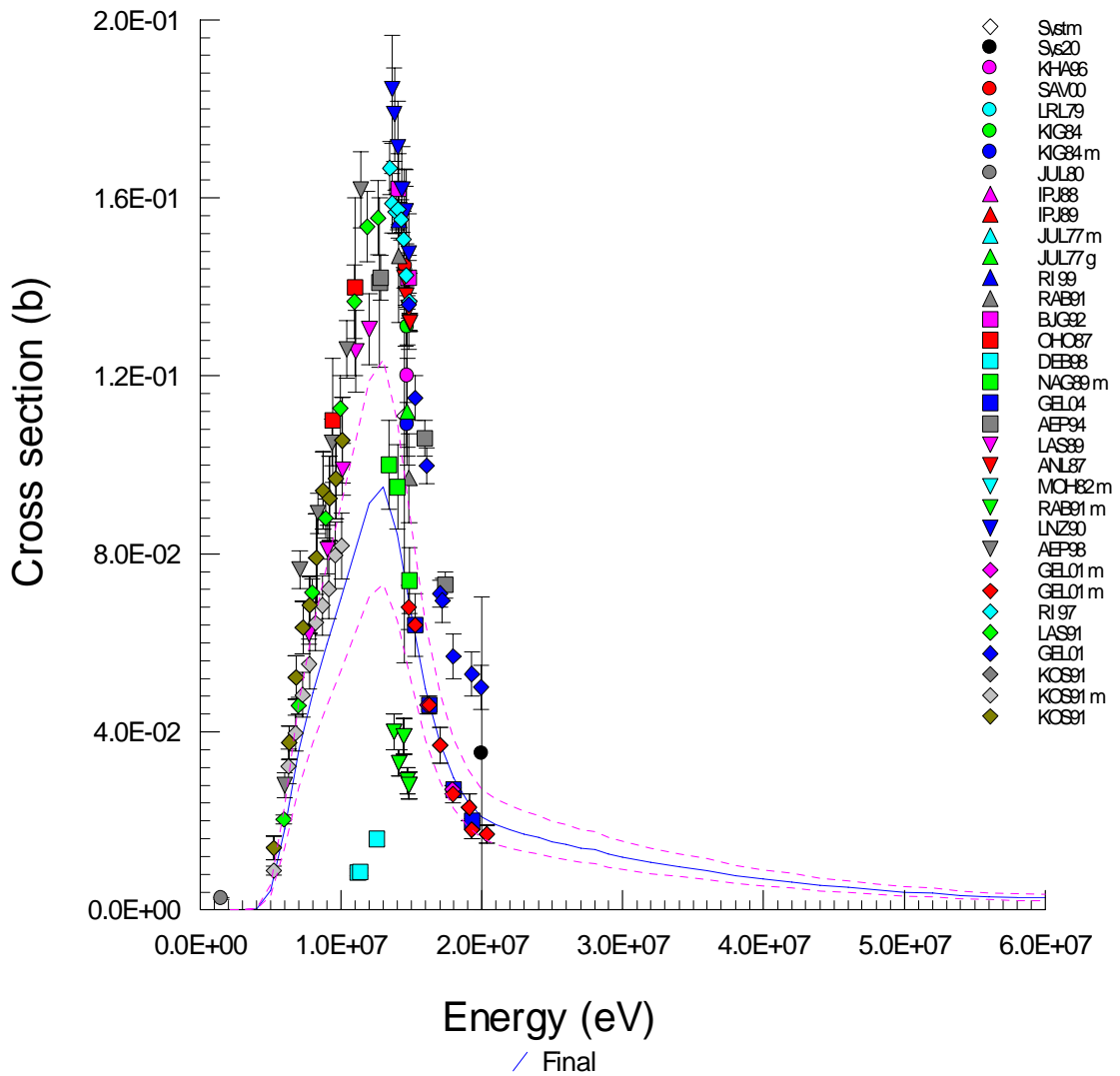
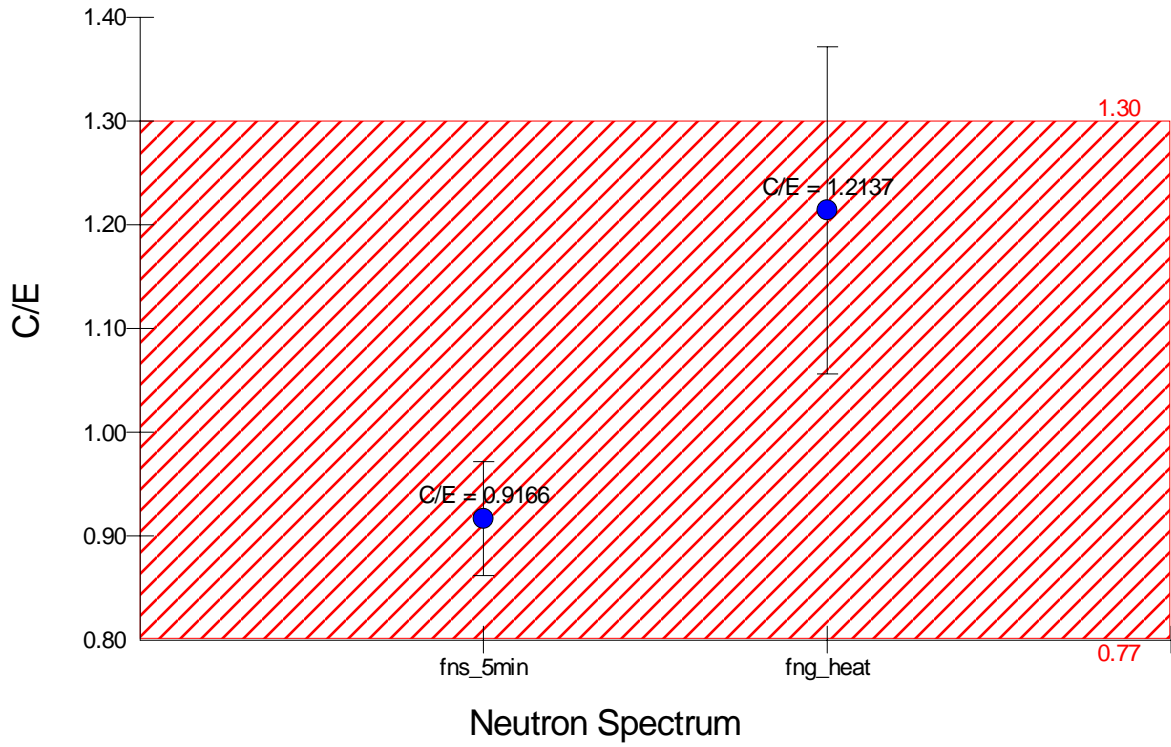
# $^{58}\text{Ni}(n,t)^{56}\text{Co}$



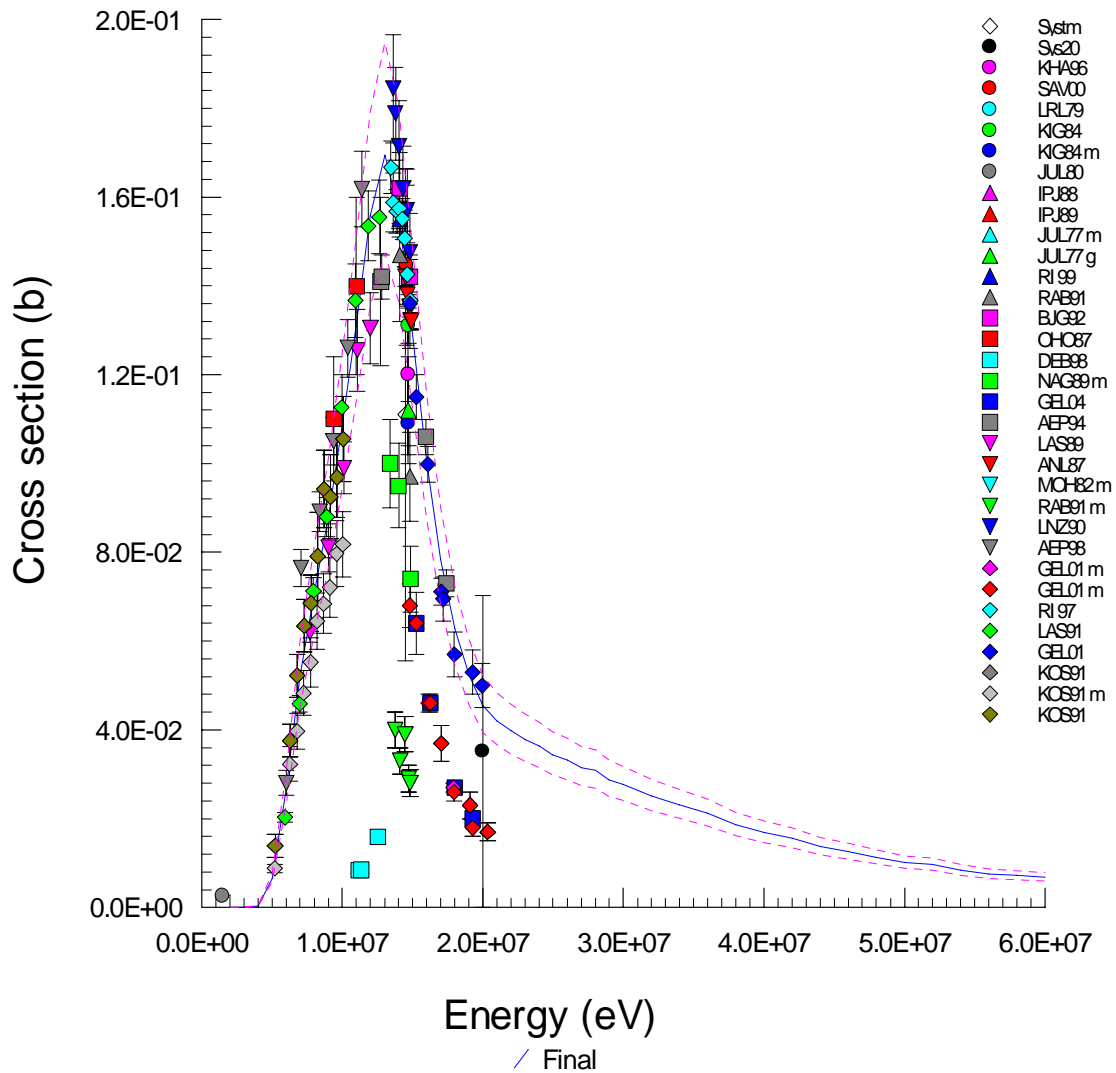
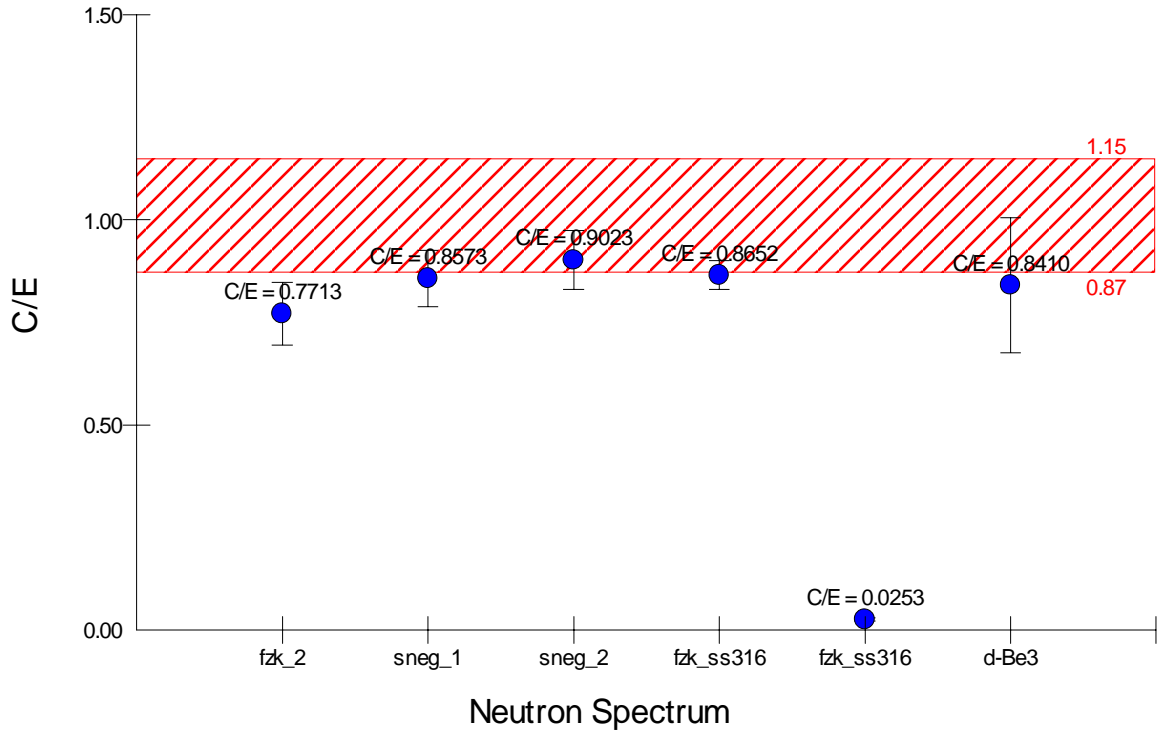


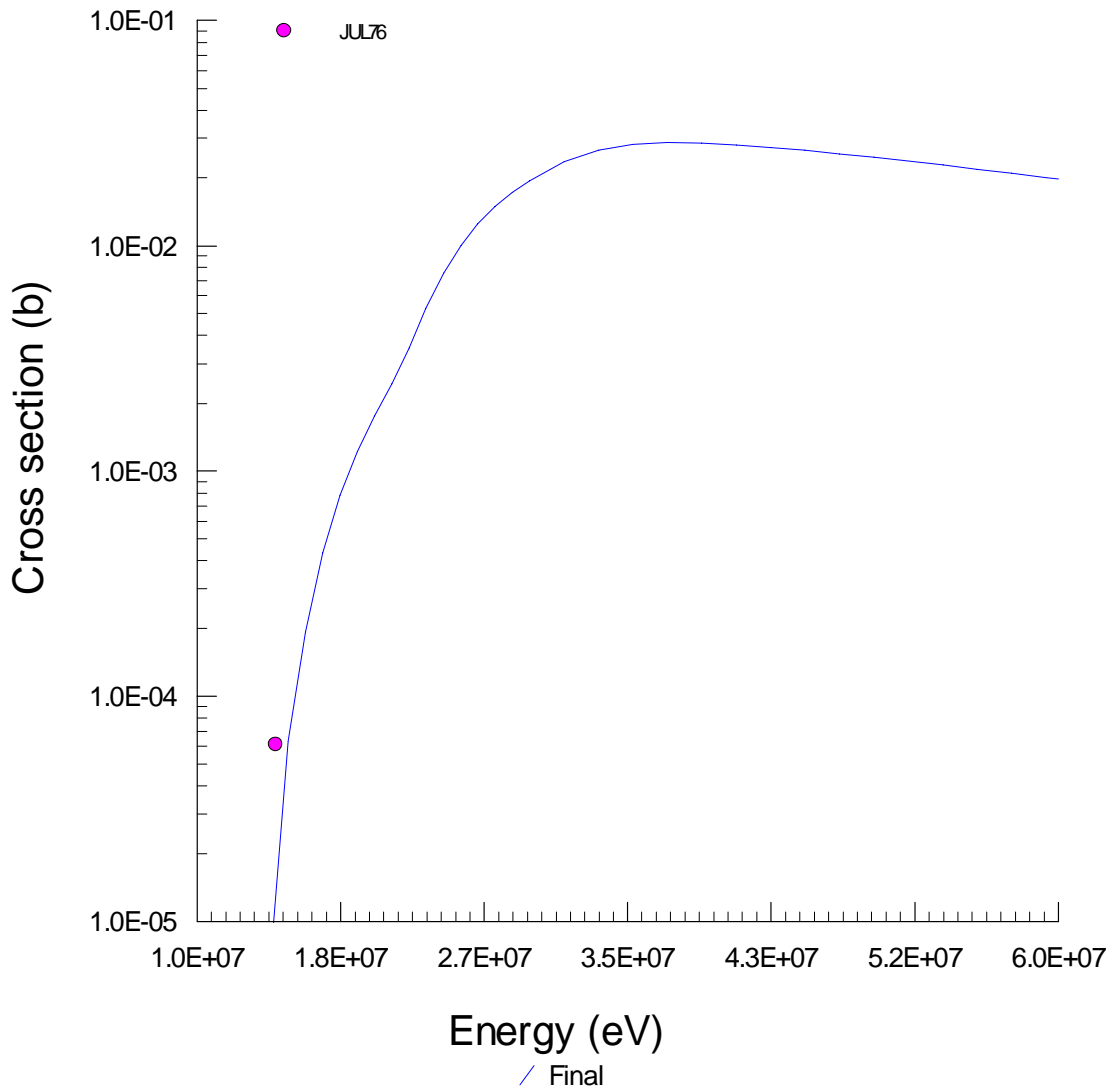
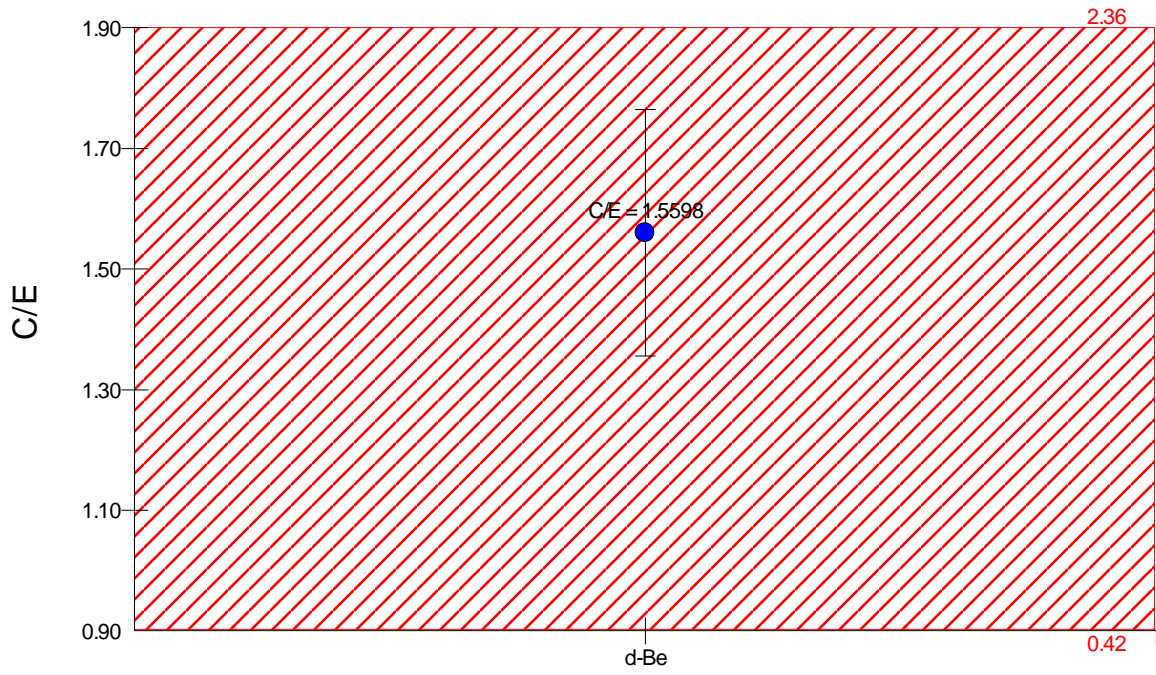
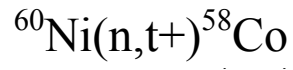


# $^{60}\text{Ni}(n,p)^{60\text{m}}\text{Co}$

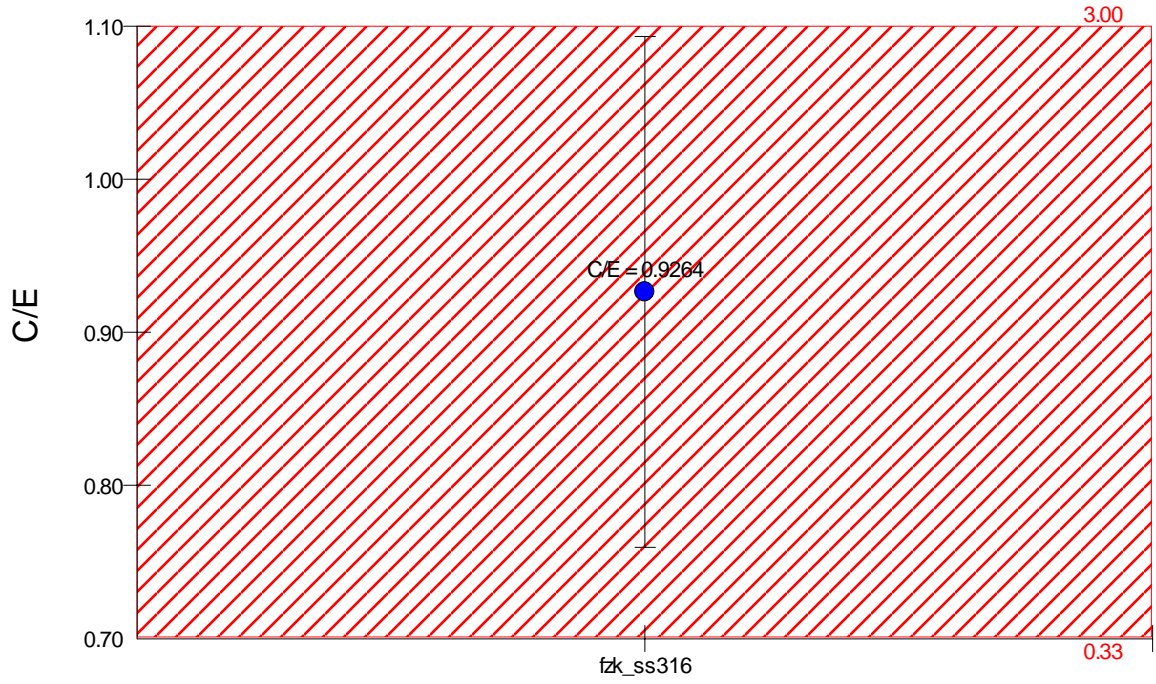


# $^{60}\text{Ni}(n,p)^{60}\text{Co} \blacktriangleright 551$

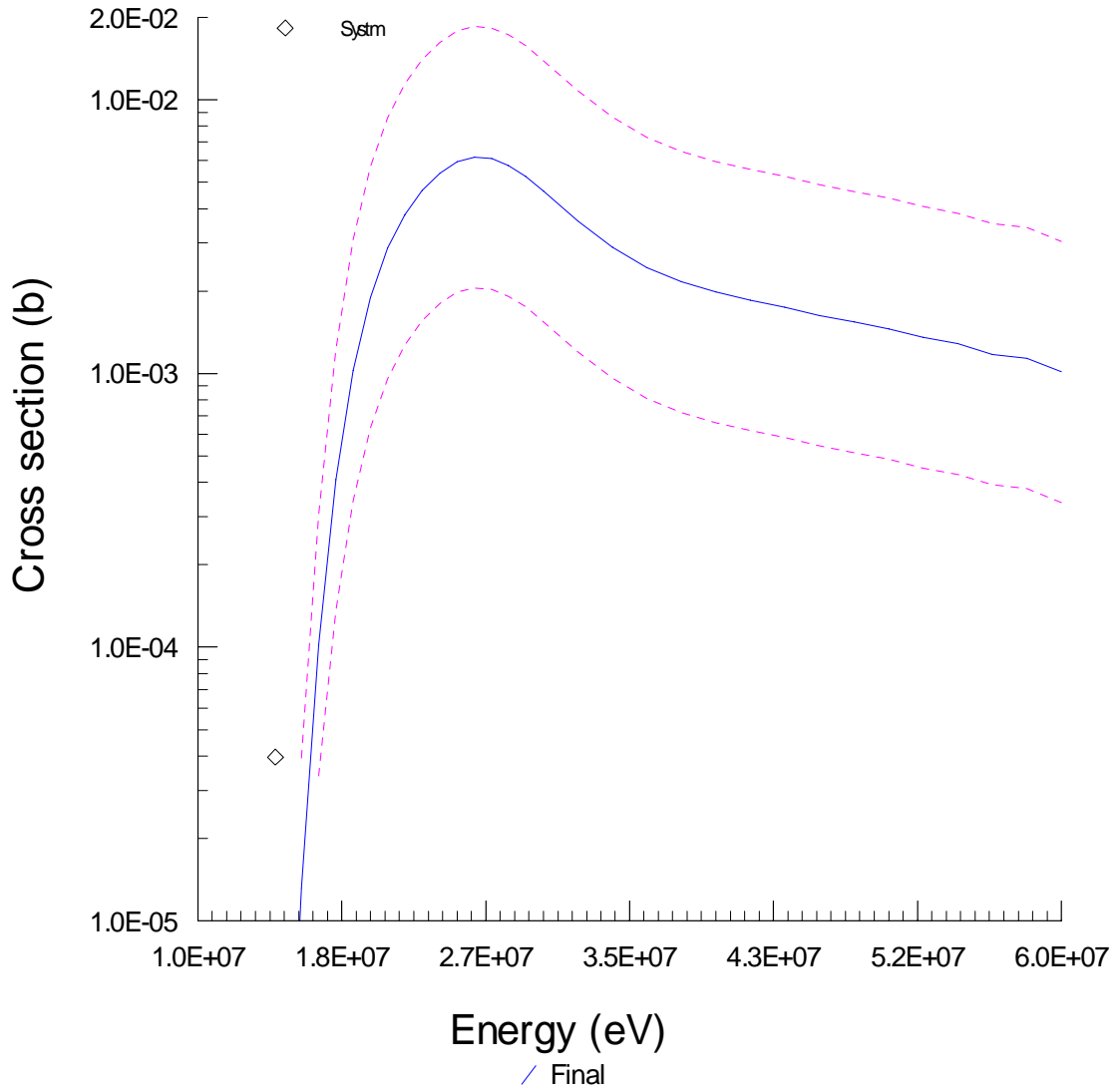




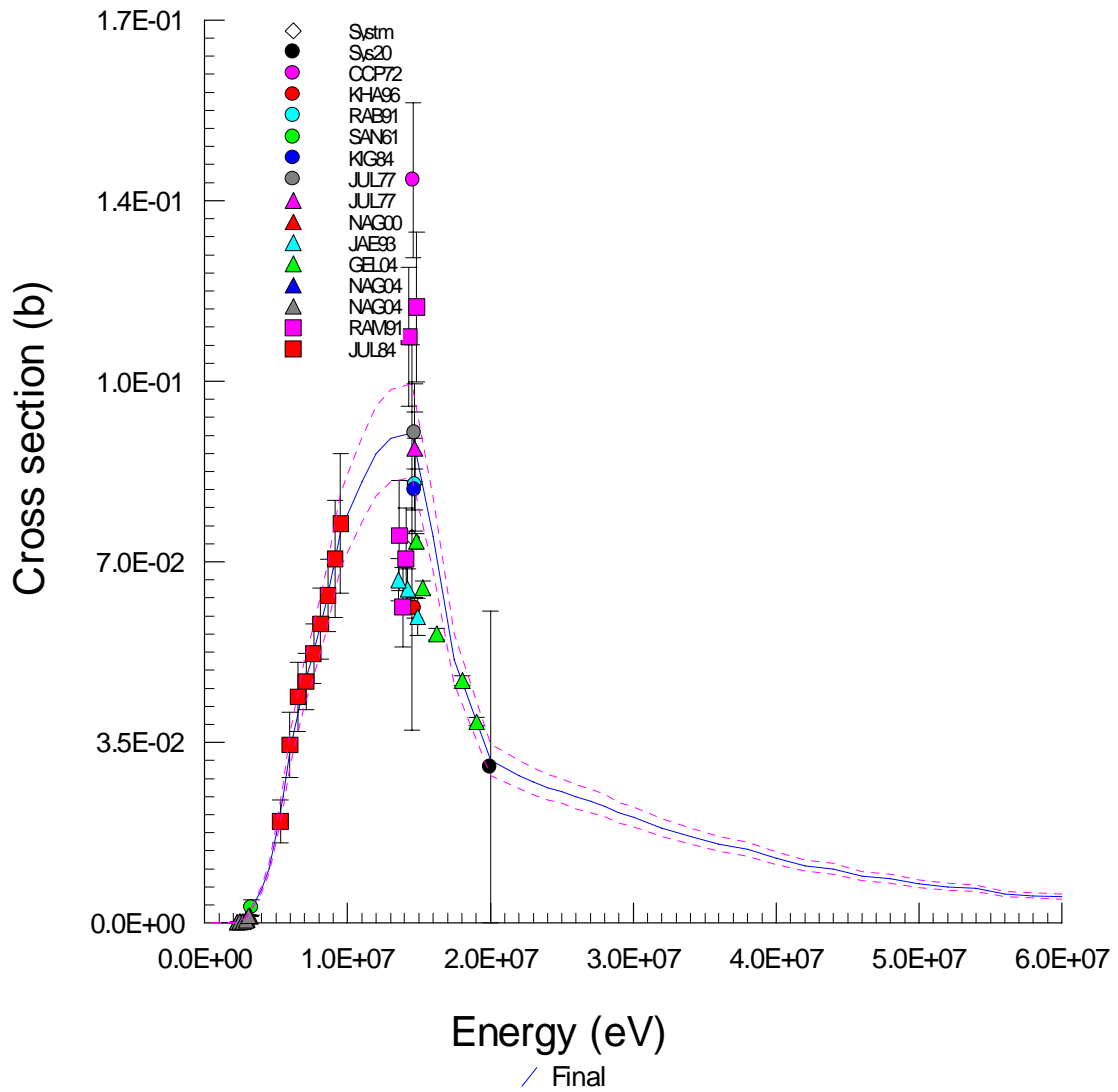
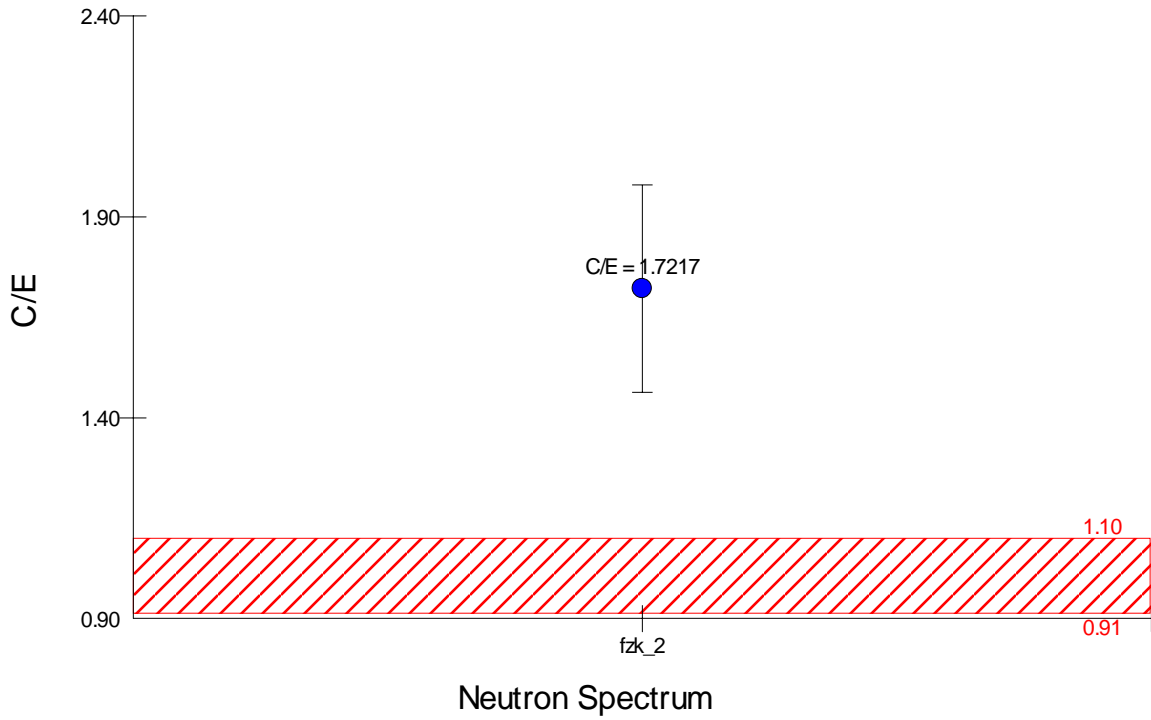
# $^{60}\text{Ni}(n,2p)^{59}\text{Fe}$

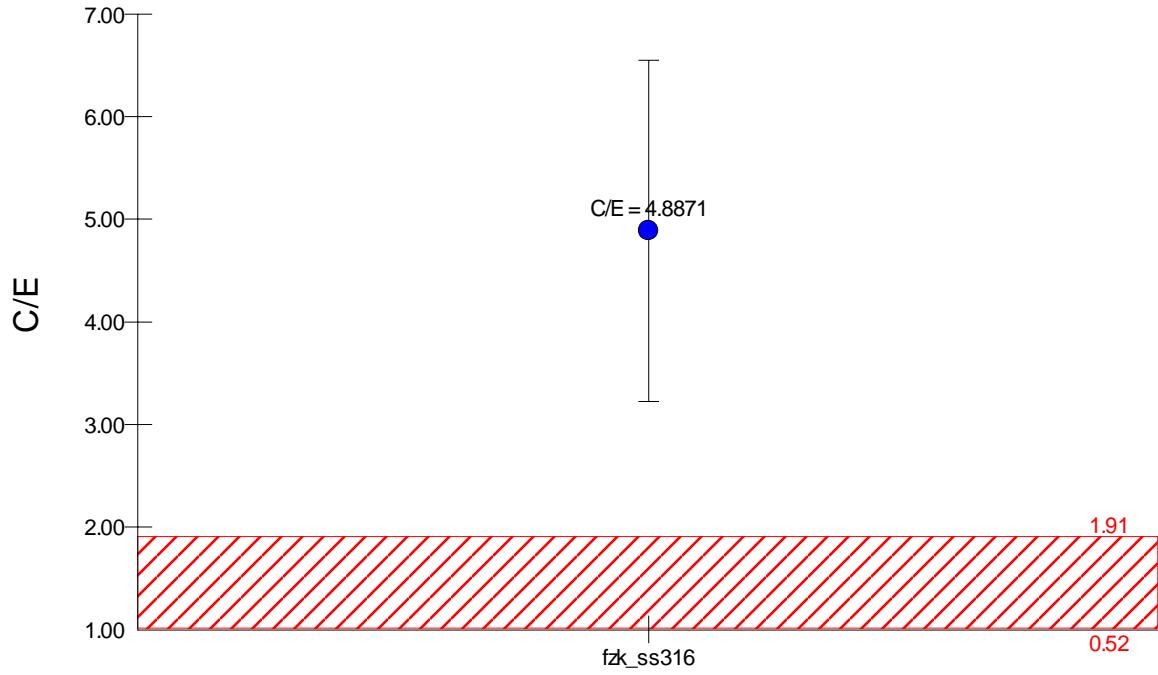
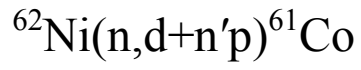


## Neutron Spectrum

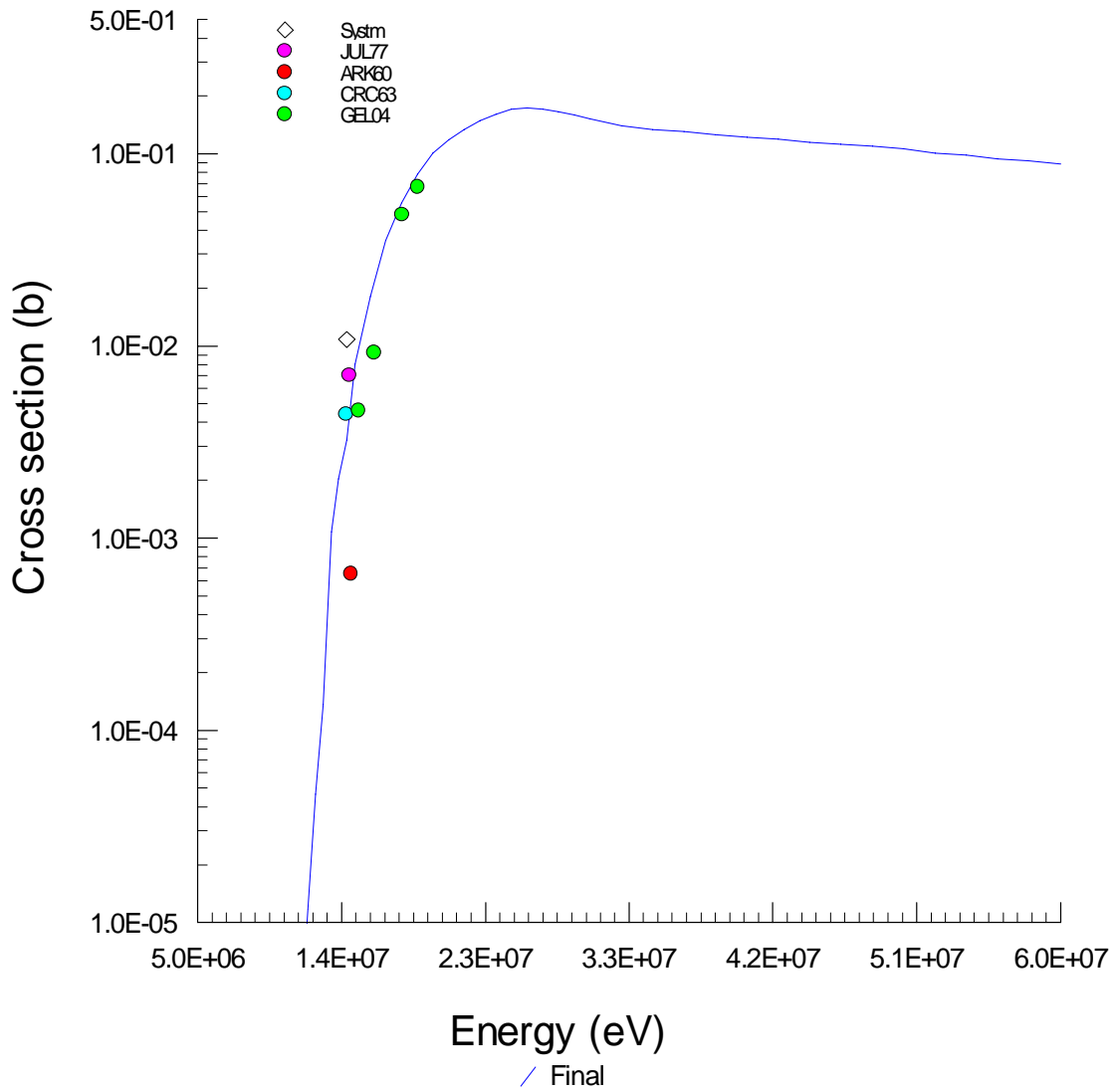


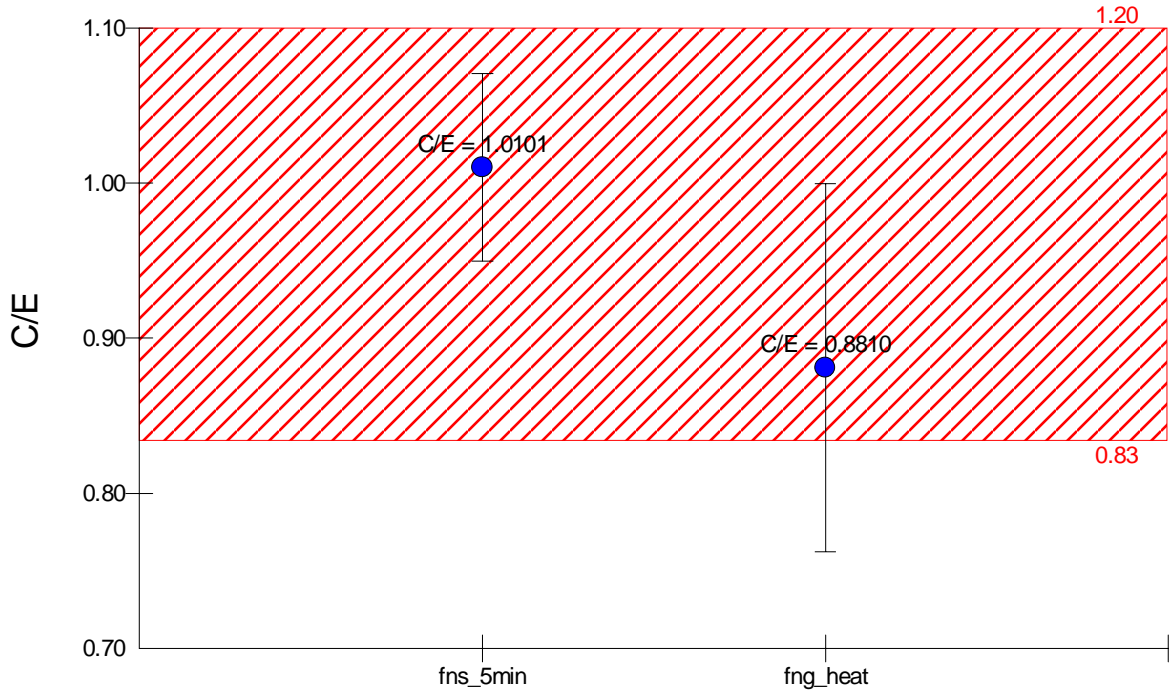
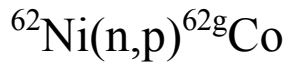
# $^{61}\text{Ni}(n,p)^{61}\text{Co}$



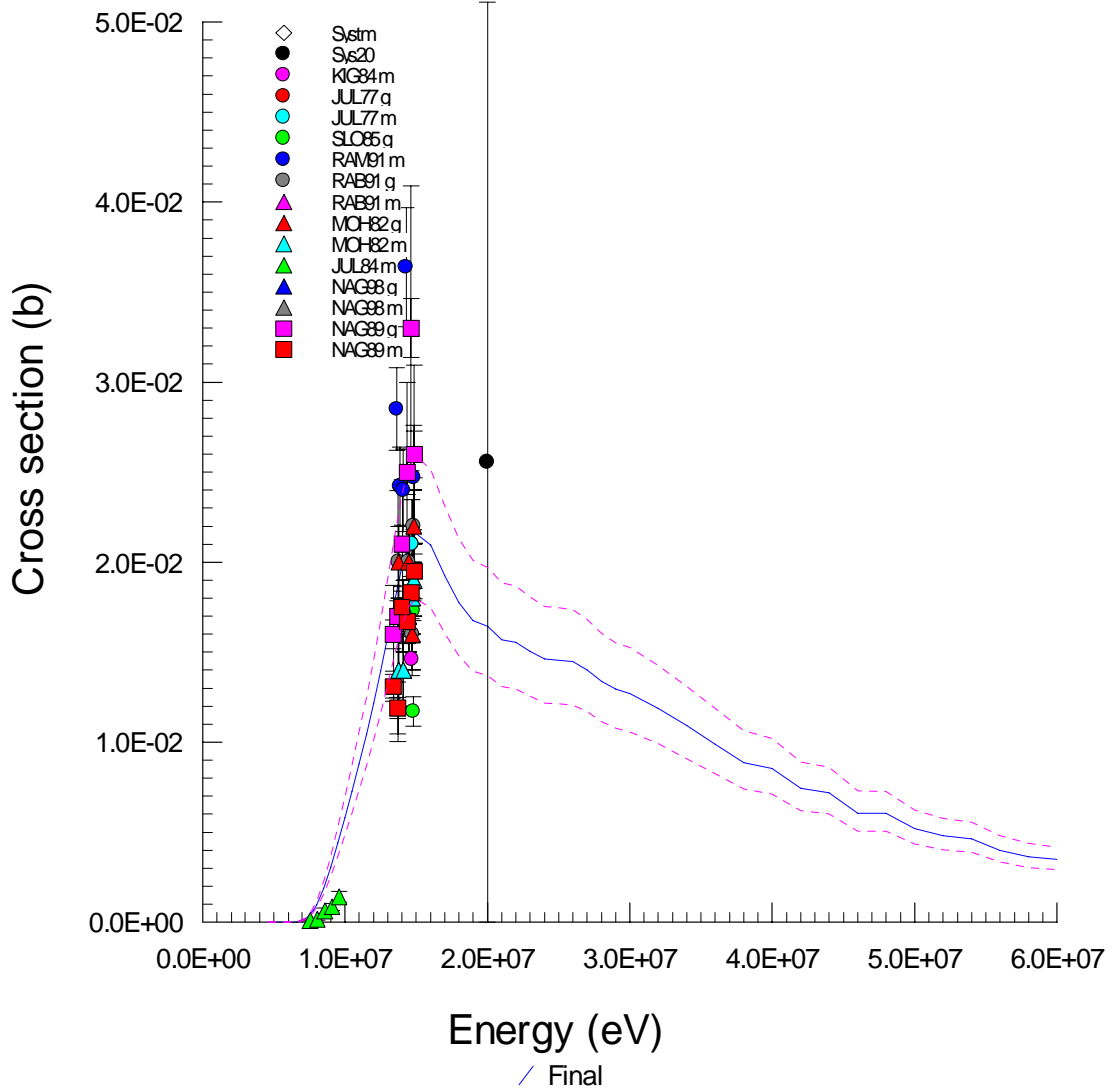


Neutron Spectrum

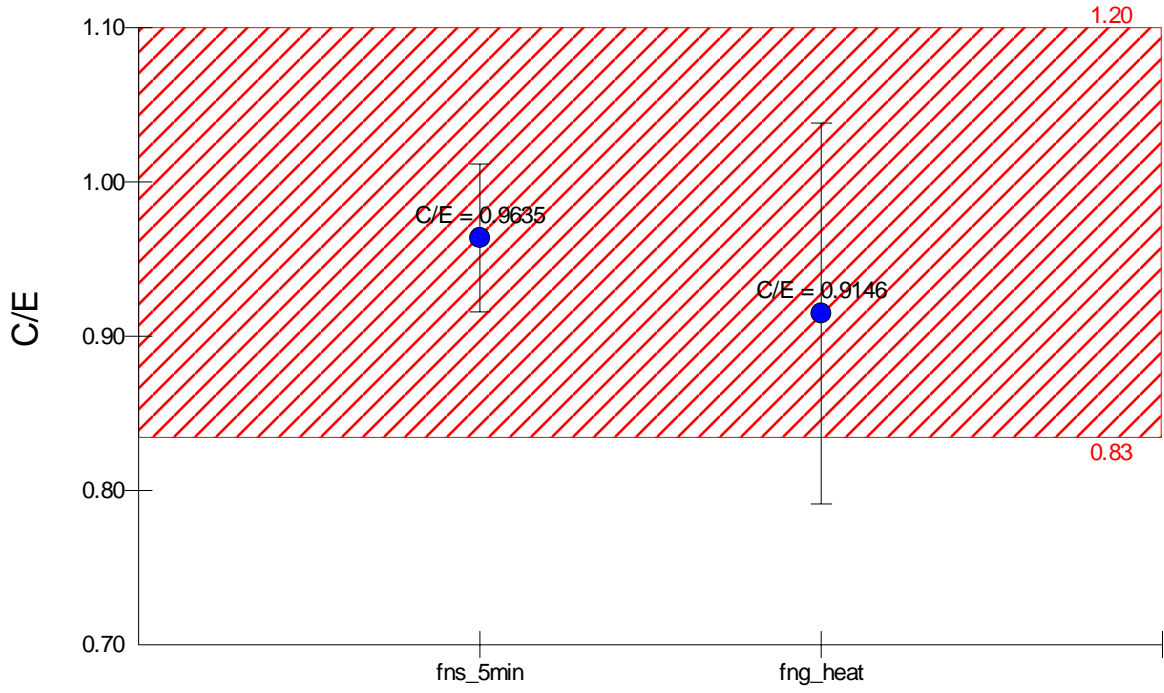




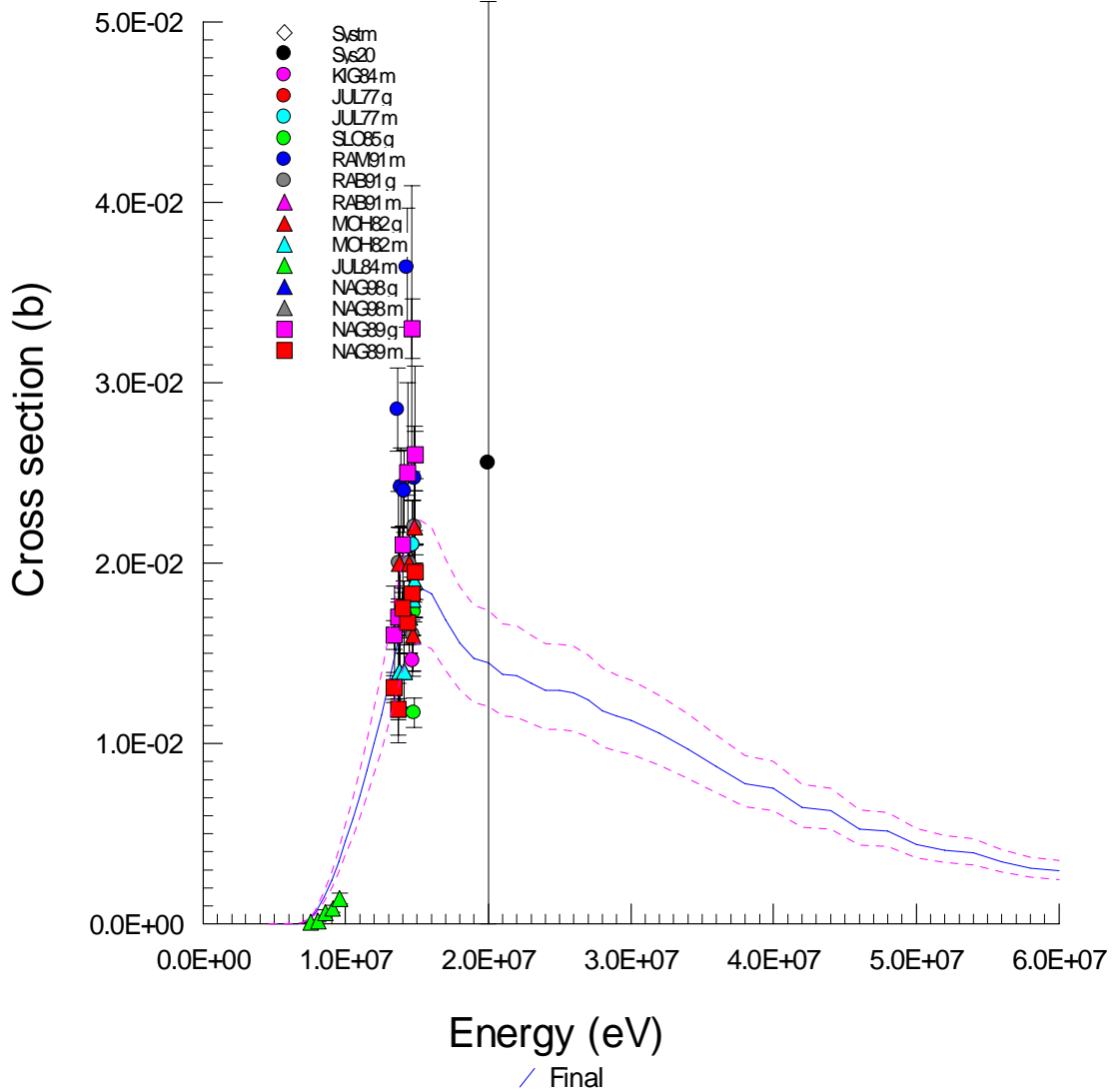
Neutron Spectrum



# $^{62}\text{Ni}(n,p)^{62m}\text{Co}$

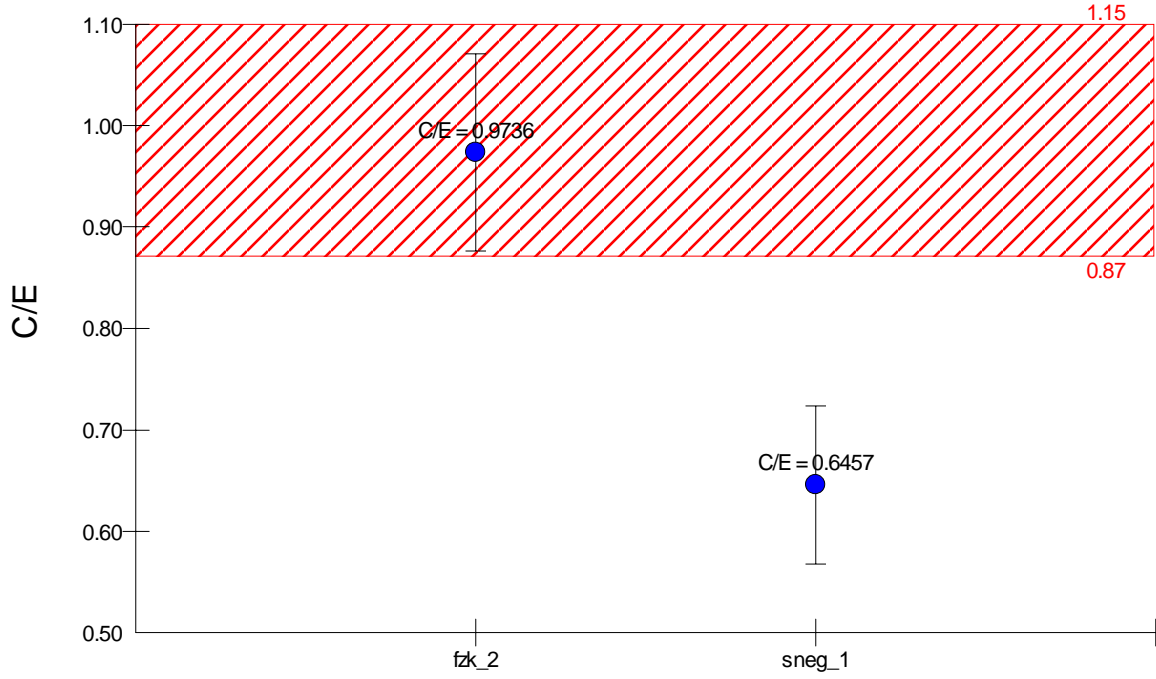


## Neutron Spectrum

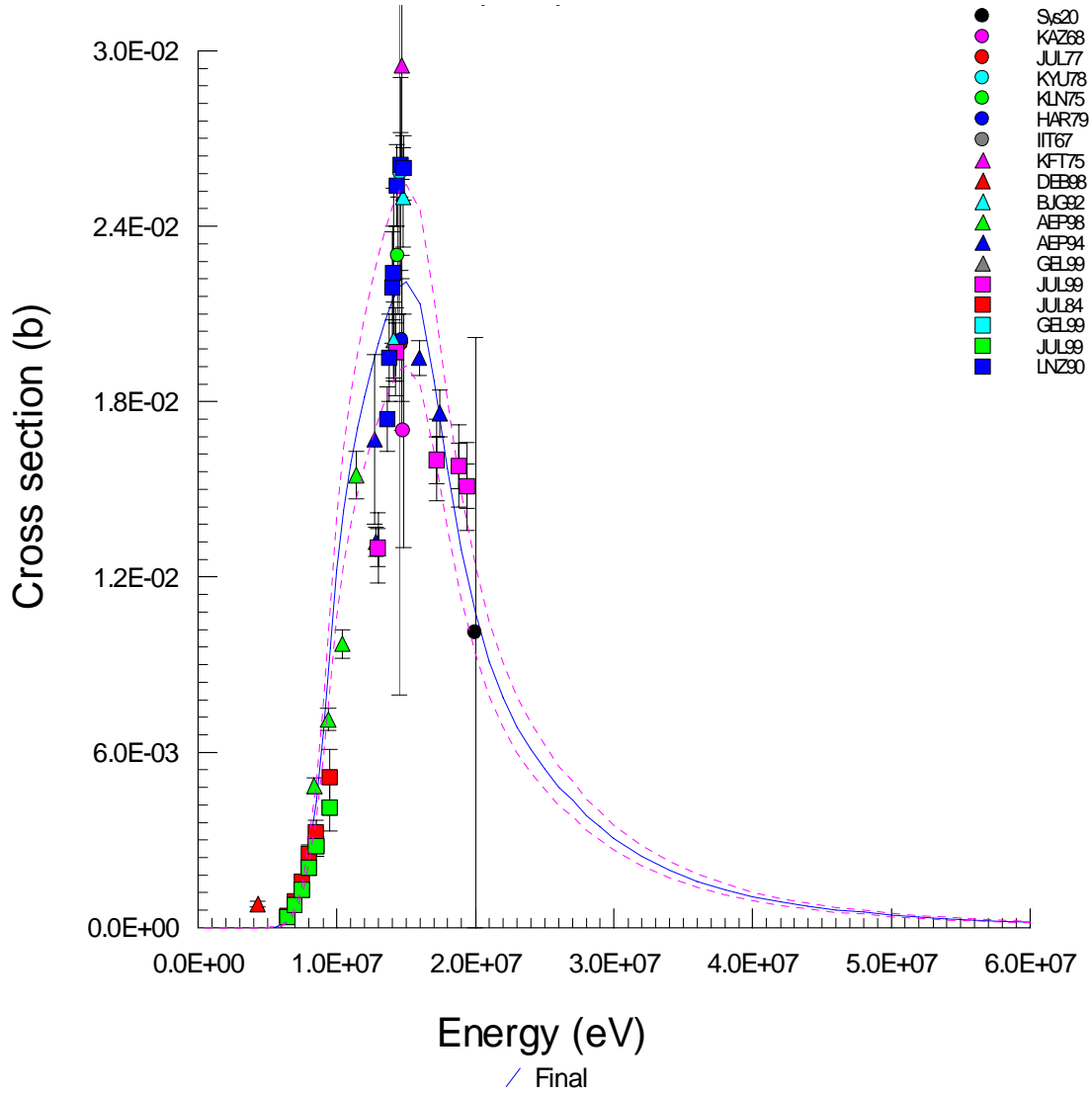




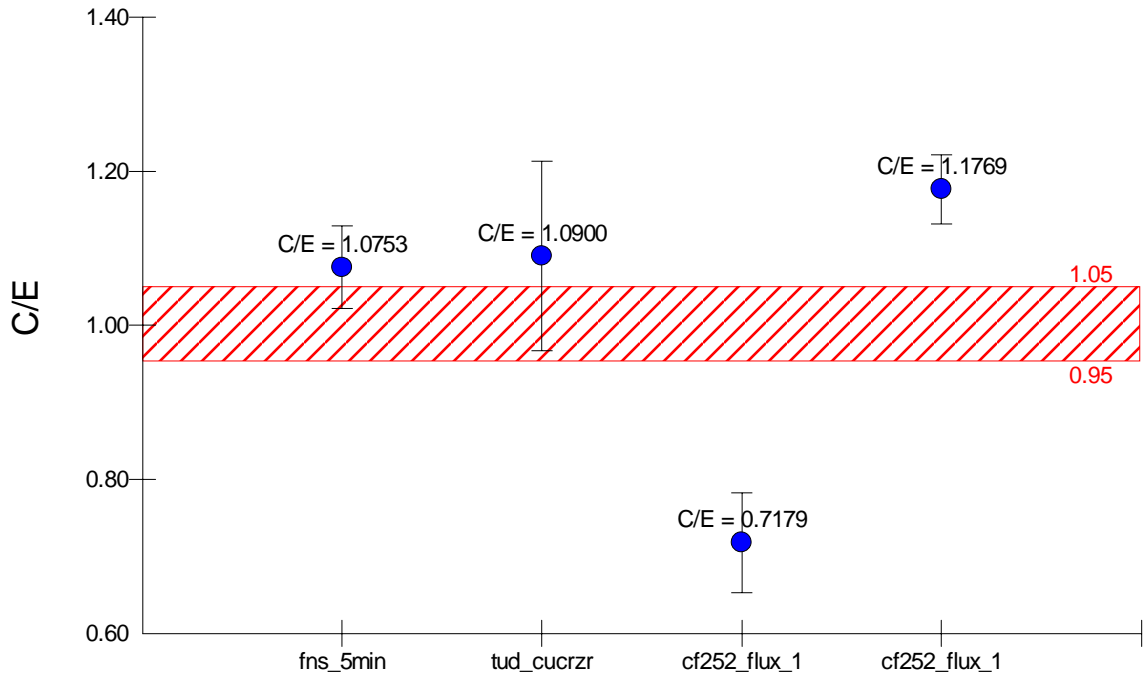
# $^{62}\text{Ni}(n,\alpha)^{59}\text{Fe}$



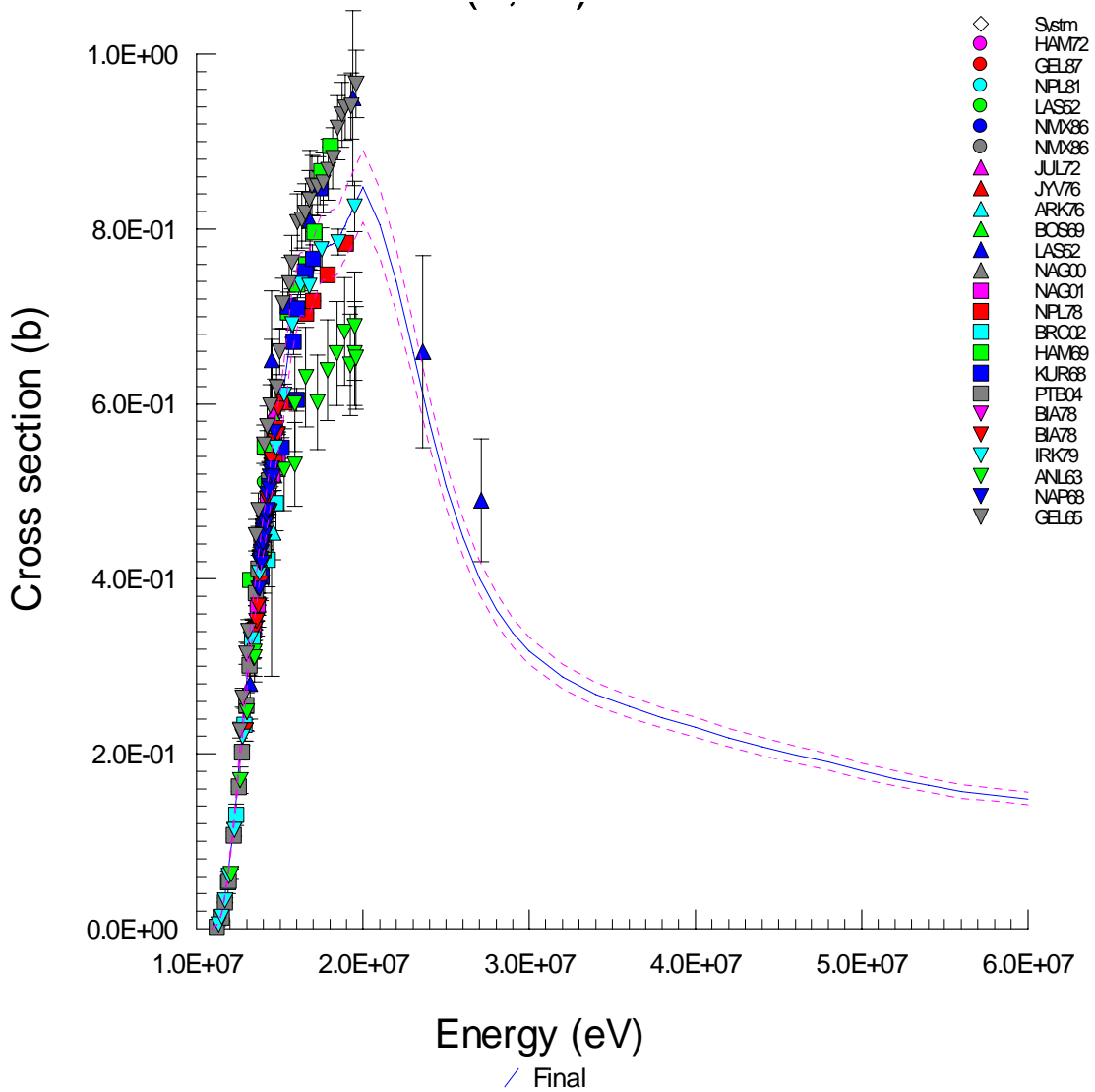
## Neutron Spectrum

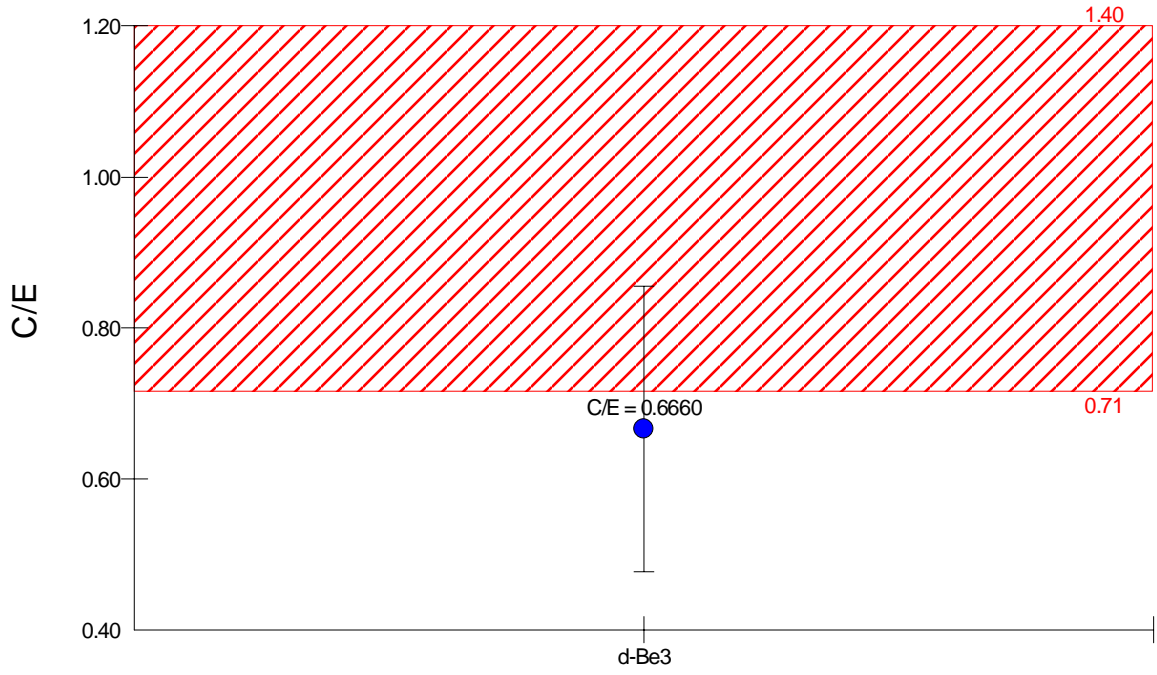
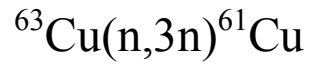


# $^{63}\text{Cu}(n,2n)^{62}\text{Cu}$

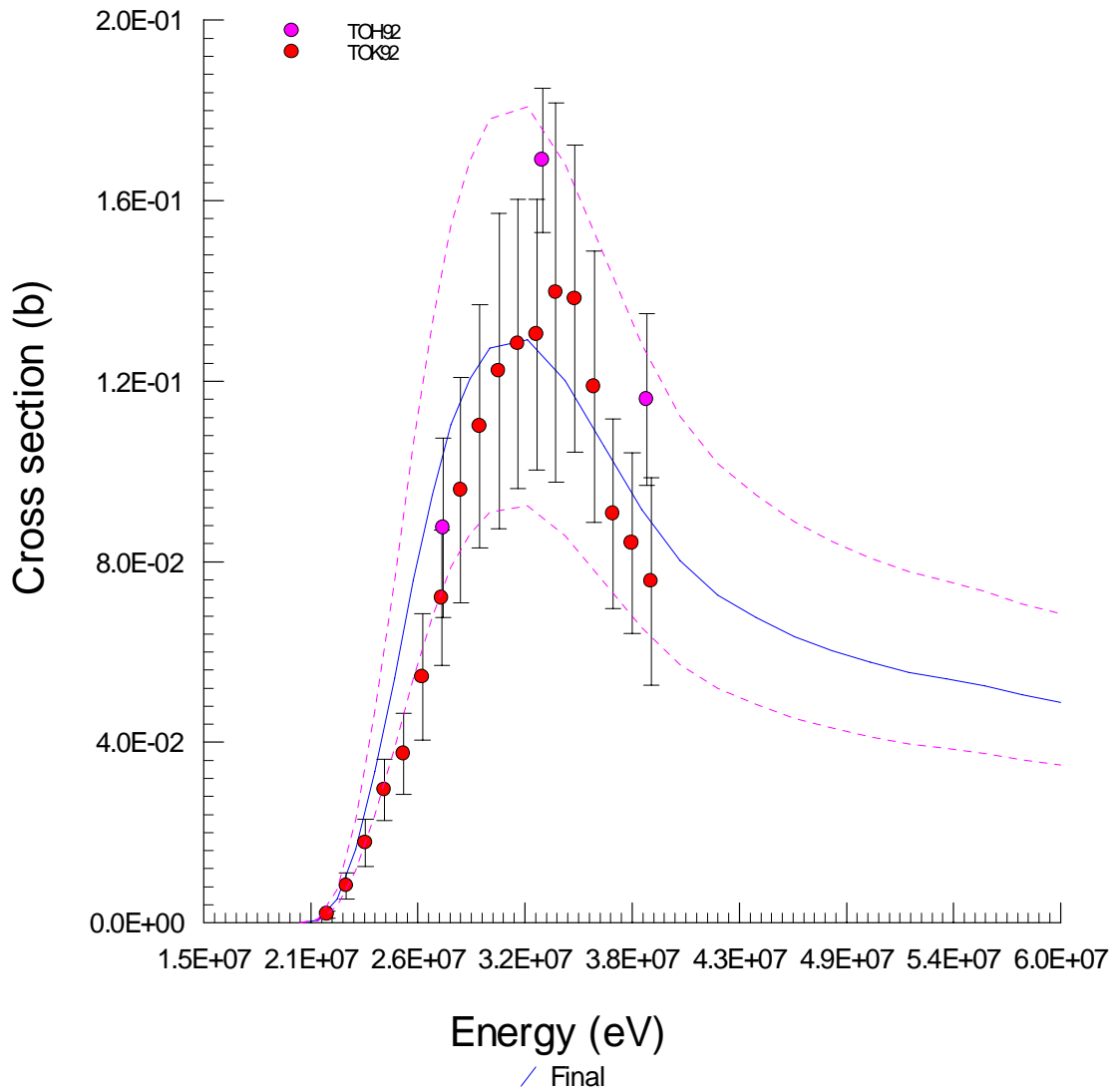


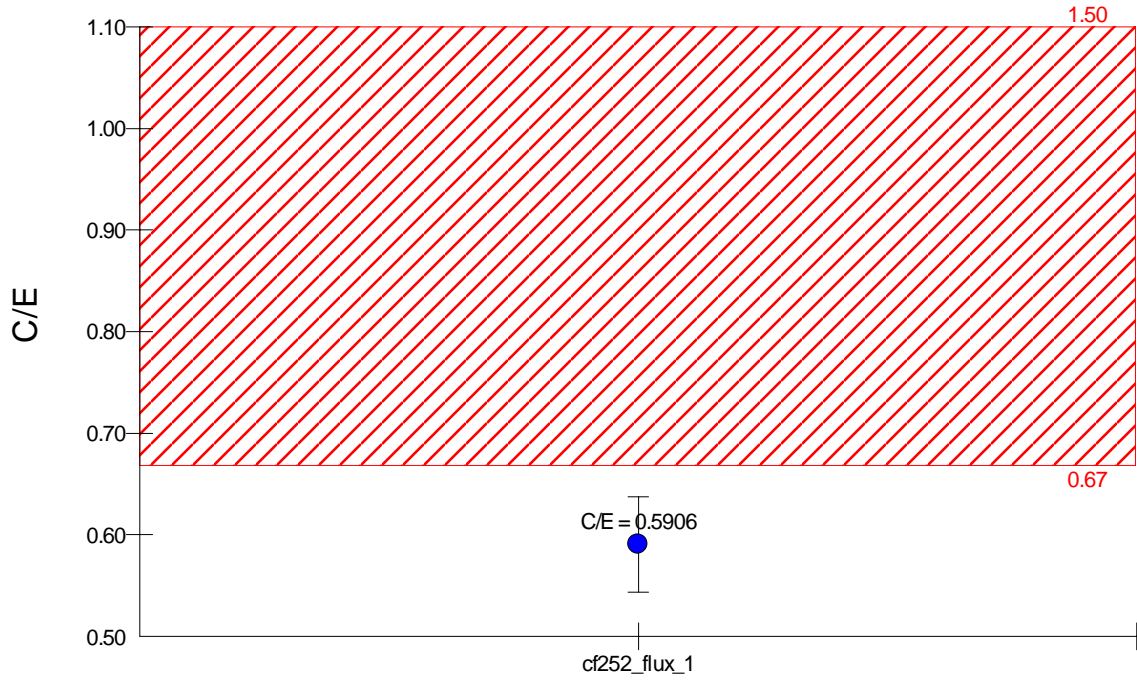
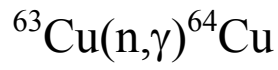
## Neutron Spectrum



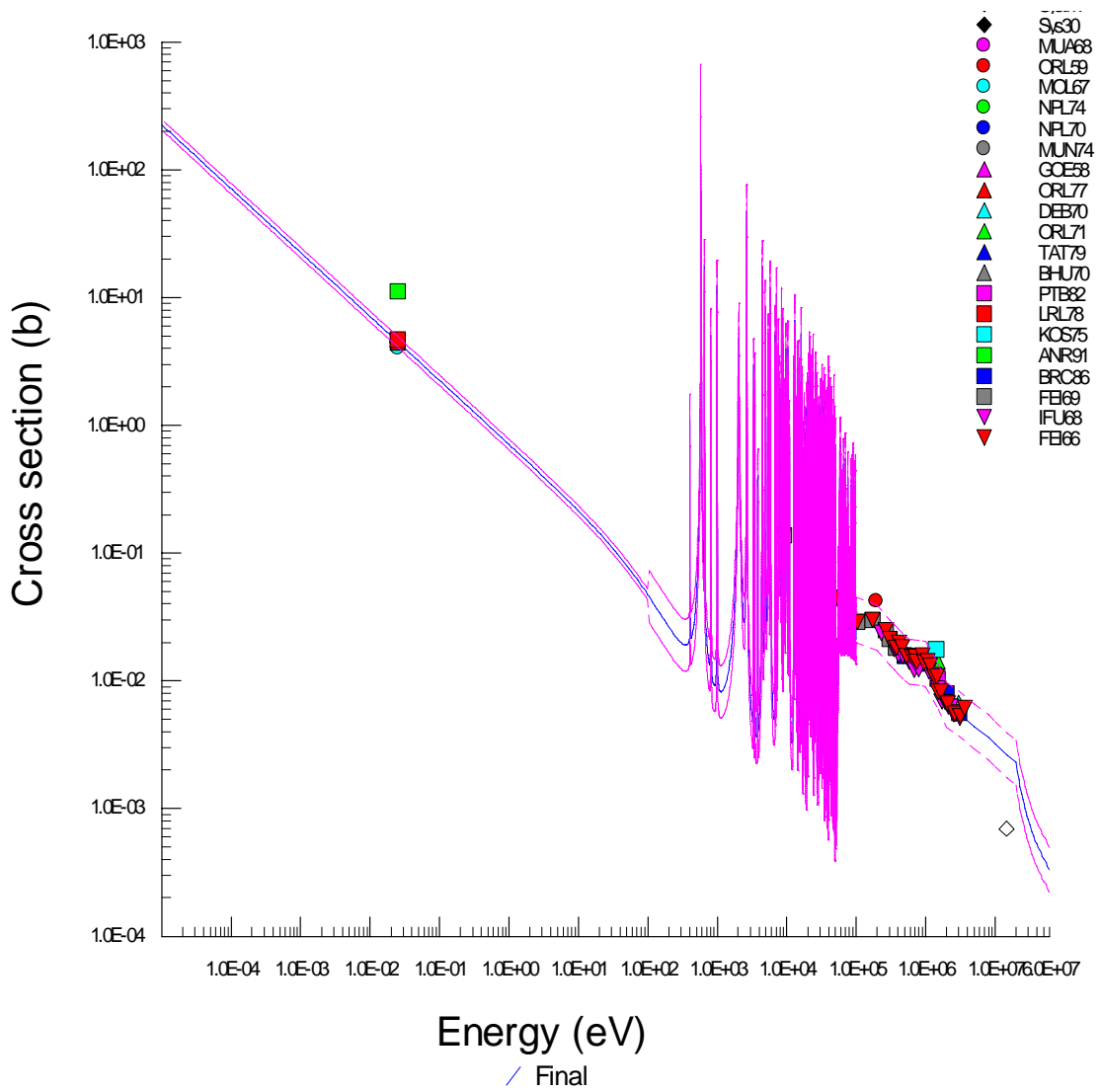


Neutron Spectrum

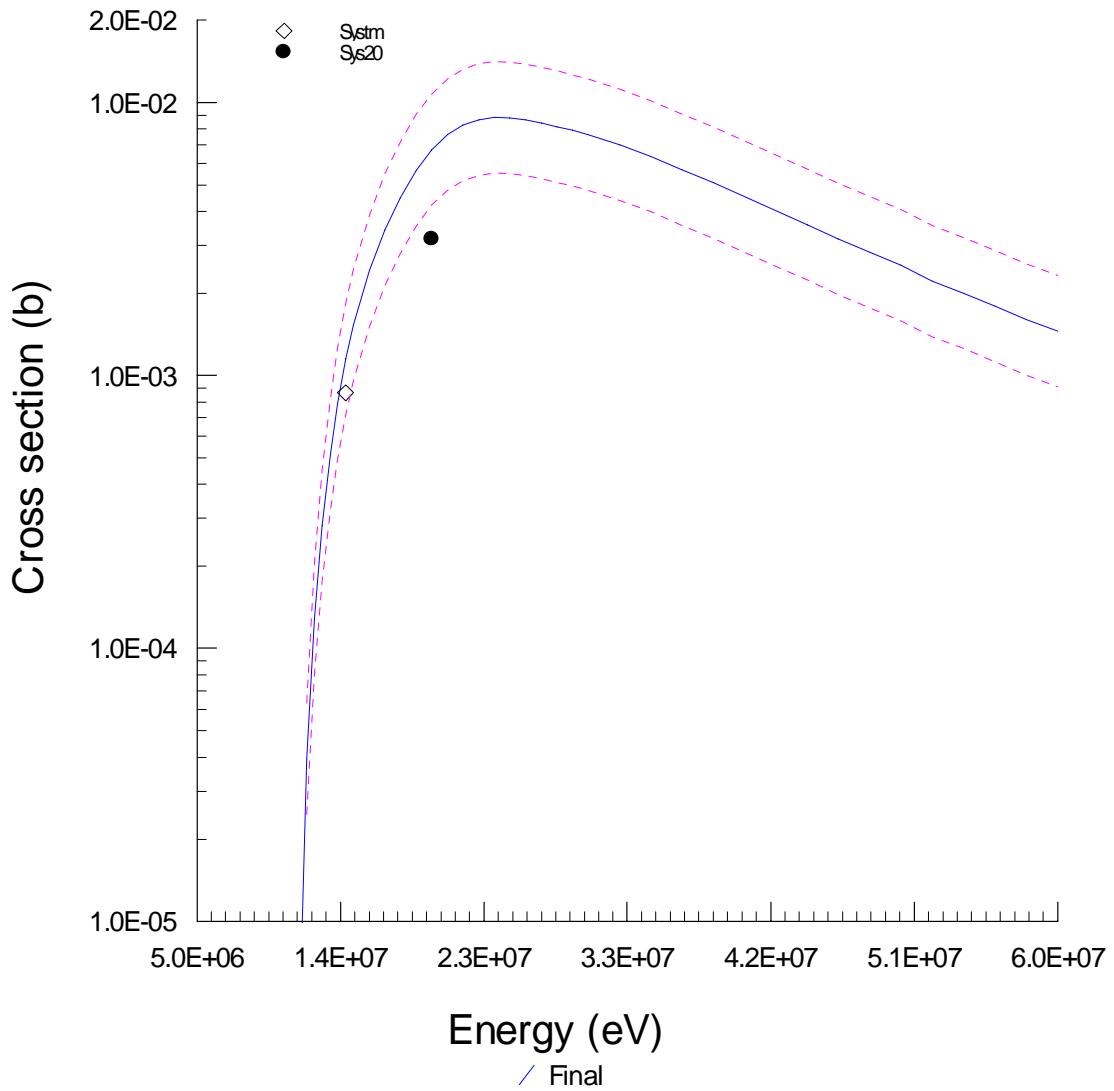
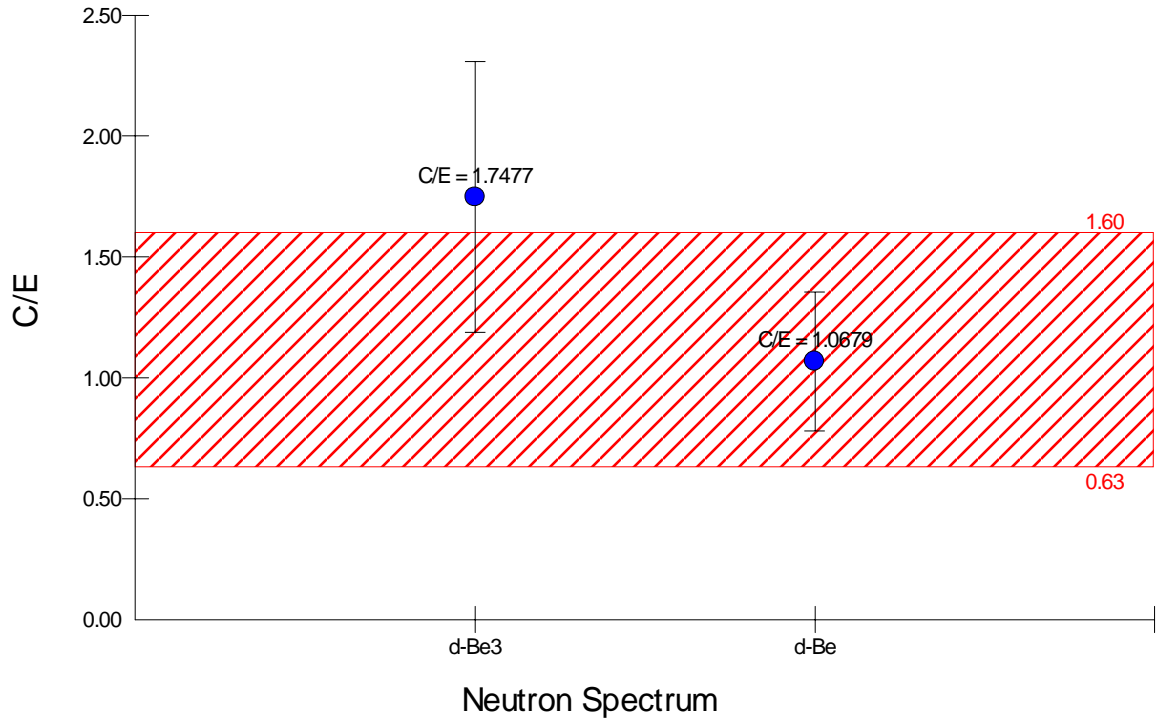




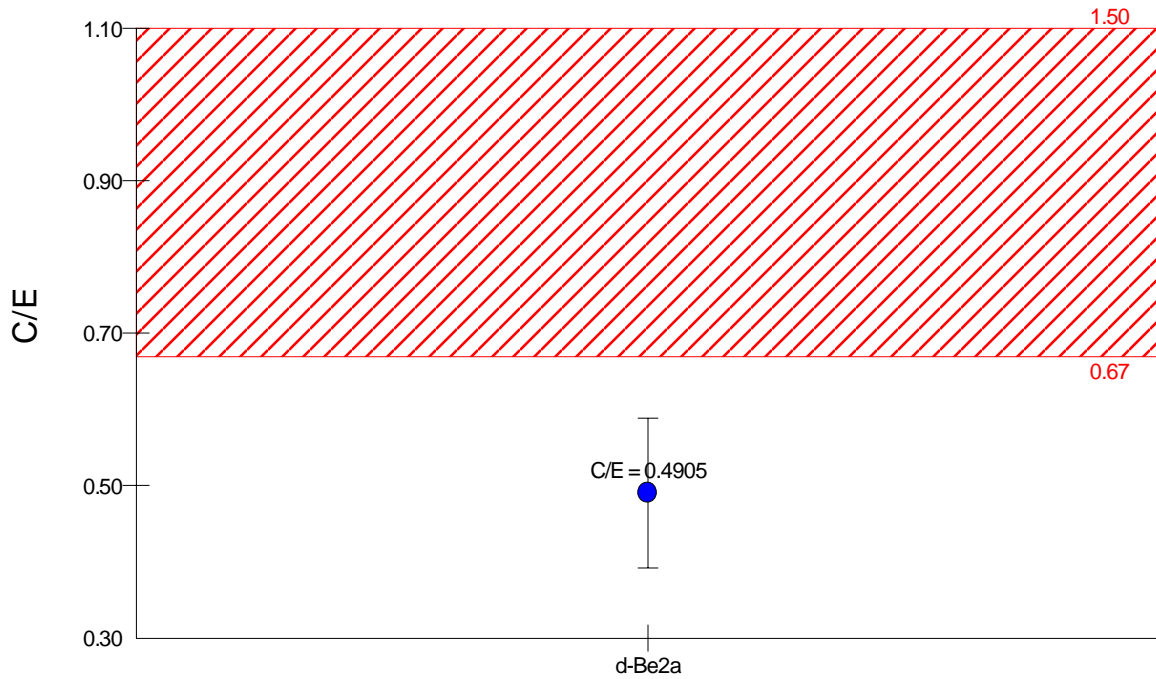
Neutron Spectrum



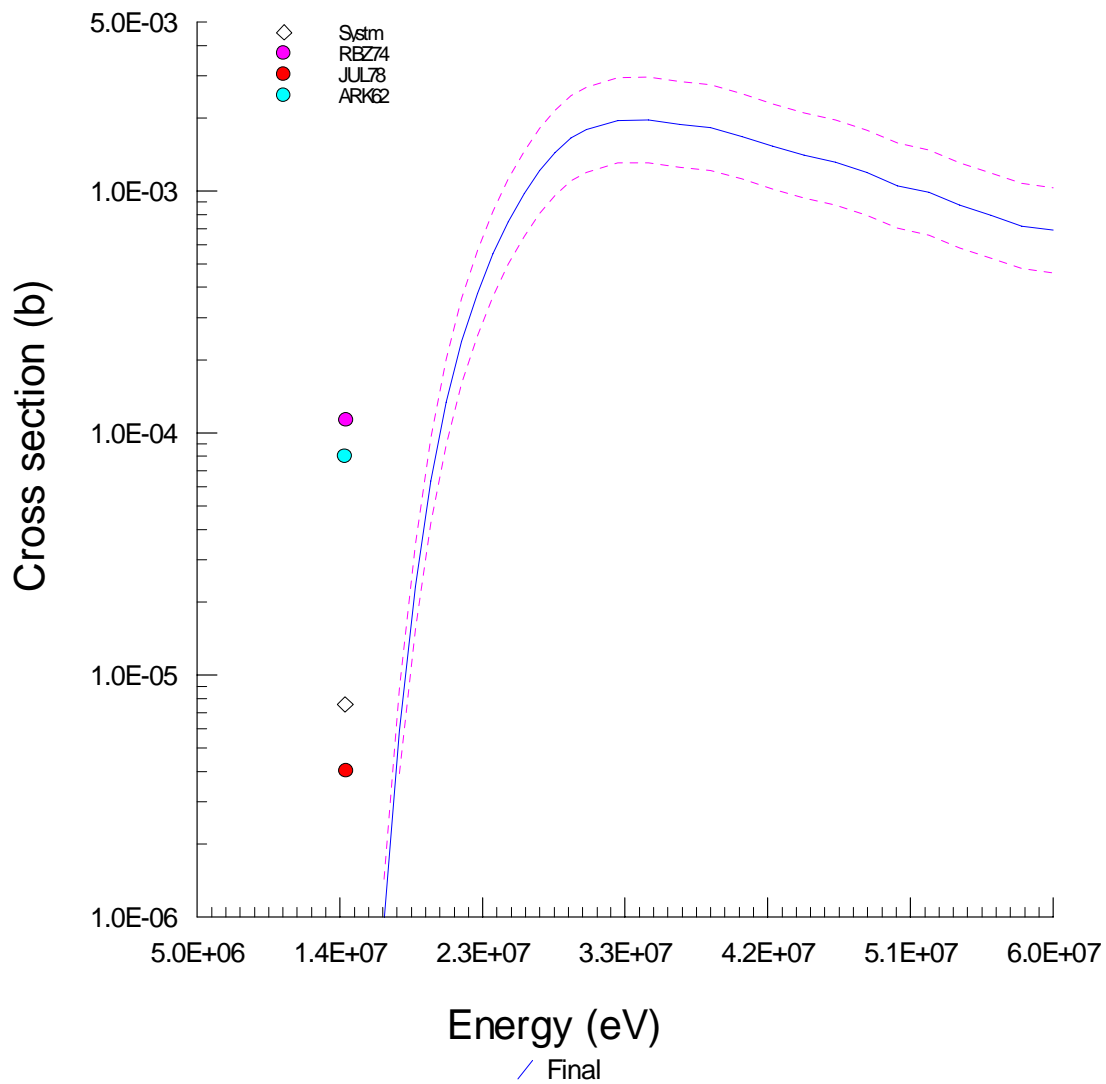
# $^{63}\text{Cu}(n,t)^{61}\text{Ni}$



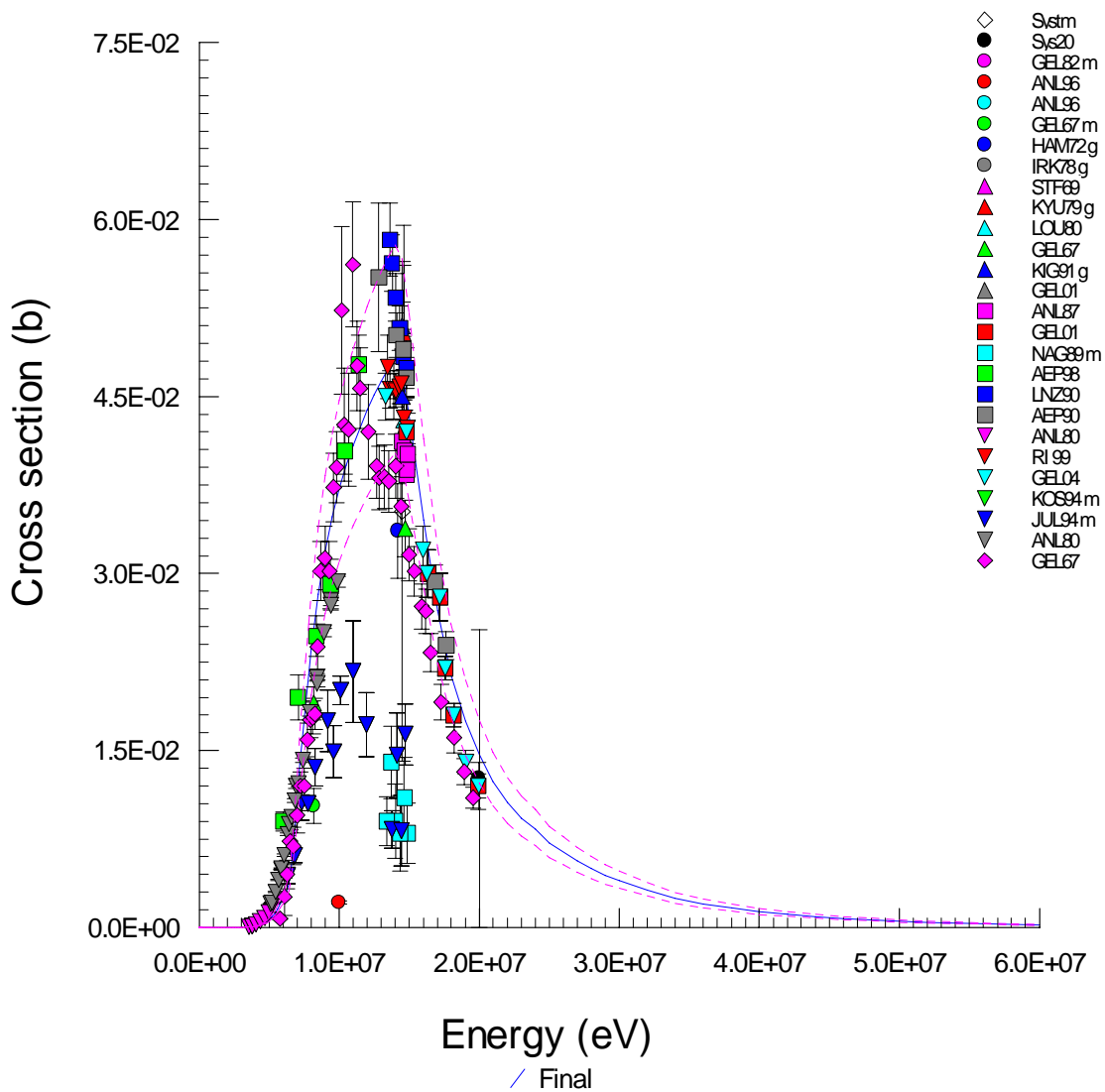
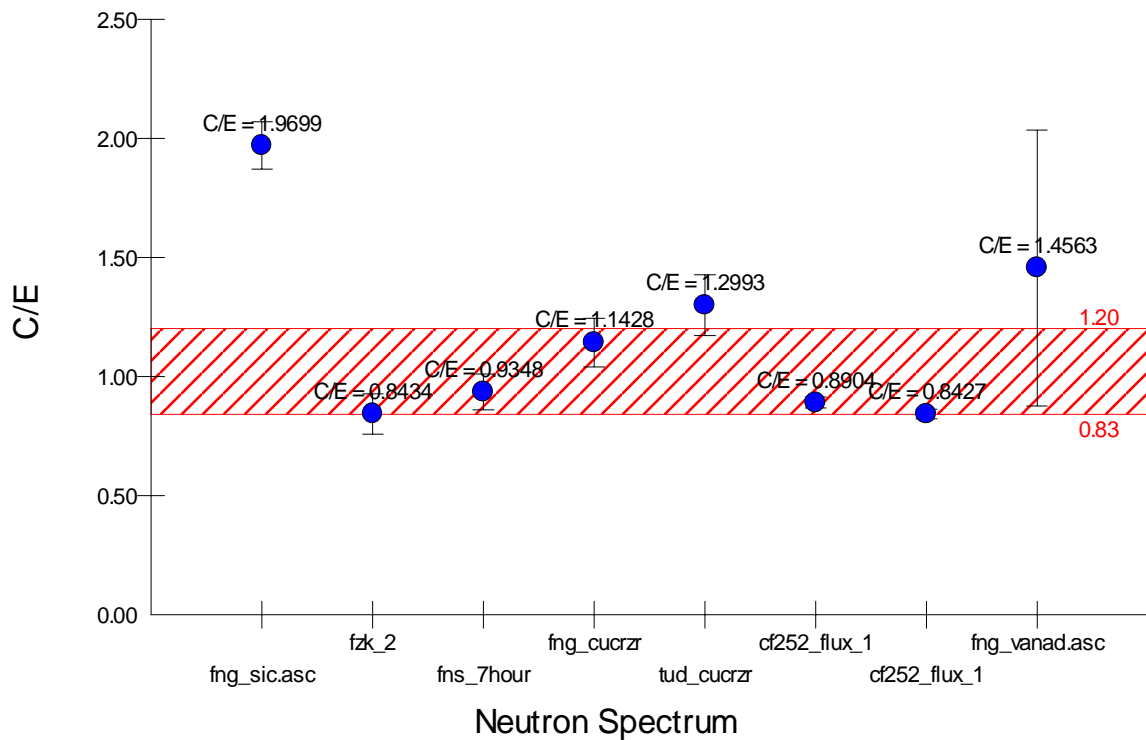
# $^{63}\text{Cu}(n,h)^{61}\text{Co}$



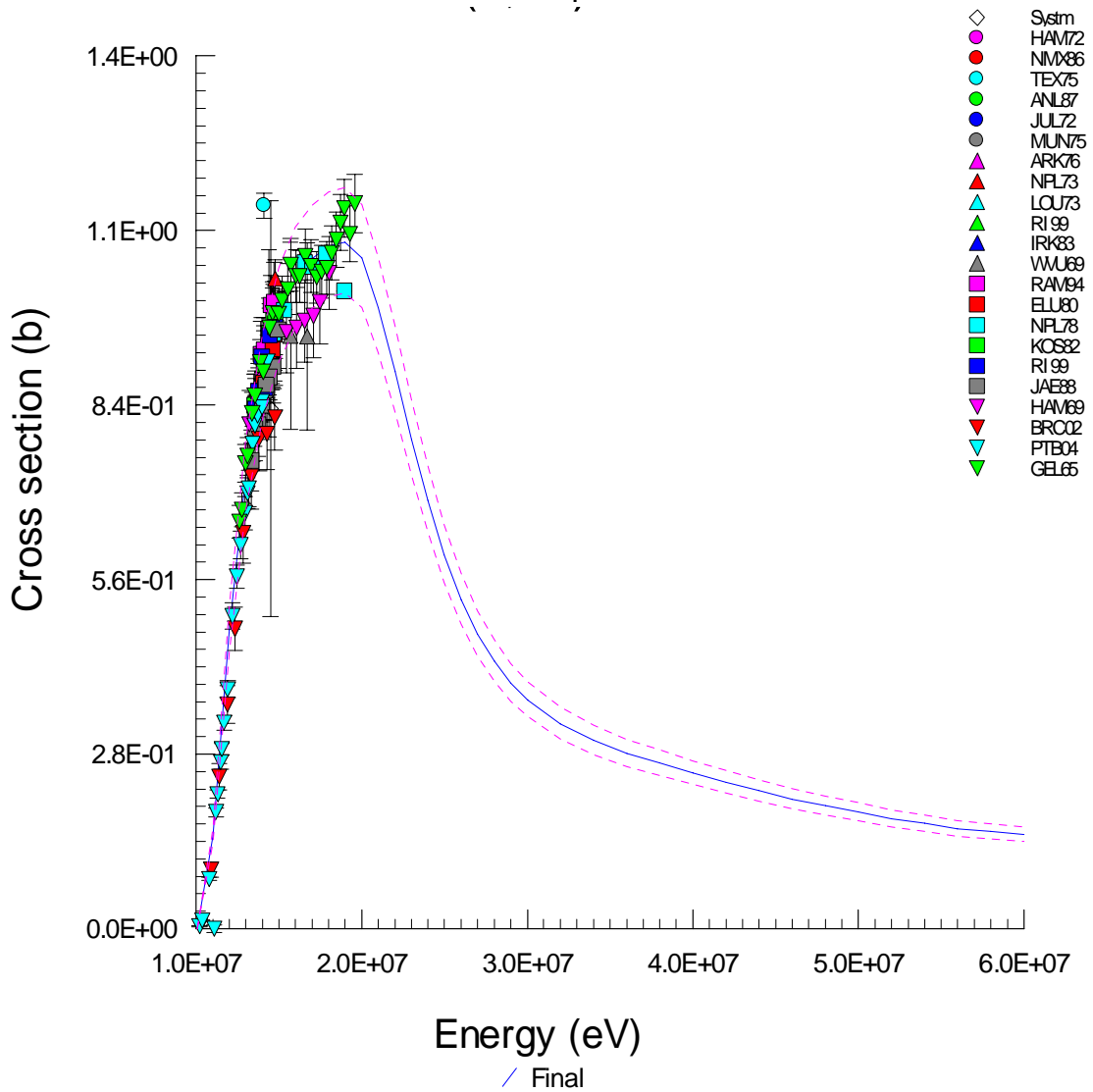
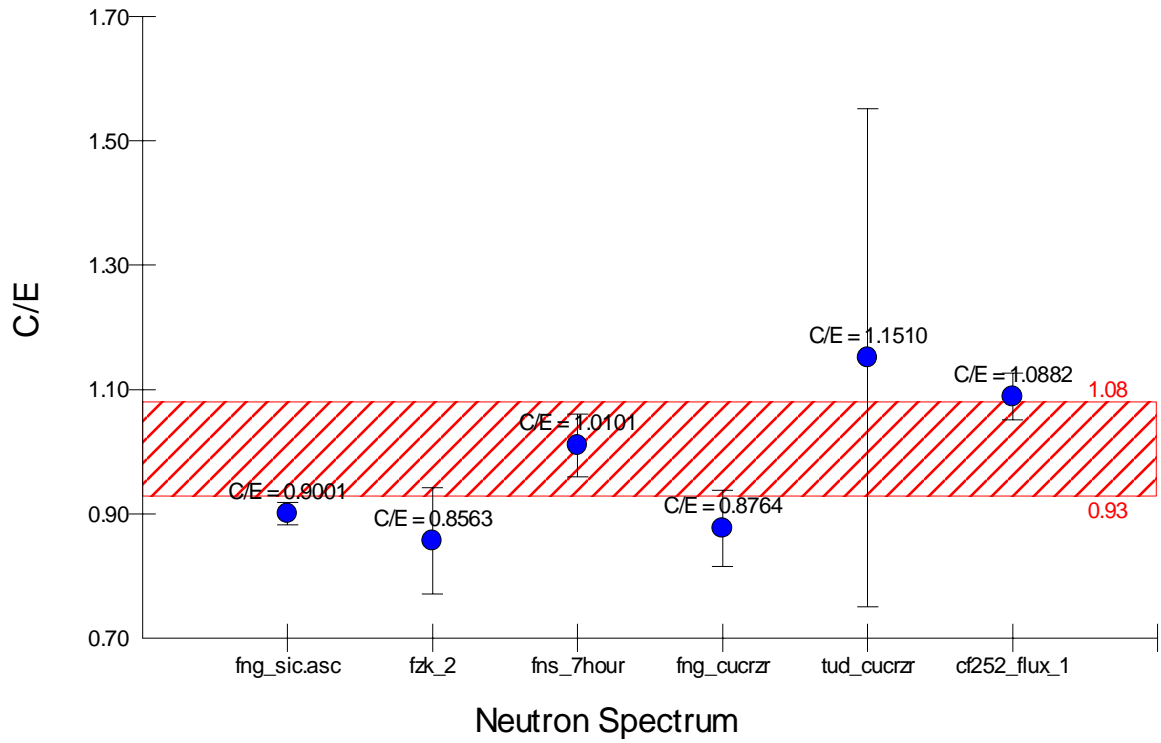
Neutron Spectrum



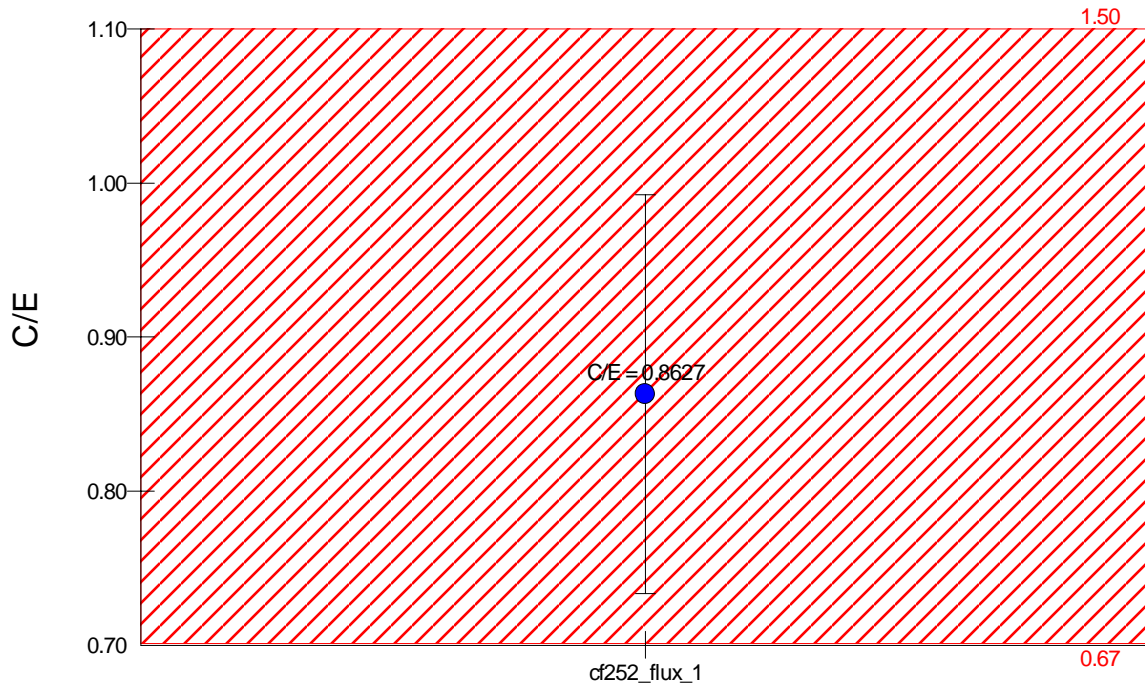
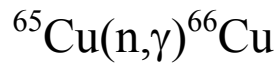
# $^{63}\text{Cu}(n,\alpha)^{60}\text{Co} \blacktriangleright 551$



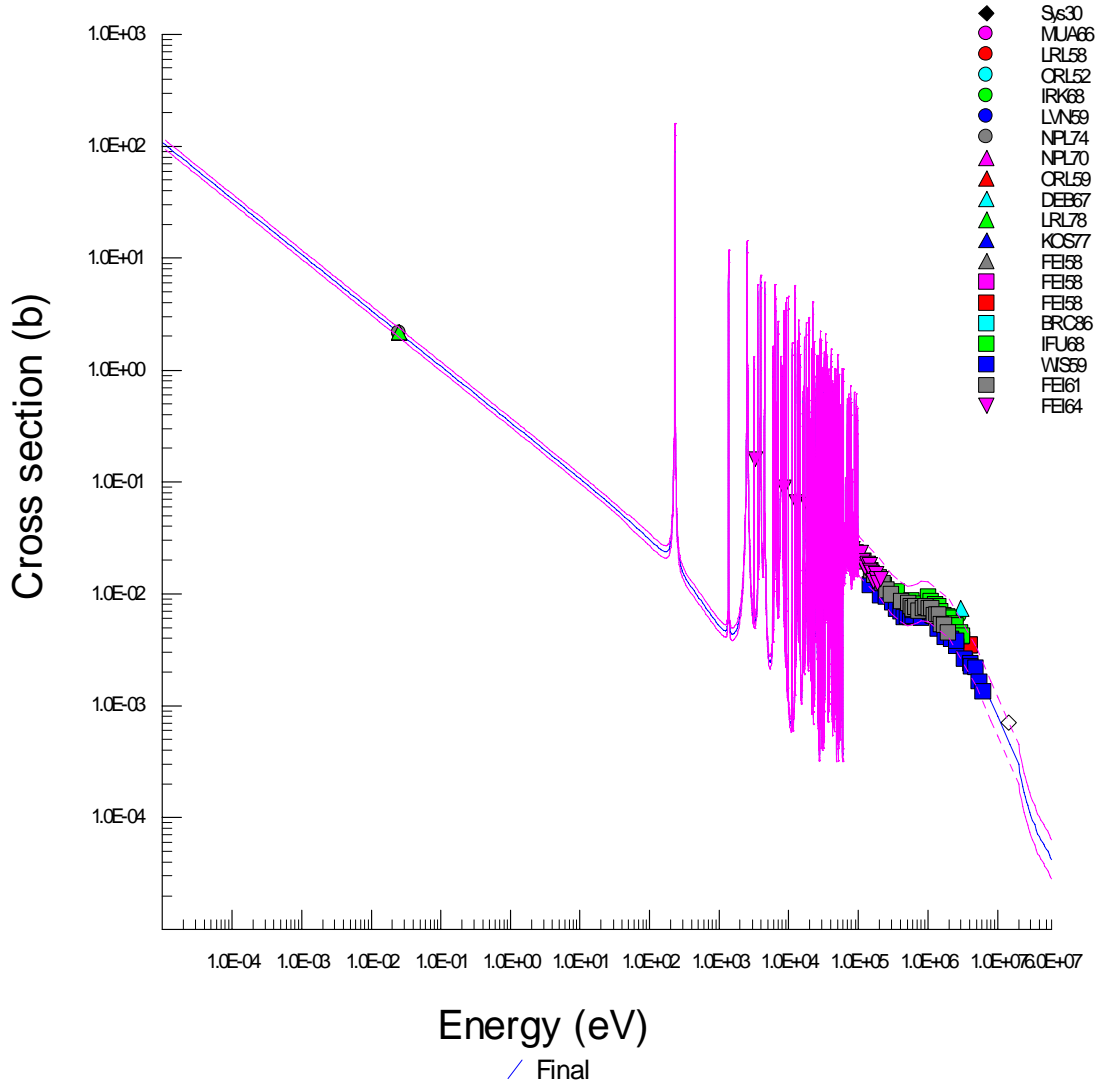
$^{65}\text{Cu}(n,2n)^{64}\text{Cu} \blacktriangleright 552$

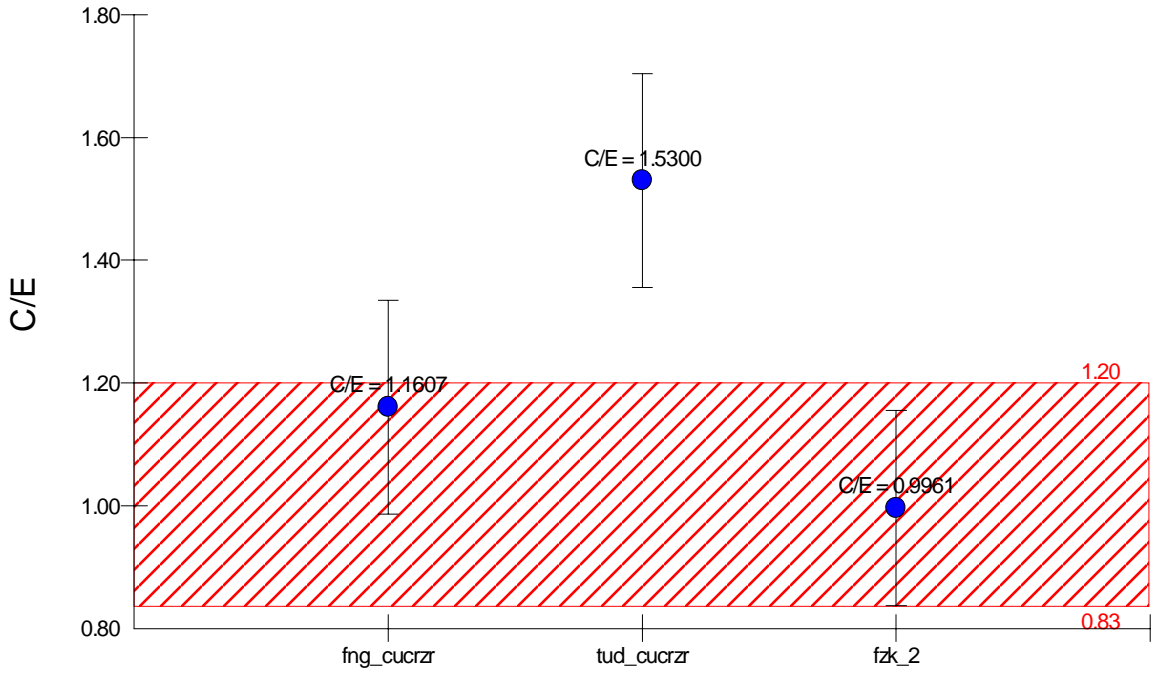
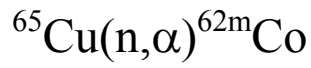




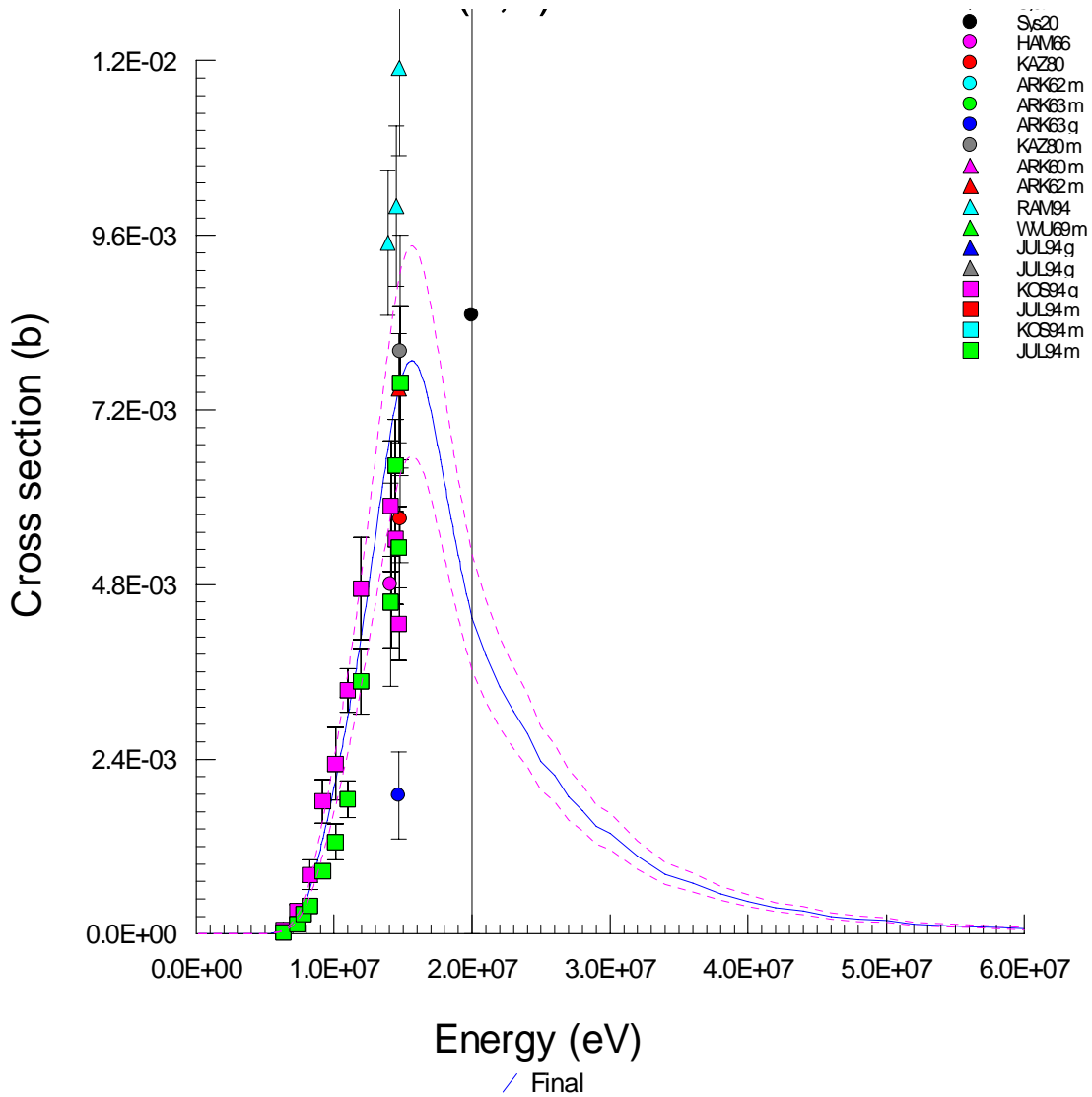


Neutron Spectrum

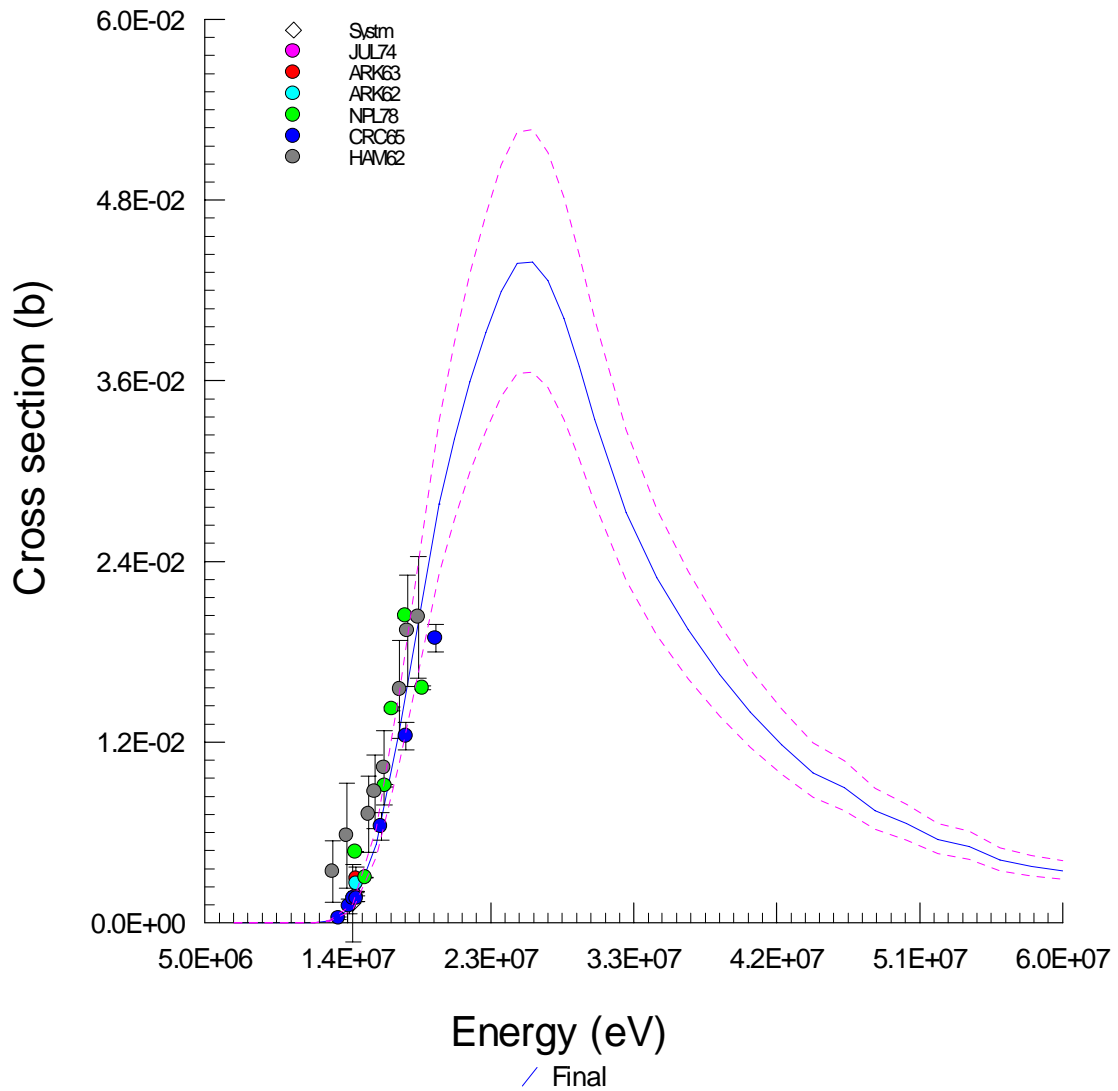
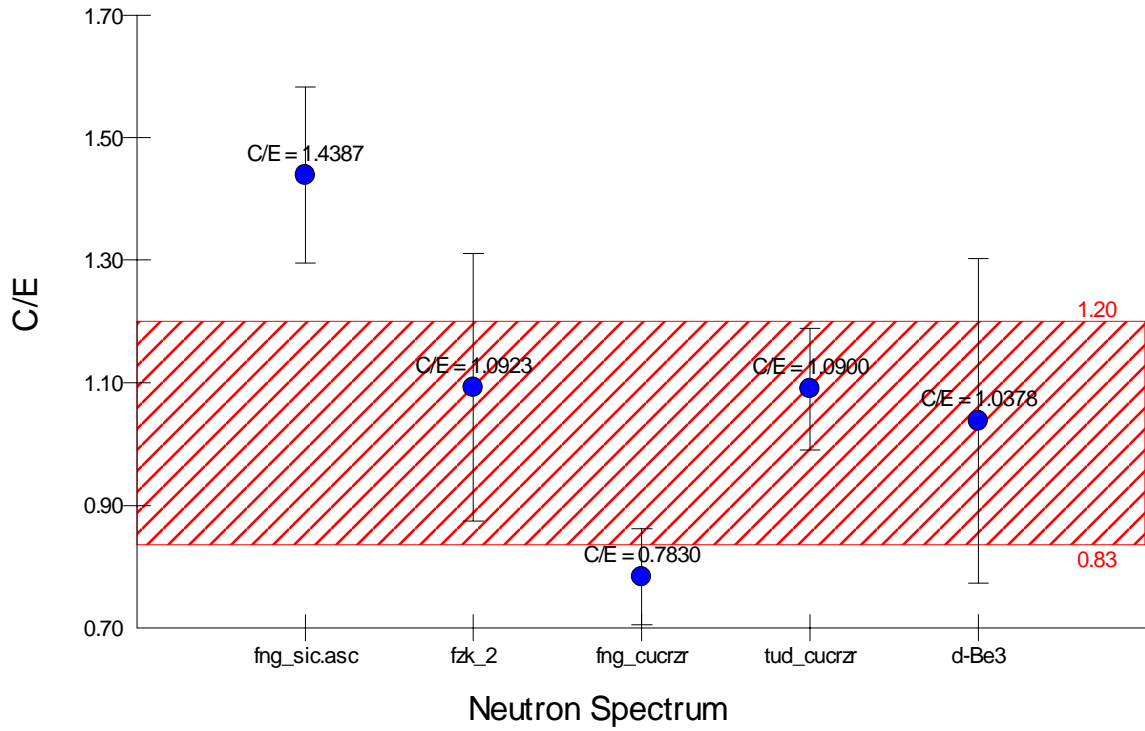




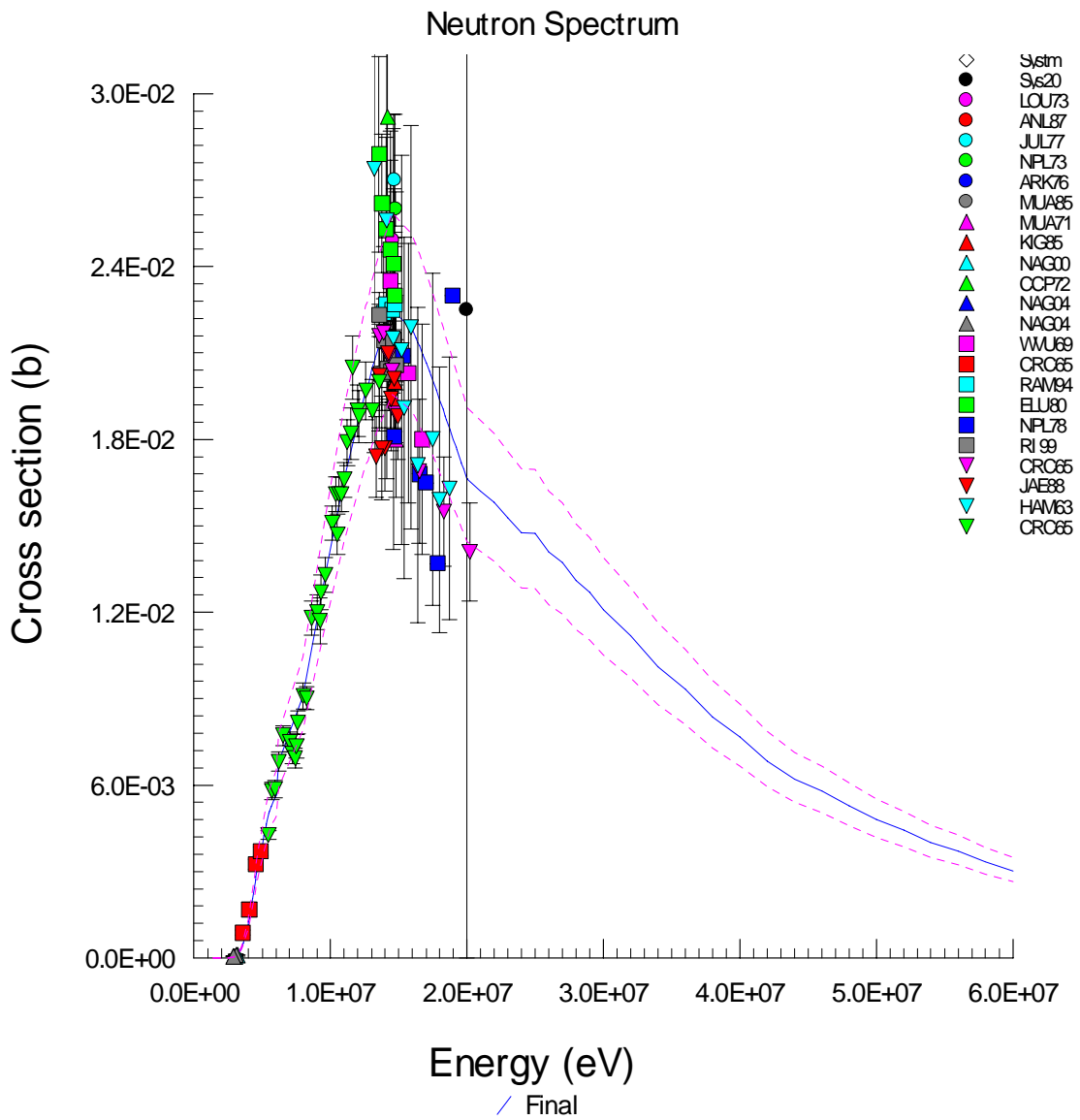
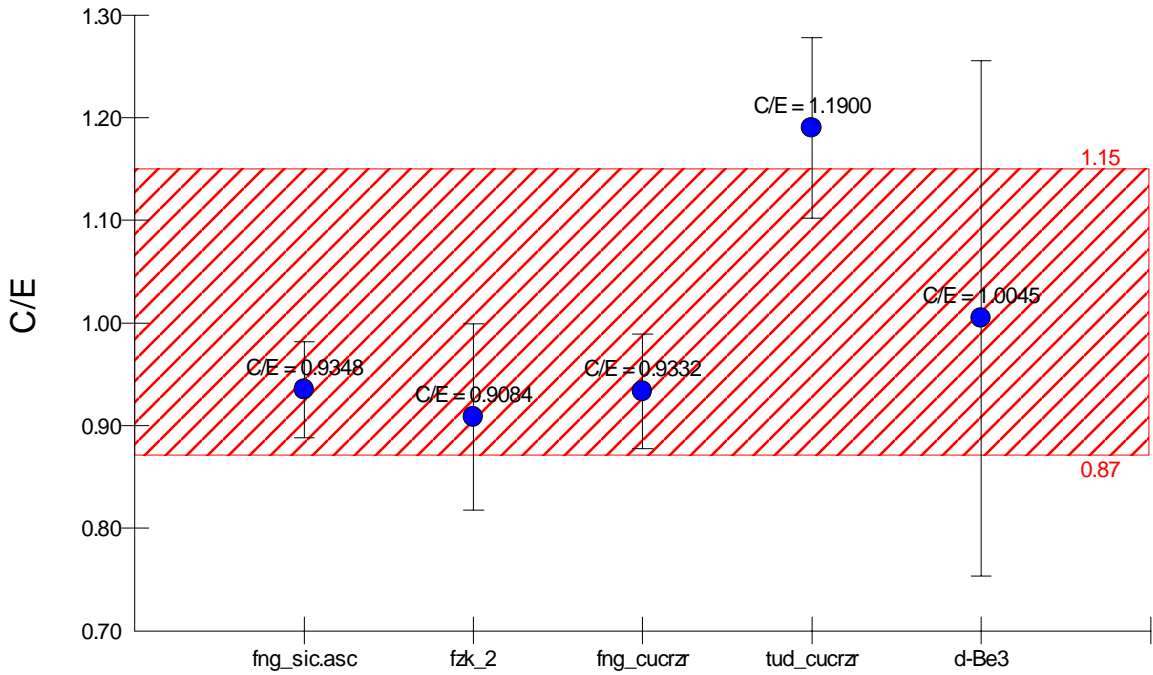
Neutron Spectrum

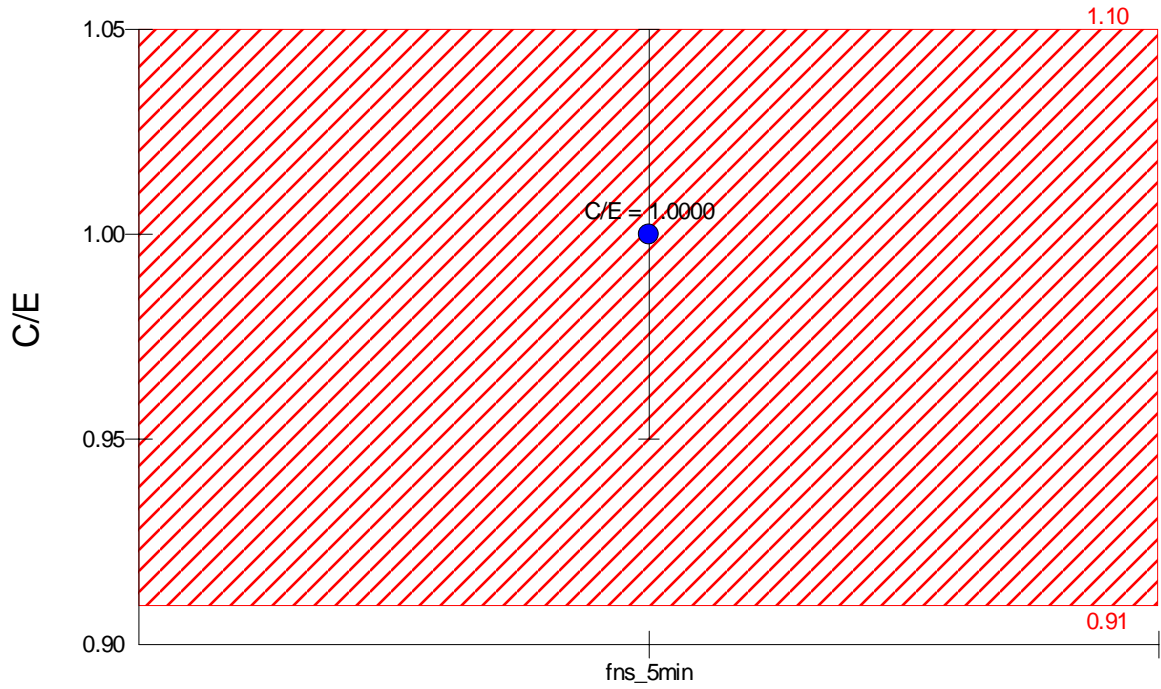
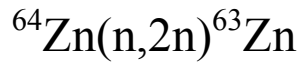


# $^{65}\text{Cu}(n,n'\alpha)^{61}\text{Co}$

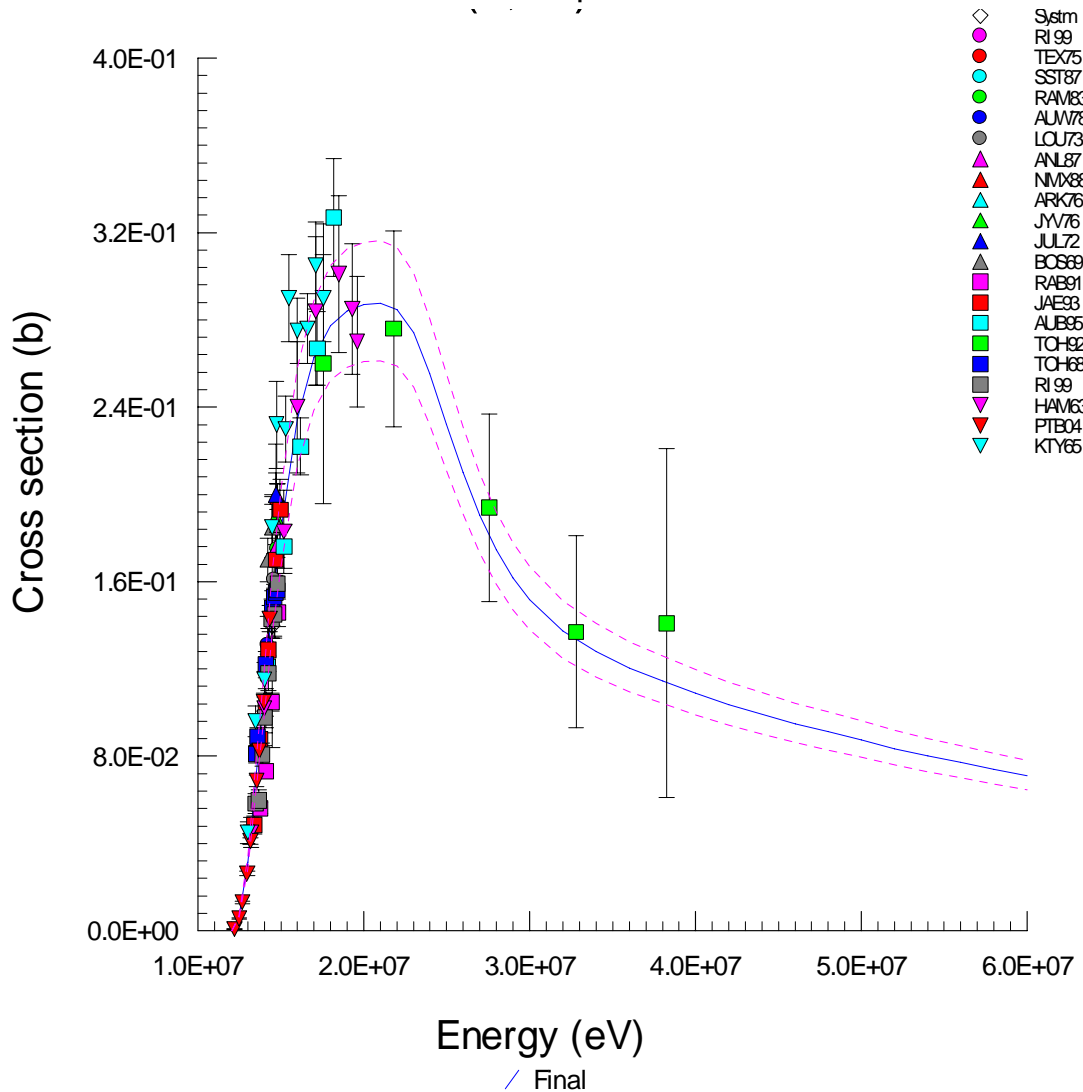


# $^{65}\text{Cu}(n,p)^{65}\text{Ni}$

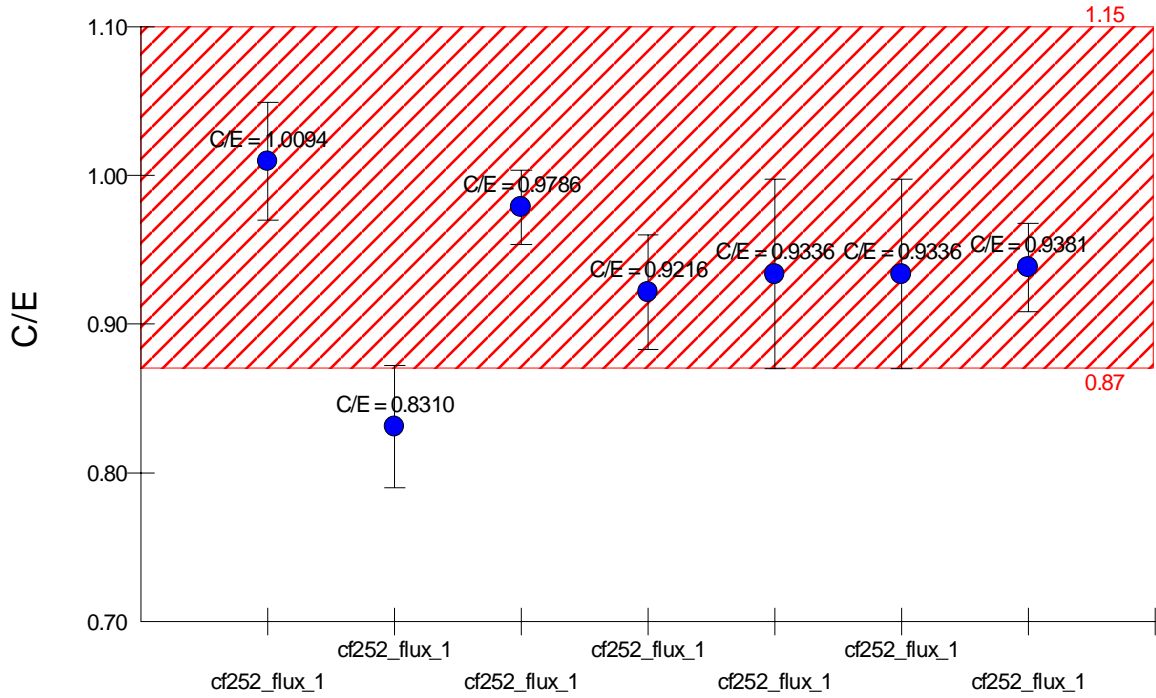




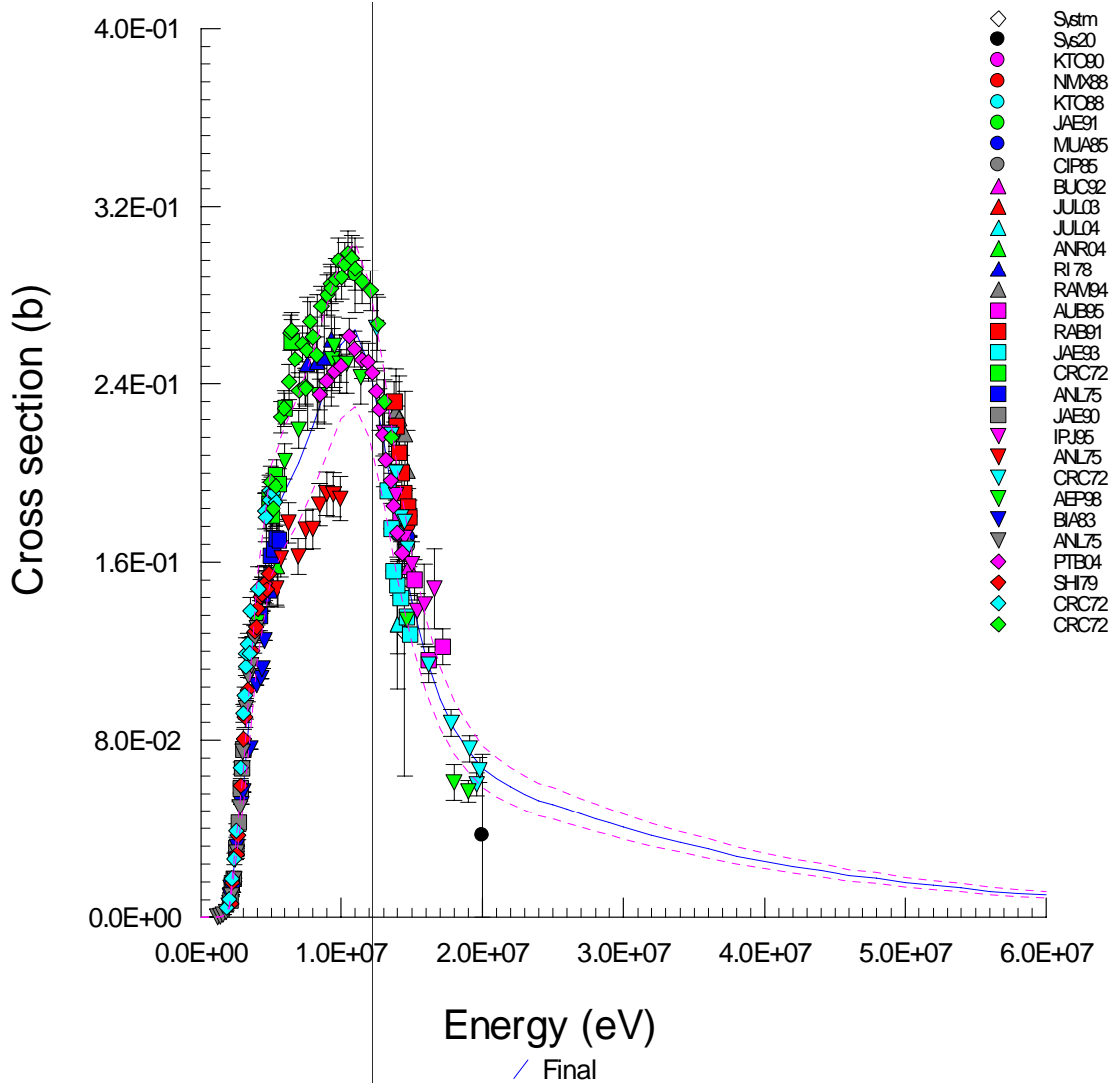
Neutron Spectrum

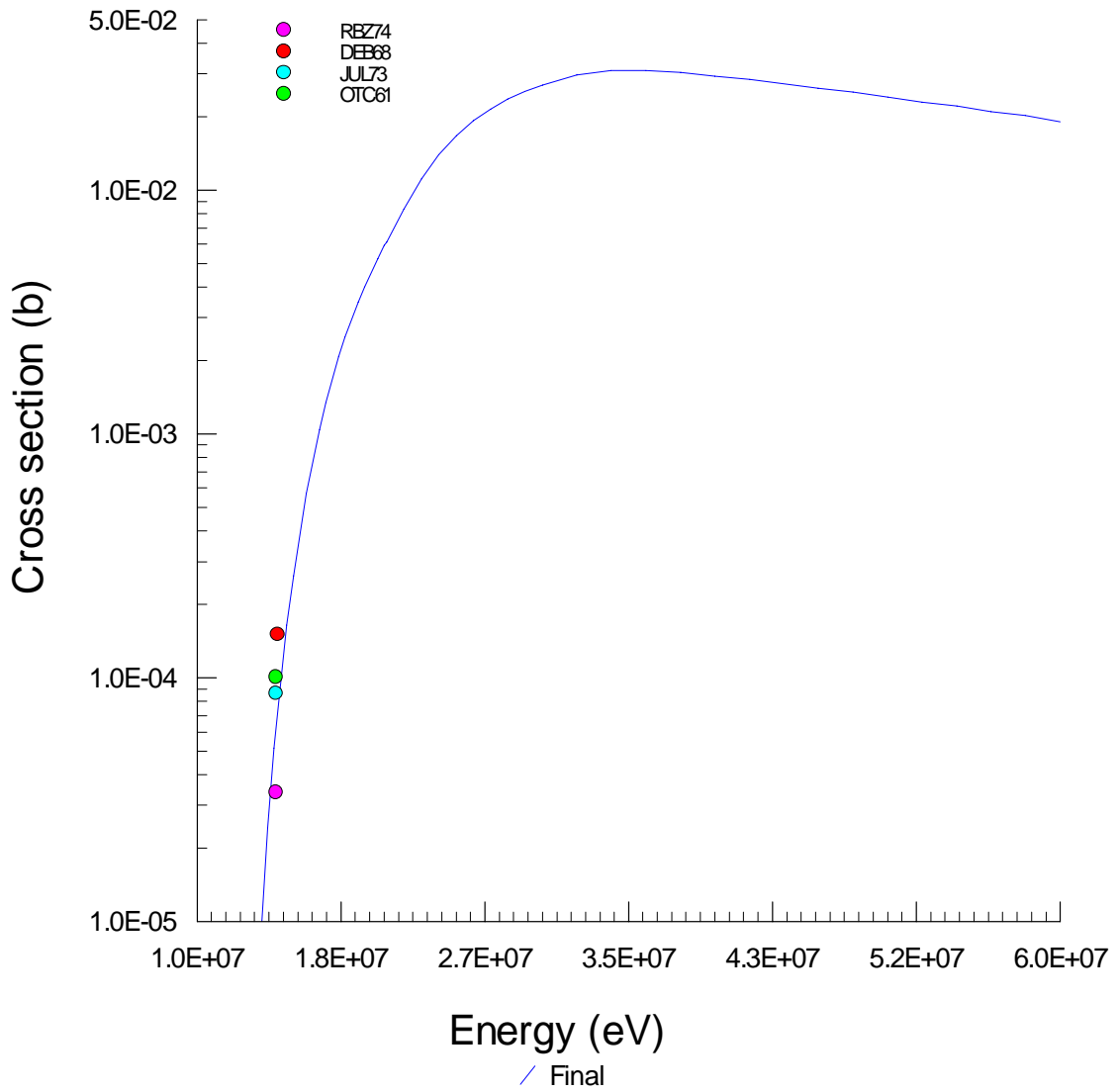
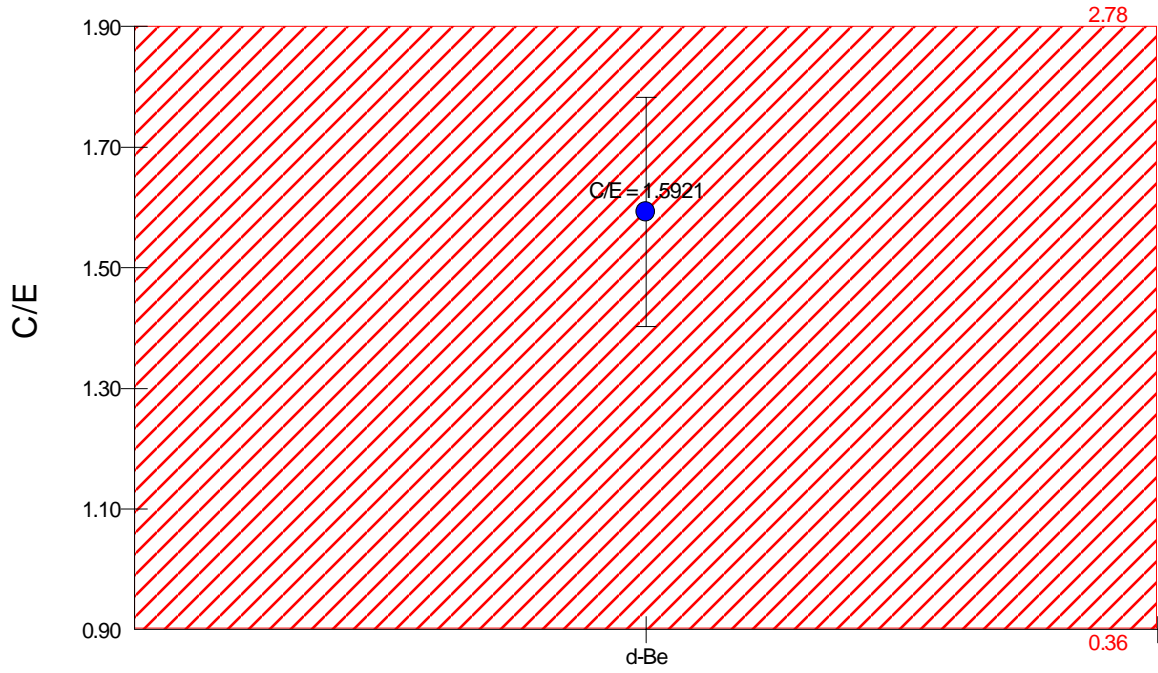
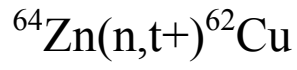


# $^{64}\text{Zn}(n,p)^{64}\text{Cu}$

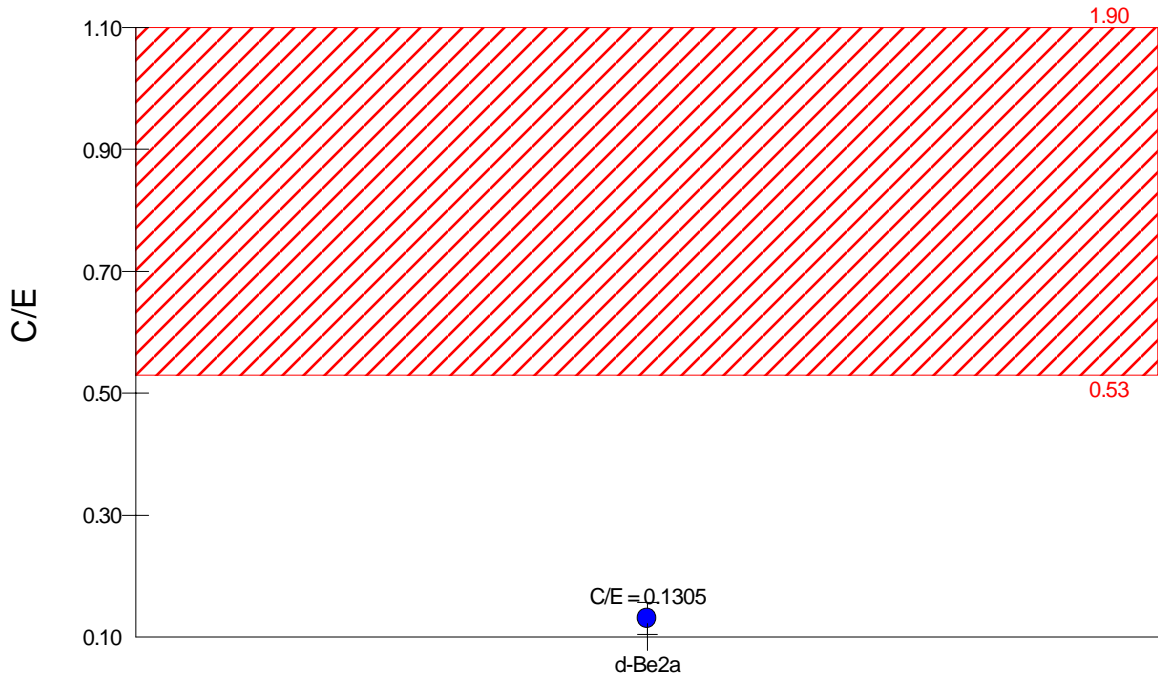


## Neutron Spectrum

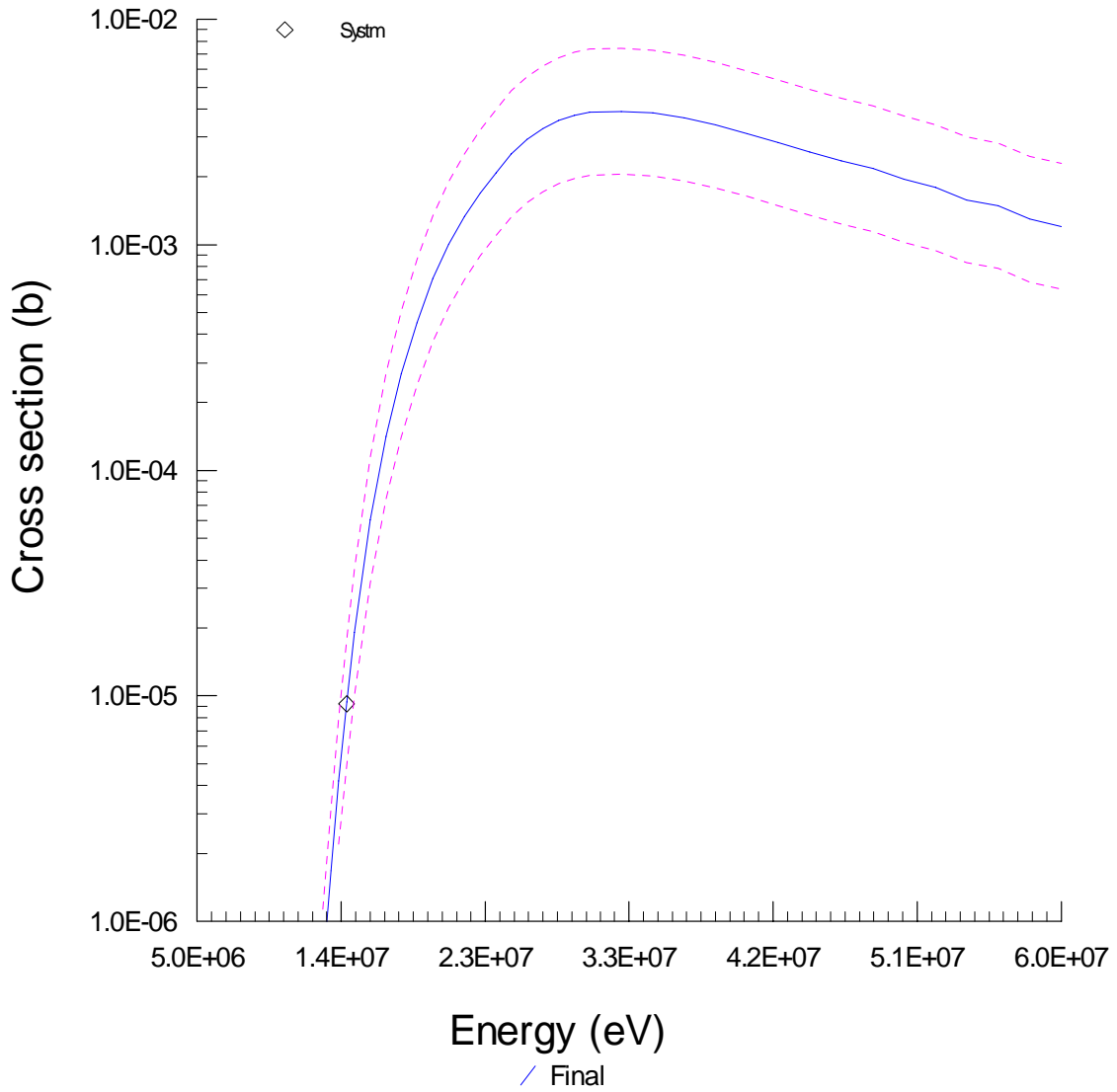




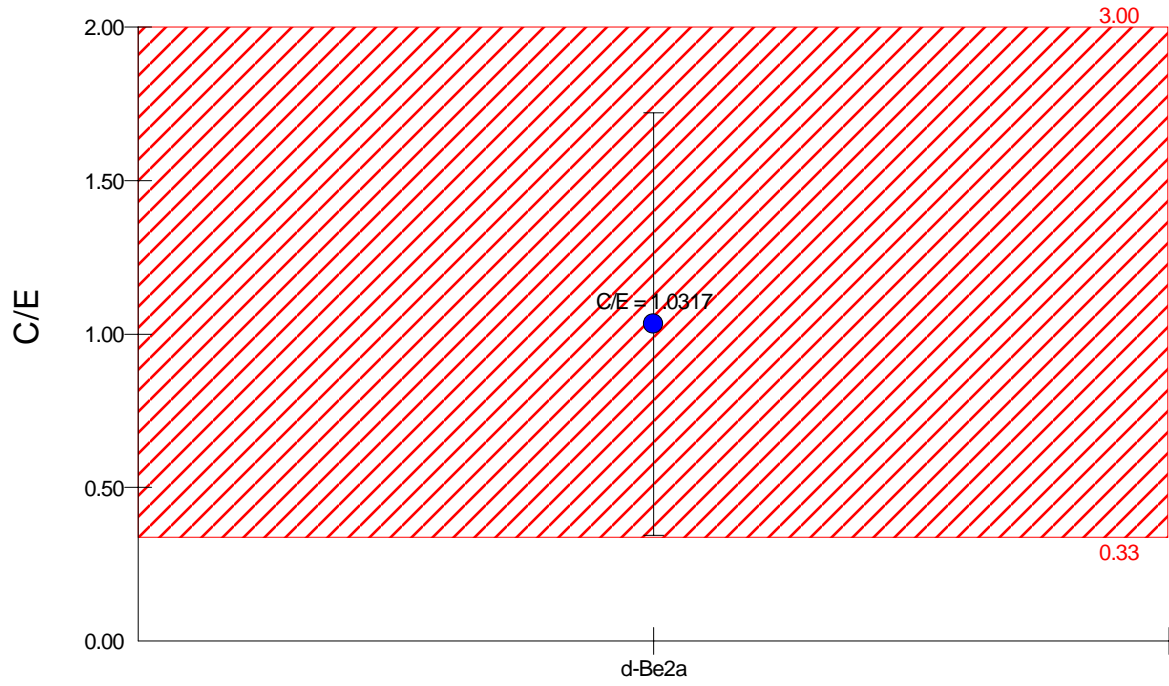
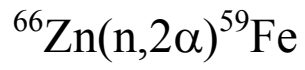
# $^{64}\text{Zn}(n,h)^{62}\text{Ni}$



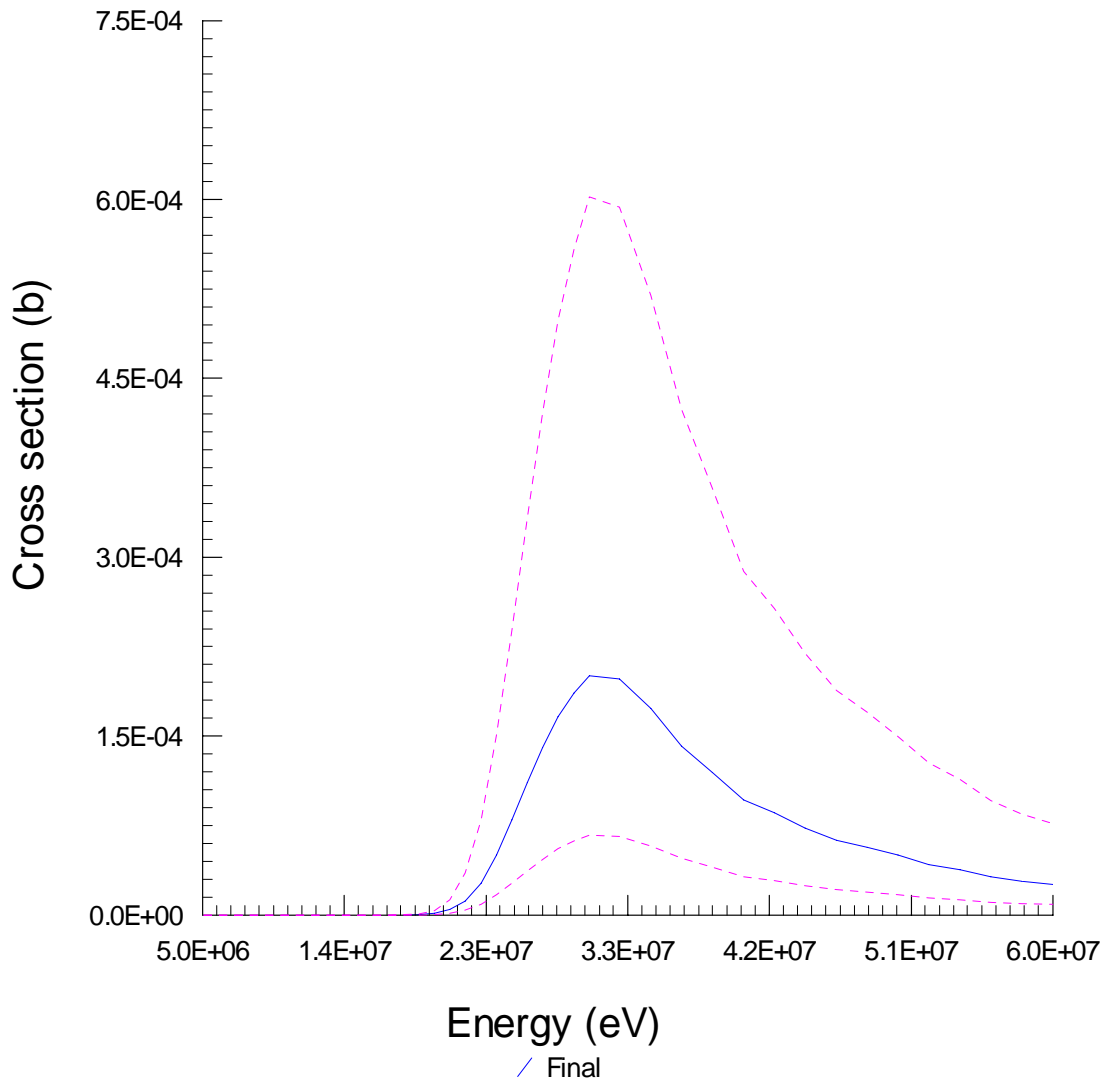
## Neutron Spectrum



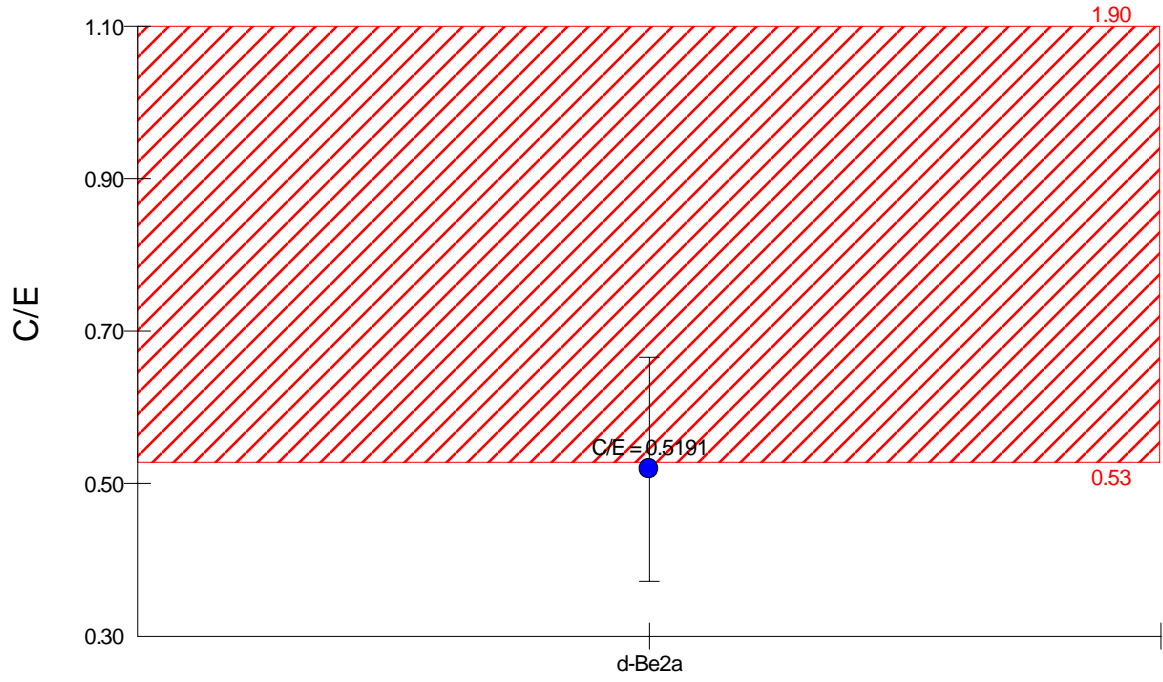




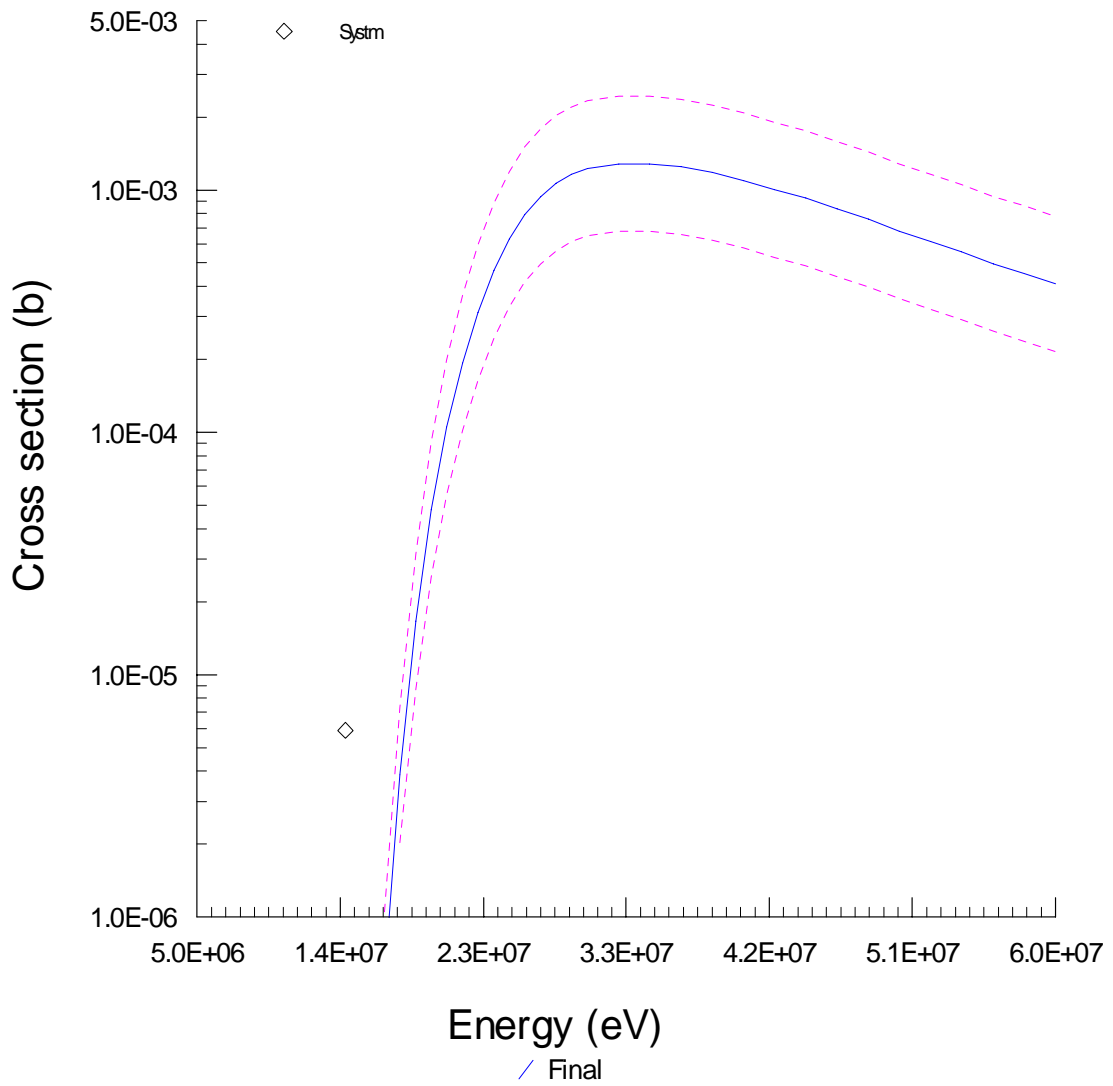
Neutron Spectrum

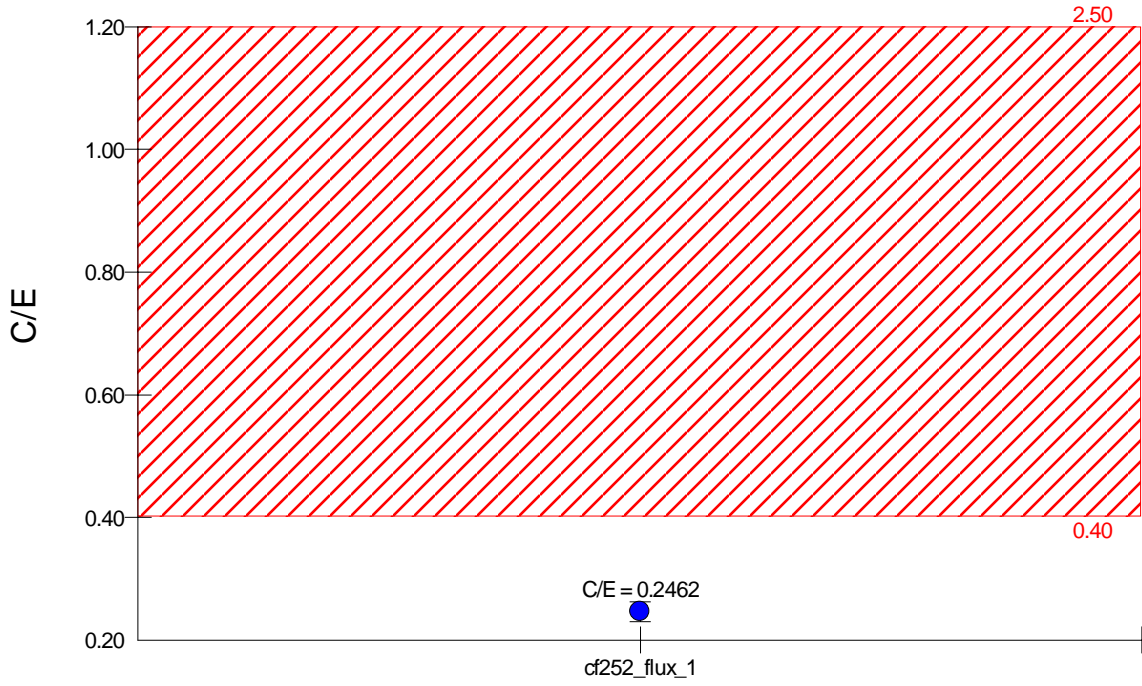
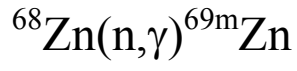


# $^{67}\text{Zn}(n,h)^{65}\text{Ni}$

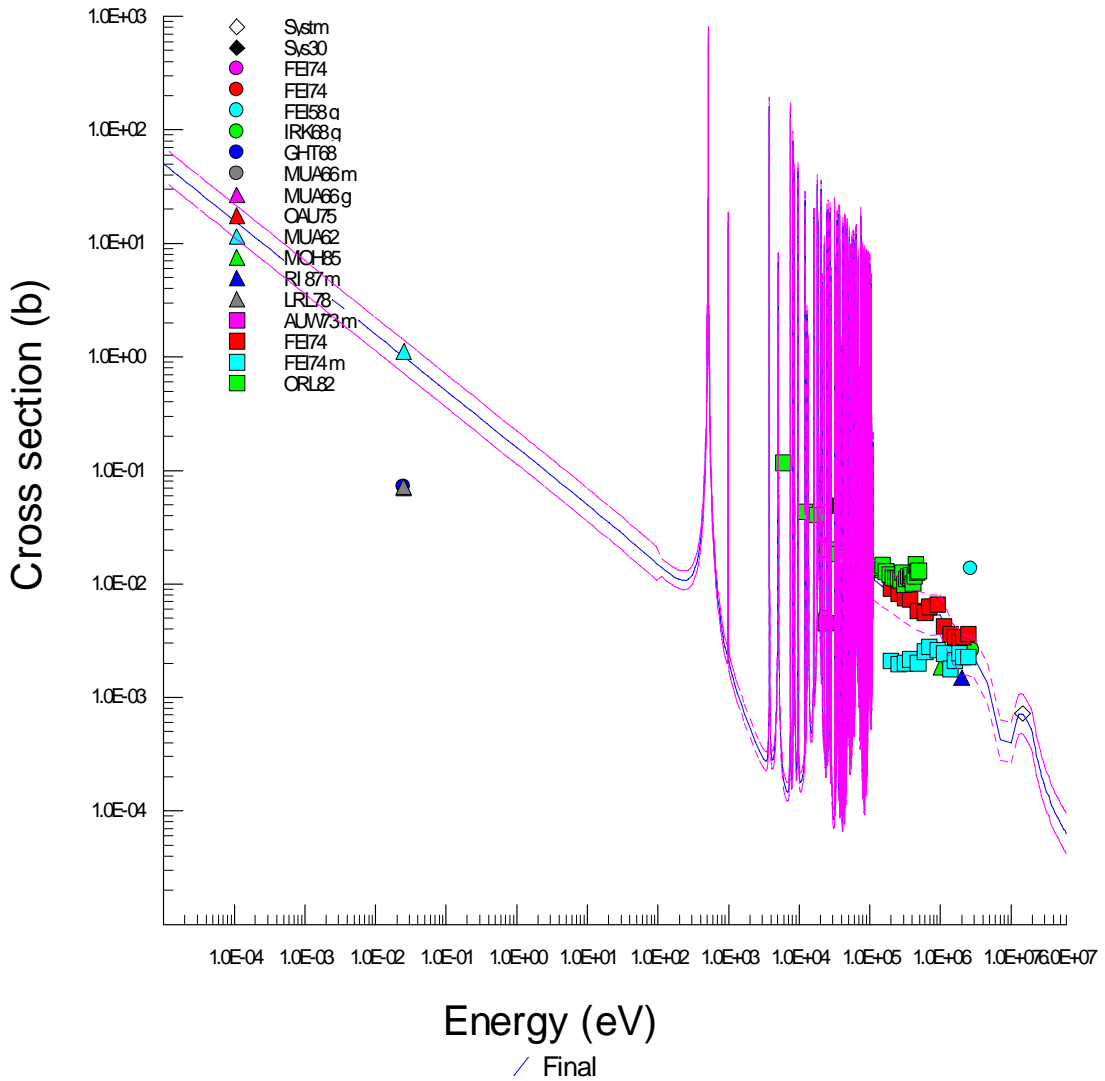


Neutron Spectrum

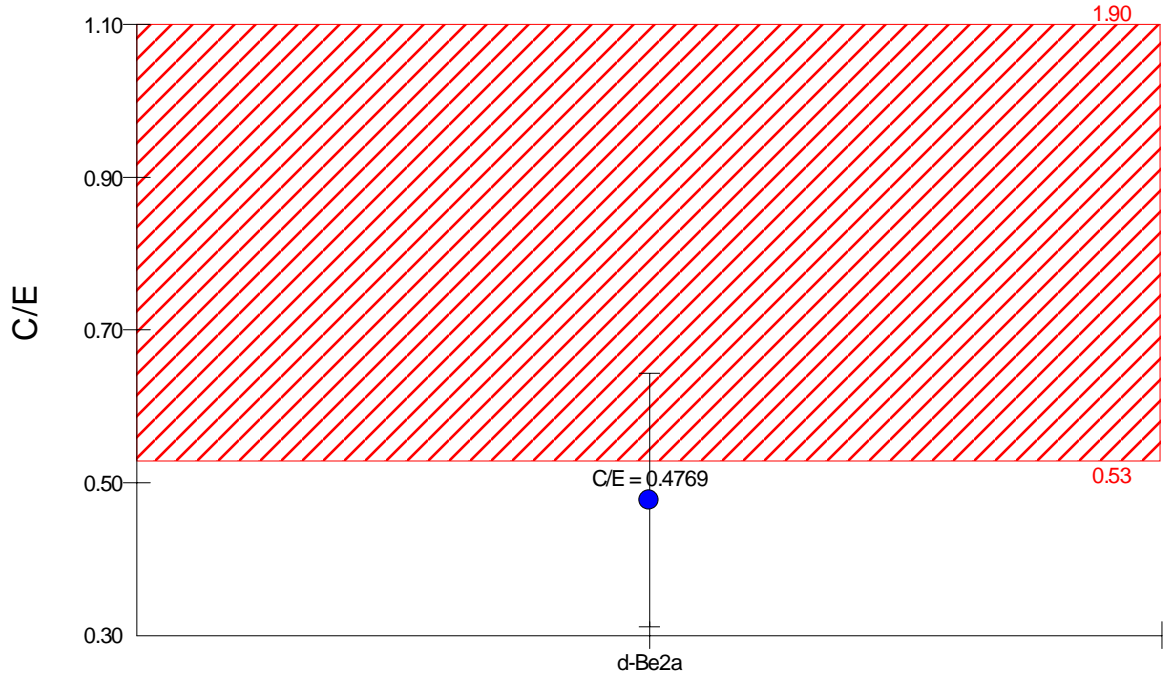




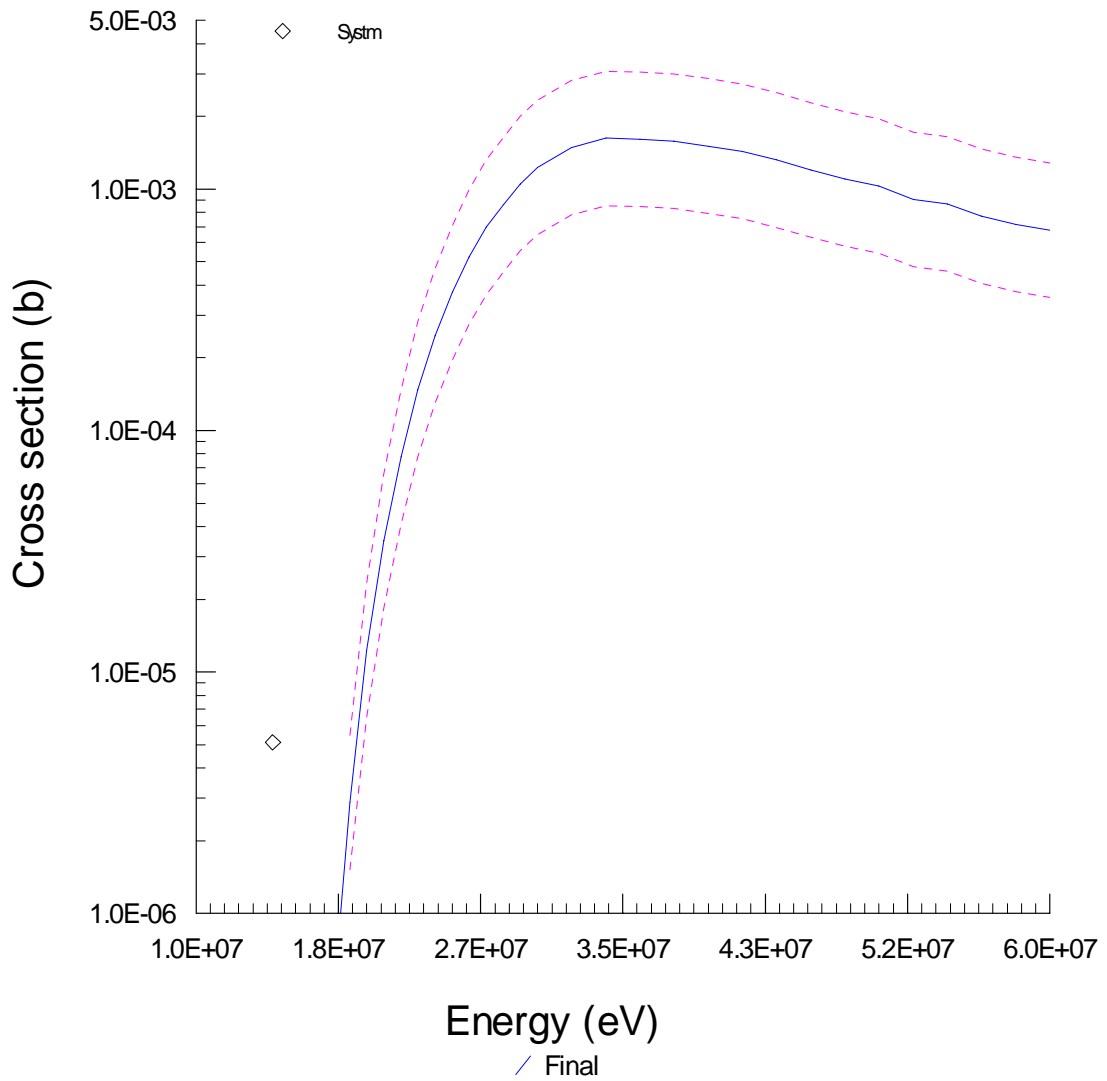
Neutron Spectrum

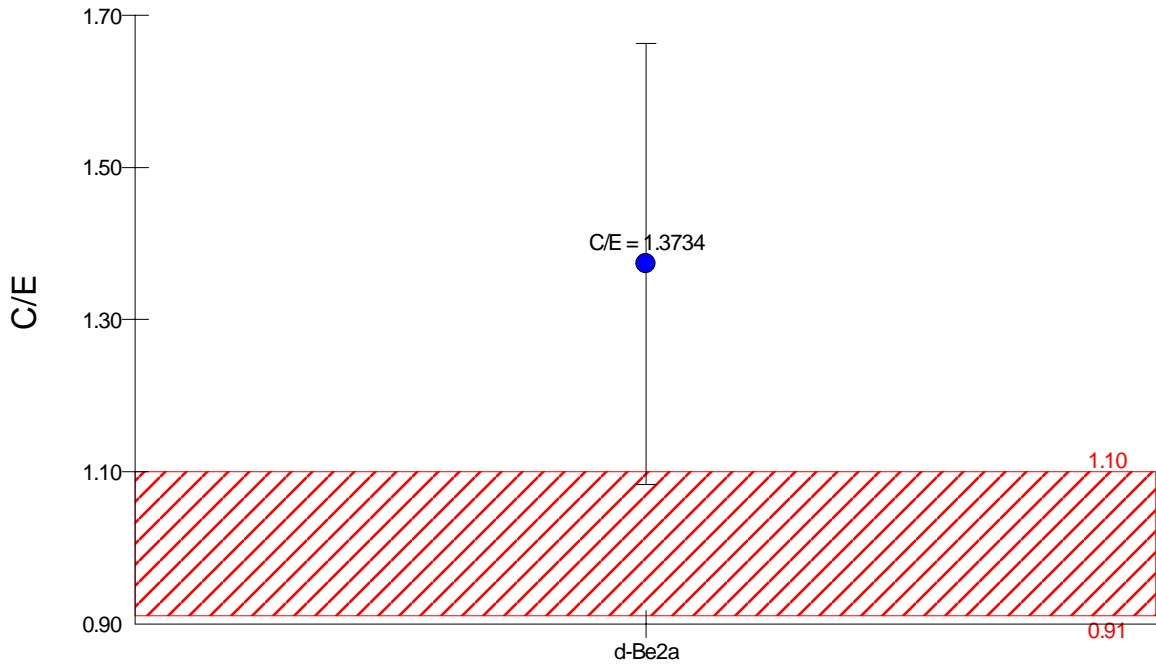
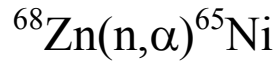


# $^{68}\text{Zn}(n,h)^{66}\text{Ni}$

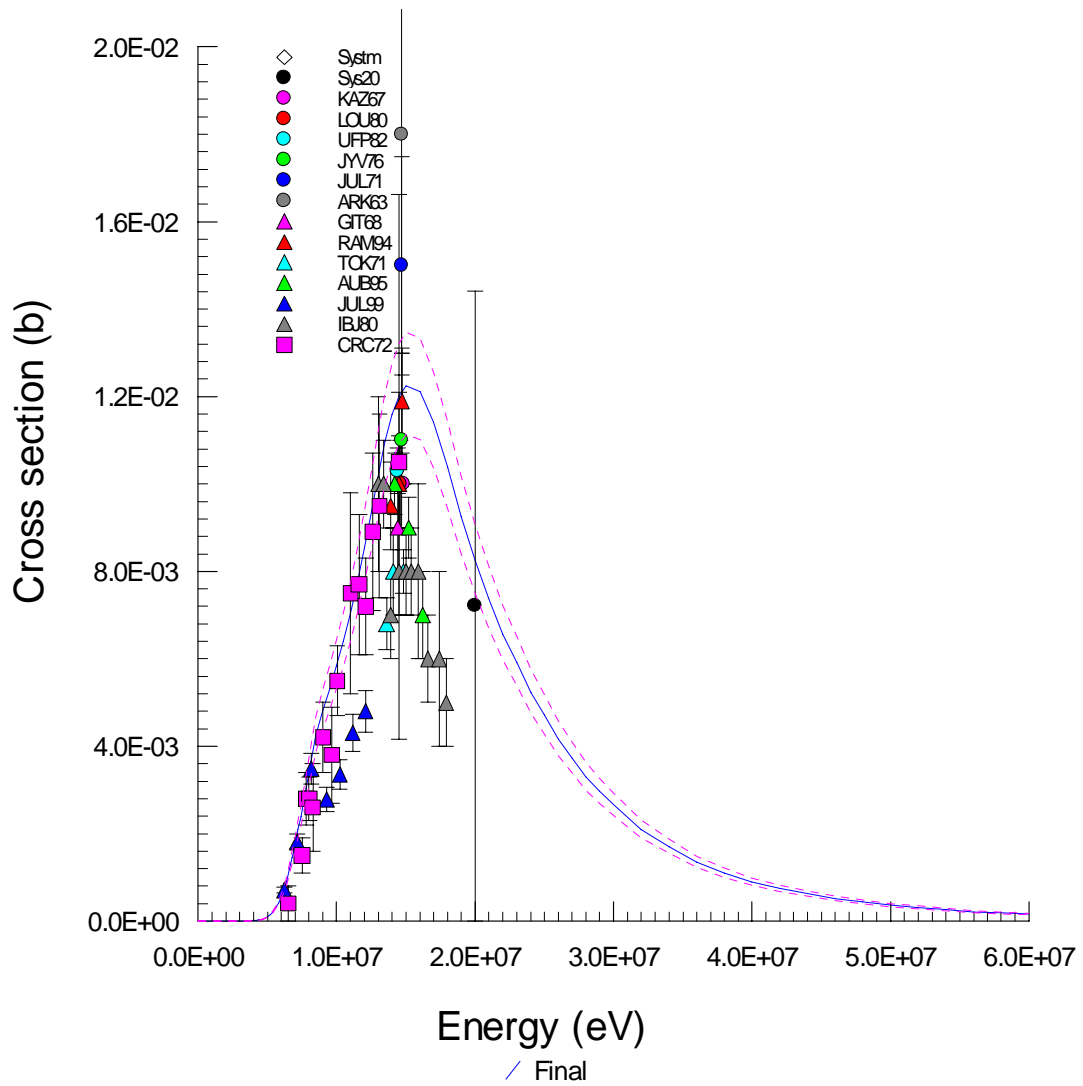


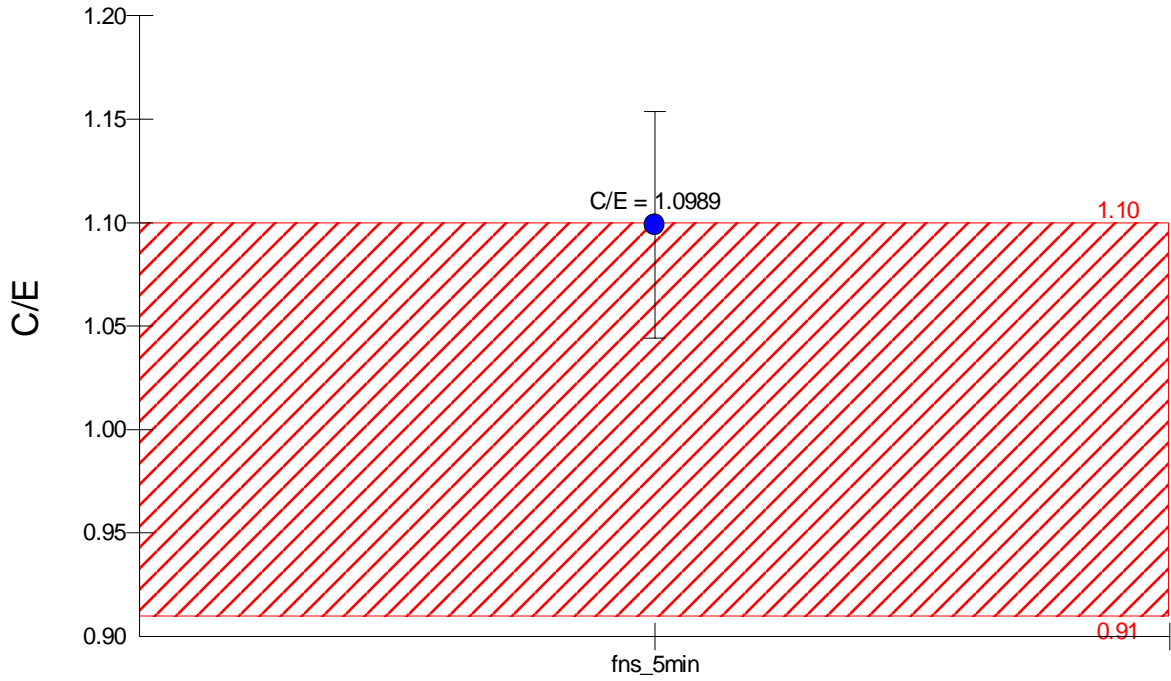
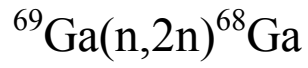
Neutron Spectrum



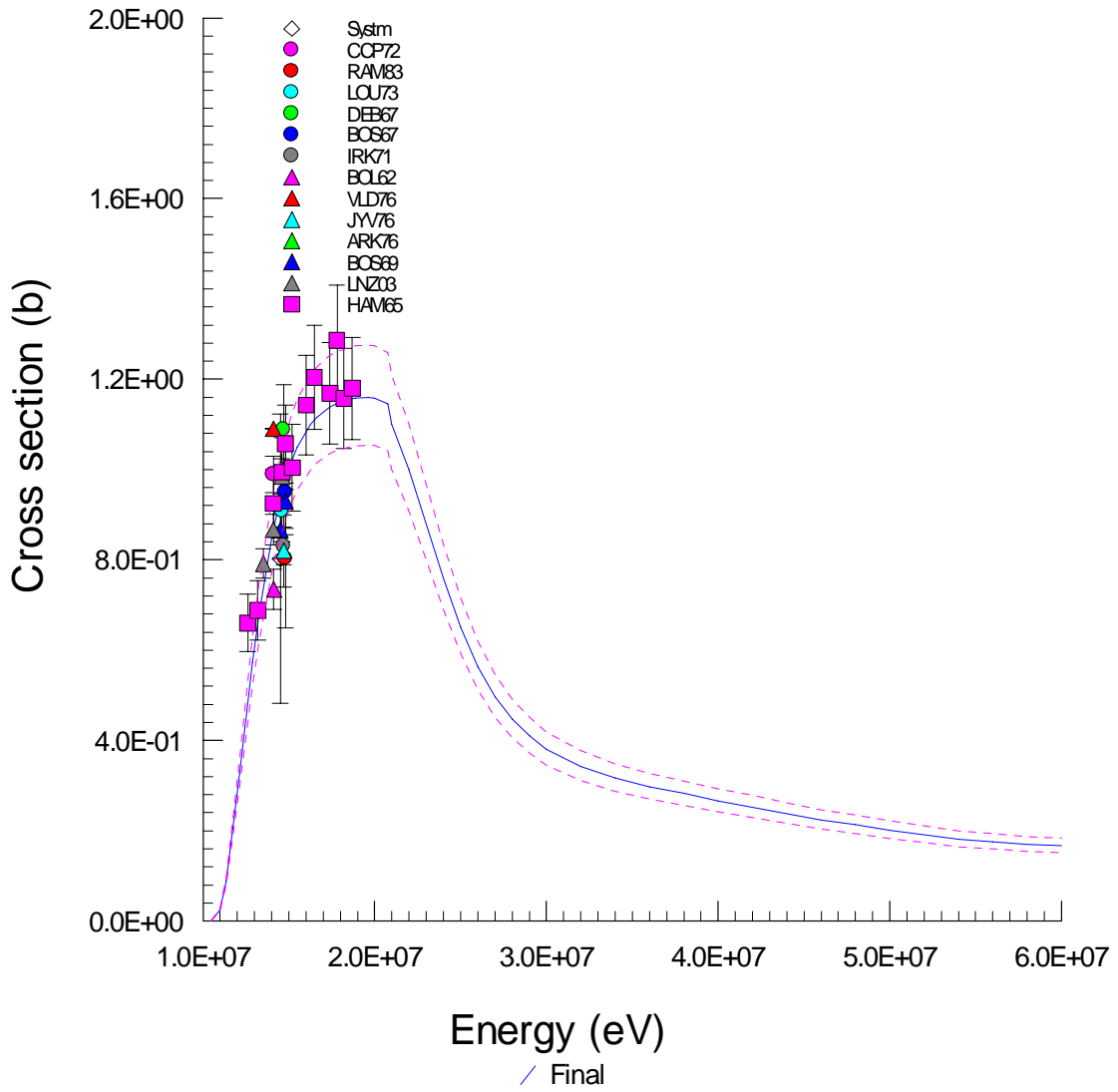


Neutron Spectrum

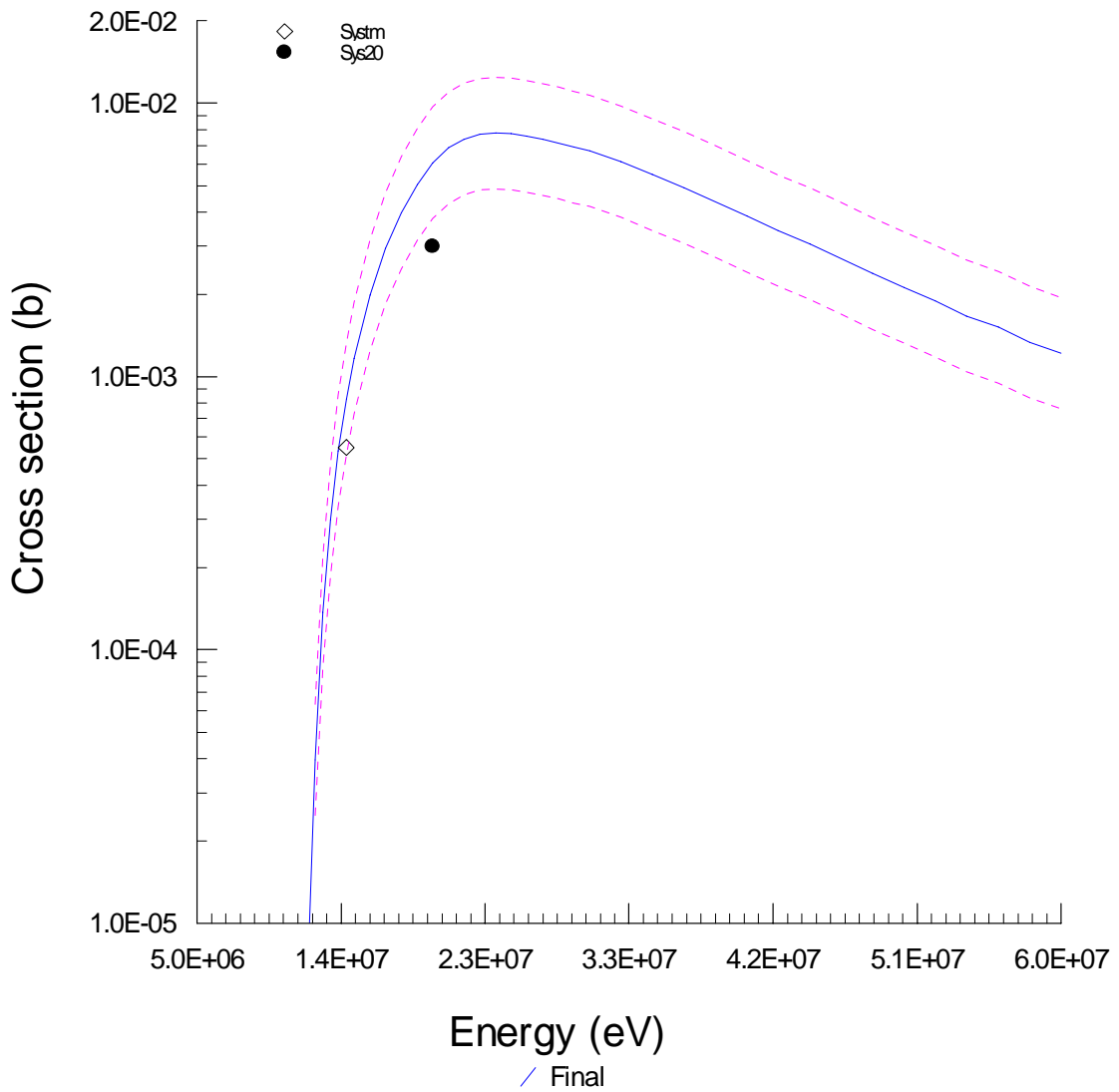
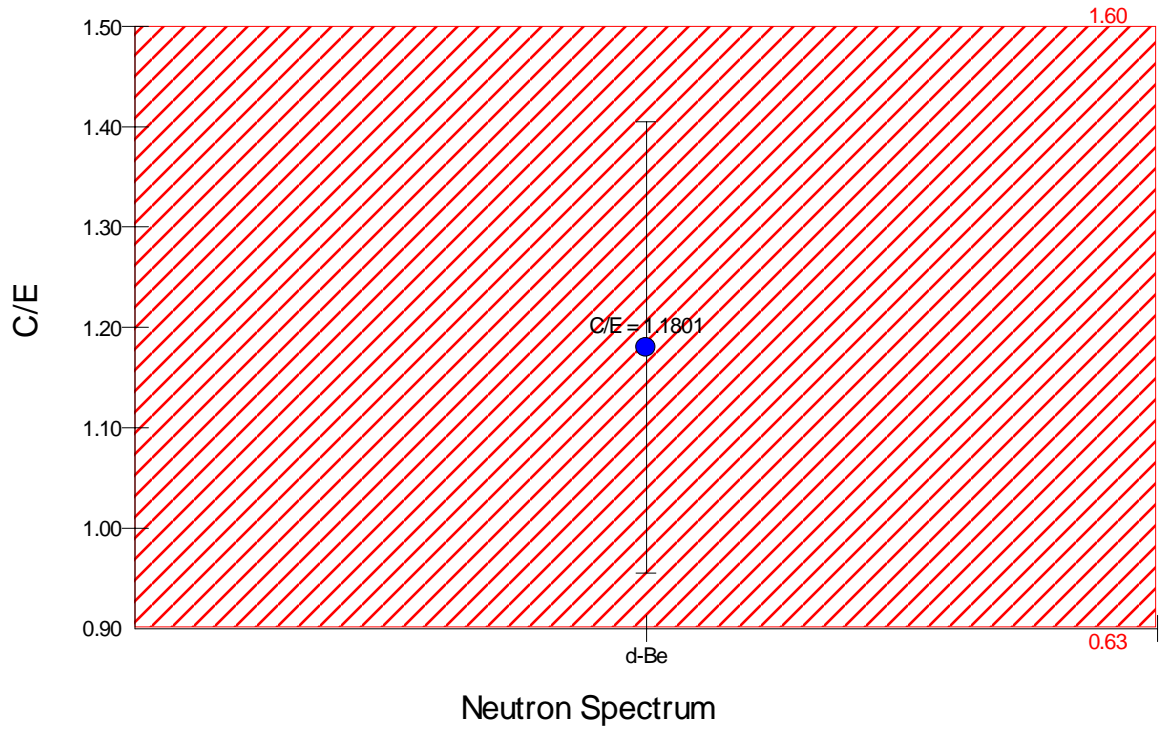


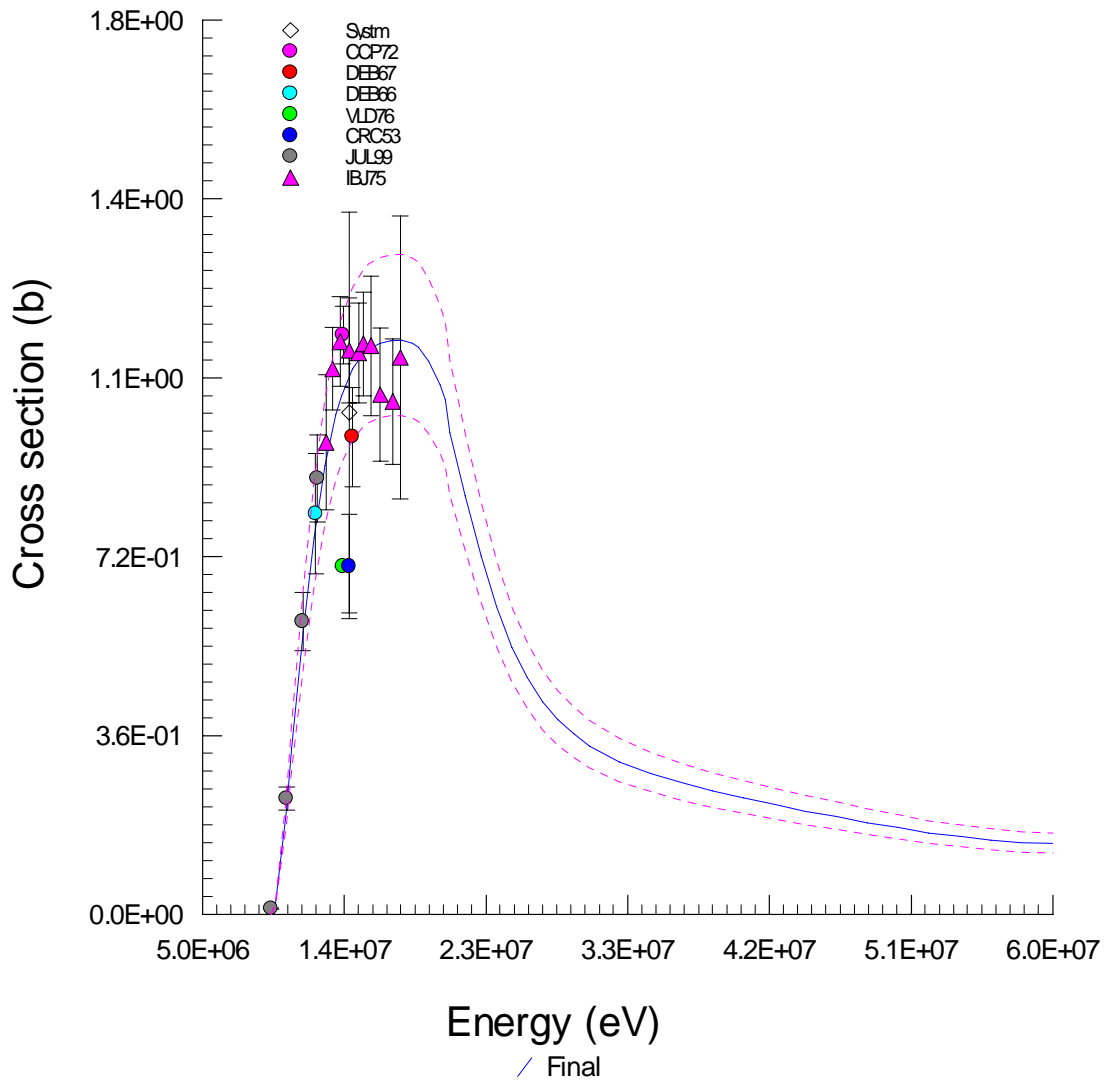
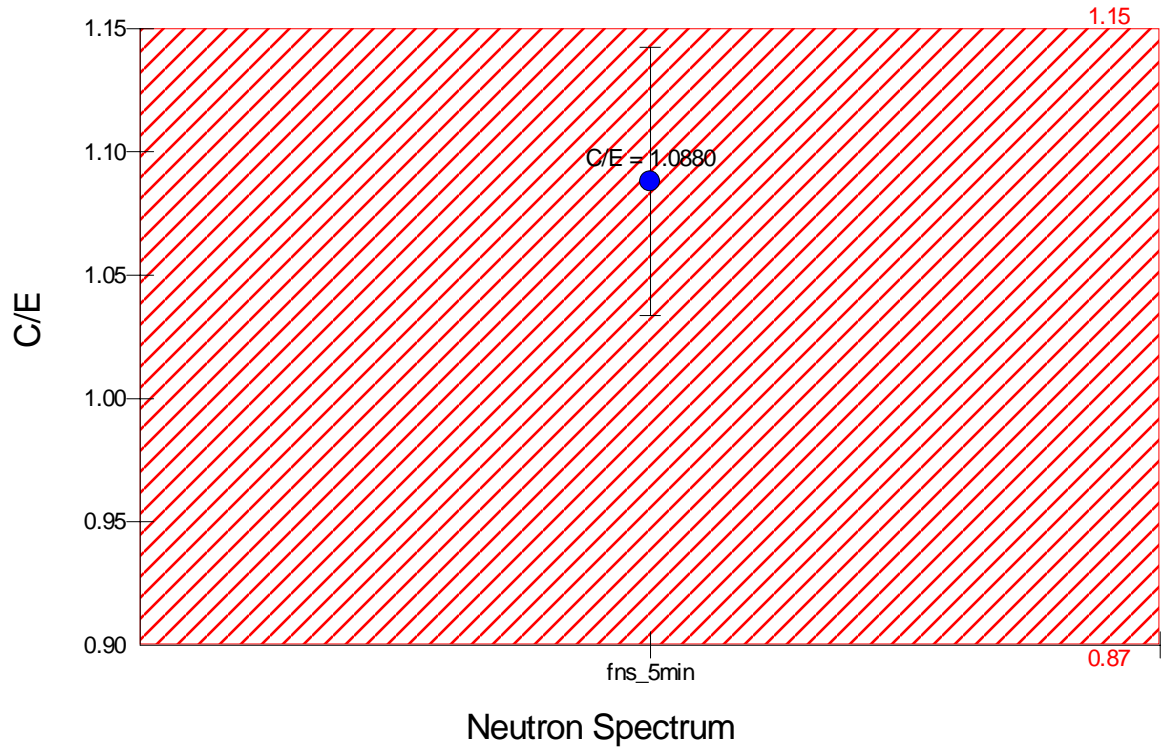
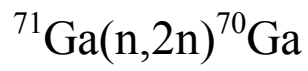


Neutron Spectrum

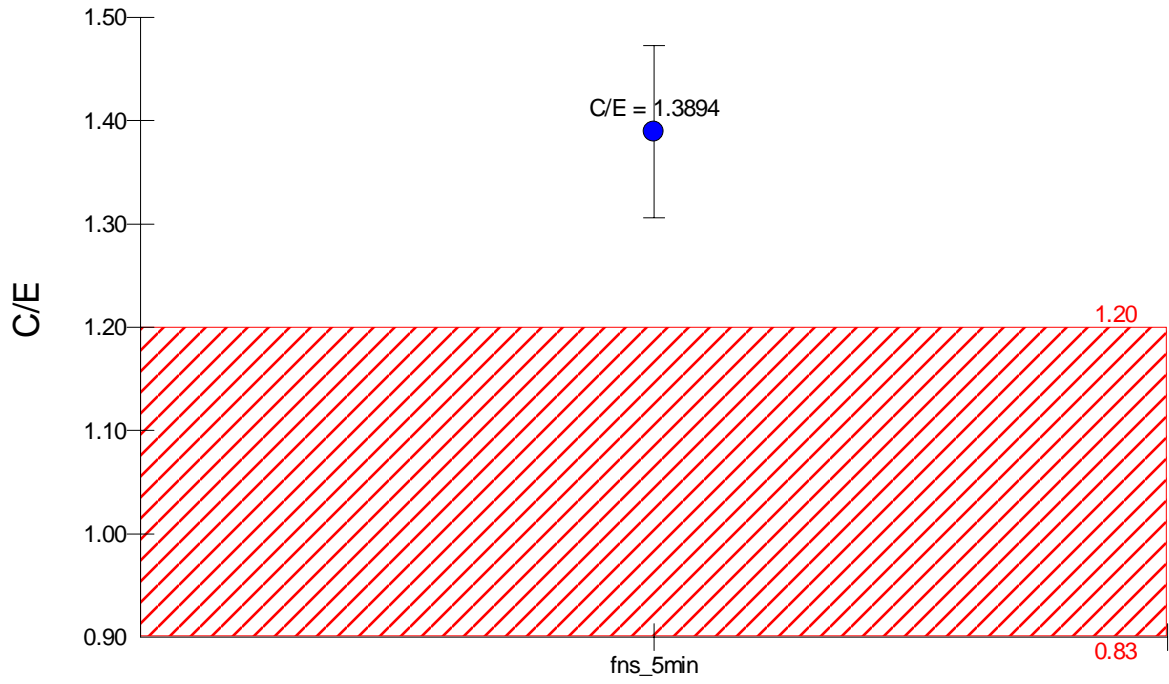
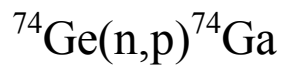


# $^{69}\text{Ga}(n,t)^{67}\text{Zn}$

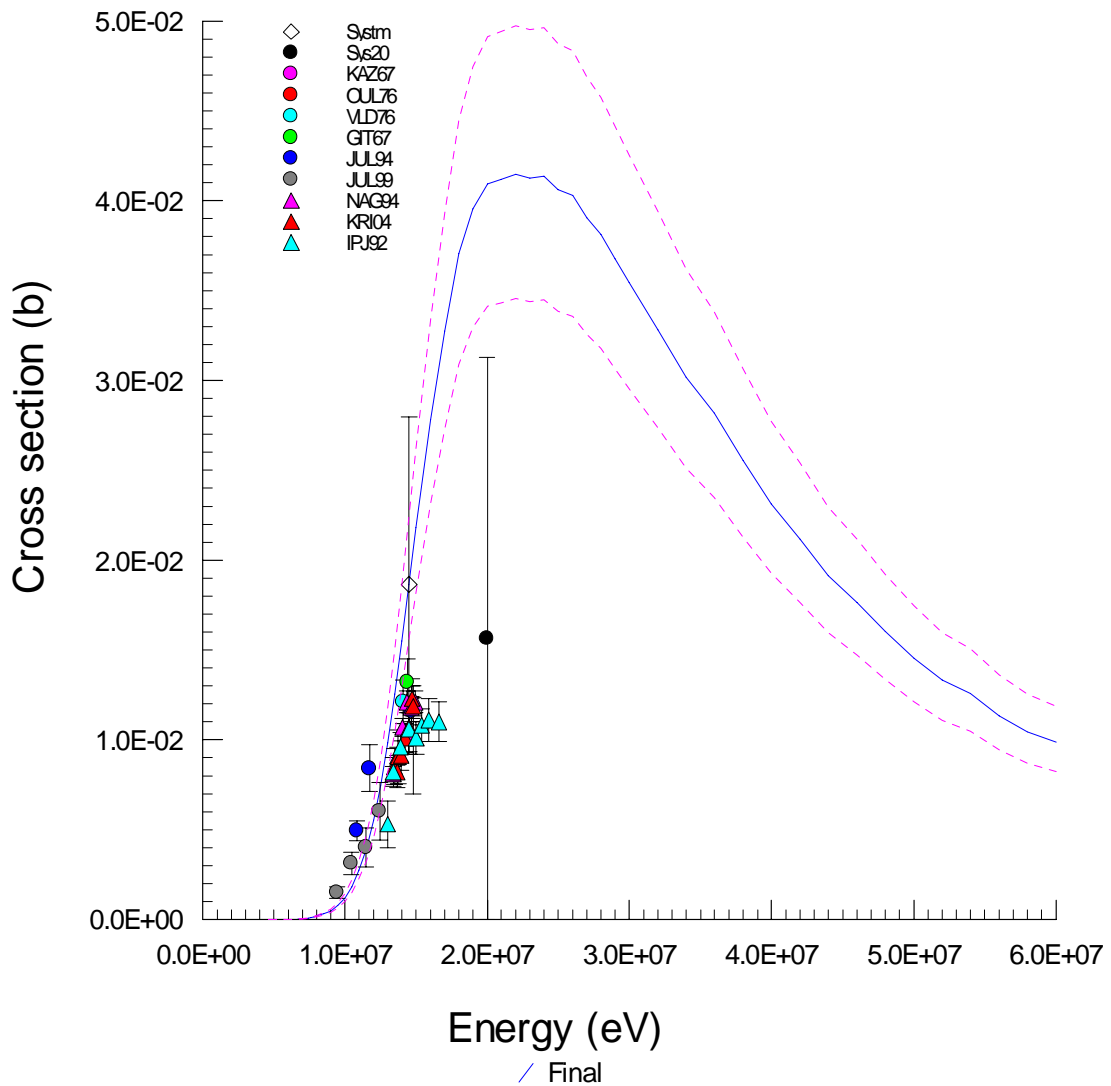


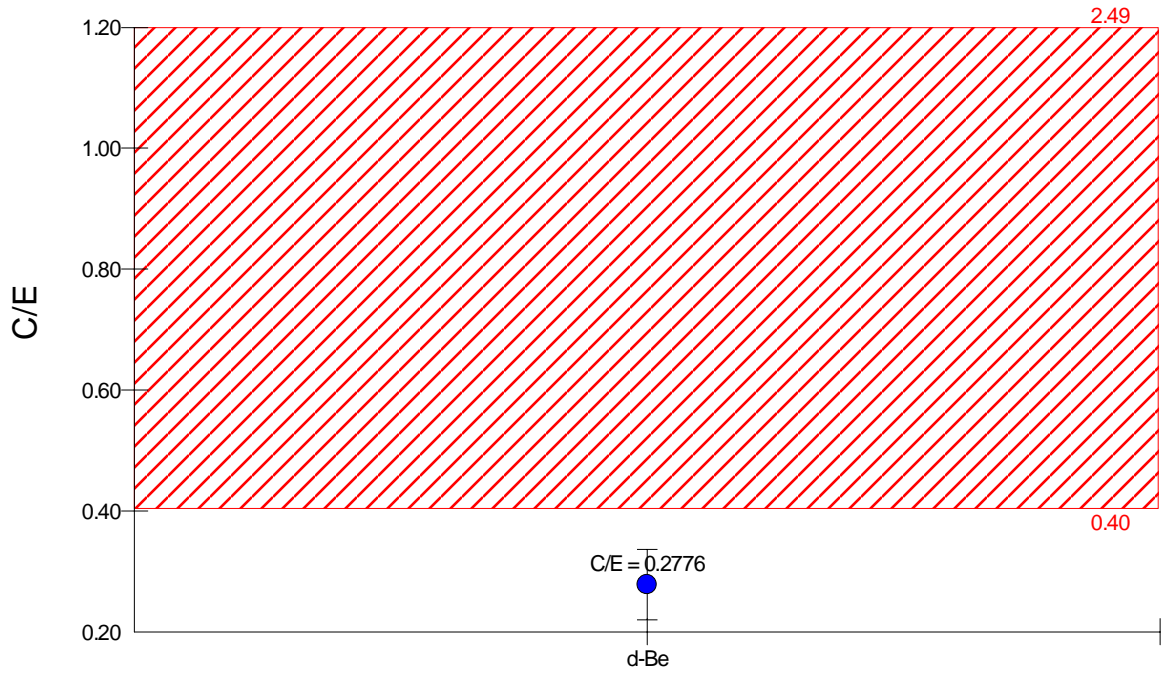
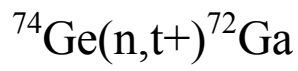




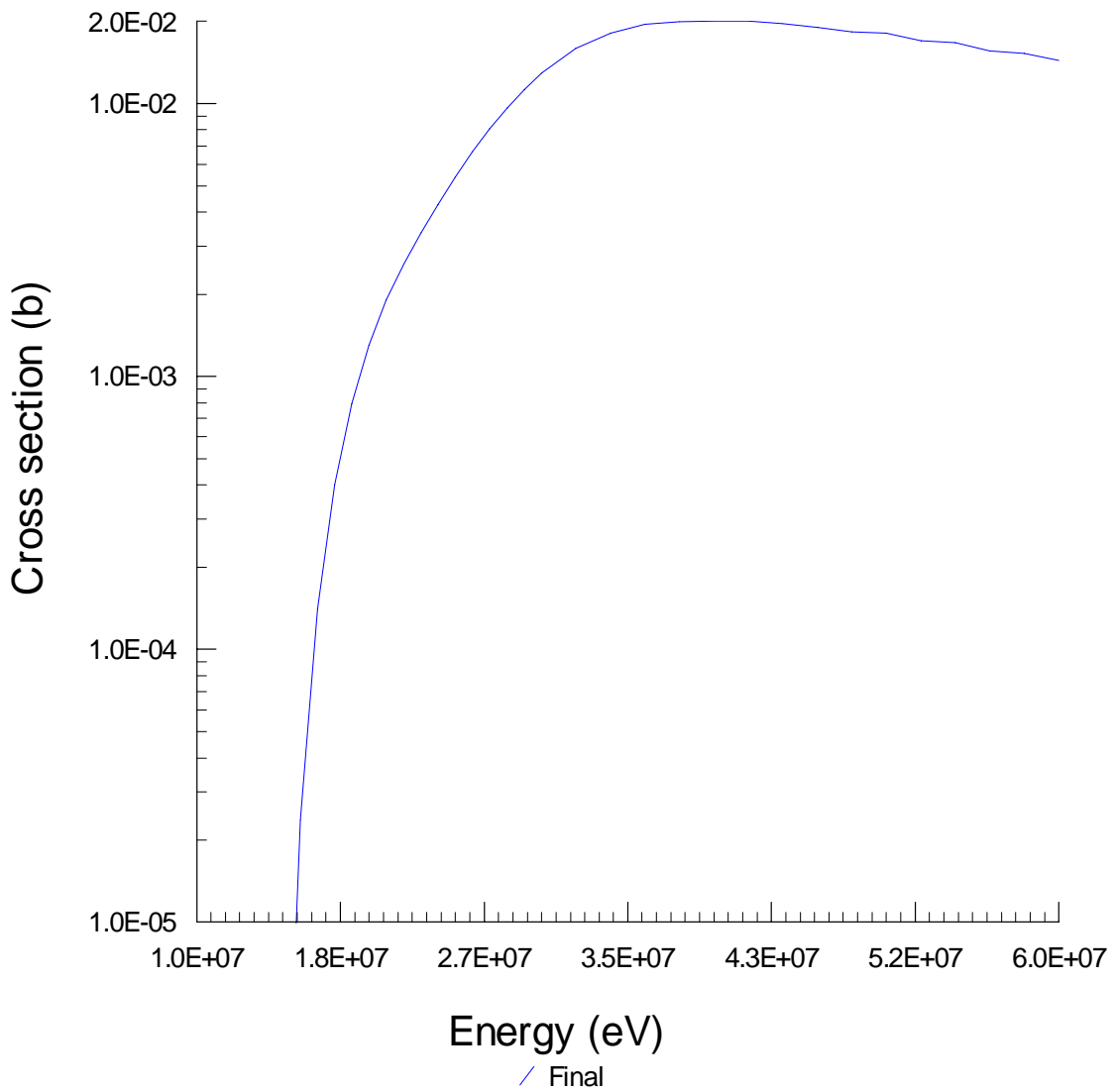


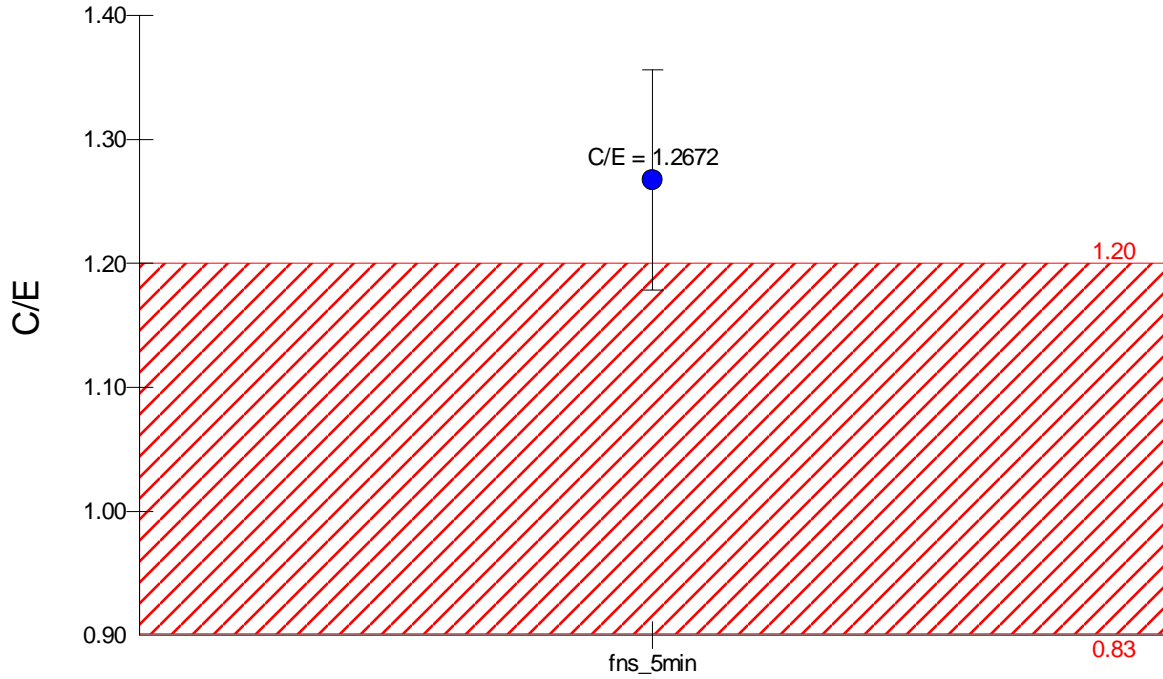
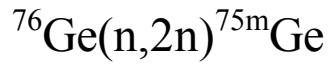
Neutron Spectrum



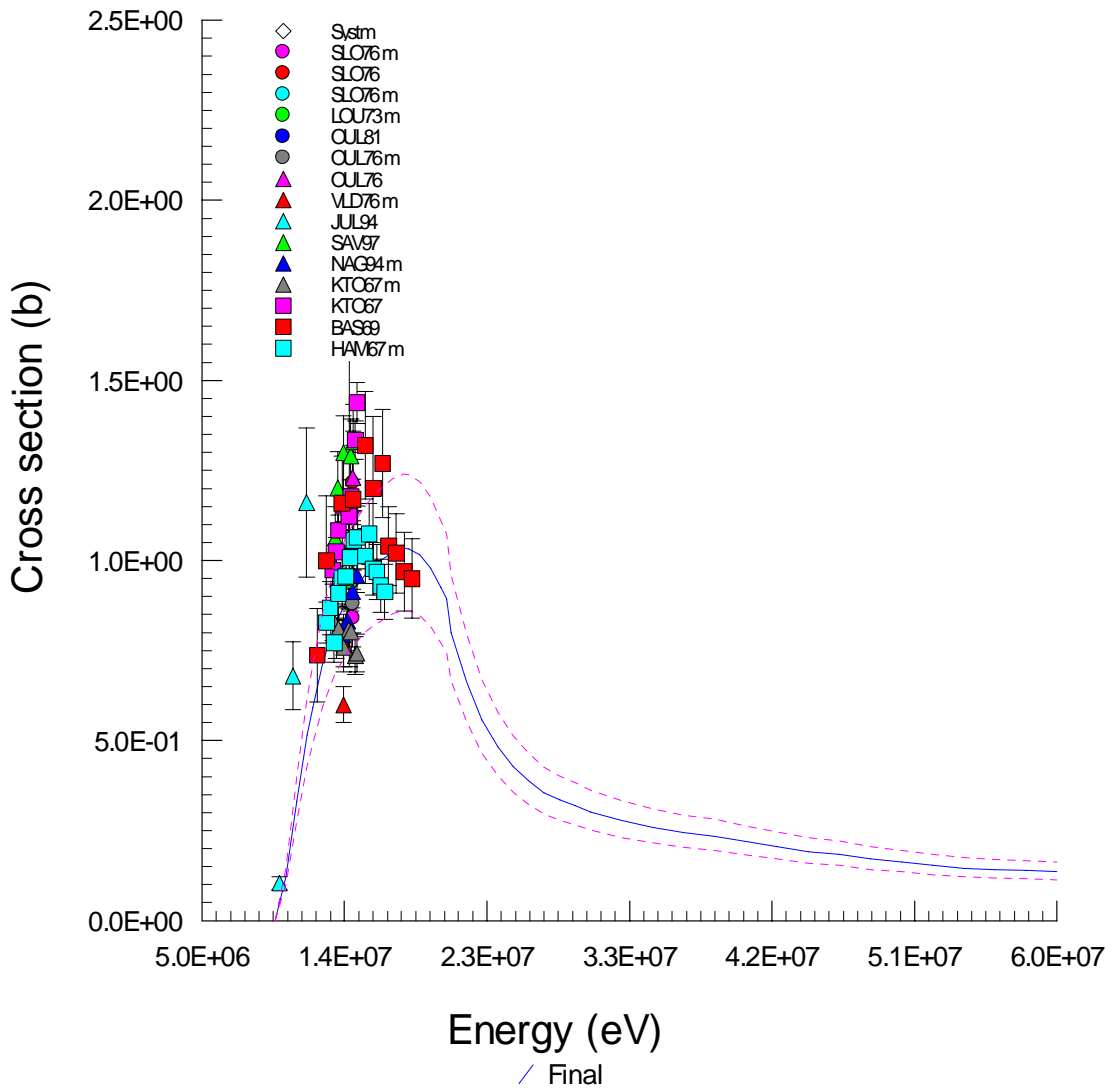


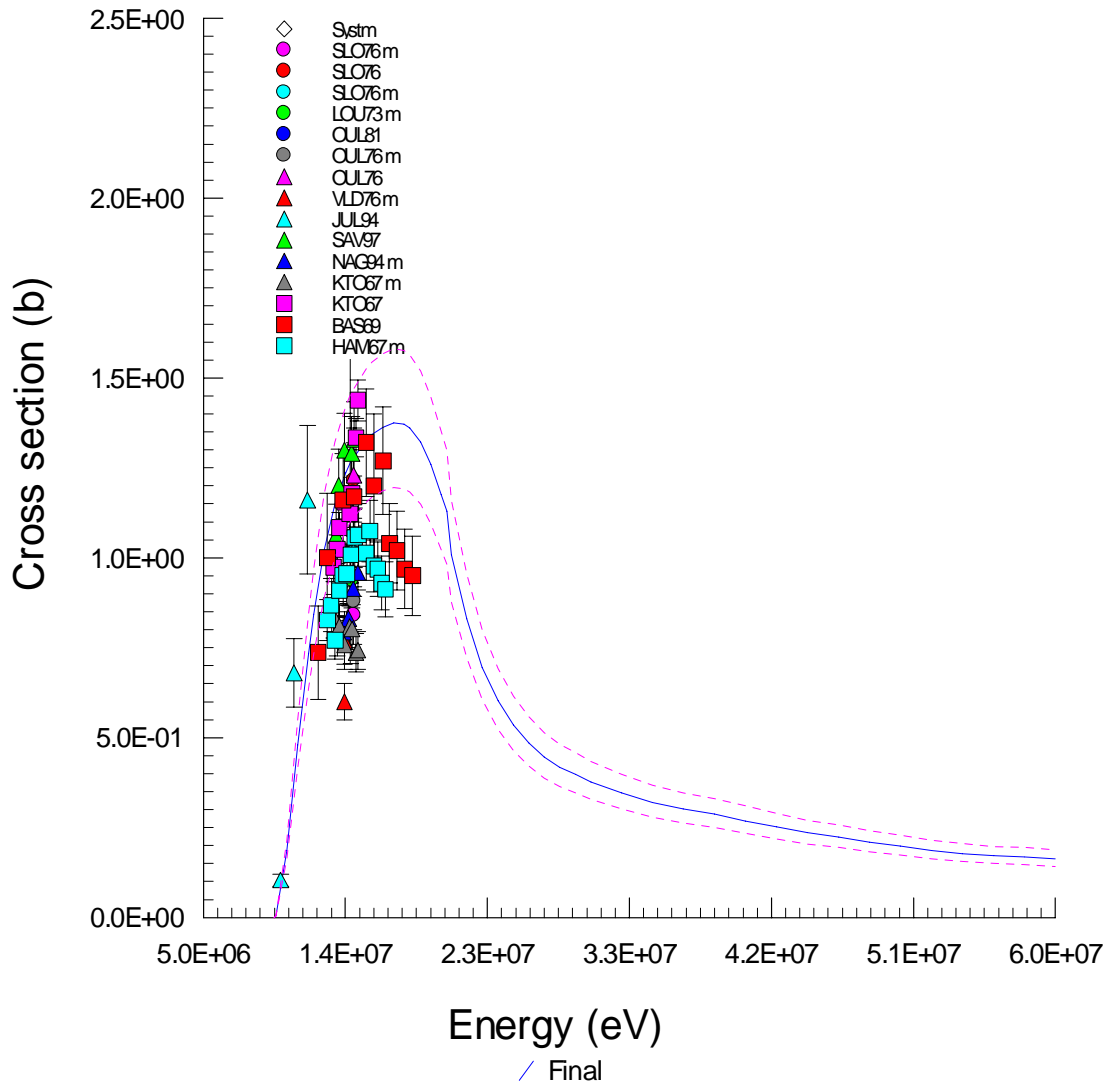
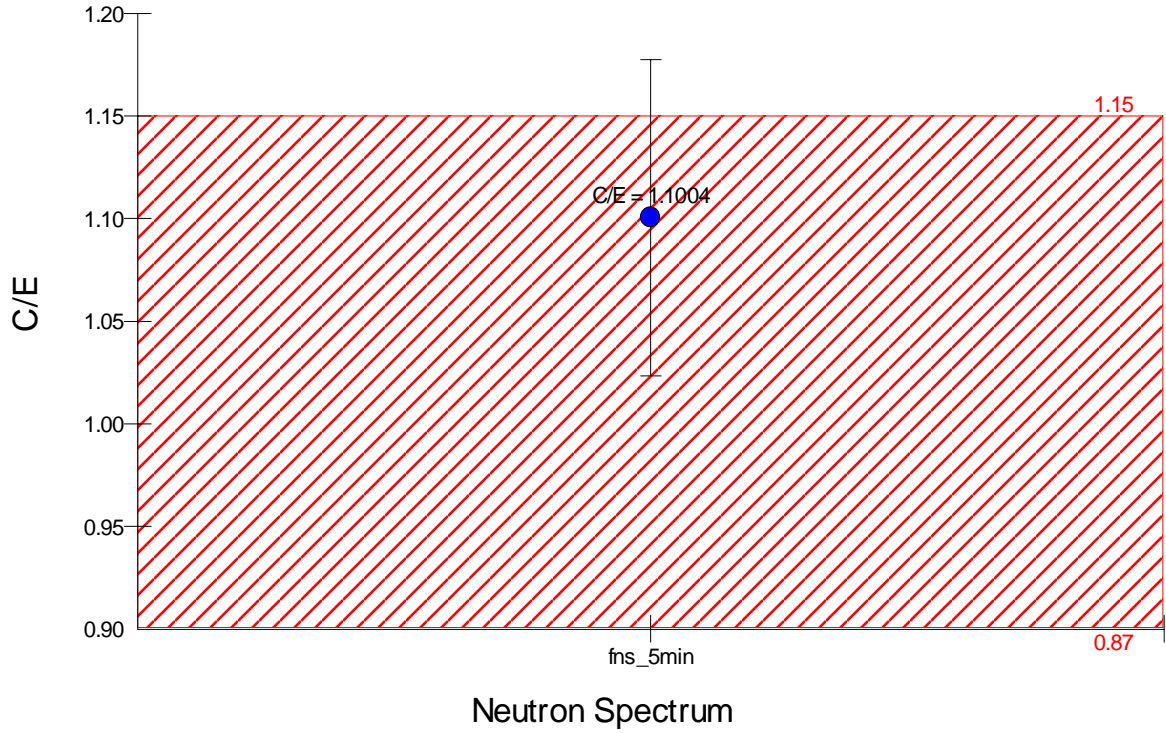
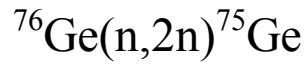
Neutron Spectrum



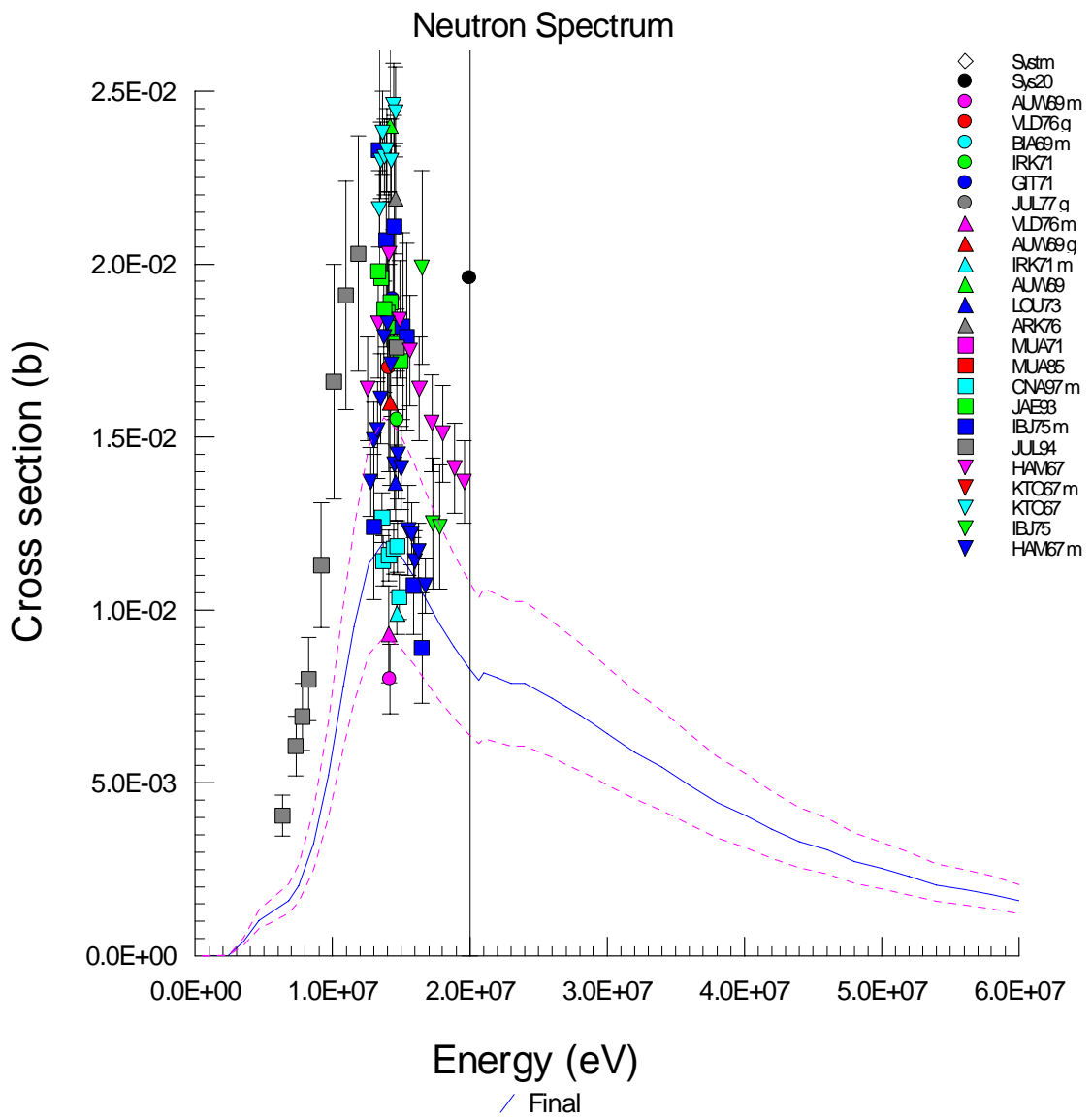
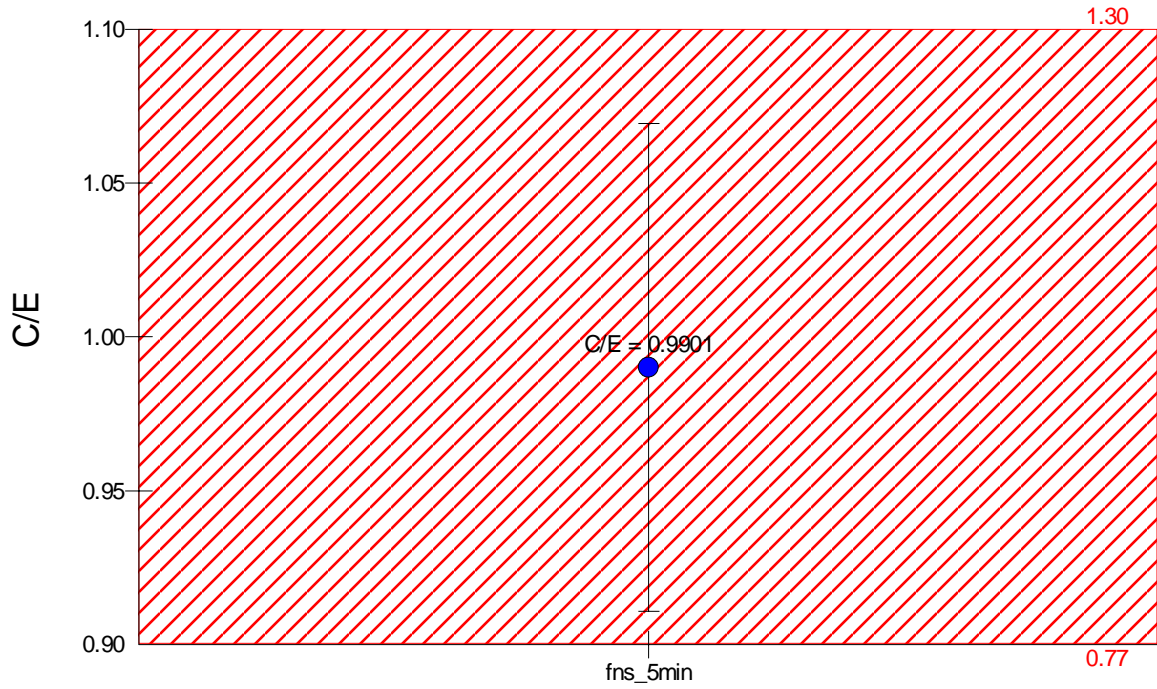


Neutron Spectrum

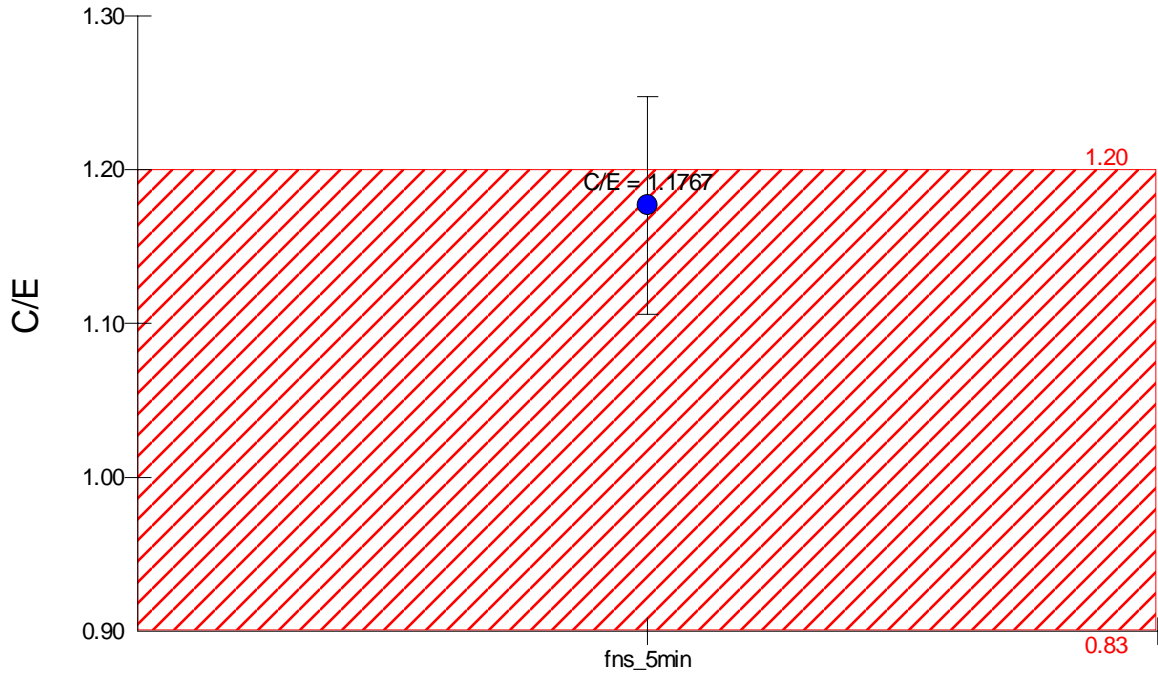




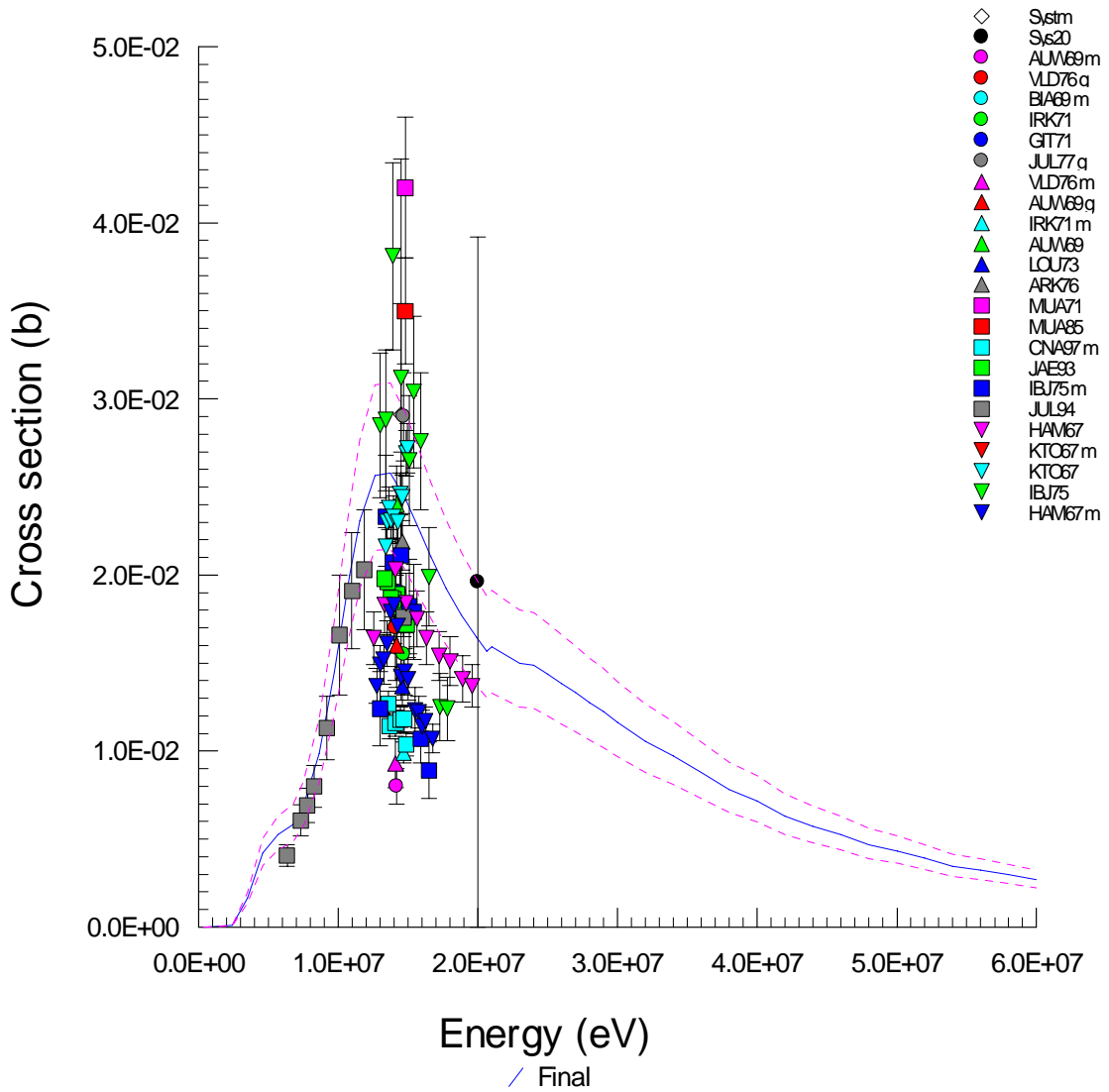
$^{75}\text{As}(n,p)^{75m}\text{Ge}$



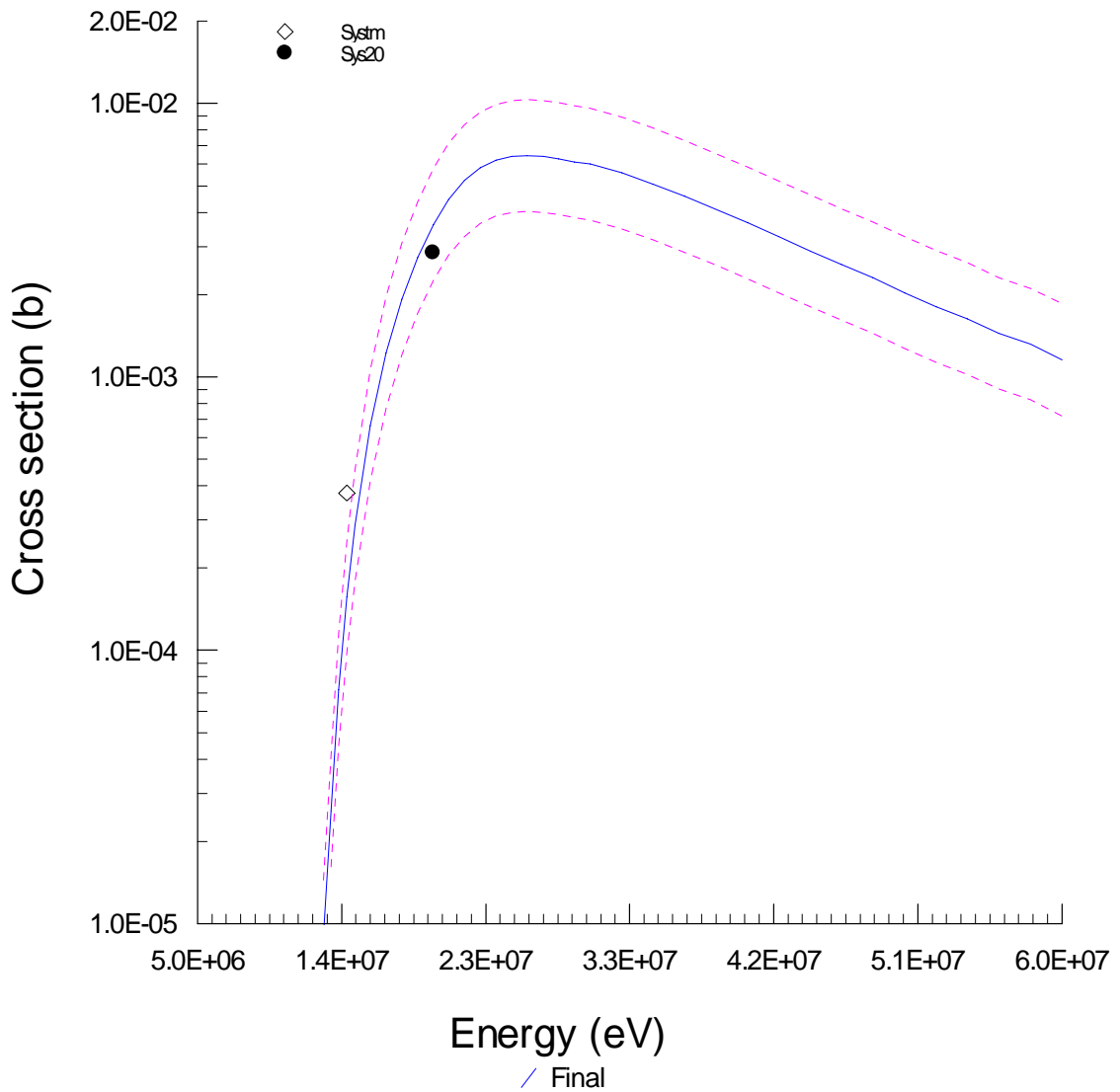
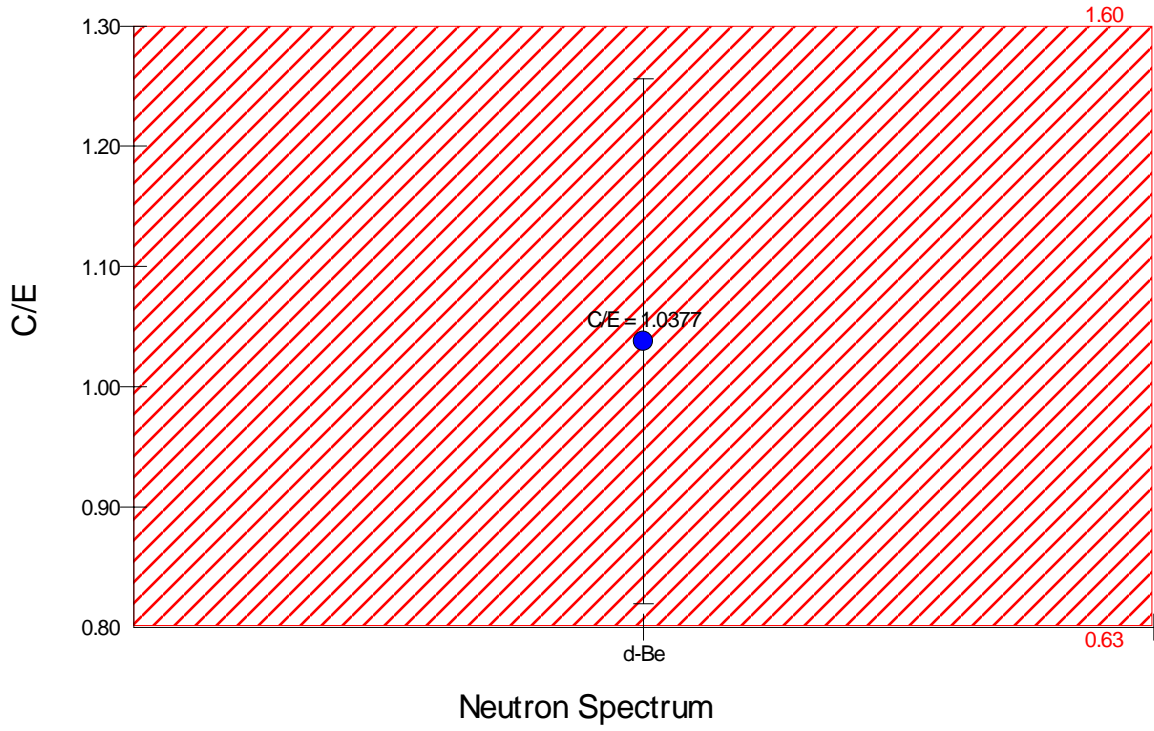
$^{75}\text{As}(n,p)^{75}\text{Ge}$



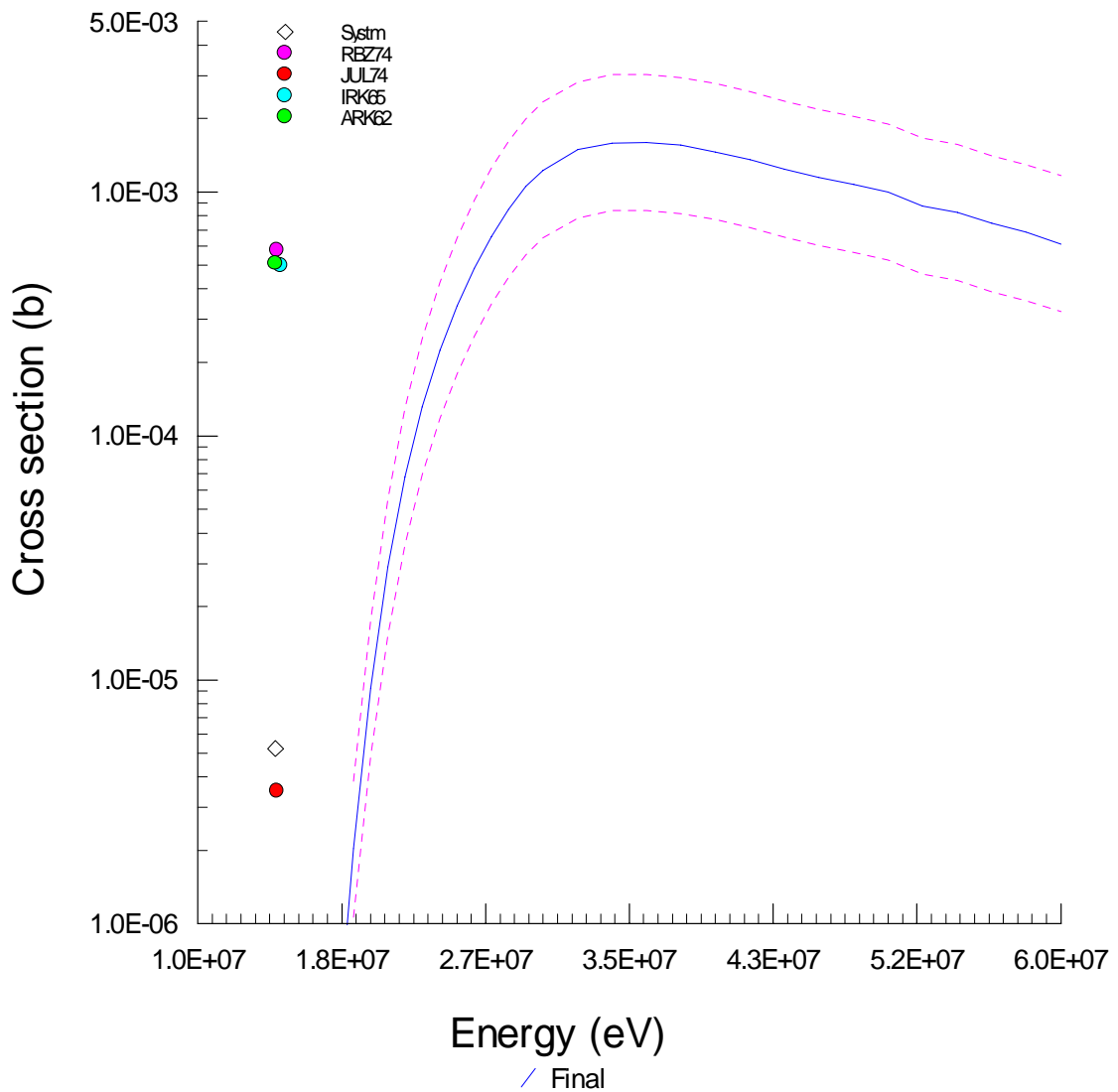
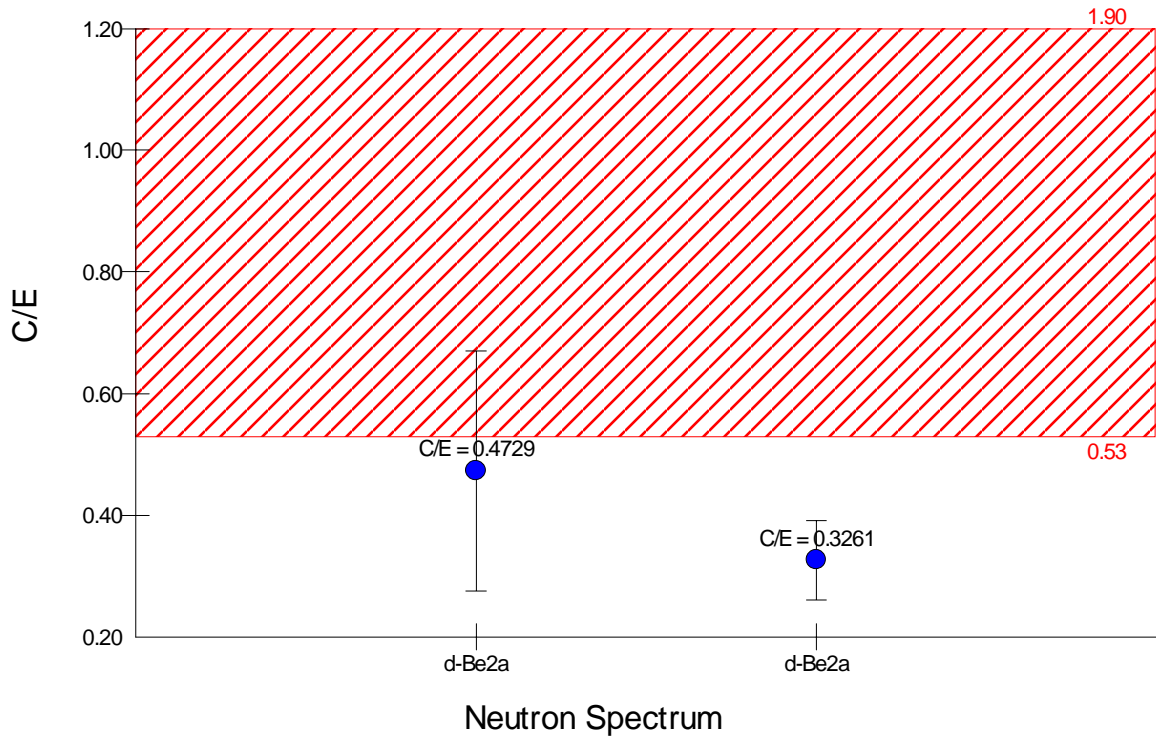
Neutron Spectrum



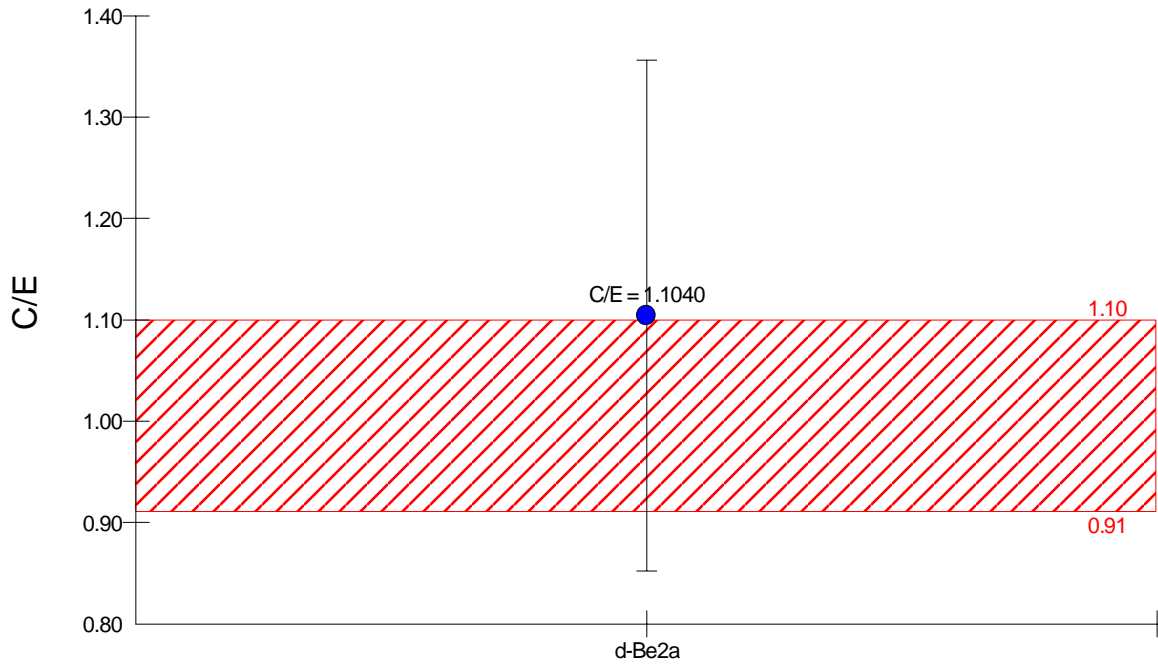
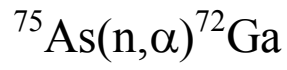
# $^{75}\text{As}(n,t)^{73}\text{Ge}$



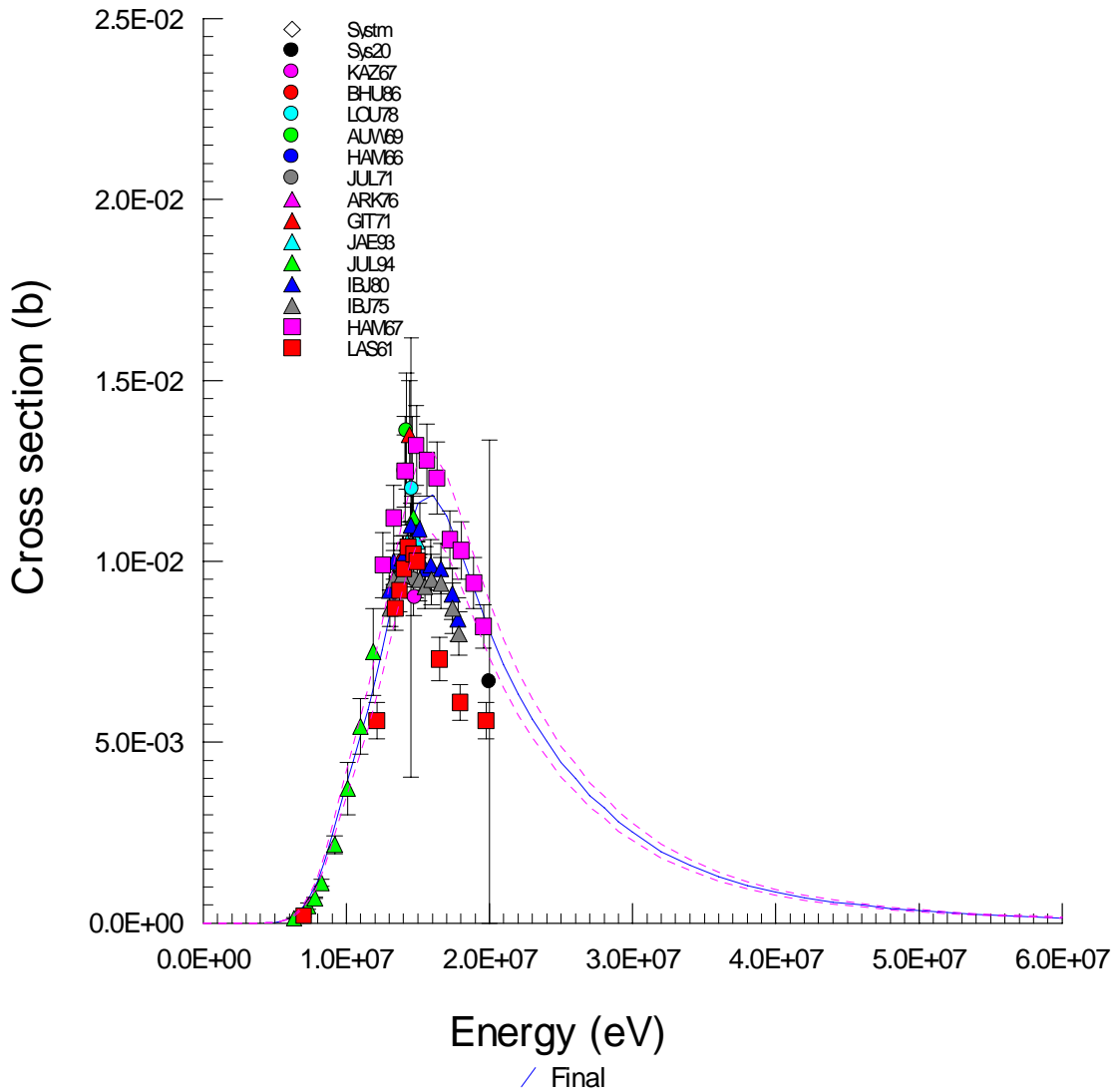
$^{75}\text{As}(n,h)^{73}\text{Ga}$

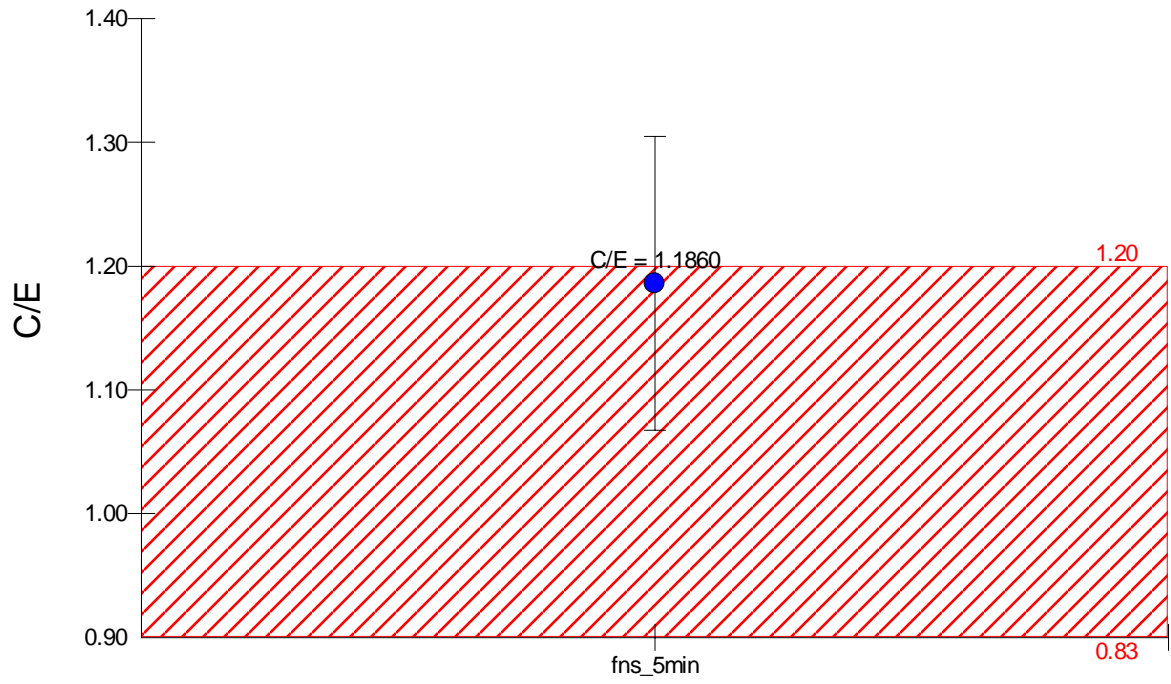
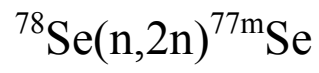




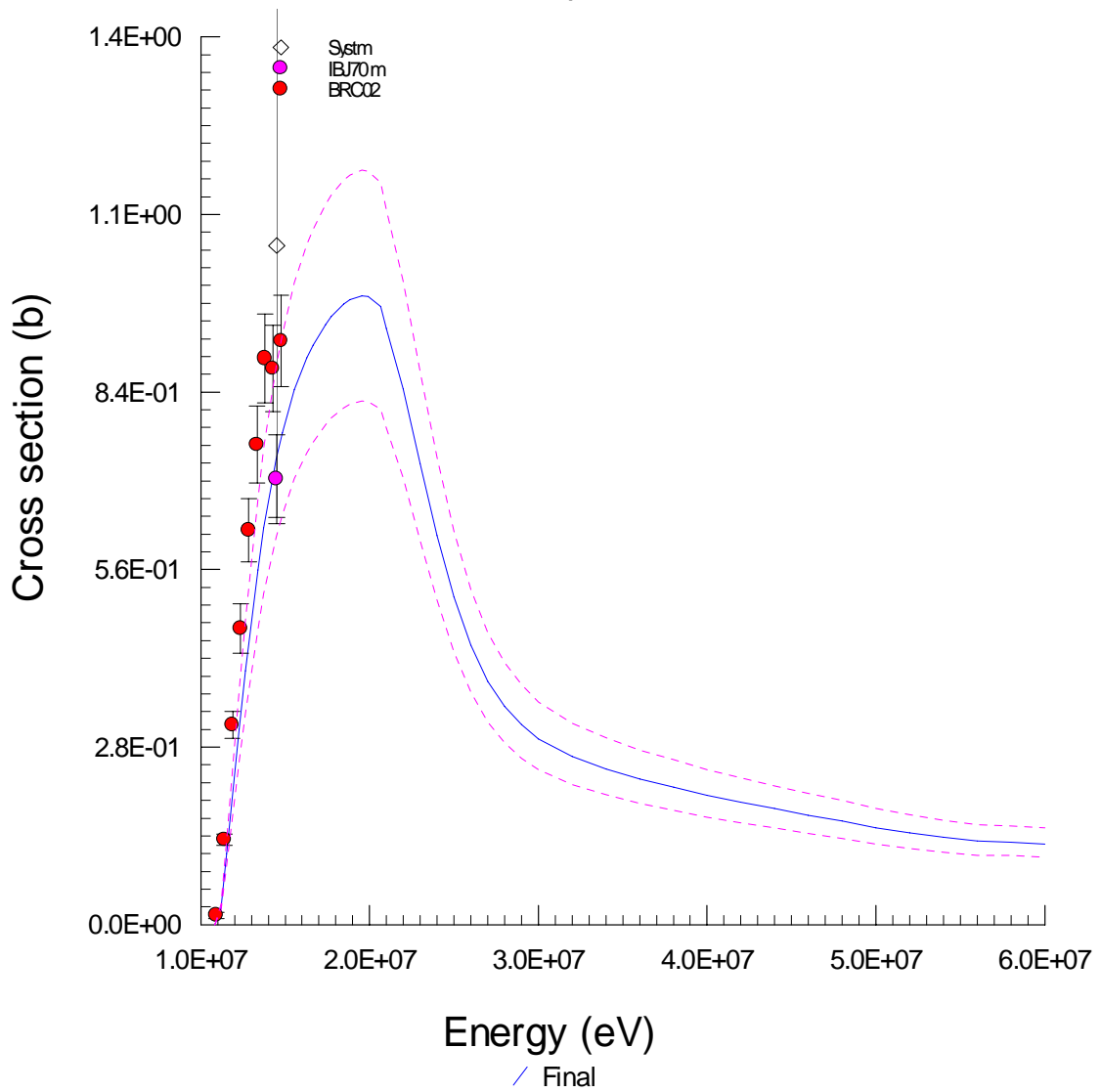


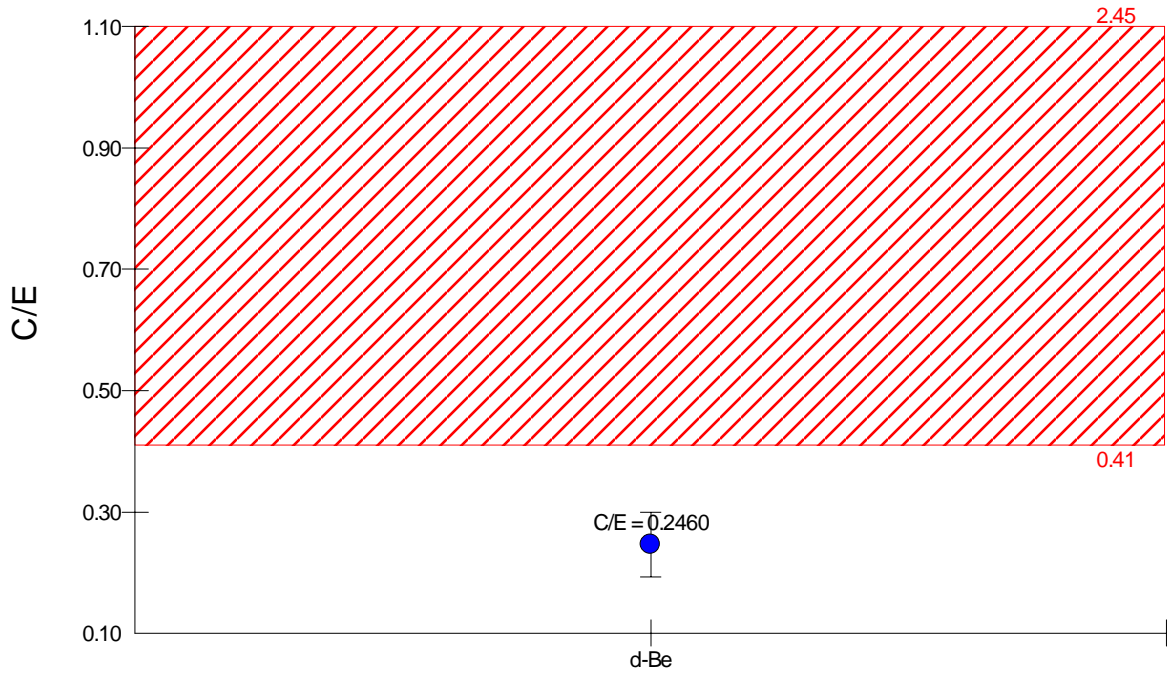
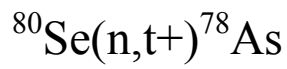
Neutron Spectrum



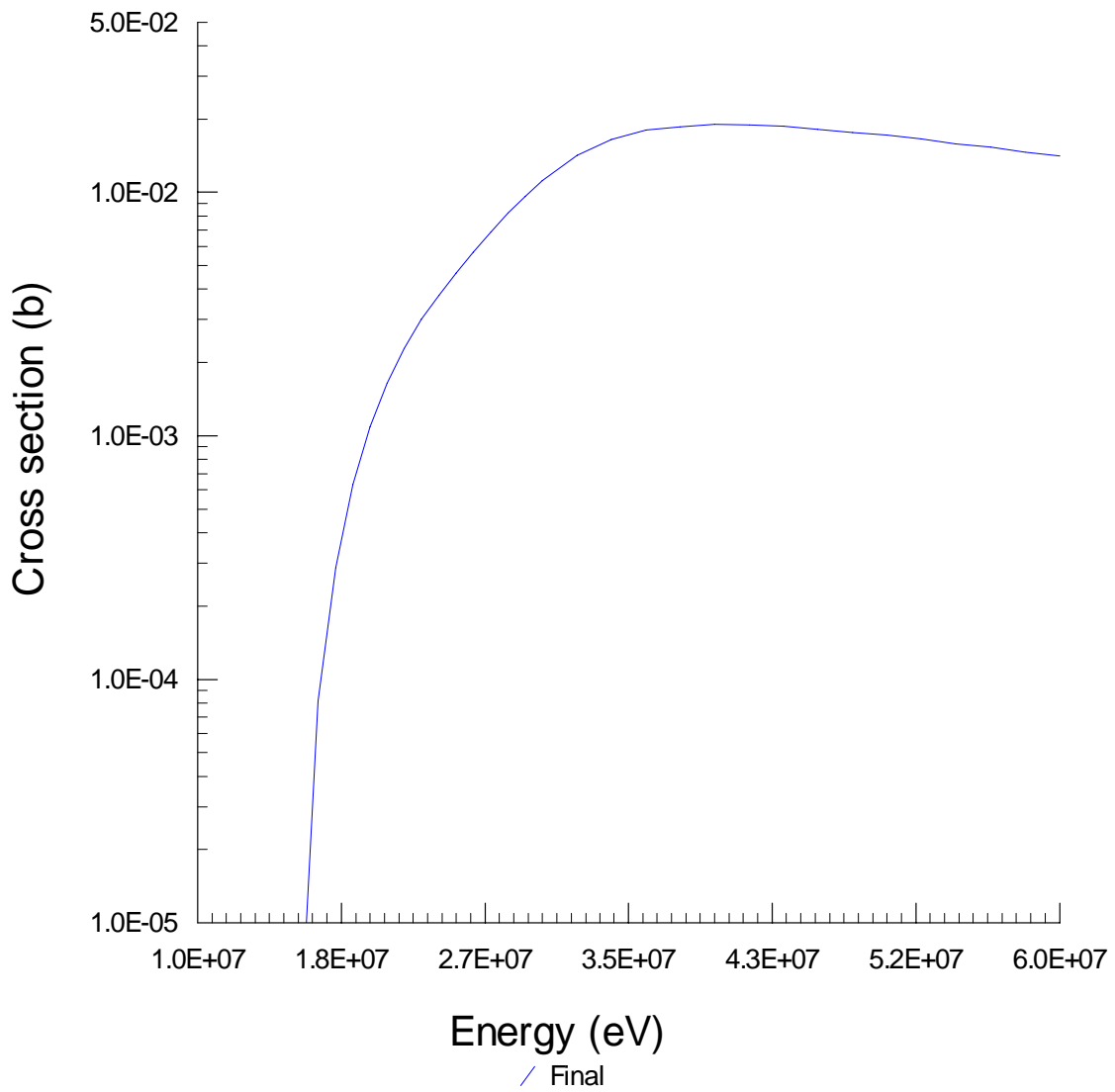


Neutron Spectrum

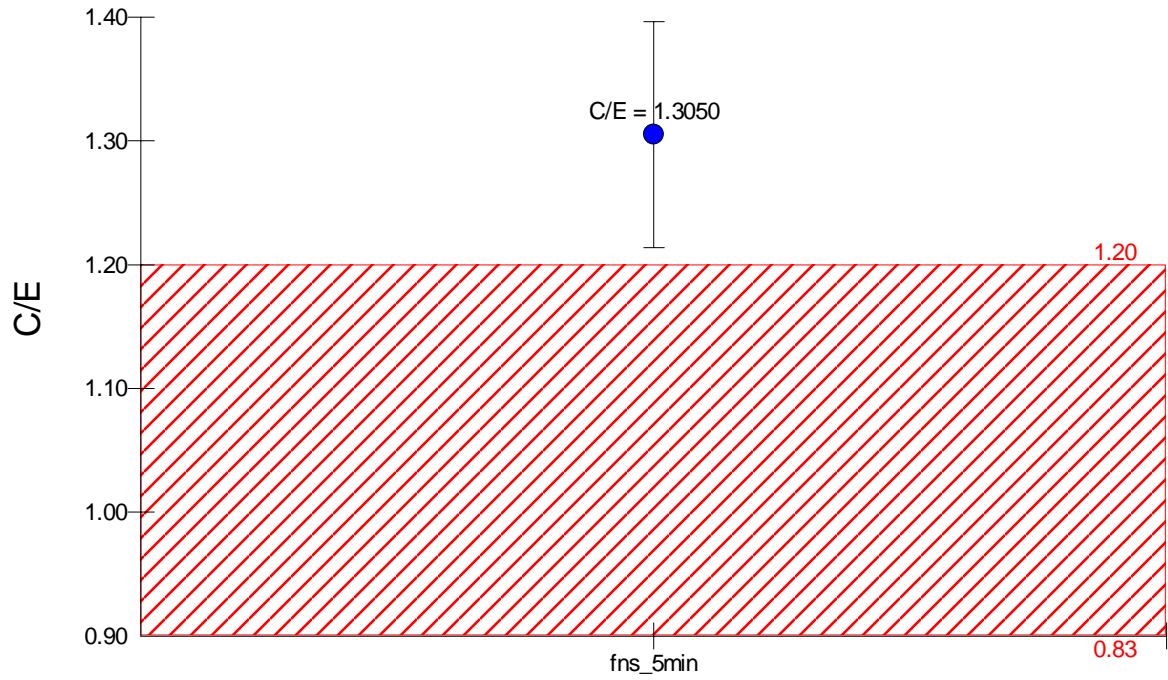




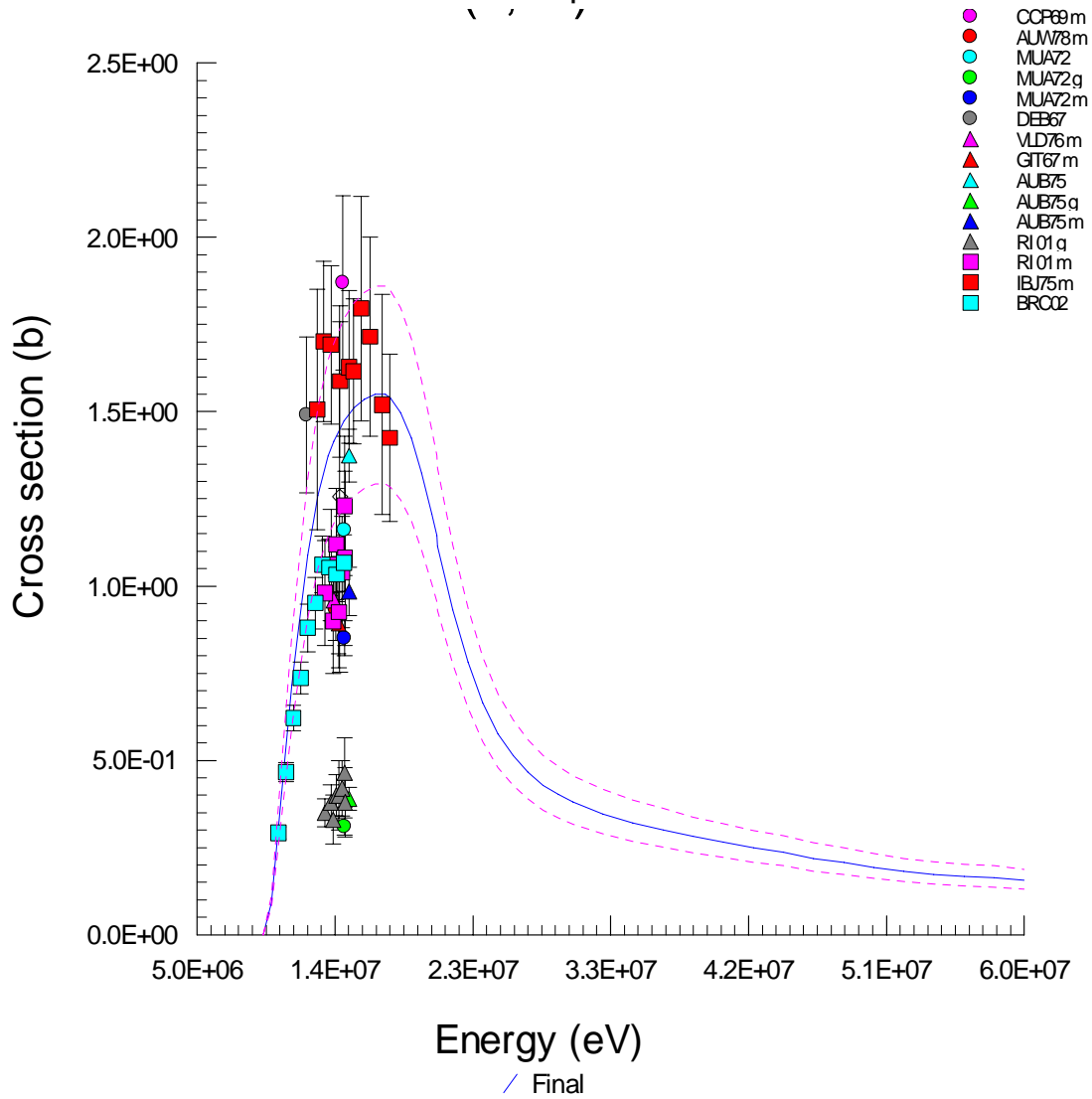
Neutron Spectrum



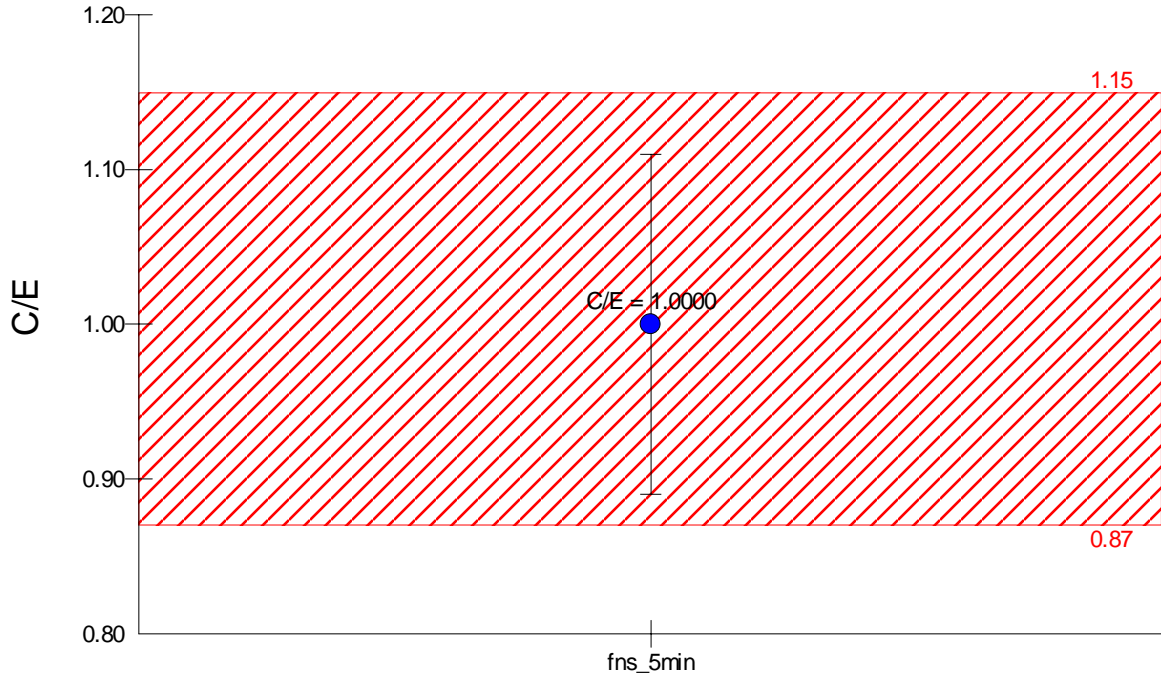
$^{82}\text{Se}(n,2n)^{81}\text{Se}$



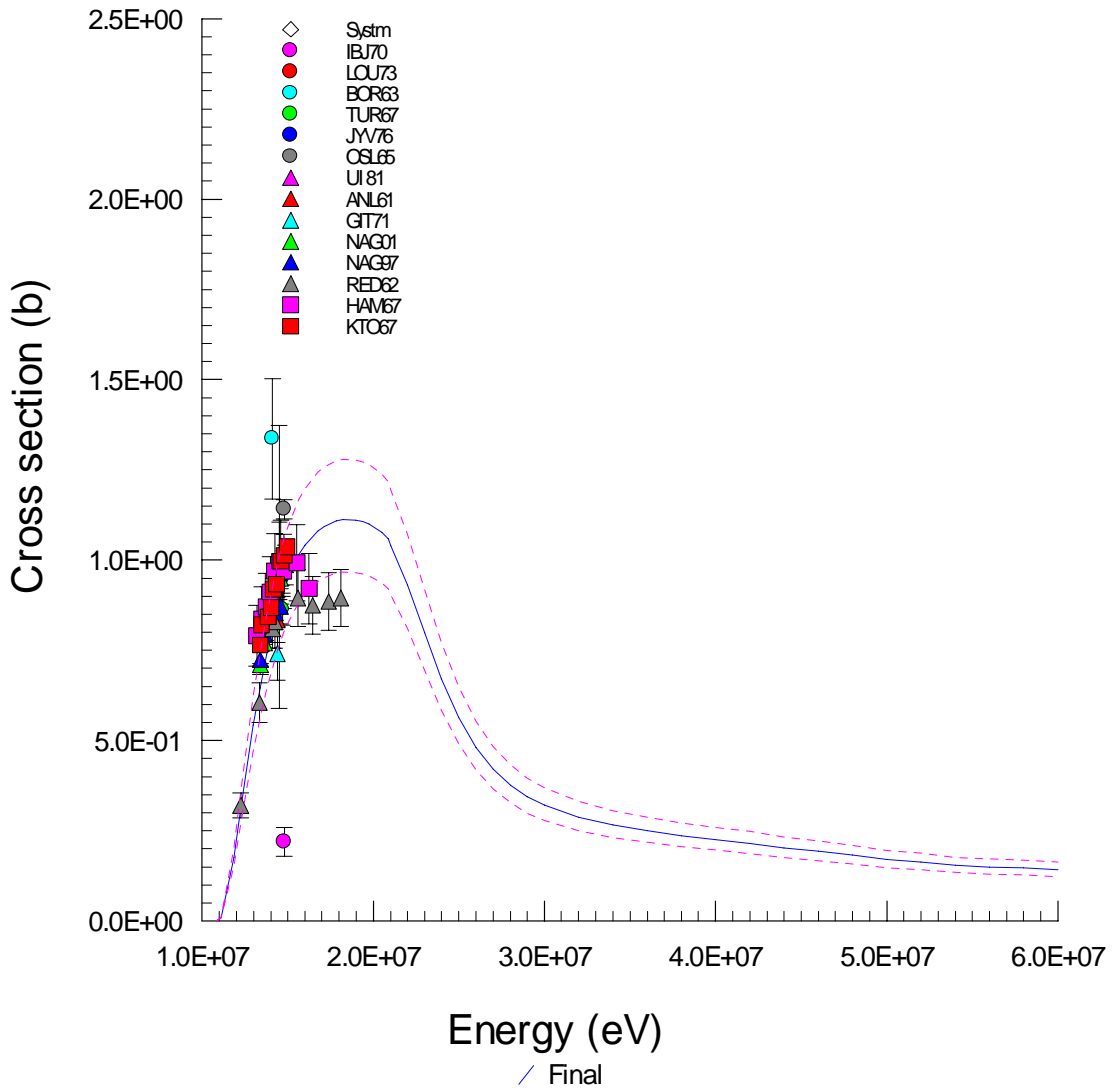
Neutron Spectrum

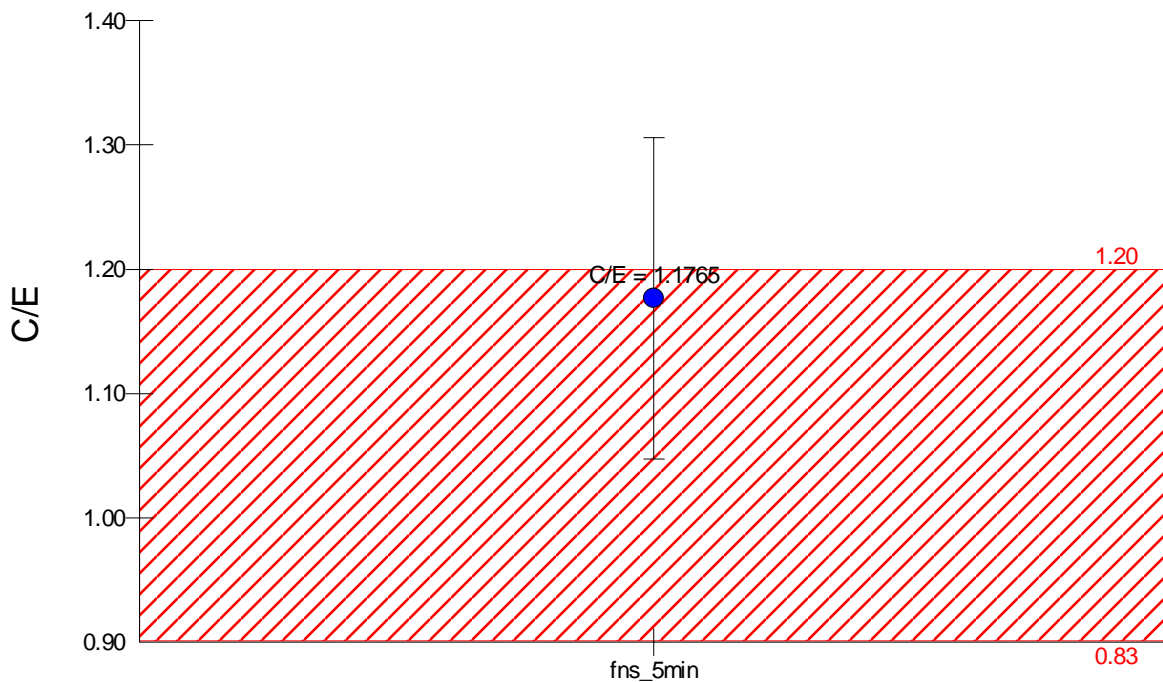
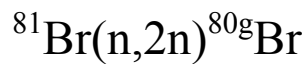


$^{79}\text{Br}(n,2n)^{78}\text{Br}$

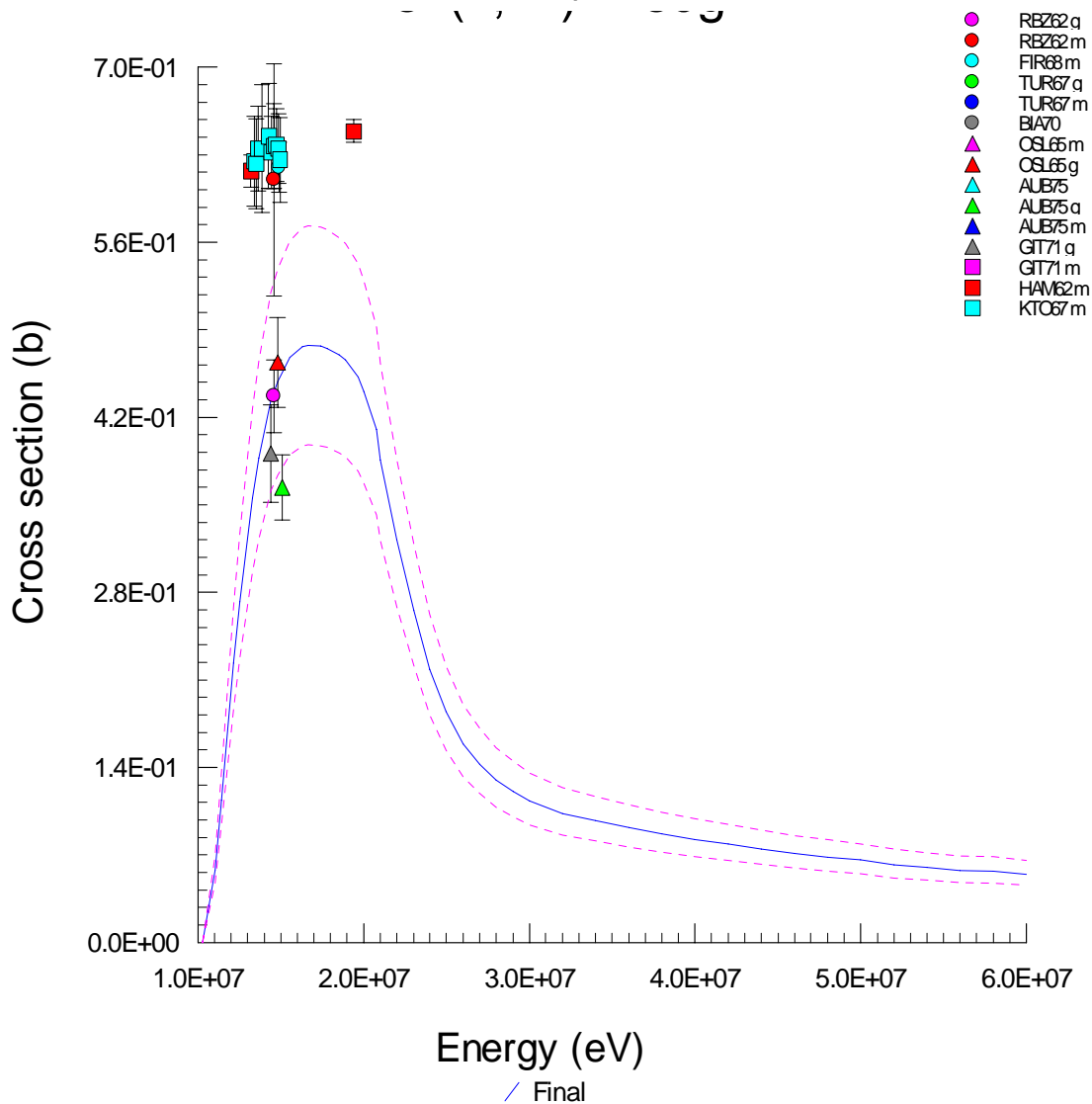


Neutron Spectrum

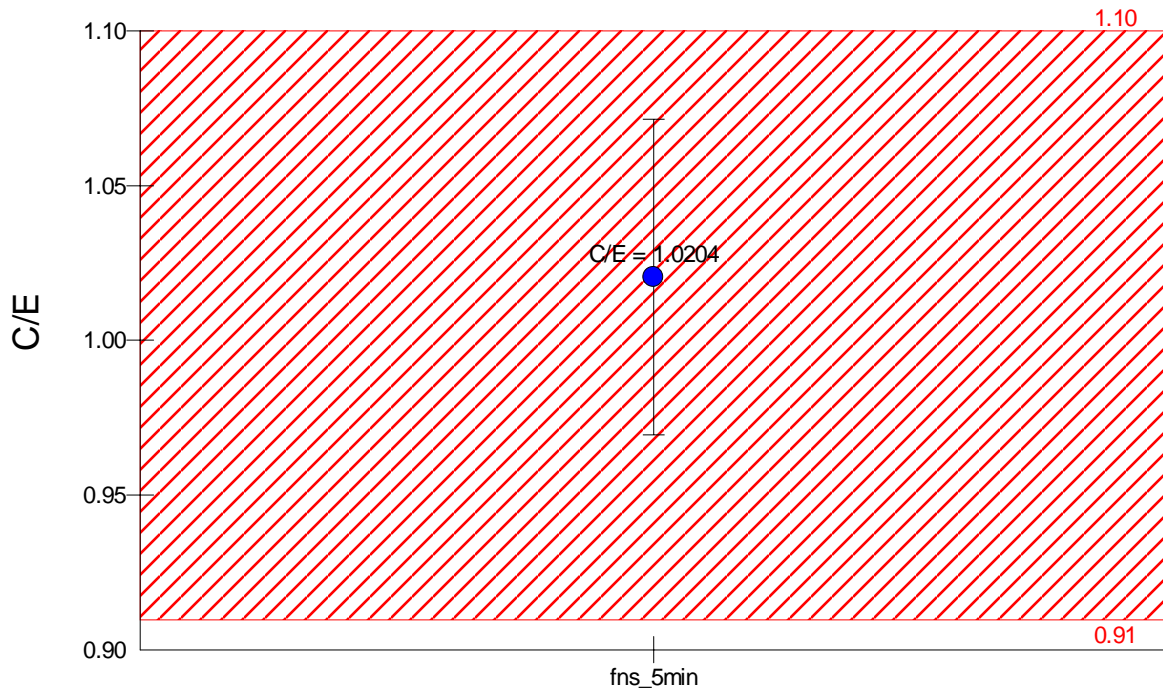




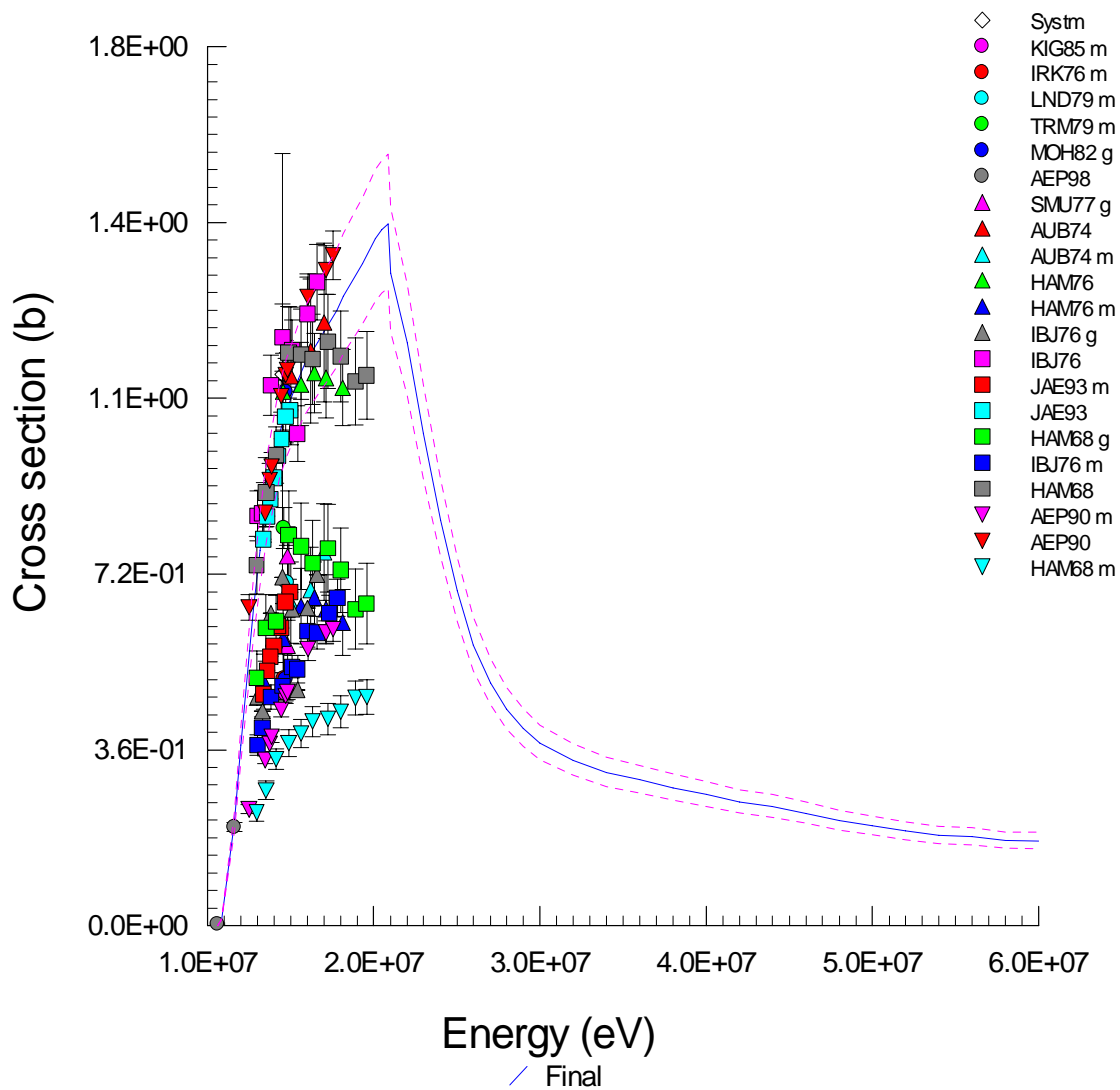
Neutron Spectrum

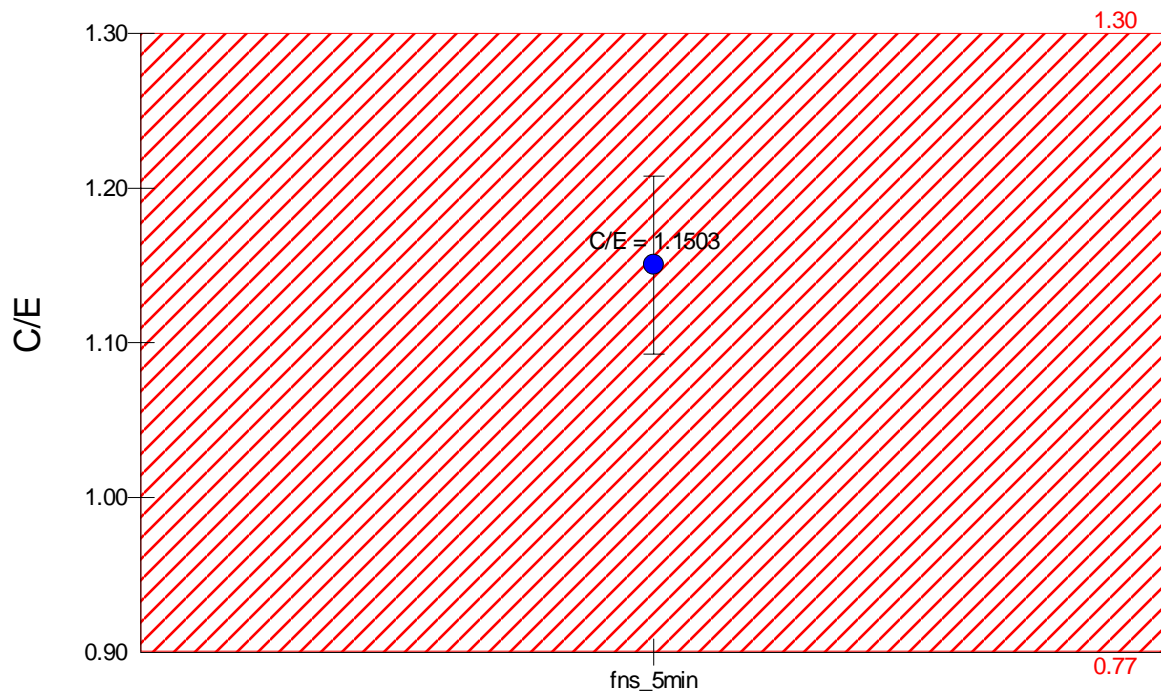
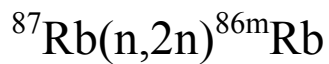


# $^{85}\text{Rb}(n,2n)^{84}\text{Rb}$

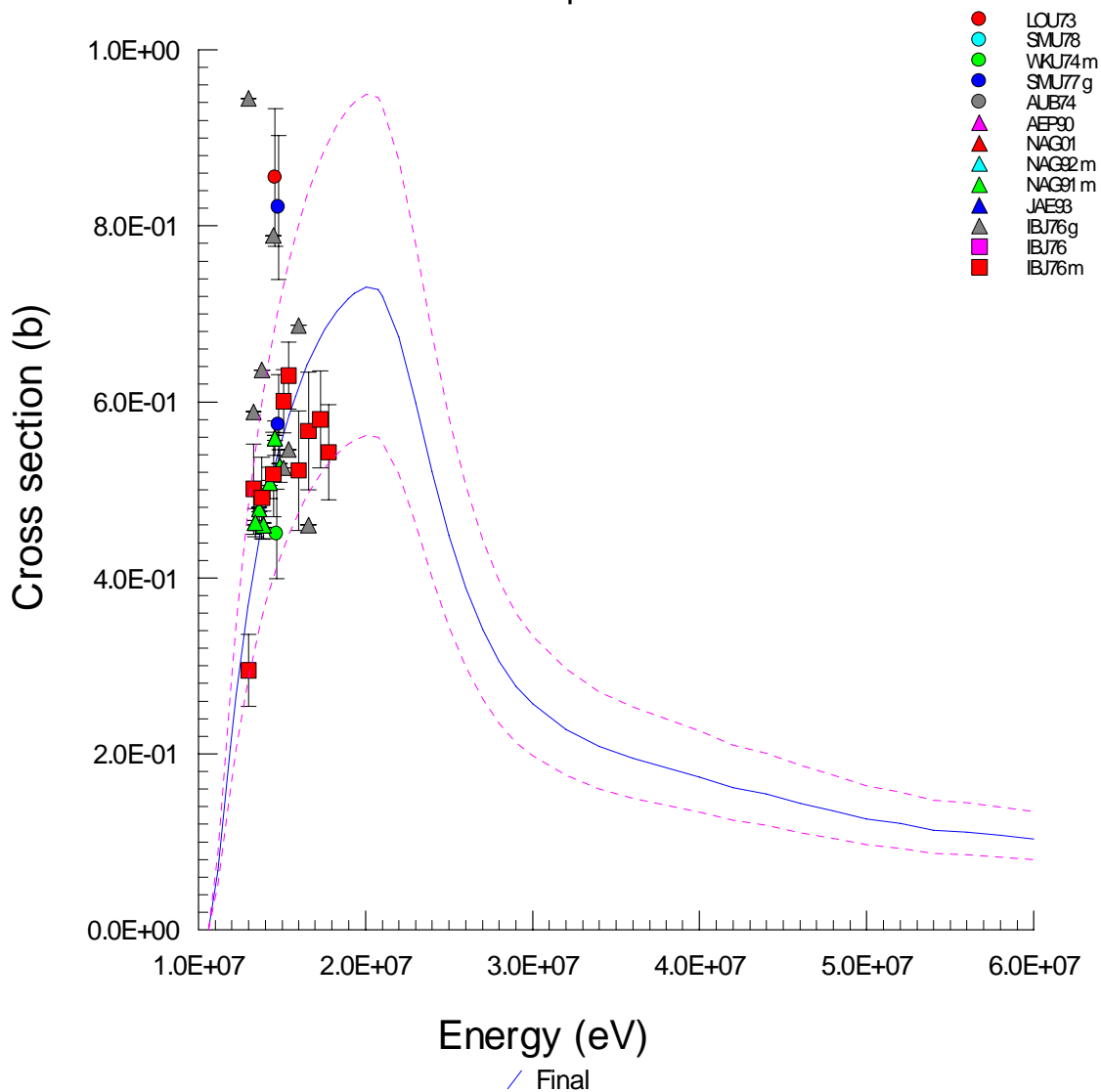


## Neutron Spectrum

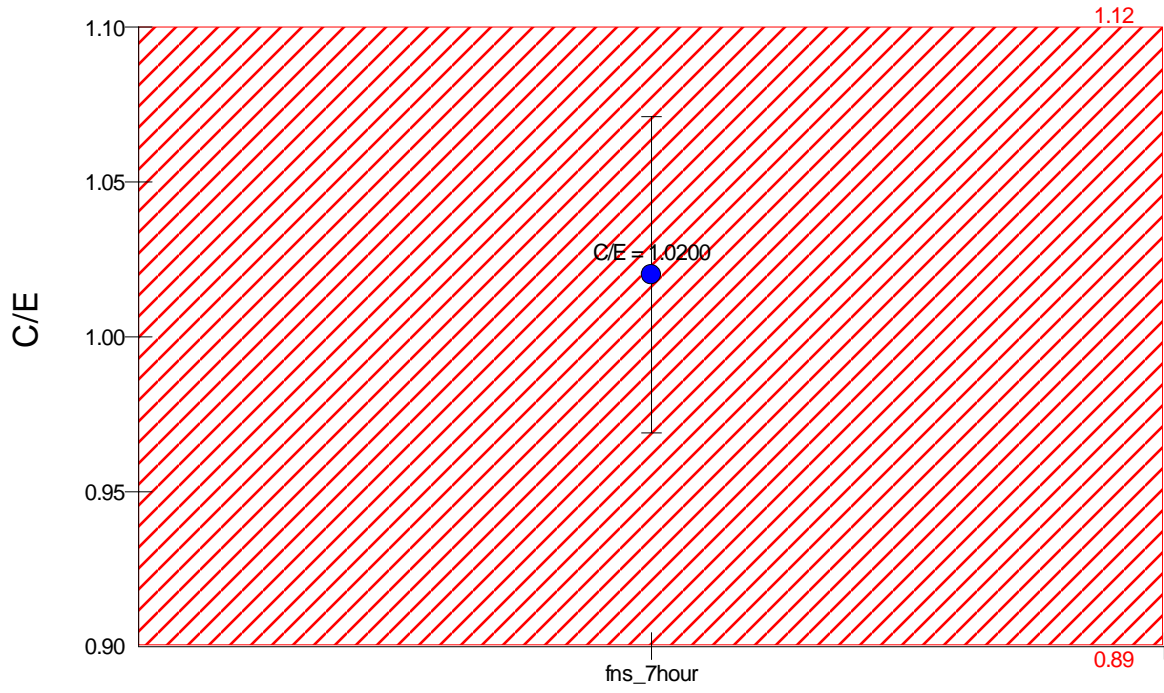
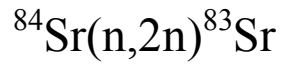




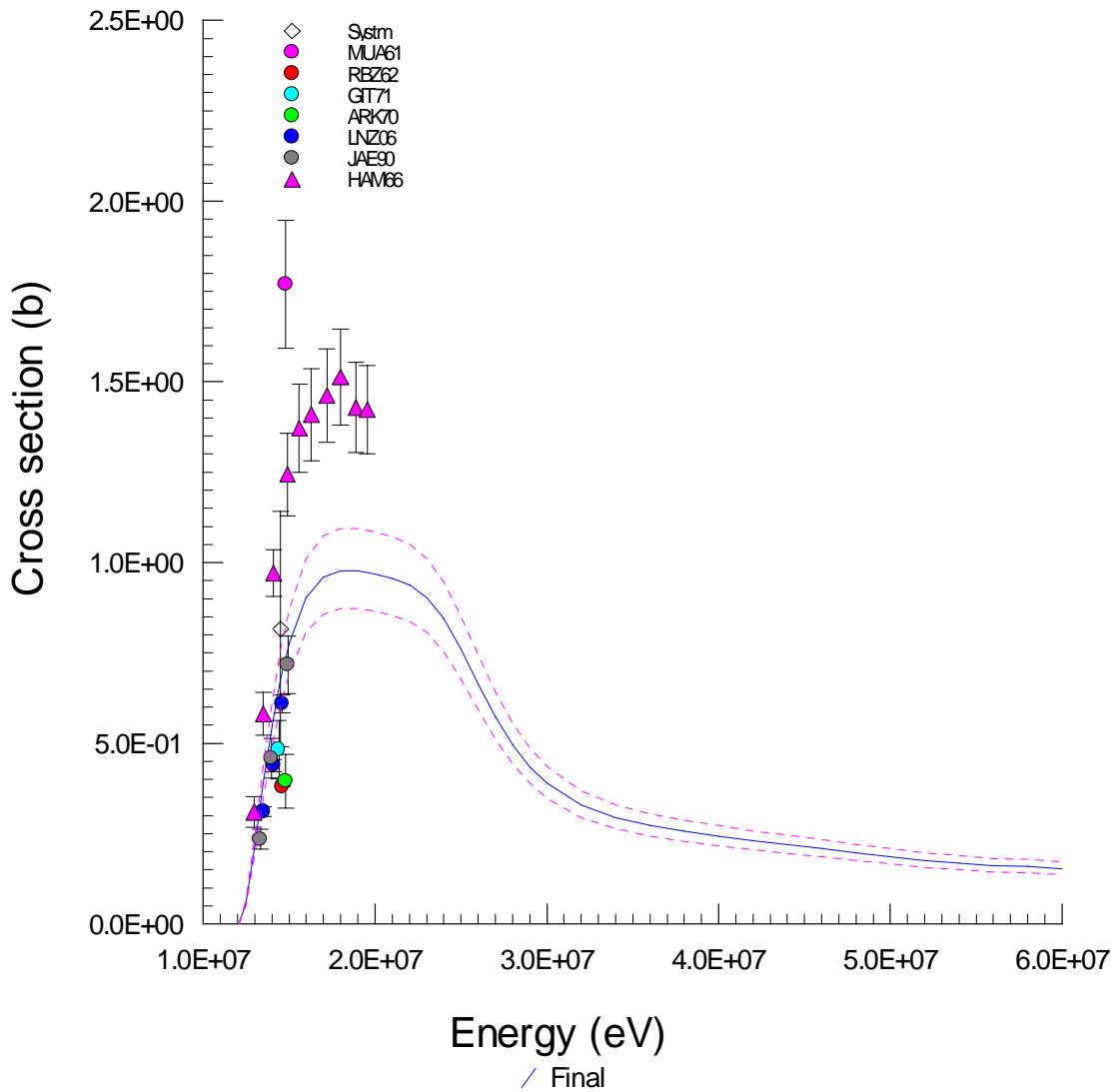
Neutron Spectrum

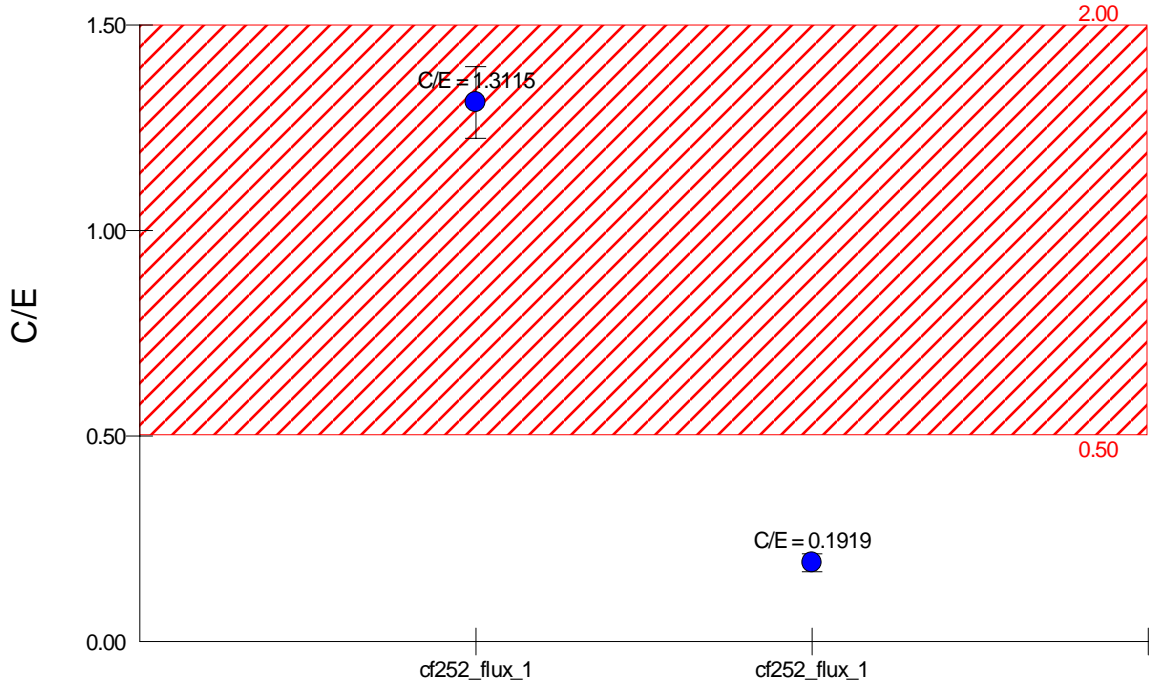
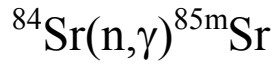




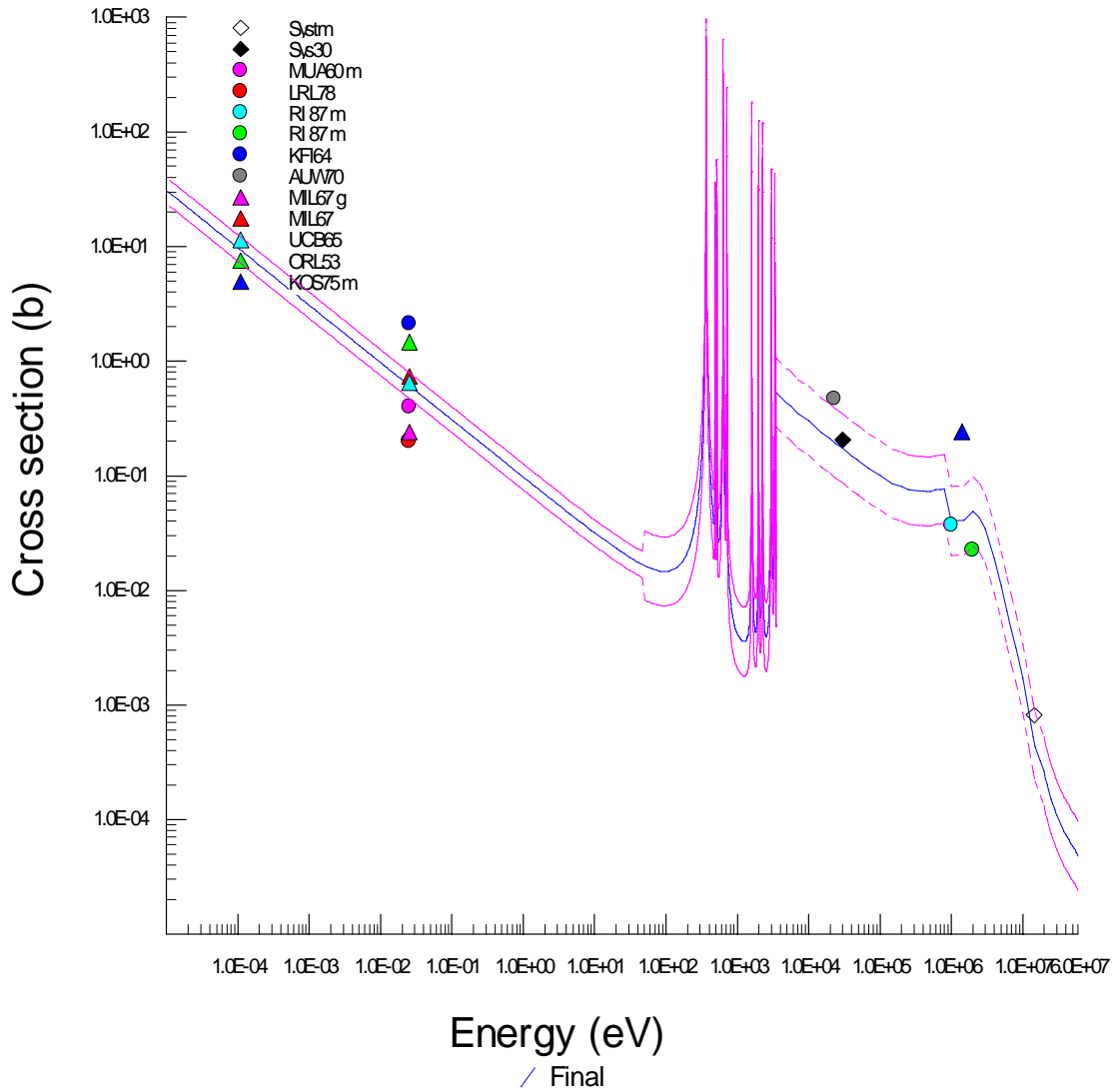


Neutron Spectrum

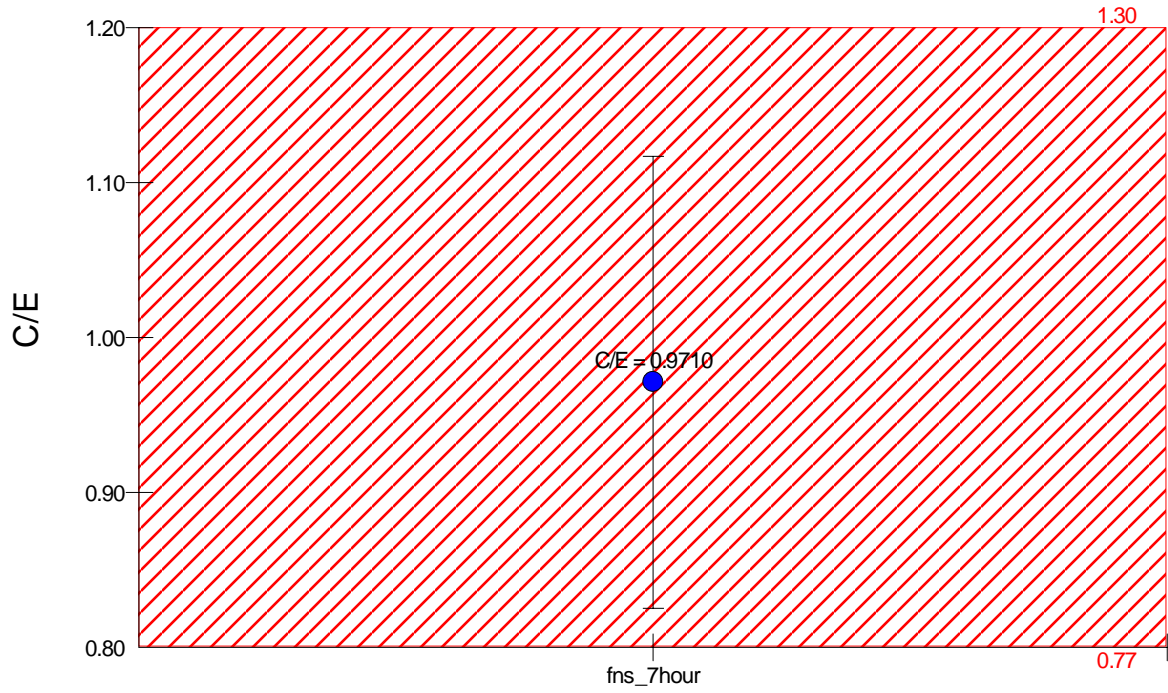




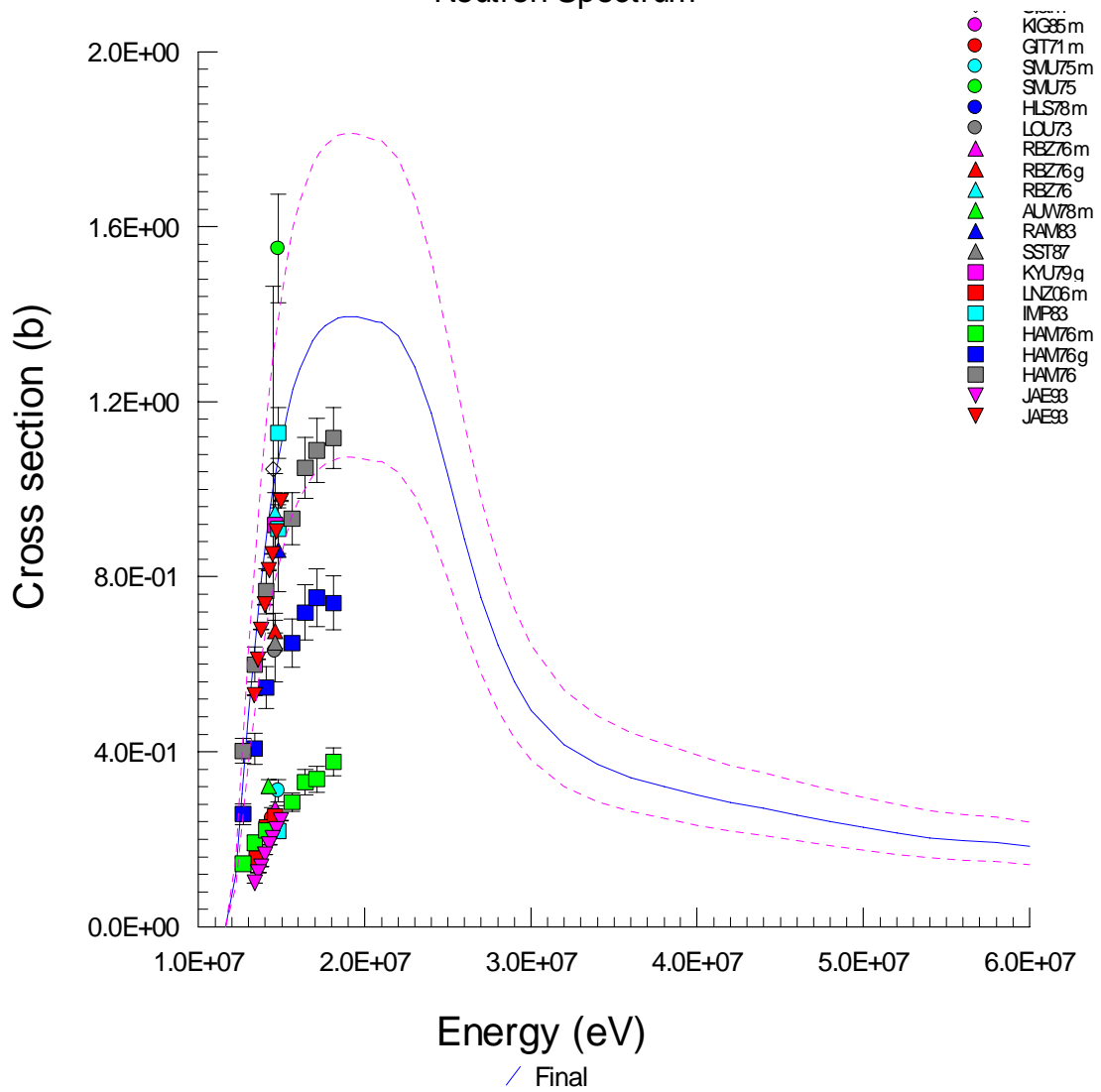
Neutron Spectrum

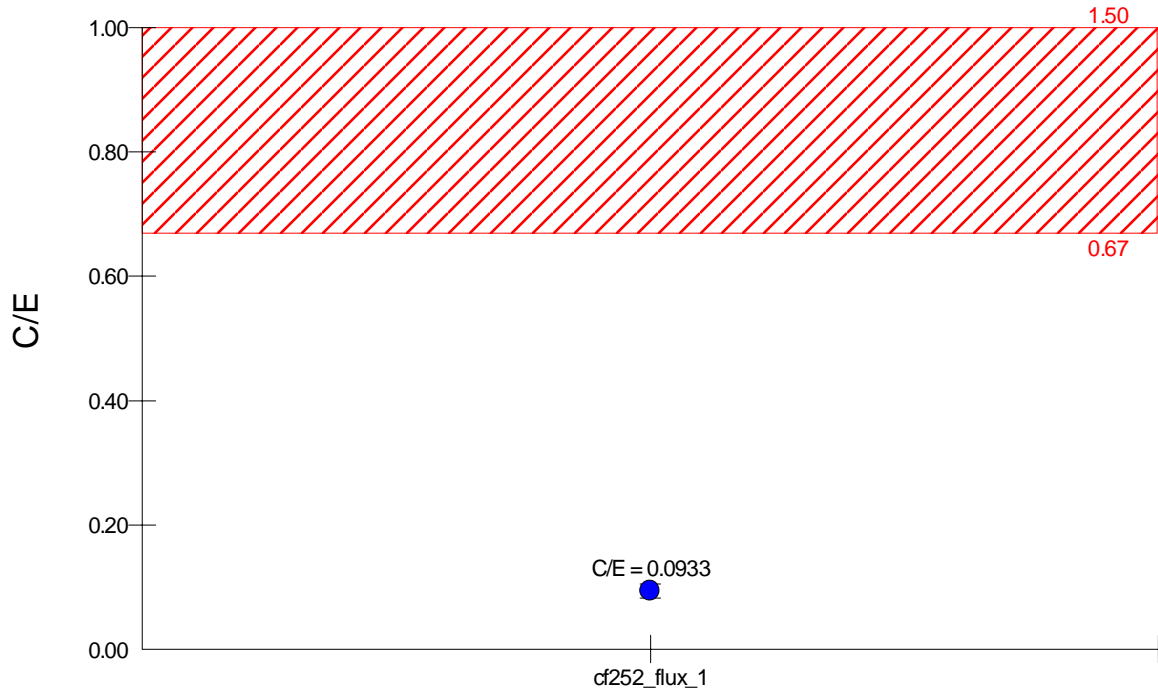
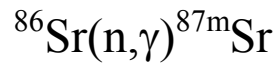


# $^{86}\text{Sr}(n,2n)^{85}\text{Sr}$

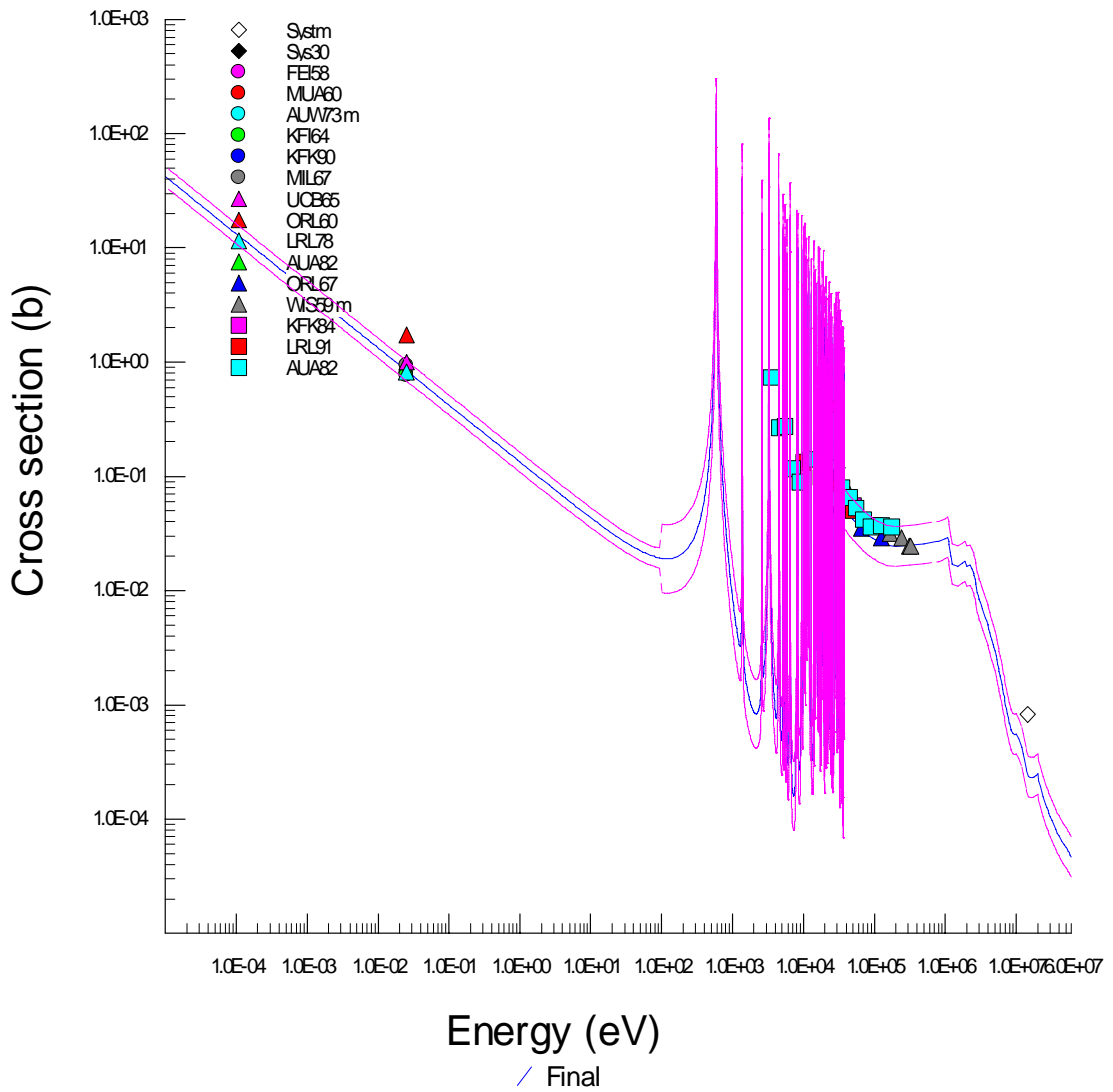


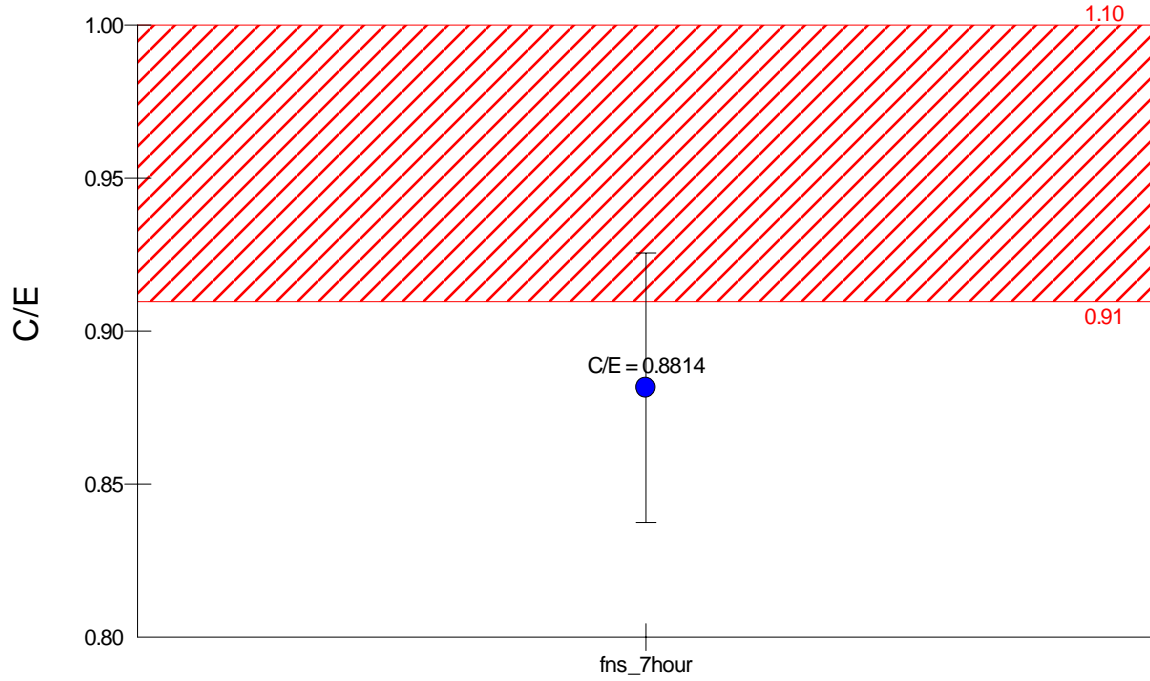
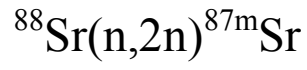
Neutron Spectrum



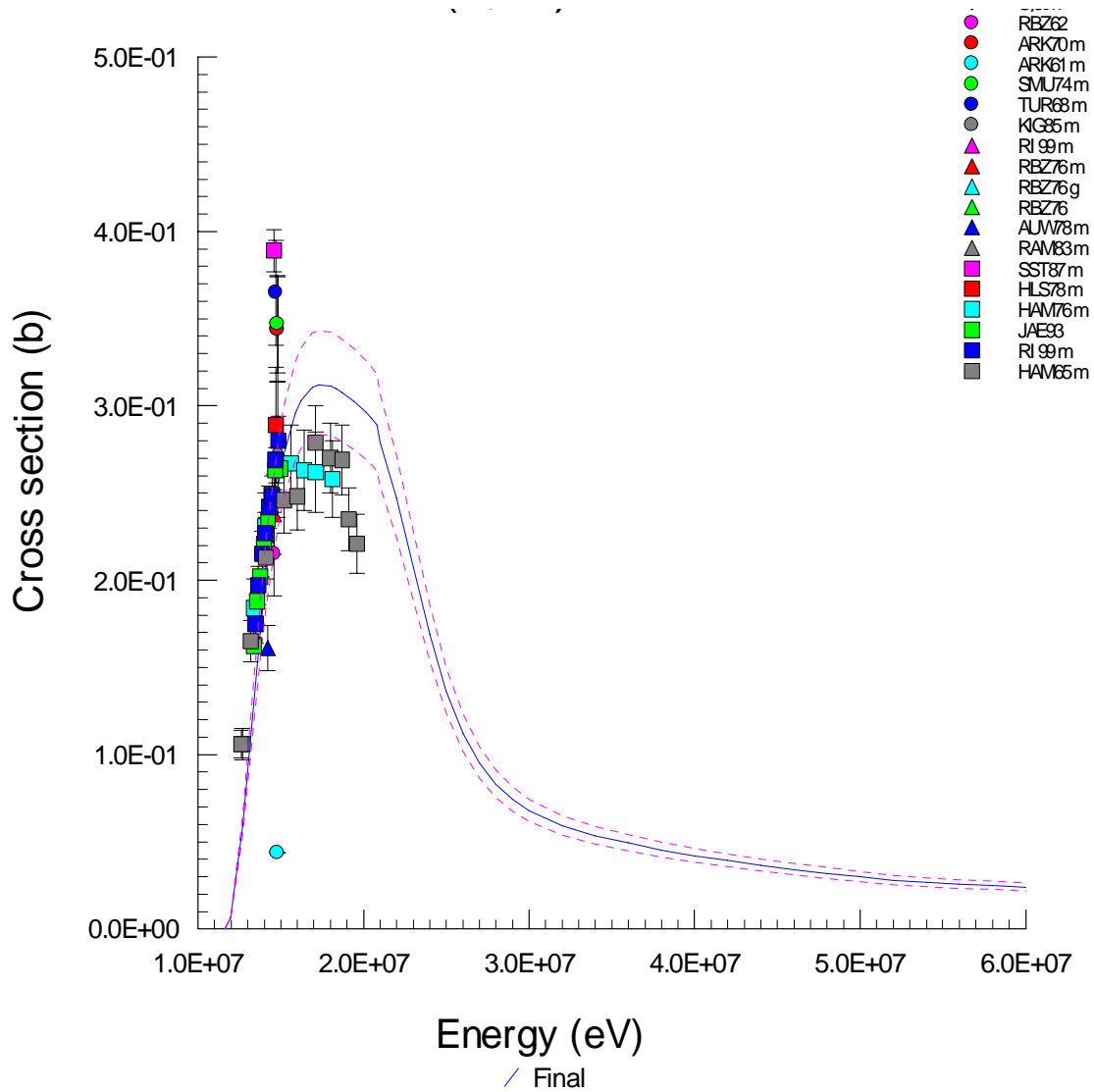


Neutron Spectrum

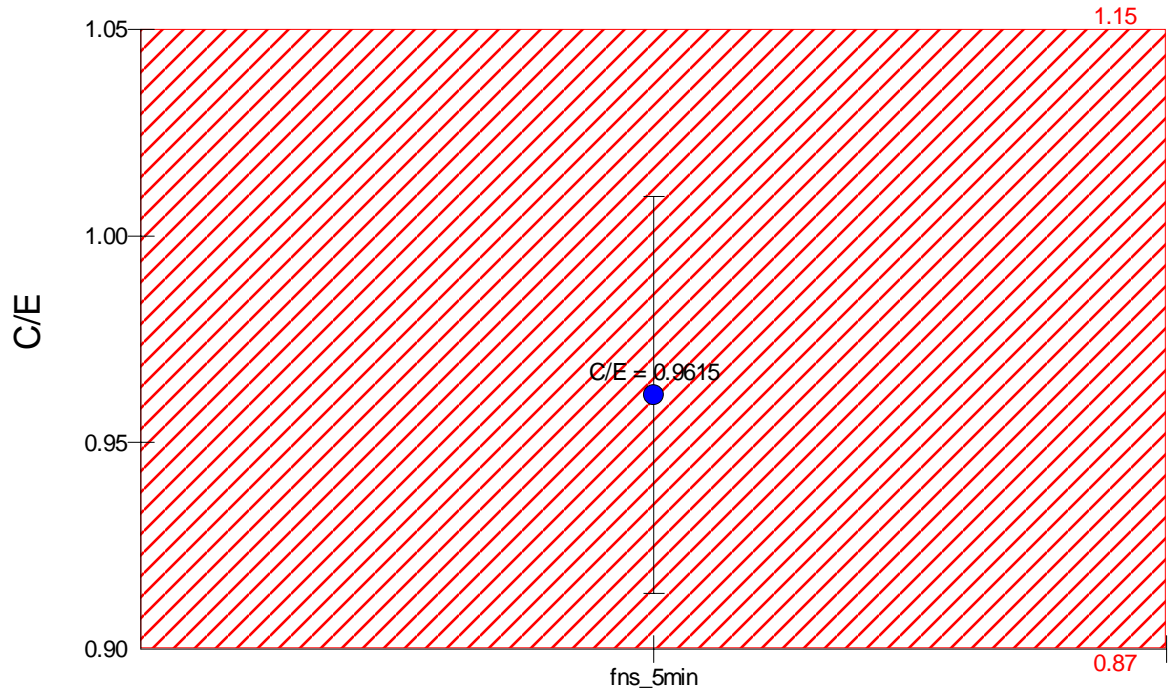




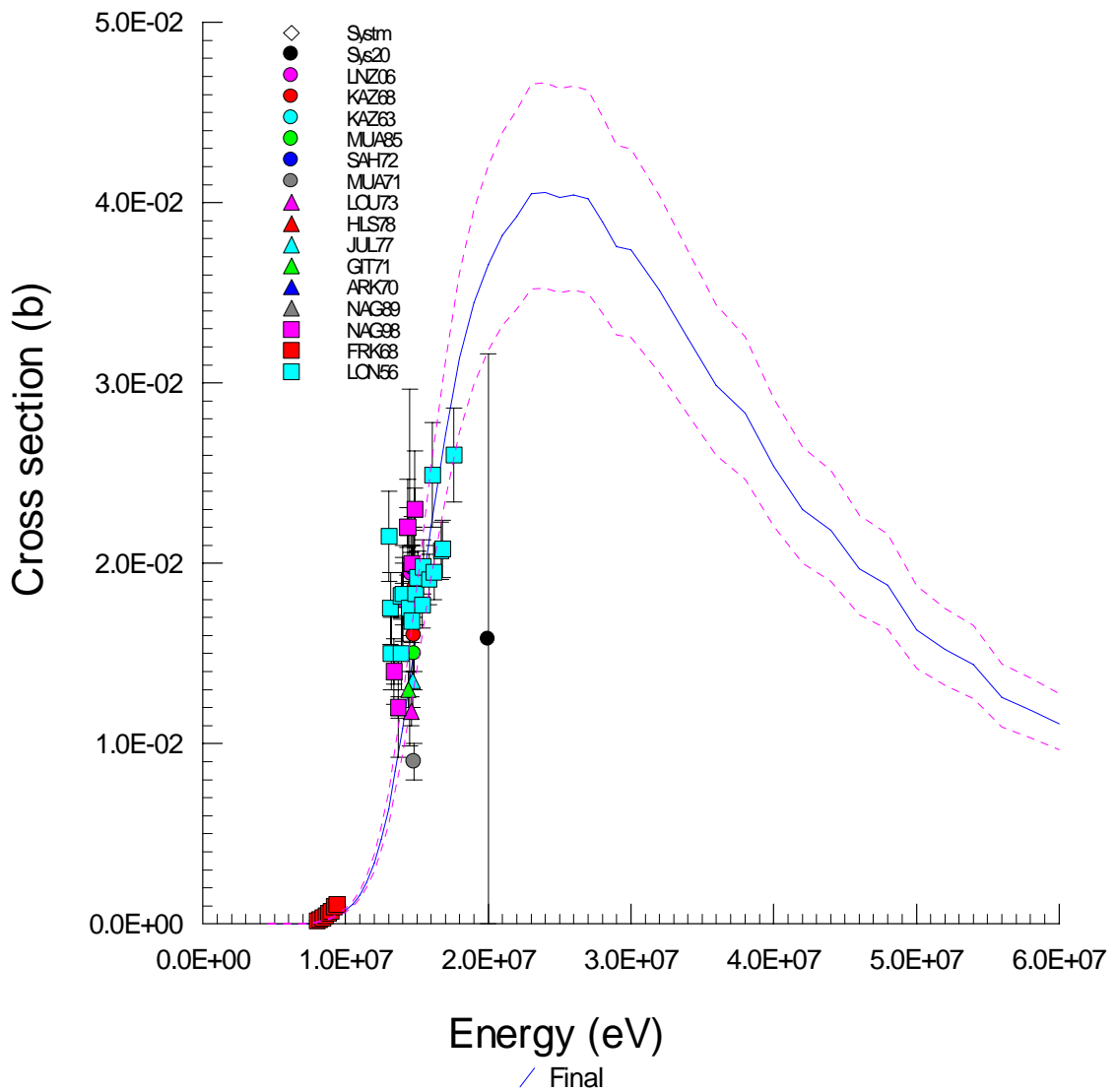
Neutron Spectrum

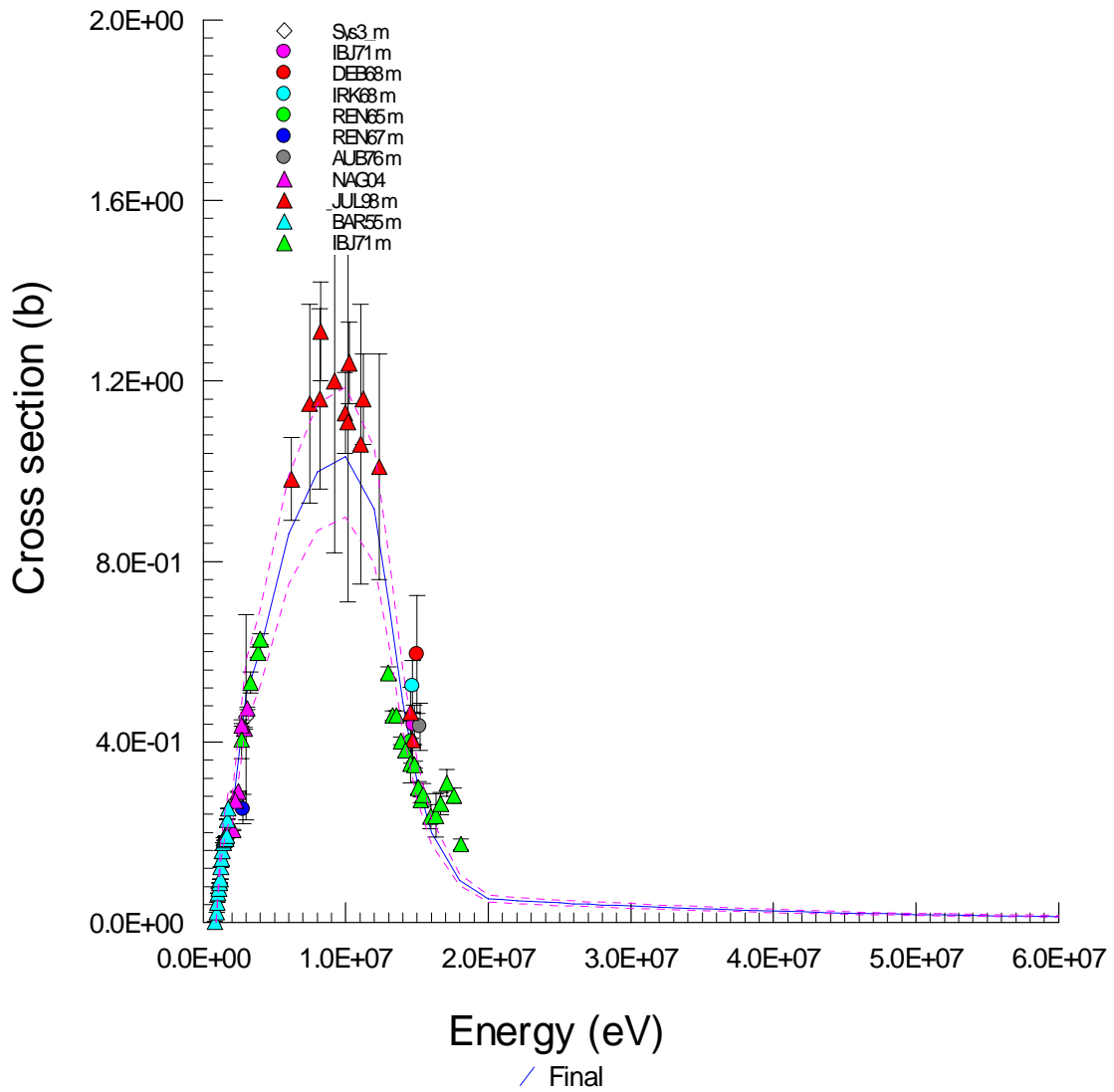
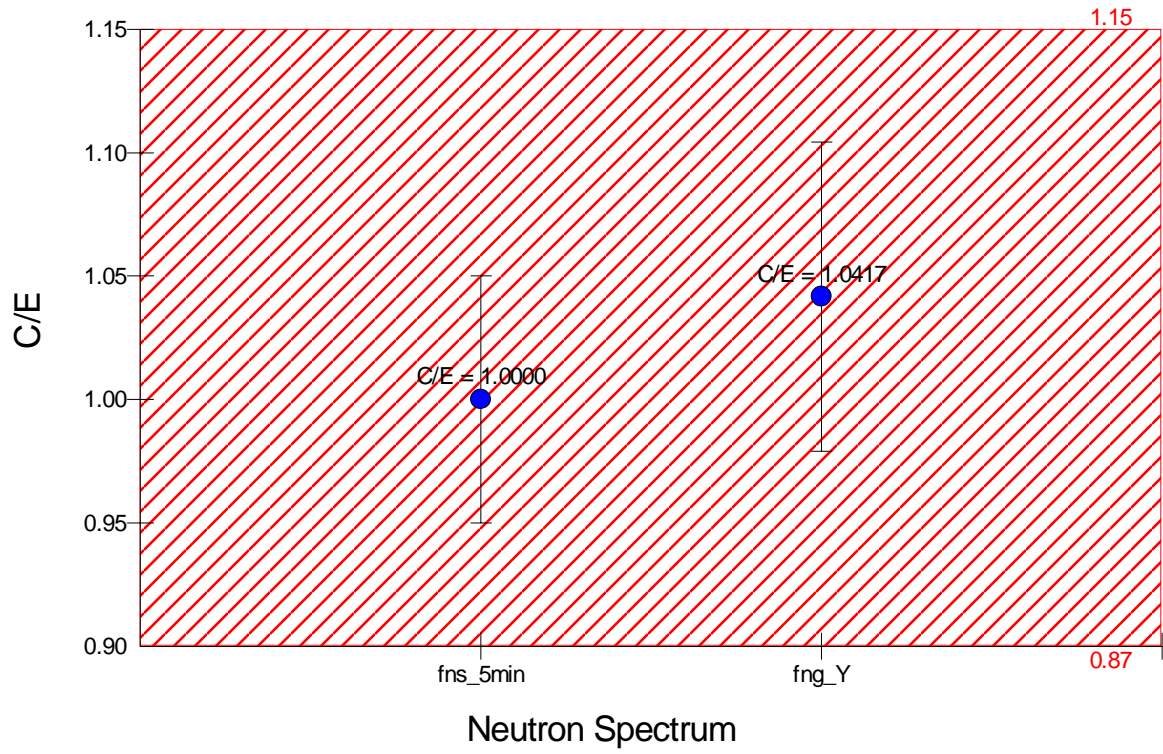
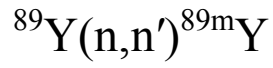


# $^{88}\text{Sr}(n,p)^{88}\text{Rb}$

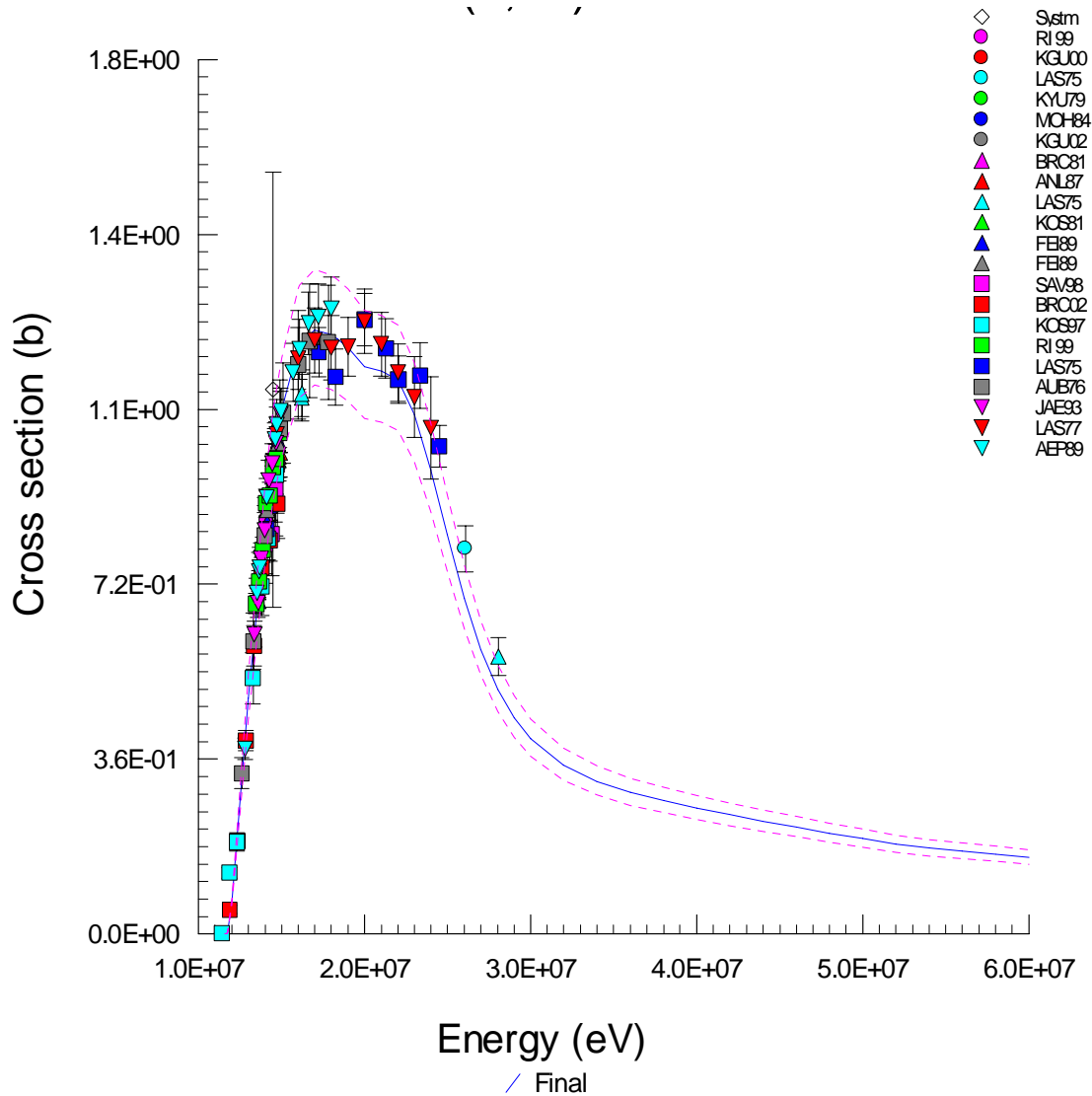
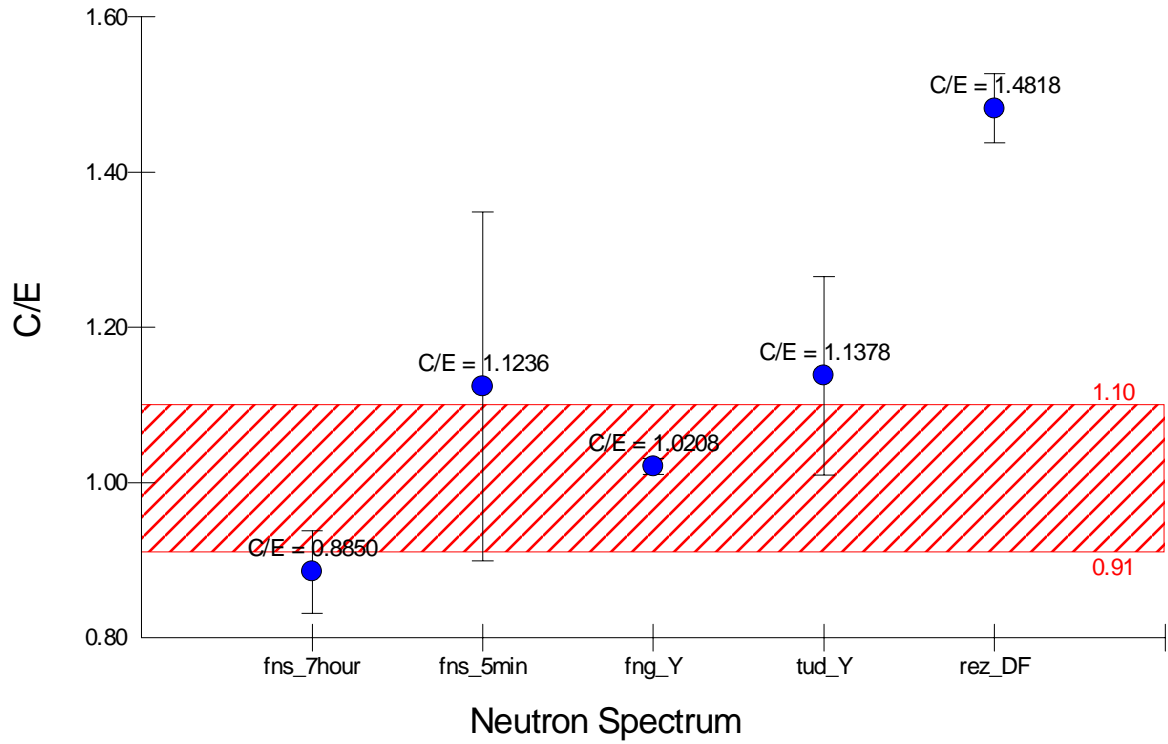


## Neutron Spectrum



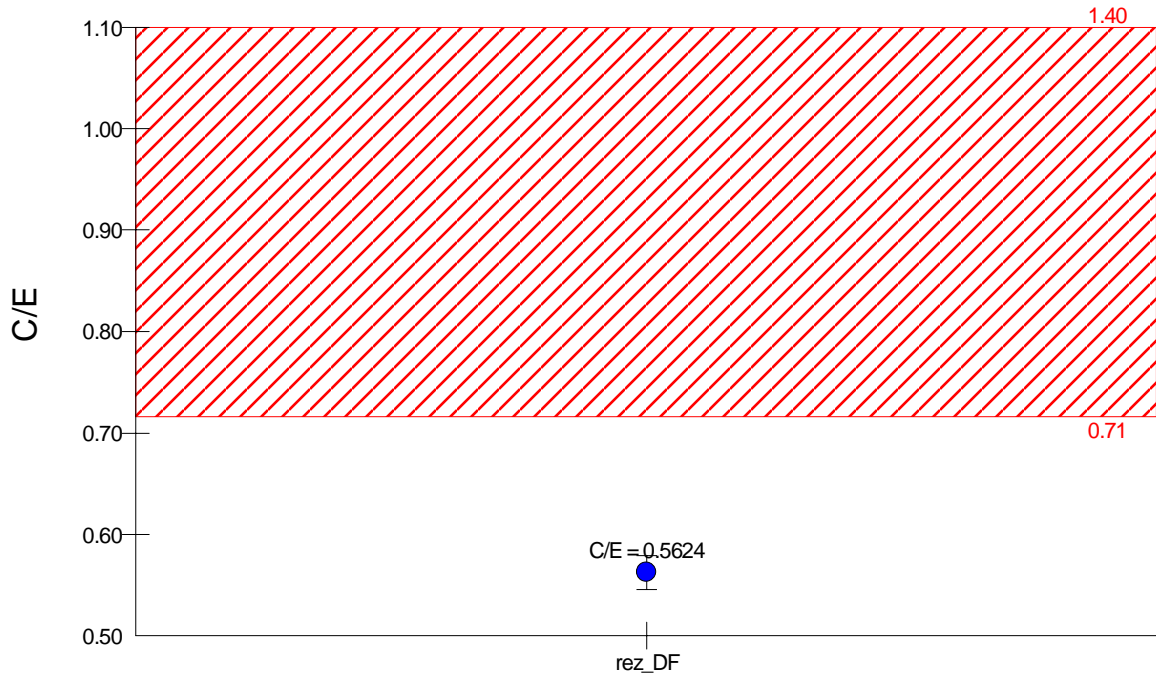


$^{89}\text{Y}(n,2n)^{88}\text{Y} \blacktriangleright 552$

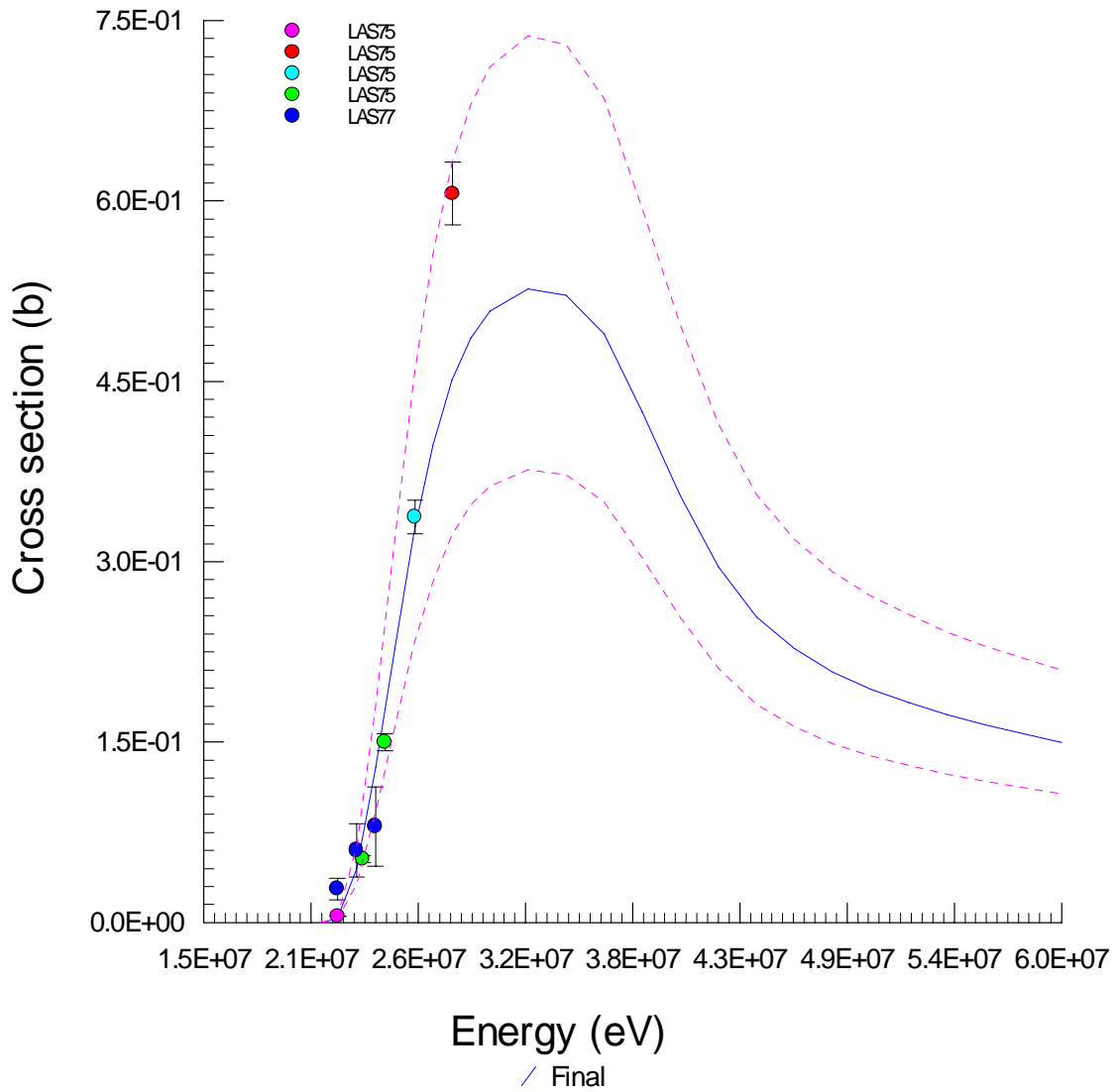


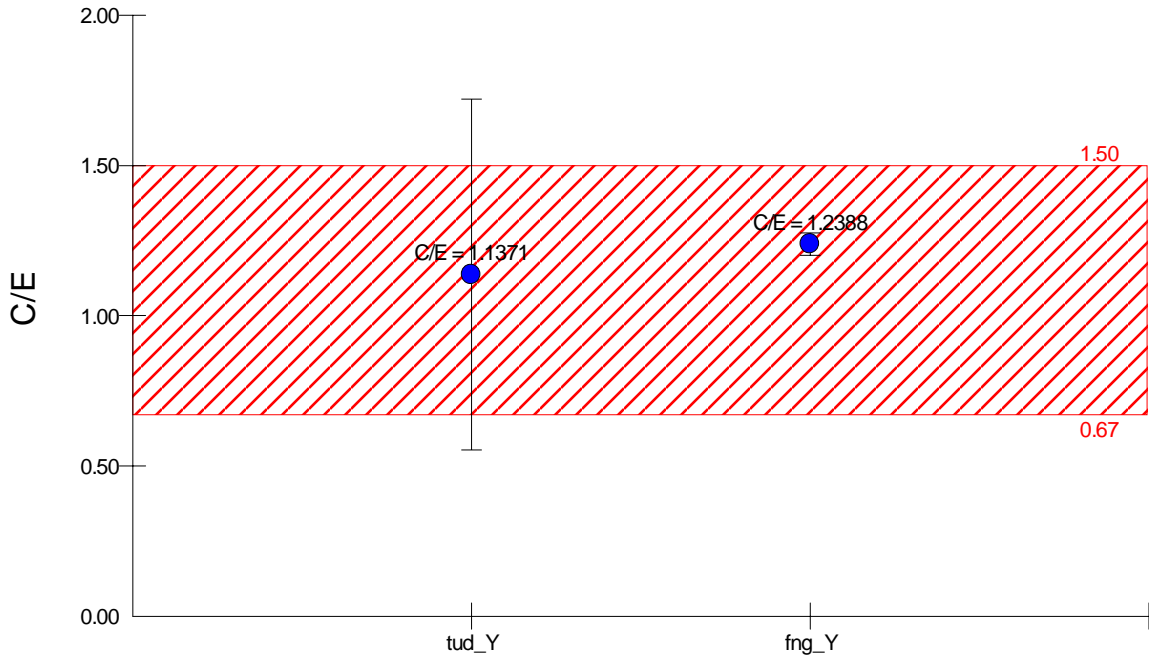
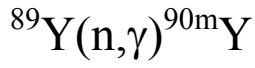


# $^{89}\text{Y}(n,3n)^{87}\text{Y}$

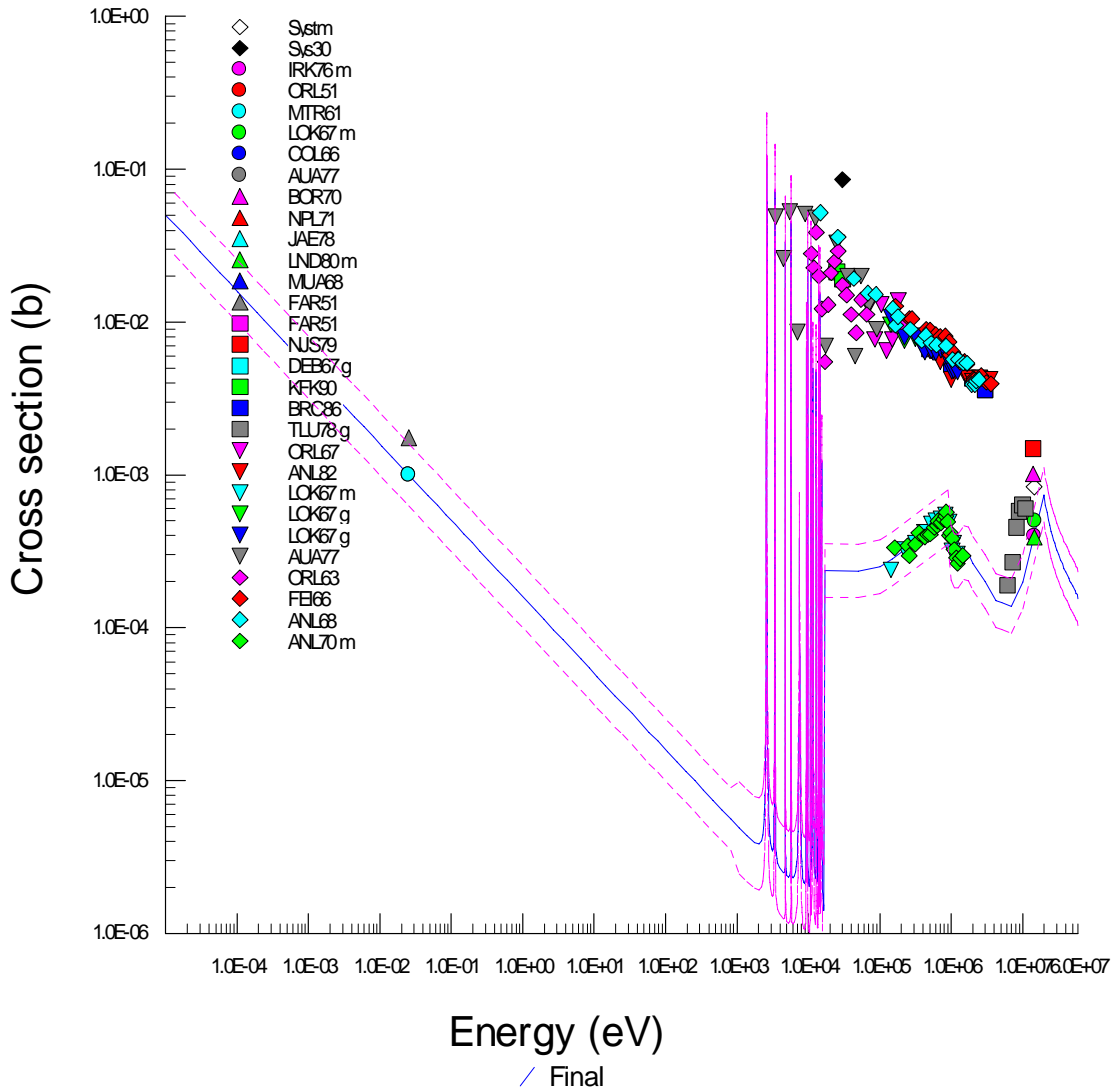


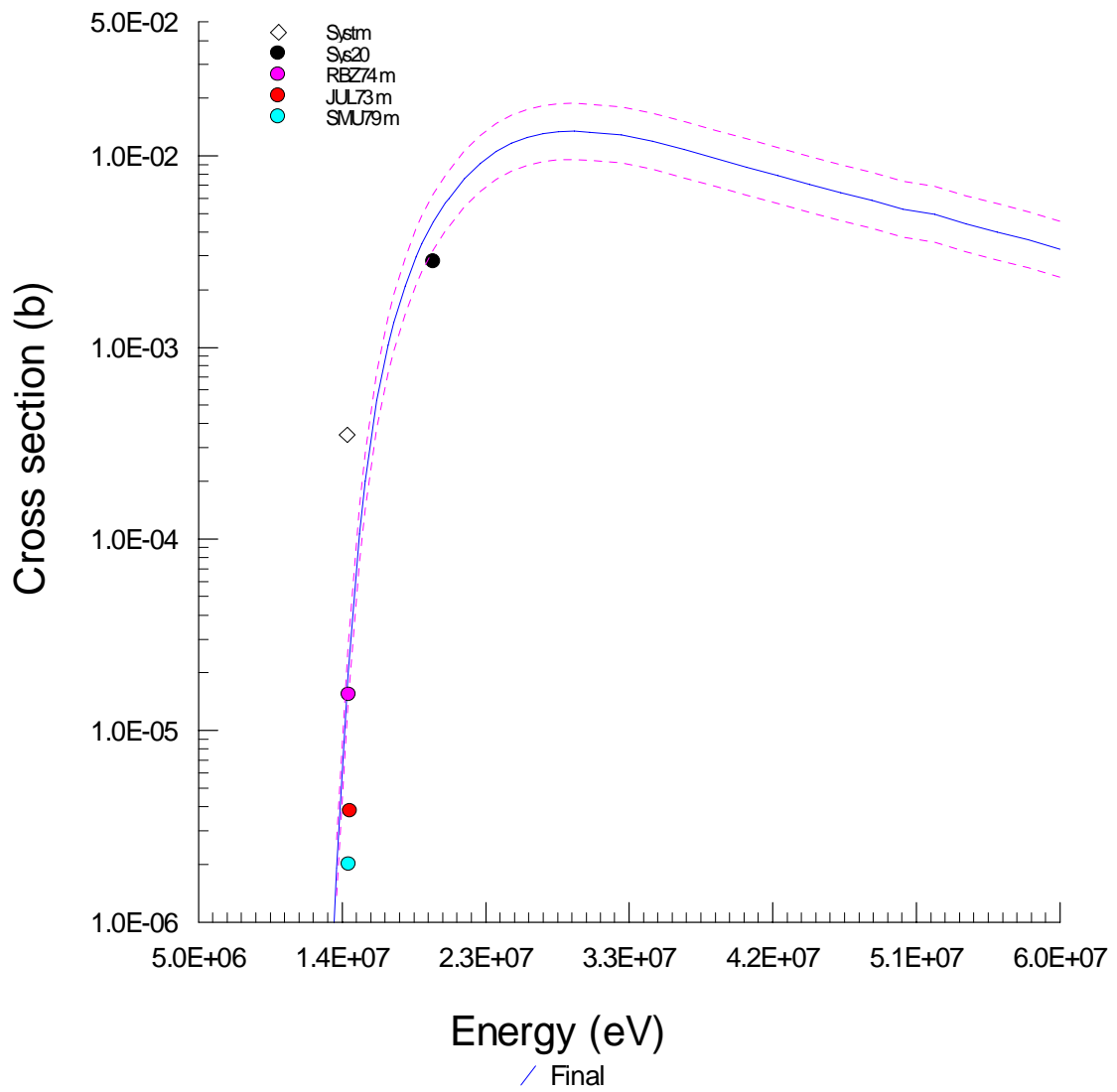
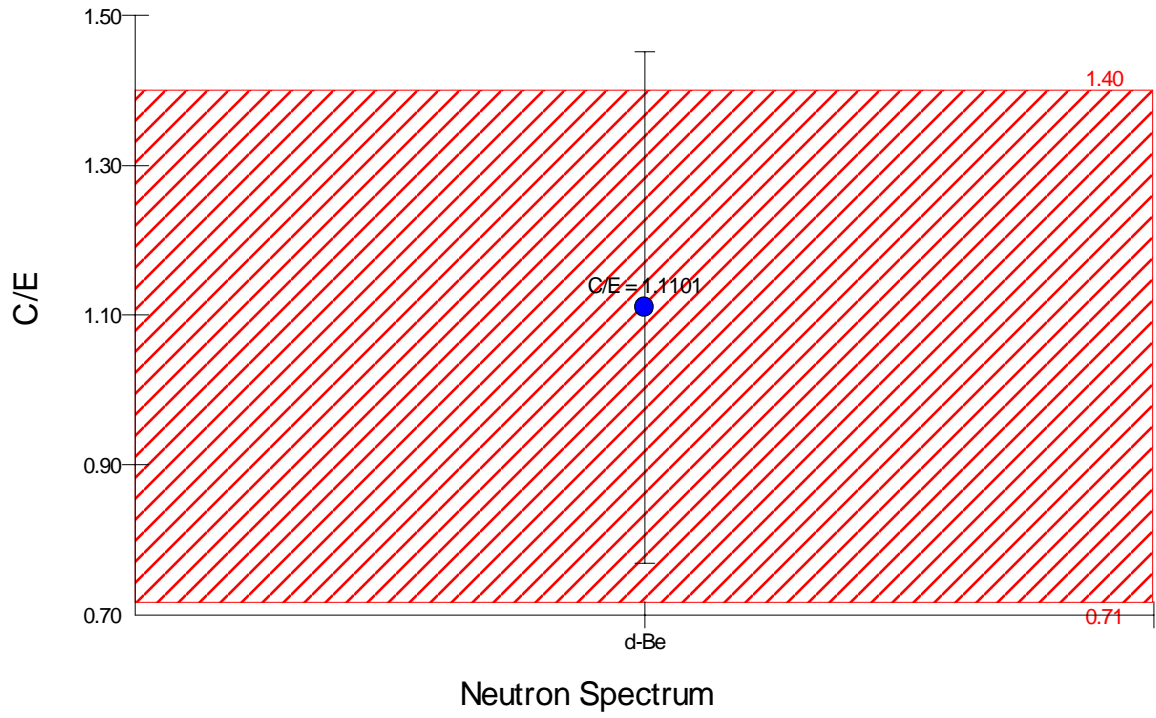
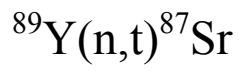
## Neutron Spectrum

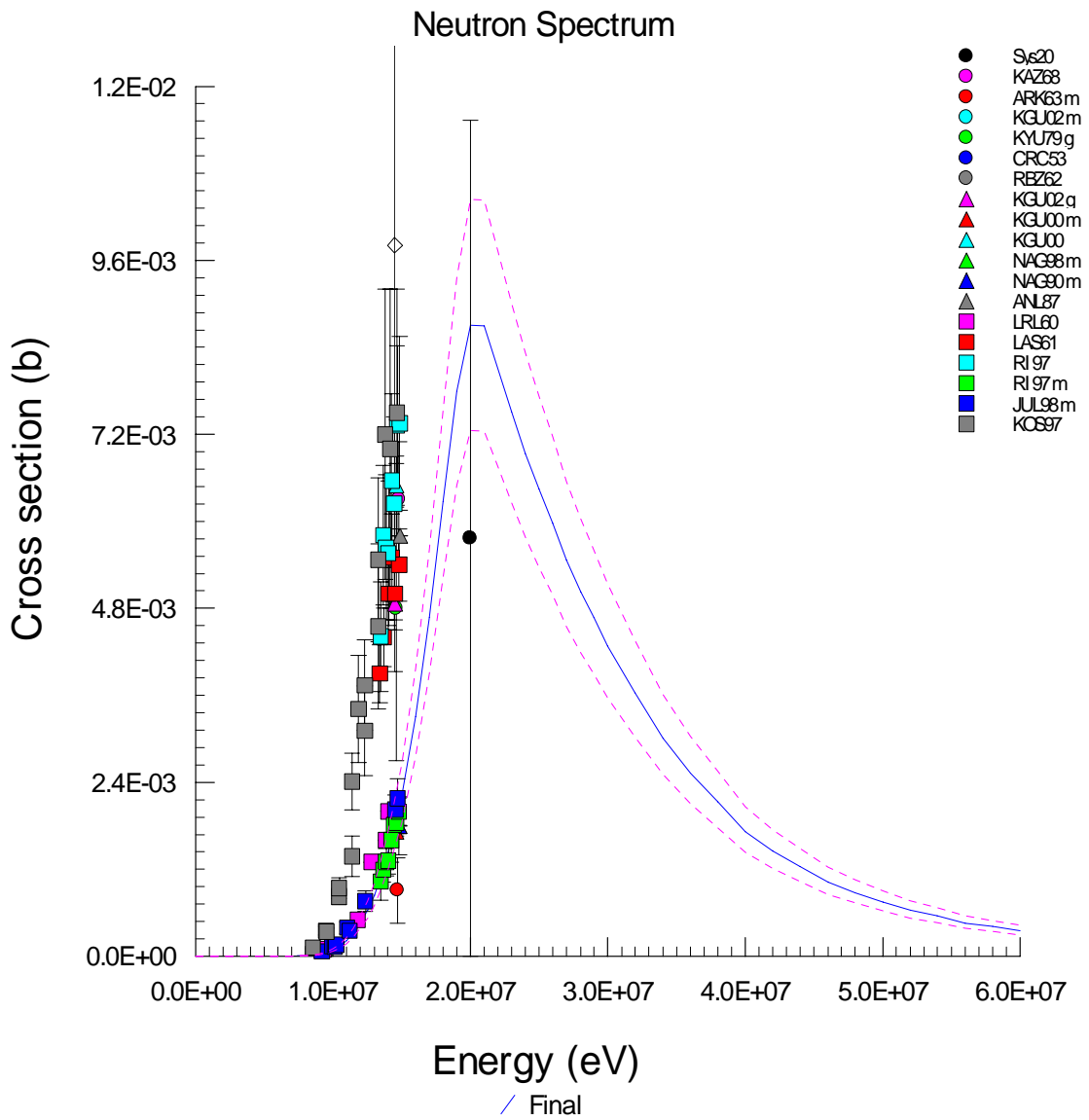
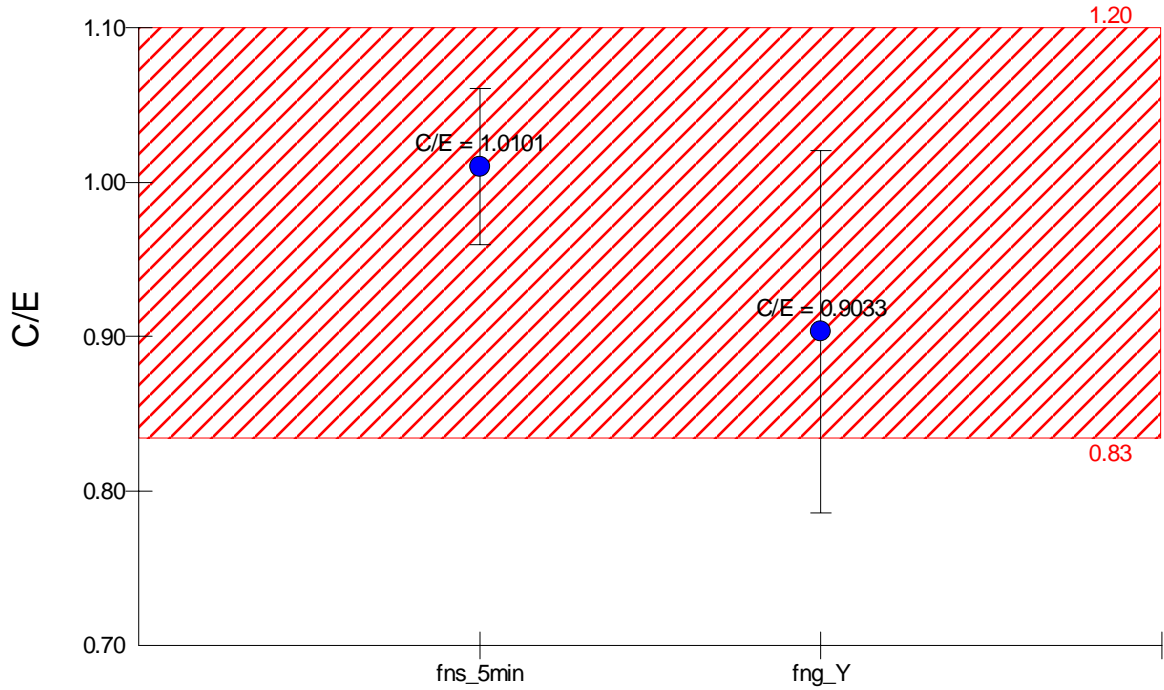
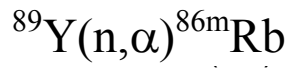




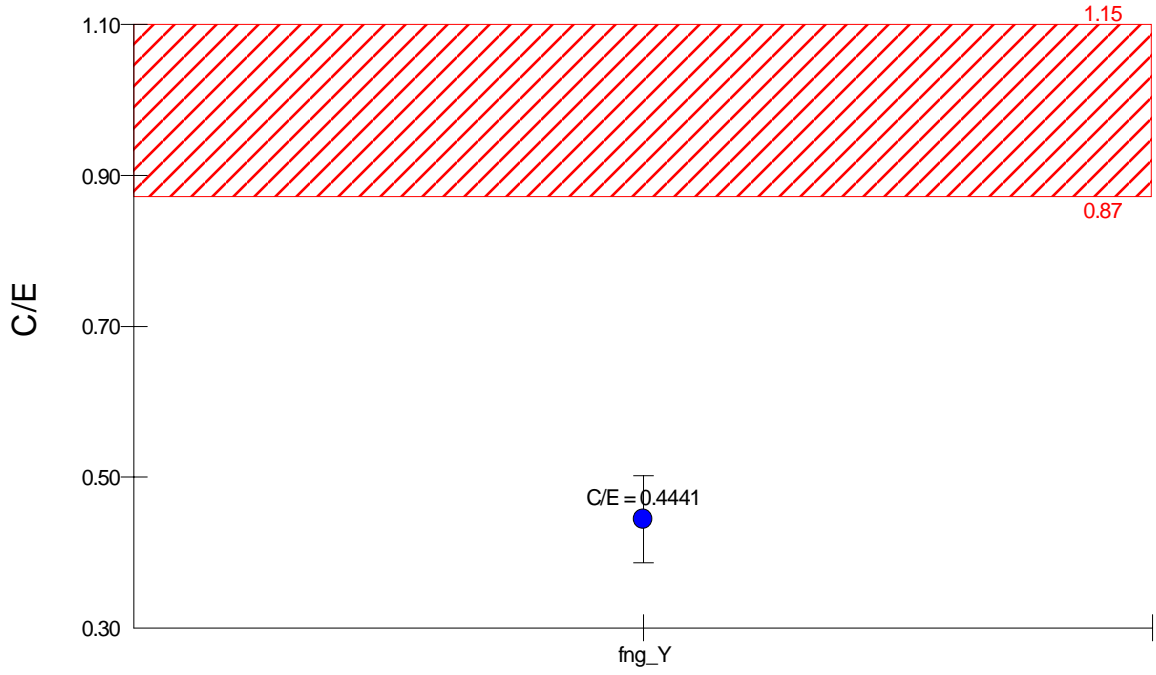
Neutron Spectrum



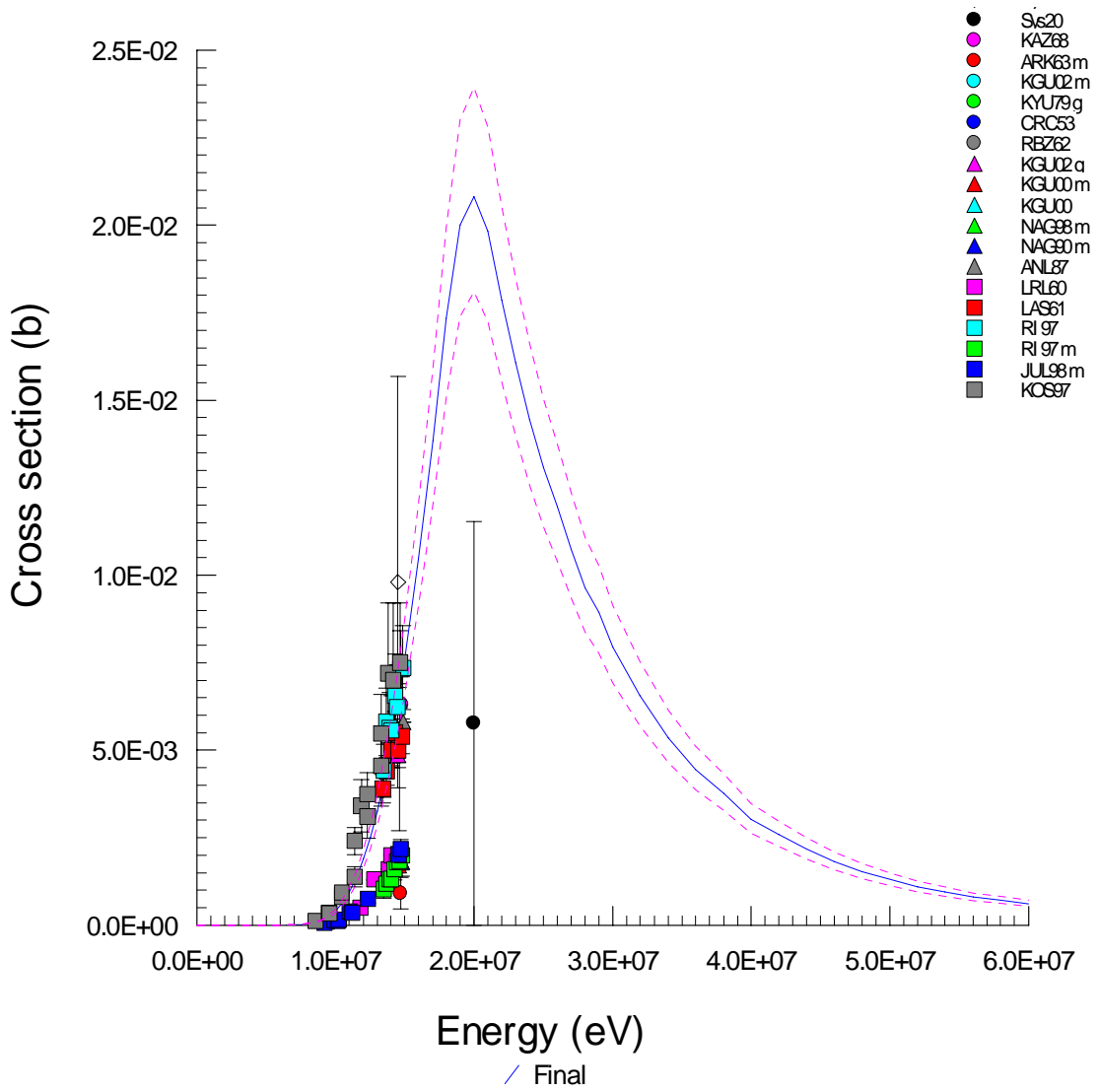


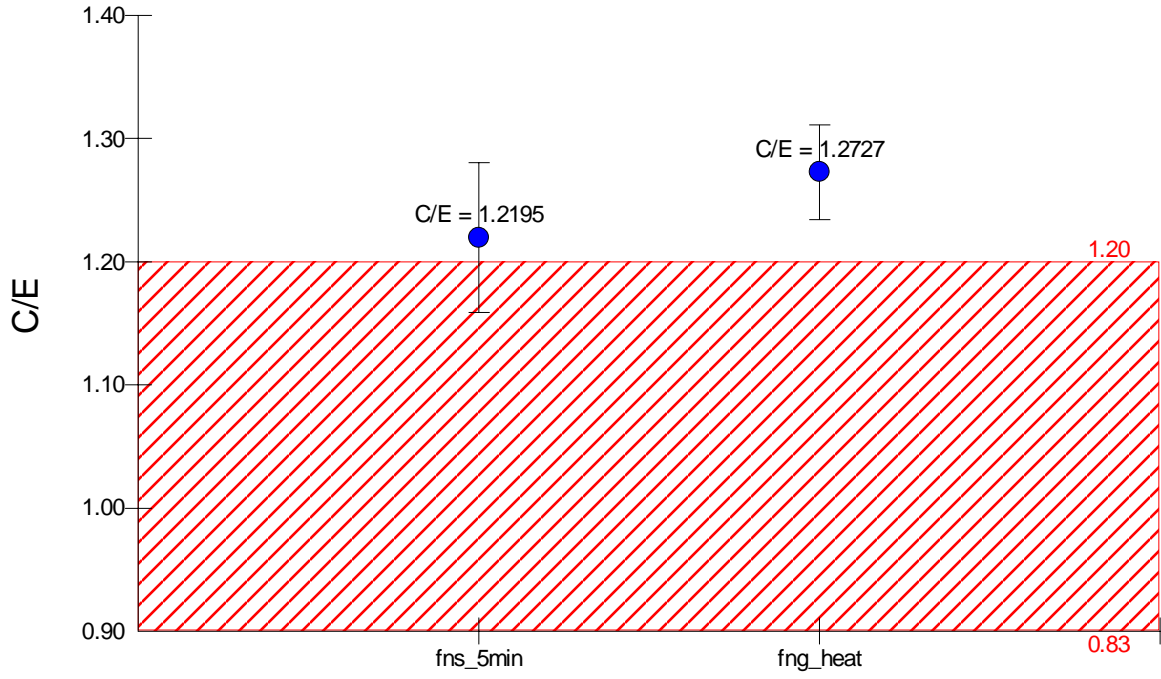
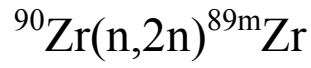


# $^{89}\text{Y}(n,\alpha)^{86}\text{Rb}$

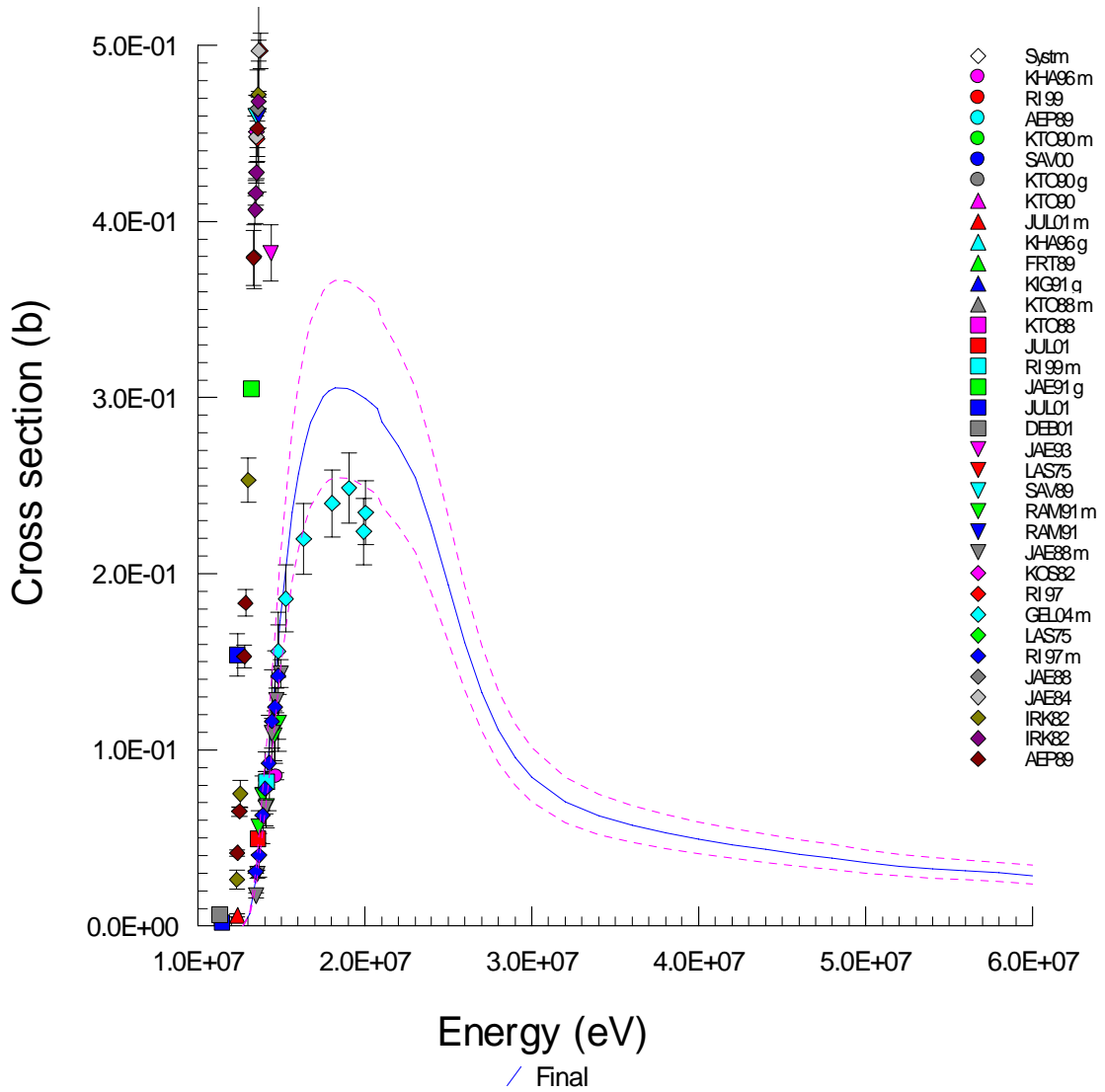


## Neutron Spectrum

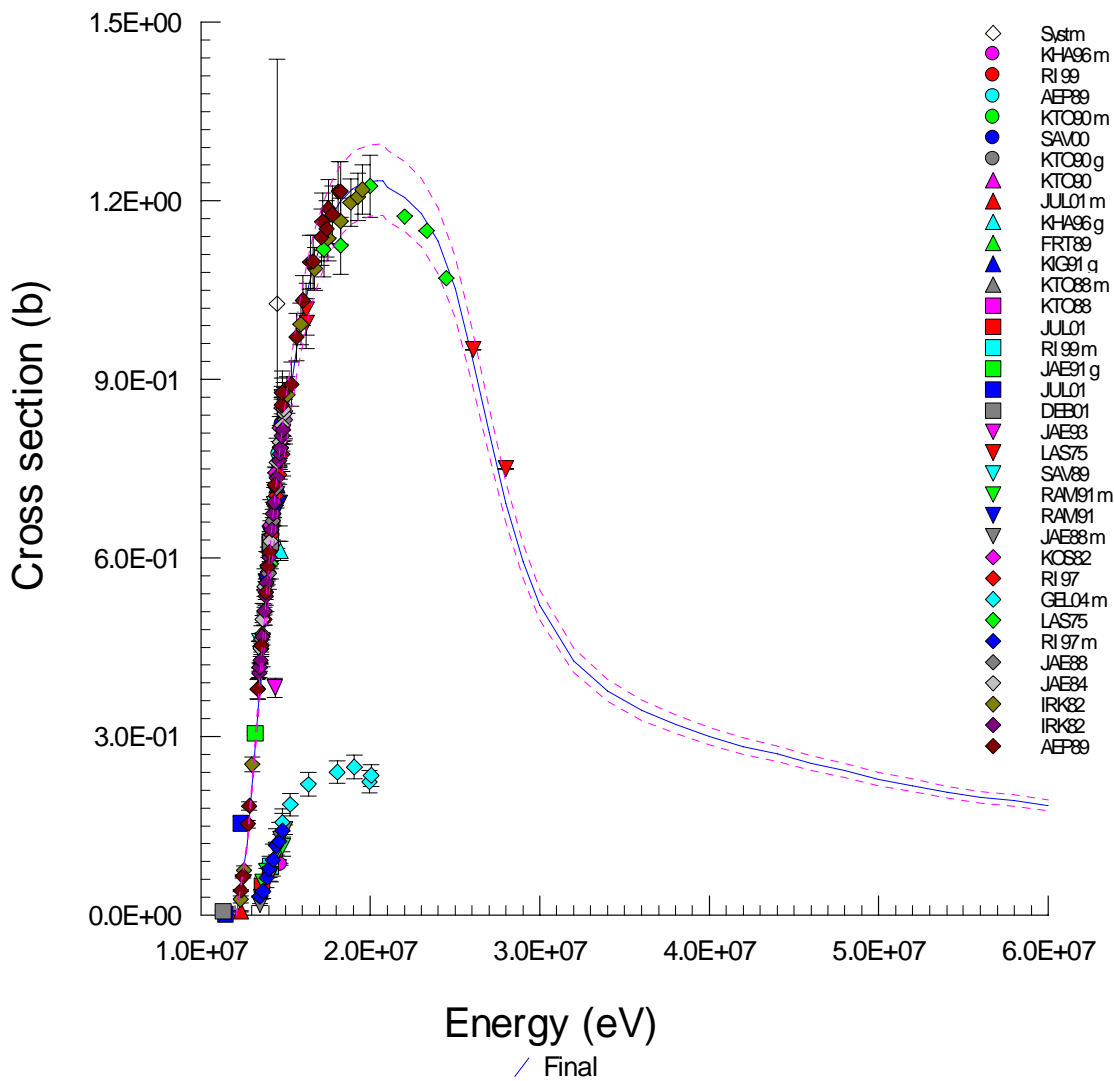
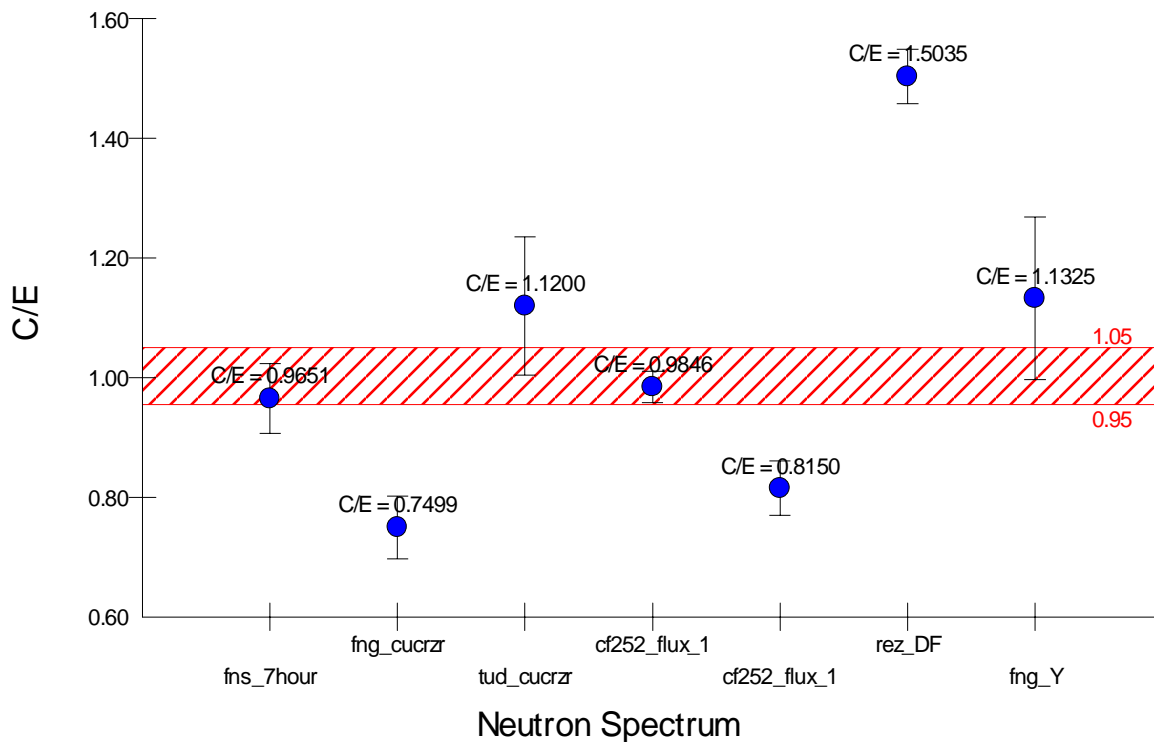




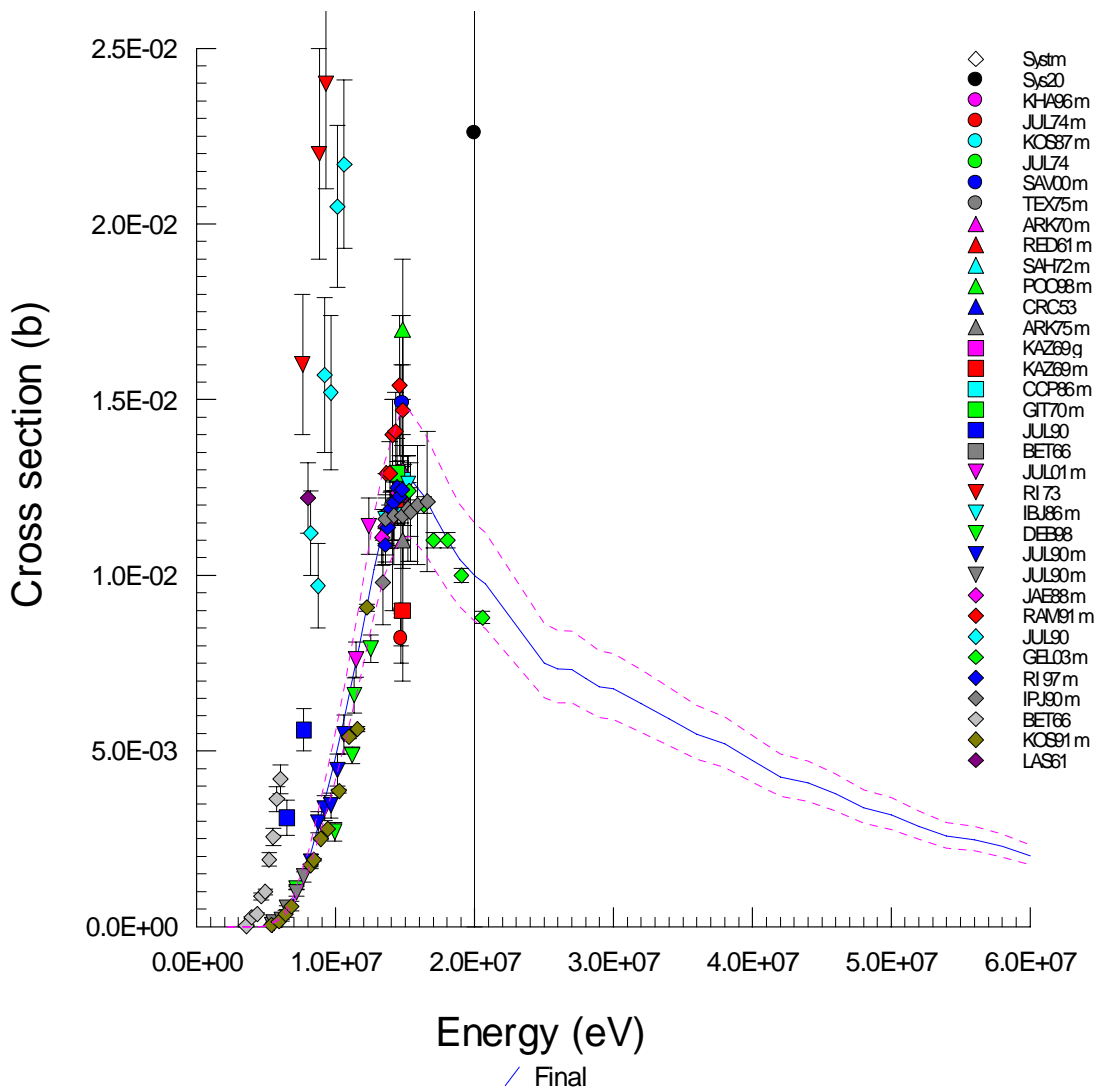
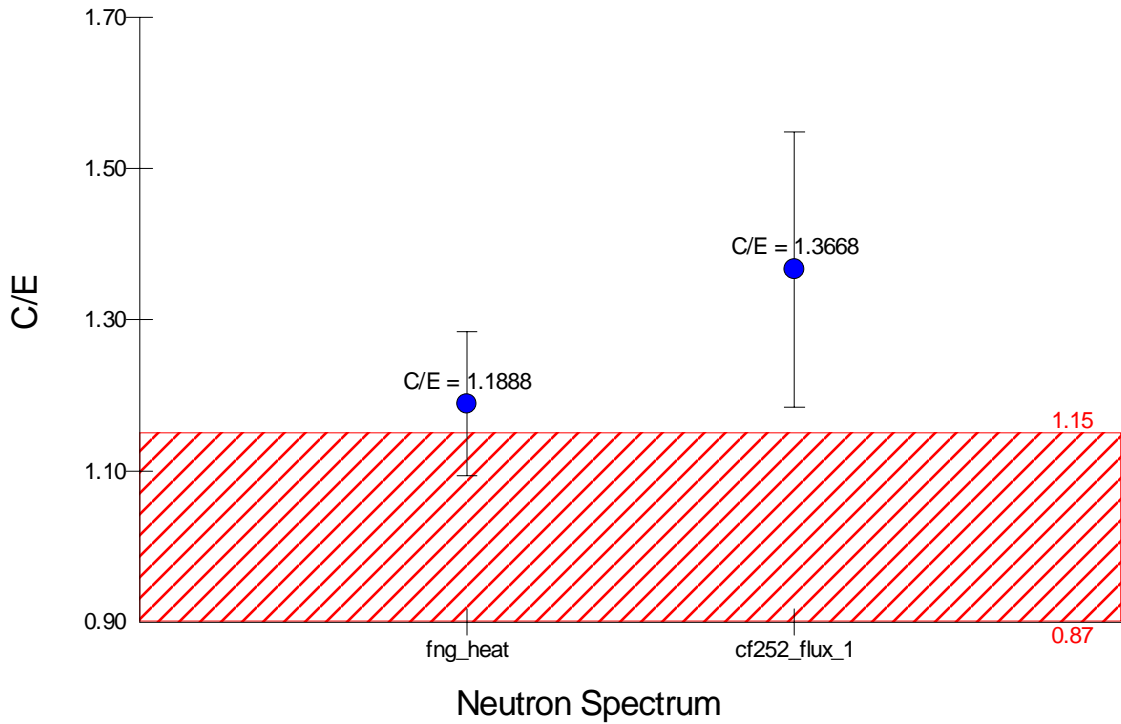
Neutron Spectrum



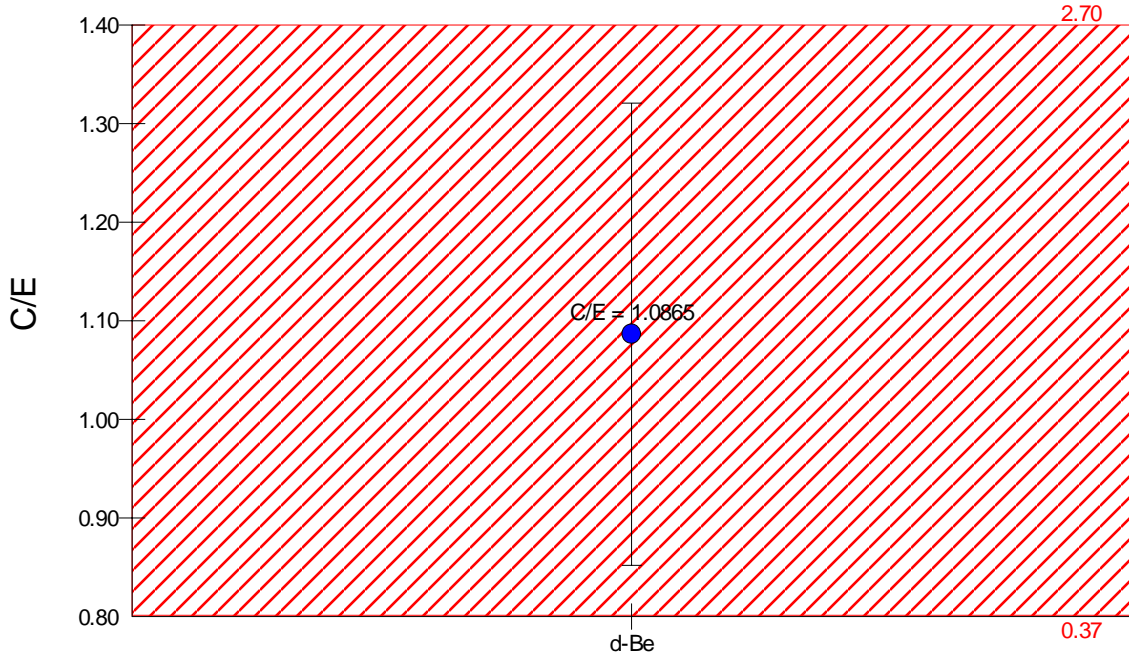
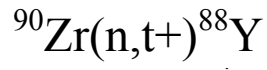
$^{90}\text{Zr}(n,2n)^{89}\text{Zr} \blacktriangleright 553$



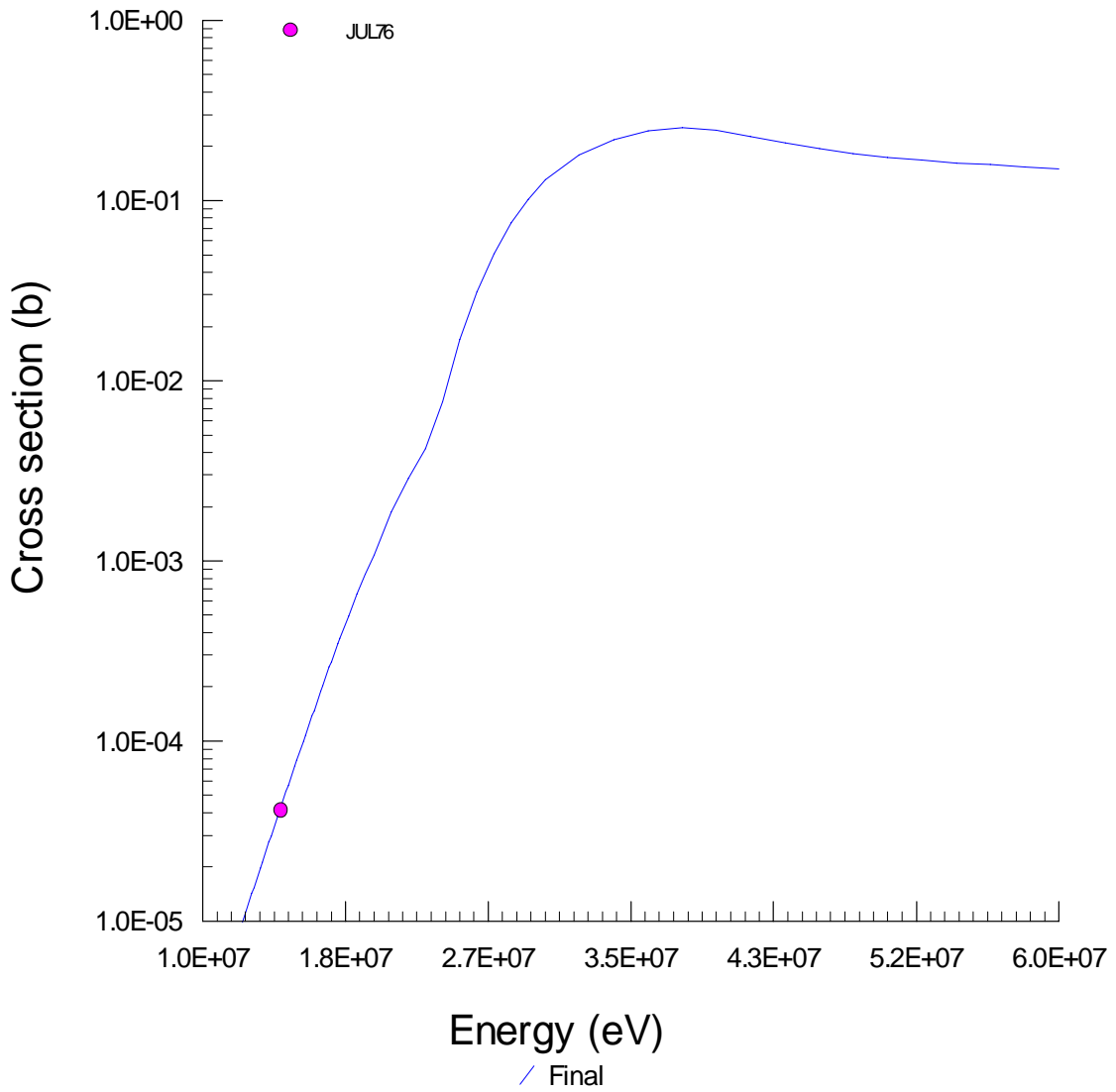
$^{90}\text{Zr}(n,p)^{90\text{m}}\text{Y}$

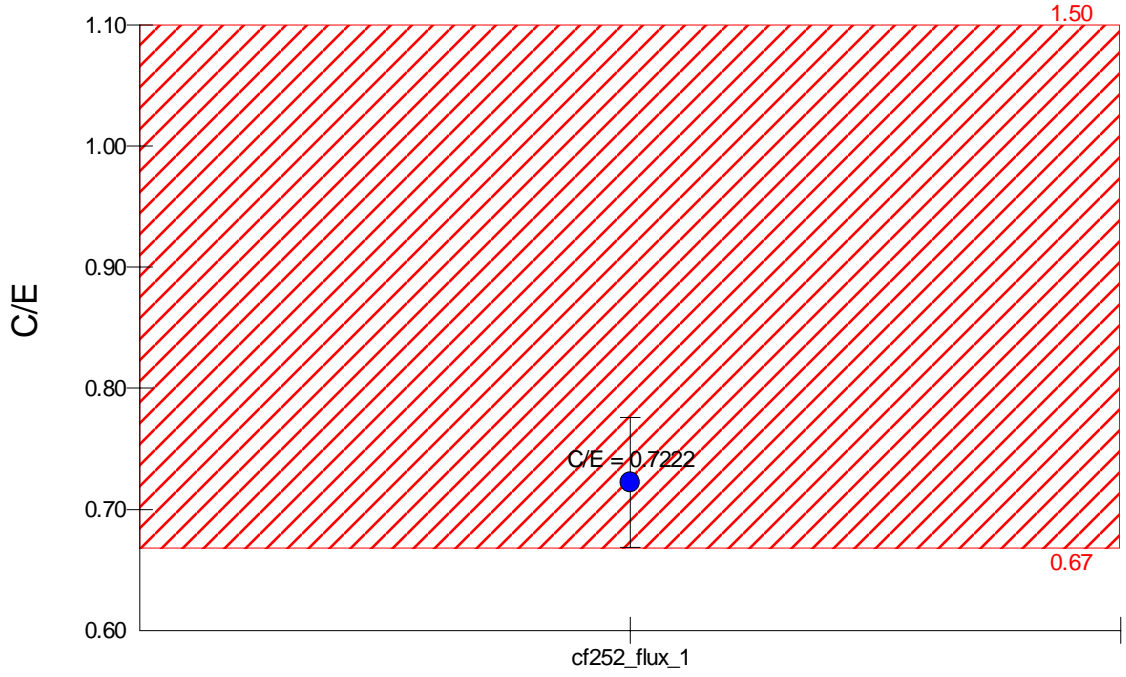
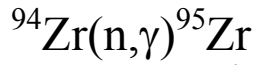




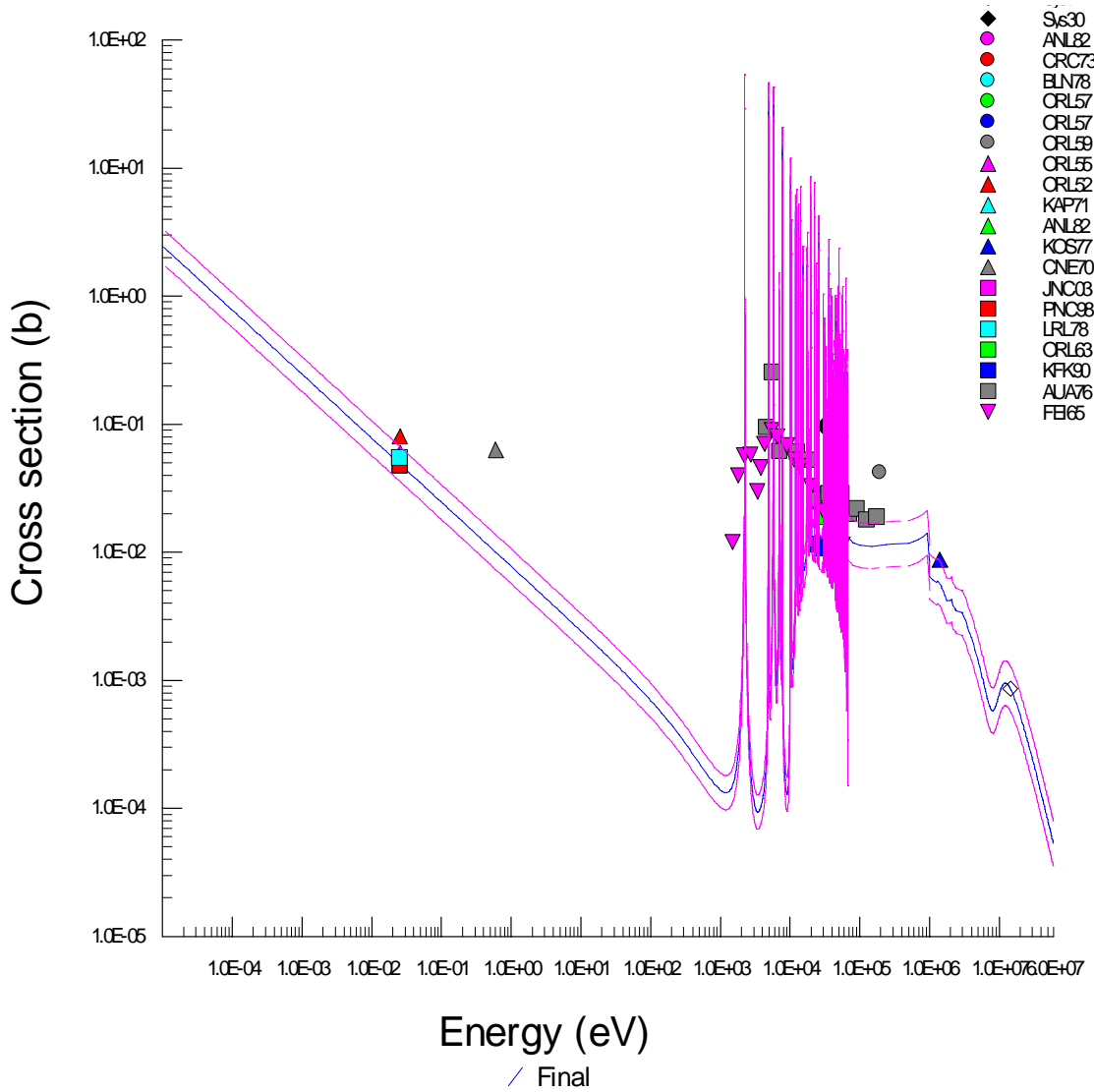


Neutron Spectrum

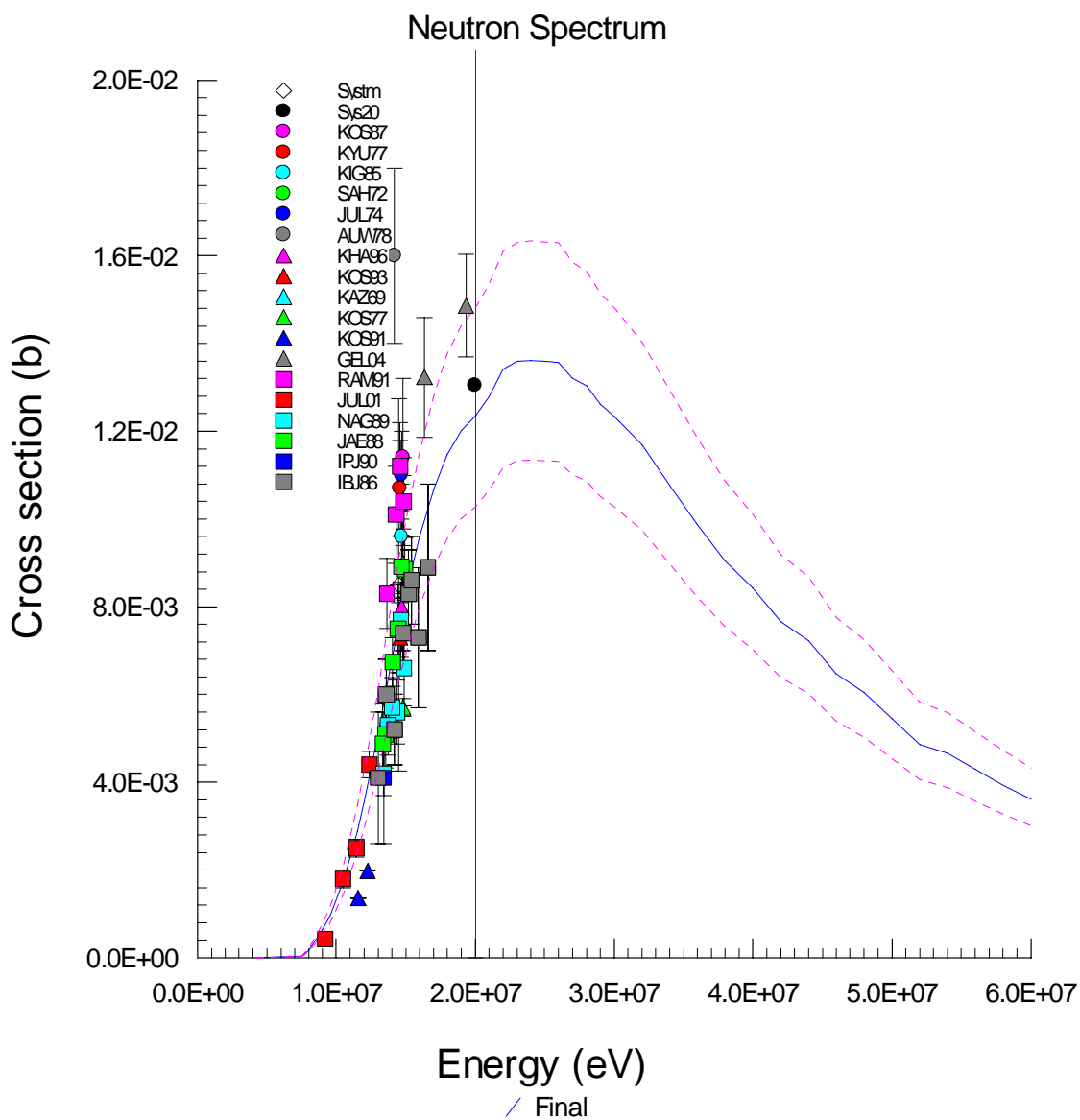
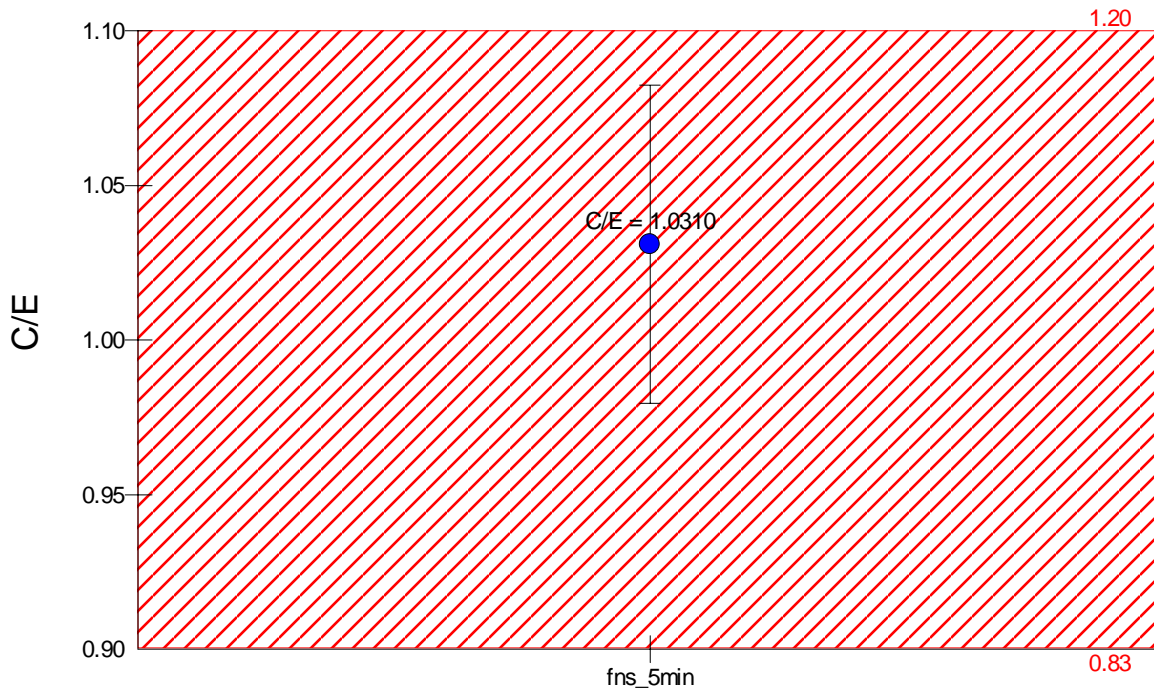




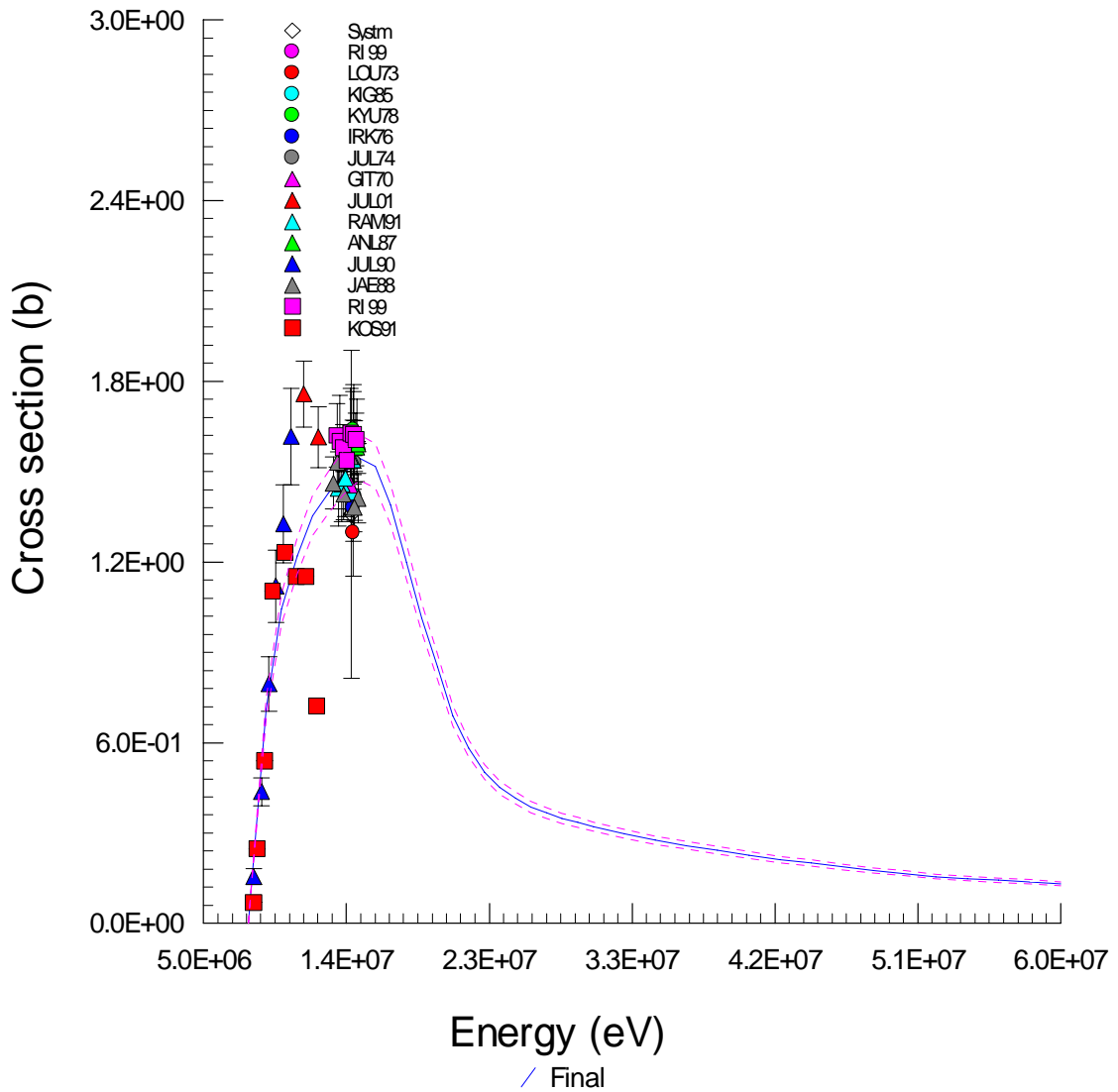
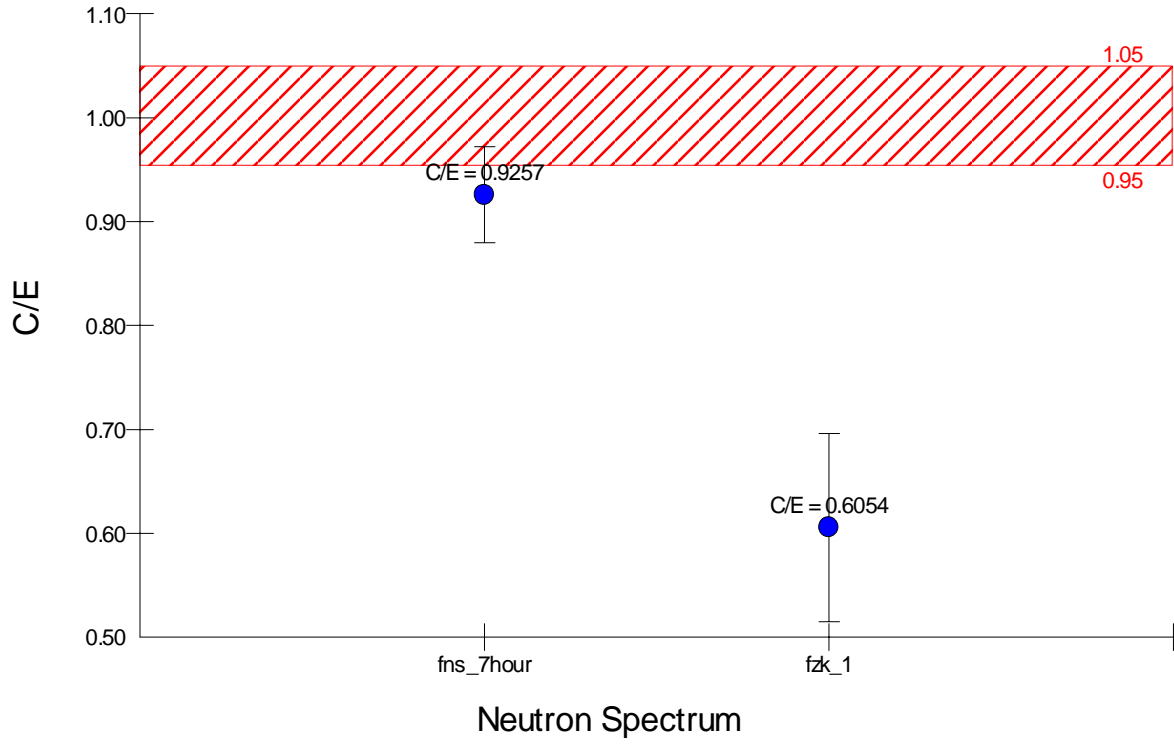
Neutron Spectrum

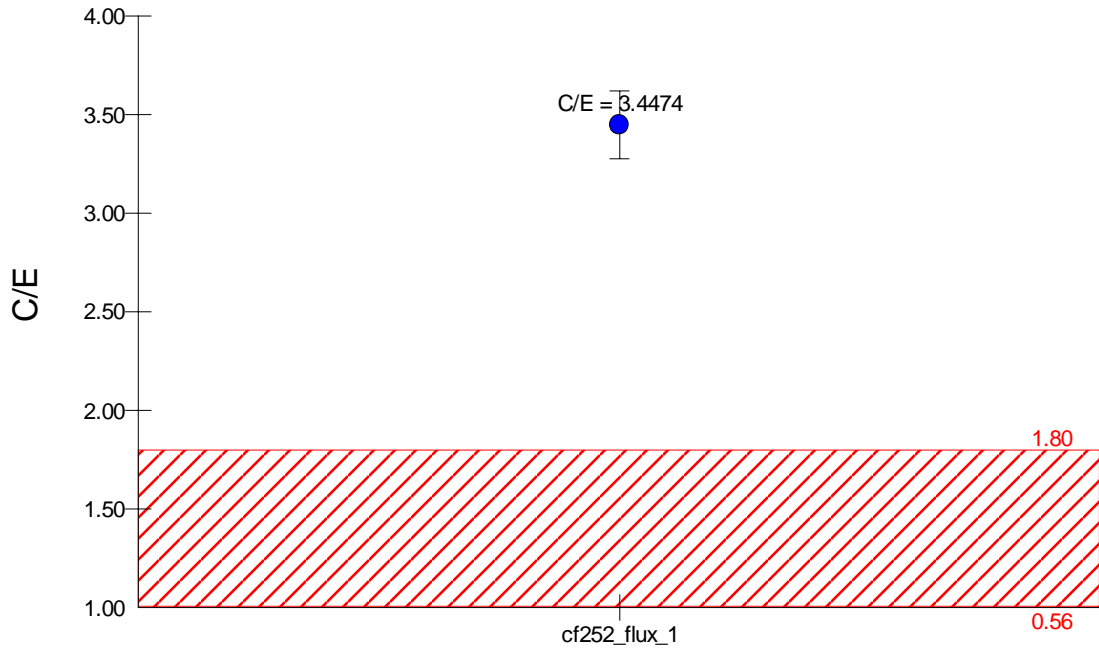
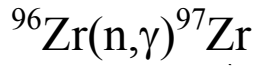


$^{94}\text{Zr}(n,p)^{94}\text{Y}$

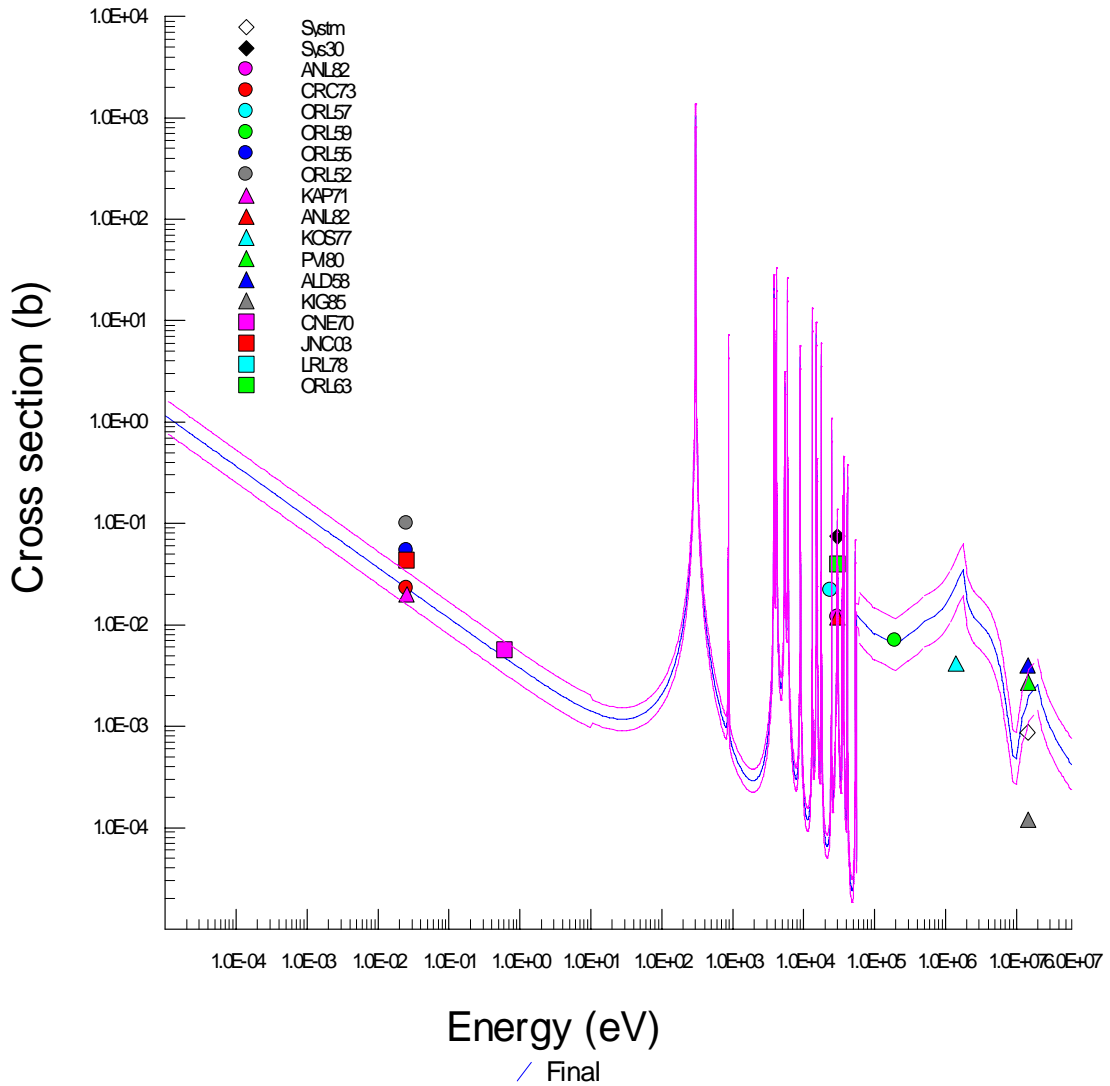


$^{96}\text{Zr}(n,2n)^{95}\text{Zr}$

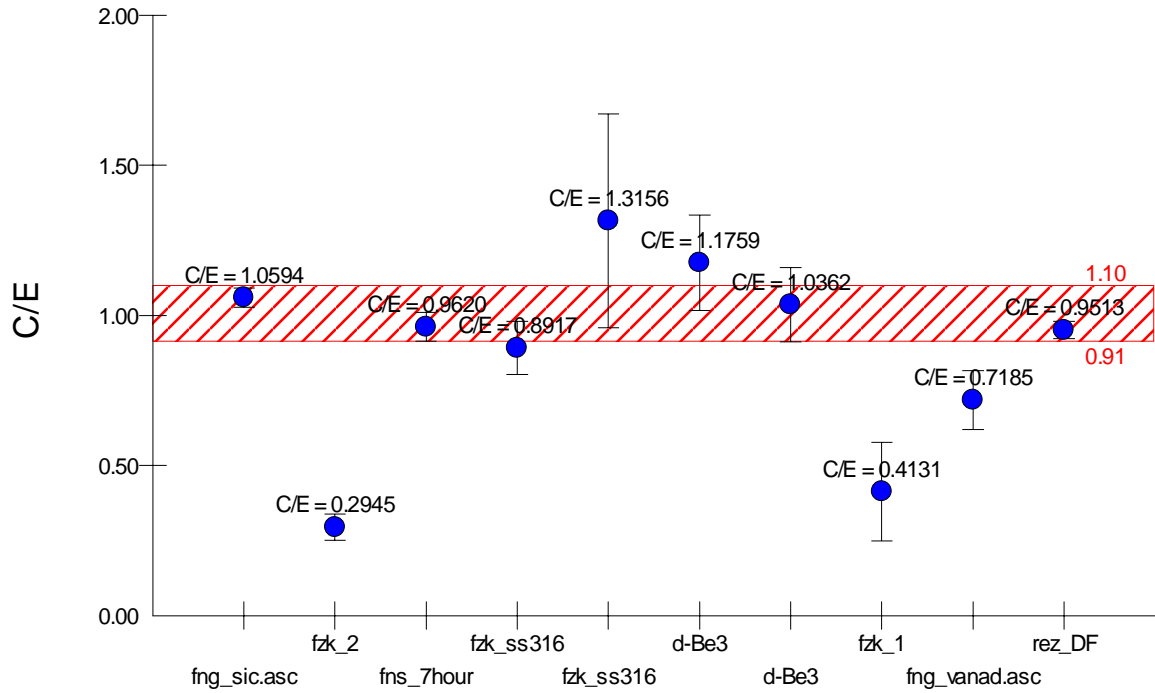




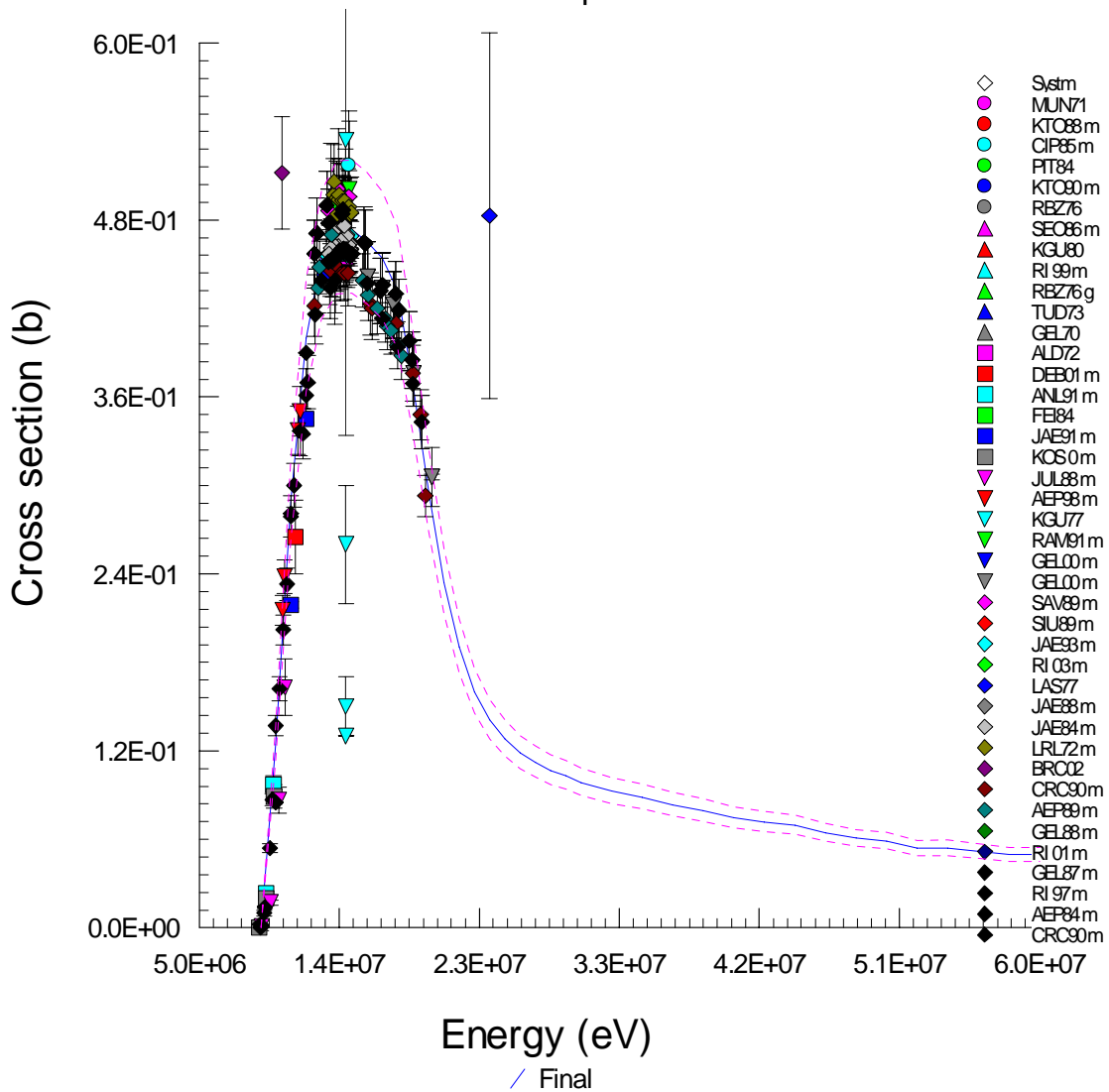
Neutron Spectrum

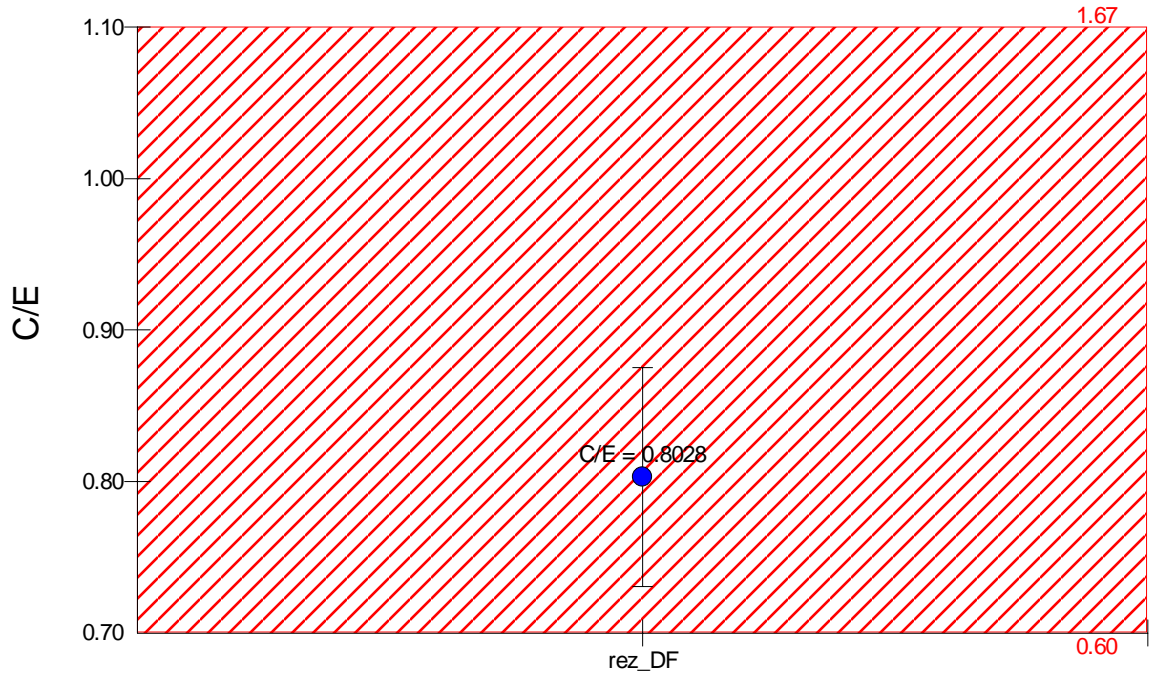
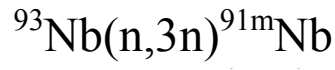


$^{93}\text{Nb}(n,2n)^{92\text{m}}\text{Nb} \blacktriangleright 553$

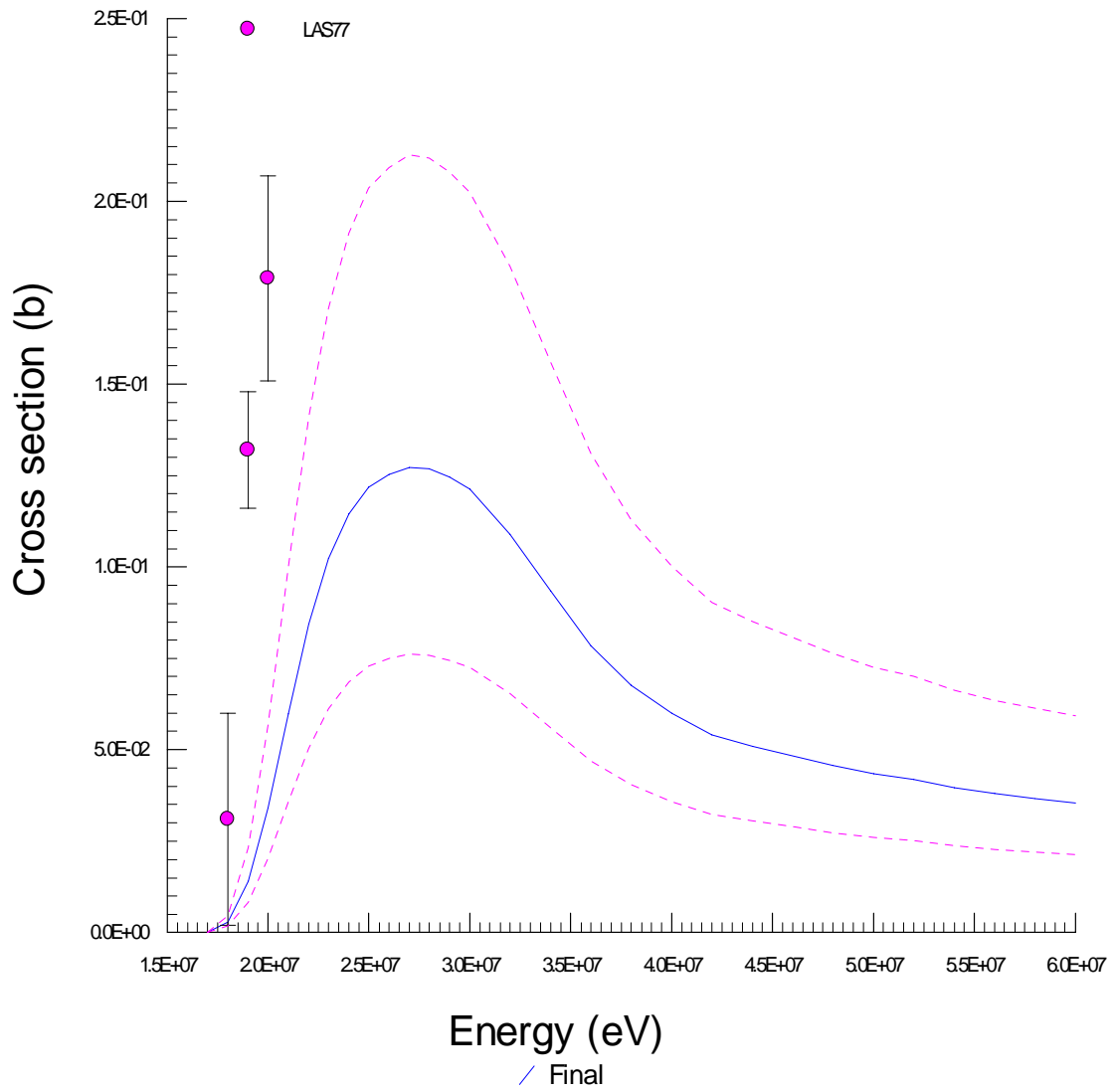


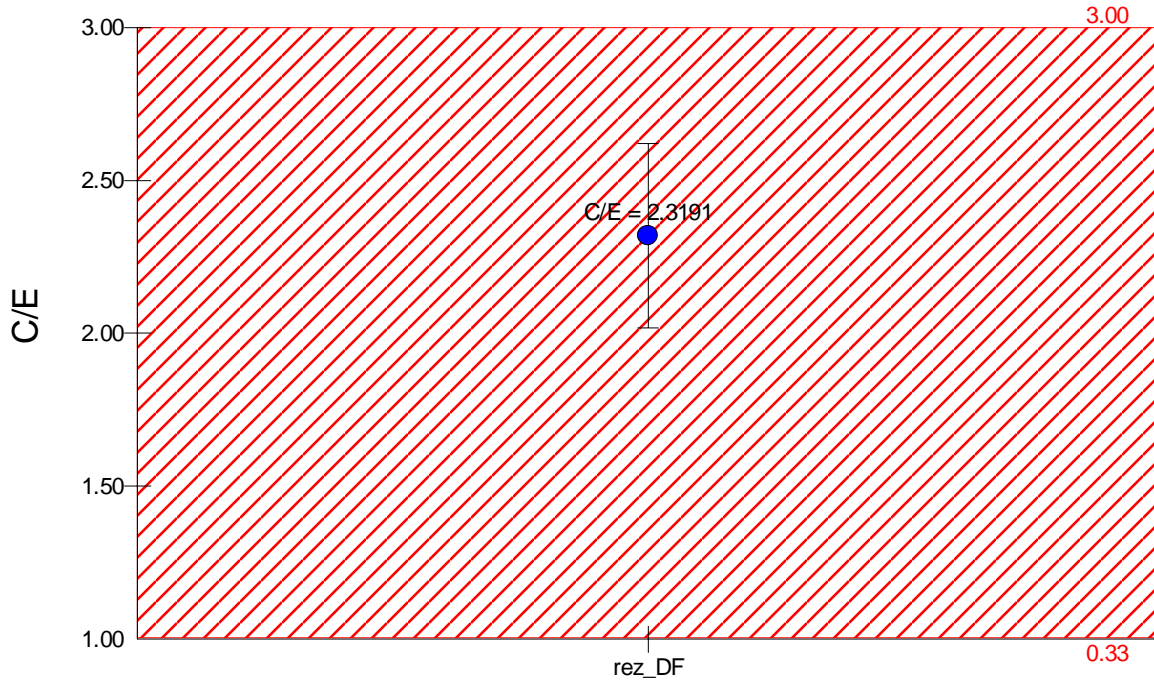
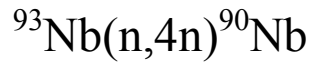
Neutron Spectrum



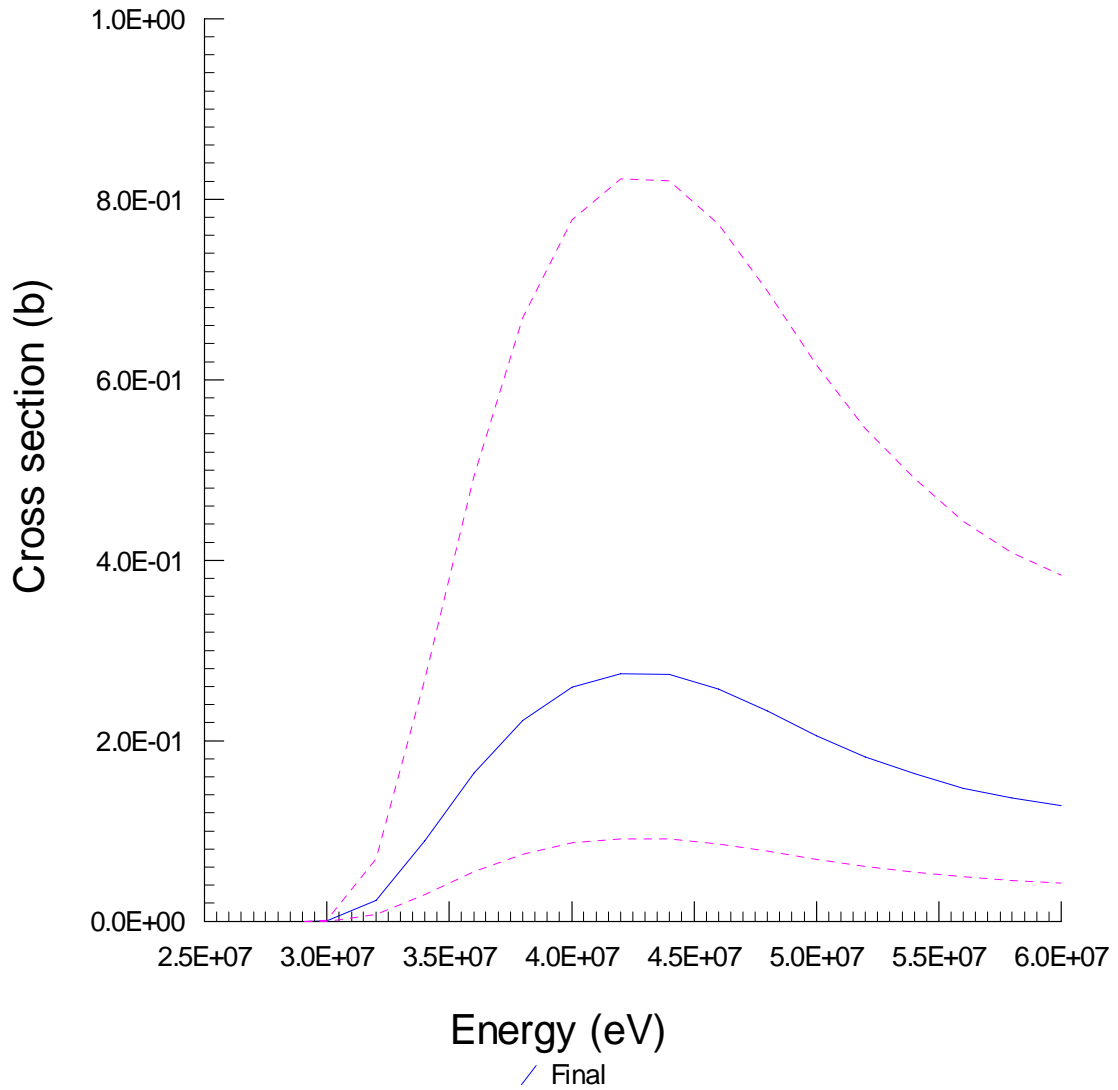


Neutron Spectrum

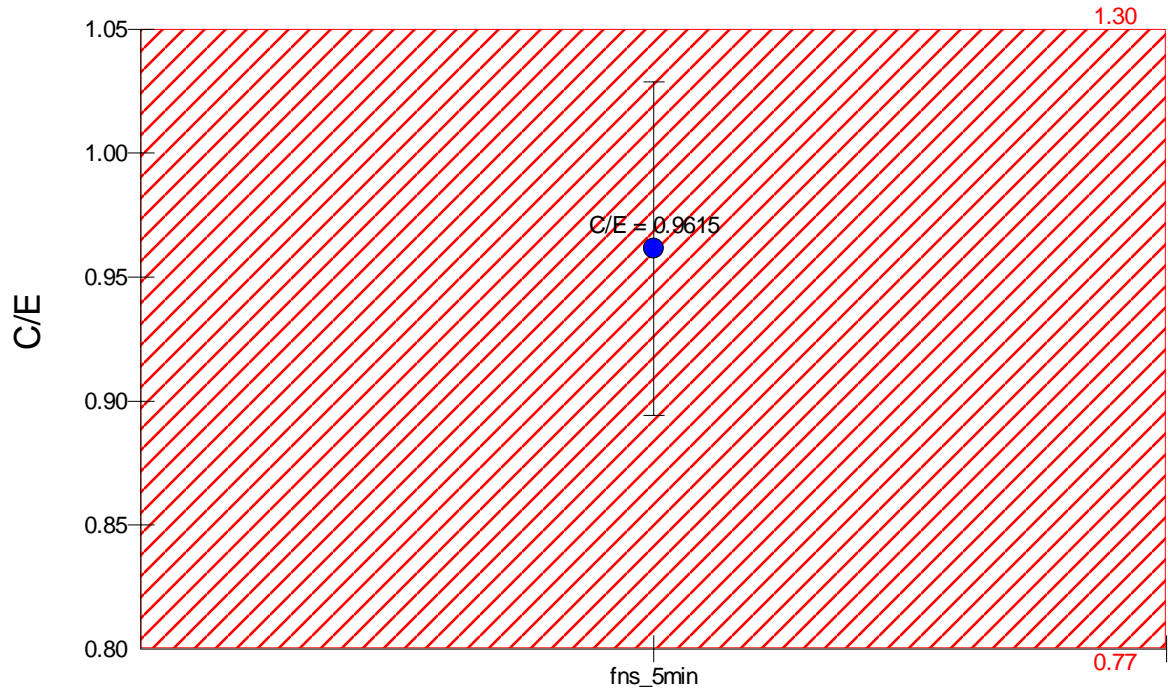
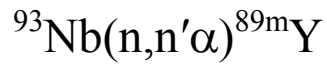




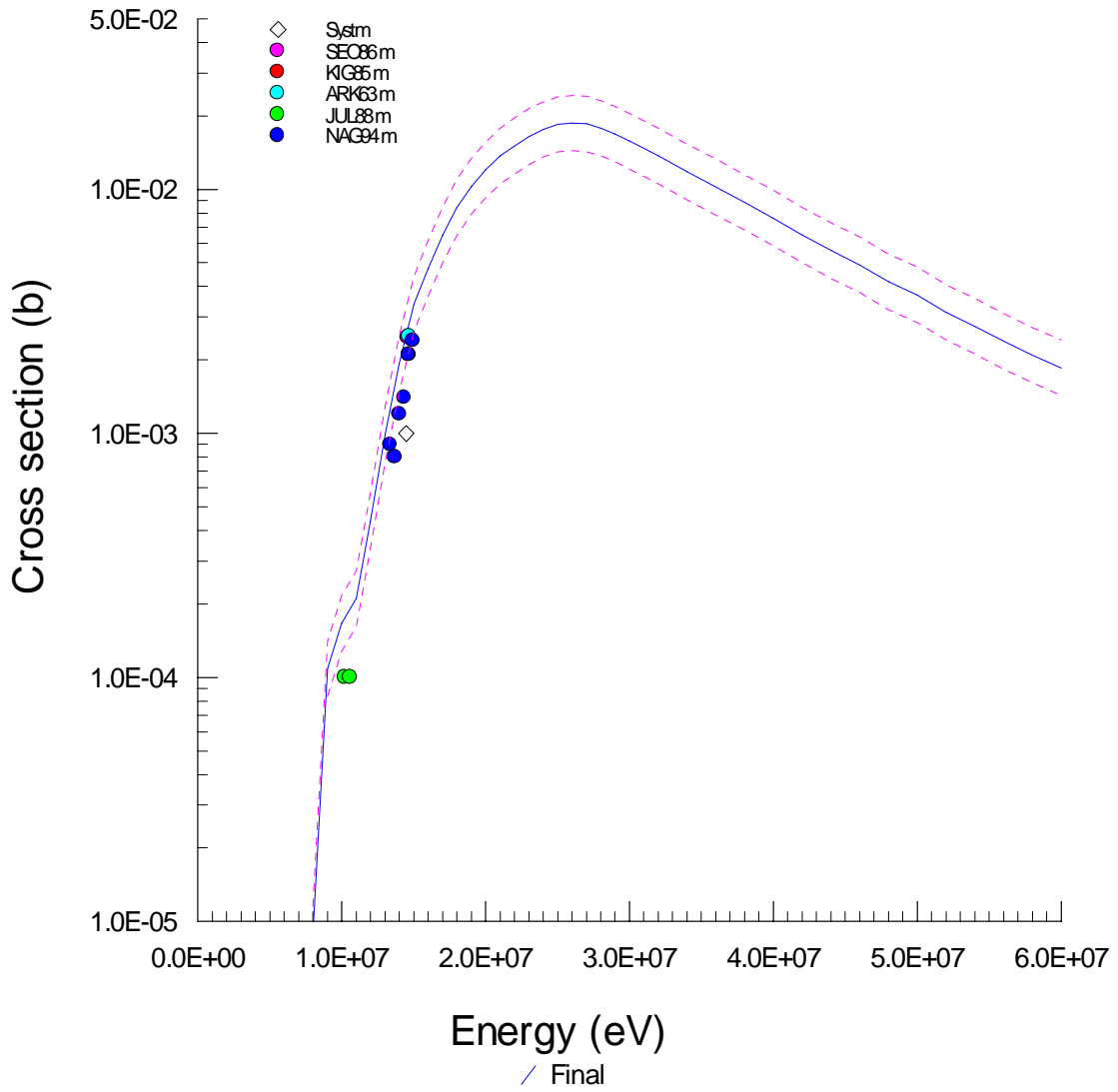
Neutron Spectrum

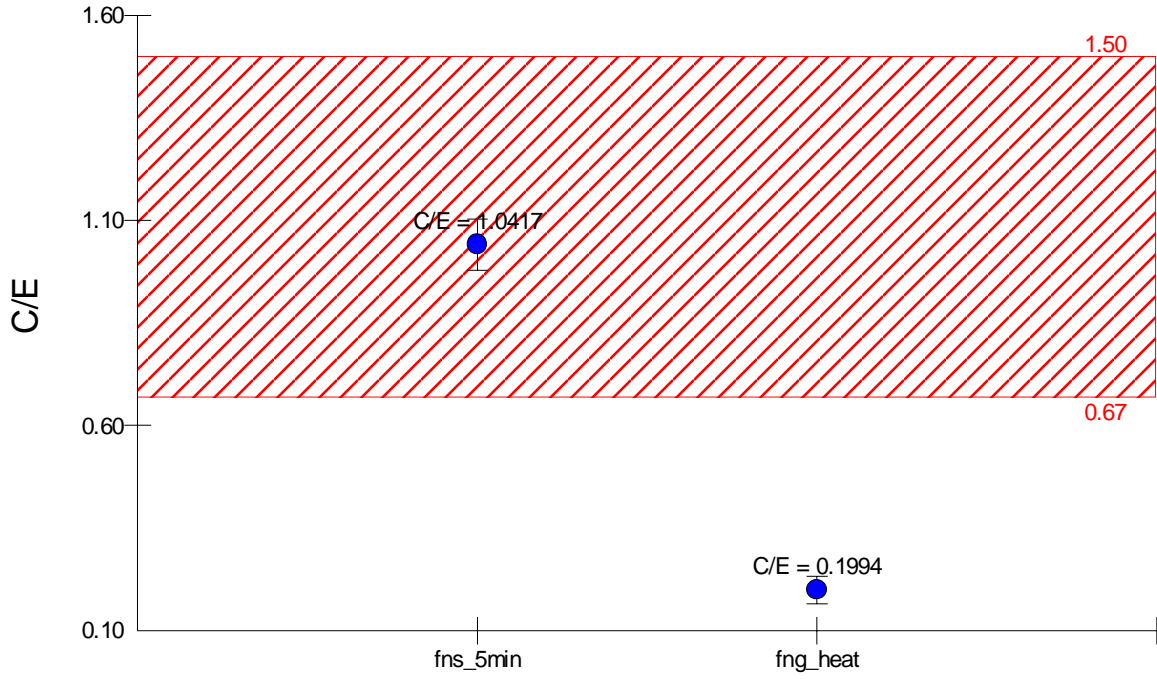
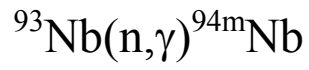




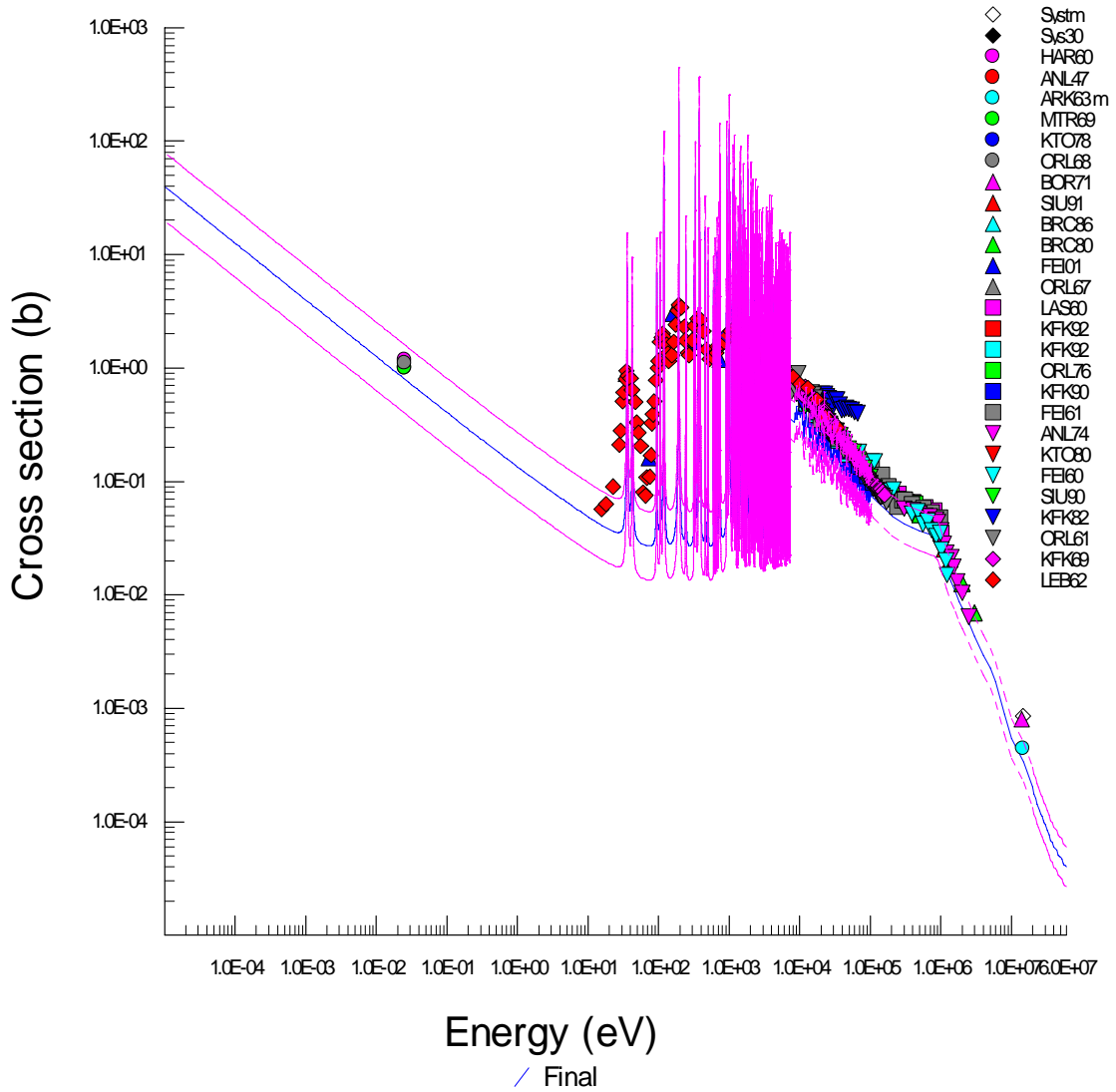


Neutron Spectrum

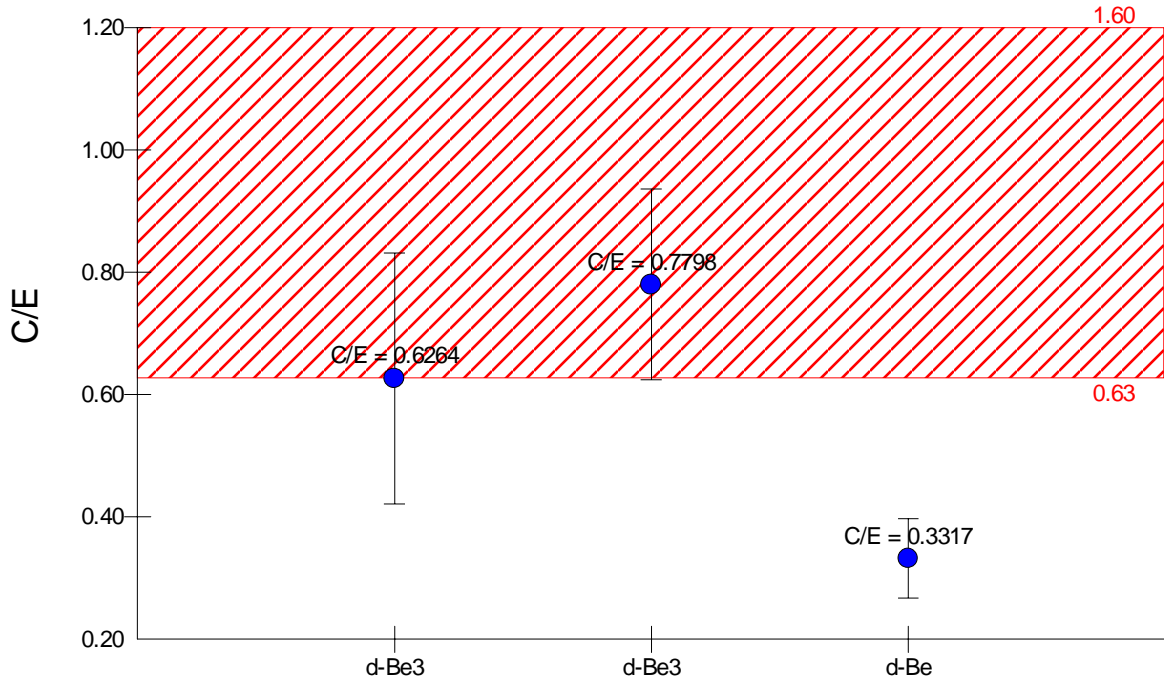




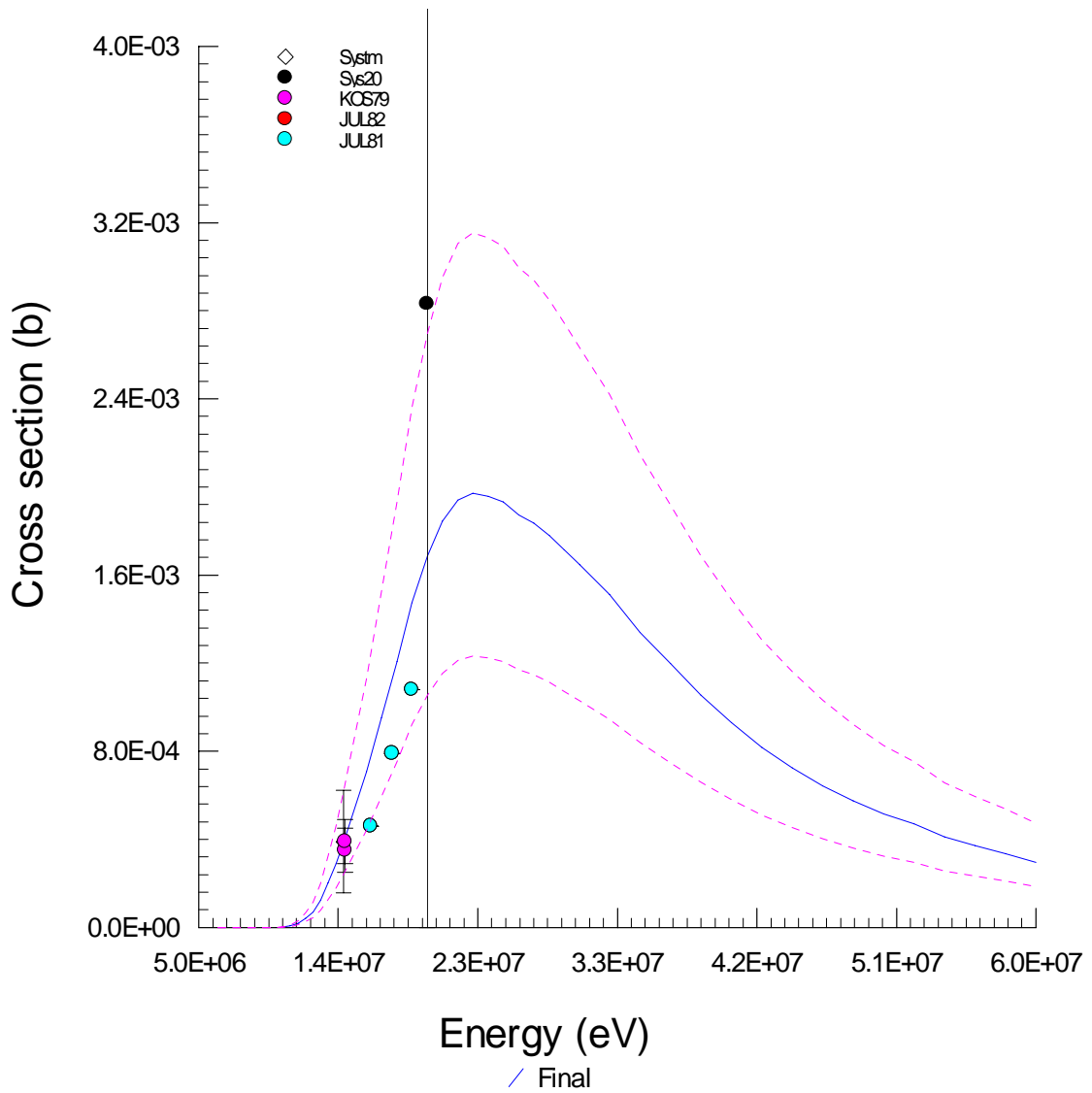
Neutron Spectrum



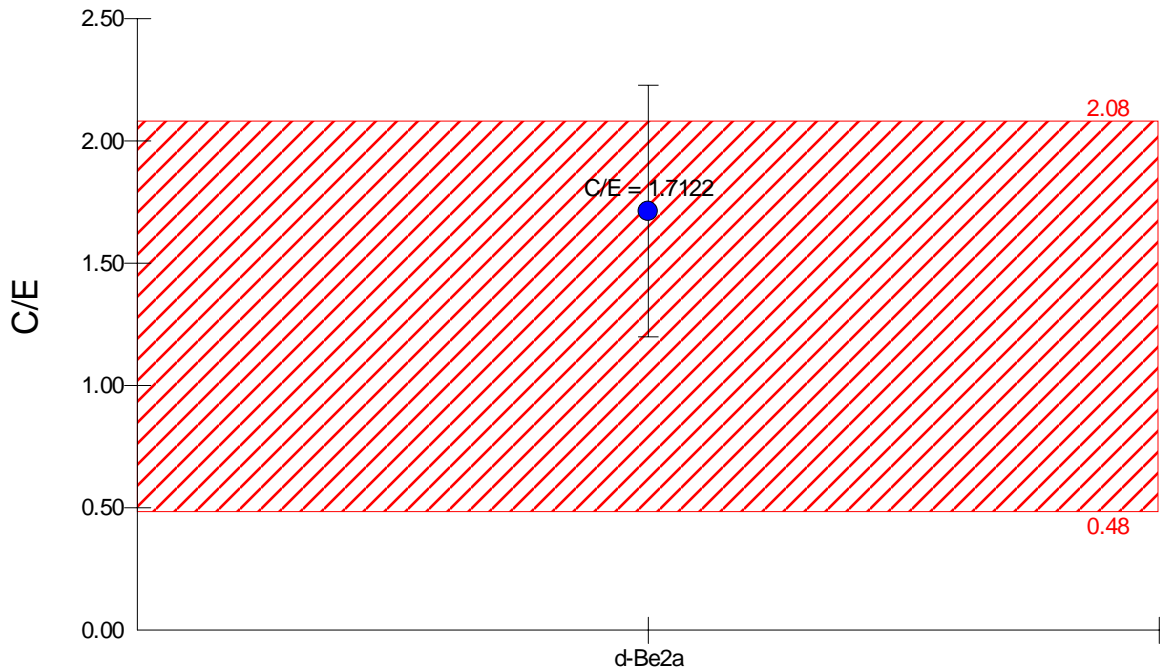
$^{93}\text{Nb}(n,t)^{91}\text{Zr}$



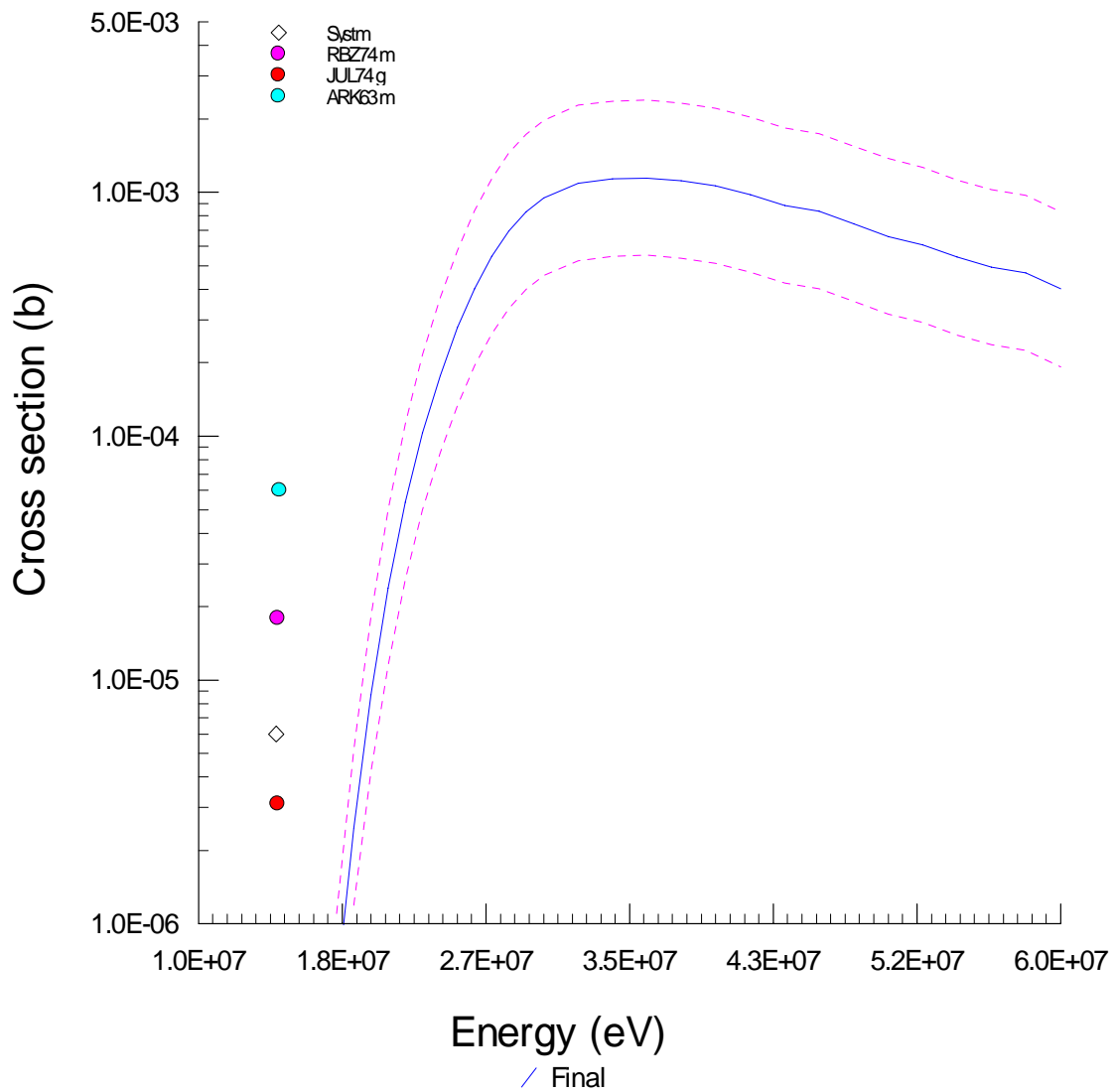
Neutron Spectrum



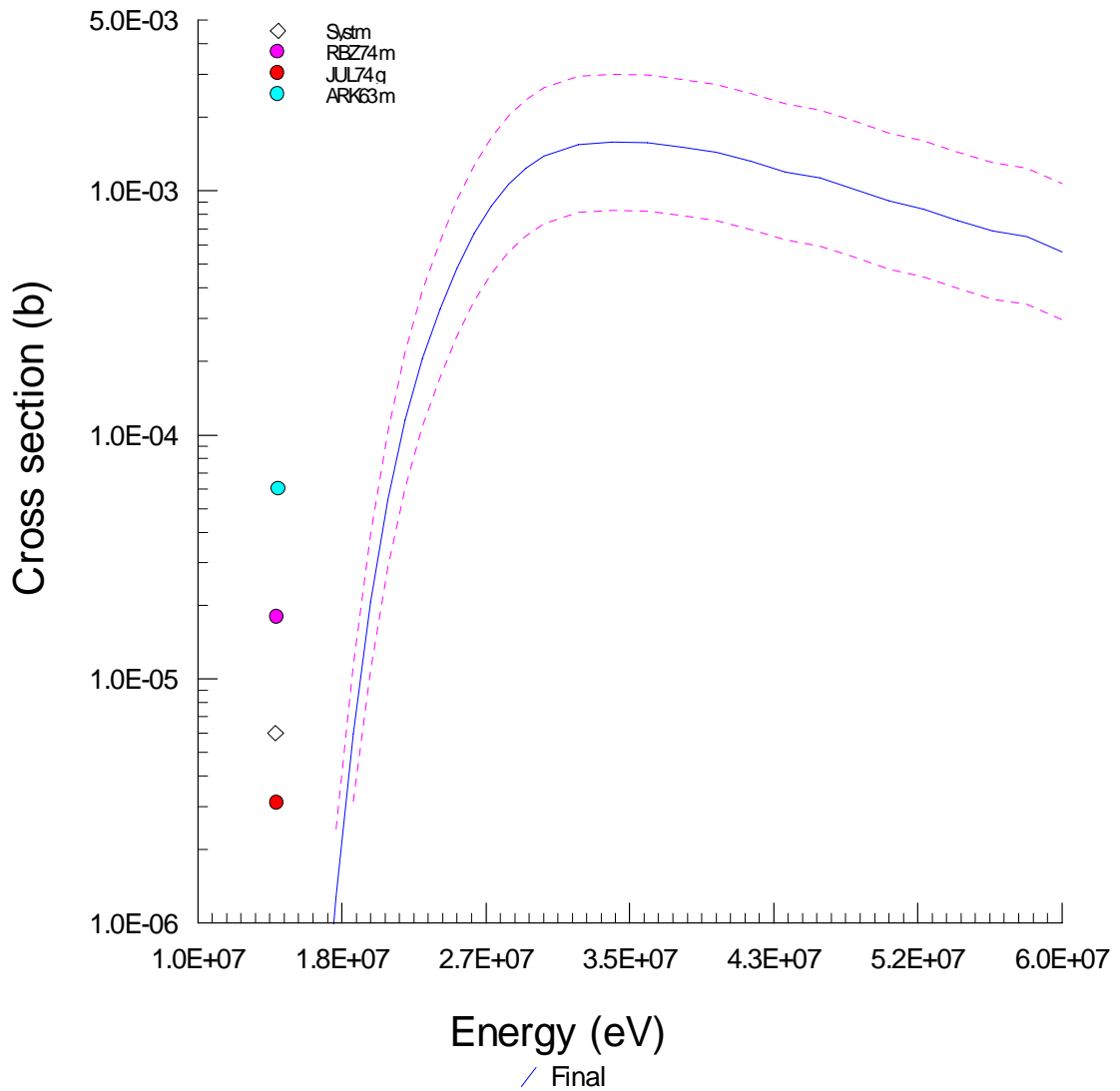
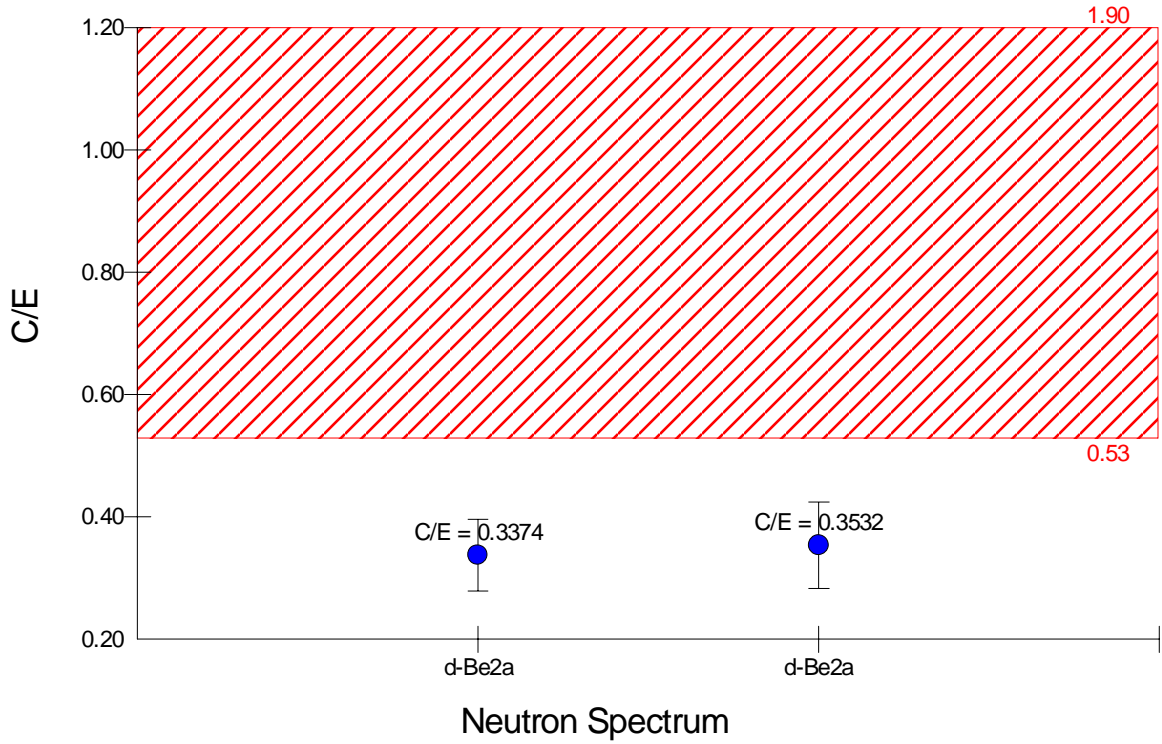
$^{93}\text{Nb}(n,h)^{91m}\text{Y}$



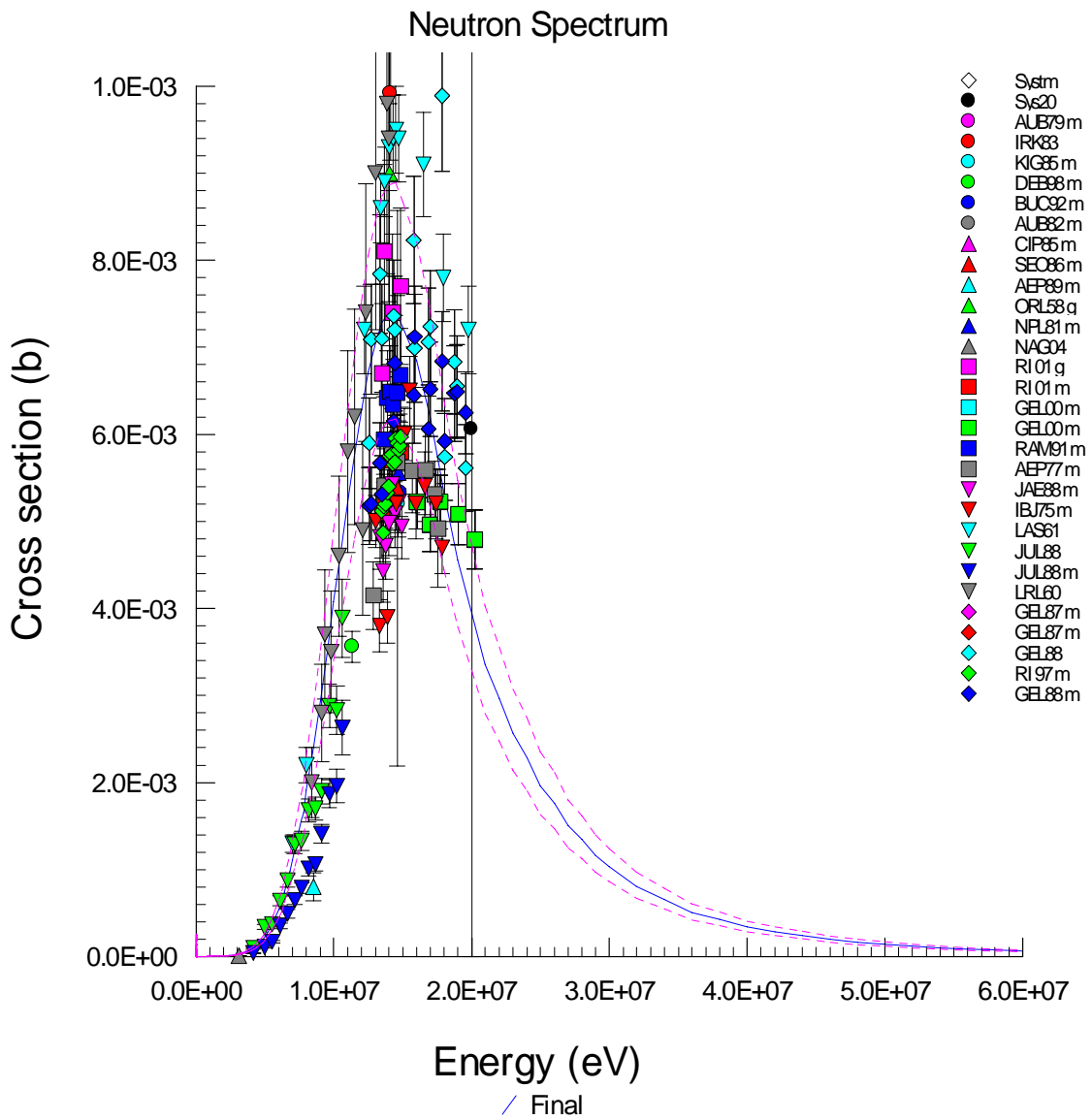
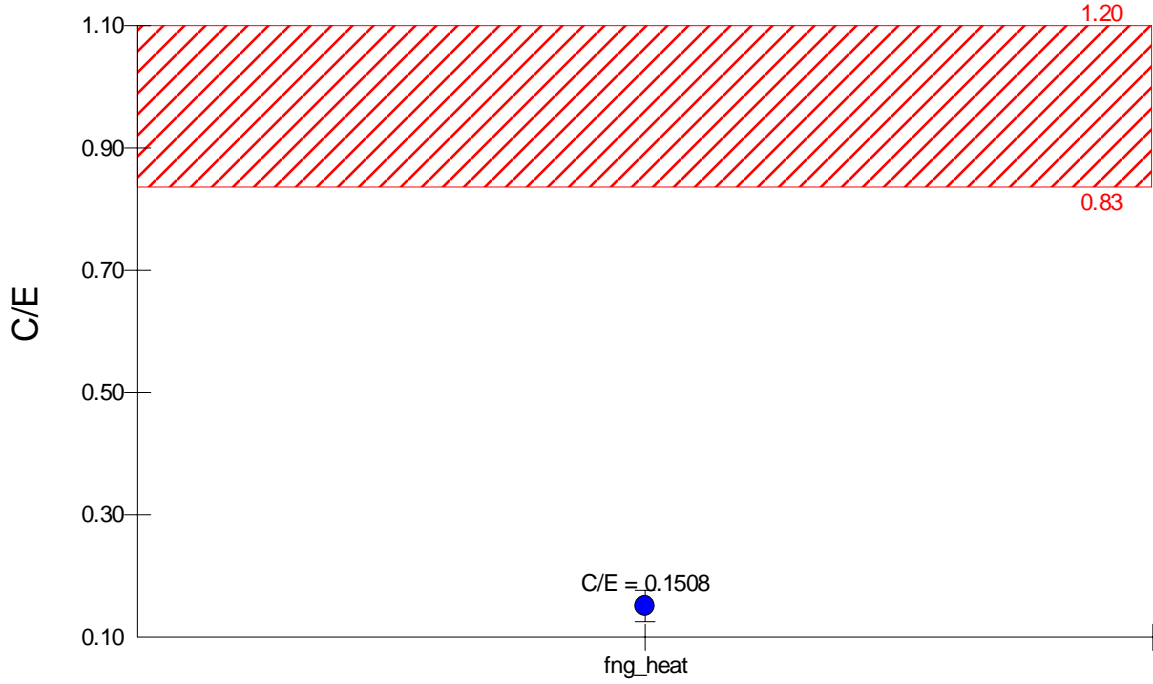
Neutron Spectrum



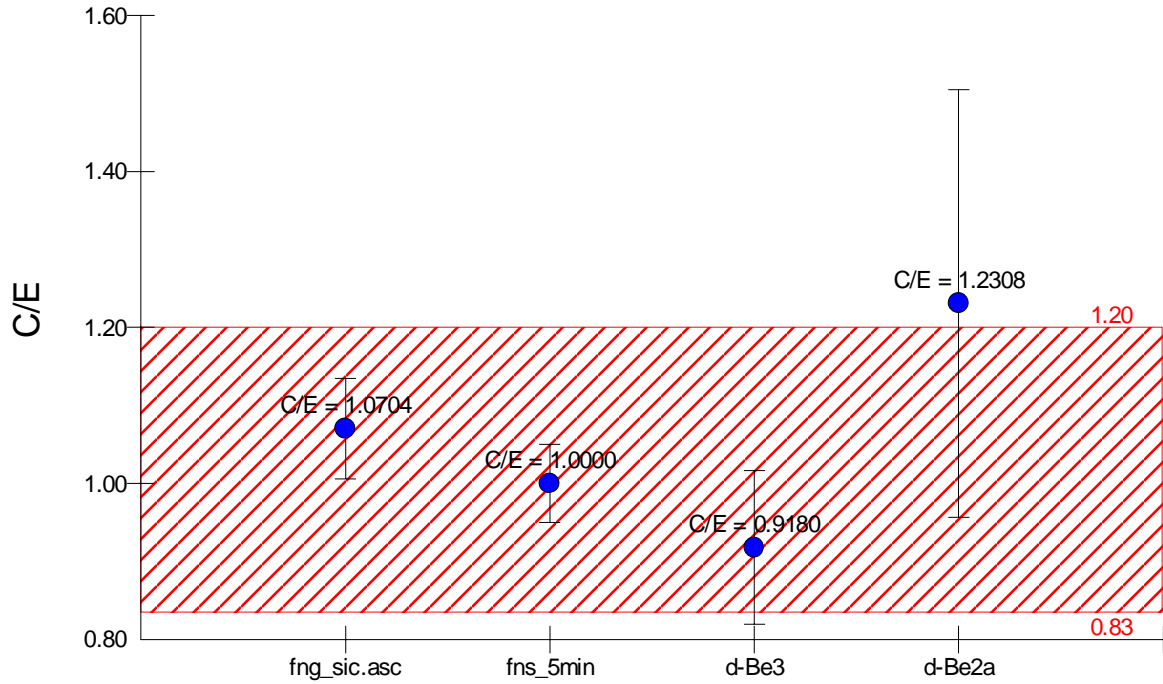
# $^{93}\text{Nb}(n,h)^{91}\text{Y}$



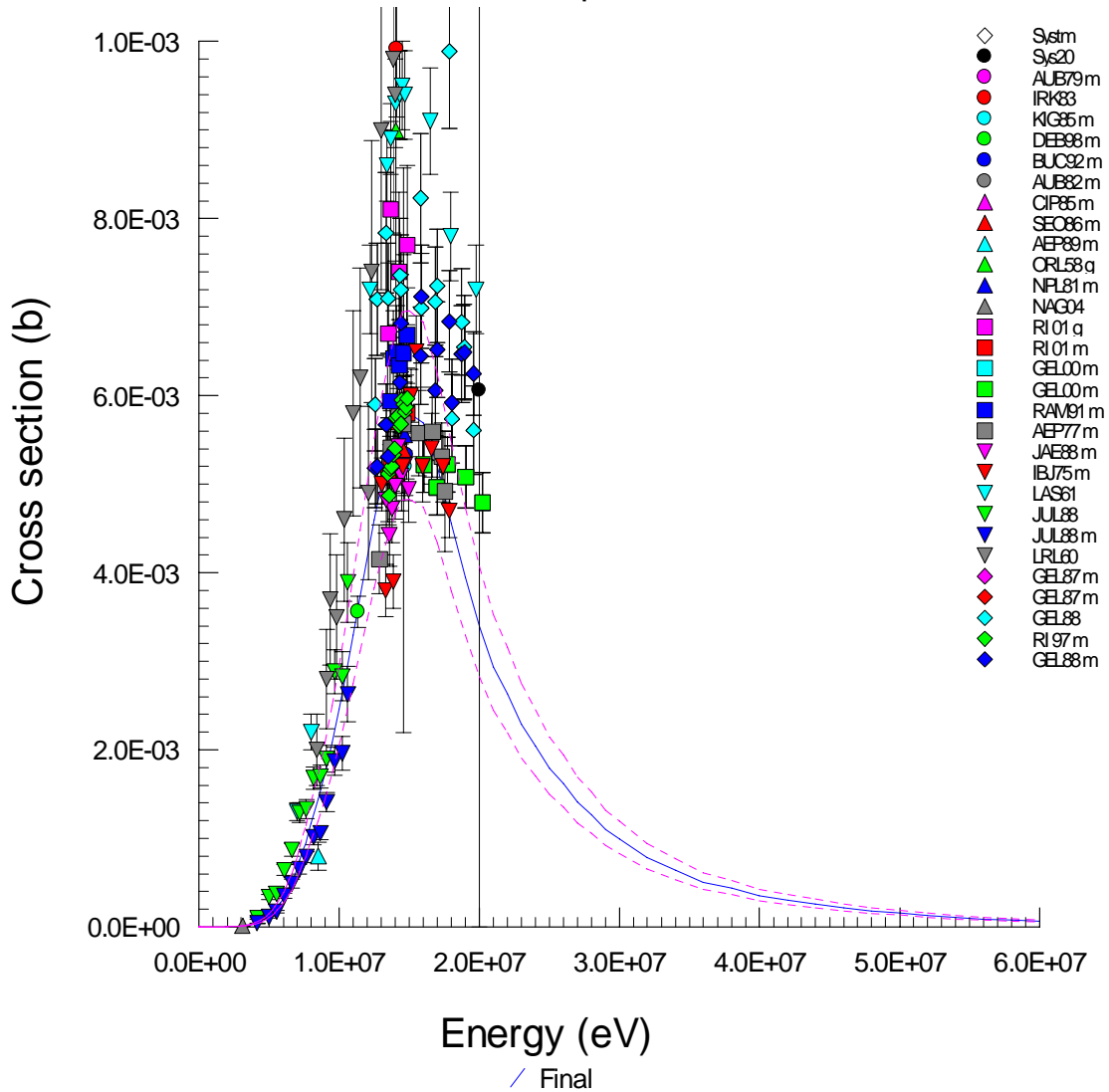
$^{93}\text{Nb}(n,\alpha)^{90\text{g}}\text{Y}$

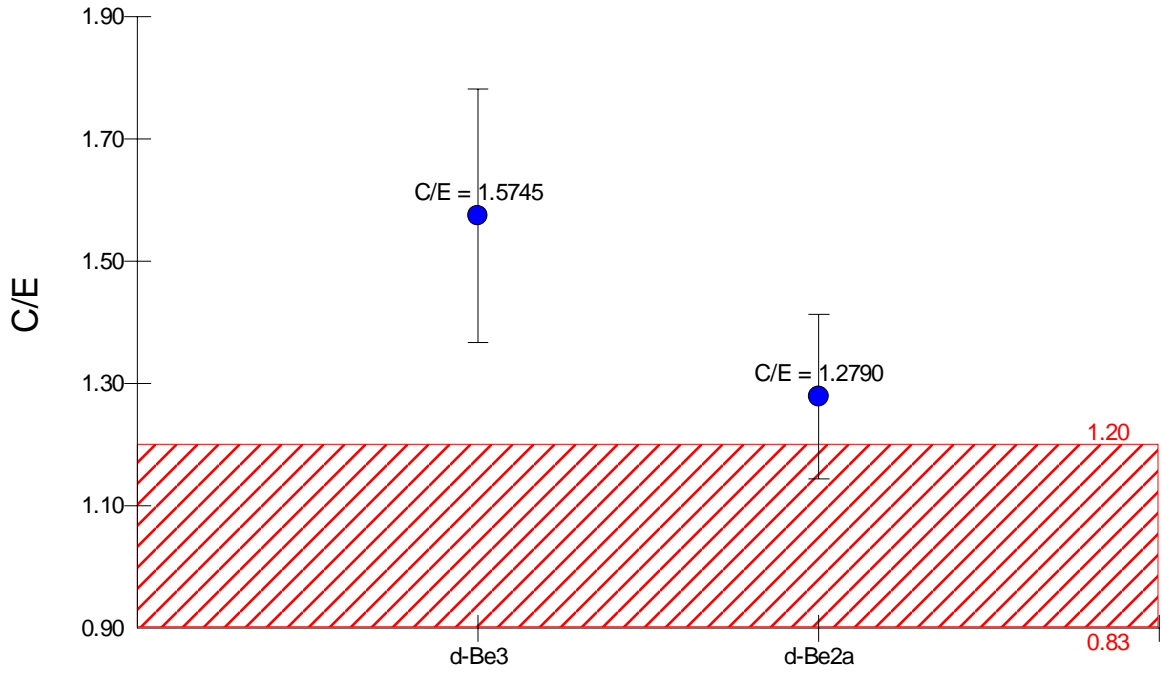
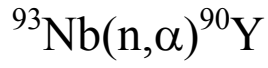


$^{93}\text{Nb}(n,\alpha)^{90\text{m}}\text{Y}$

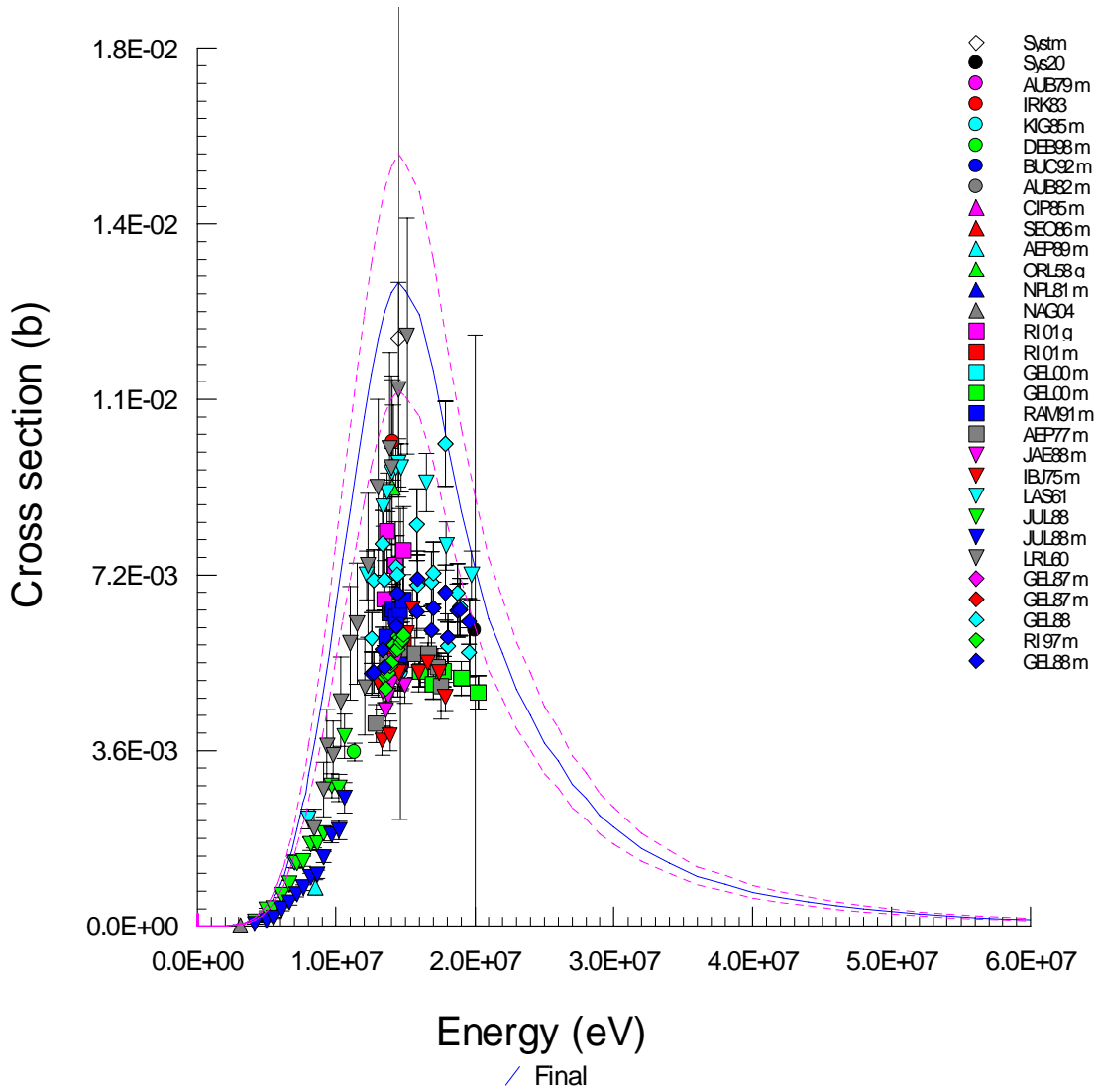


Neutron Spectrum

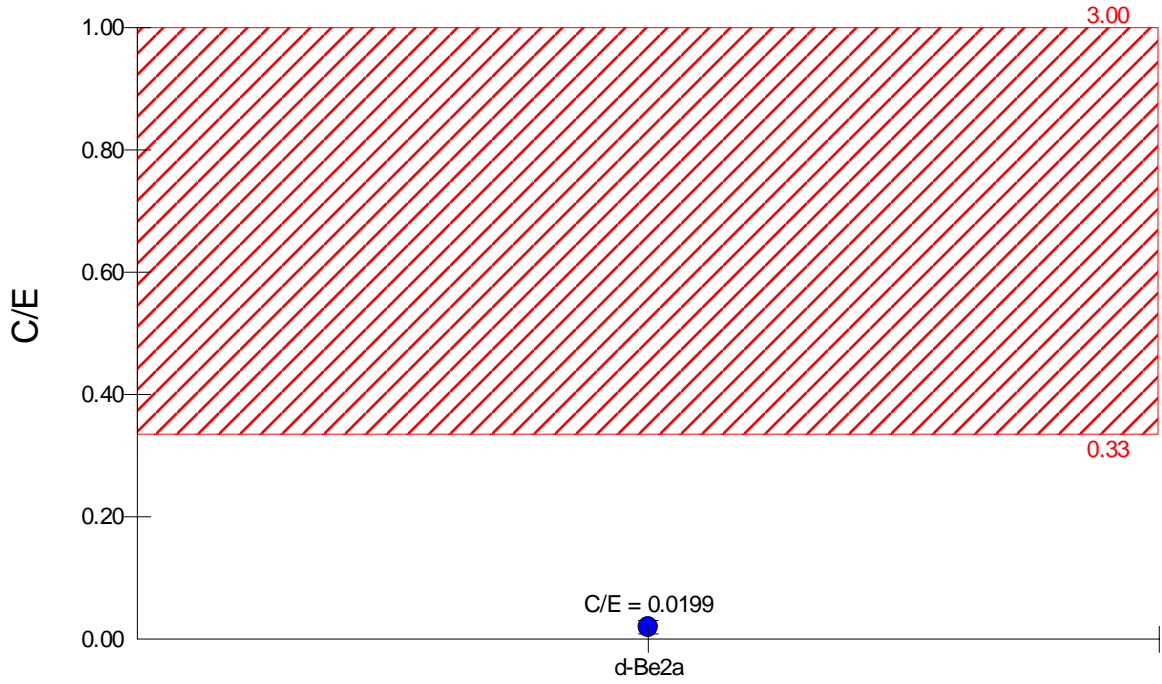
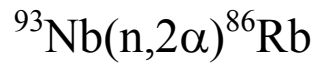




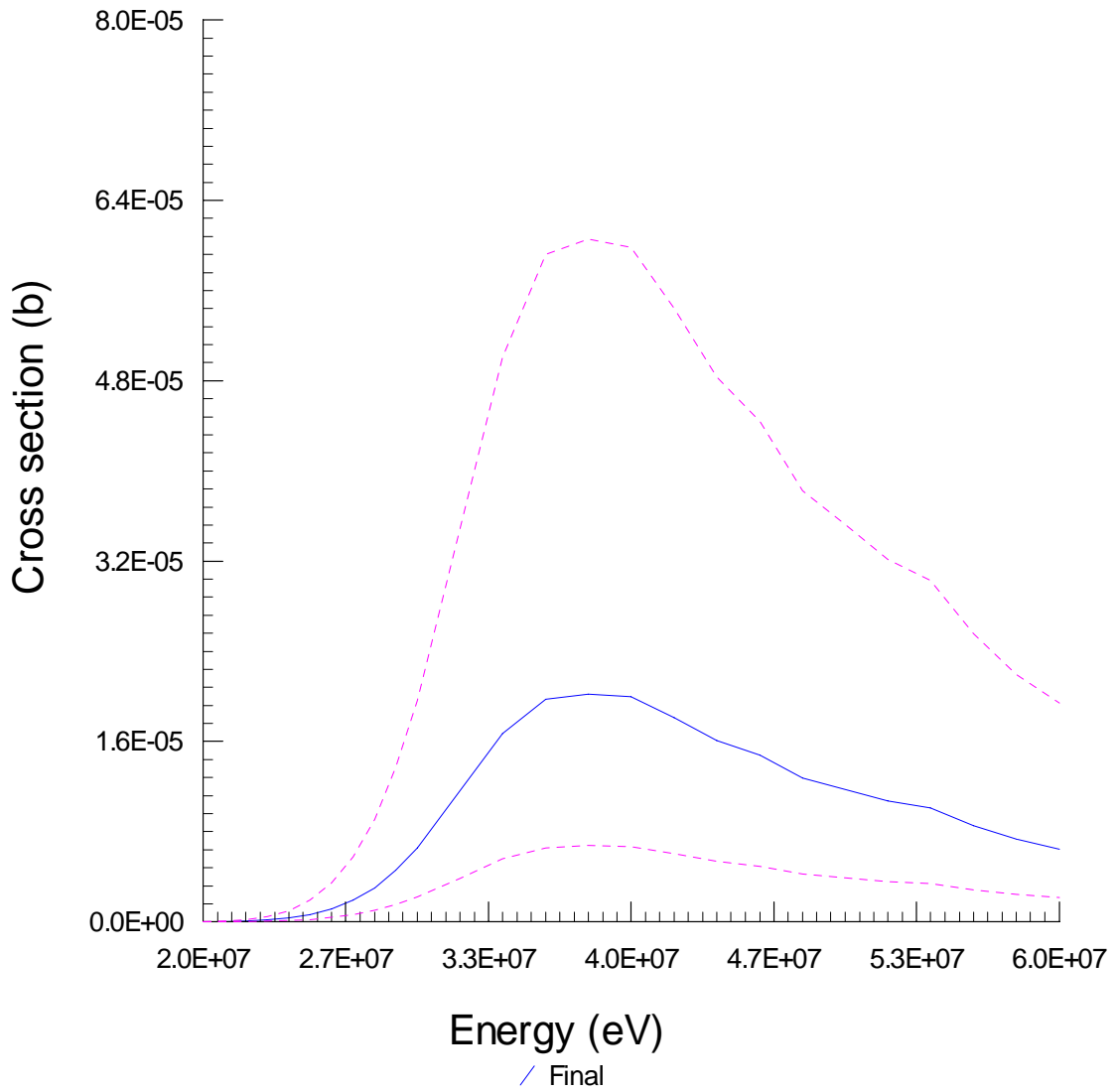
Neutron Spectrum

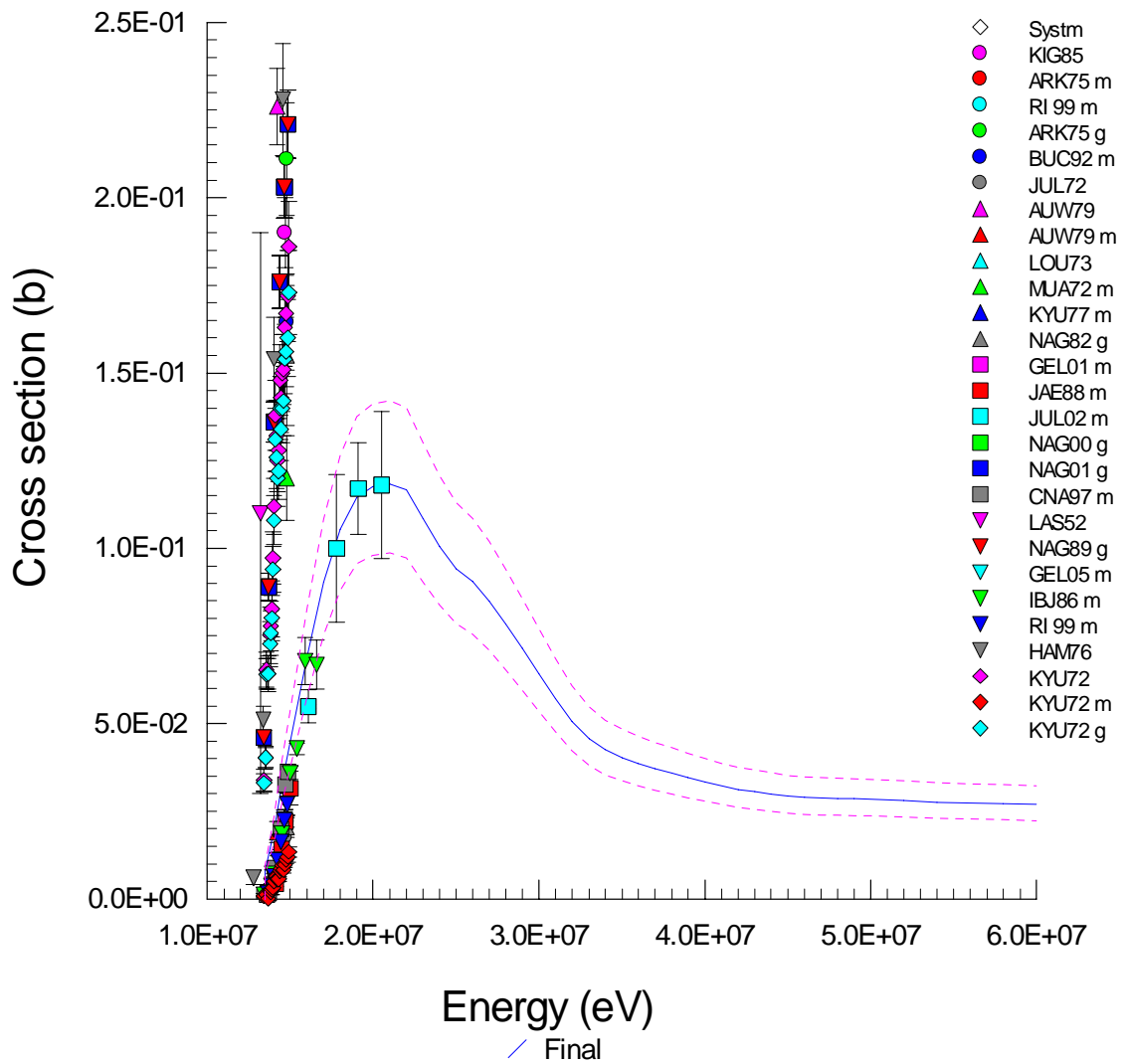
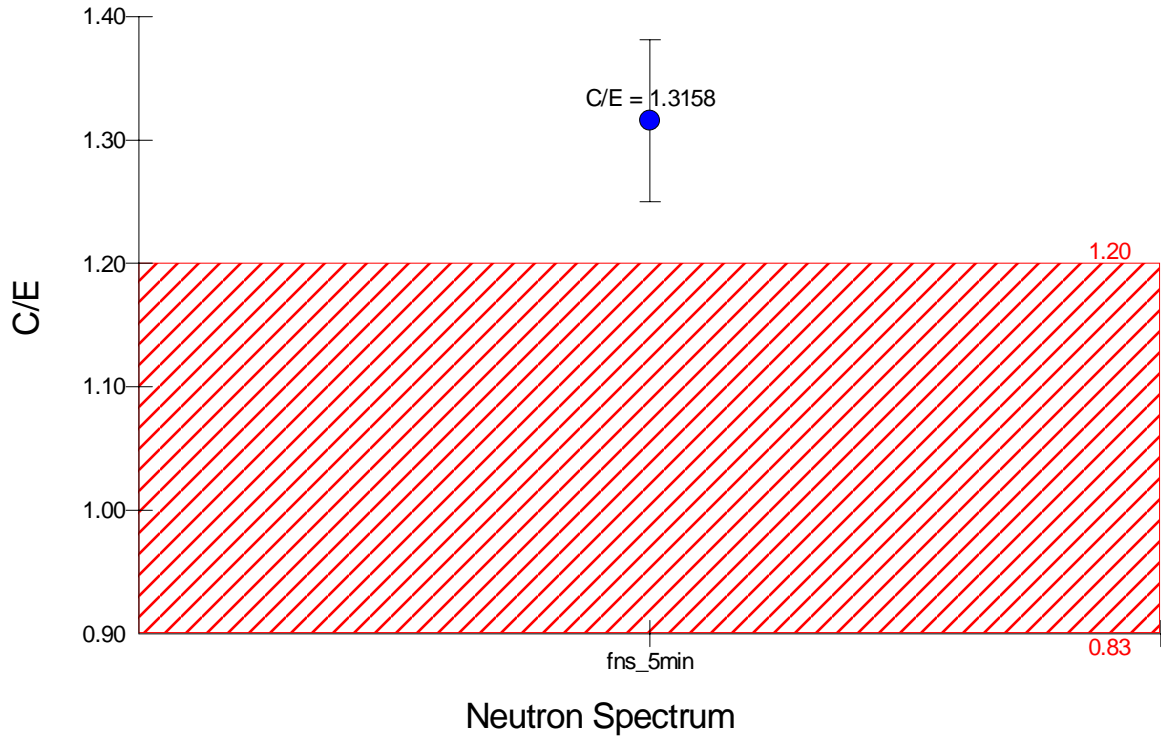
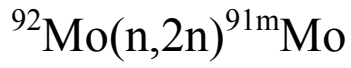




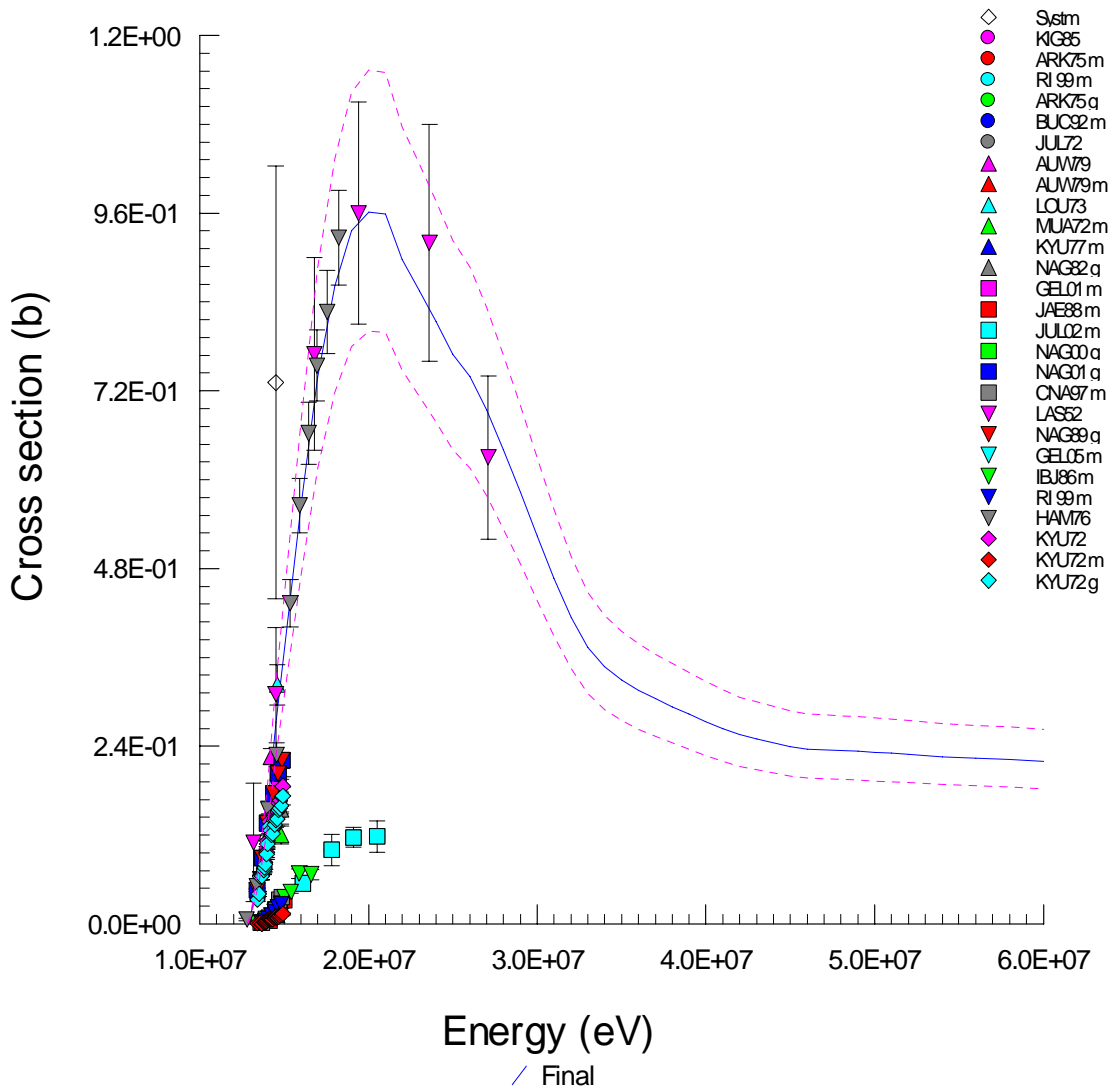
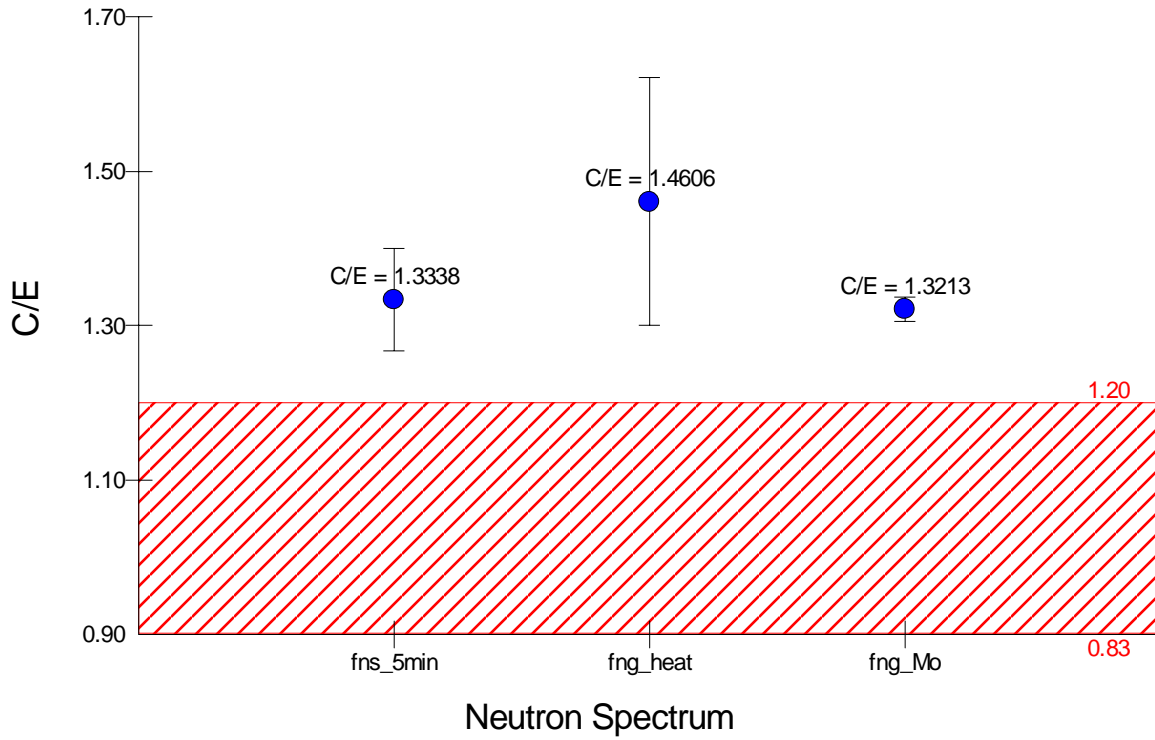


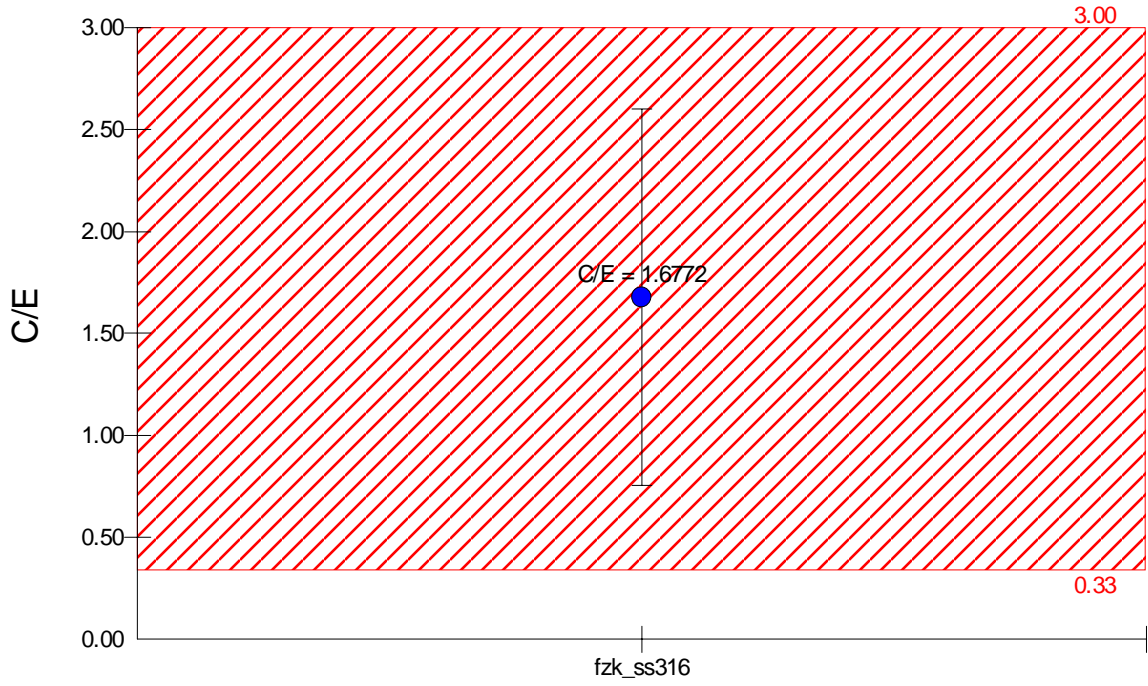
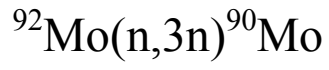
Neutron Spectrum



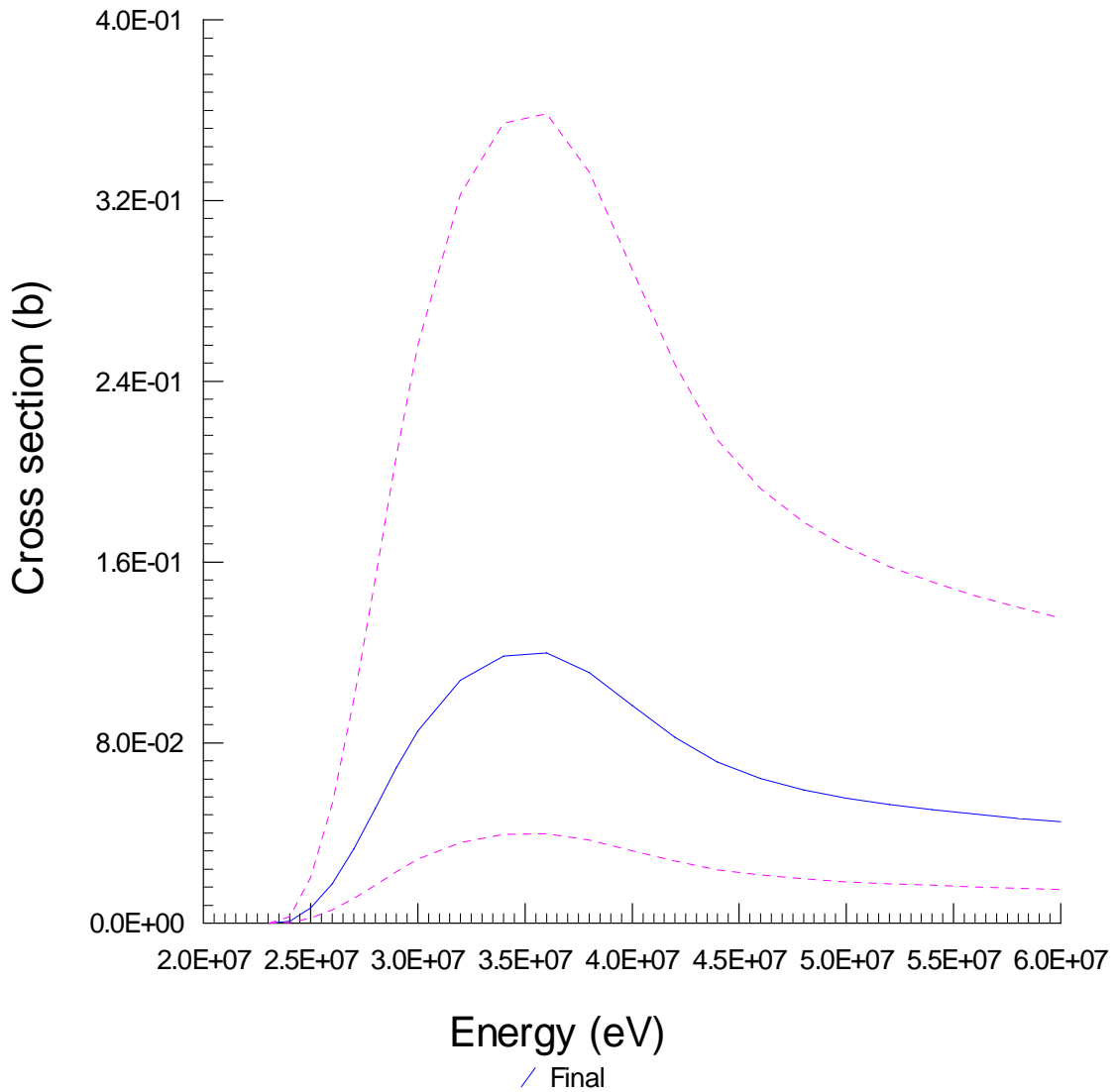


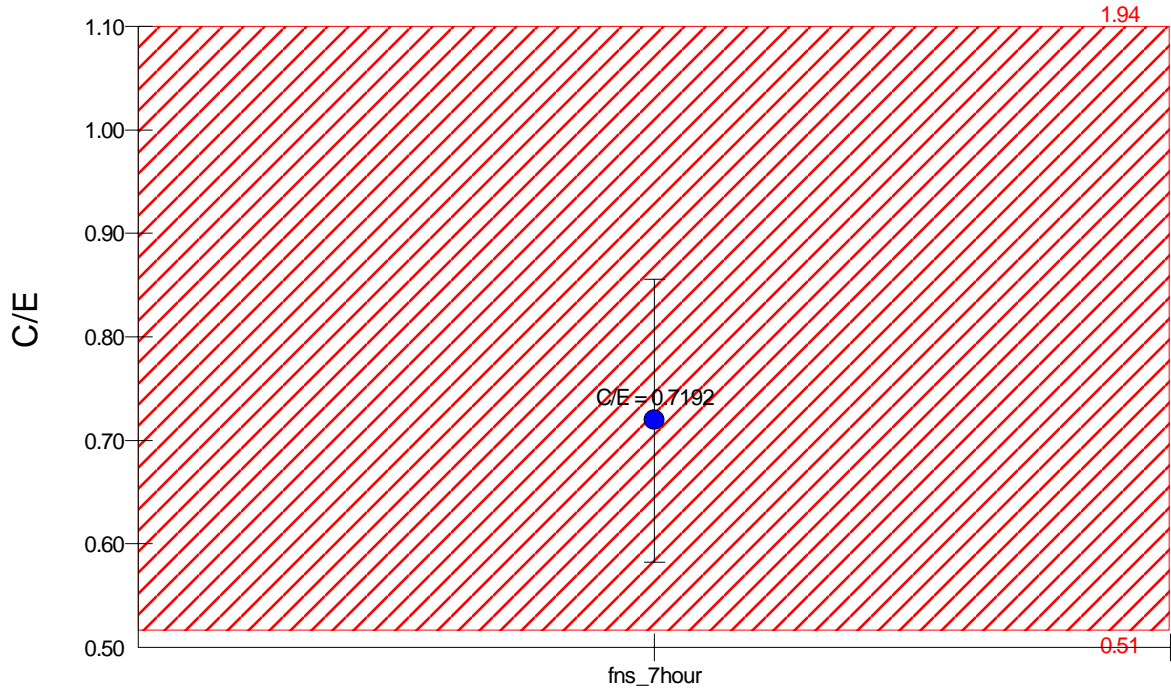
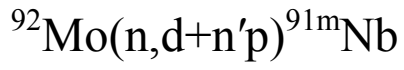
$^{92}\text{Mo}(n,2n)^{91}\text{Mo}$



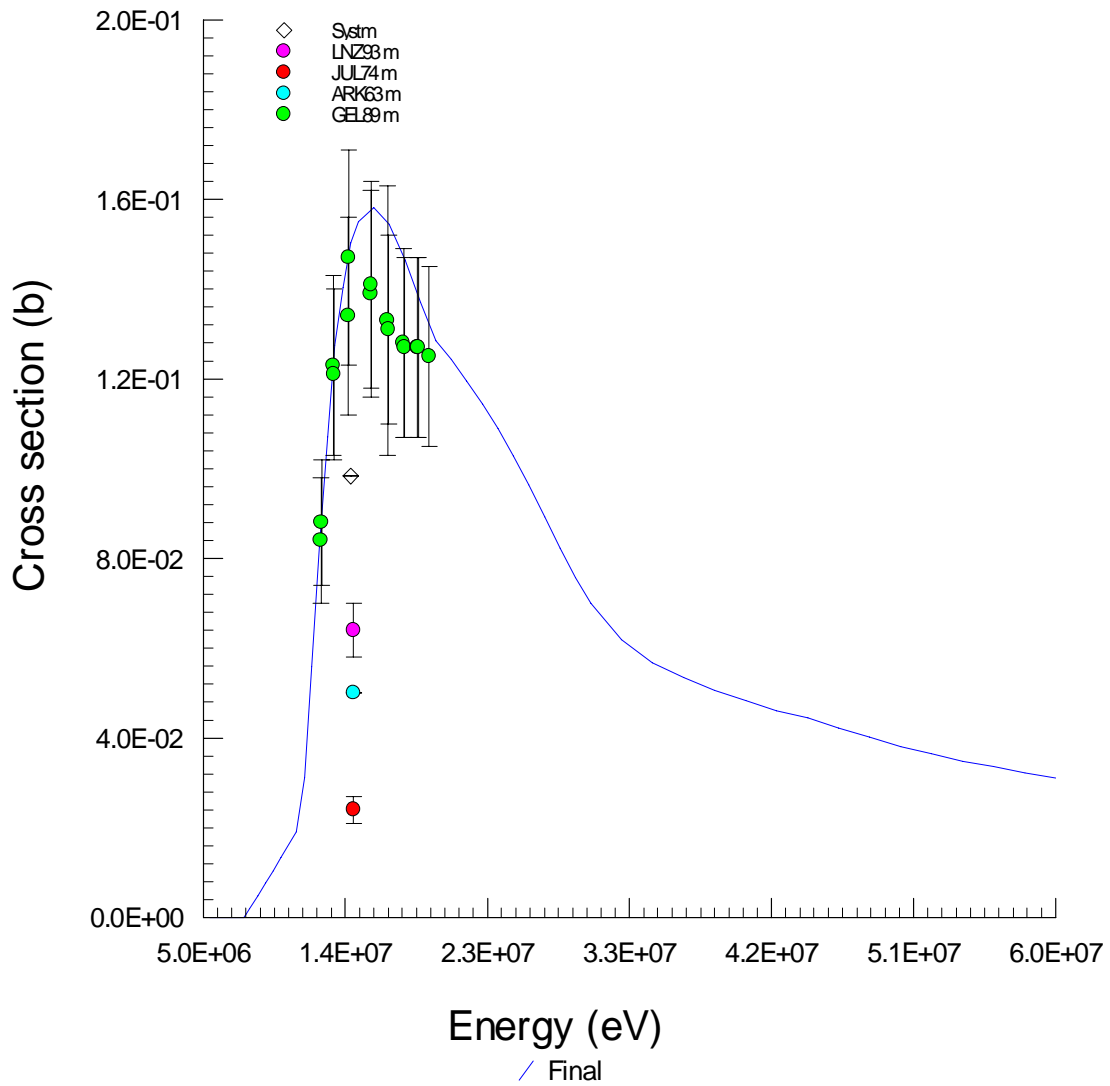


Neutron Spectrum

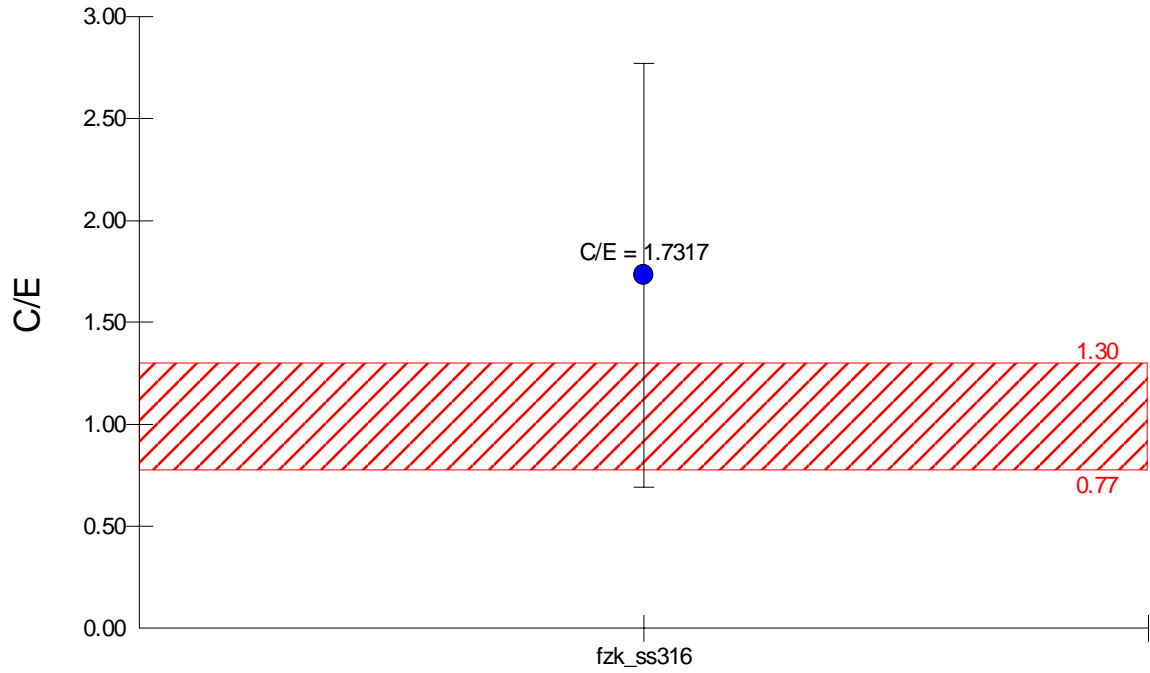




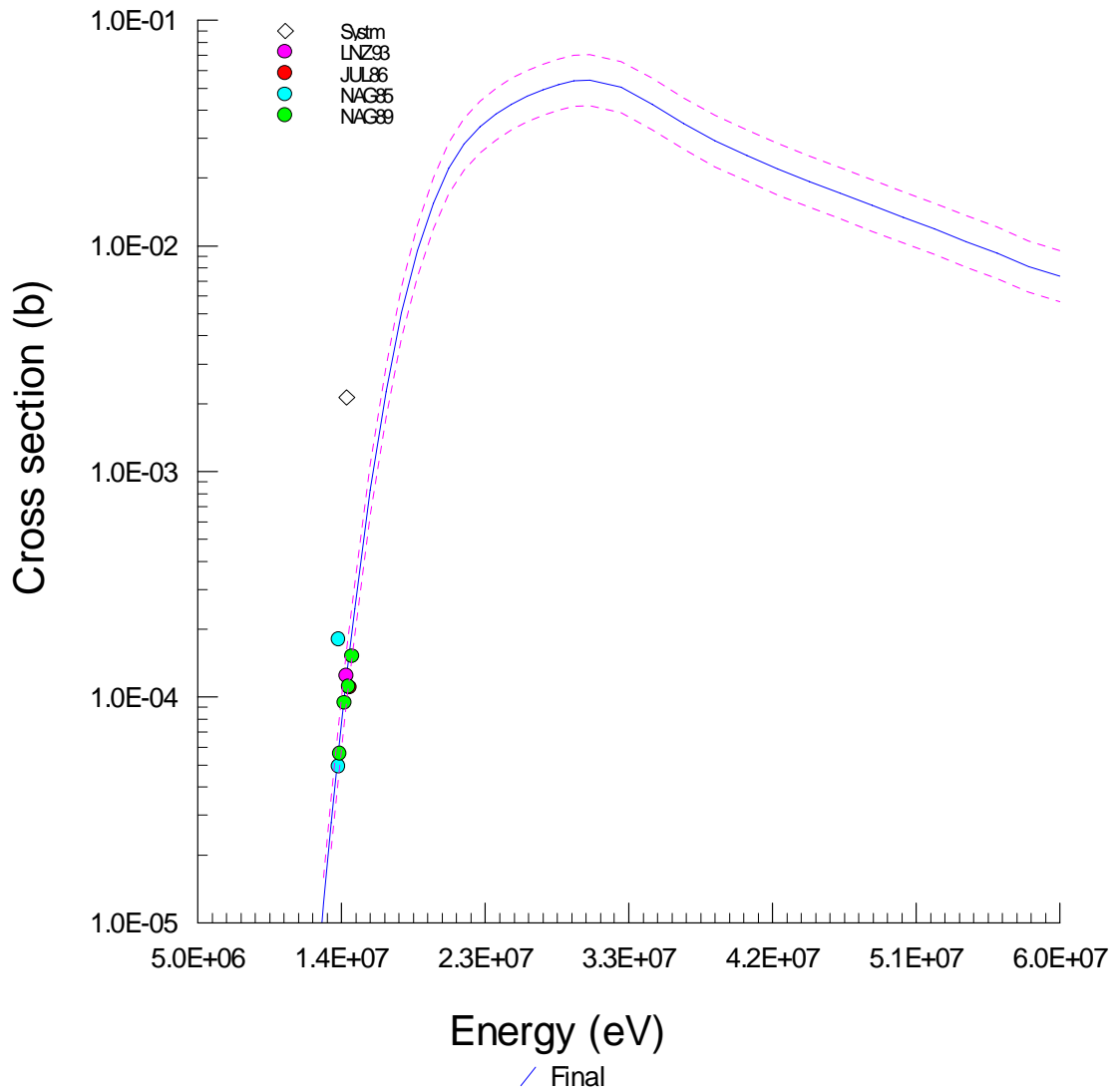
Neutron Spectrum



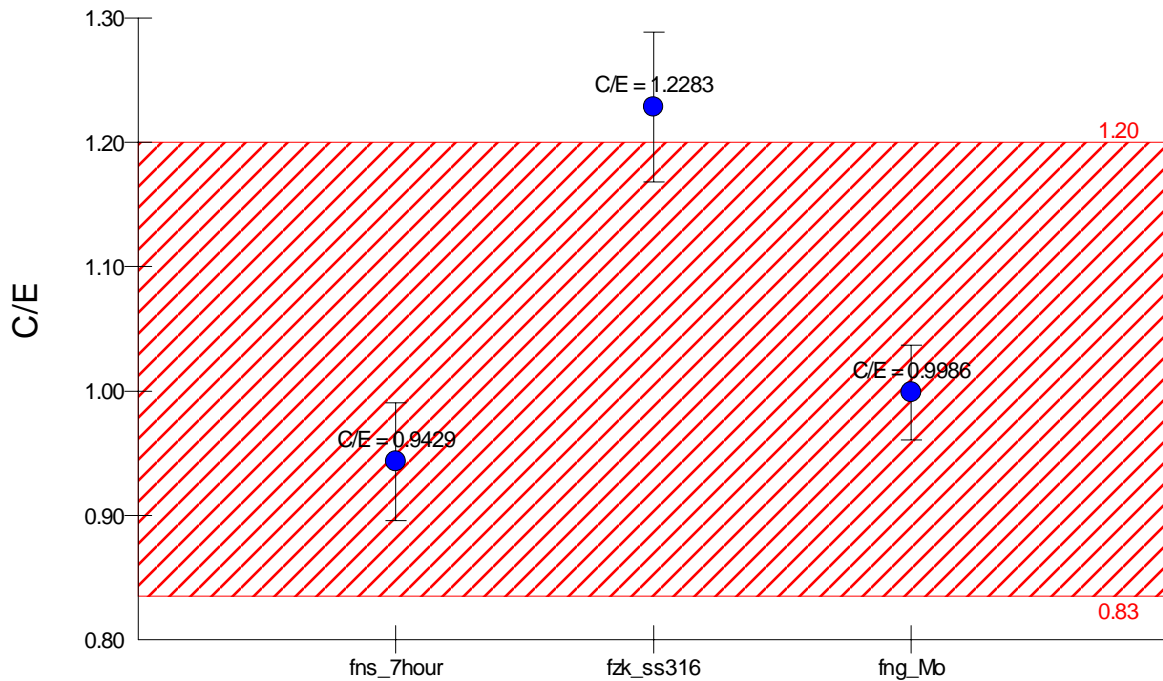
$^{92}\text{Mo}(n,n'\alpha)^{88}\text{Zr}$



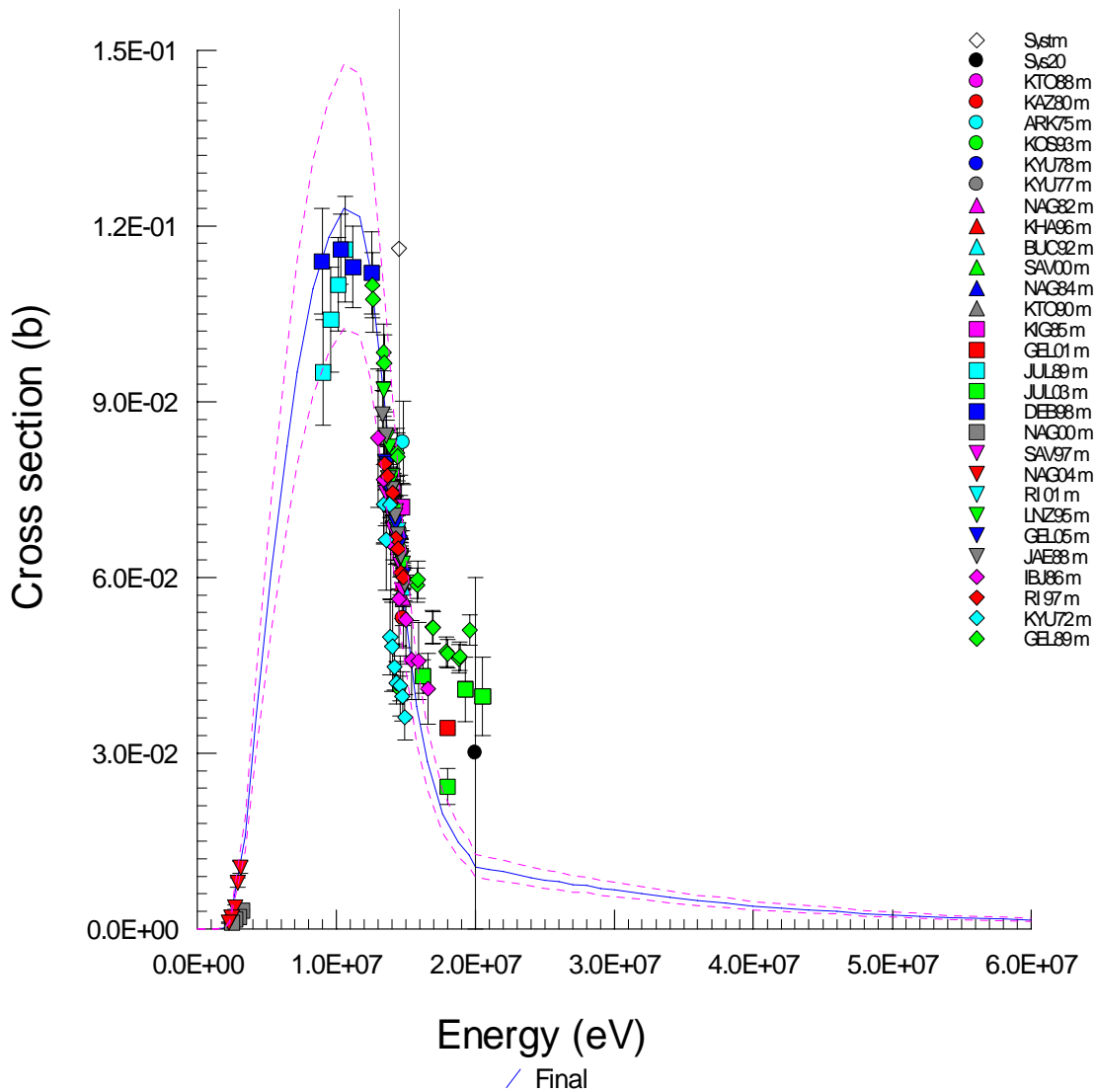
Neutron Spectrum

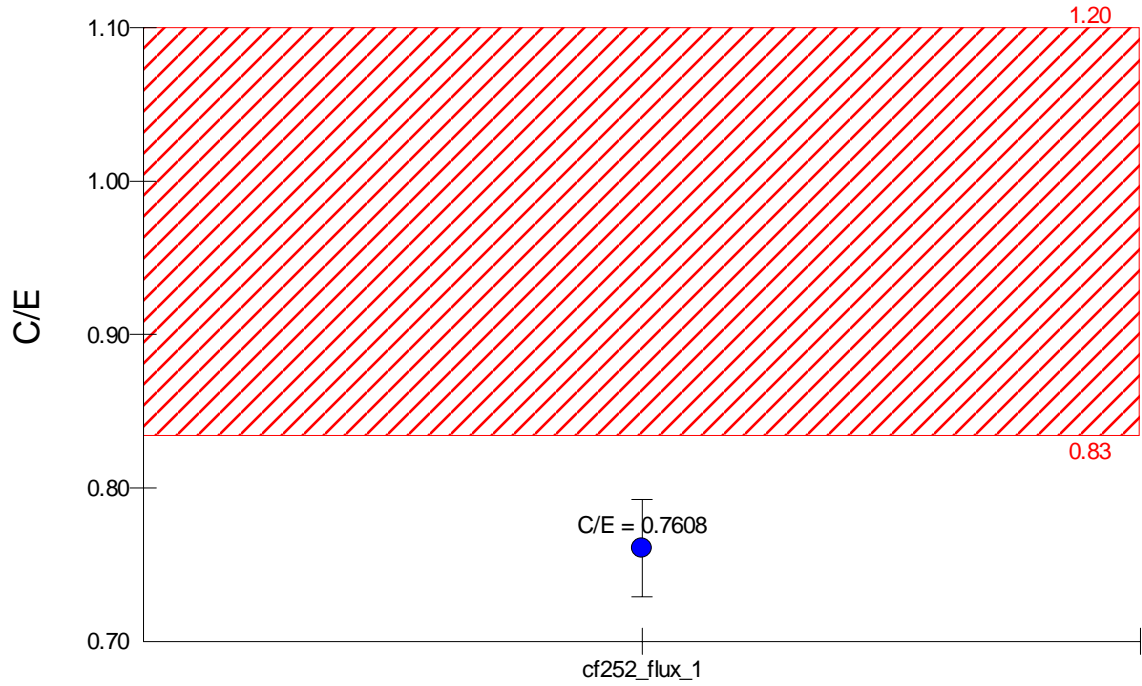
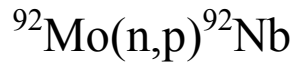


$^{92}\text{Mo}(n,p)^{92m}\text{Nb}$

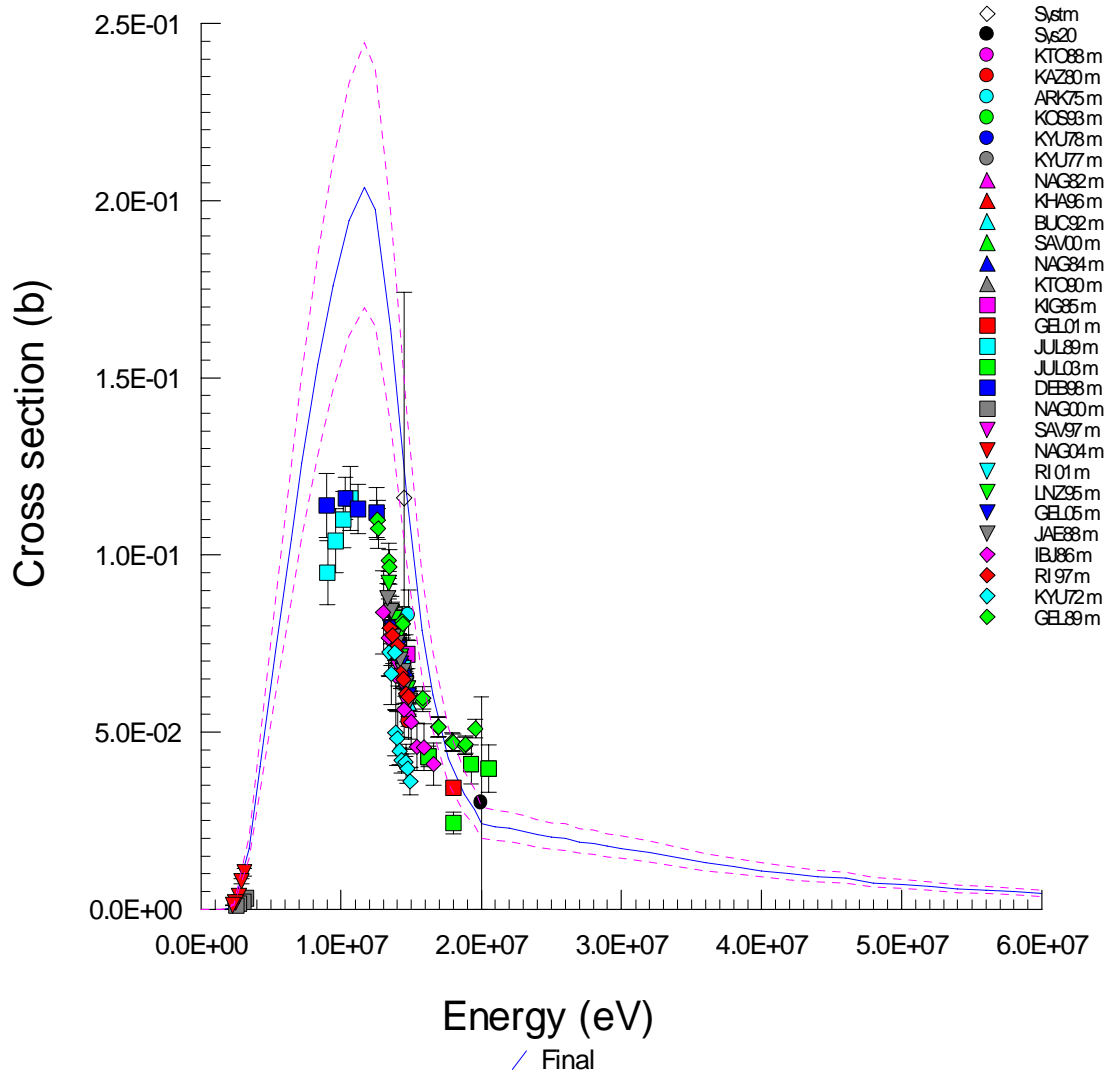


Neutron Spectrum



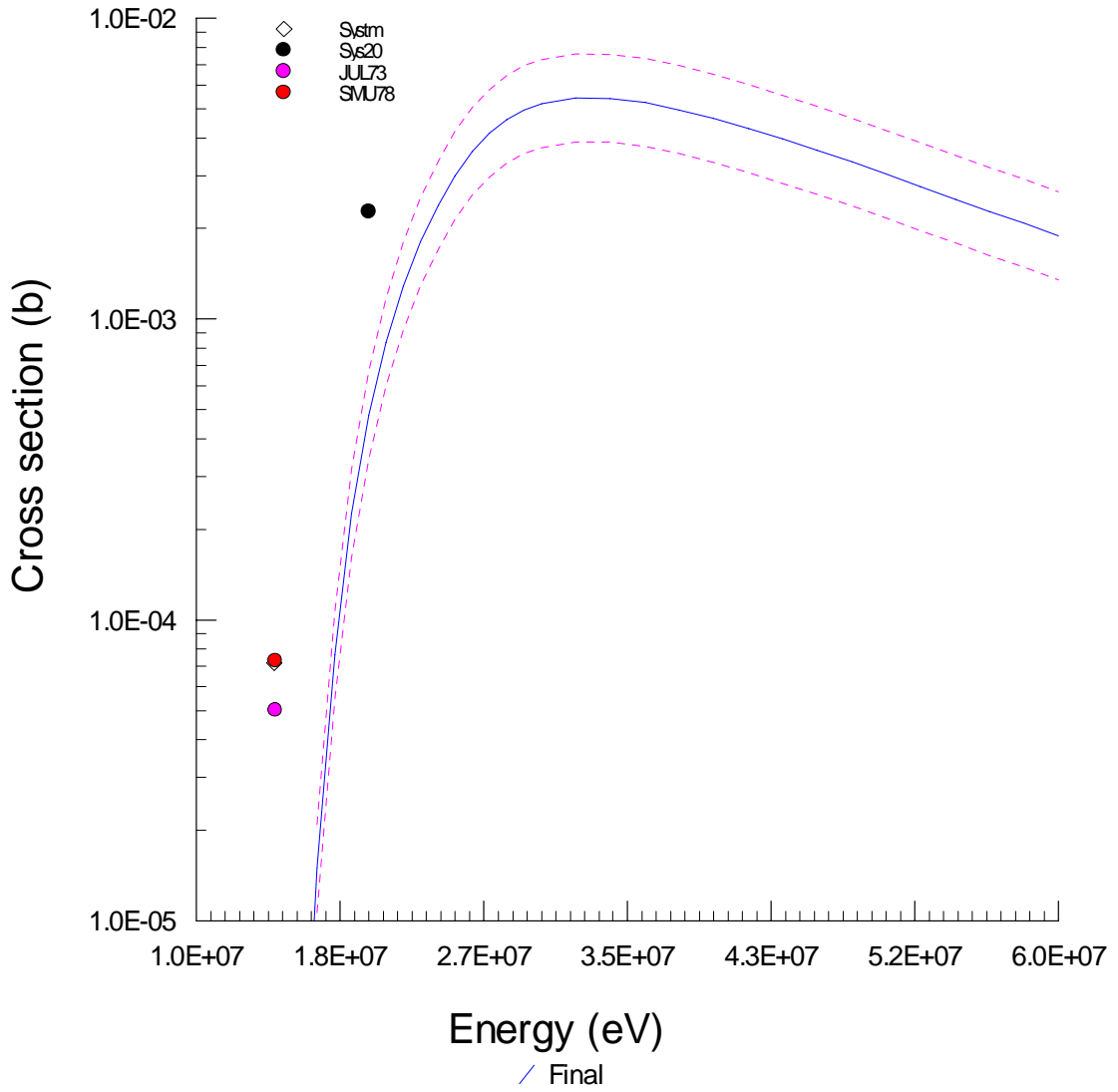
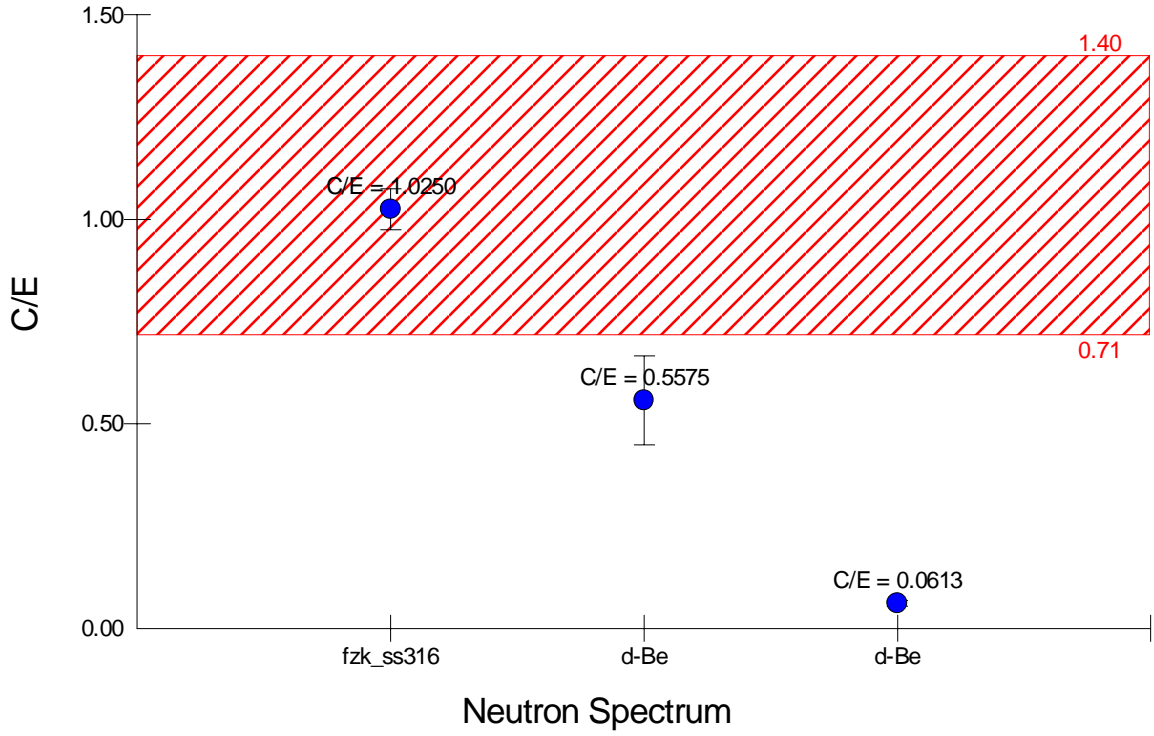


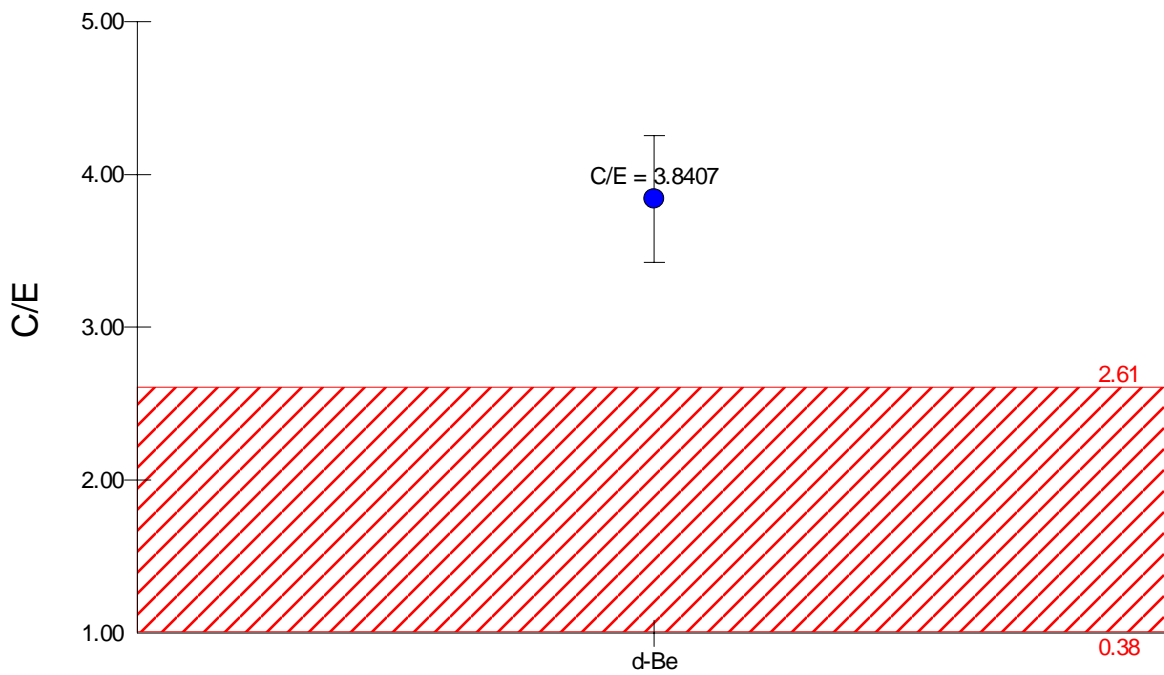
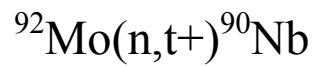
Neutron Spectrum



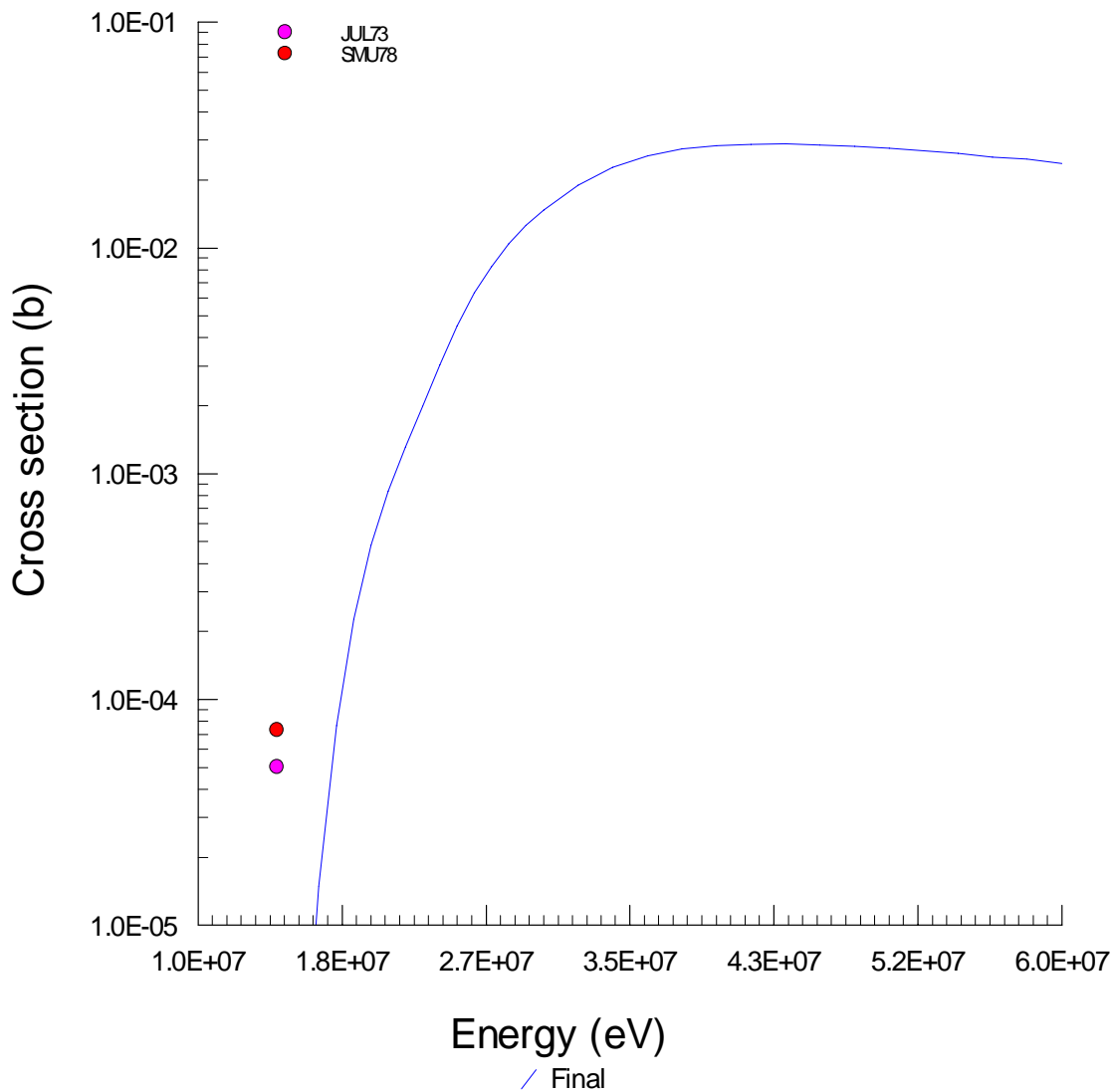


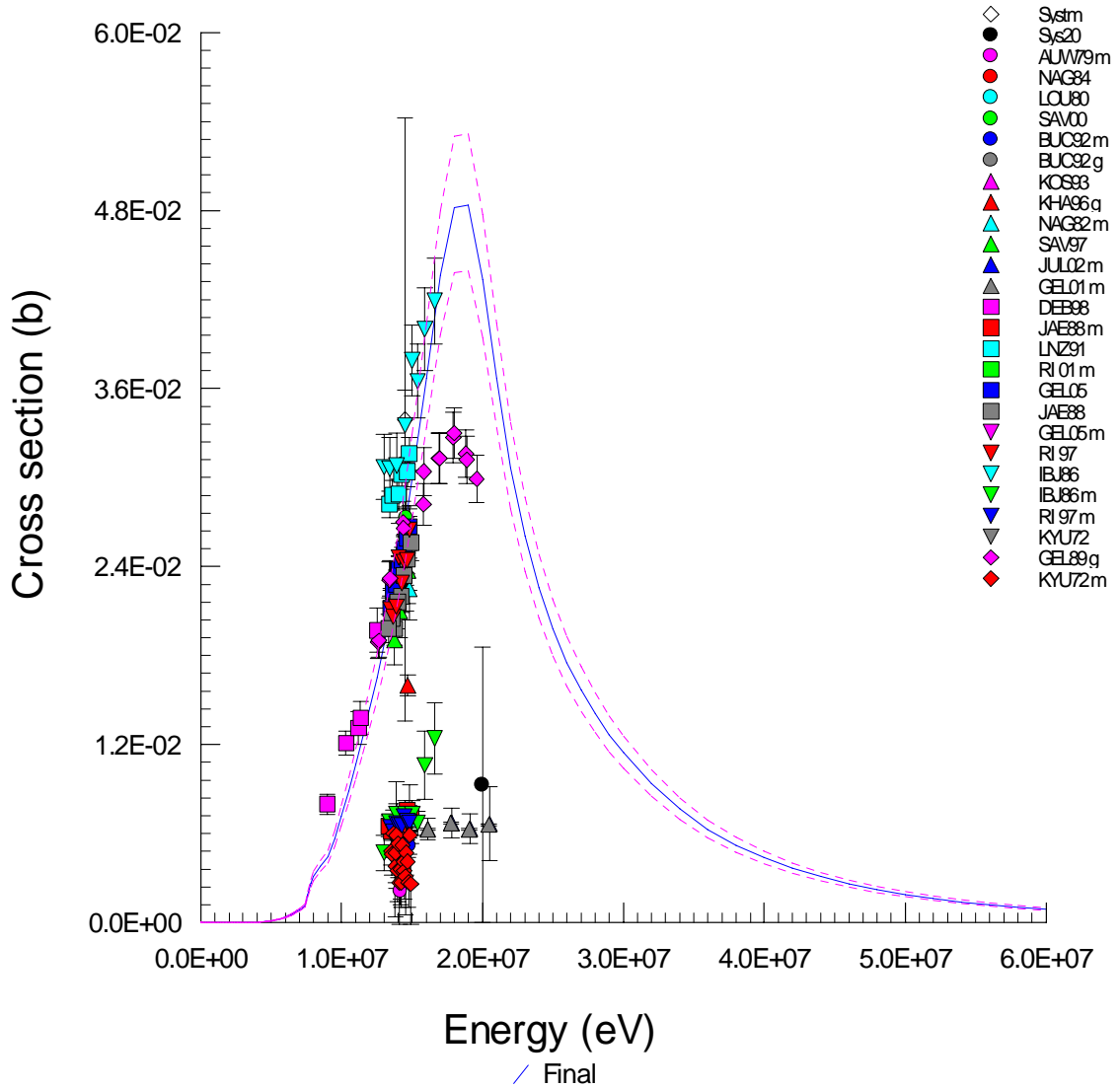
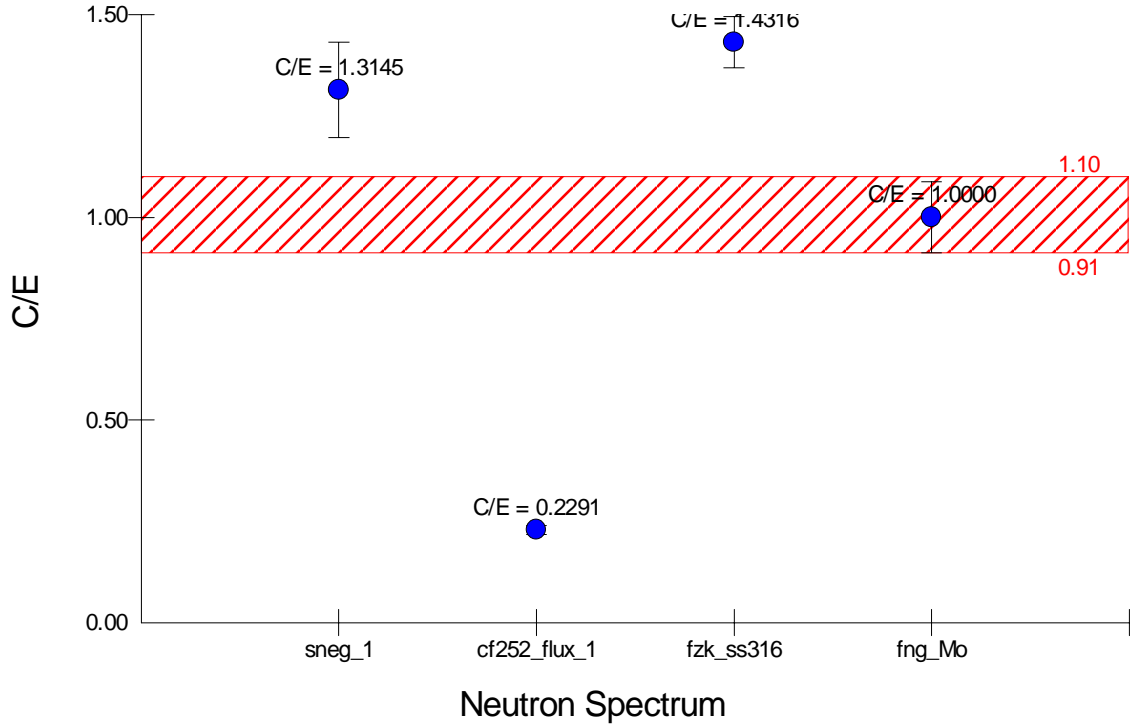
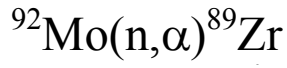
$^{92}\text{Mo}(n,t)^{90}\text{Nb}$

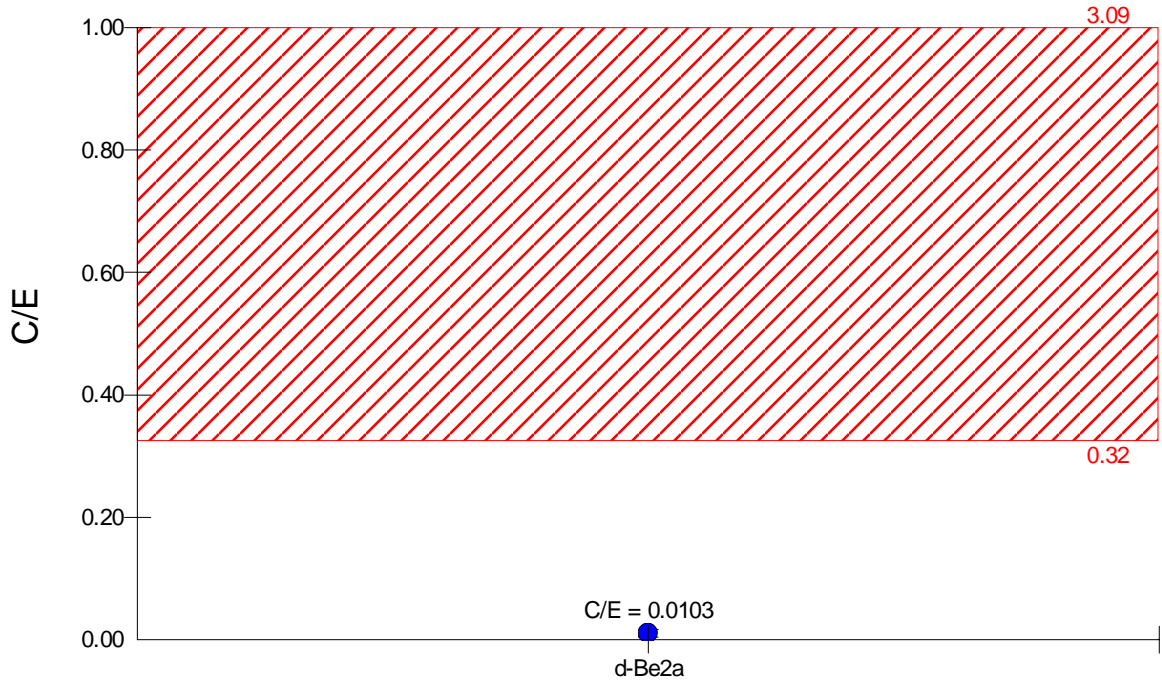
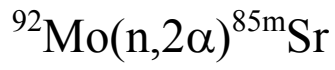




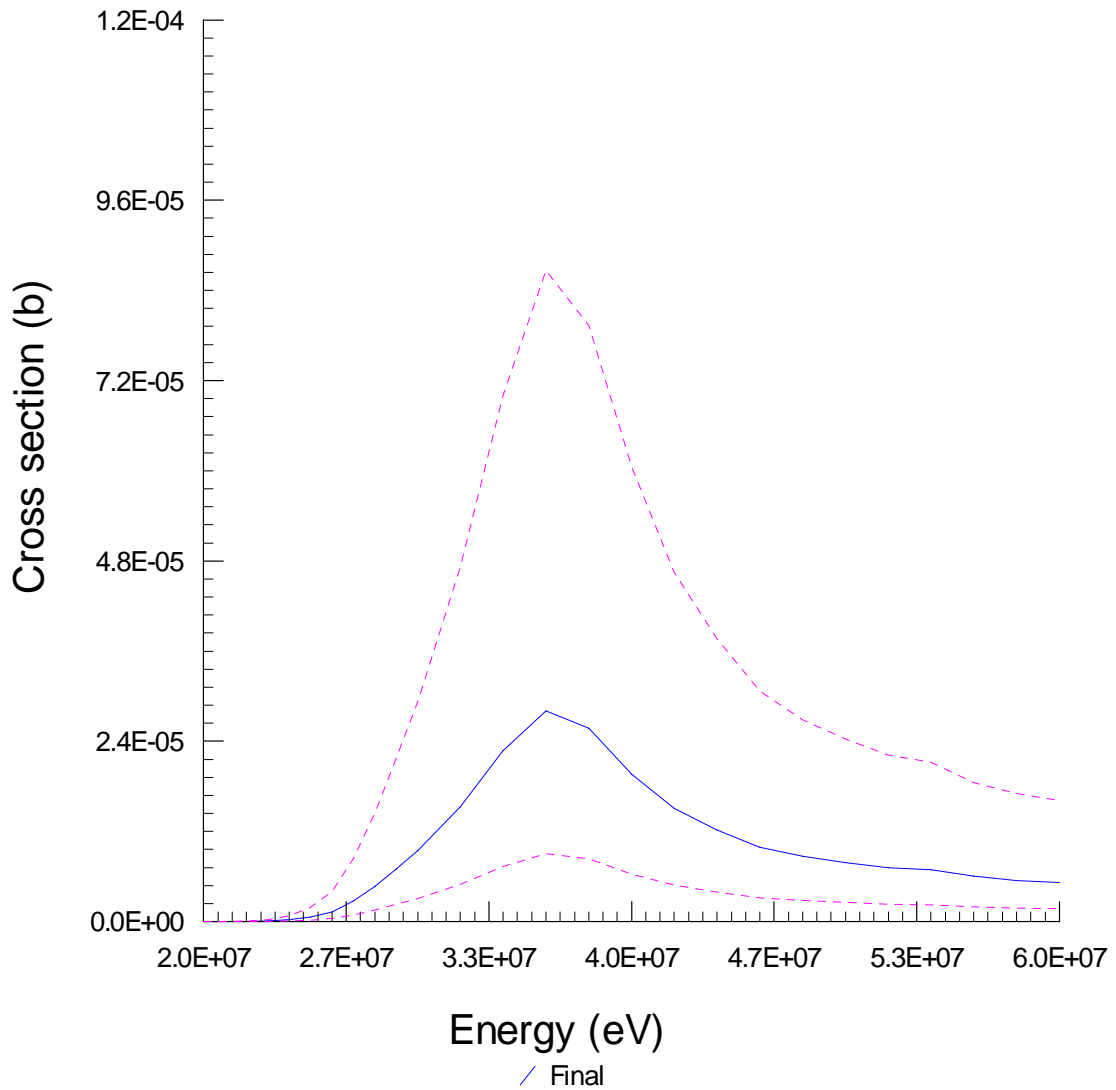
Neutron Spectrum

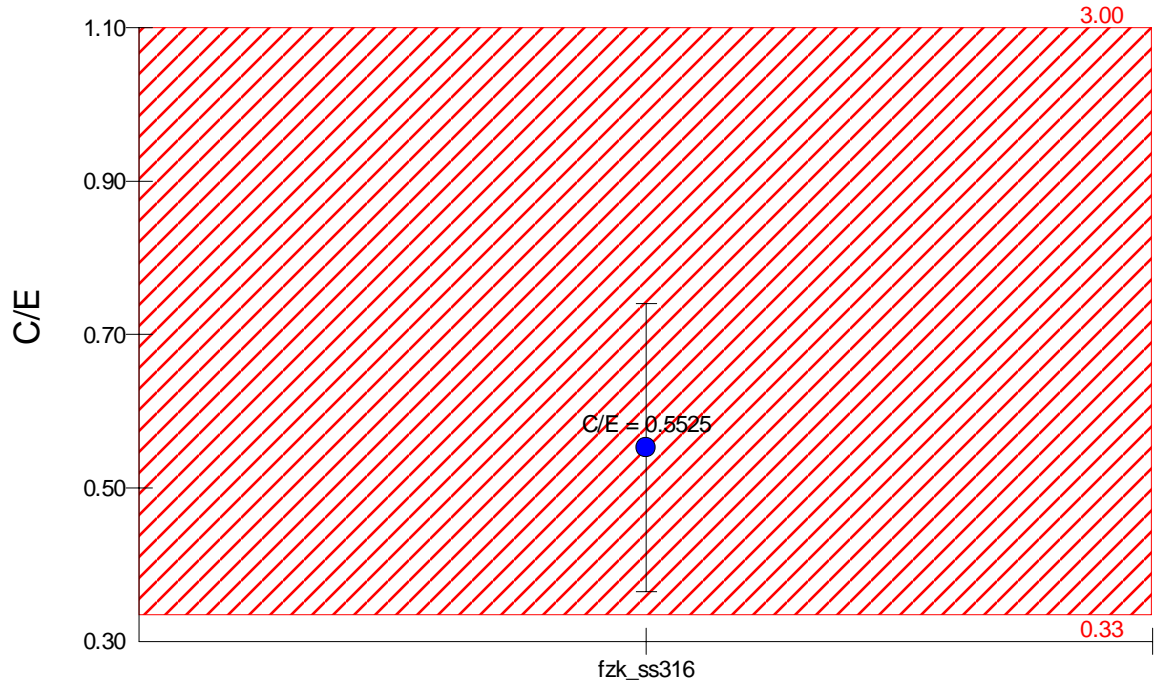
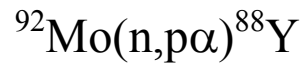




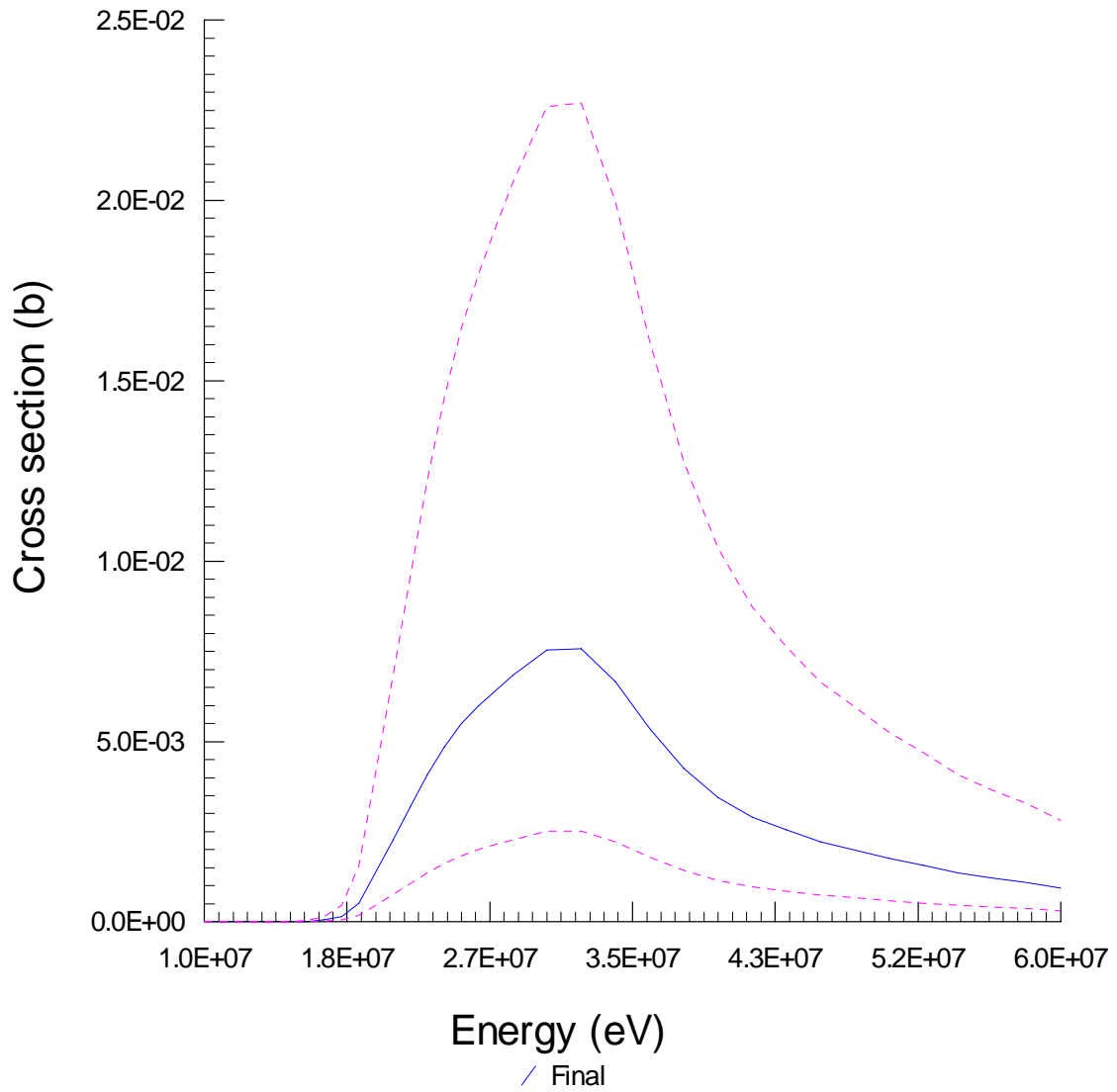


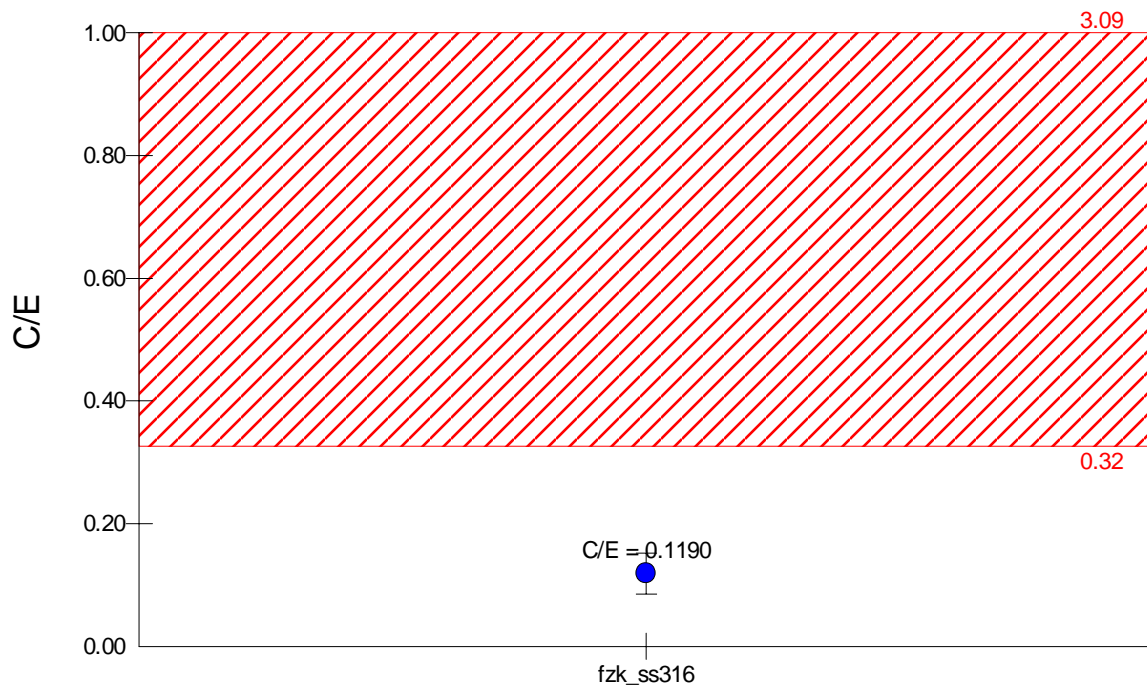
Neutron Spectrum



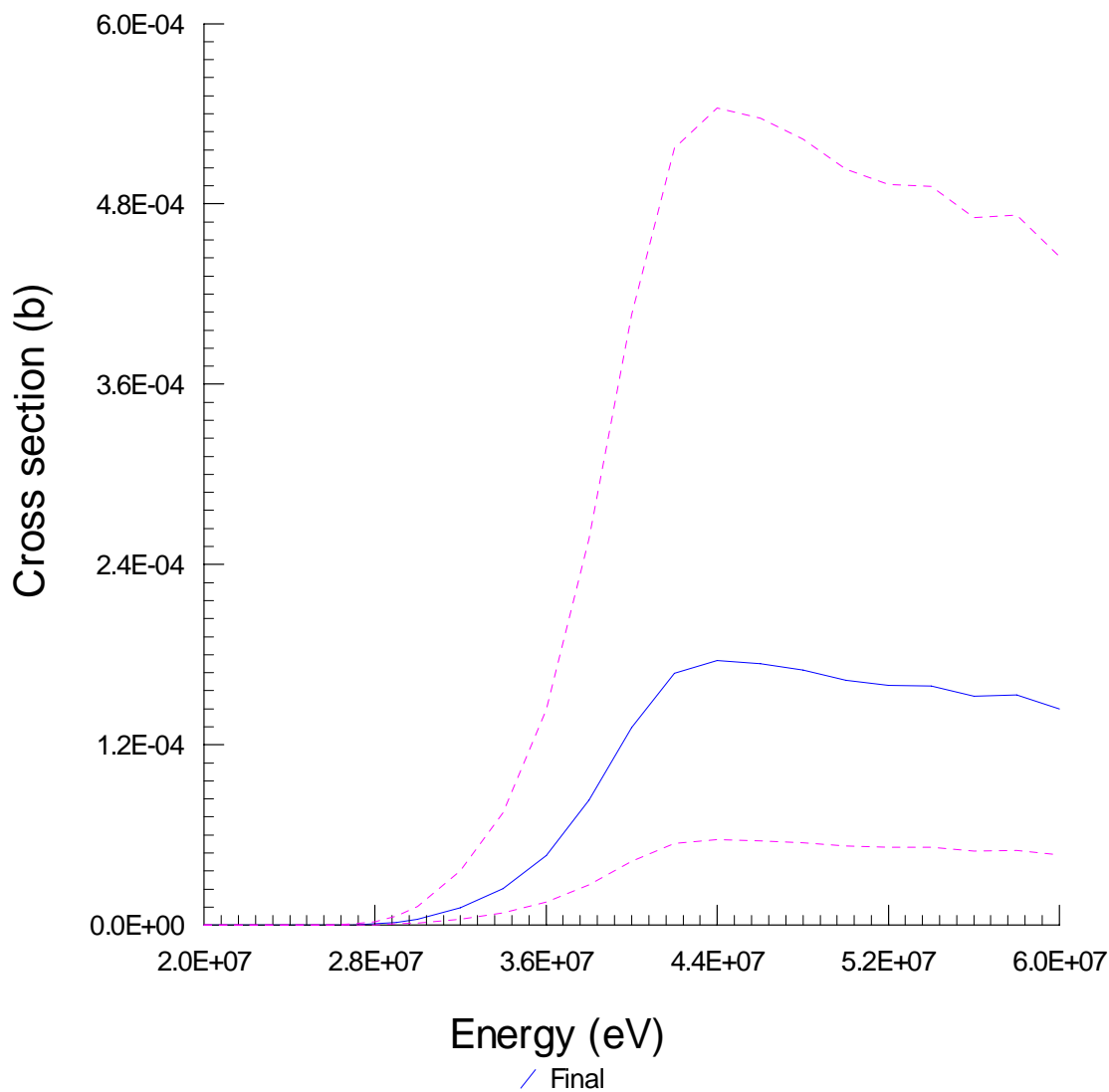


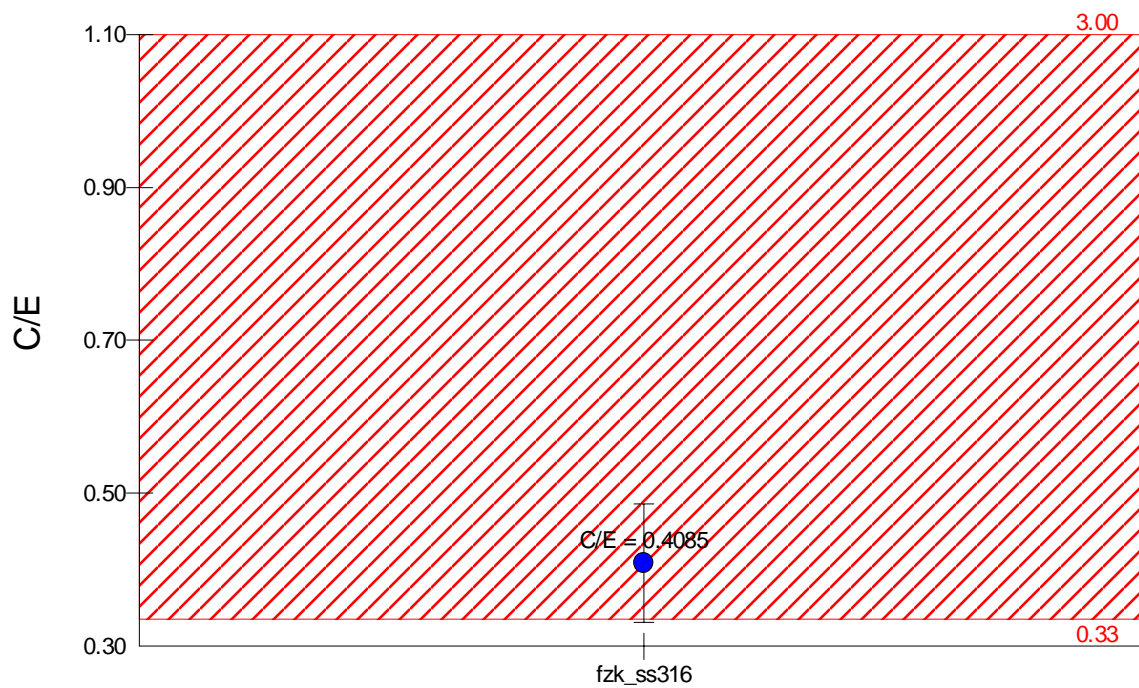
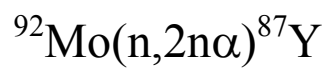
Neutron Spectrum



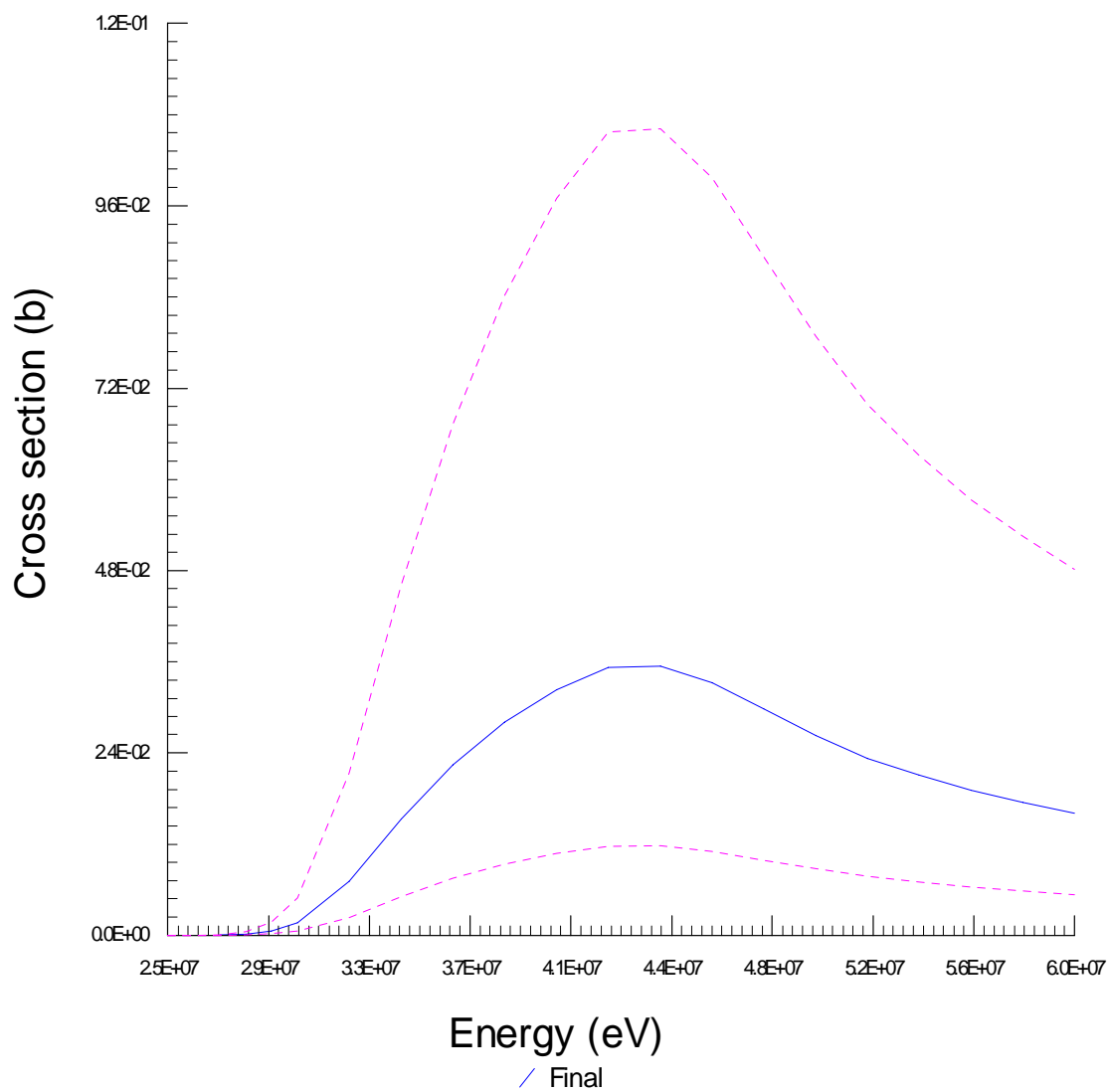


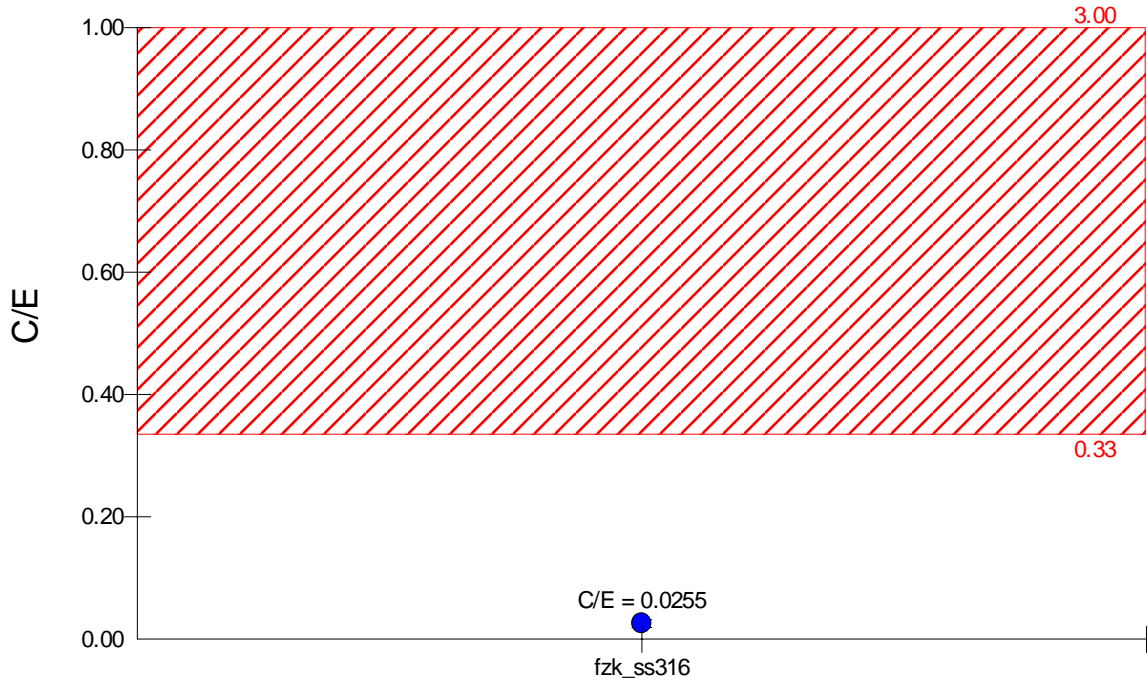
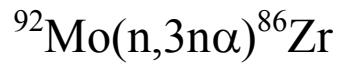
Neutron Spectrum



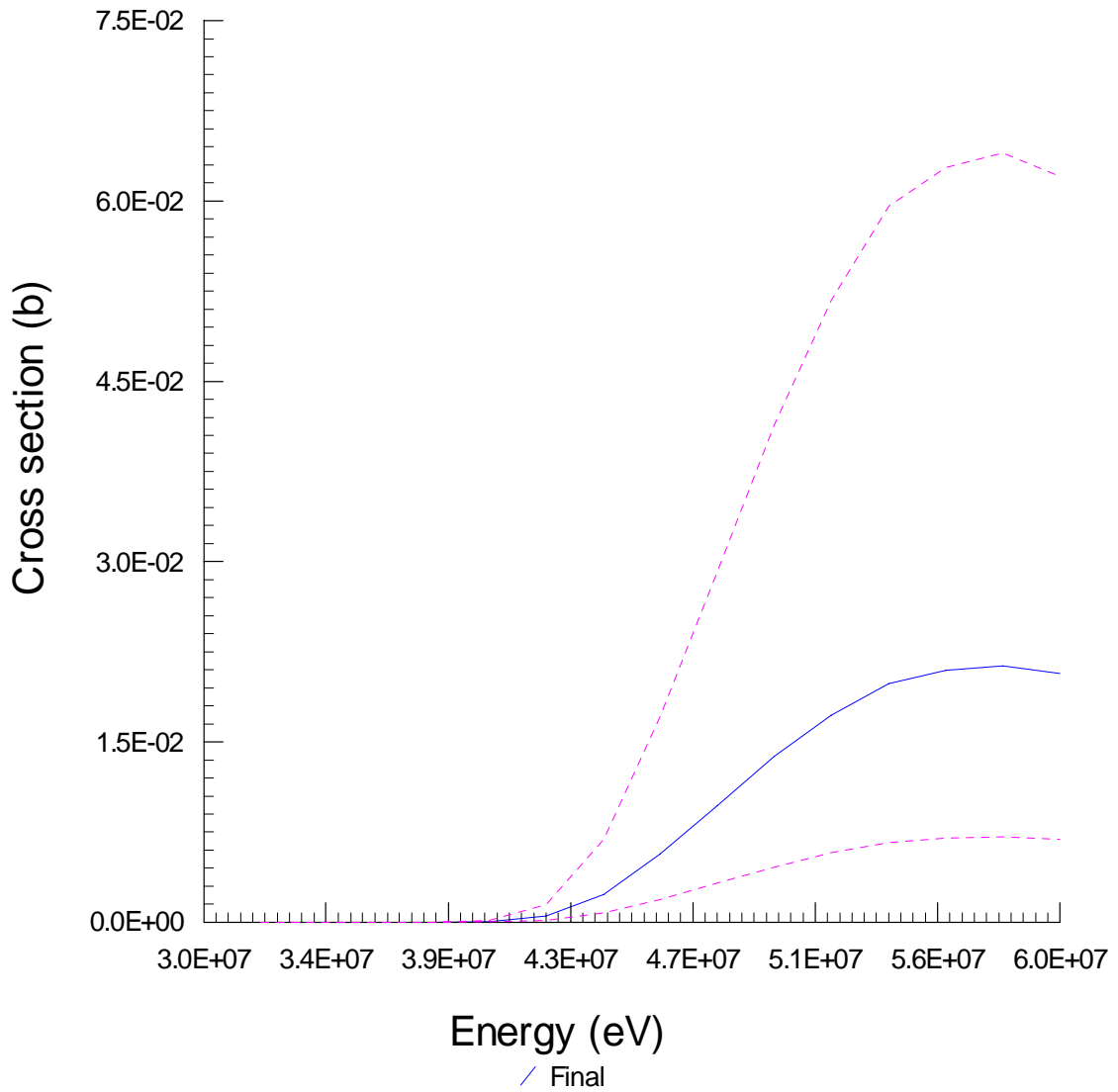


Neutron Spectrum



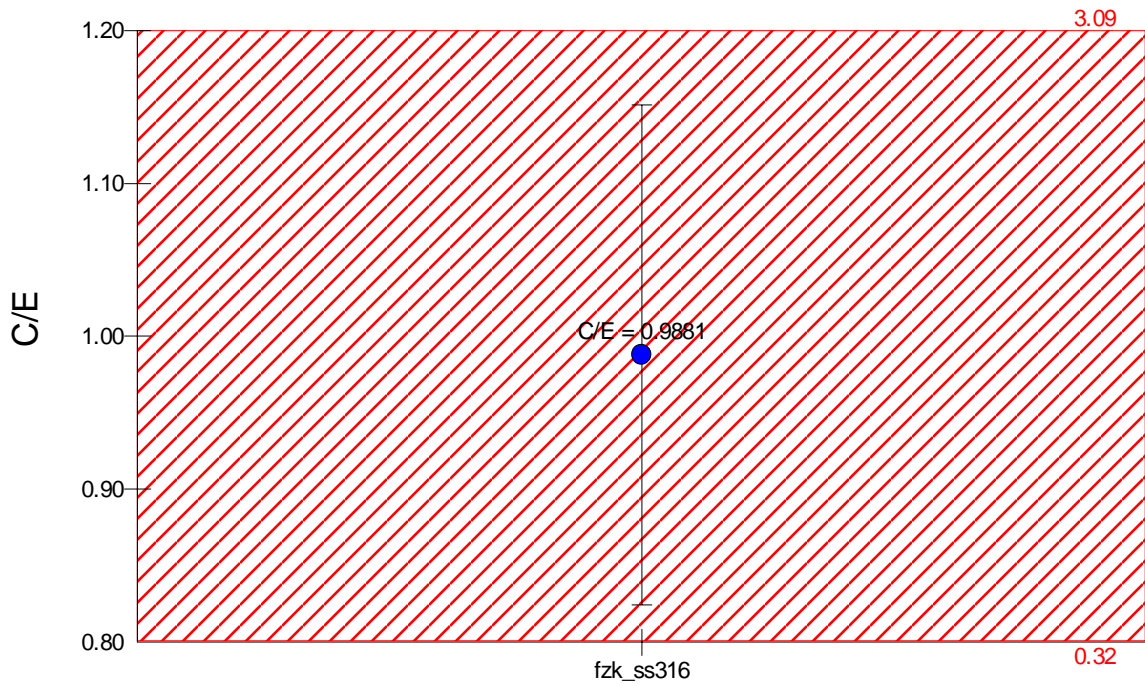


Neutron Spectrum

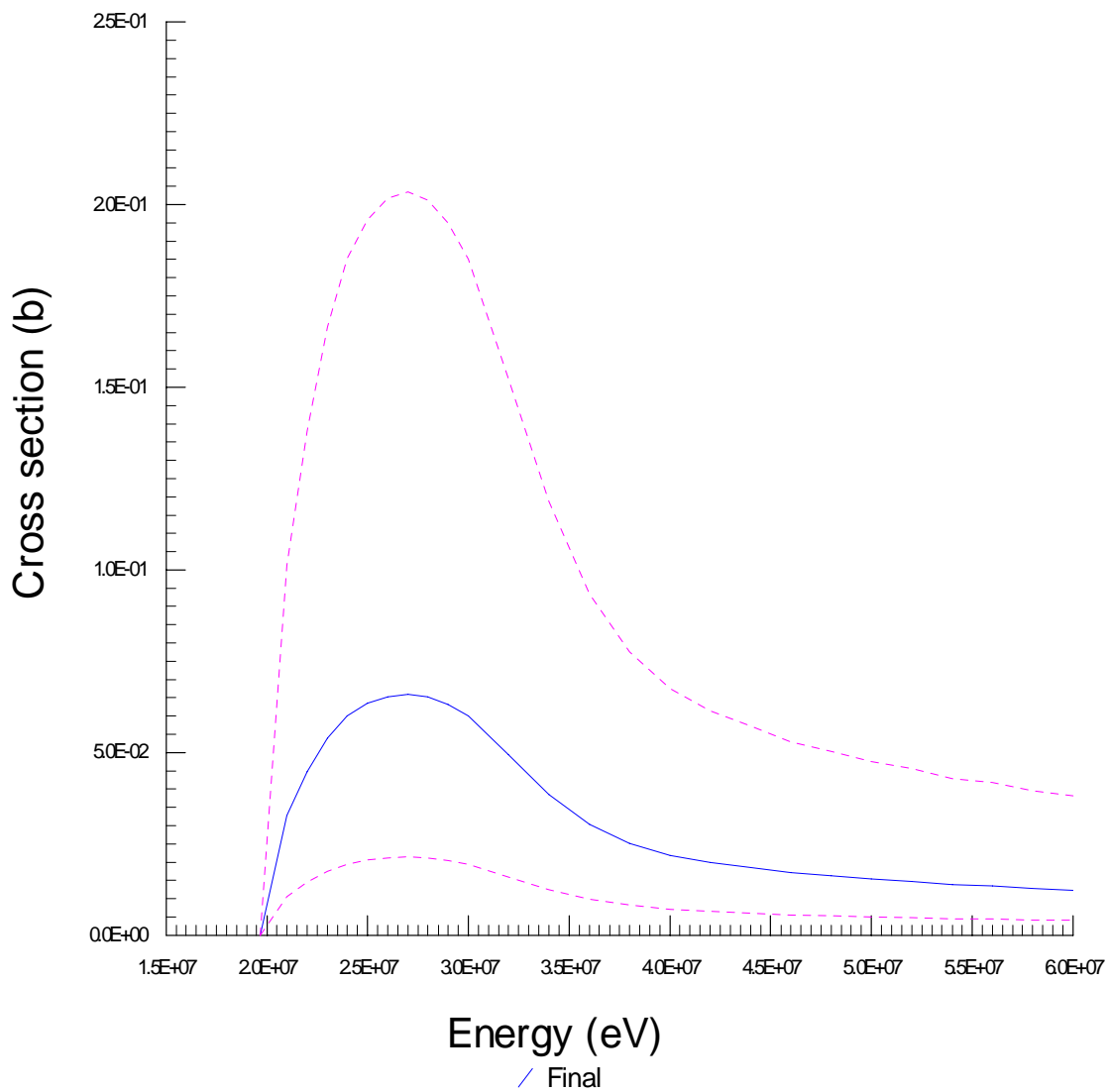




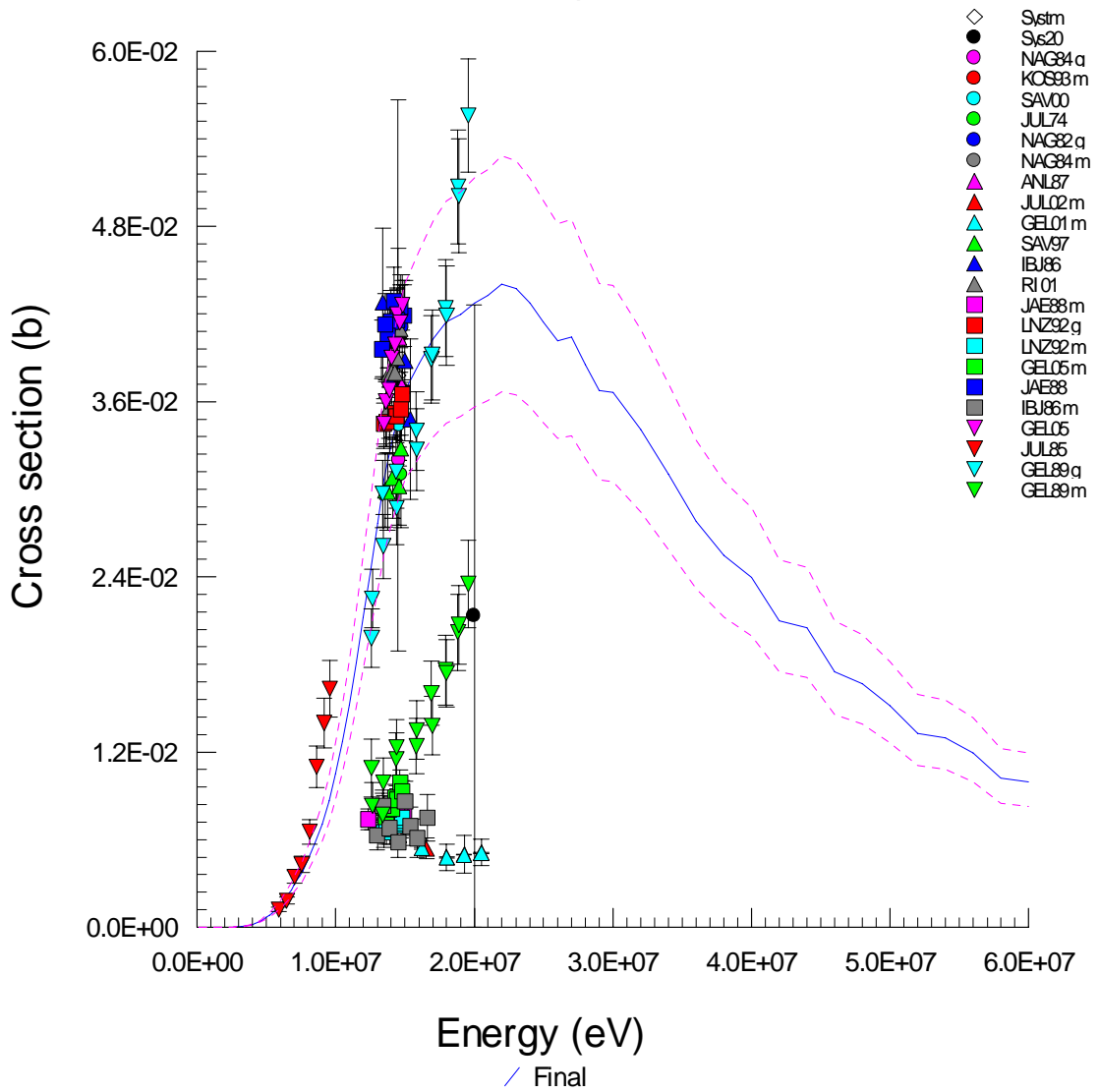
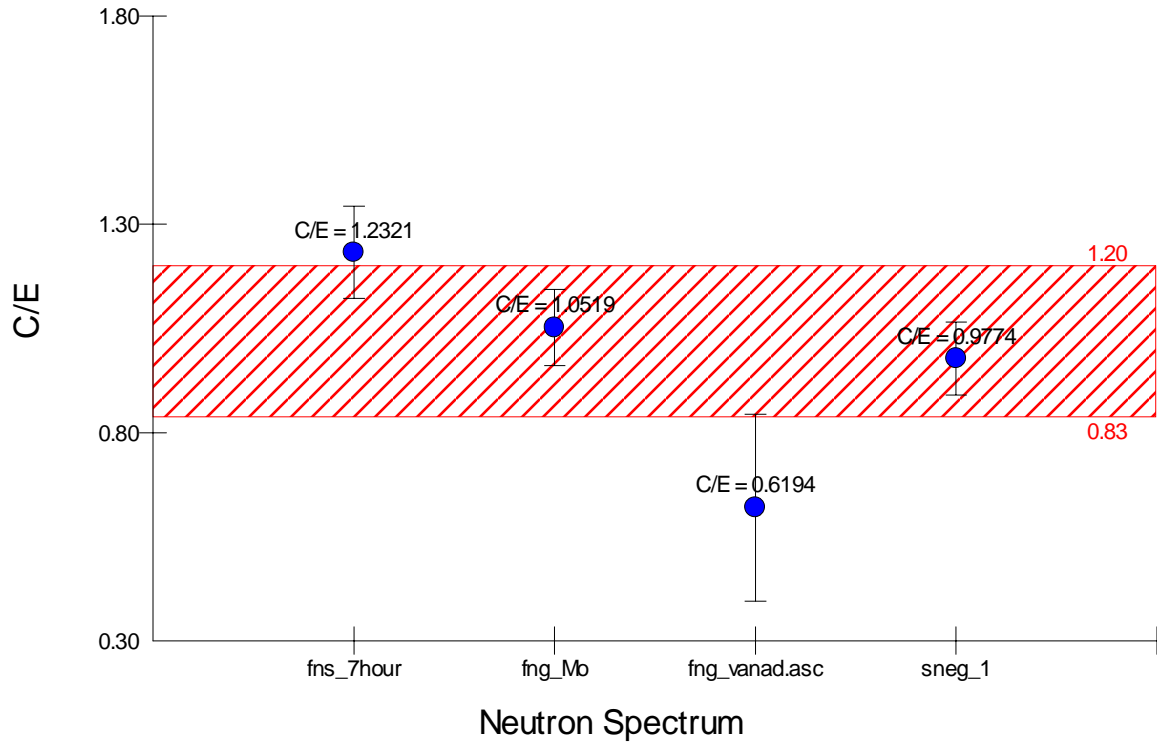
$^{95}\text{Mo}(n,3n)^{93\text{m}}\text{Mo}$



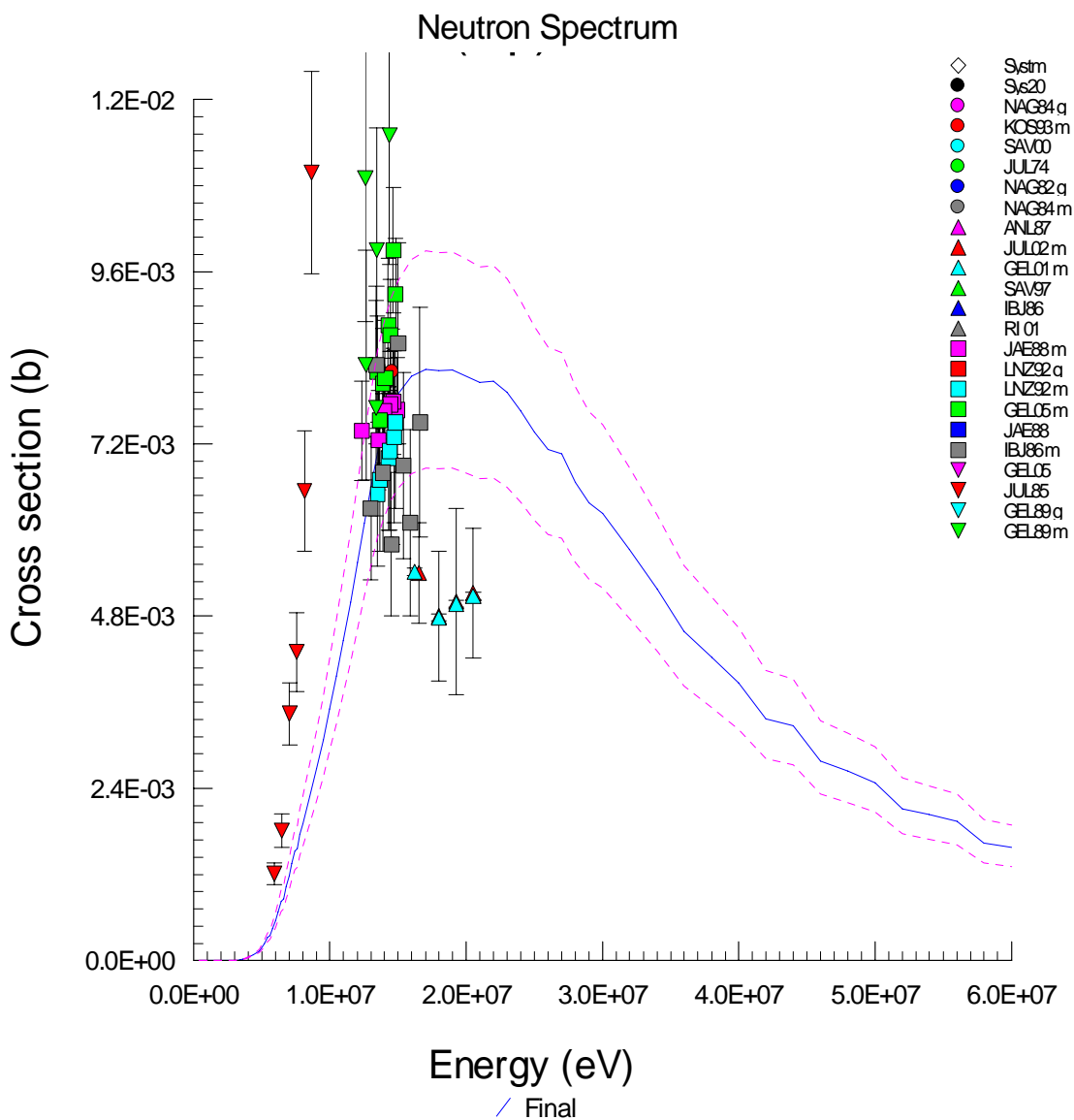
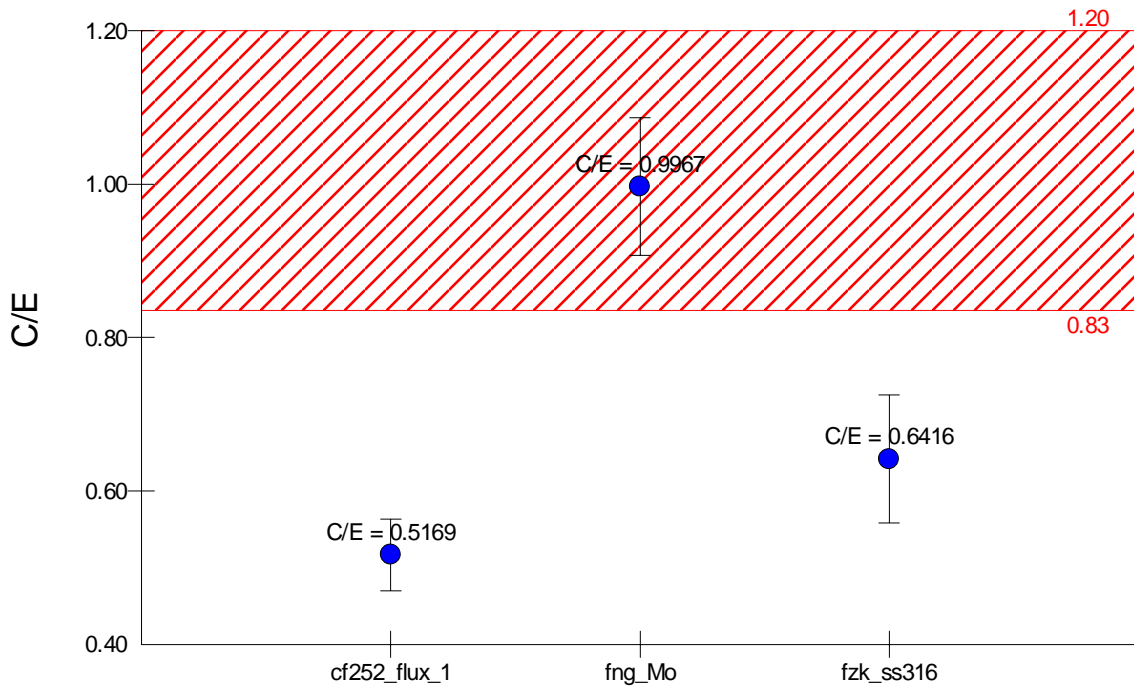
Neutron Spectrum



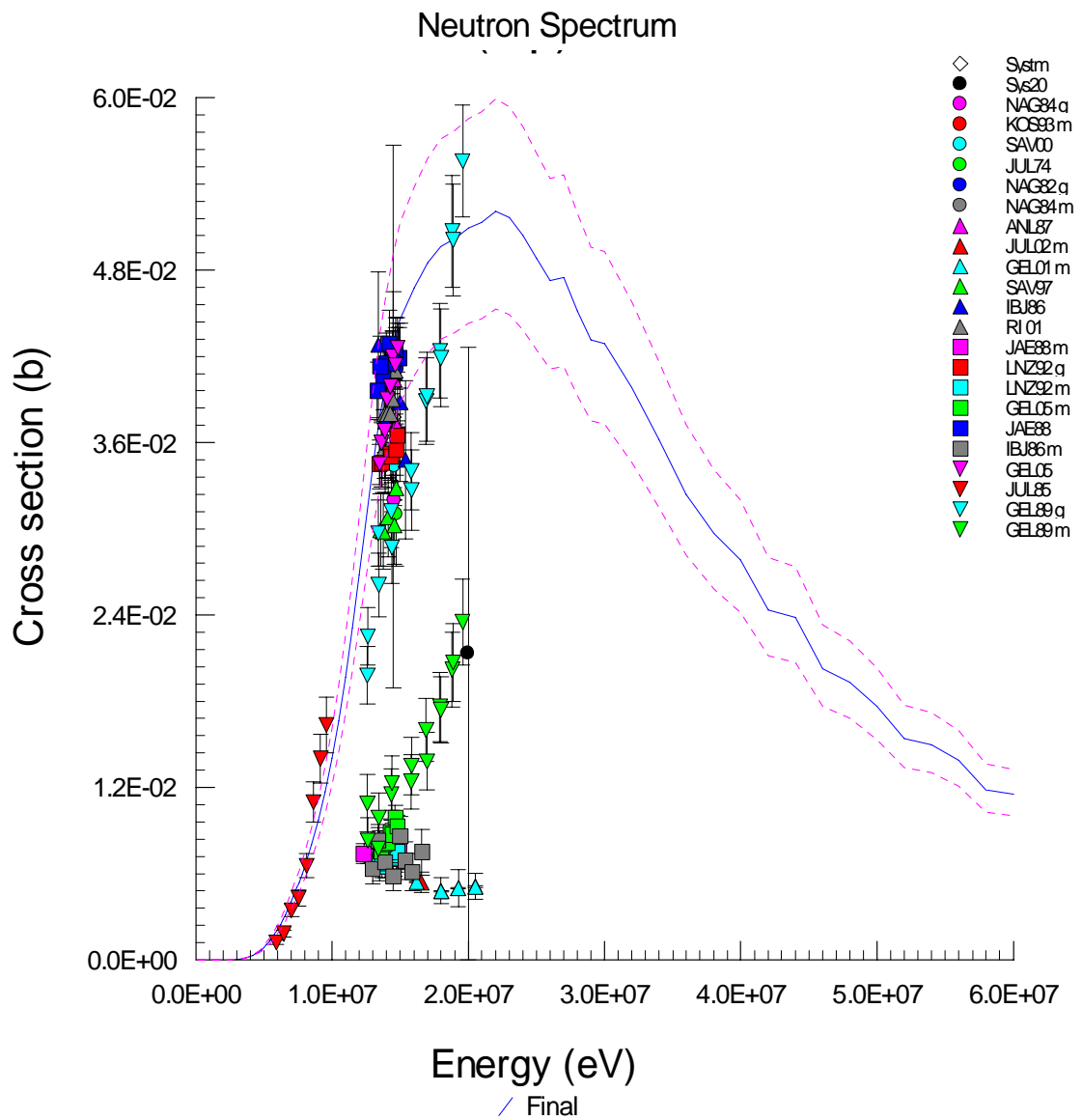
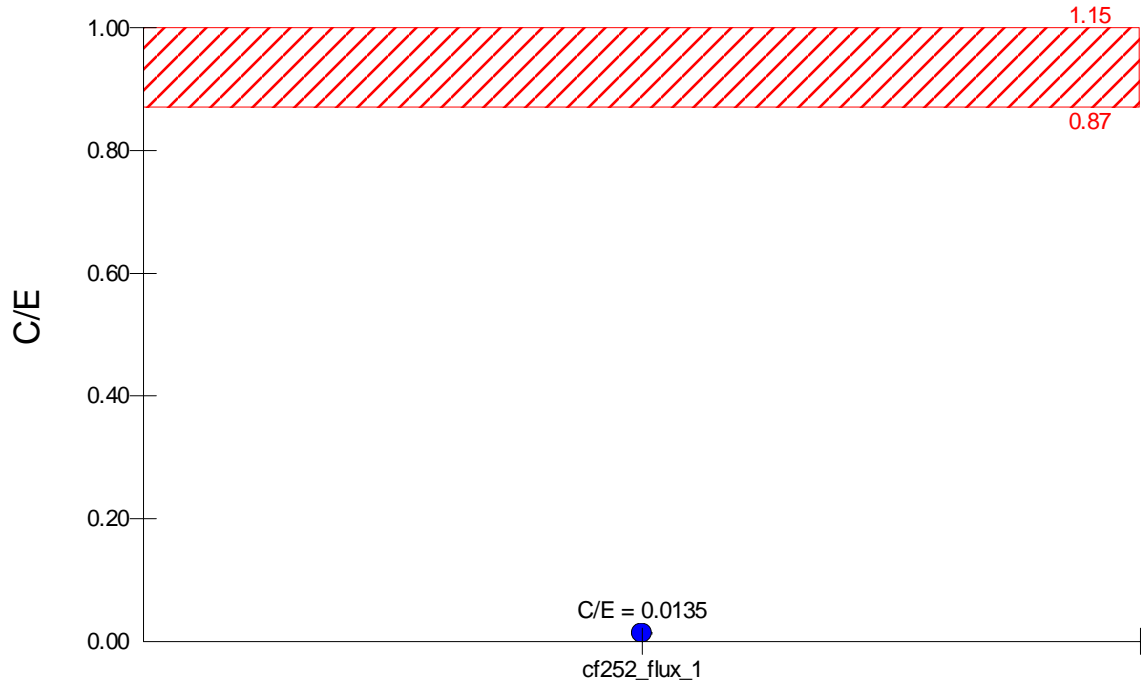
# $^{95}\text{Mo}(n,p)^{95g}\text{Nb}$



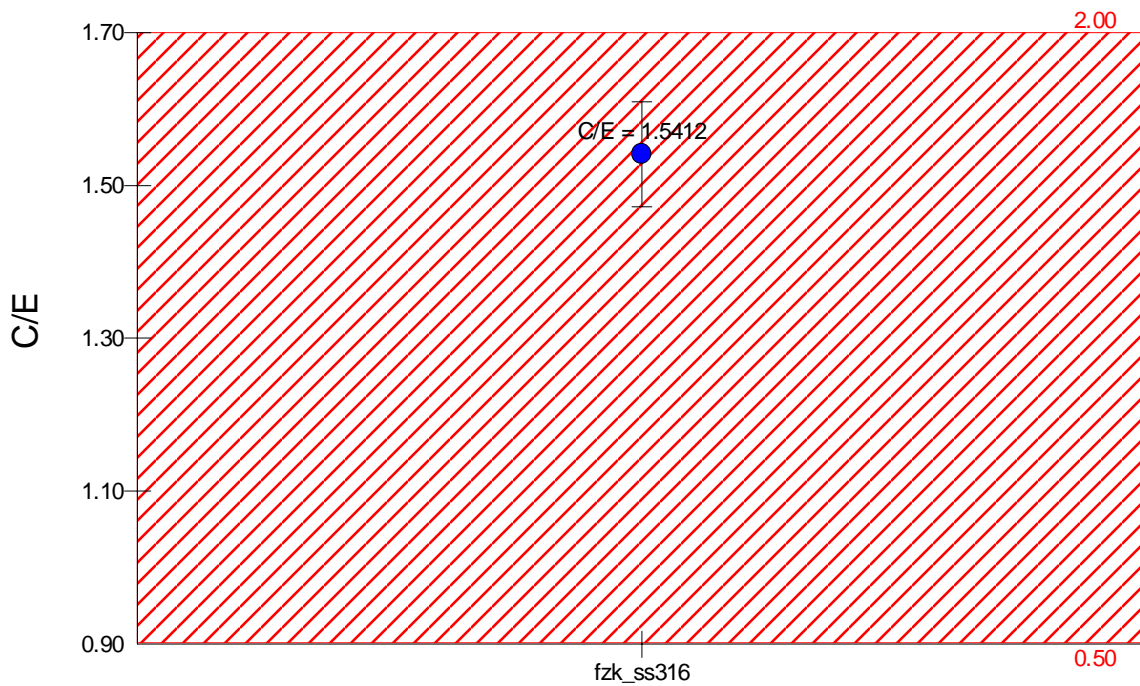
# $^{95}\text{Mo}(n,p)^{95\text{m}}\text{Nb}$



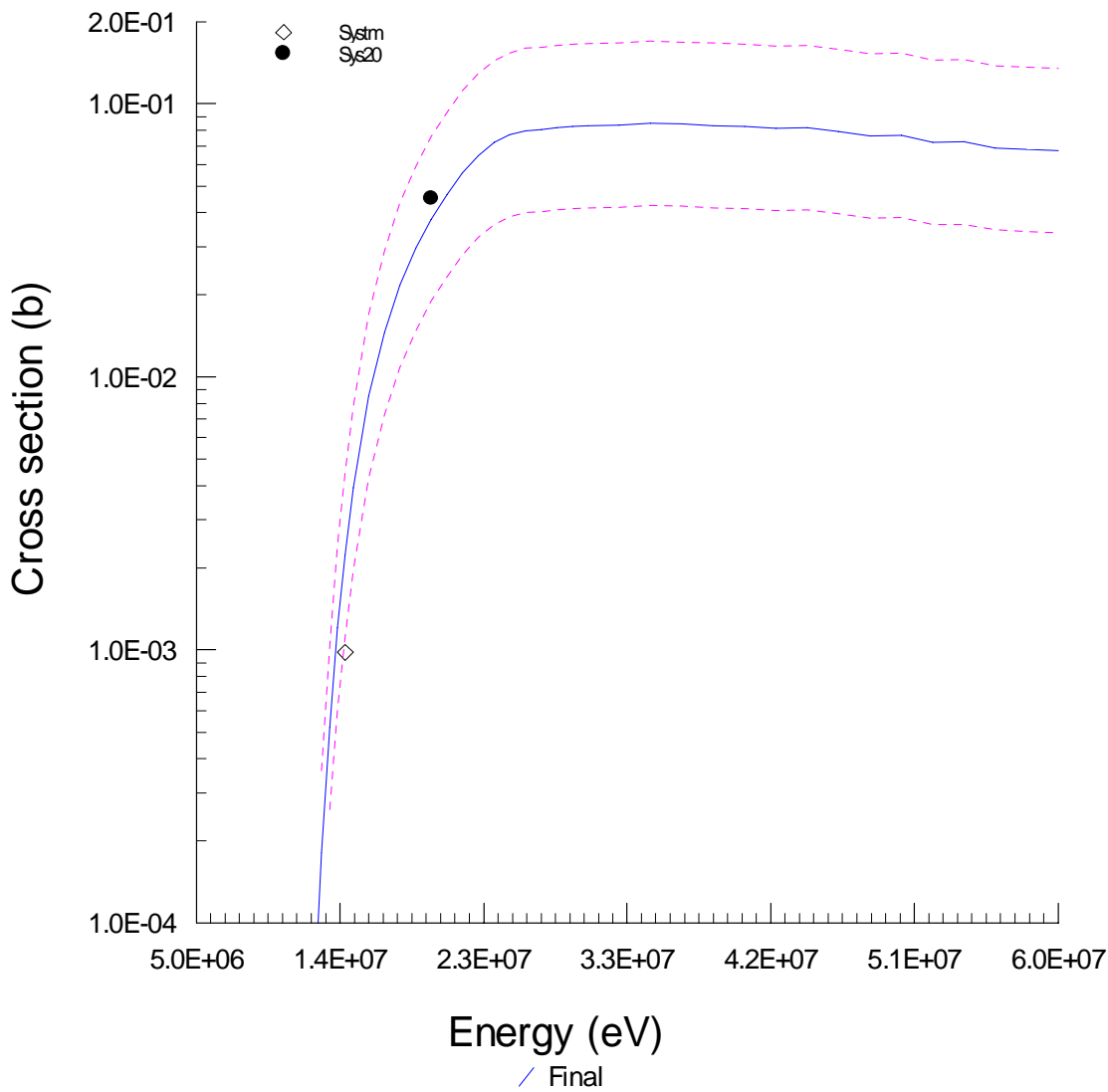
# $^{95}\text{Mo}(n,p)^{95}\text{Nb}$



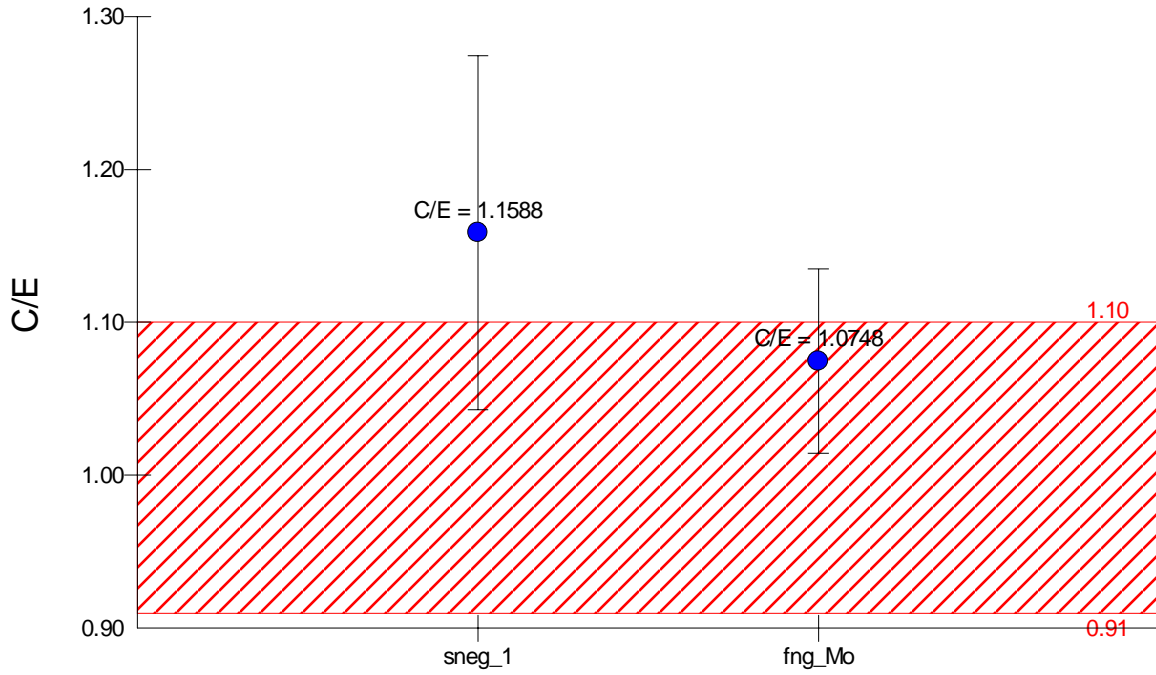
$^{96}\text{Mo}(n,n'p)^{95}\text{Nb}$



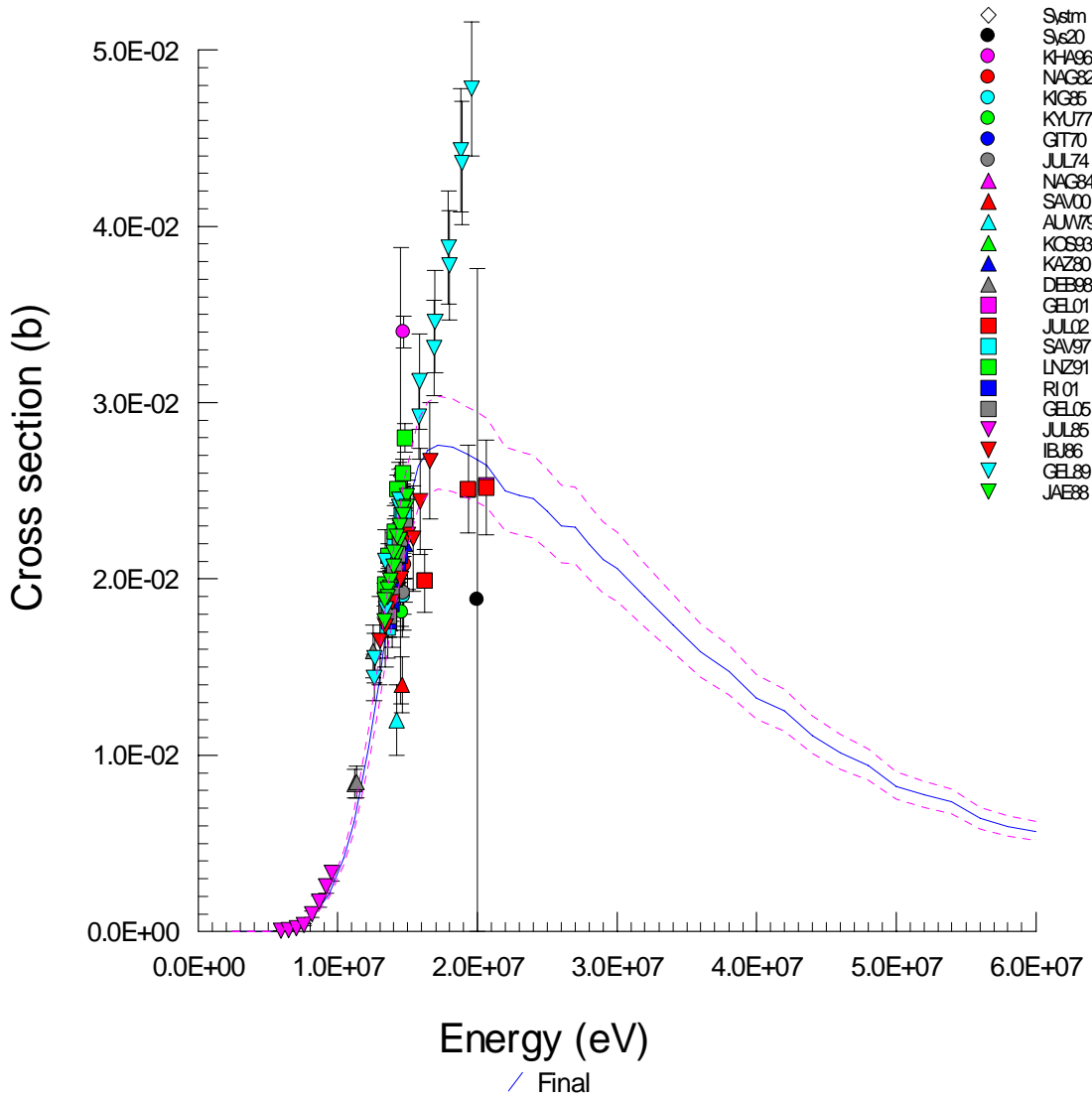
Neutron Spectrum



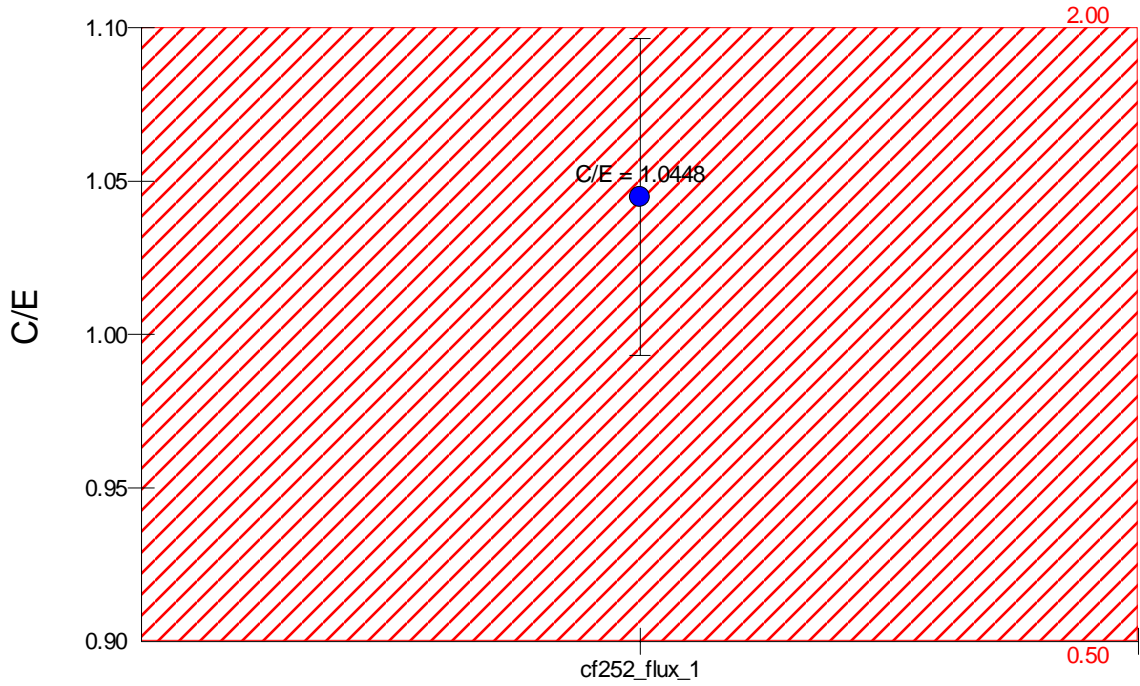
# $^{96}\text{Mo}(n,p)^{96}\text{Nb}$



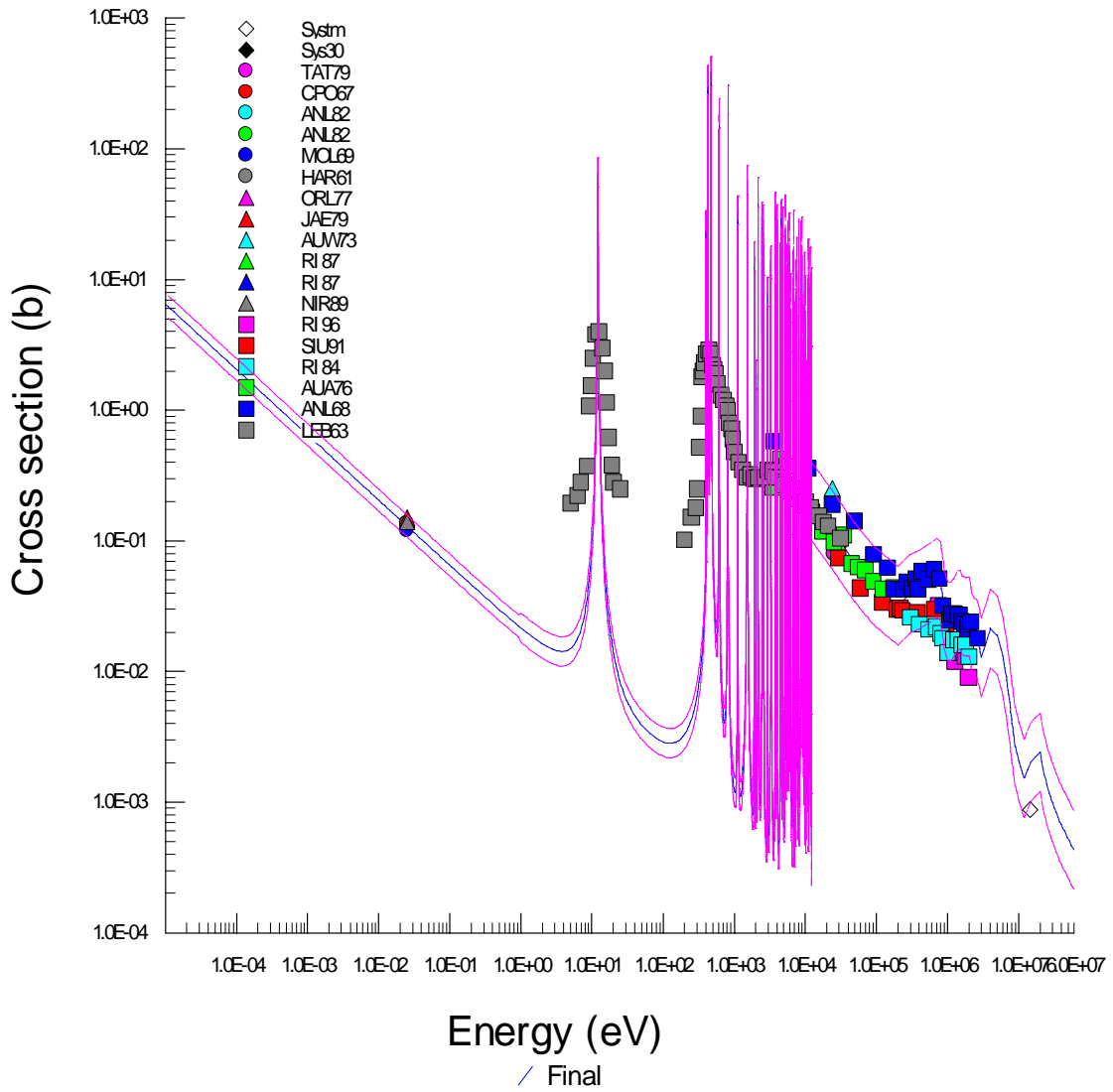
## Neutron Spectrum



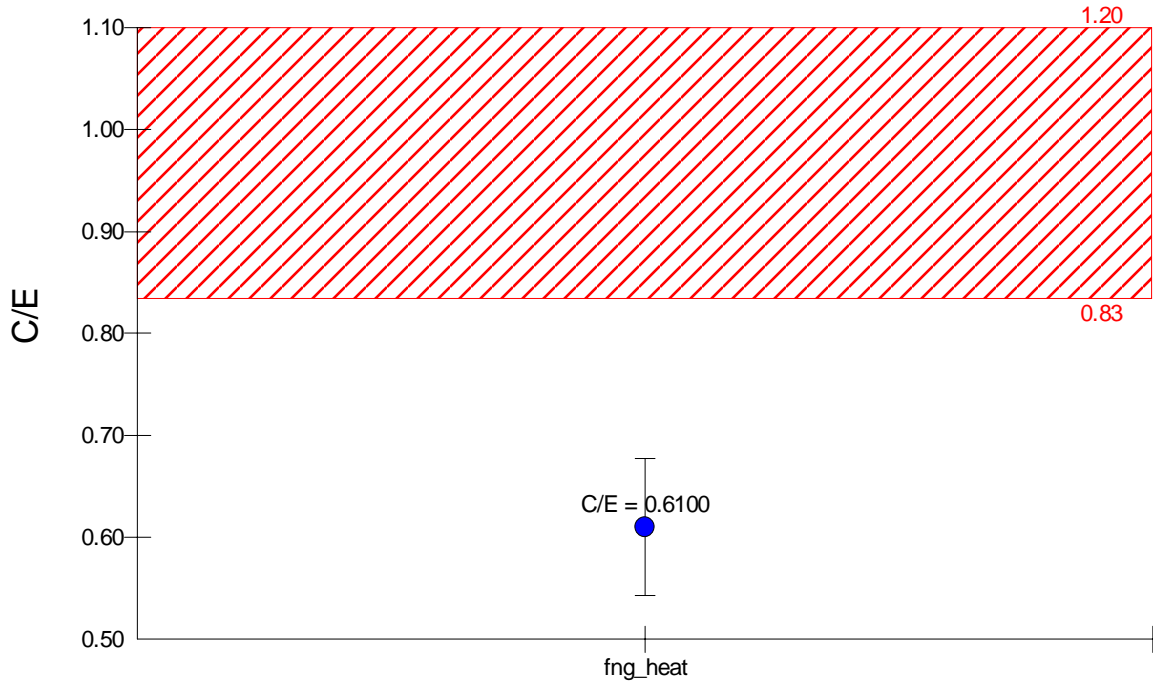
# $^{98}\text{Mo}(n,\gamma)^{99}\text{Mo}$



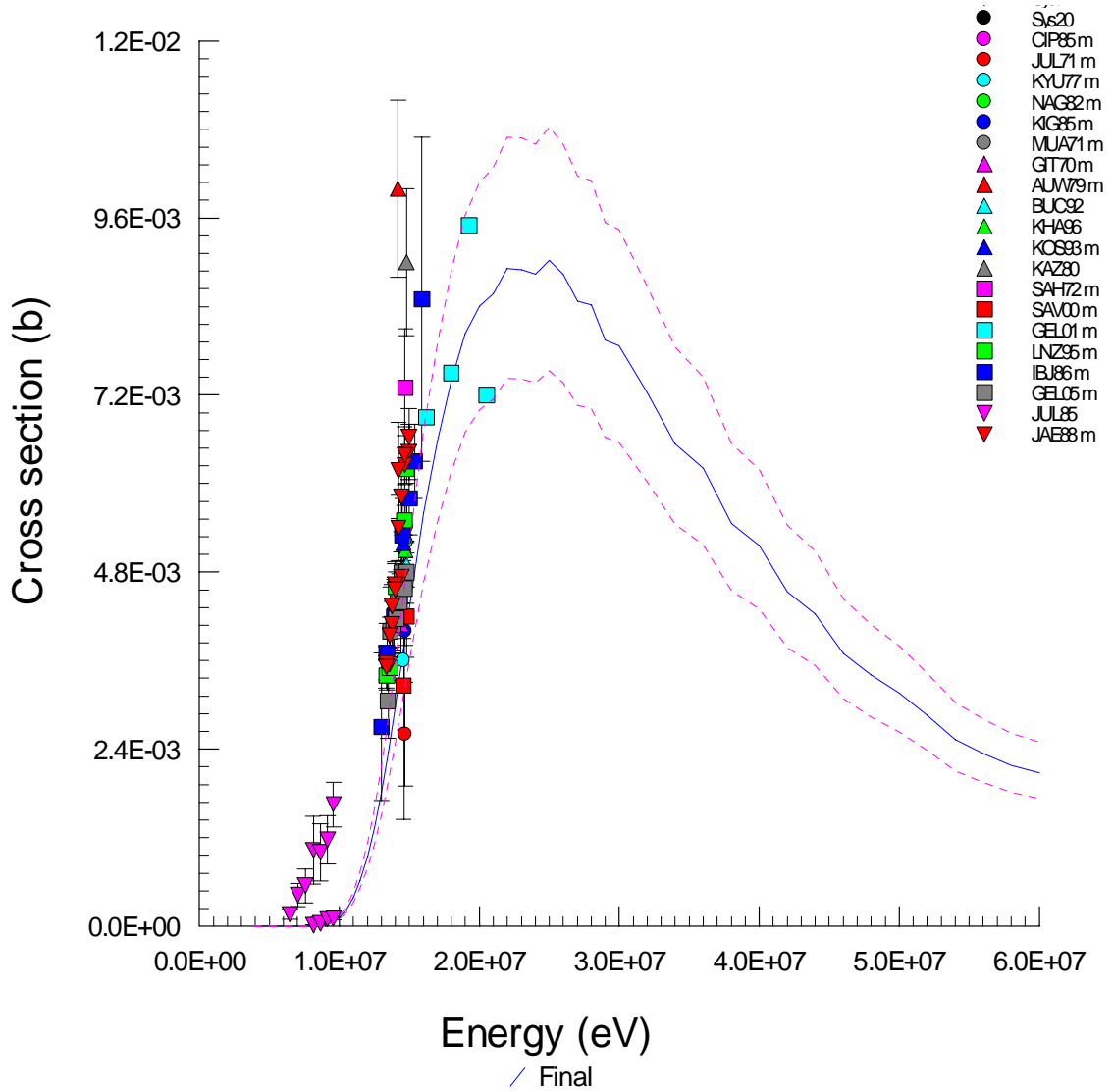
## Neutron Spectrum



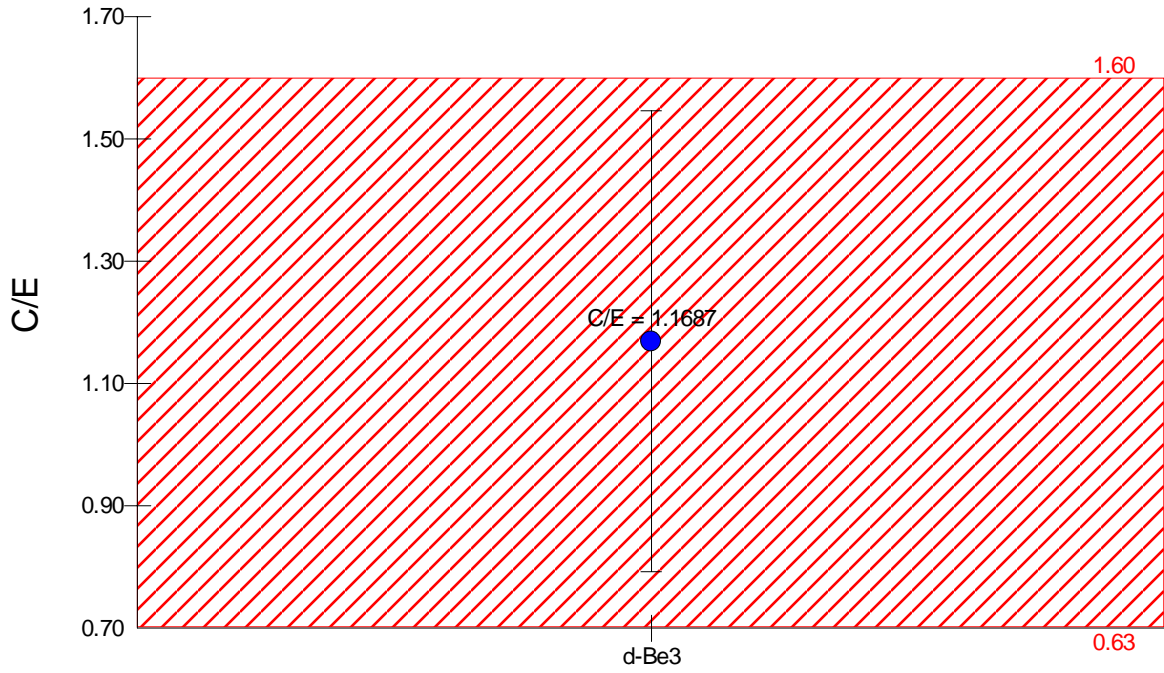
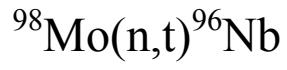
$^{98}\text{Mo}(n,p)^{98\text{m}}\text{Nb}$



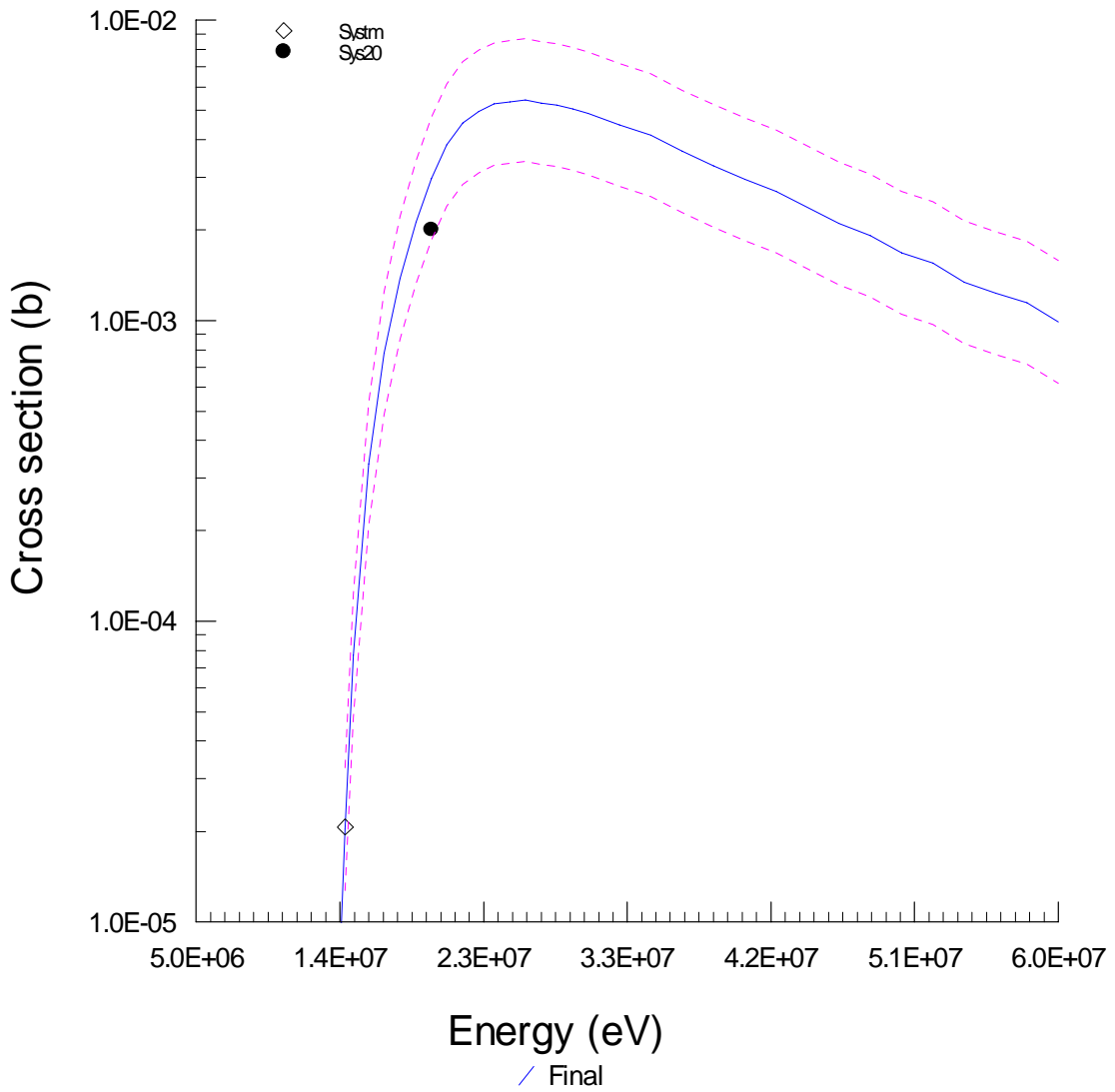
Neutron Spectrum

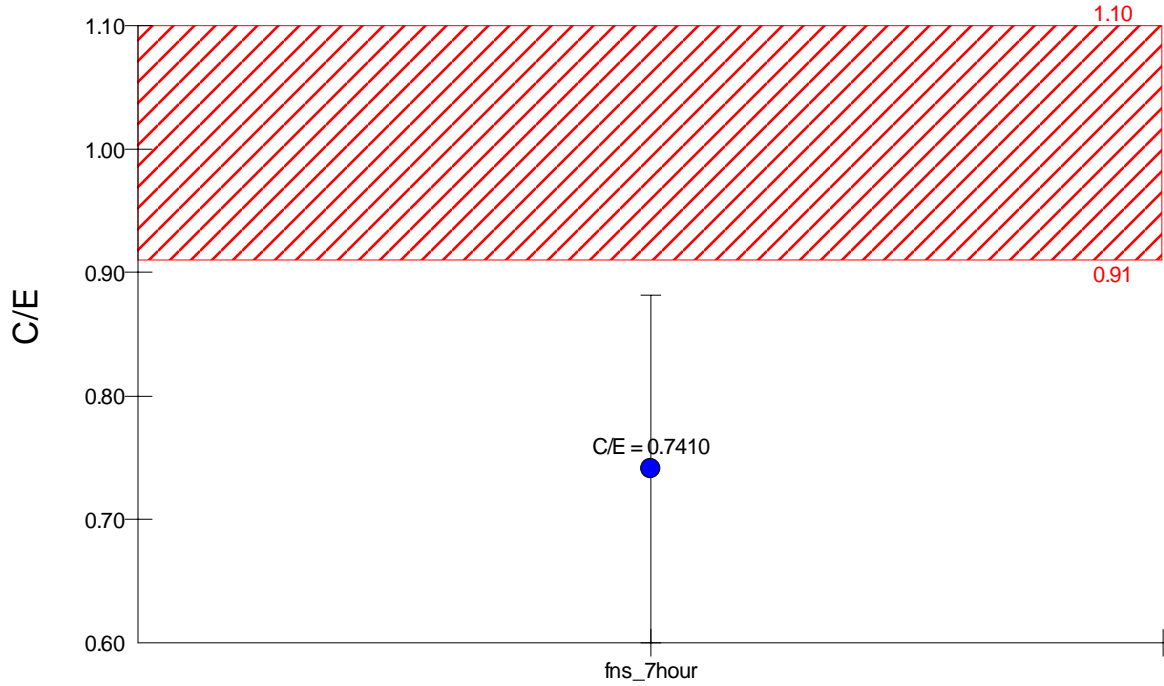
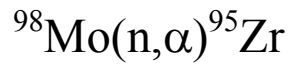




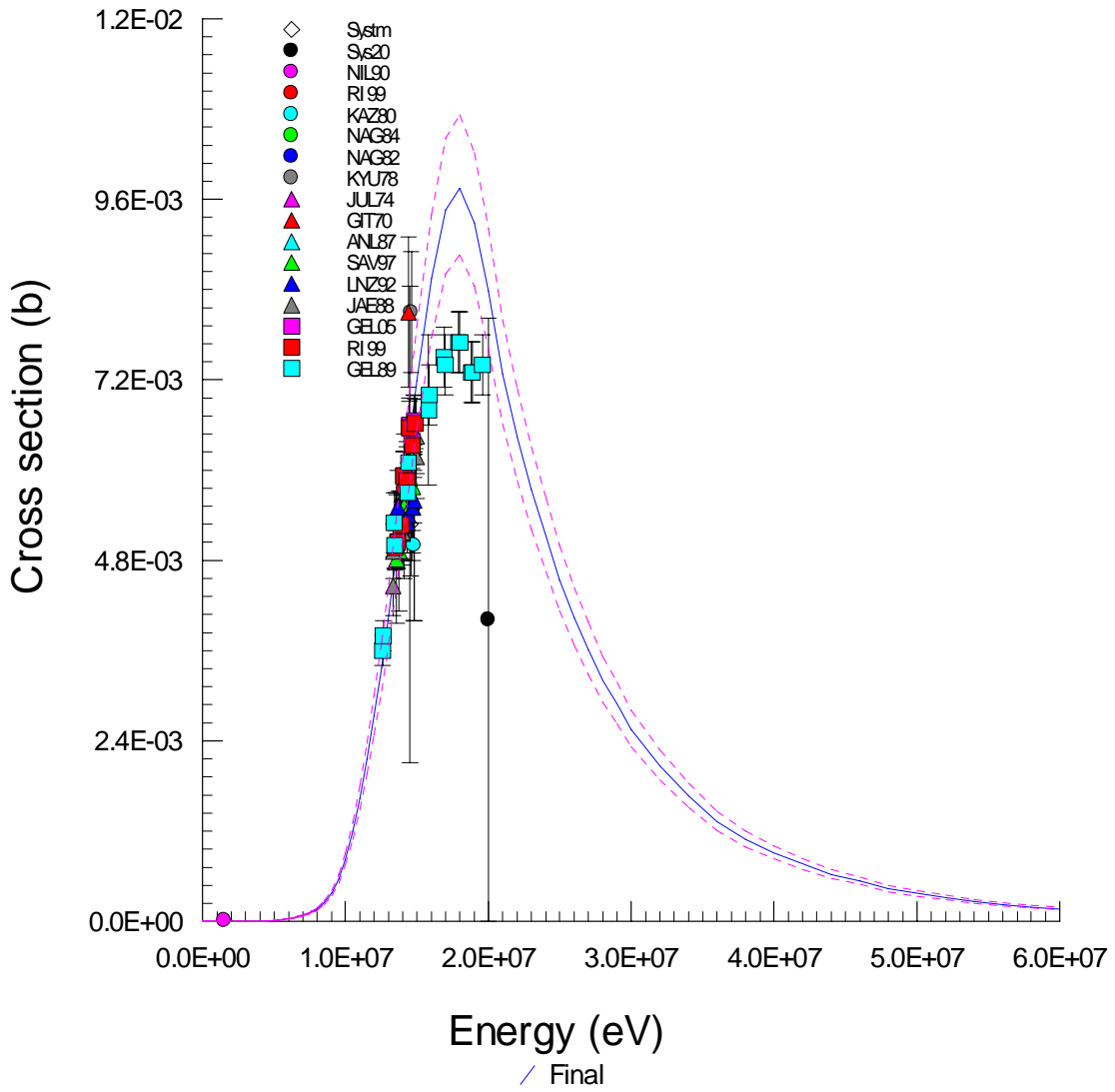


Neutron Spectrum

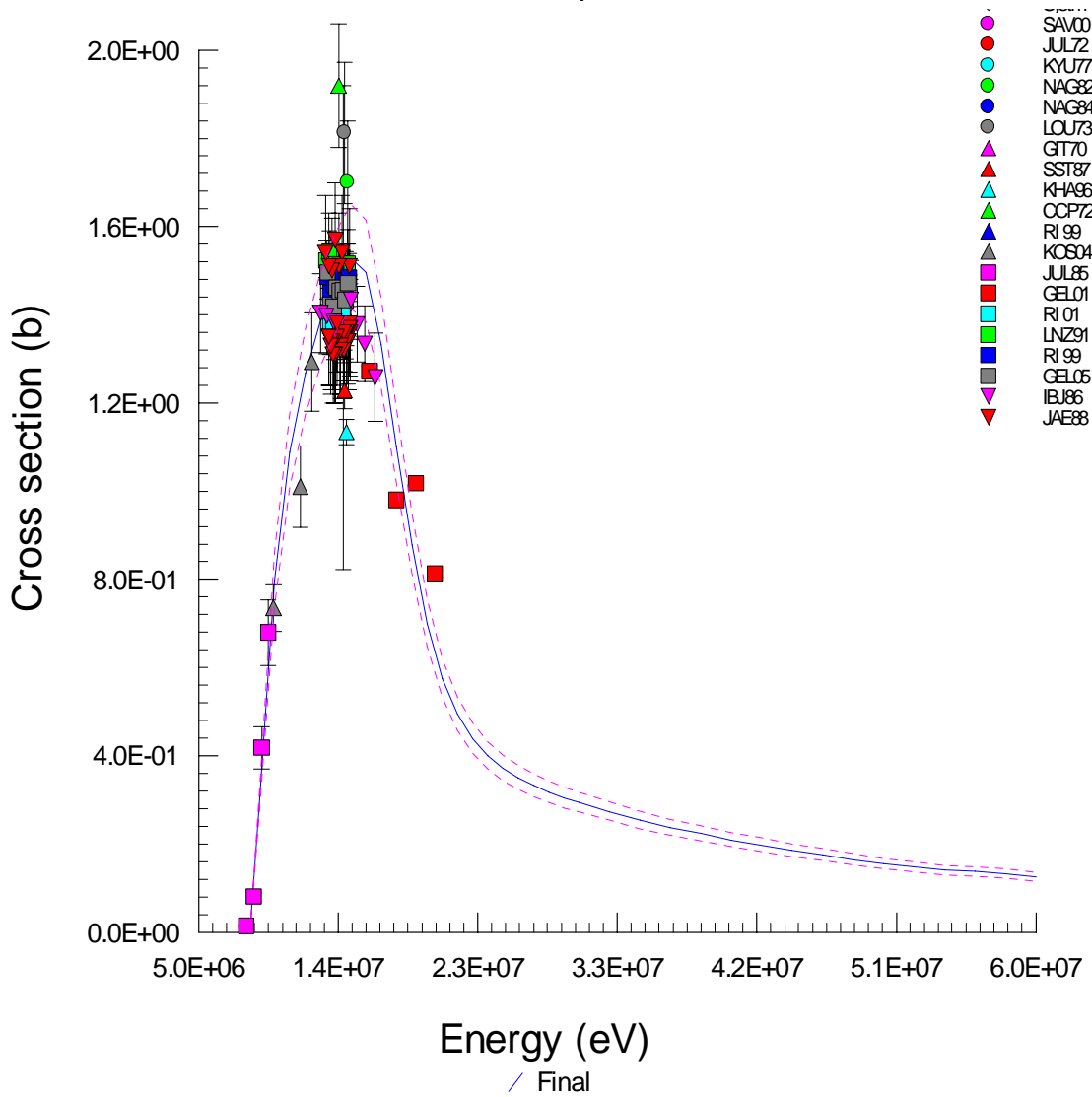
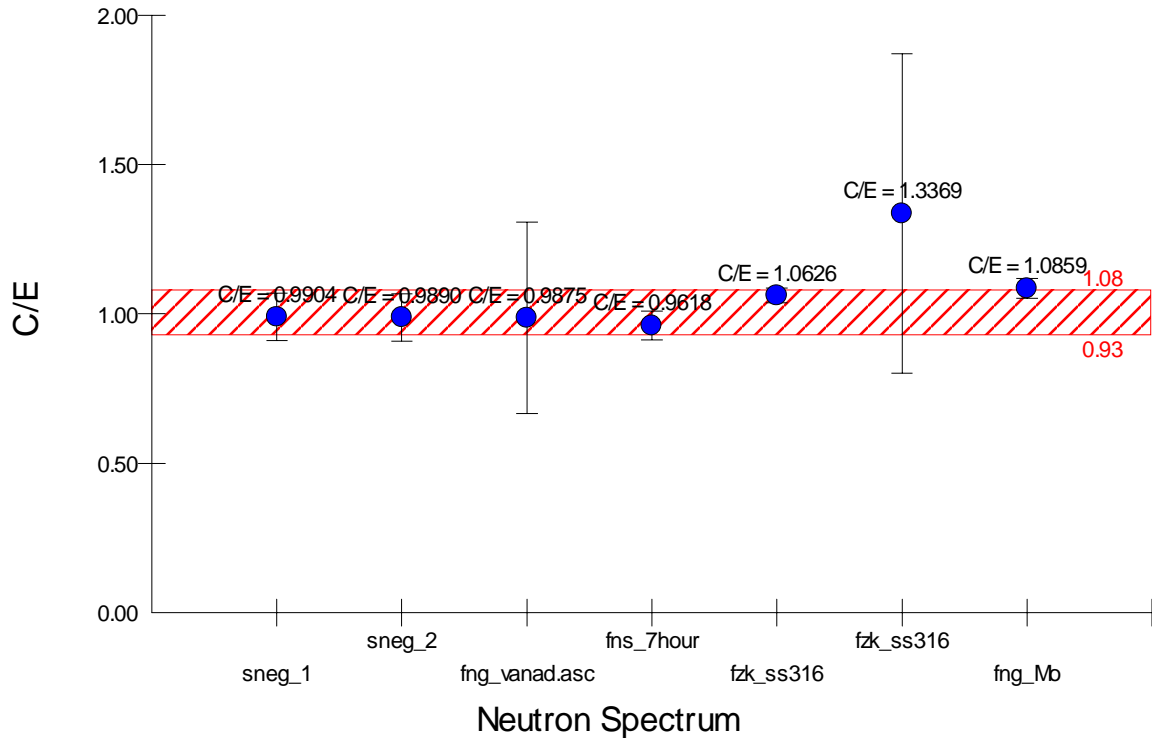


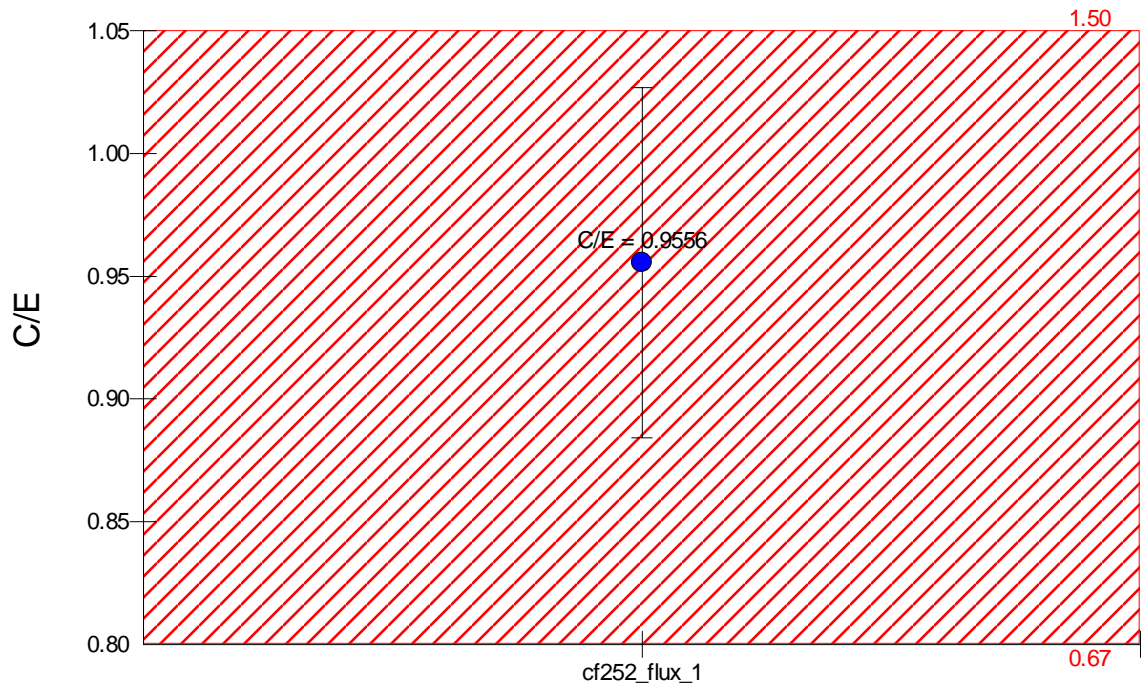
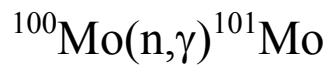


Neutron Spectrum

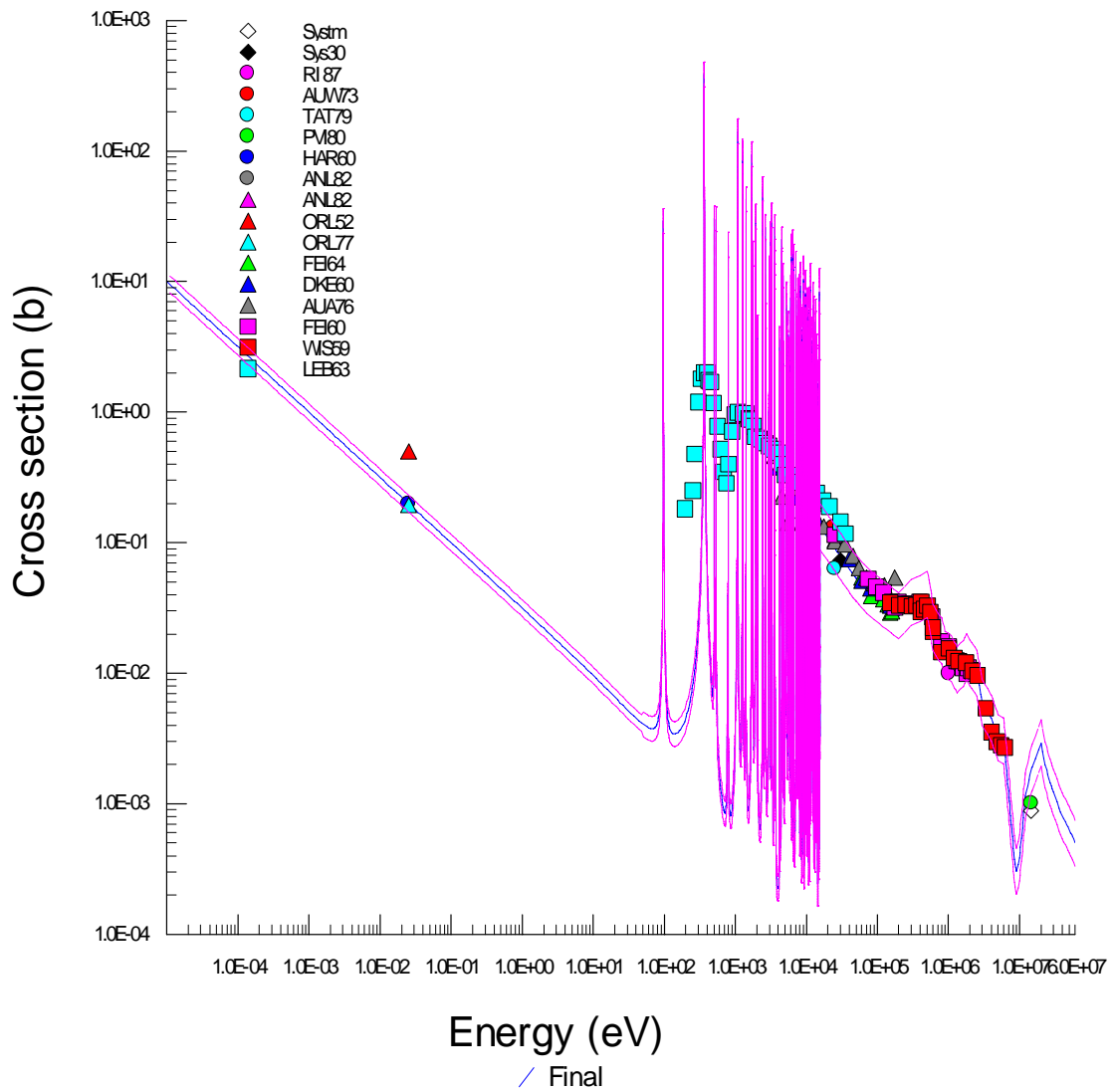


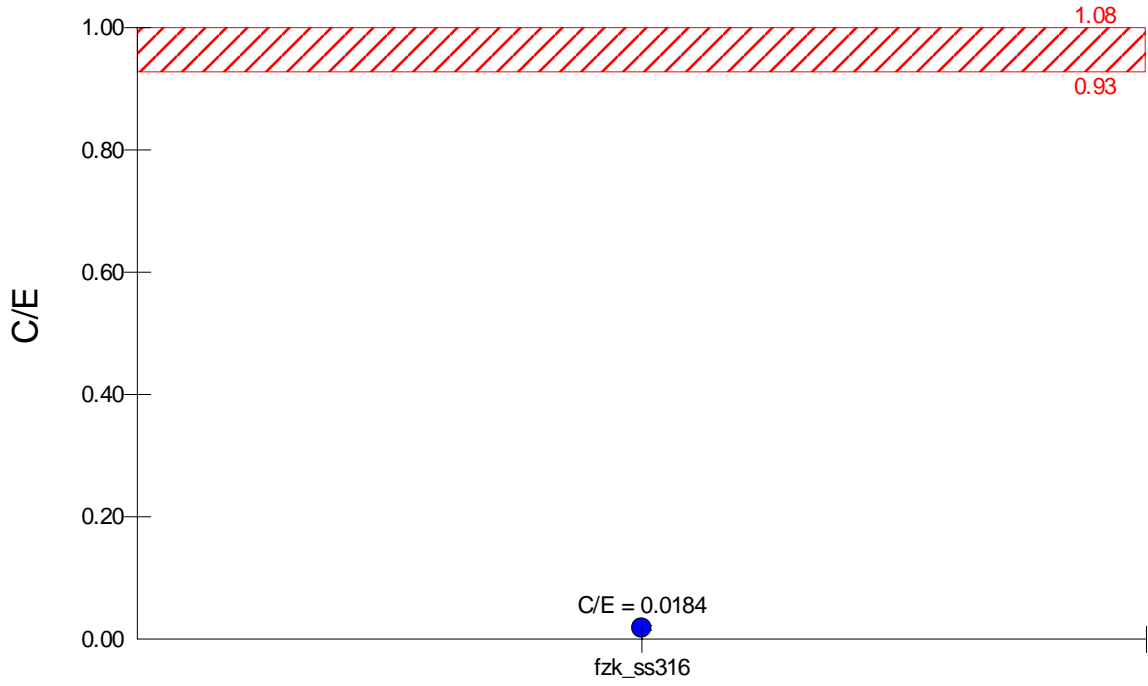
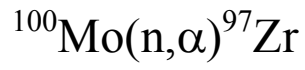
$^{100}\text{Mo}(n,2n)^{99}\text{Mo} \blacktriangleright 554$



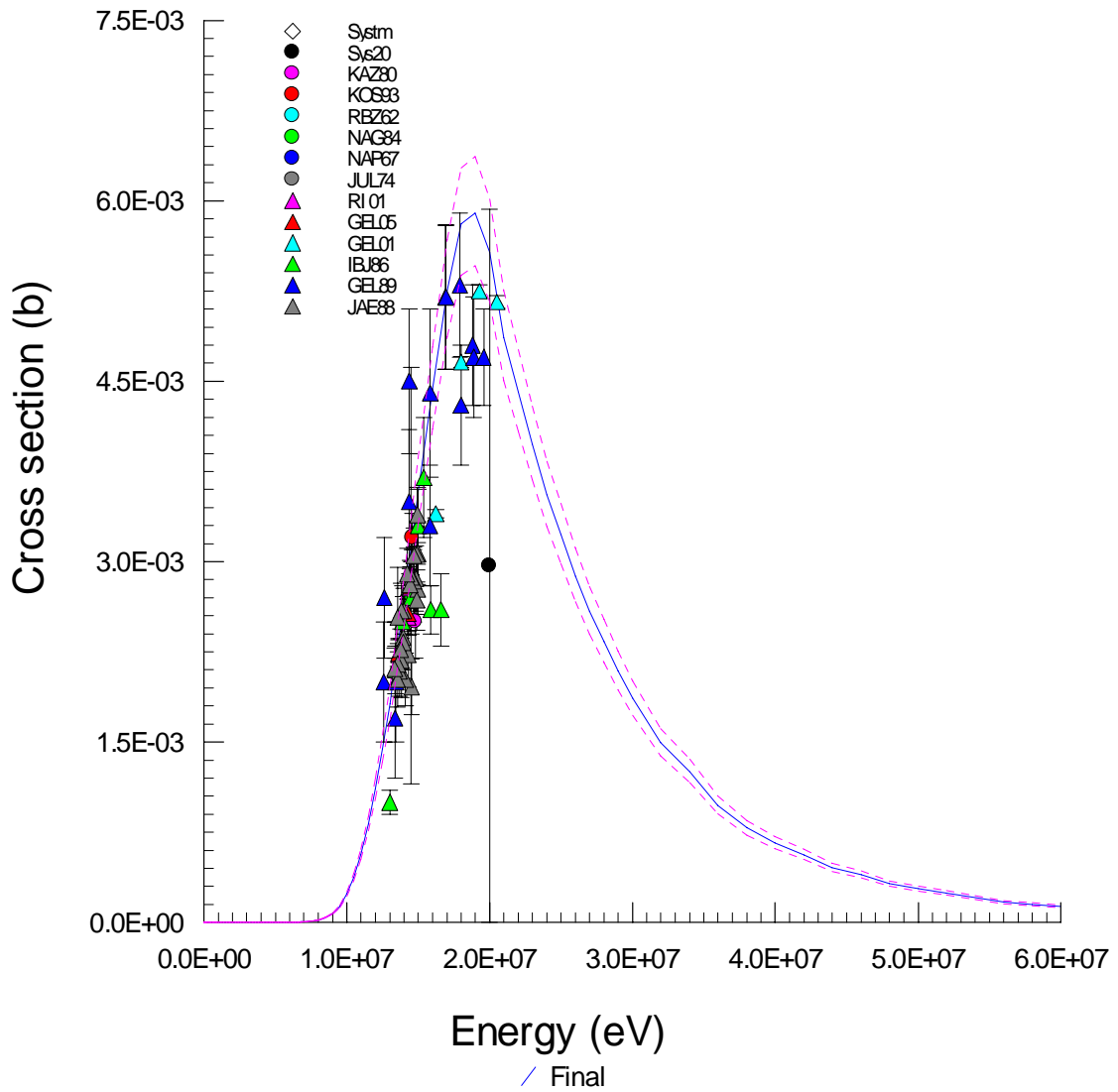


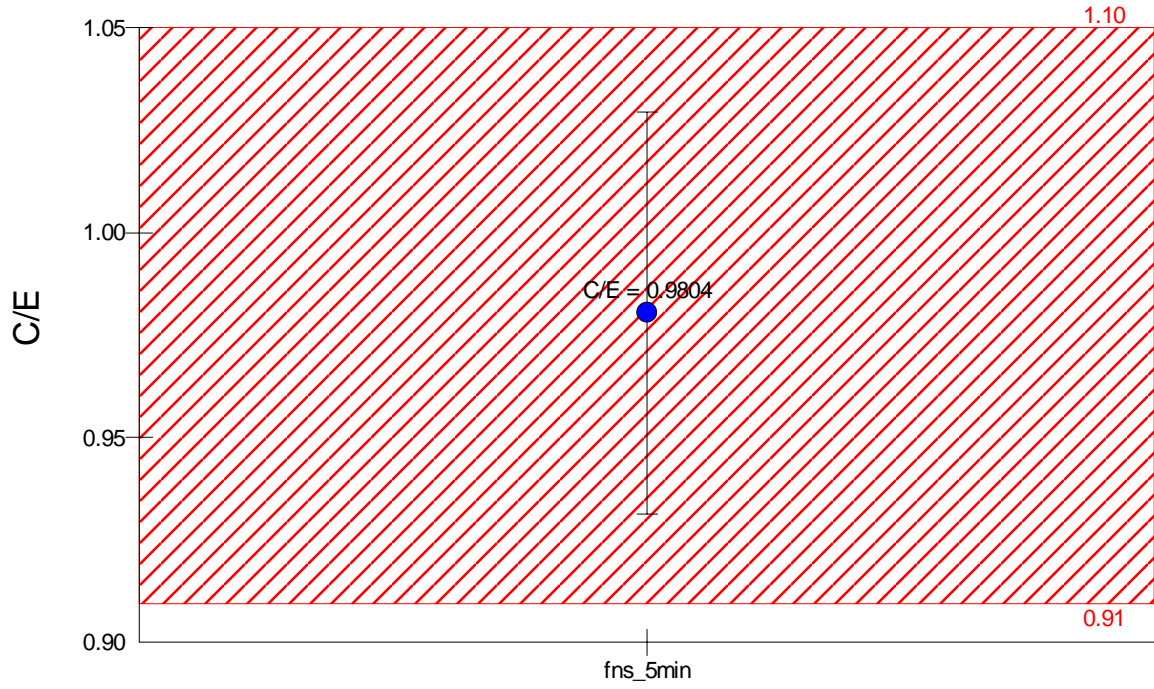
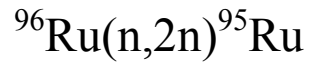
Neutron Spectrum



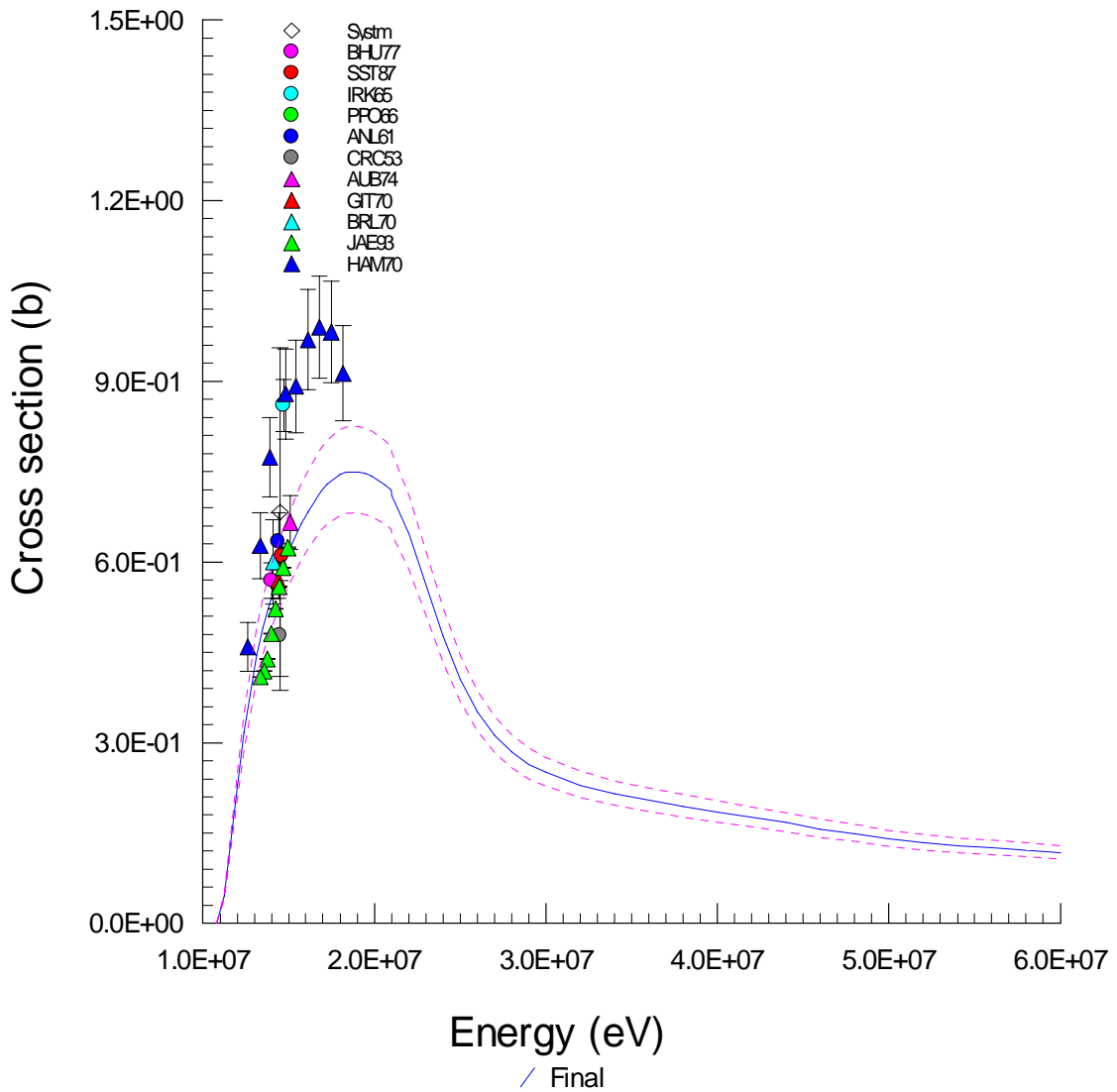


Neutron Spectrum

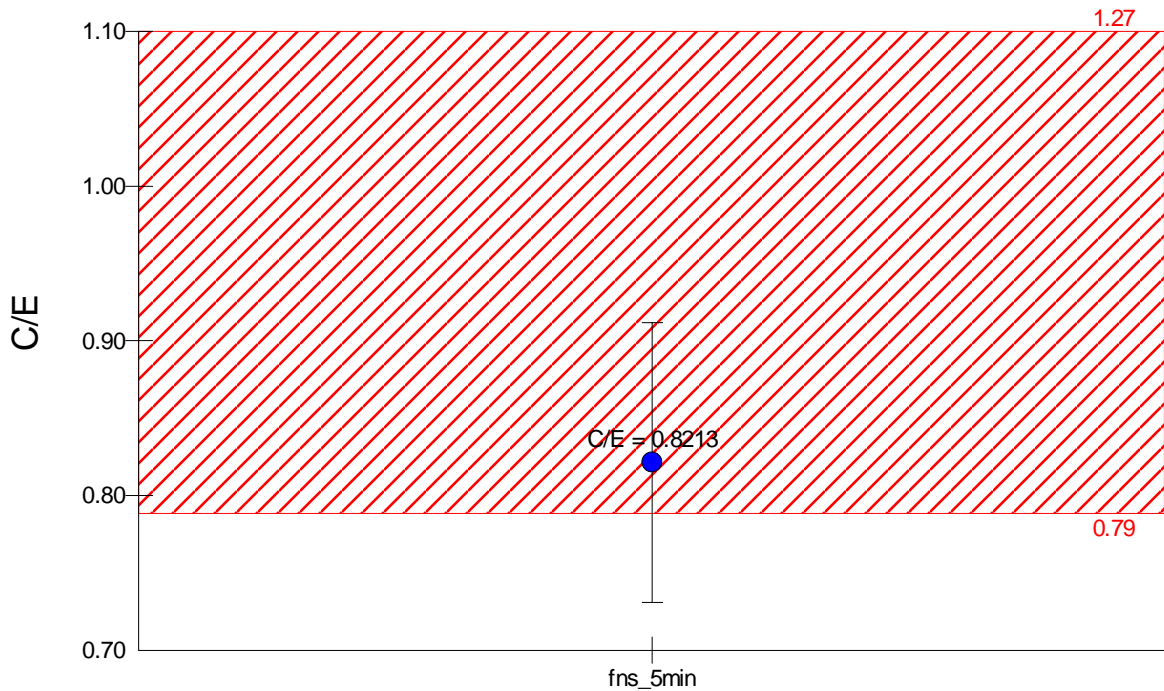




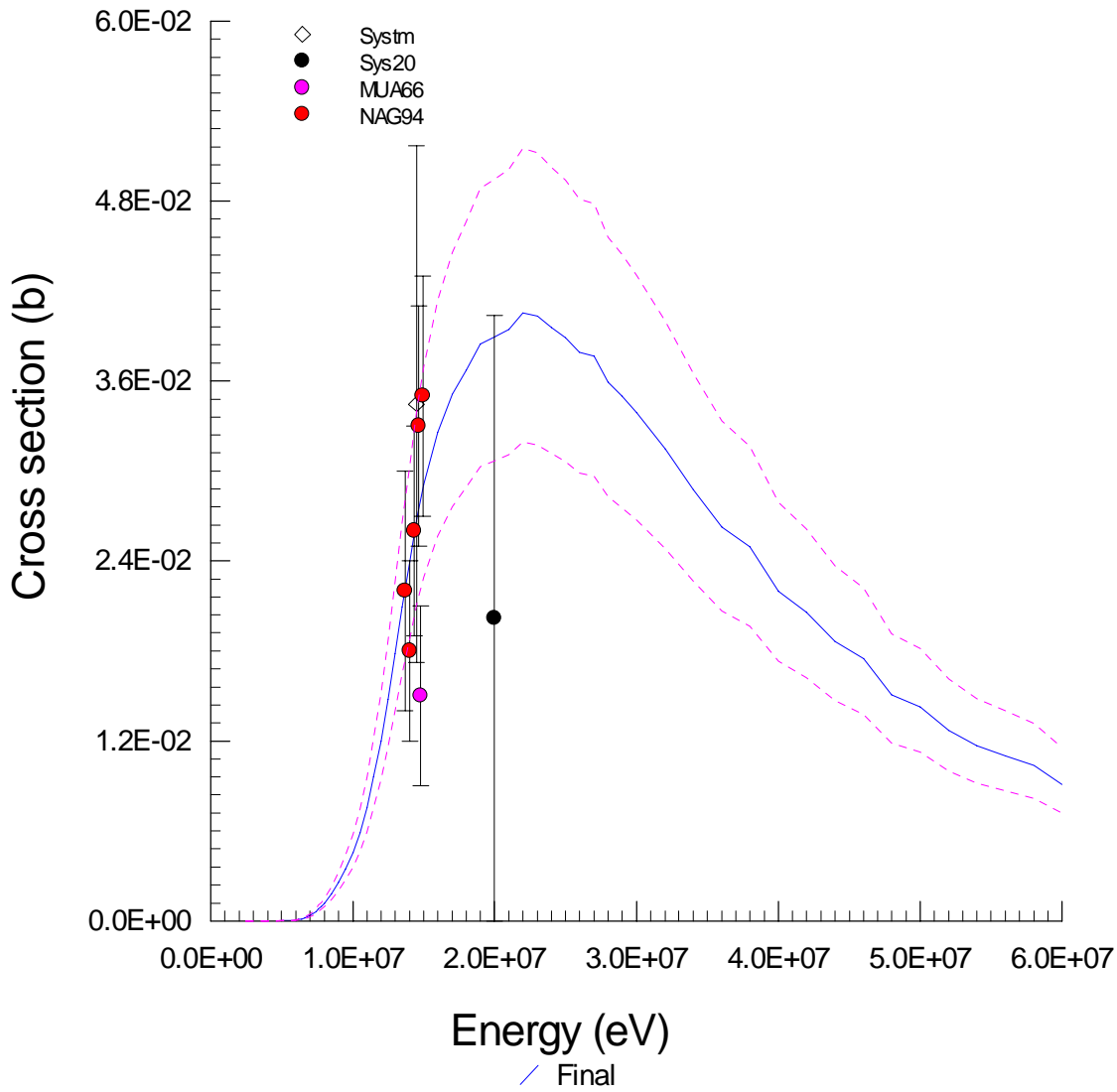
Neutron Spectrum

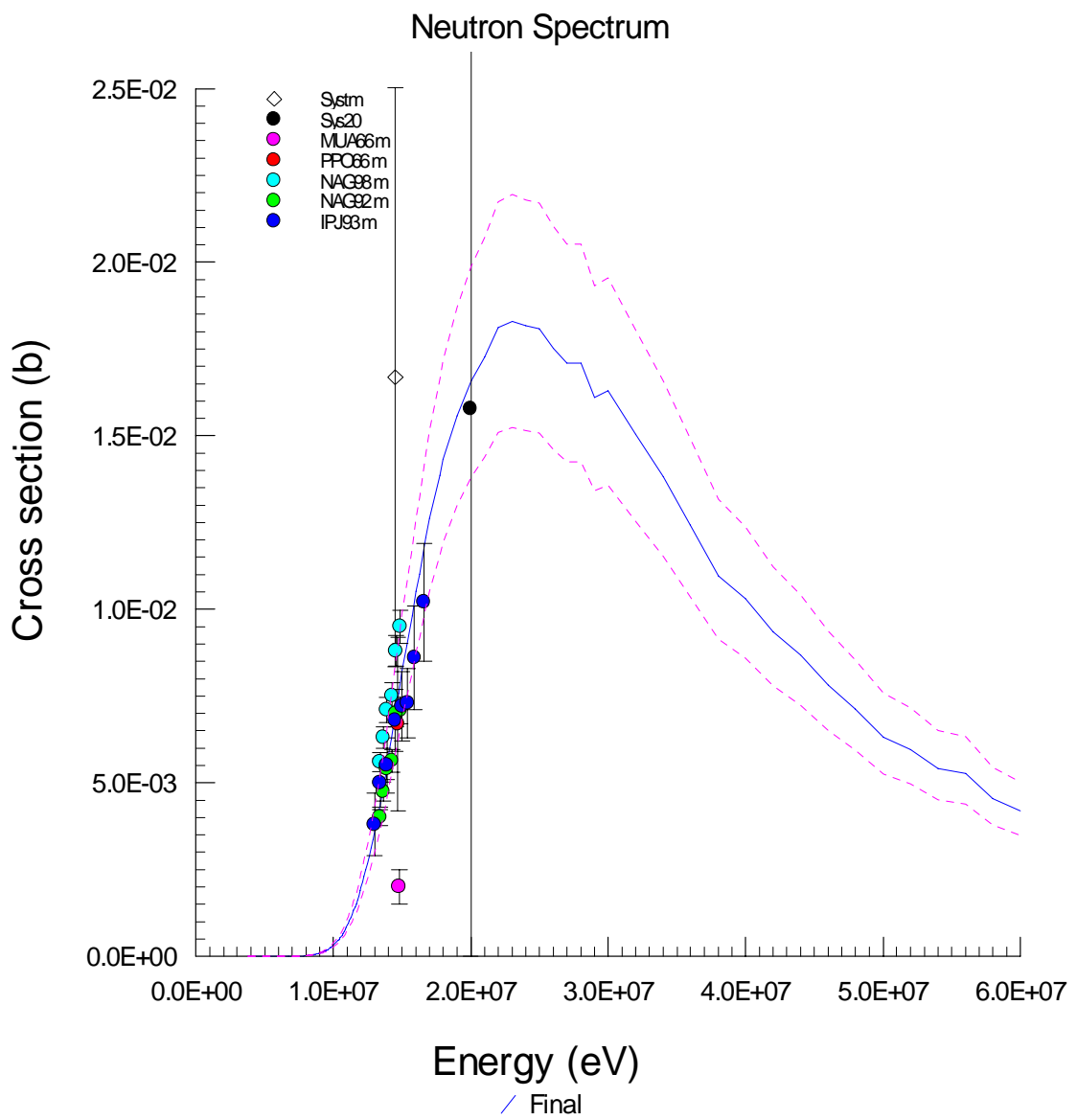
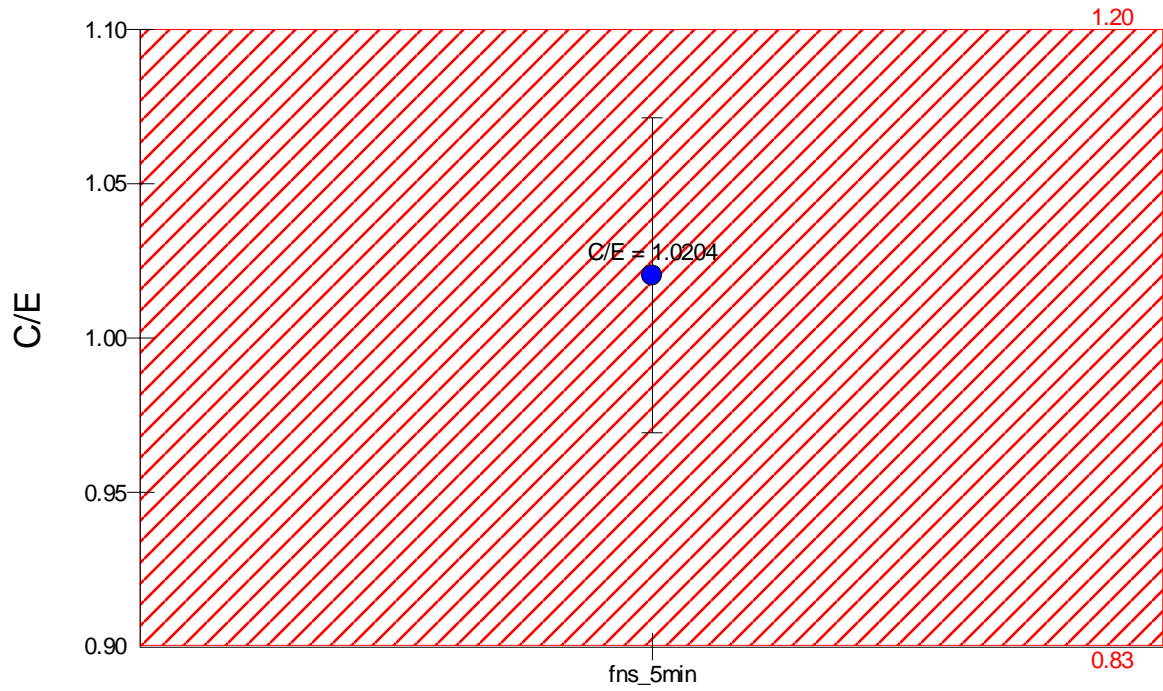
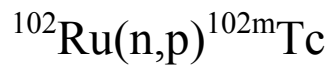


# $^{100}\text{Ru}(n,p)^{100}\text{Tc}$



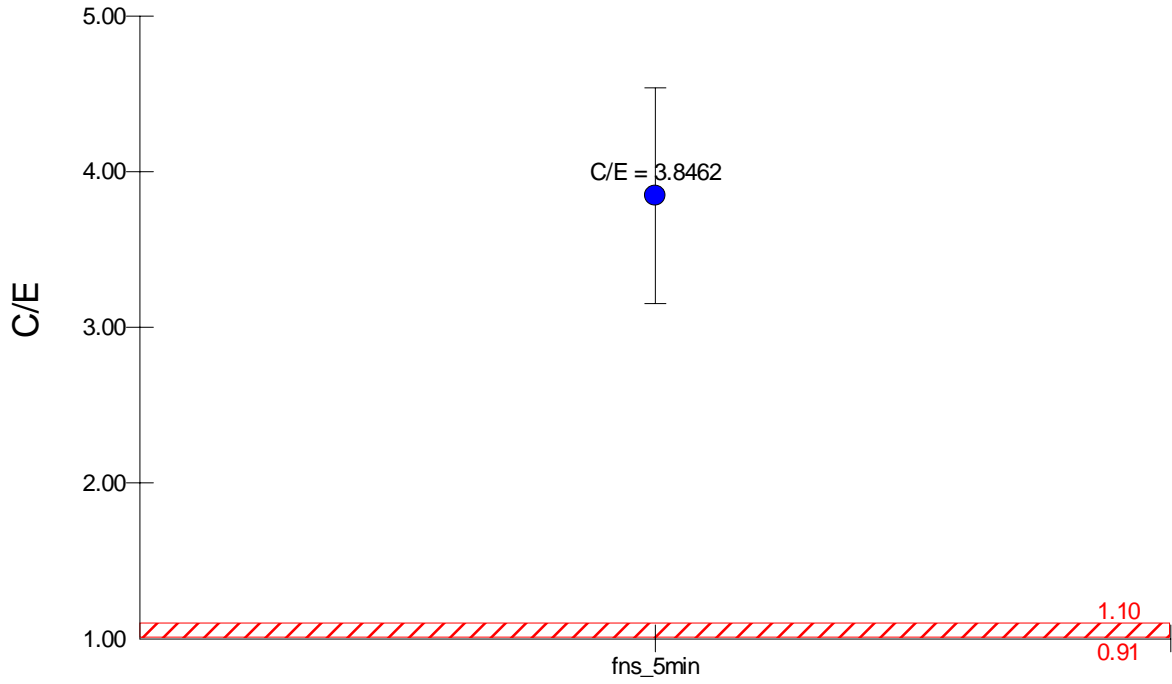
## Neutron Spectrum



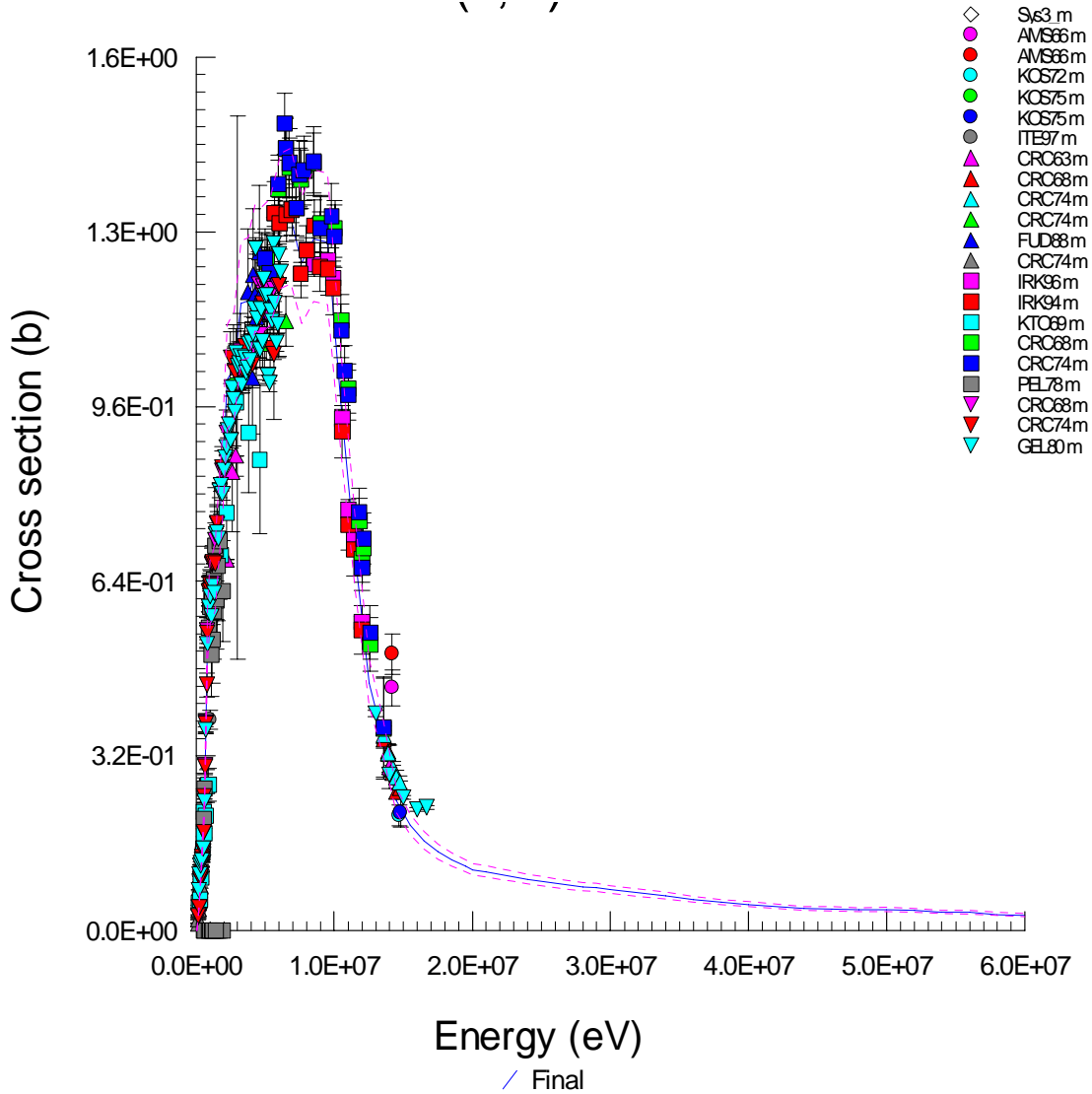




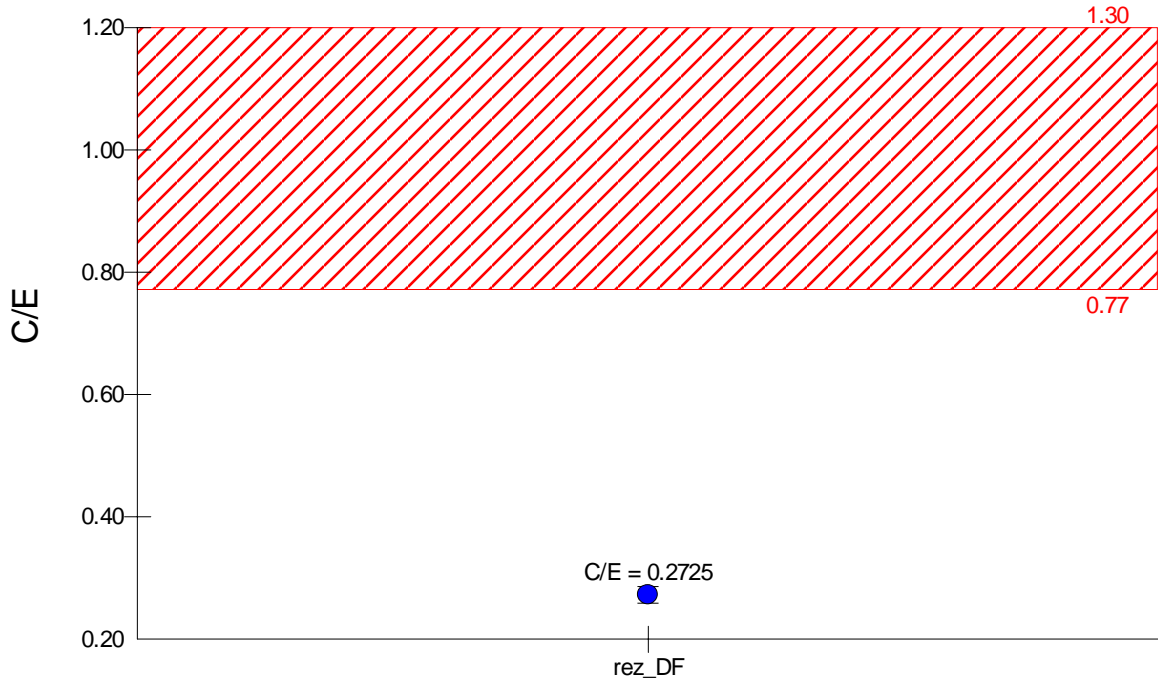
$^{103}\text{Rh}(n,n')^{103\text{m}}\text{Rh}$



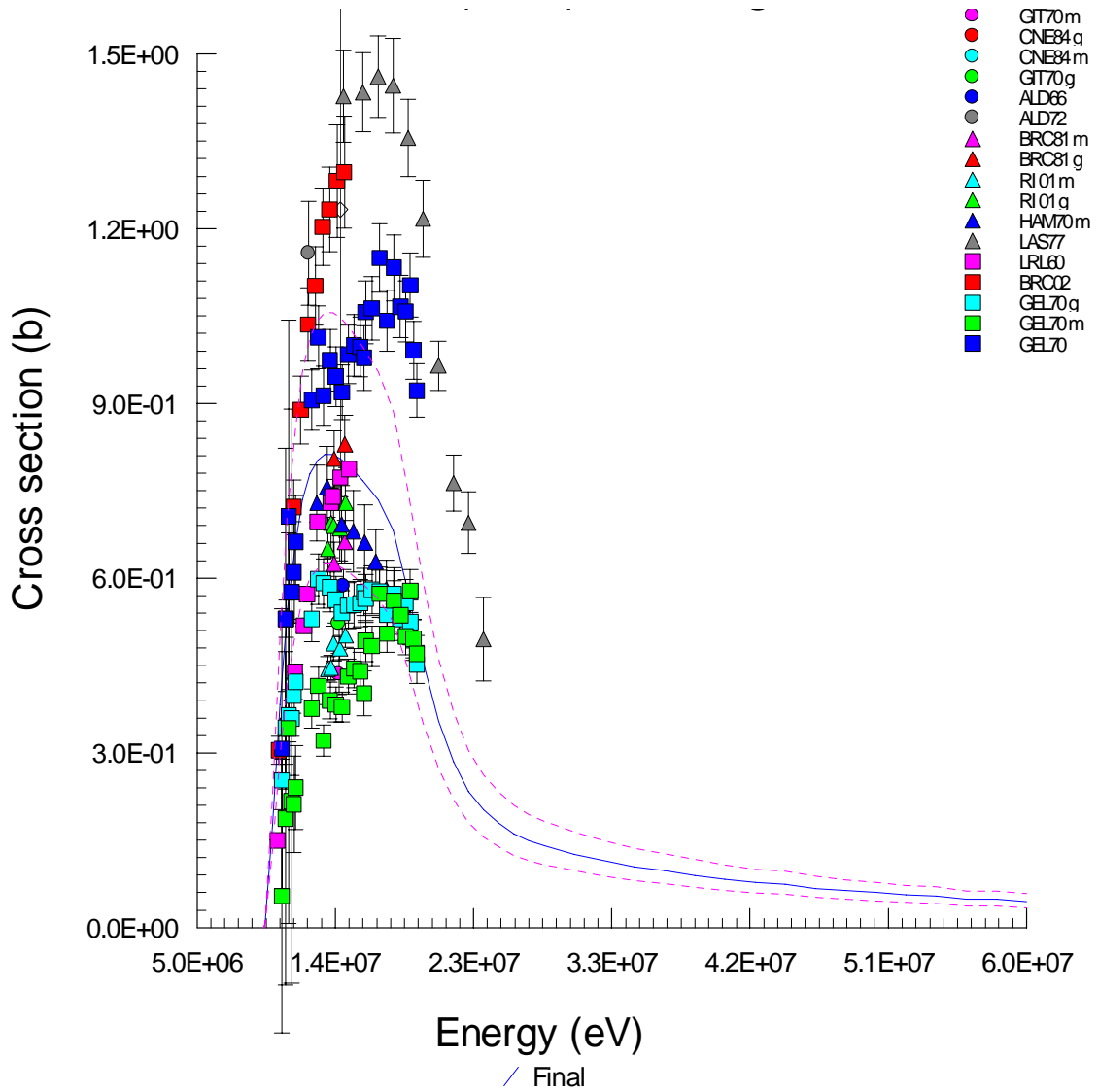
Neutron Spectrum

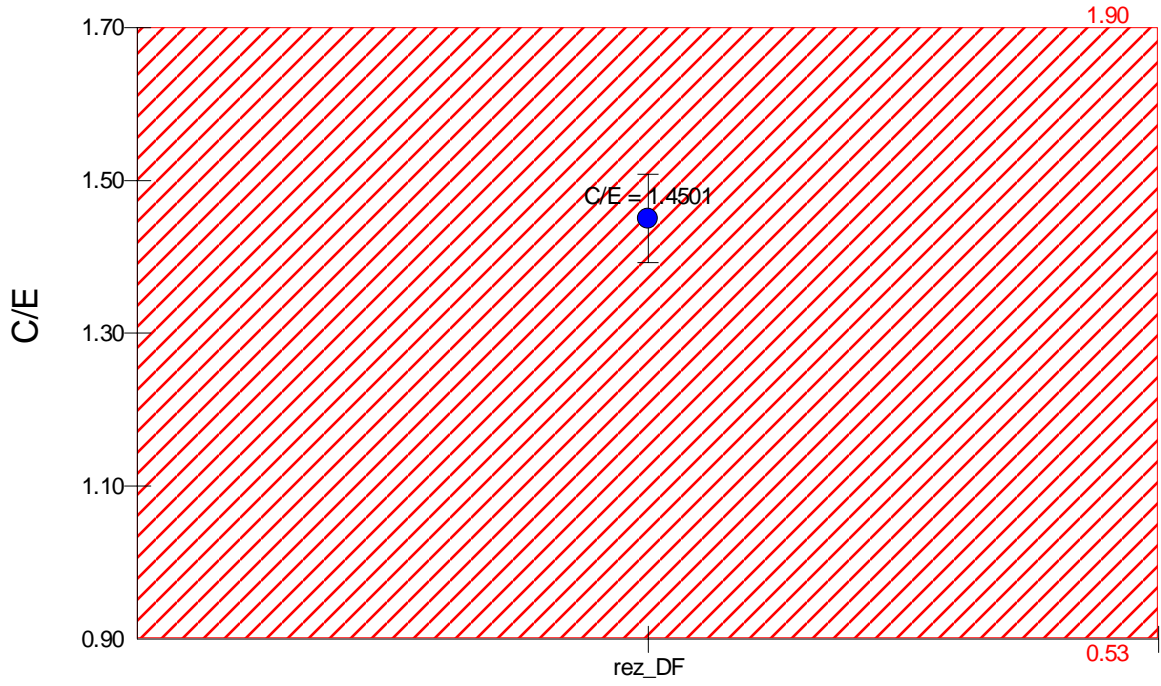
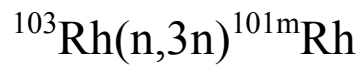


$^{103}\text{Rh}(n,2n)^{102g}\text{Rh}$

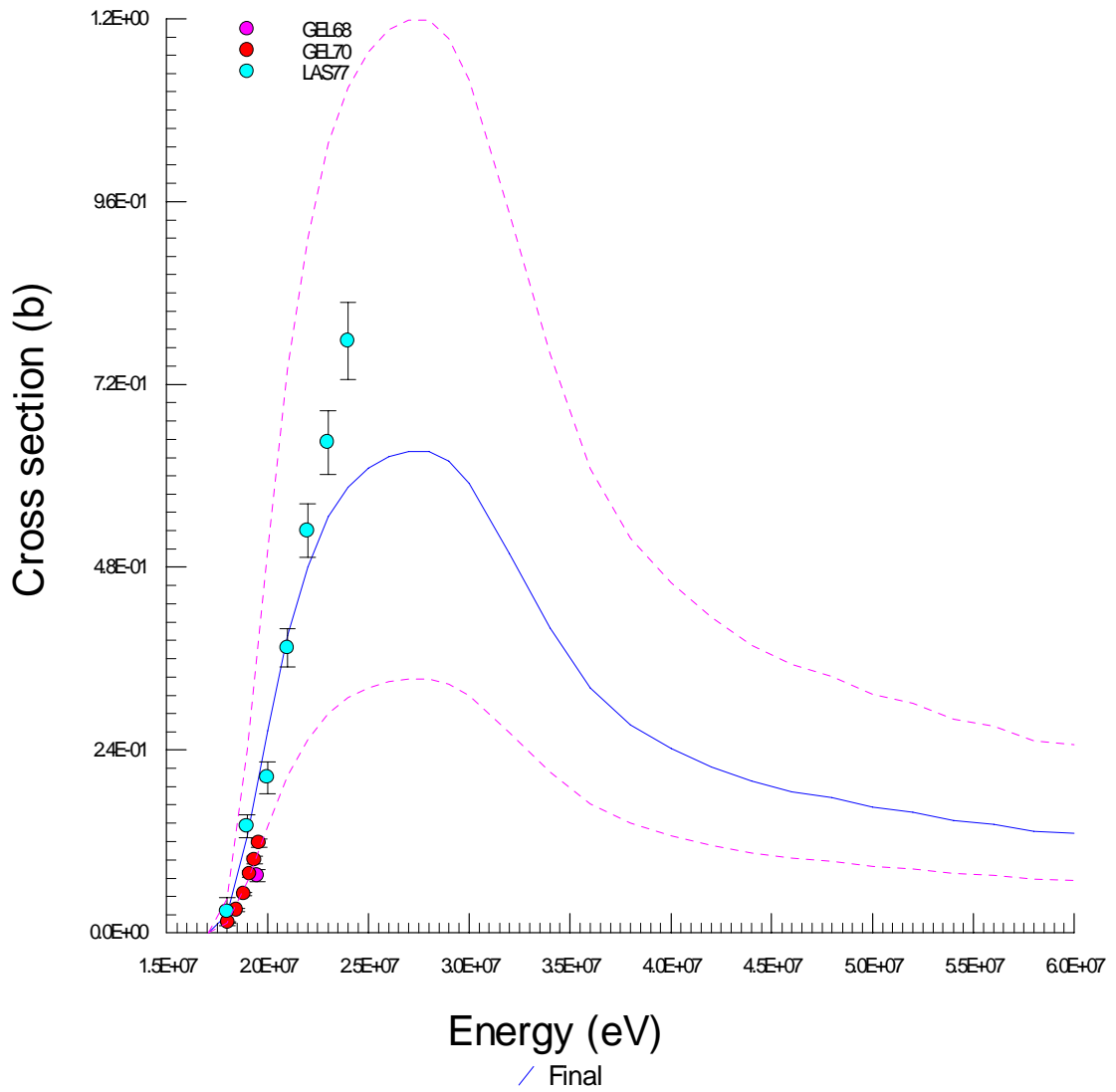


Neutron Spectrum

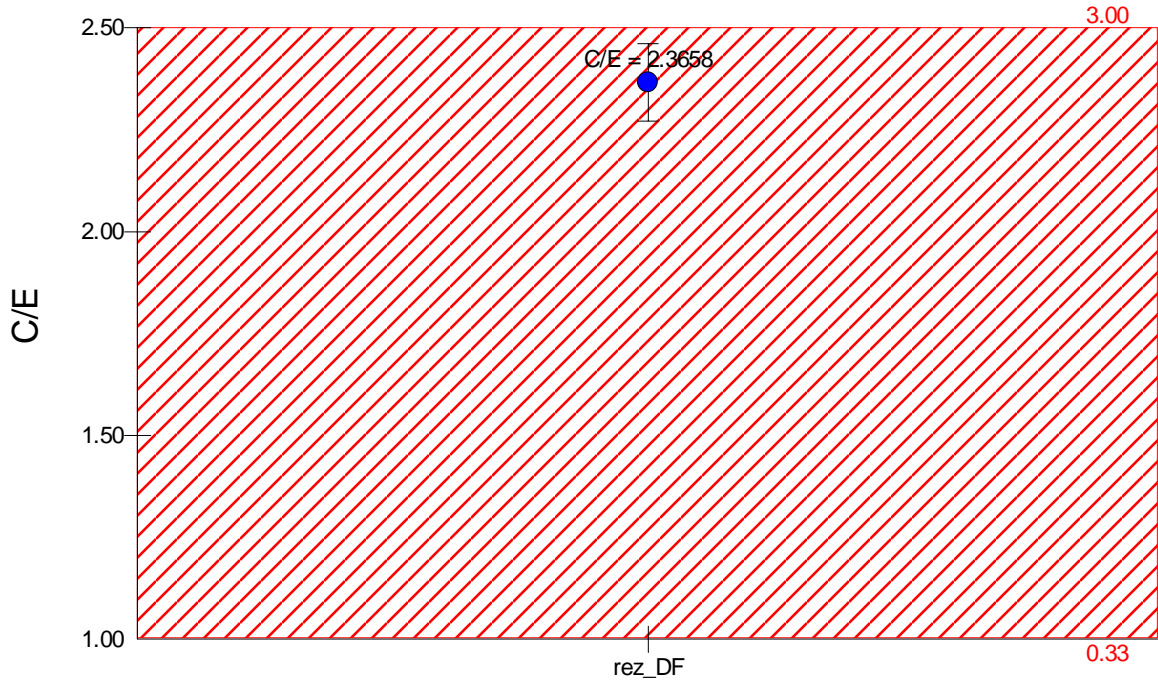




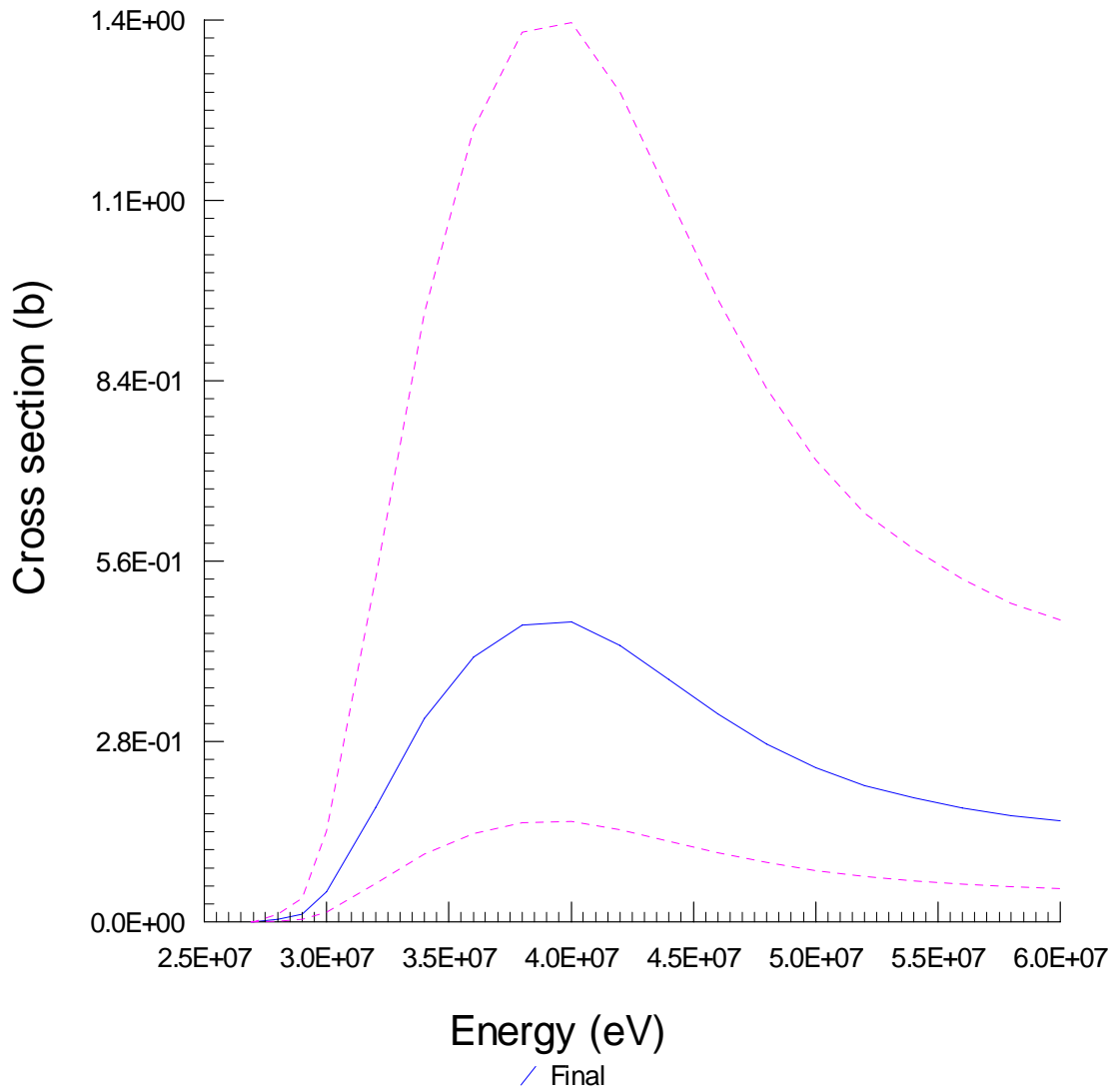
Neutron Spectrum

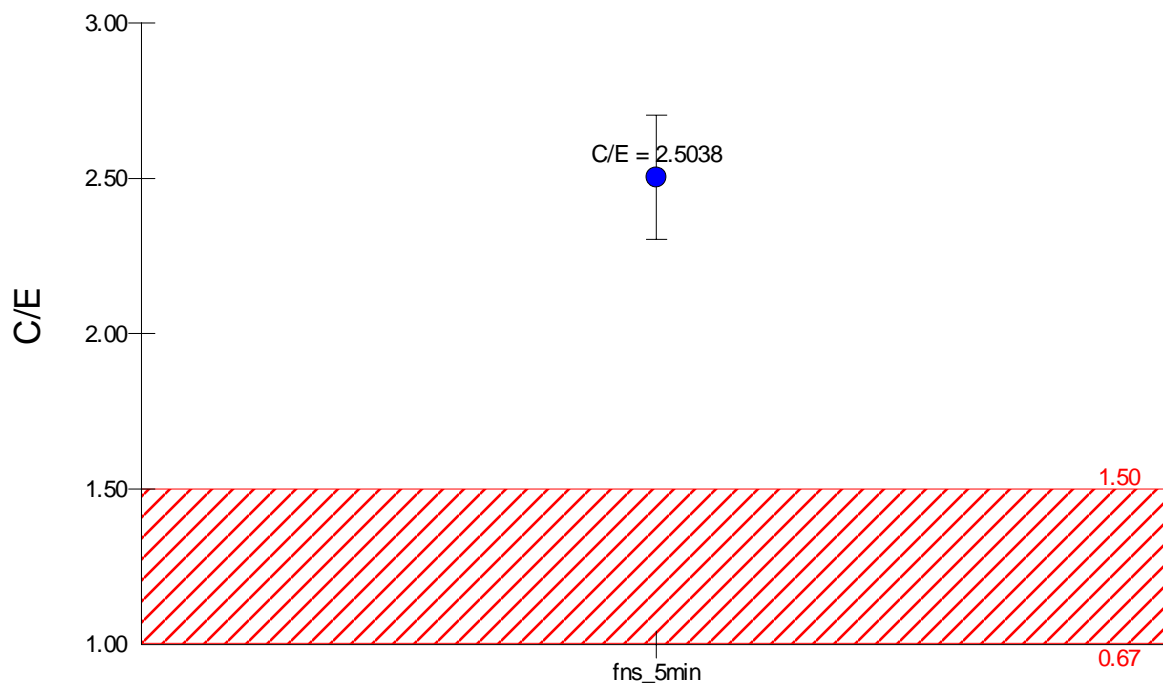
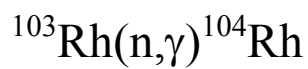


$^{103}\text{Rh}(n,4n)^{100}\text{Rh}$

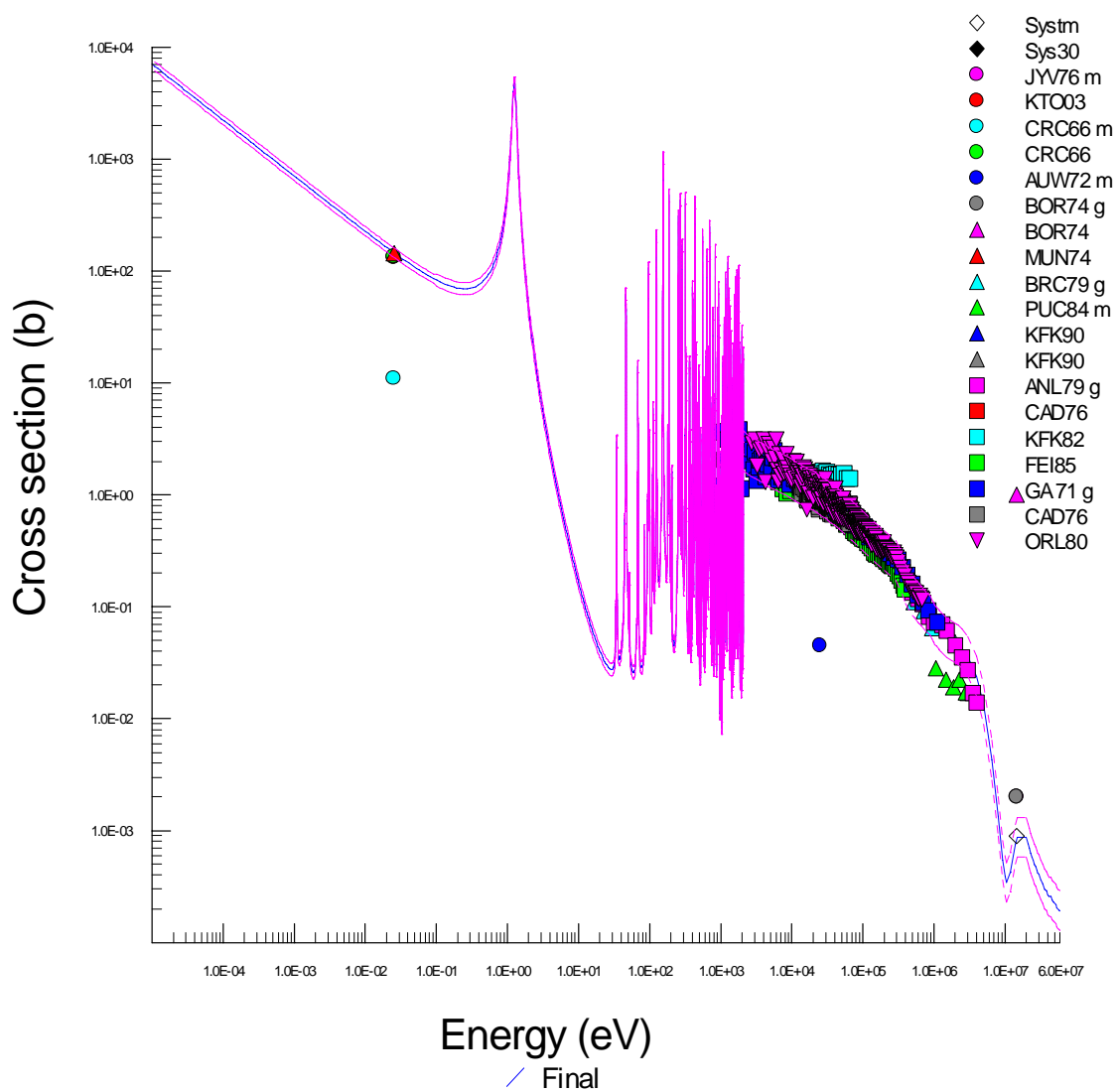


Neutron Spectrum

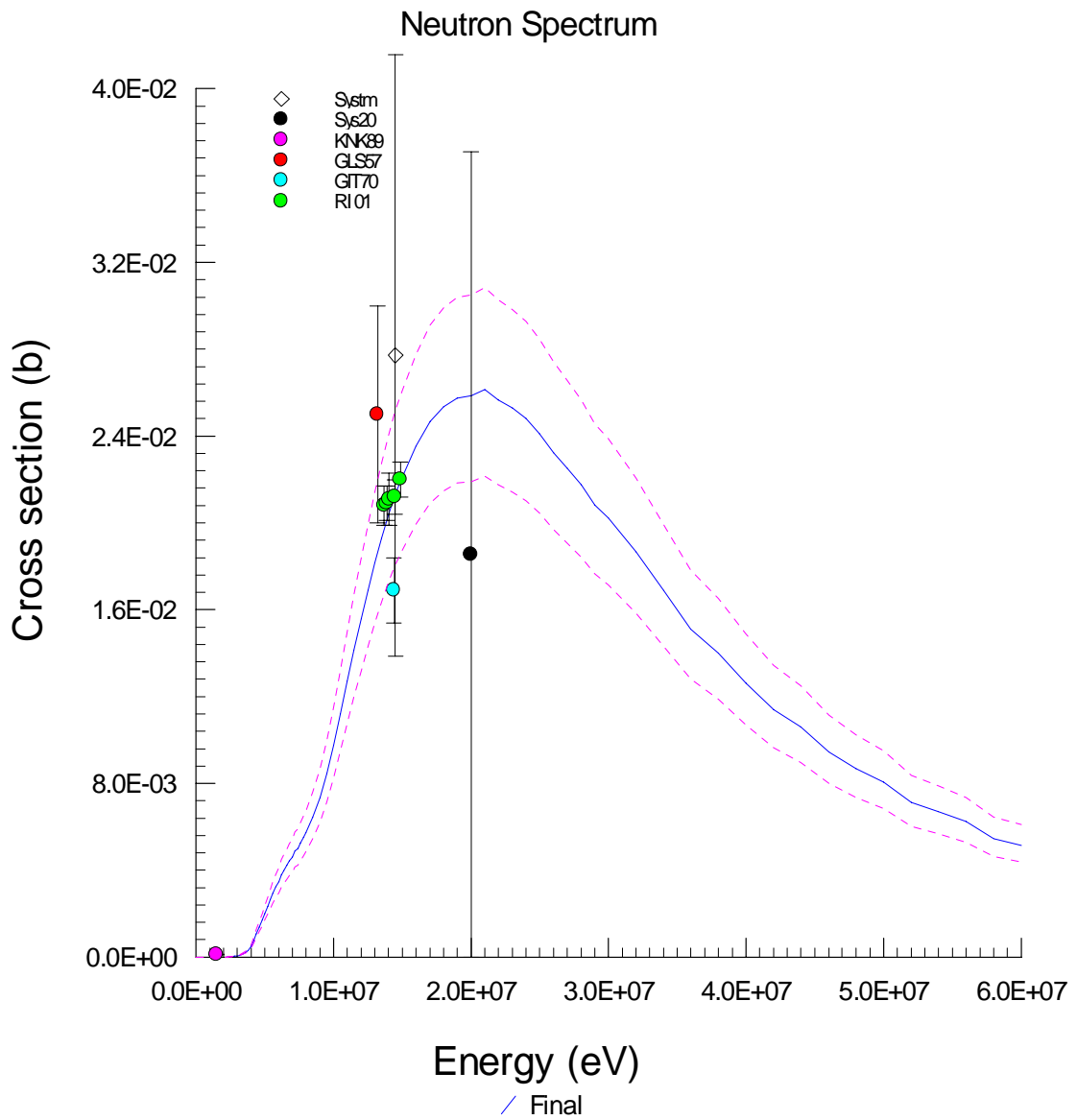
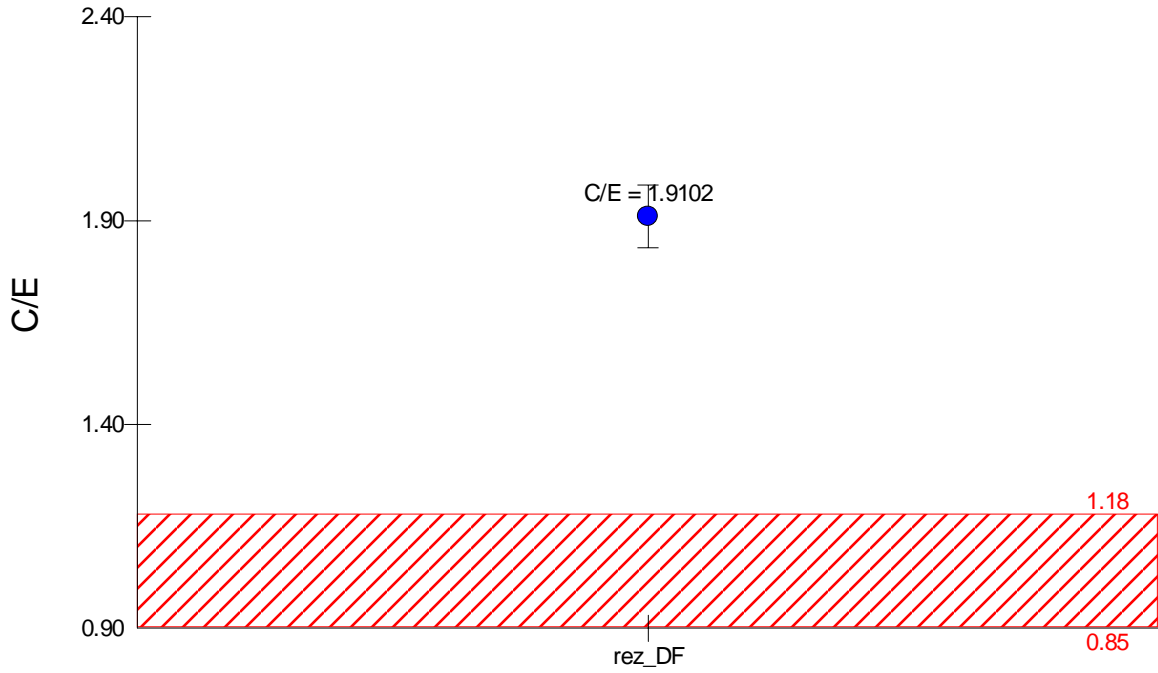


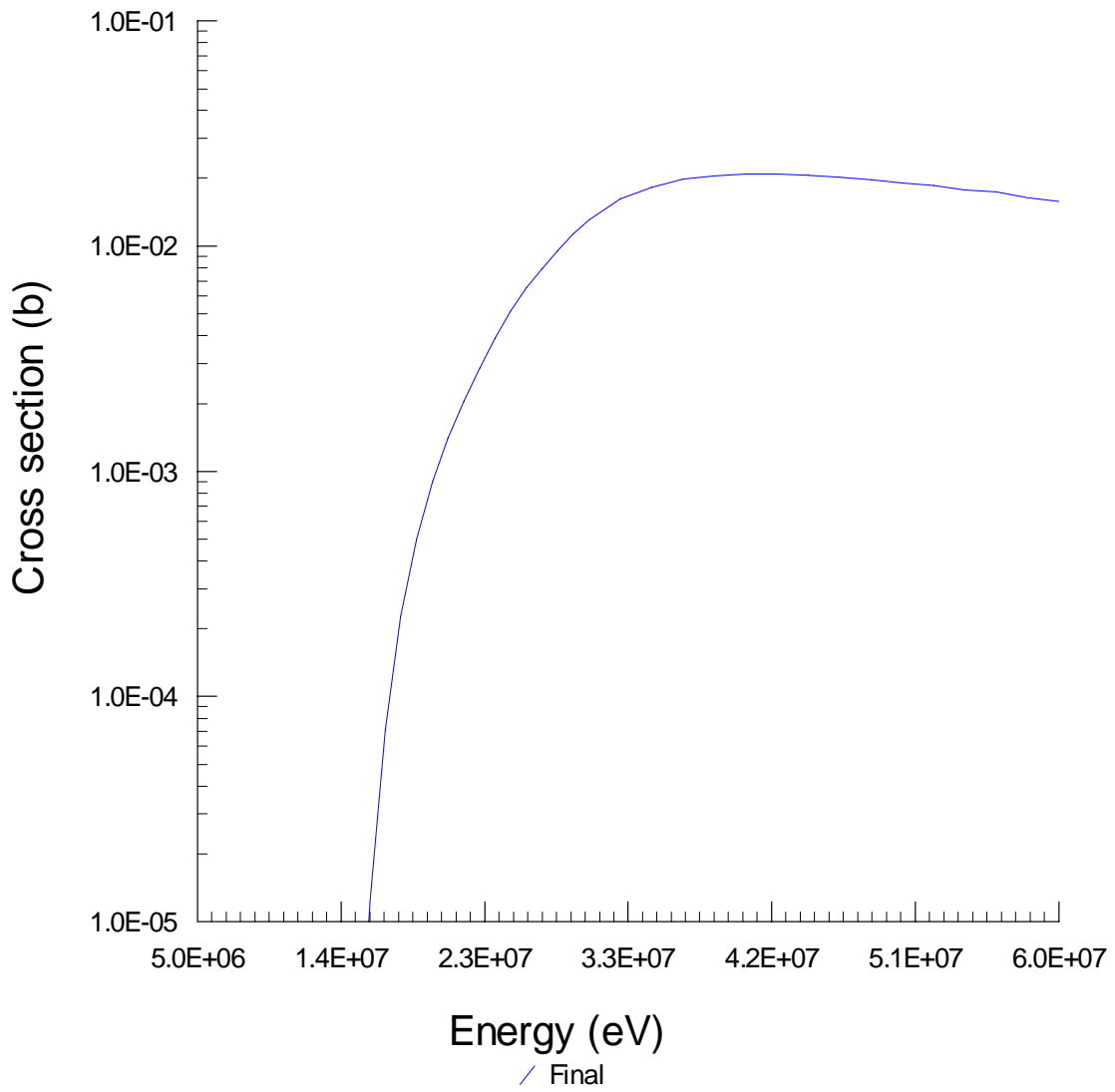
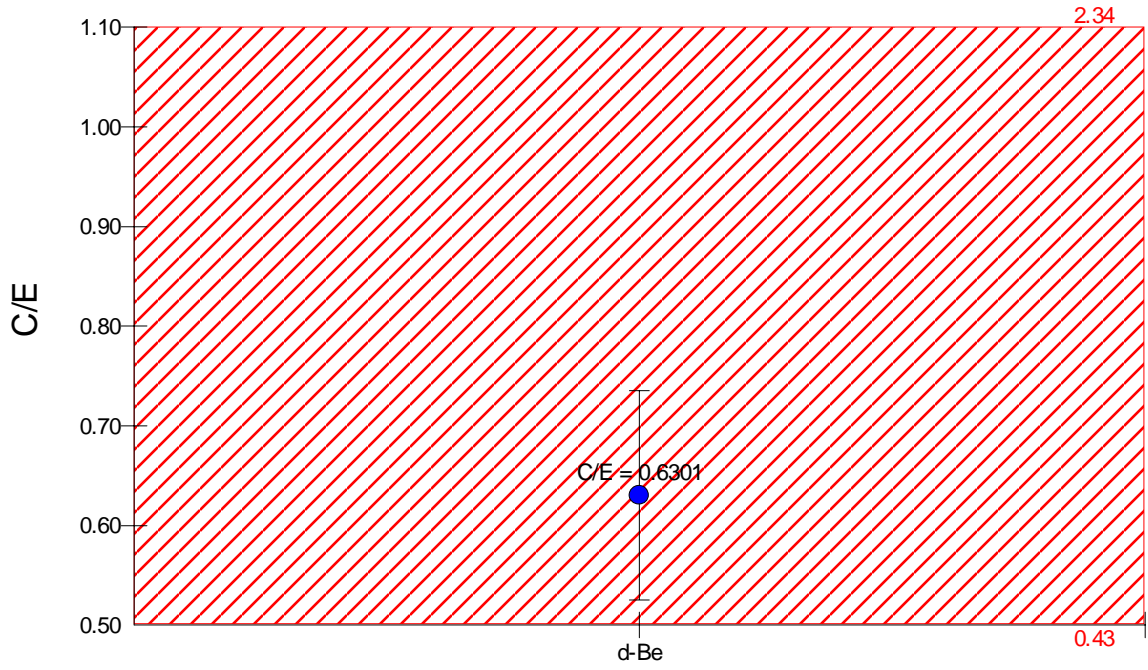
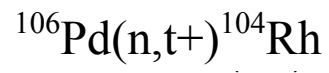


Neutron Spectrum

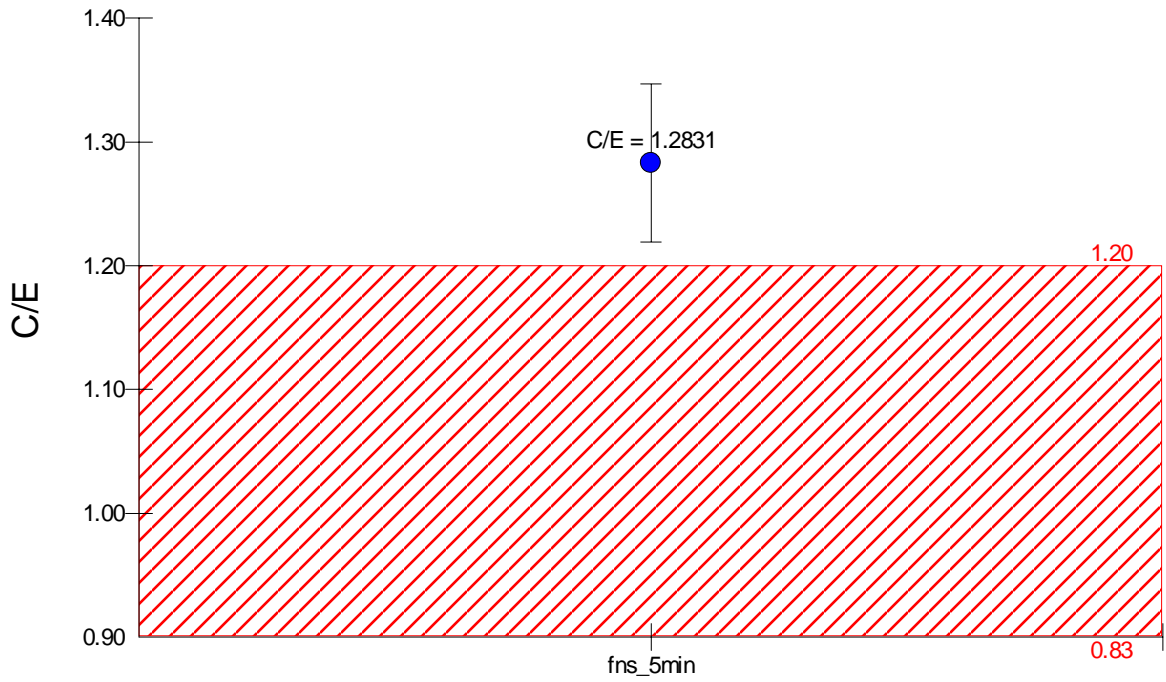


$^{103}\text{Rh}(n,p)^{103}\text{Ru}$

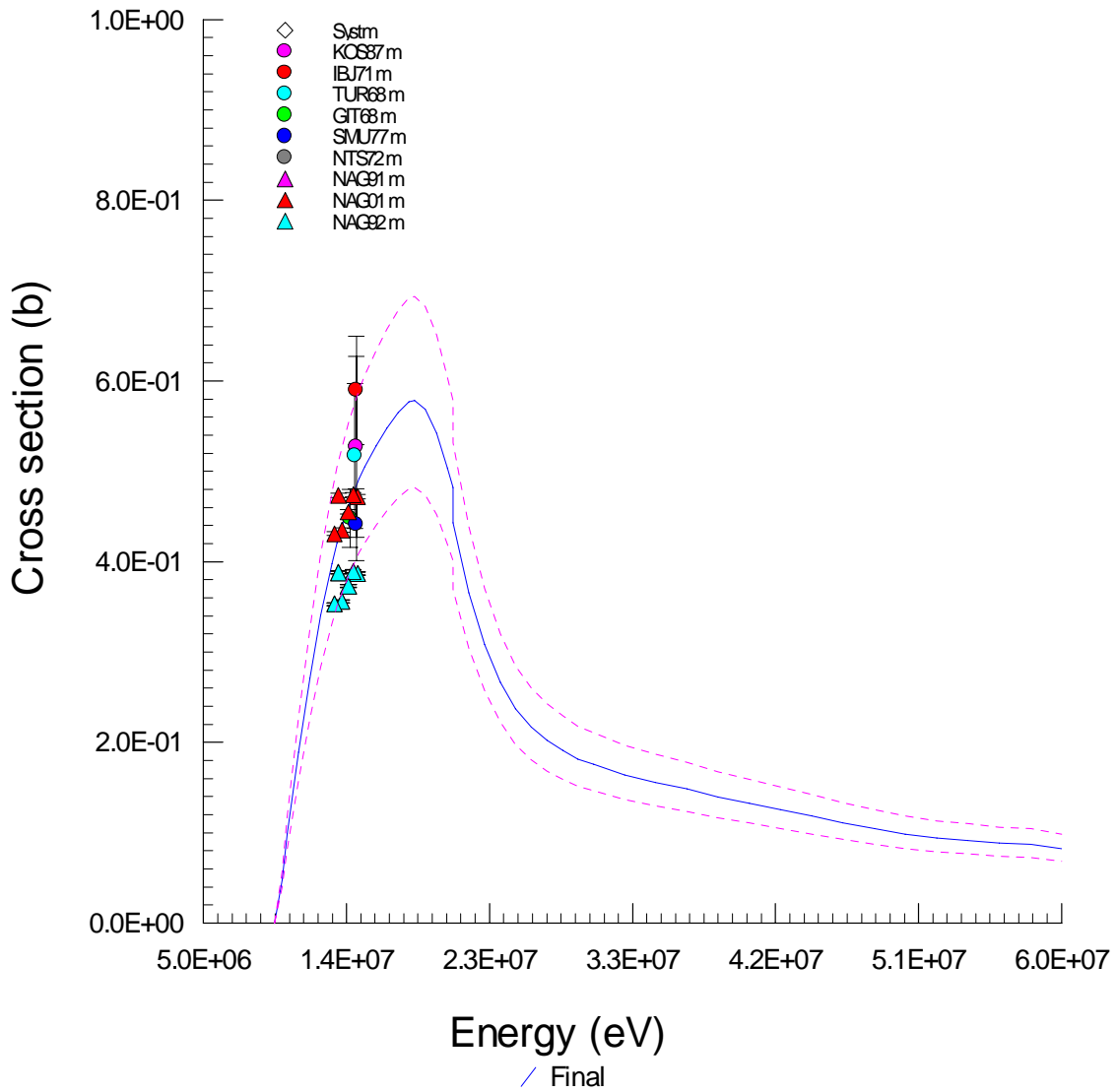




$^{108}\text{Pd}(n,2n)^{107\text{m}}\text{Pd}$

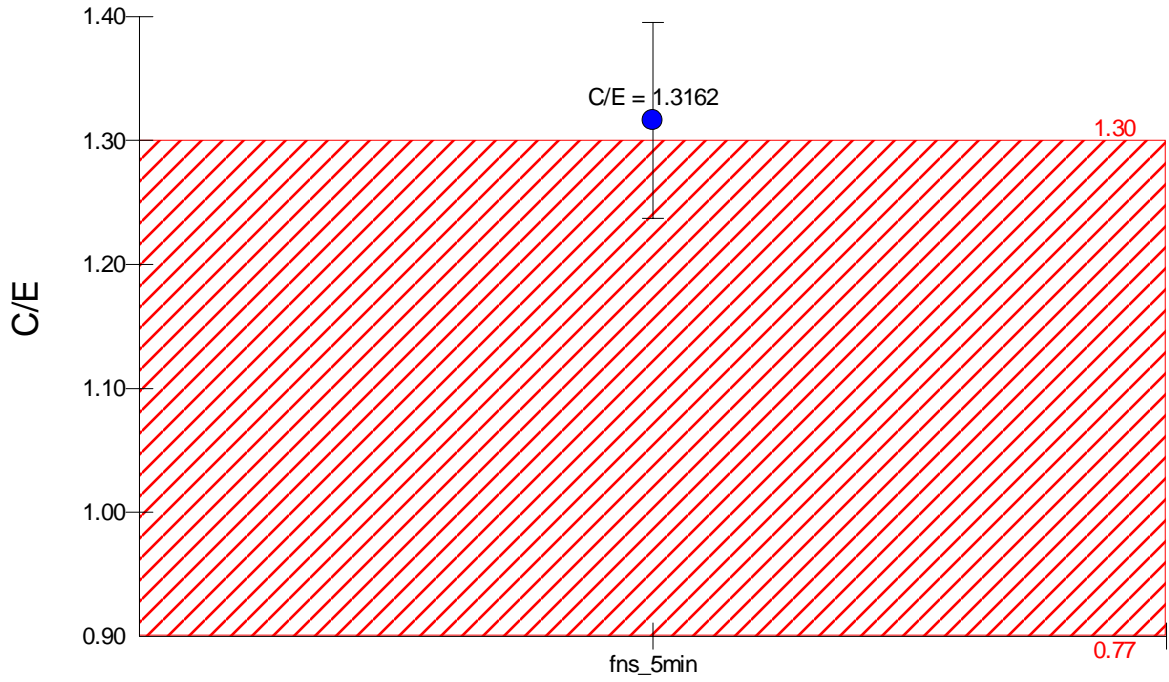


Neutron Spectrum

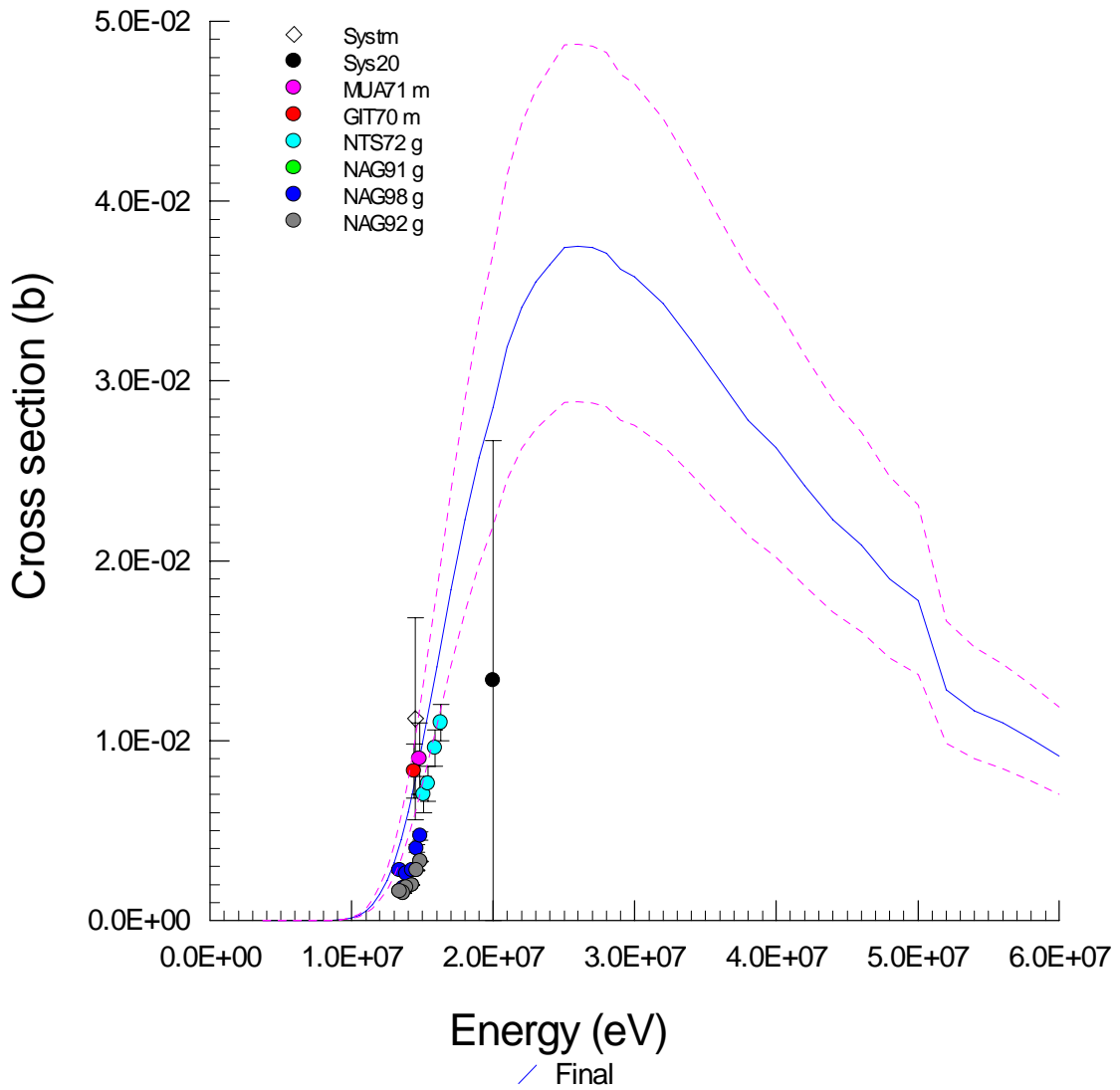


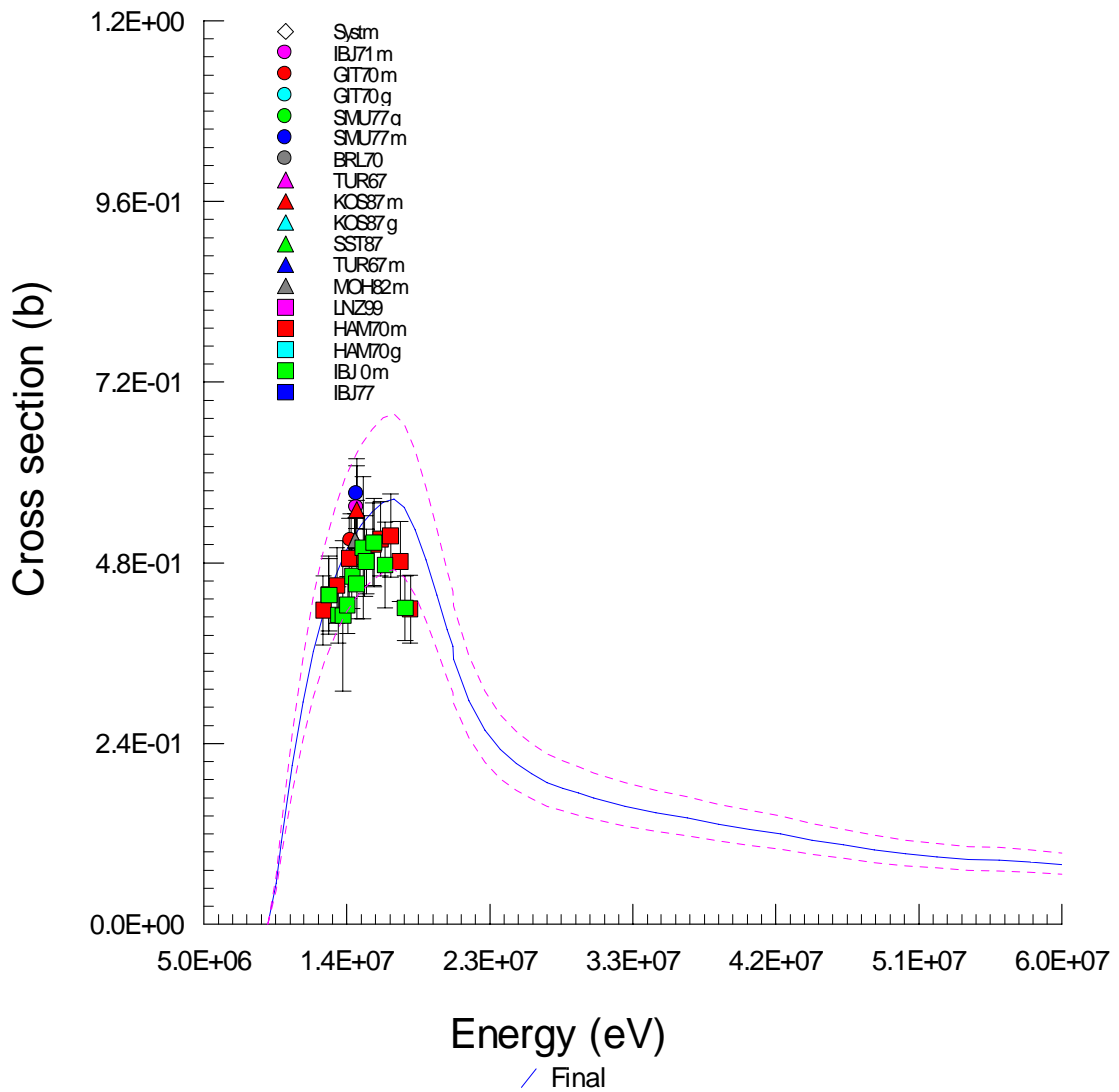
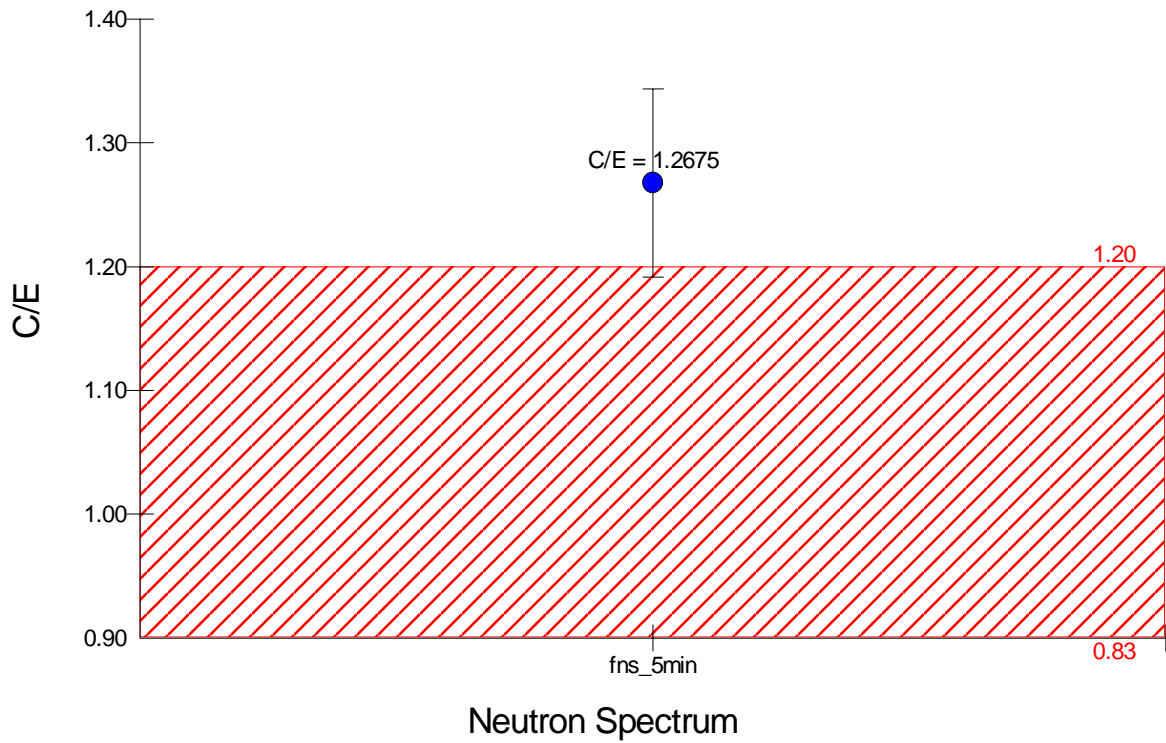
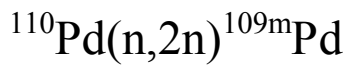


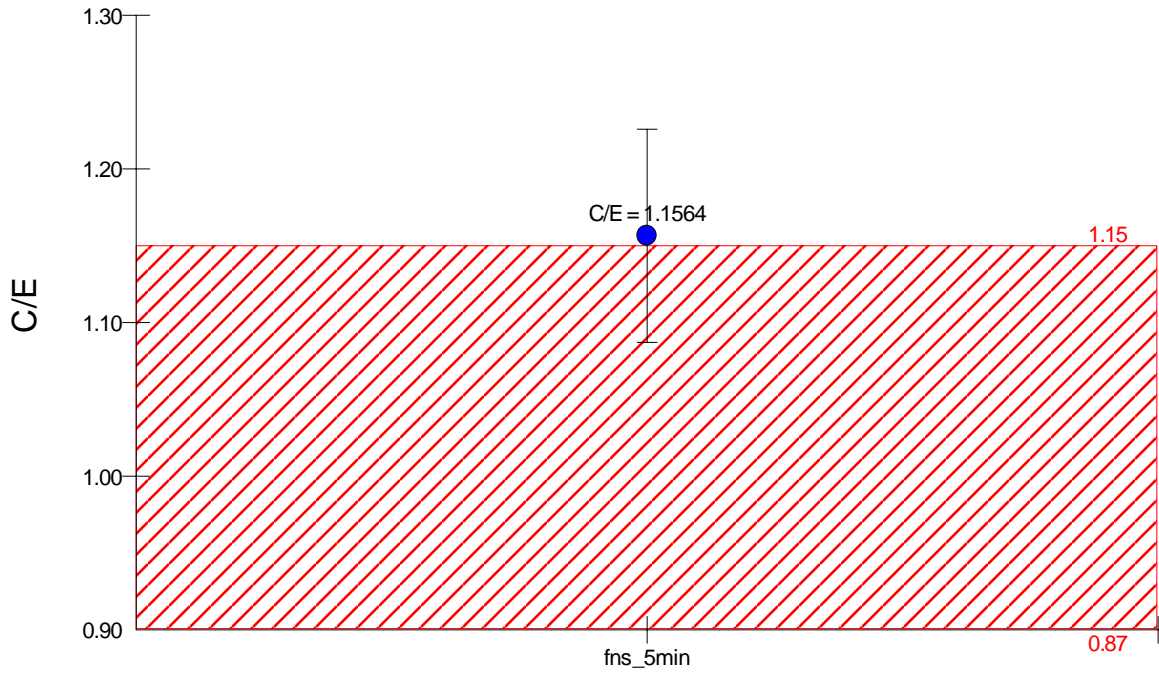
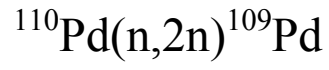
$^{108}\text{Pd}(n,p)^{108\text{m}}\text{Rh}$



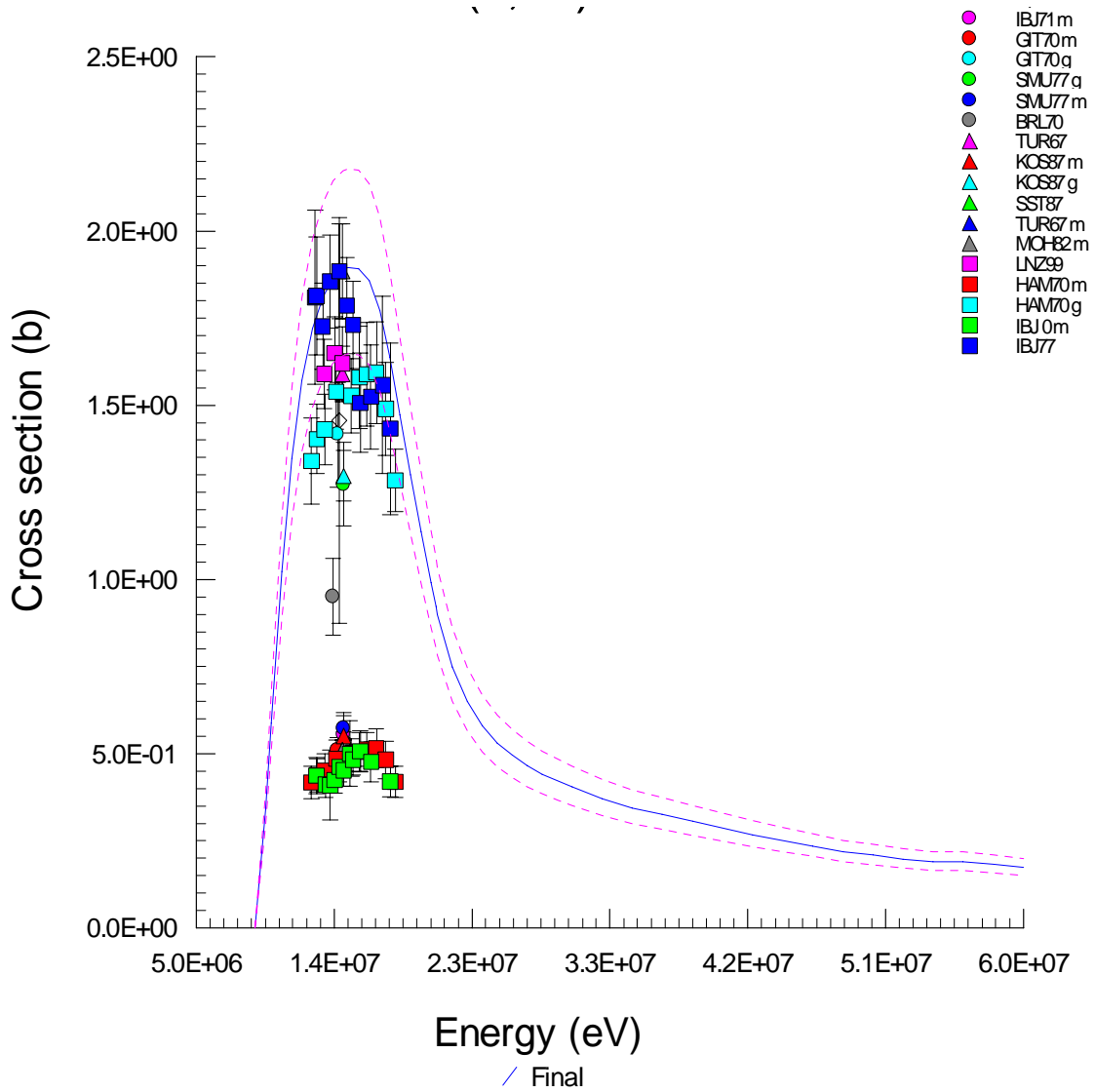
Neutron Spectrum

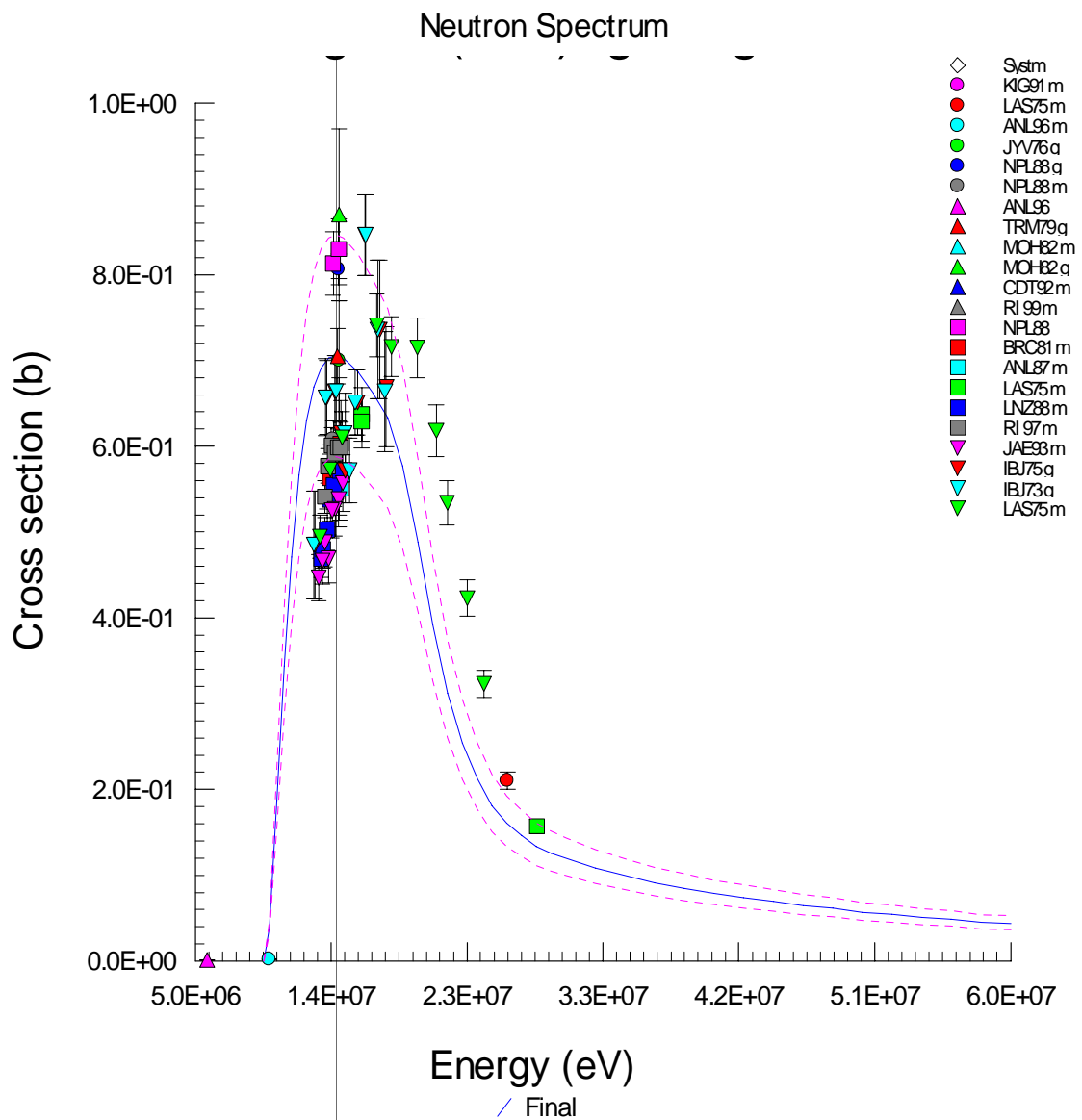
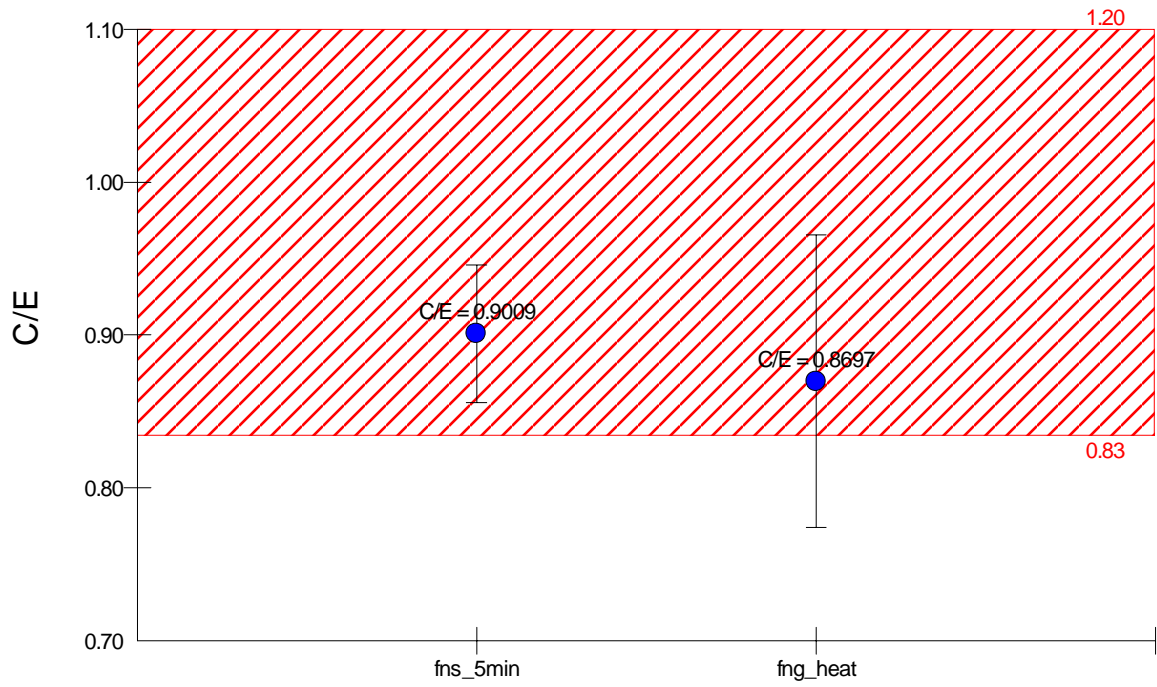
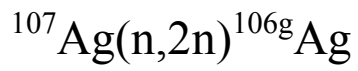


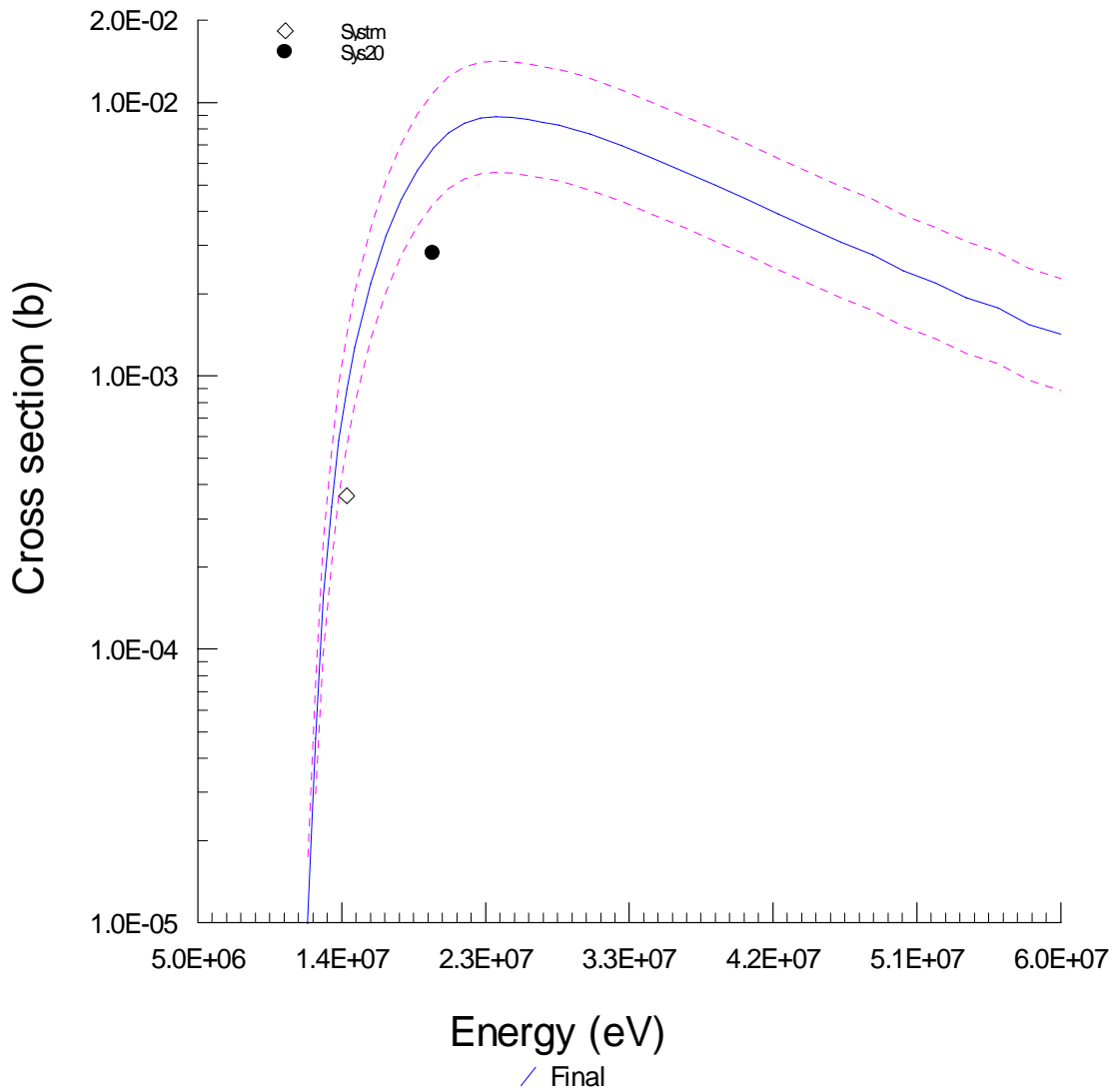
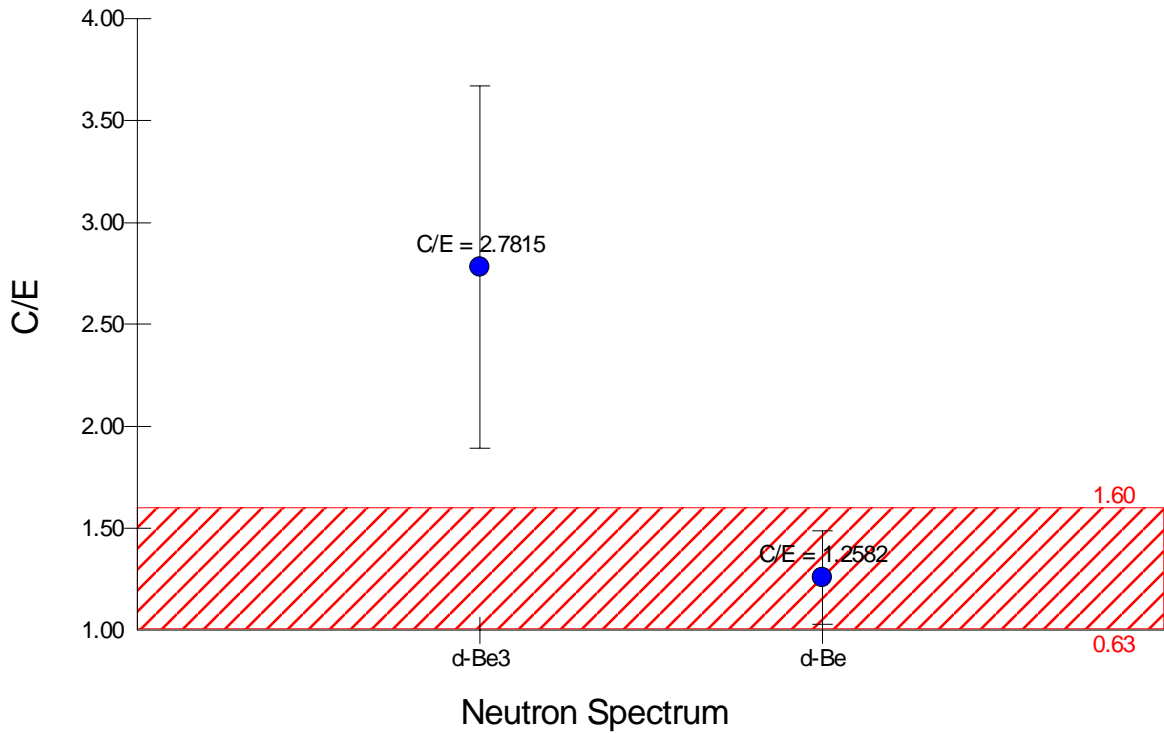
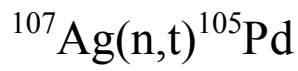


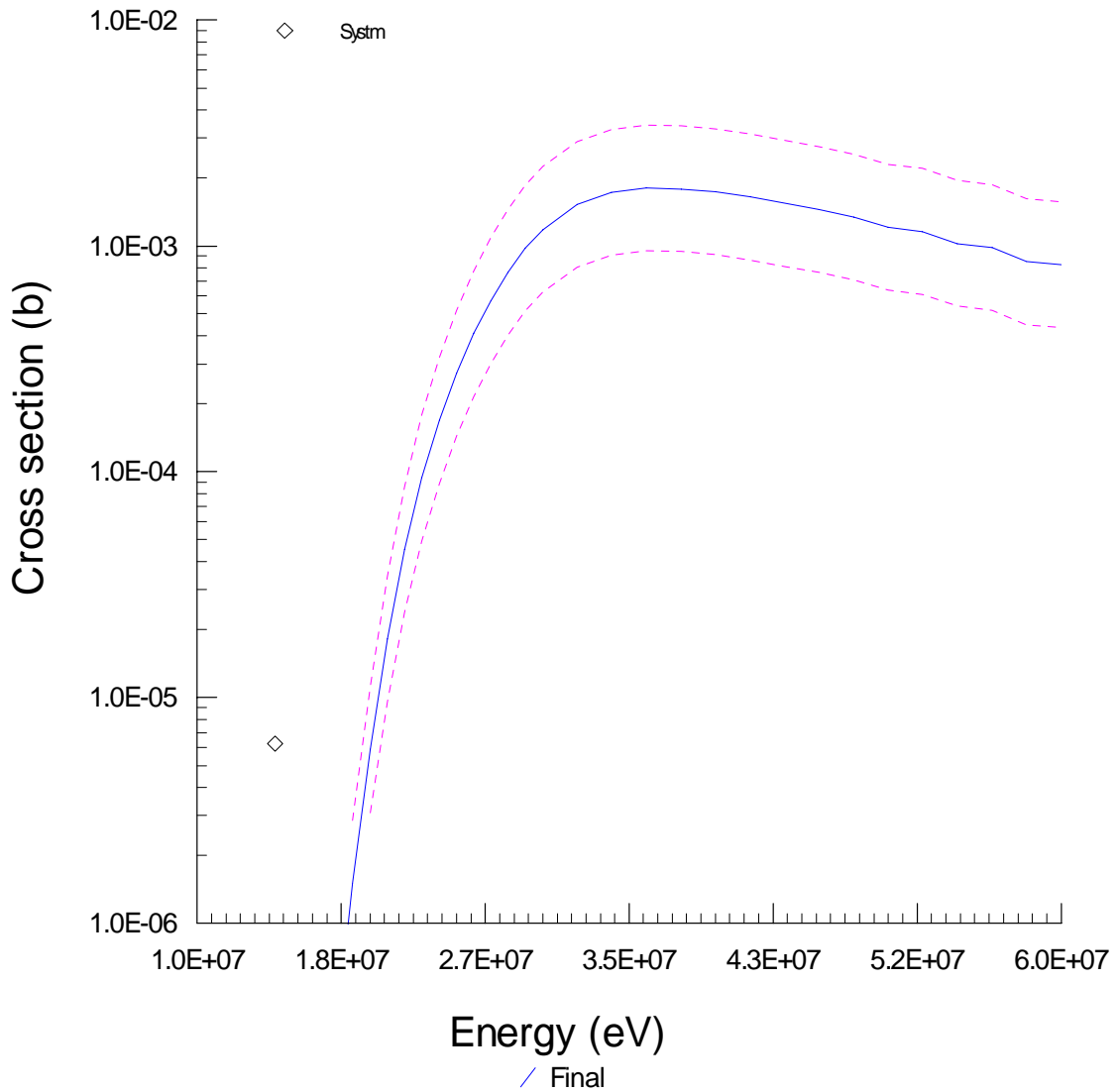
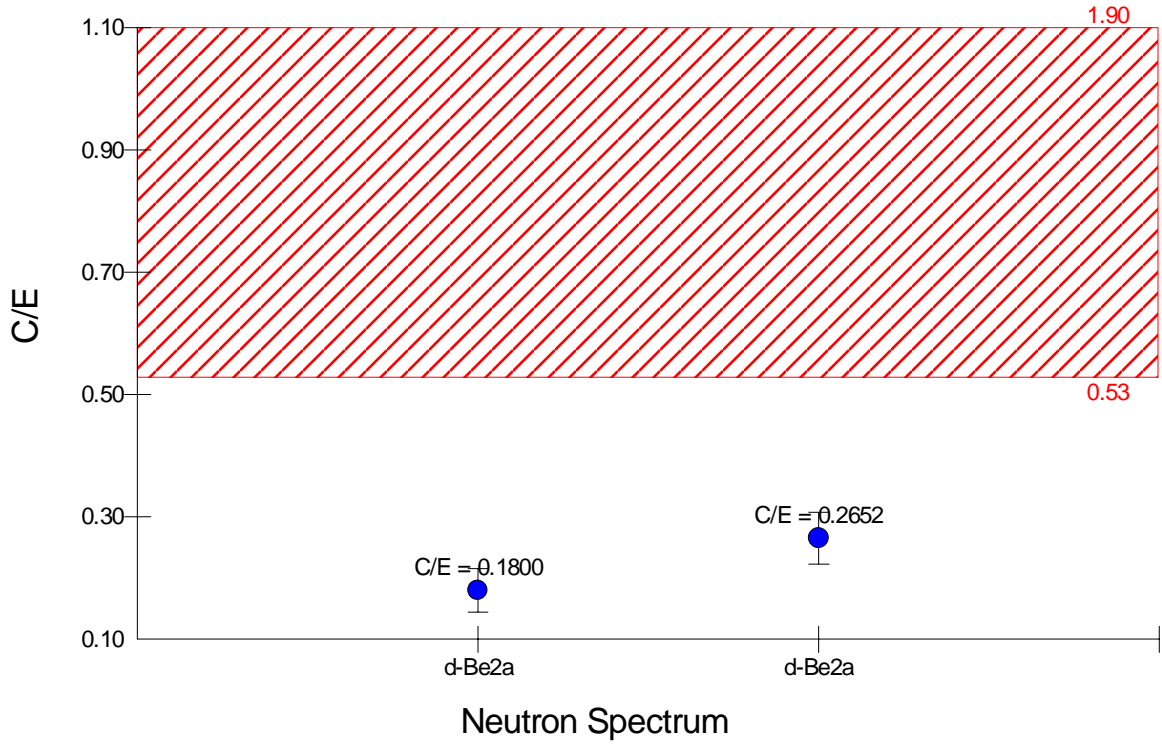
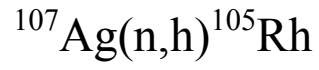


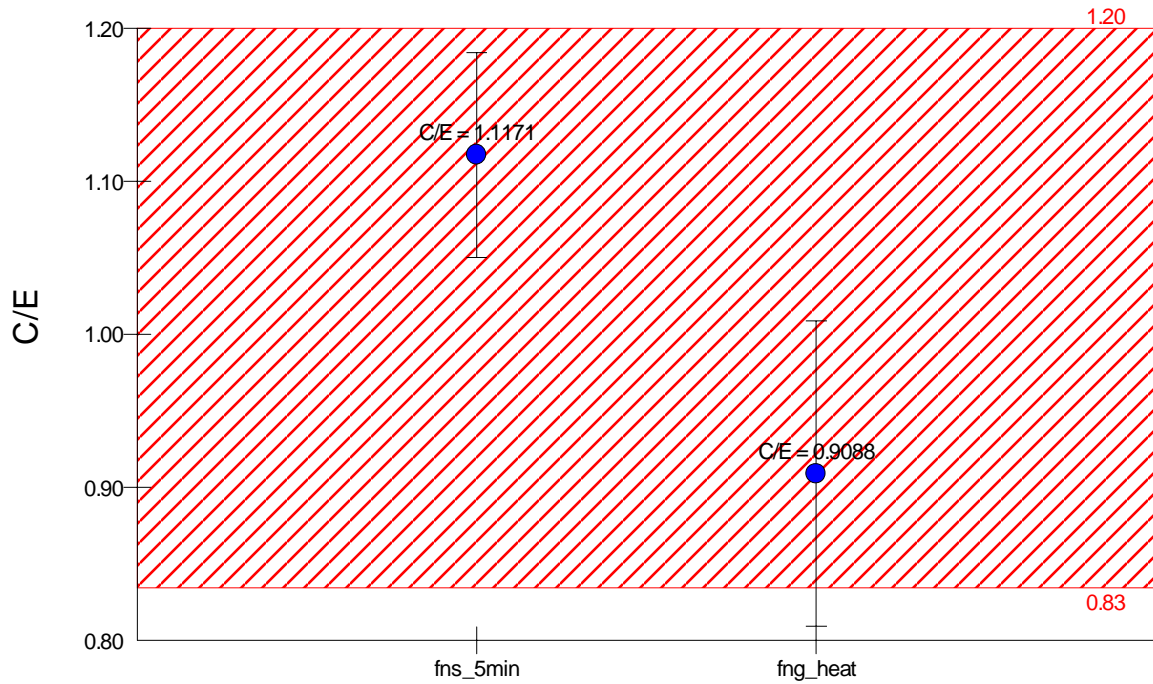
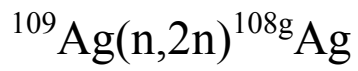
Neutron Spectrum



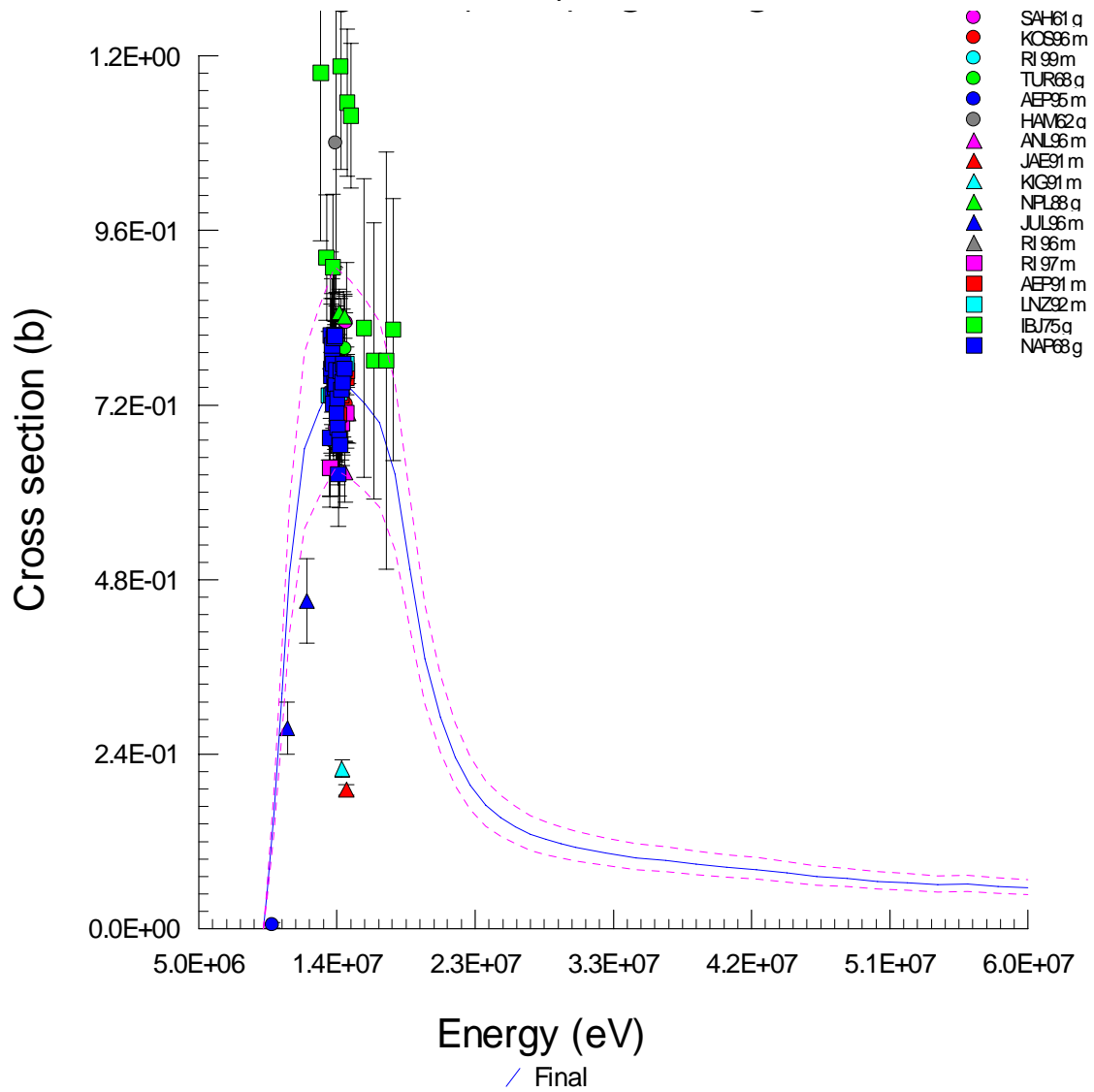




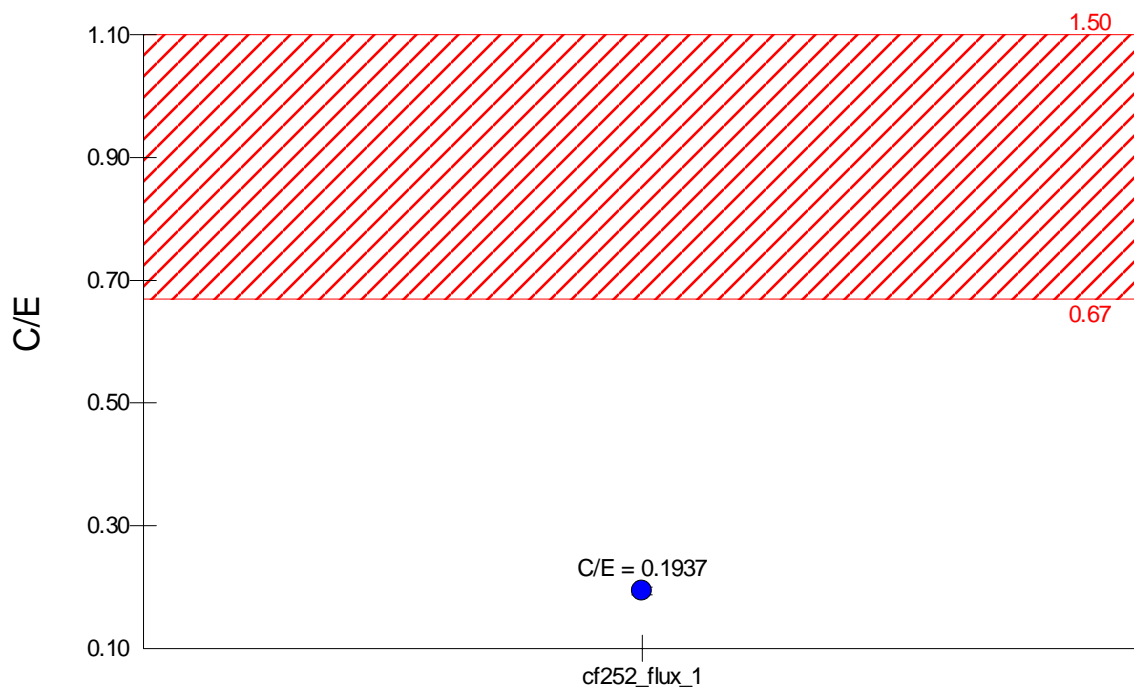




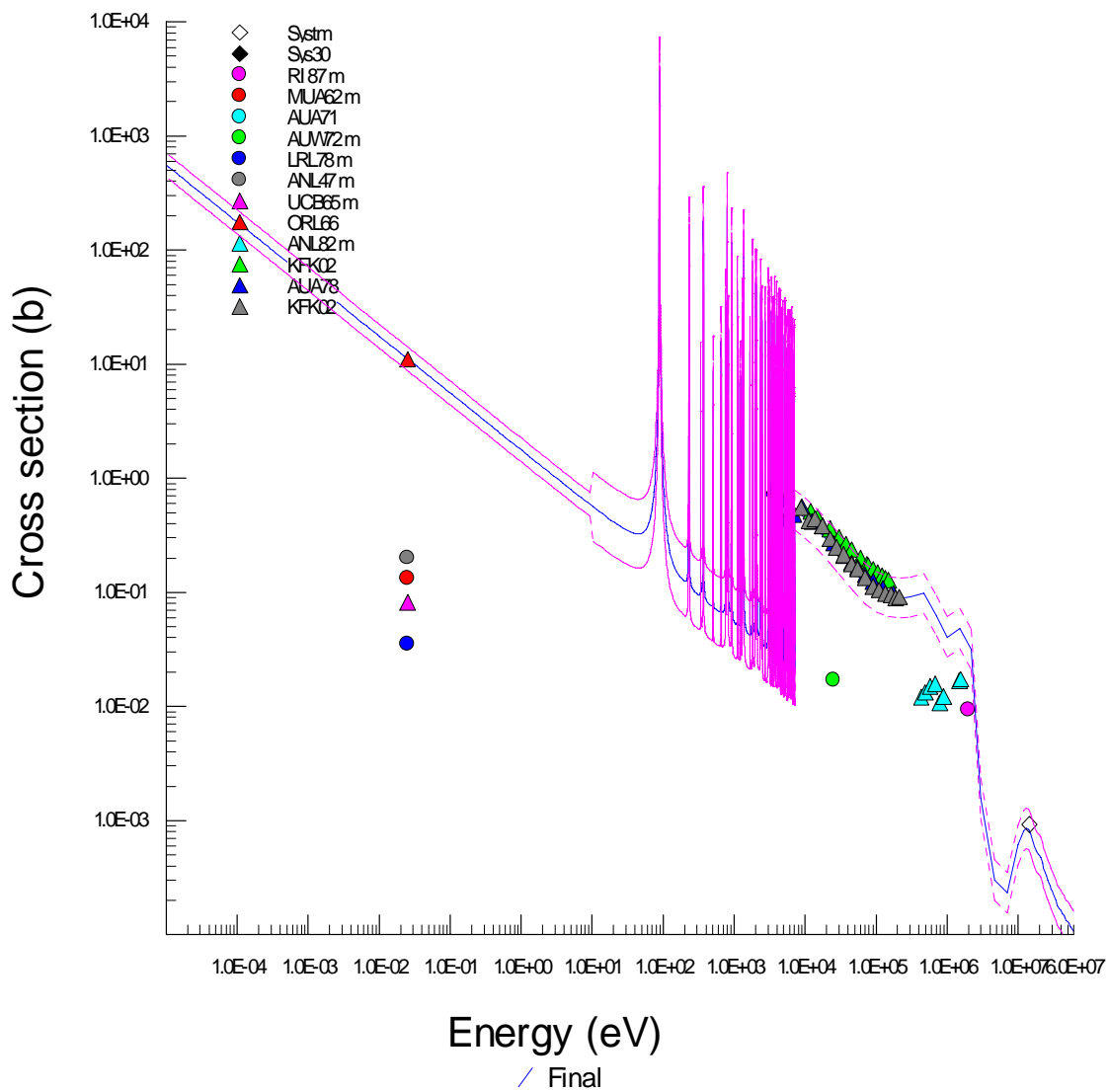
Neutron Spectrum



# $^{110}\text{Cd}(n,\gamma)^{111}\text{Cd}$

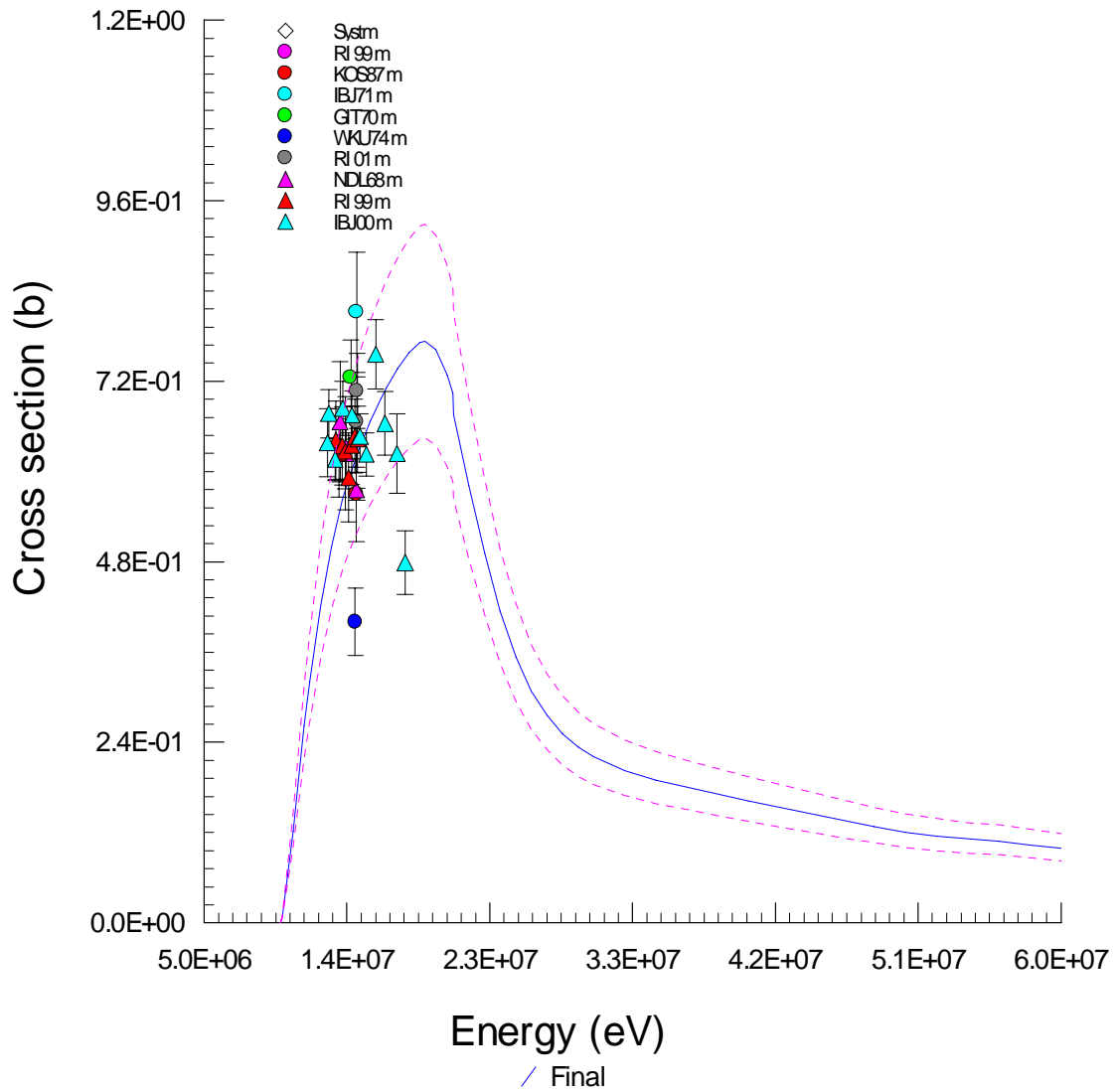
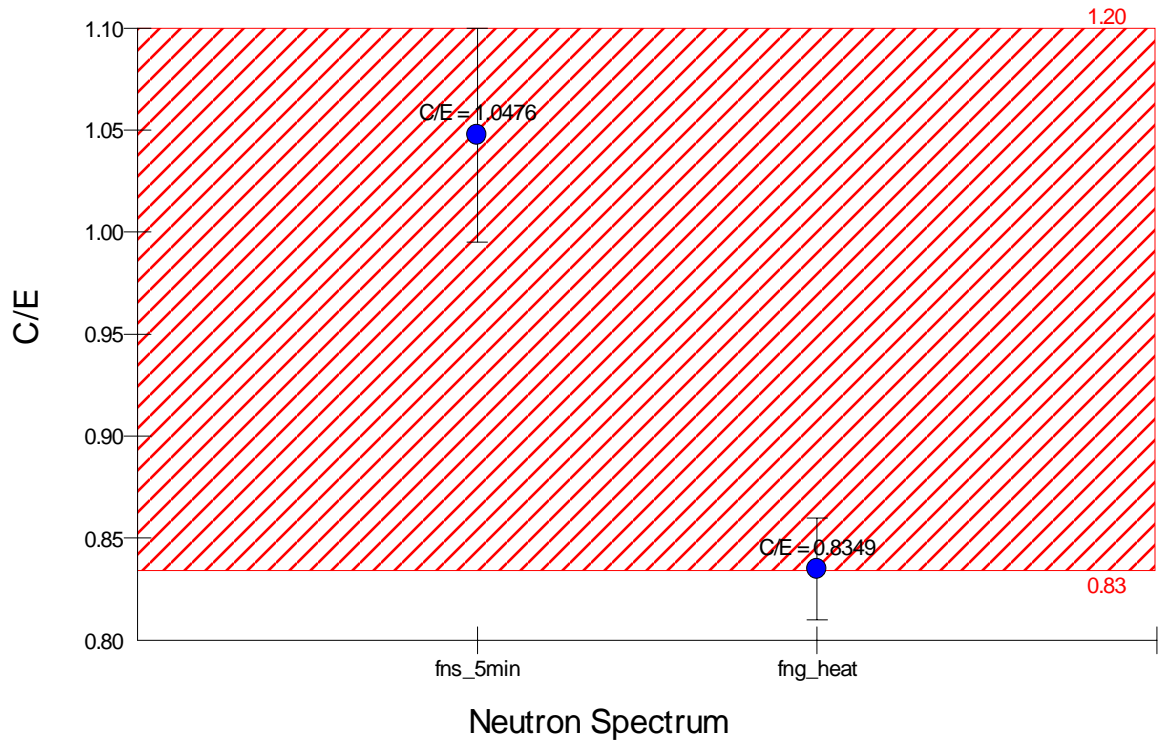


## Neutron Spectrum

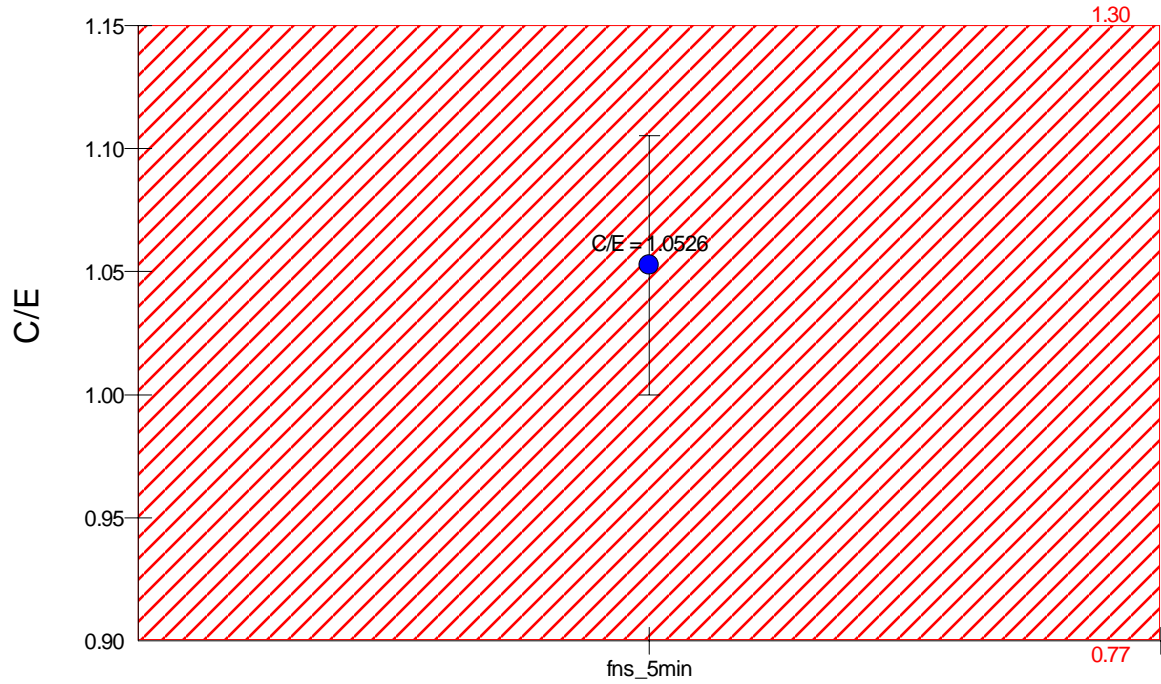




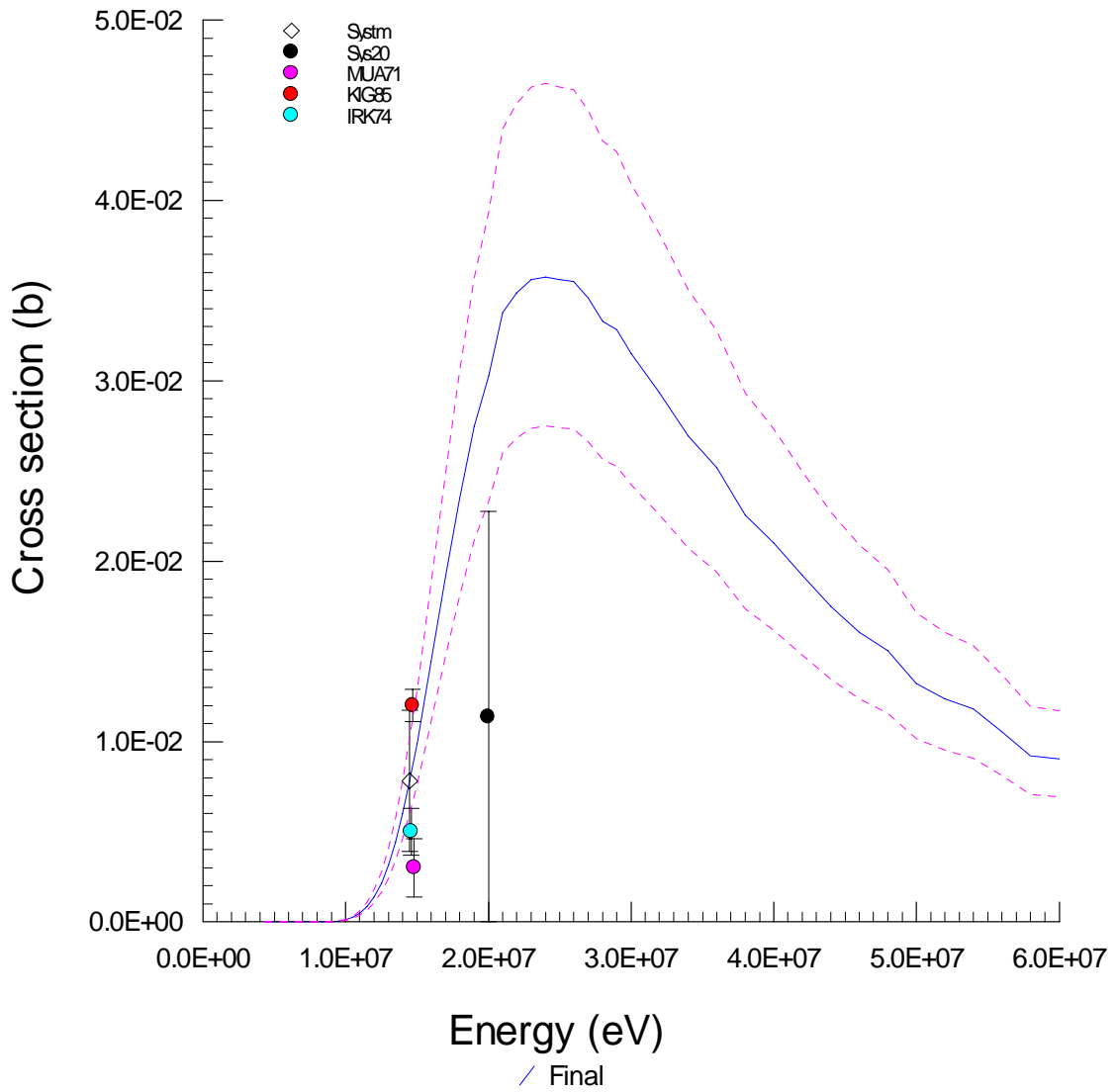
# $^{112}\text{Cd}(n,2n)^{111\text{m}}\text{Cd}$

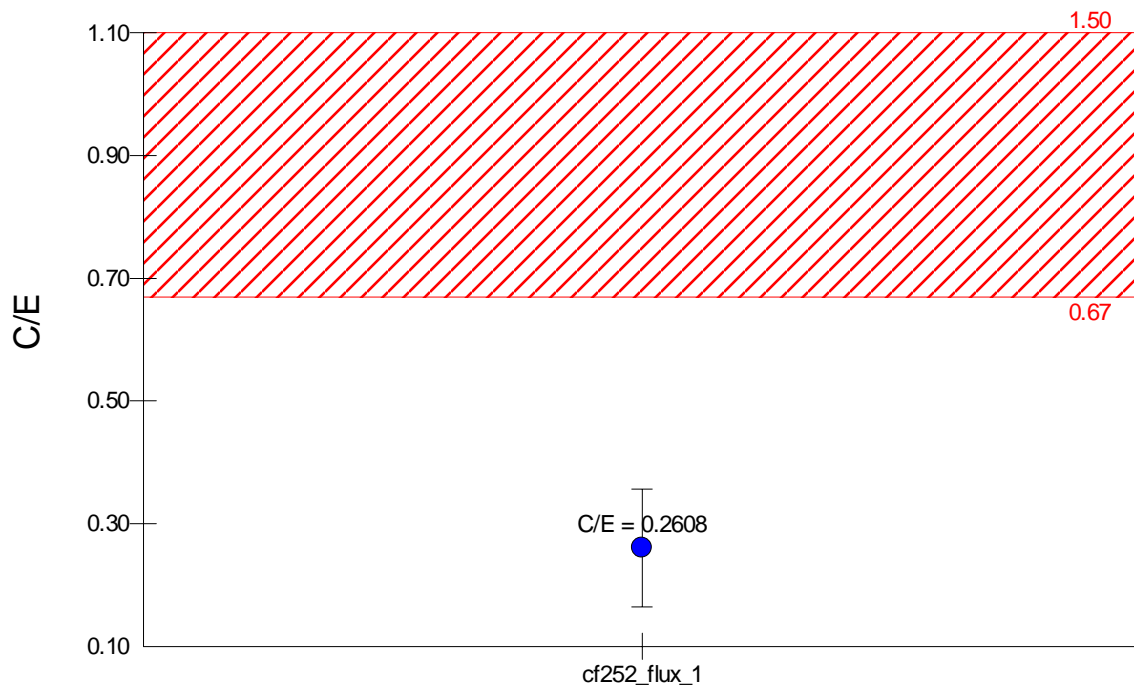
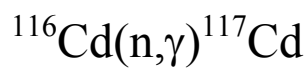


# $^{114}\text{Cd}(n,p)^{114}\text{Ag}$

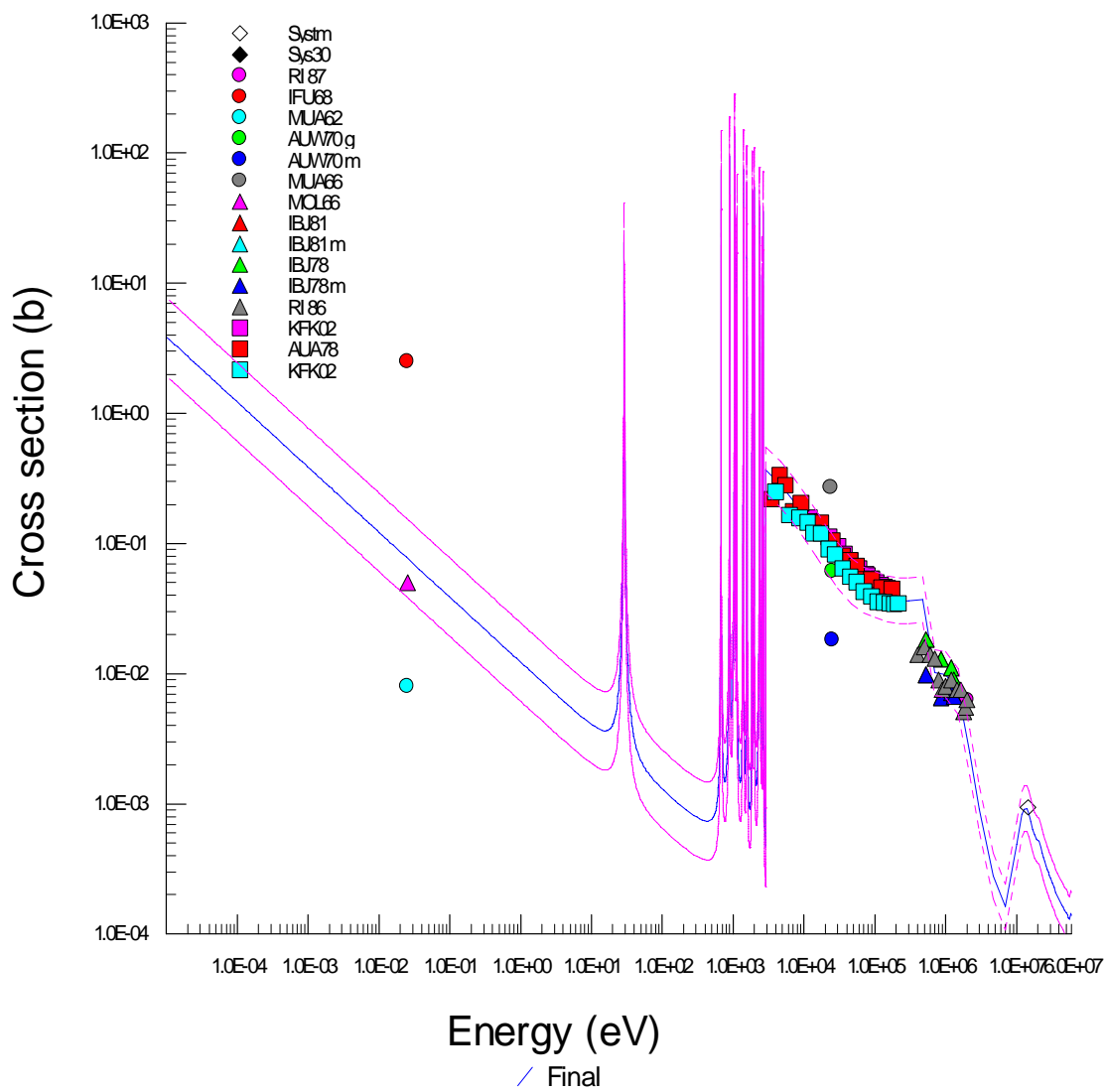


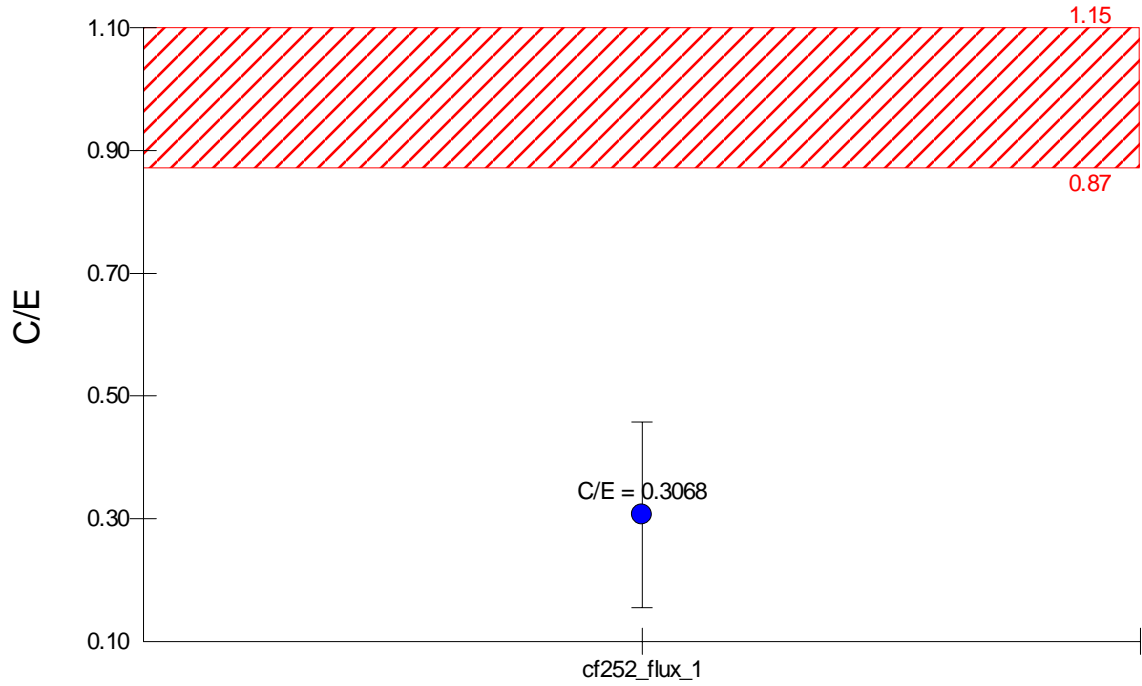
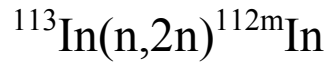
## Neutron Spectrum



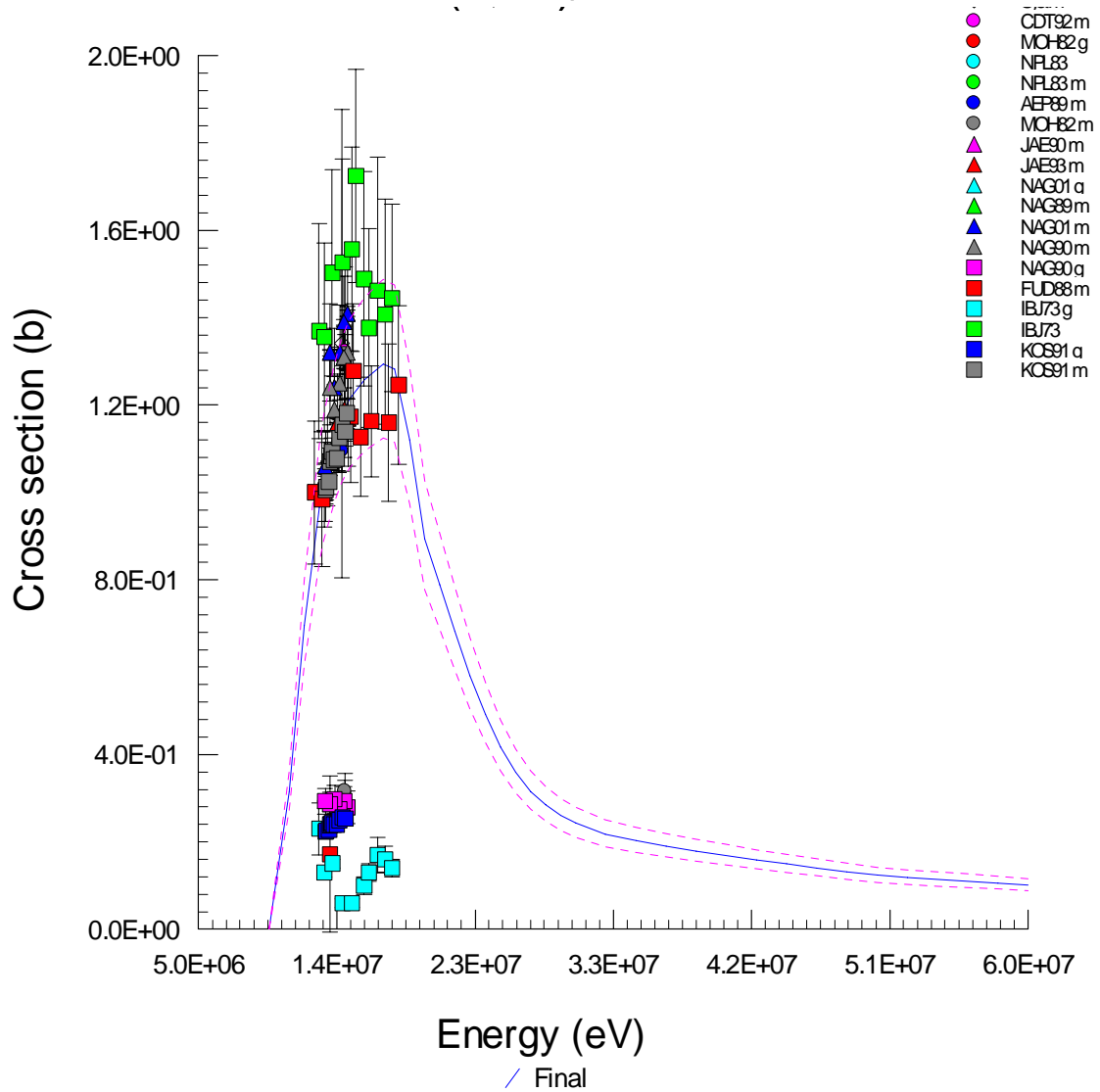


Neutron Spectrum

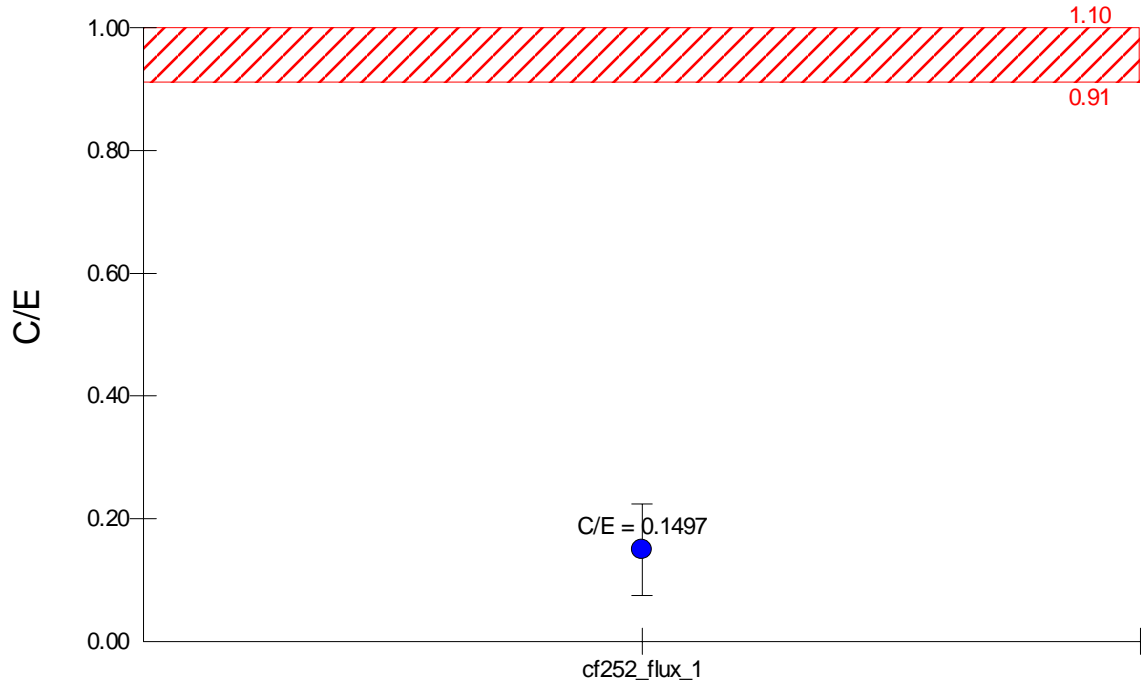




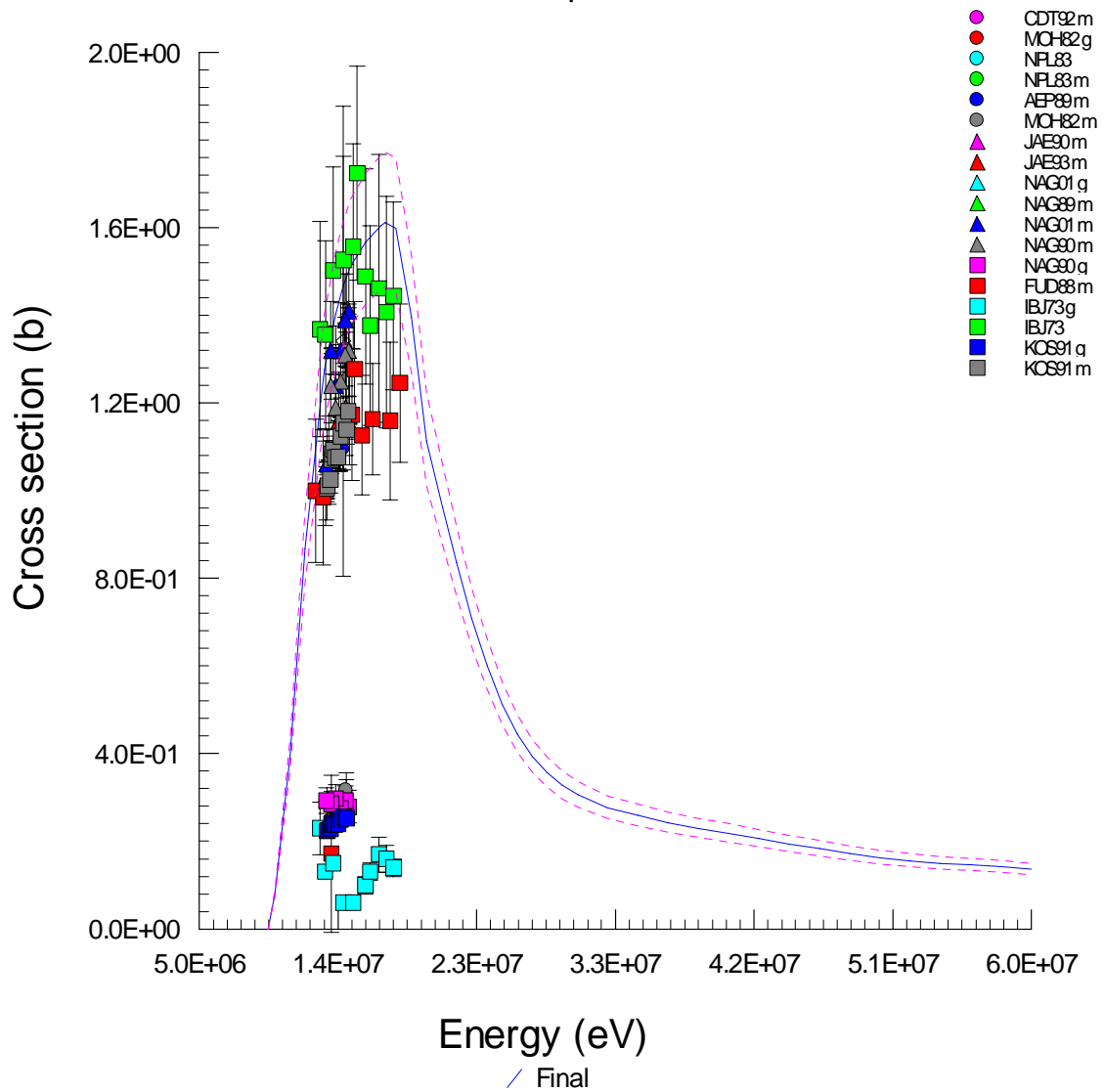
Neutron Spectrum



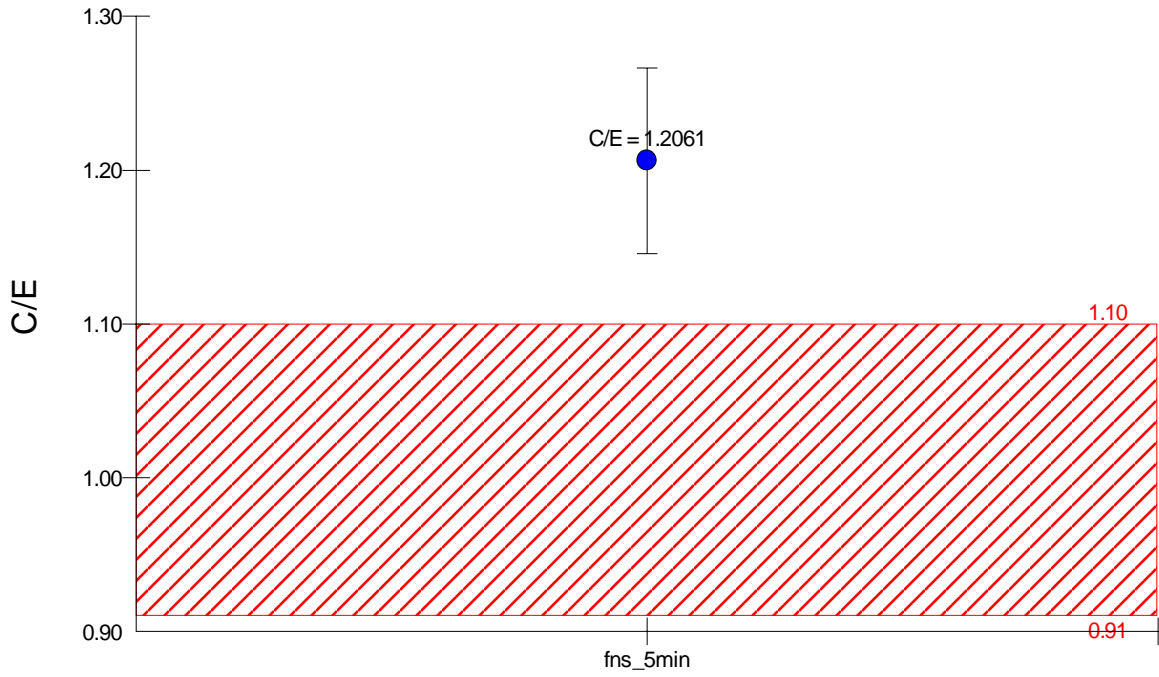
$^{113}\text{In}(n,2n)^{112}\text{In}$



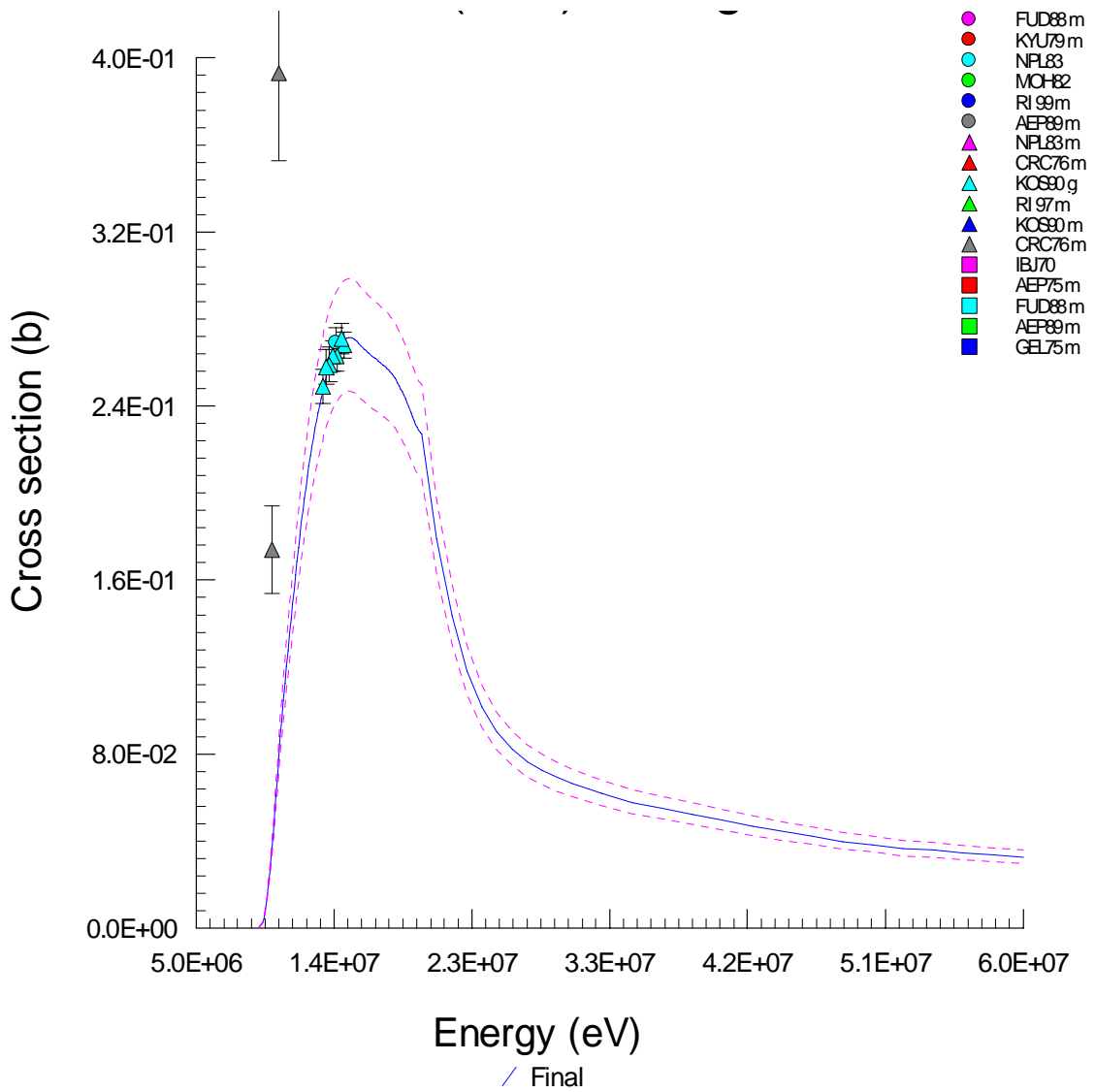
Neutron Spectrum



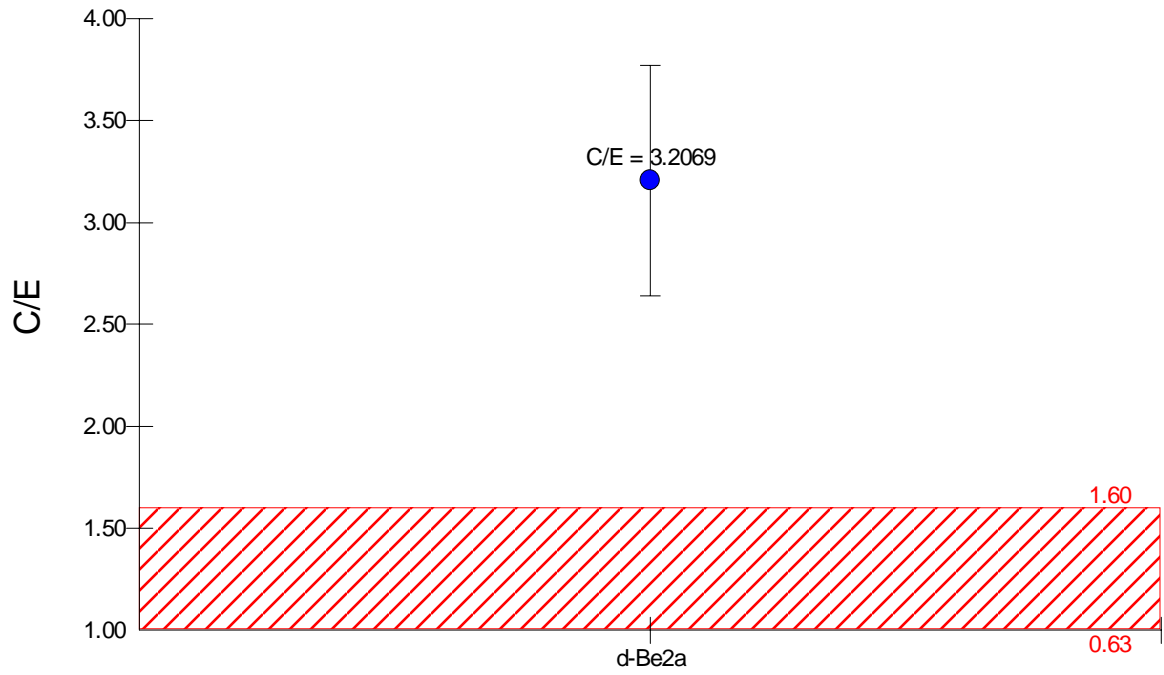
# $^{115}\text{In}(n,2n)^{114g}\text{In}$



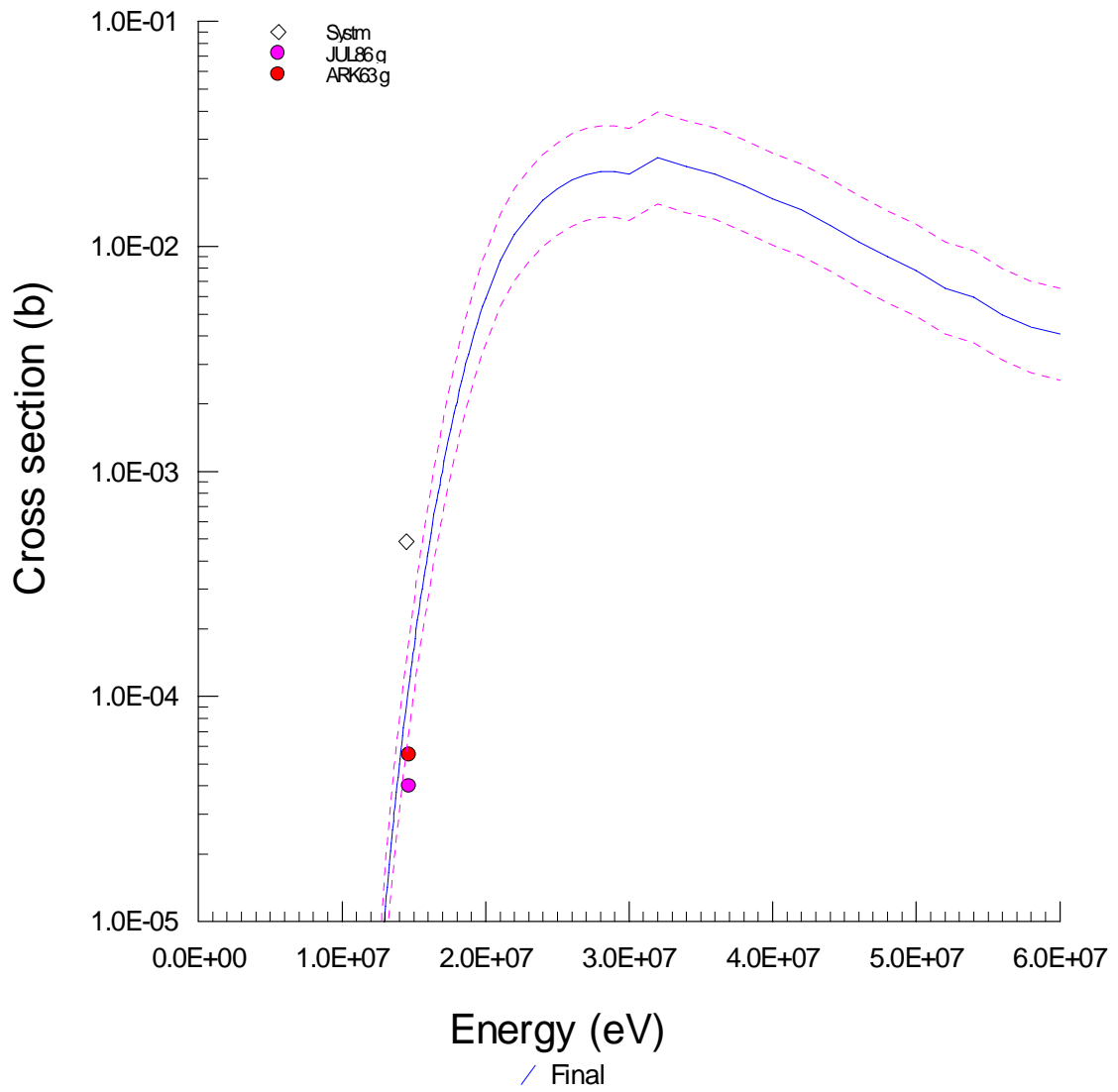
## Neutron Spectrum

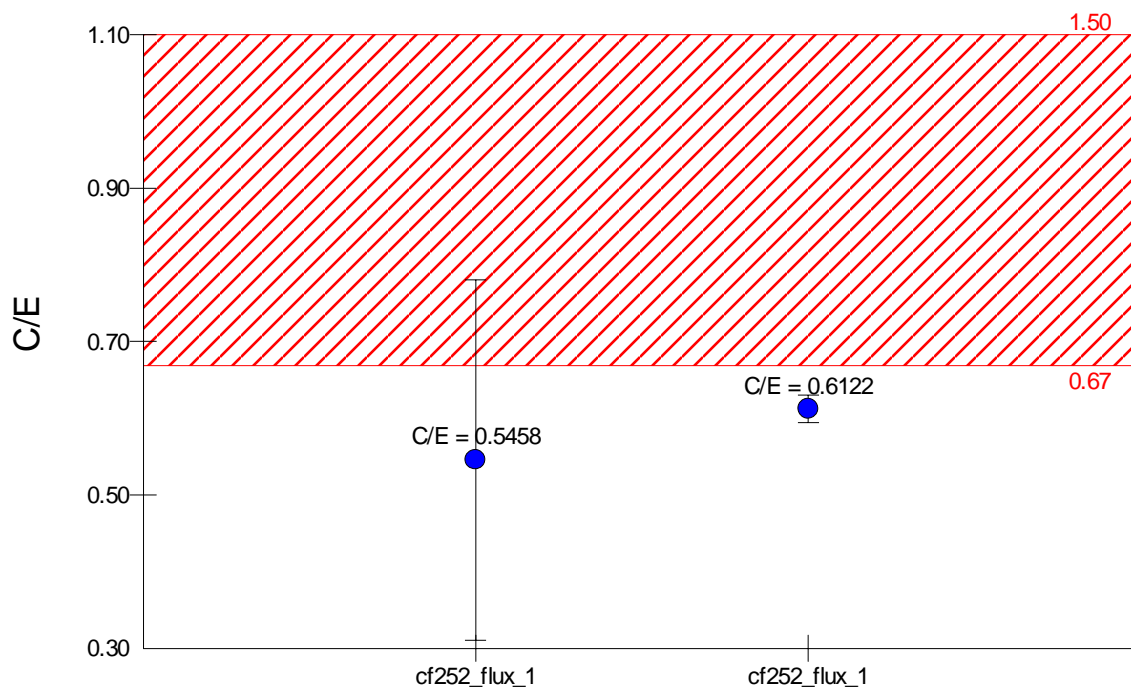
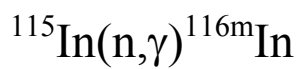


$^{115}\text{In}(n,n'\alpha)^{111}\text{Ag}$

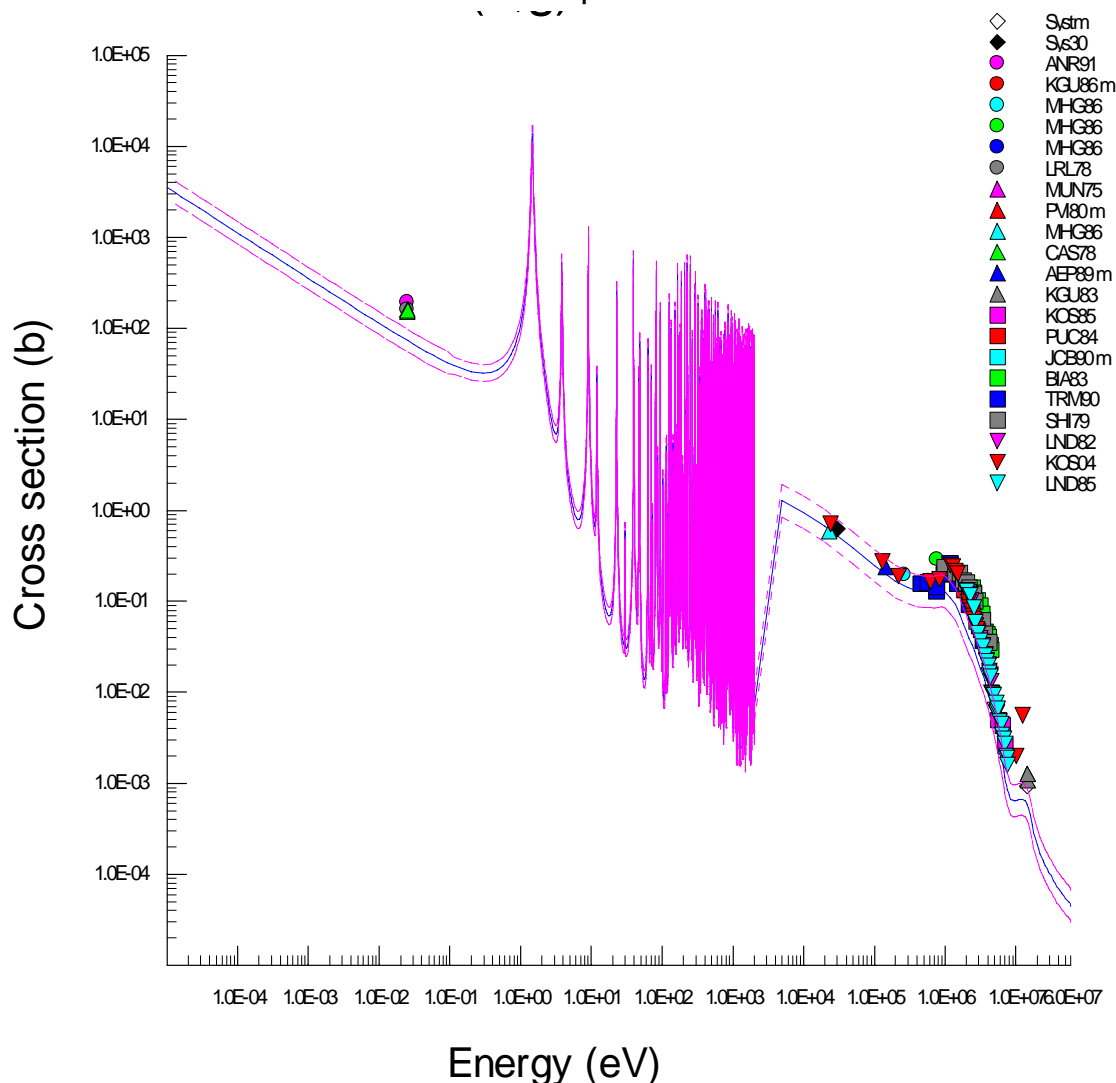


Neutron Spectrum



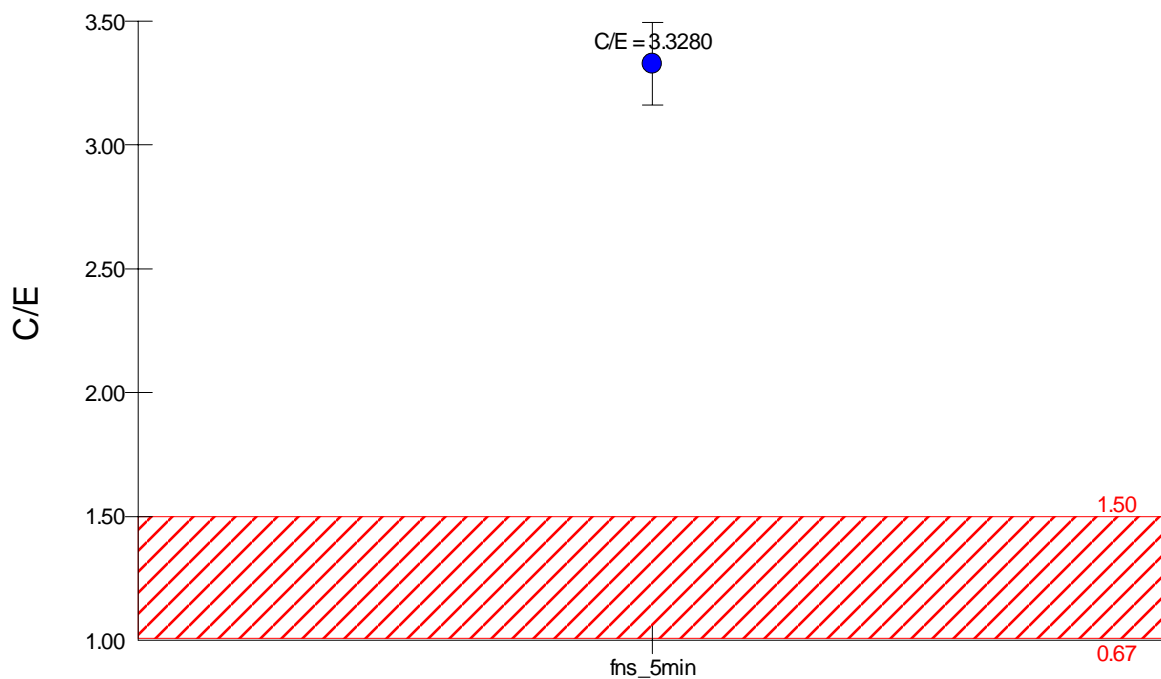


Neutron Spectrum

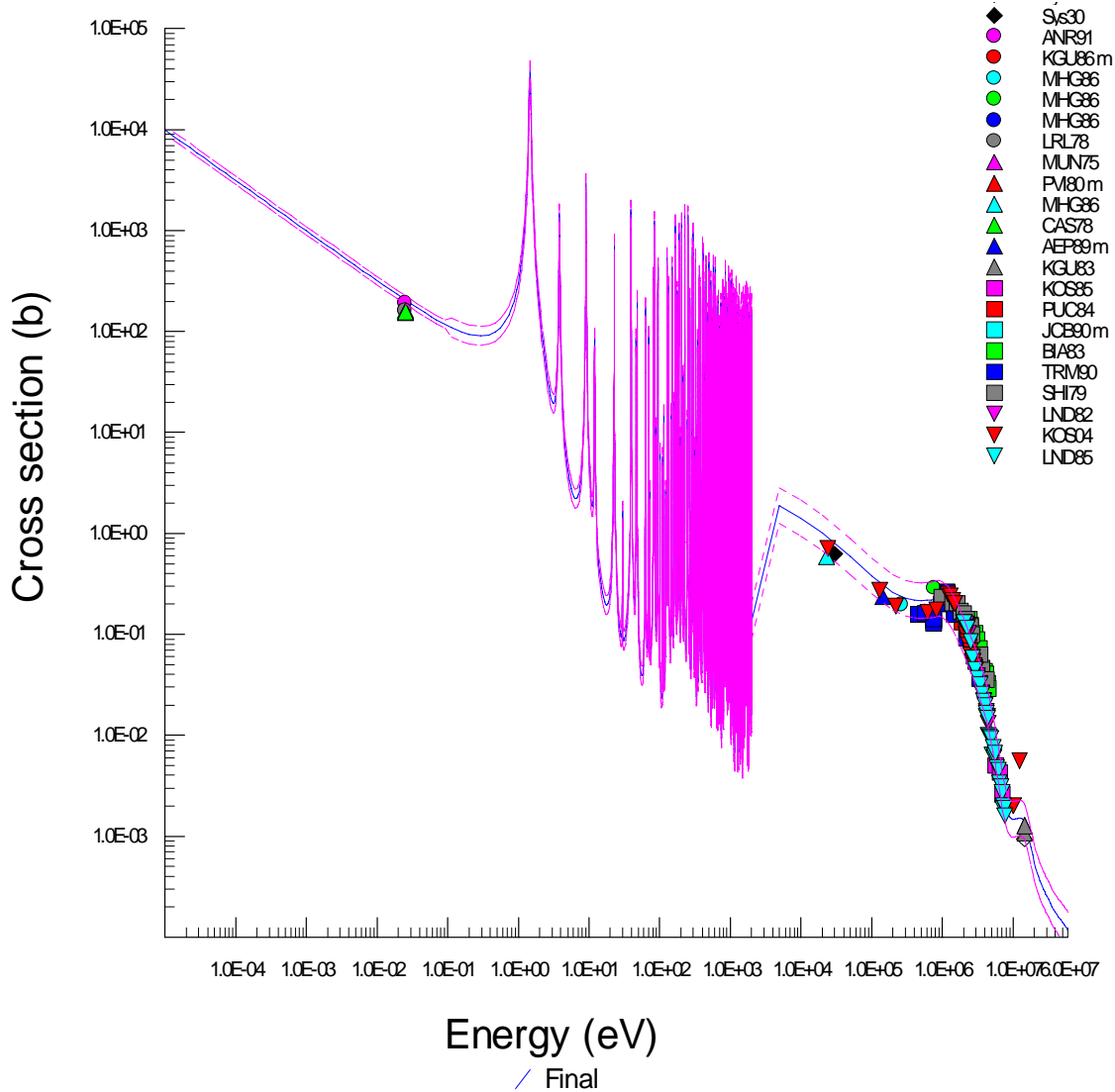




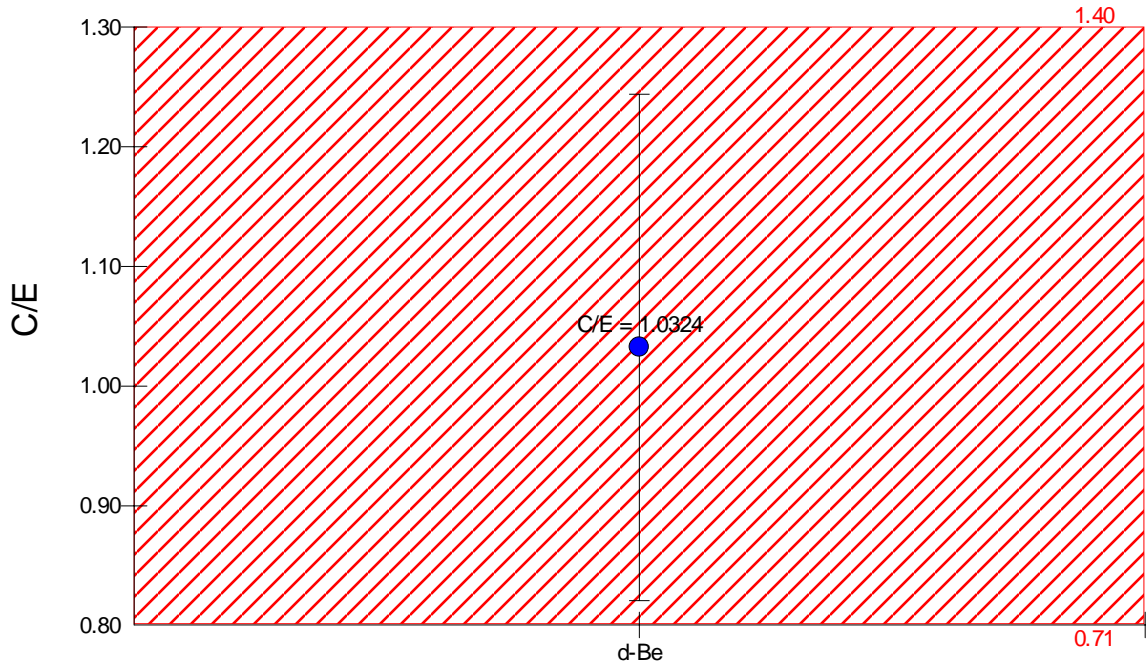
# $^{115}\text{In}(n,\gamma)^{116}\text{In}$



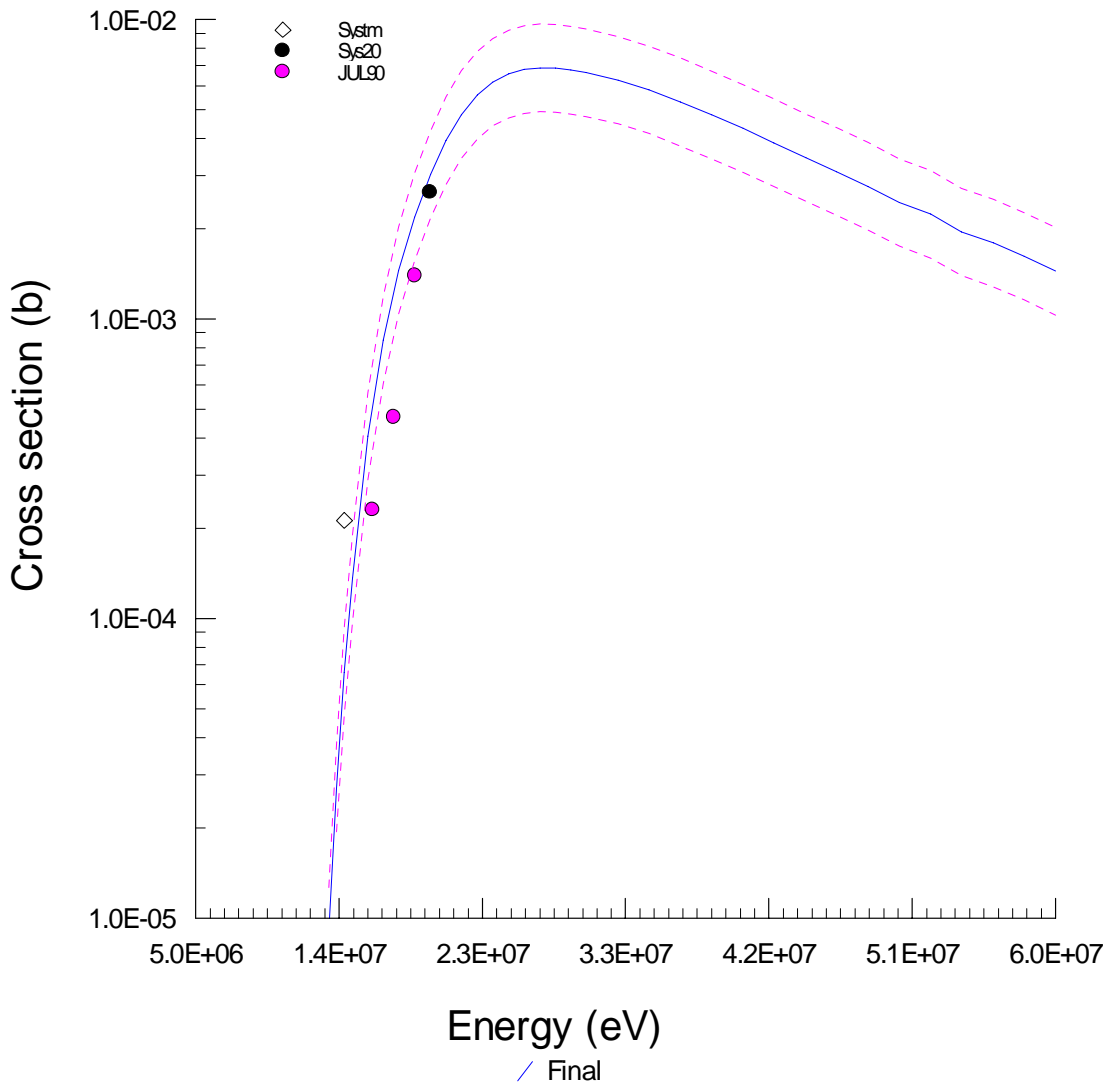
## Neutron Spectrum



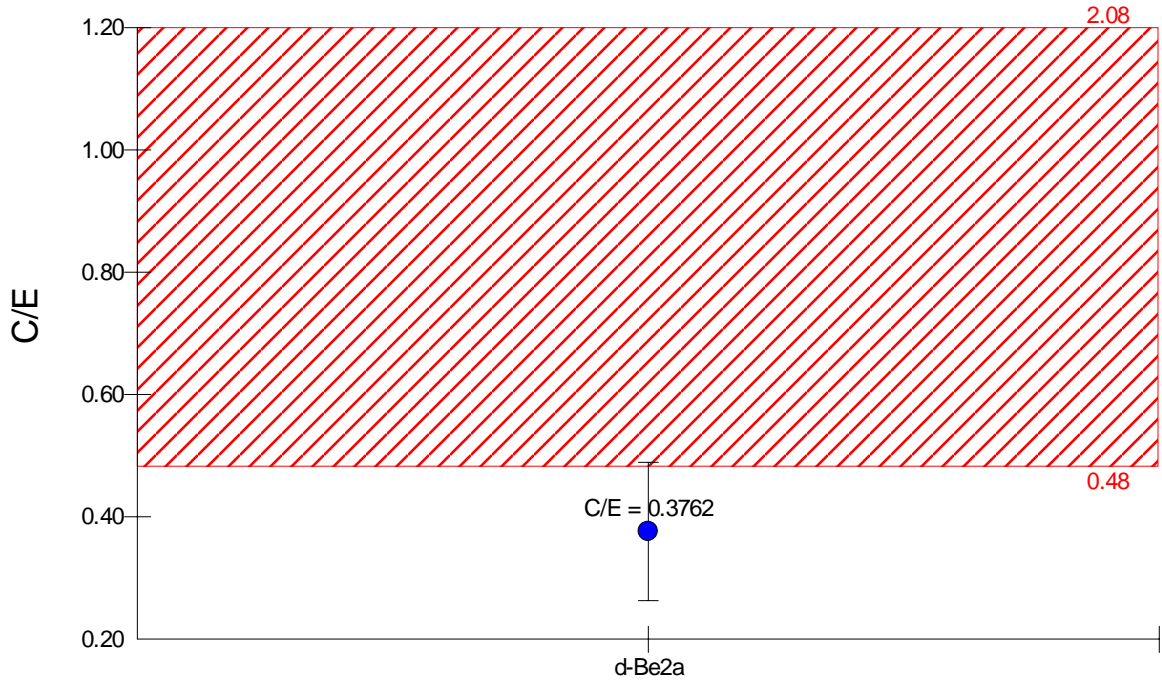
# $^{115}\text{In}(n,t)^{113}\text{Cd}$



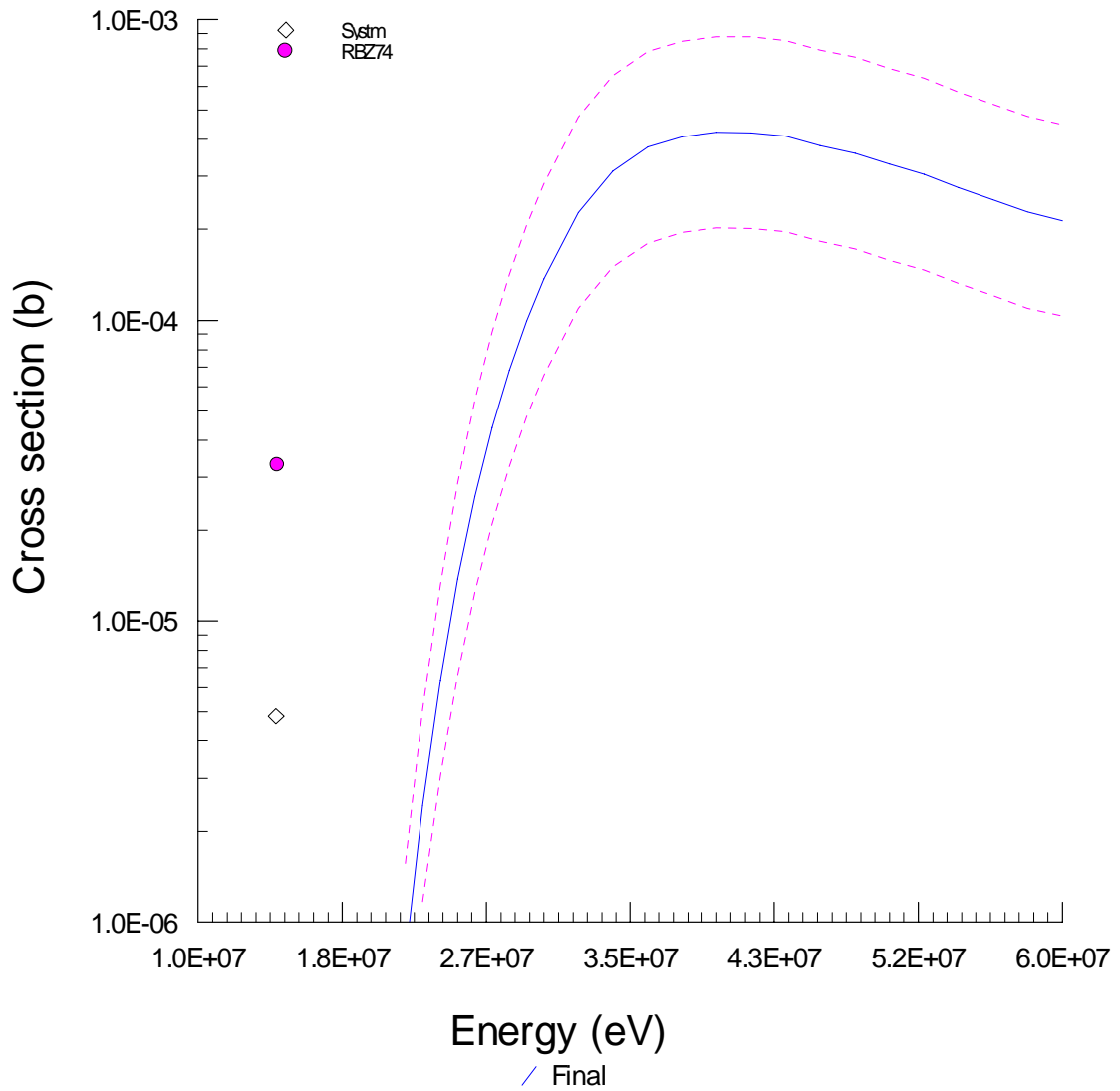
## Neutron Spectrum



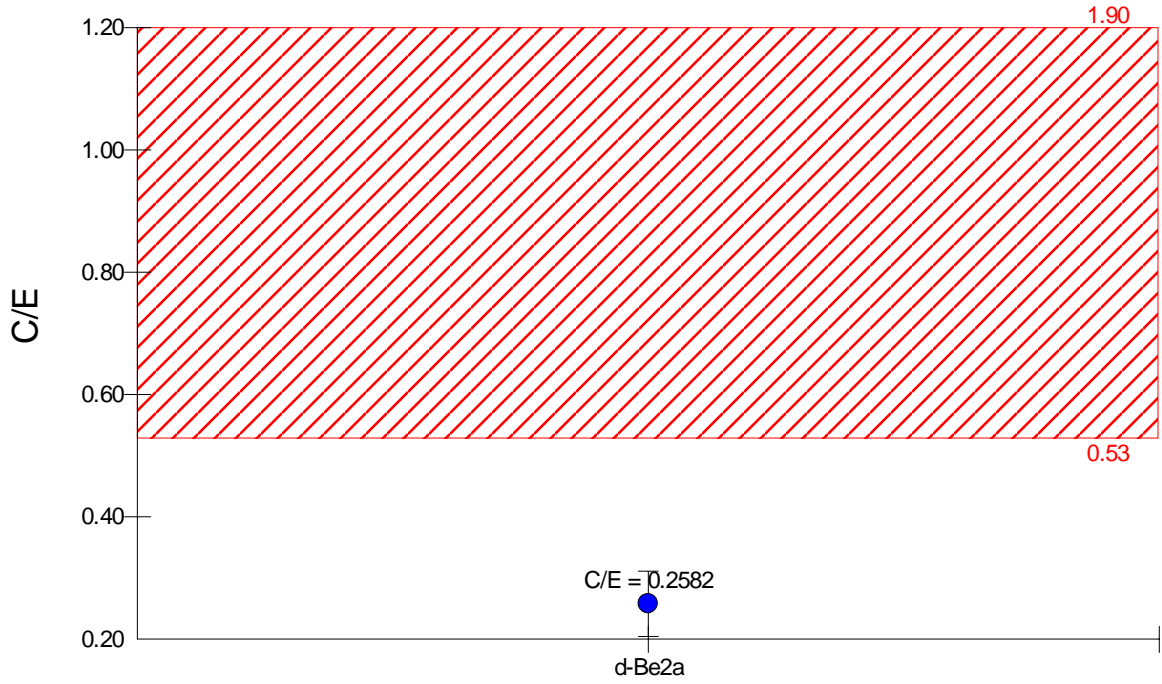
# $^{115}\text{In}(n,h)^{113g}\text{Ag}$



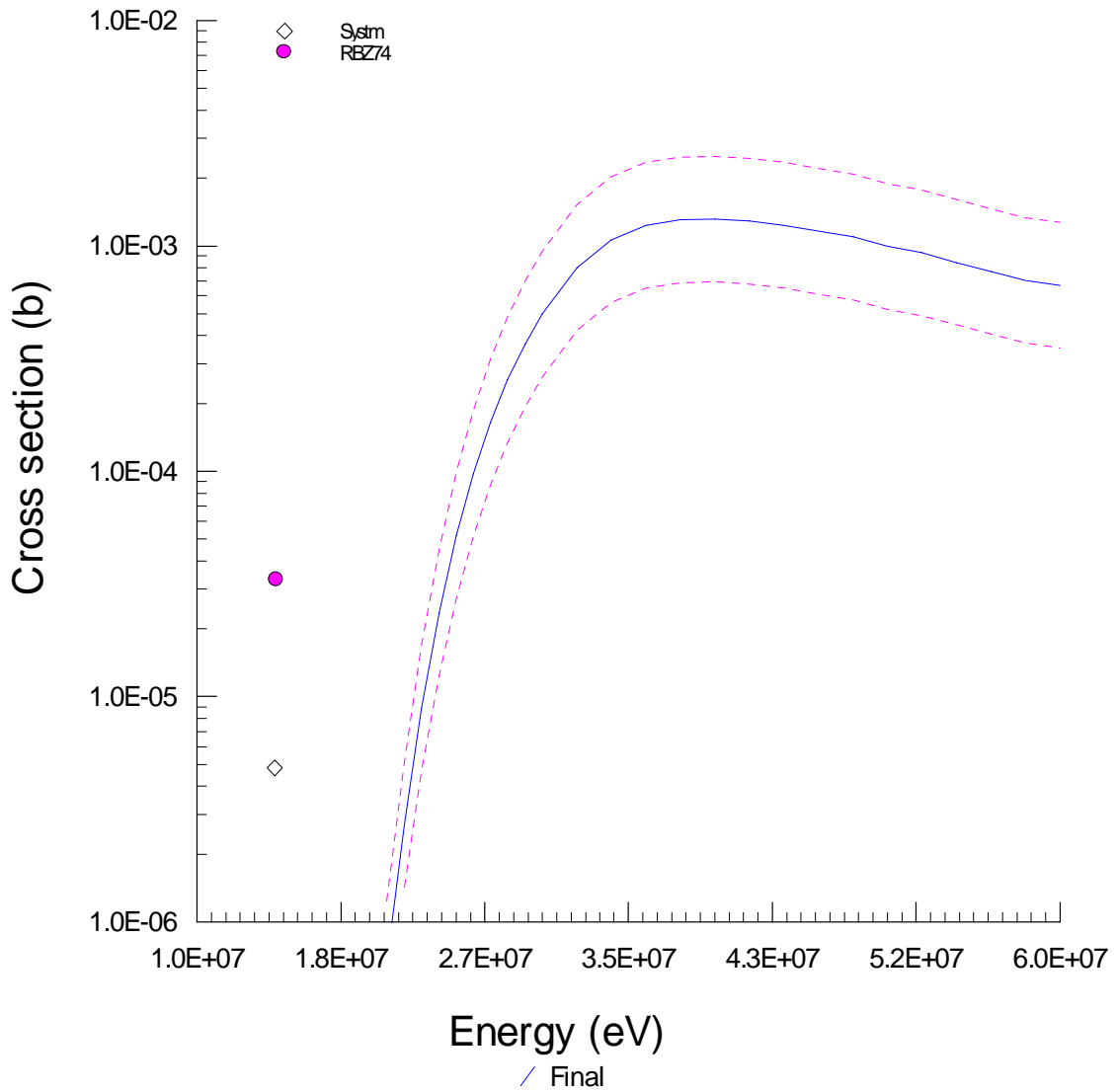
## Neutron Spectrum

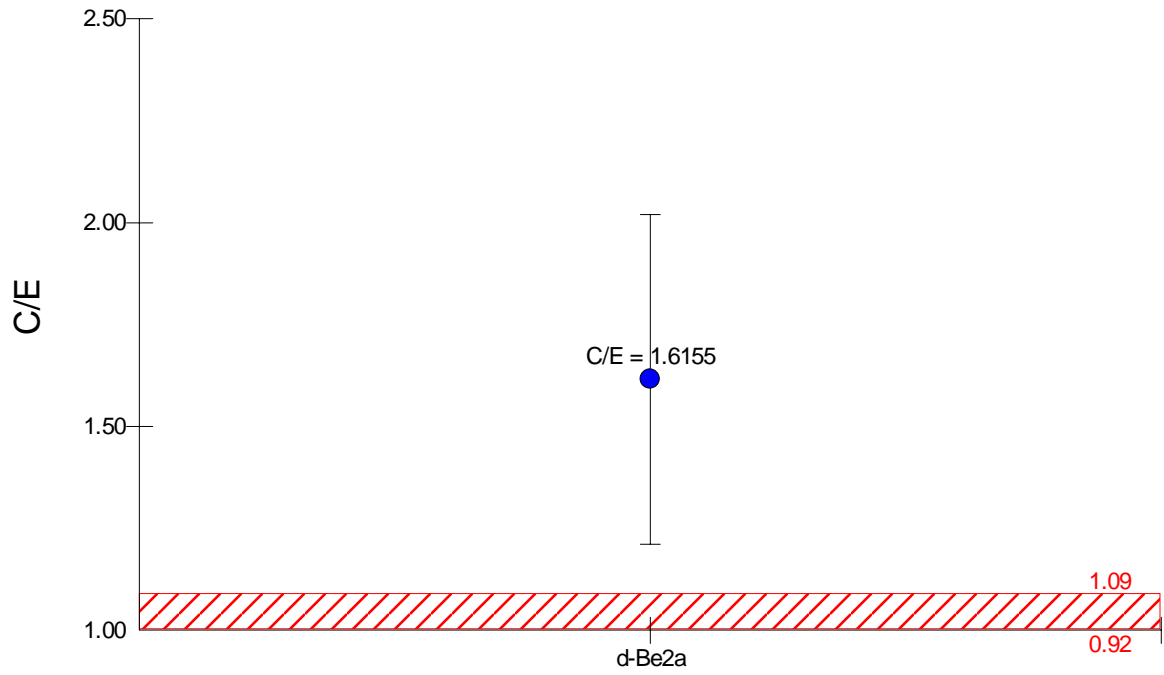
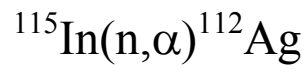


# $^{115}\text{In}(n,h)^{113}\text{Ag}$

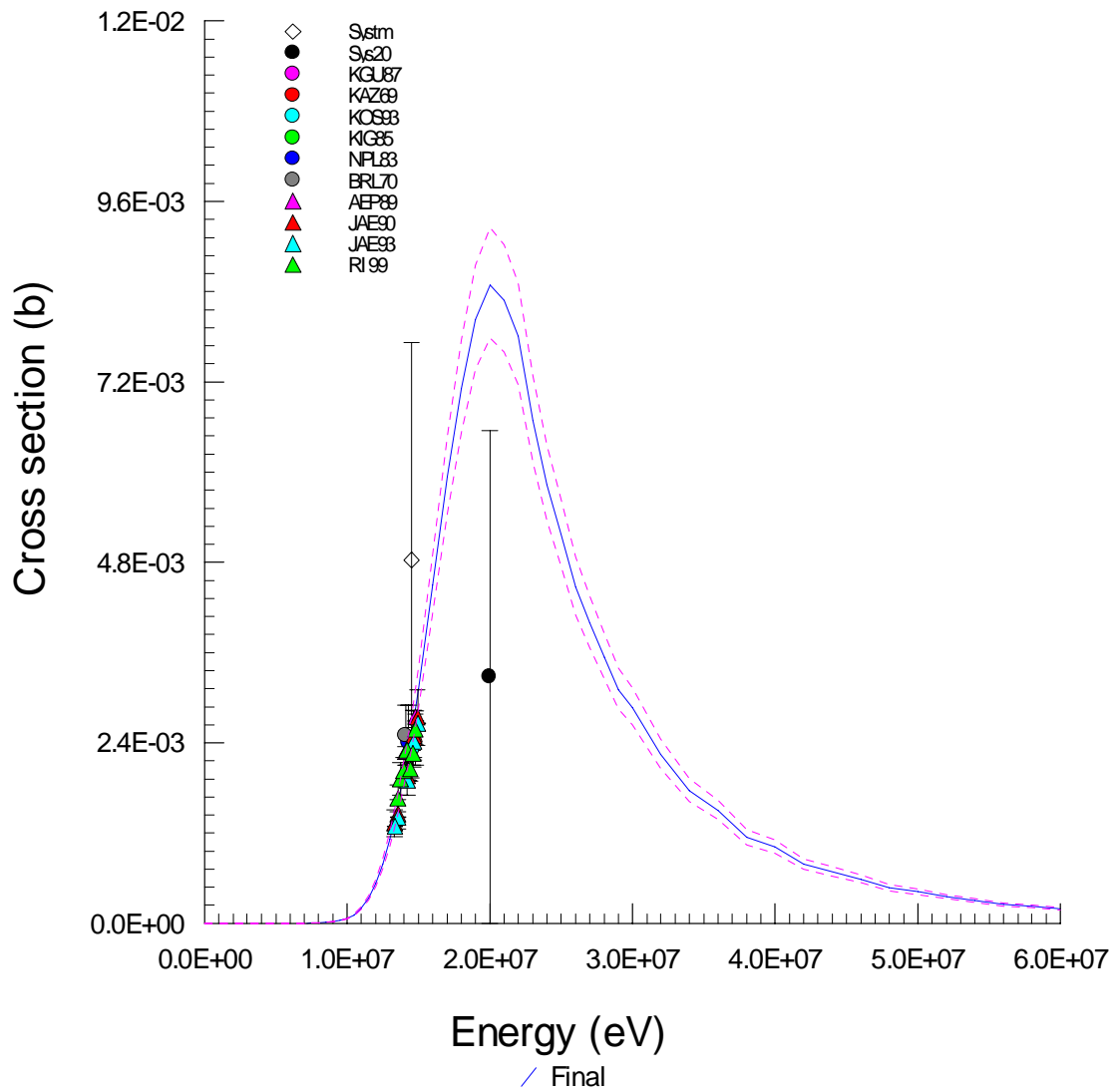


## Neutron Spectrum

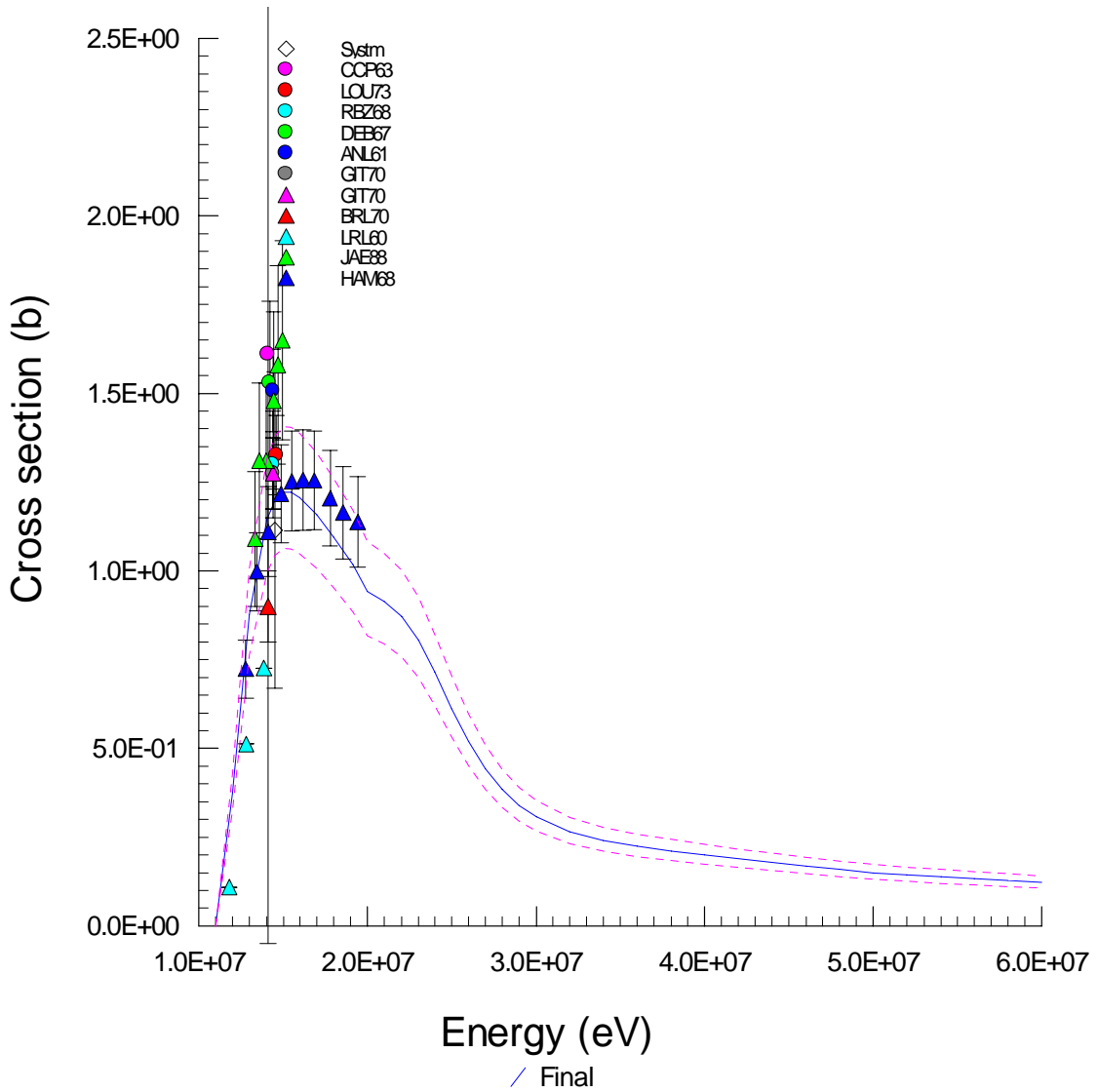
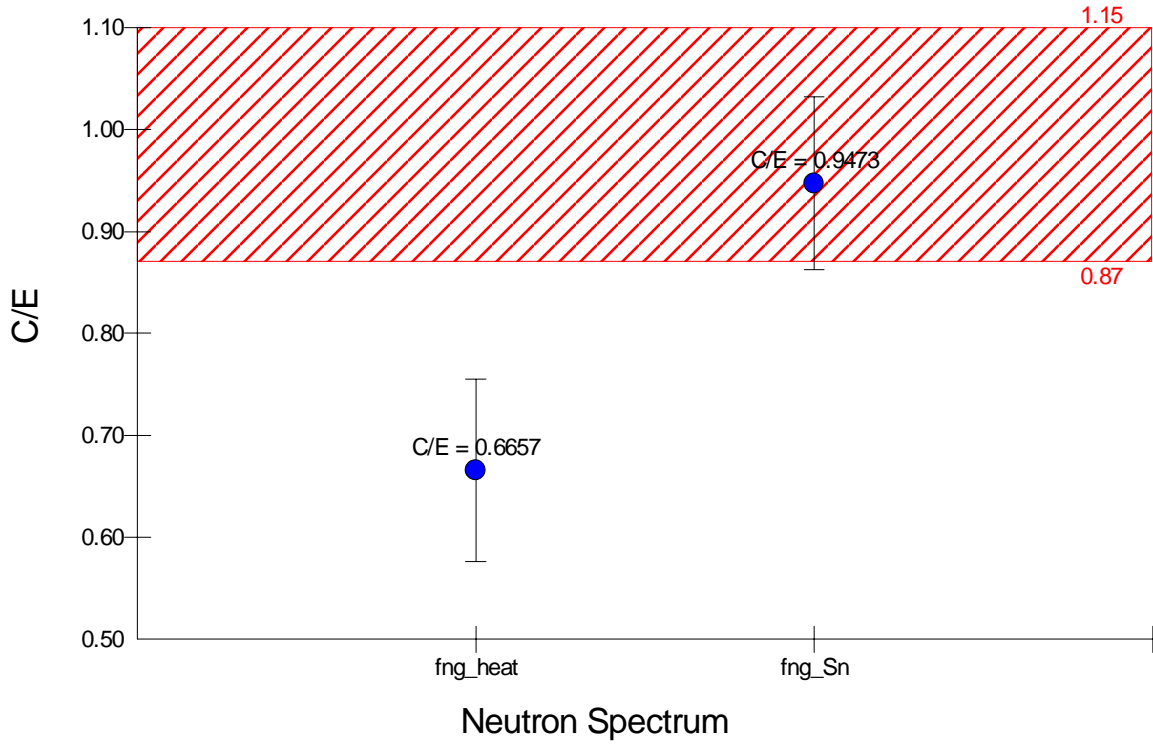




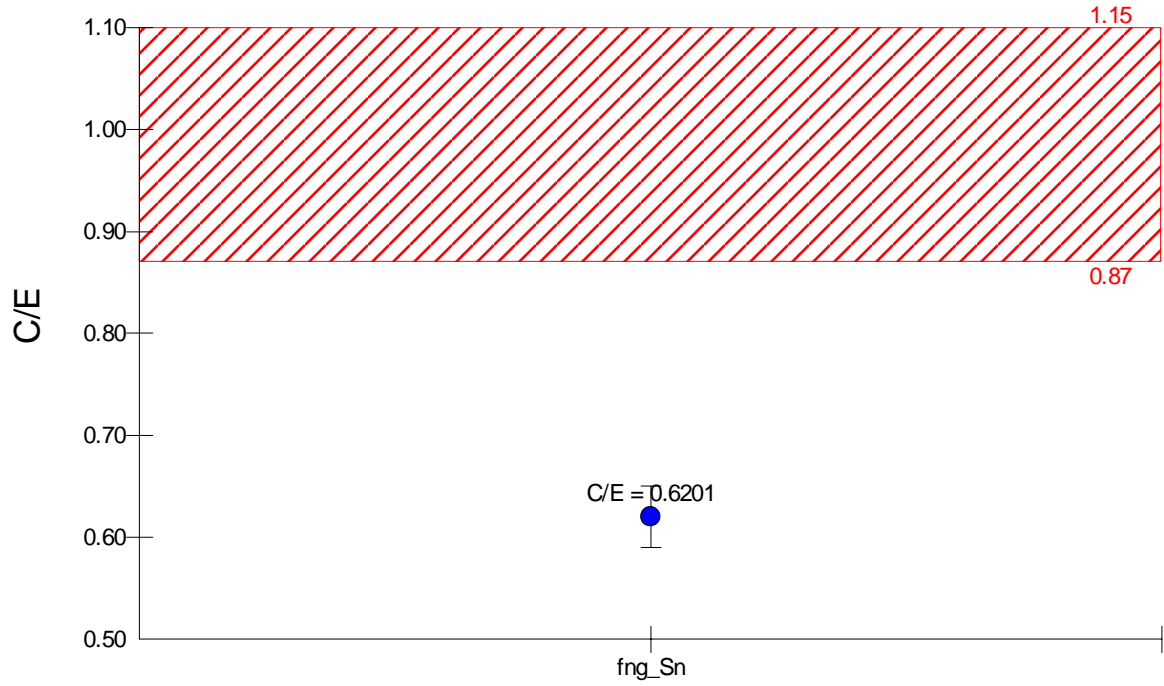
Neutron Spectrum



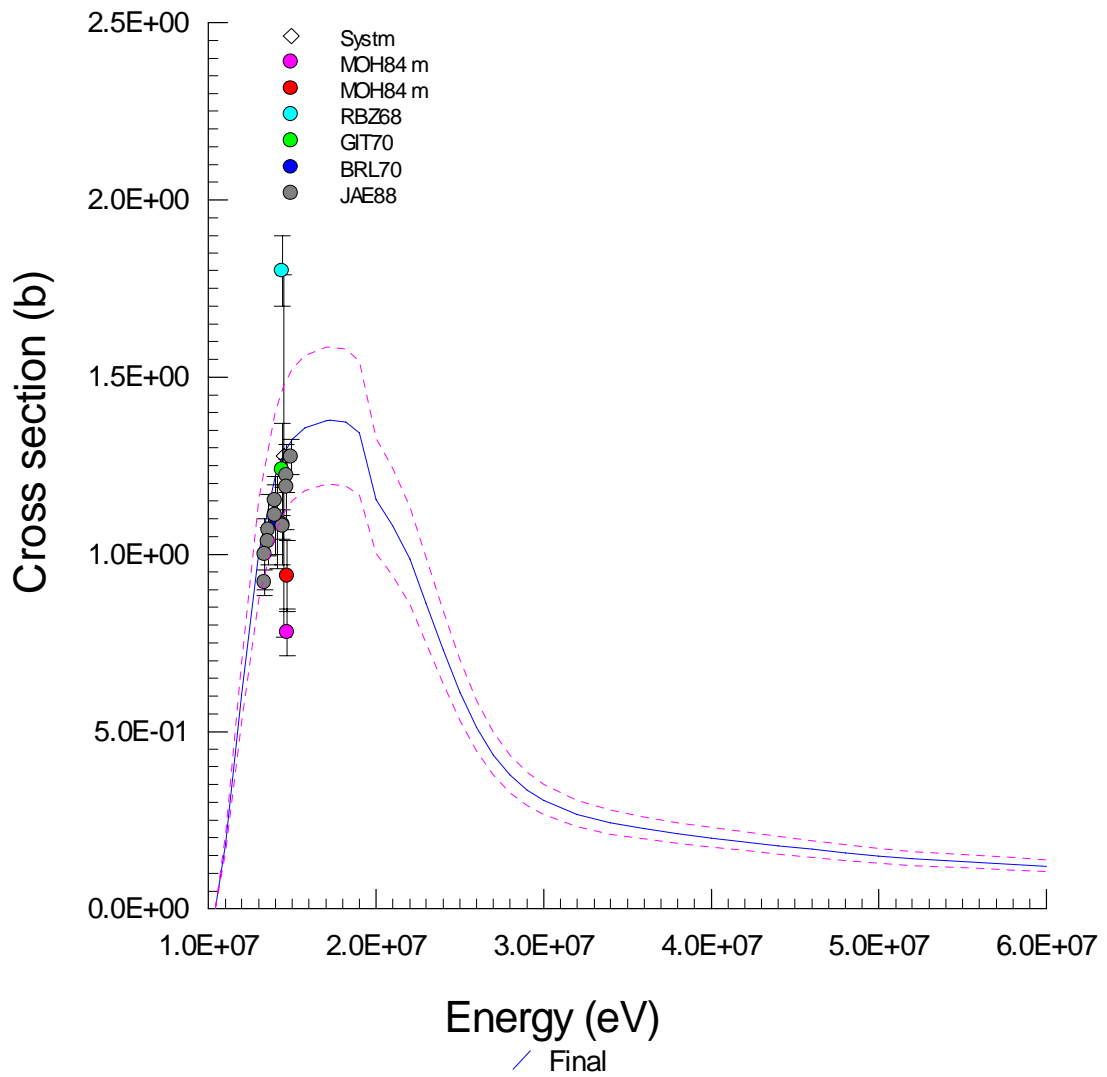
# $^{112}\text{Sn}(n,2n)^{111}\text{Sn}$

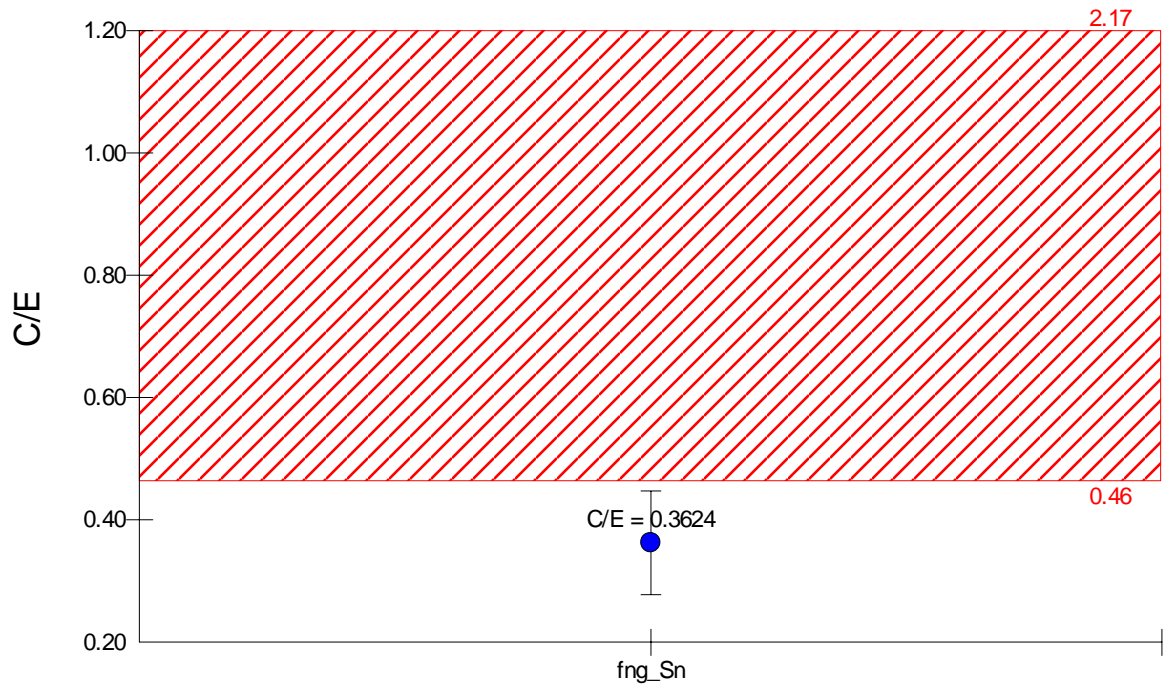
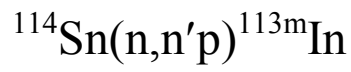


# $^{114}\text{Sn}(n,2n)^{113}\text{Sn}$

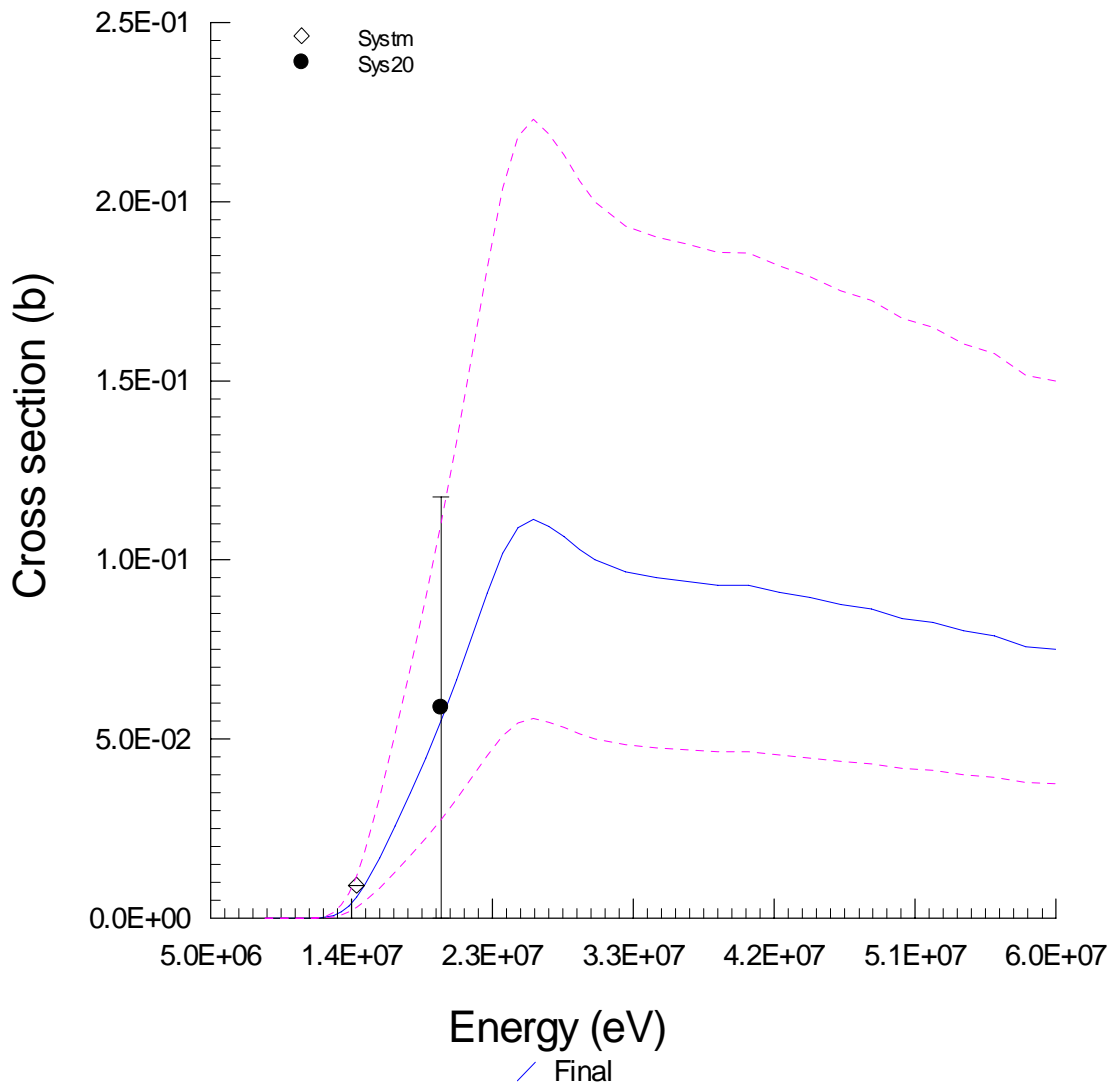


## Neutron Spectrum

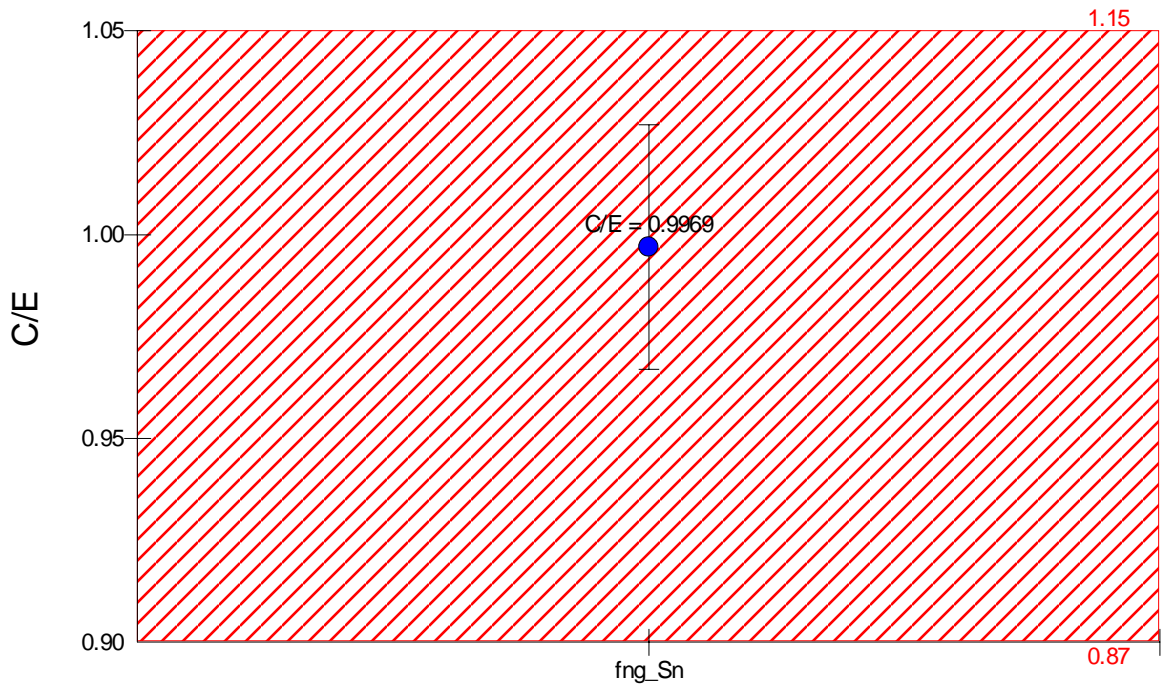
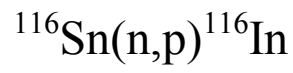




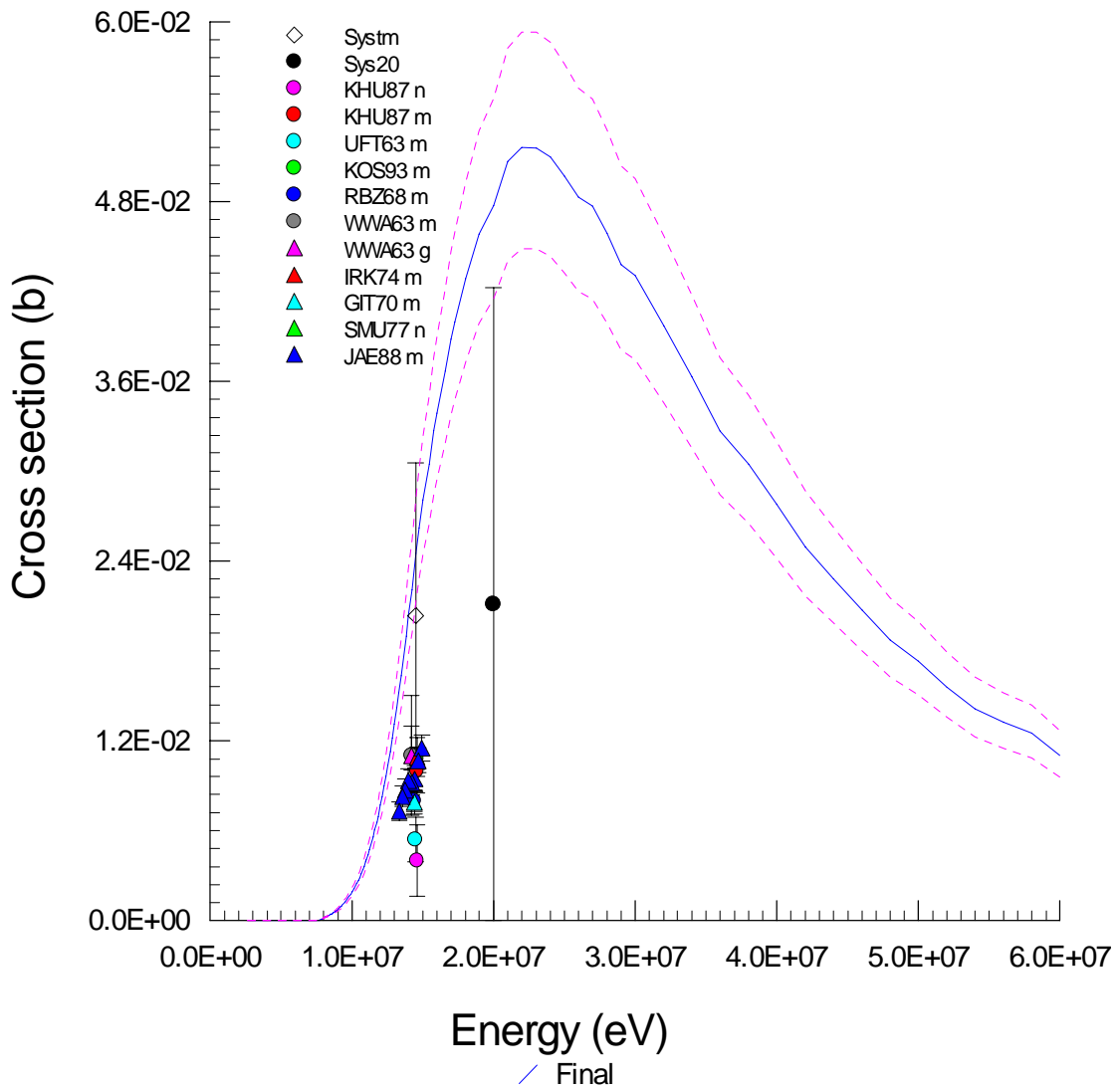
Neutron Spectrum



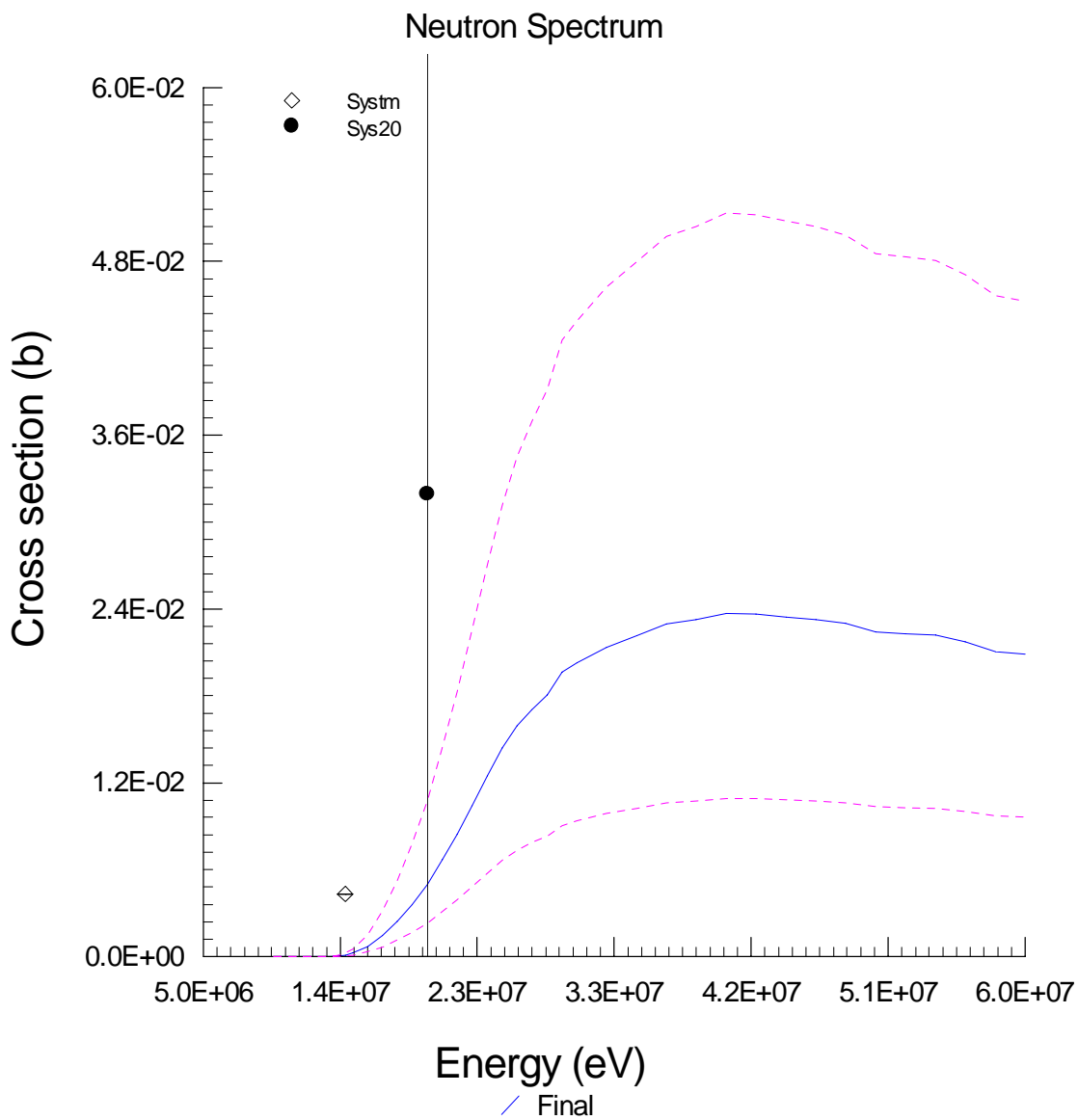
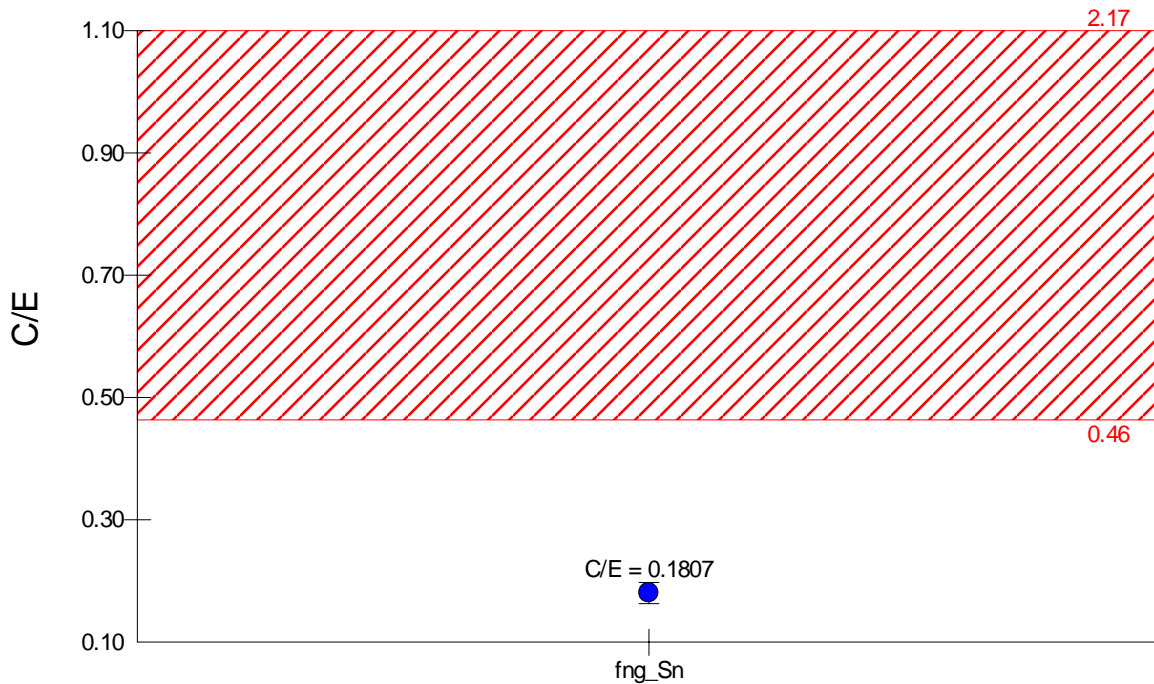




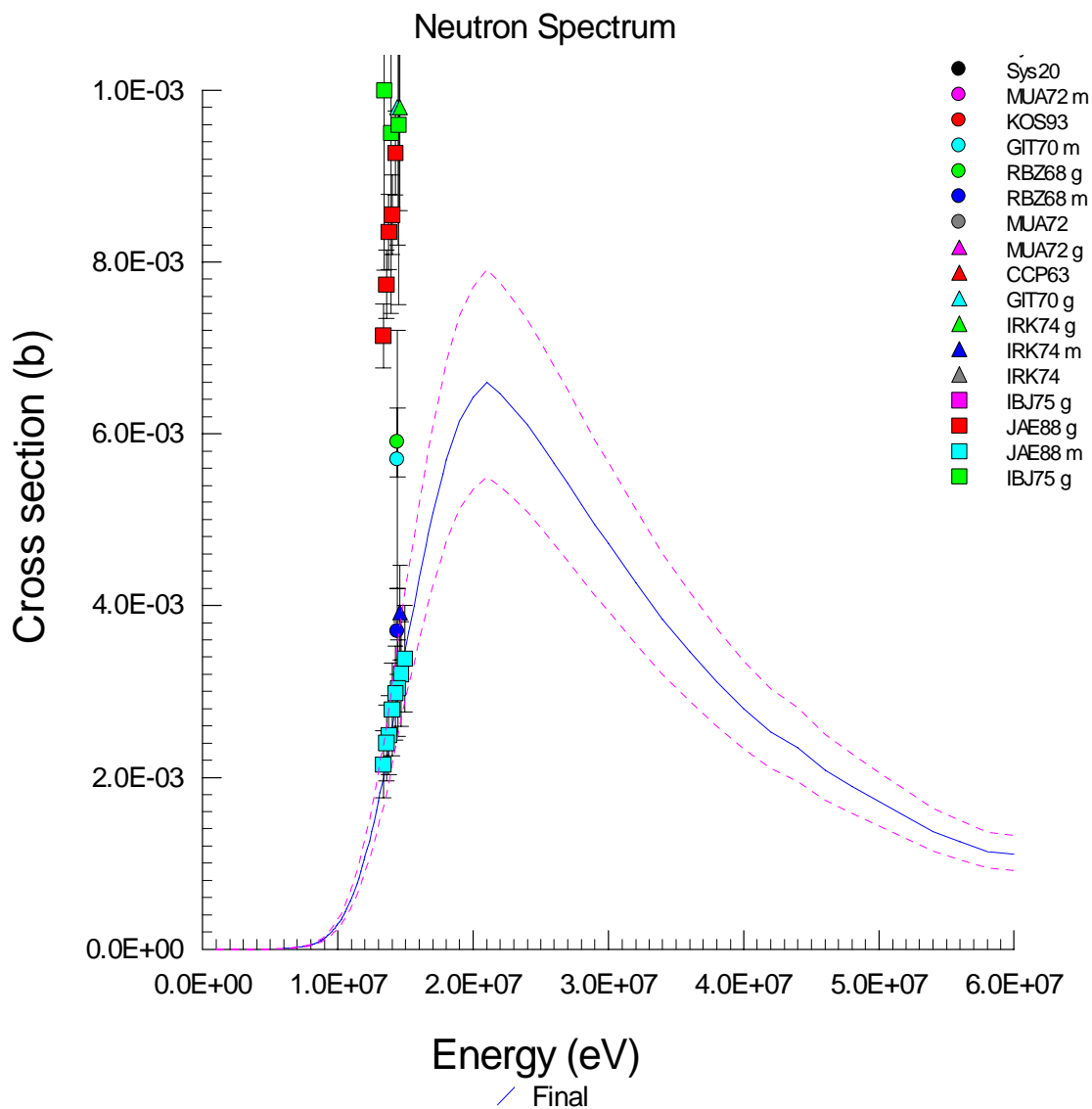
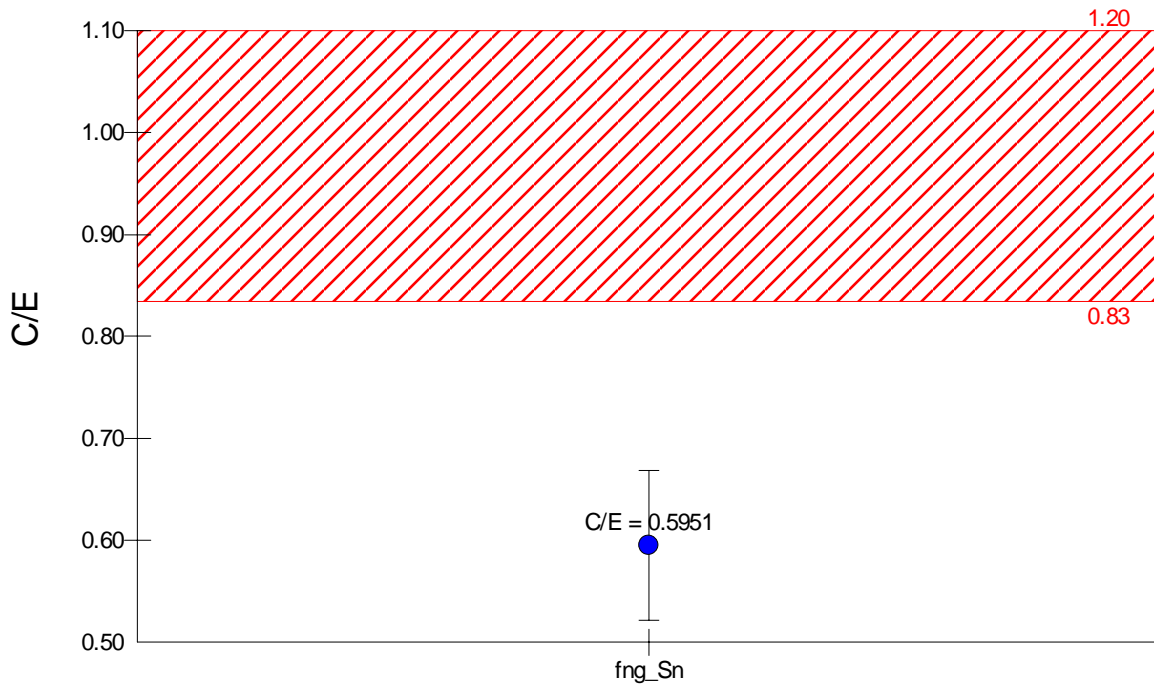
Neutron Spectrum



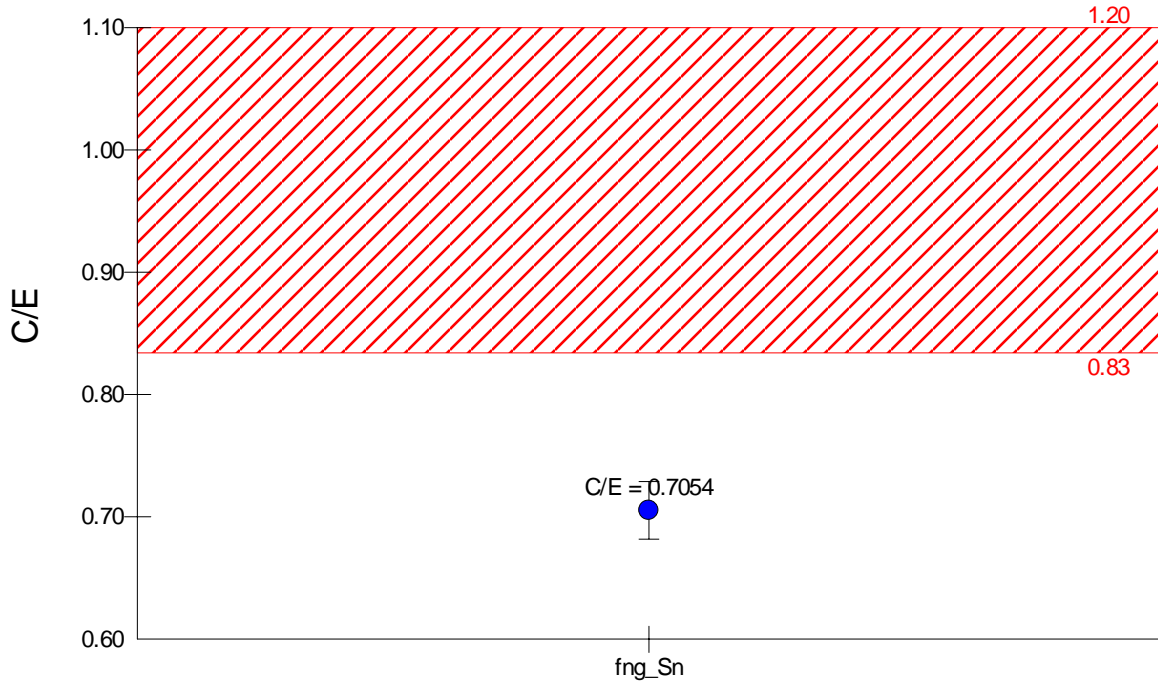
# $^{116}\text{Sn}(n,n'p)^{115\text{m}}\text{In}$



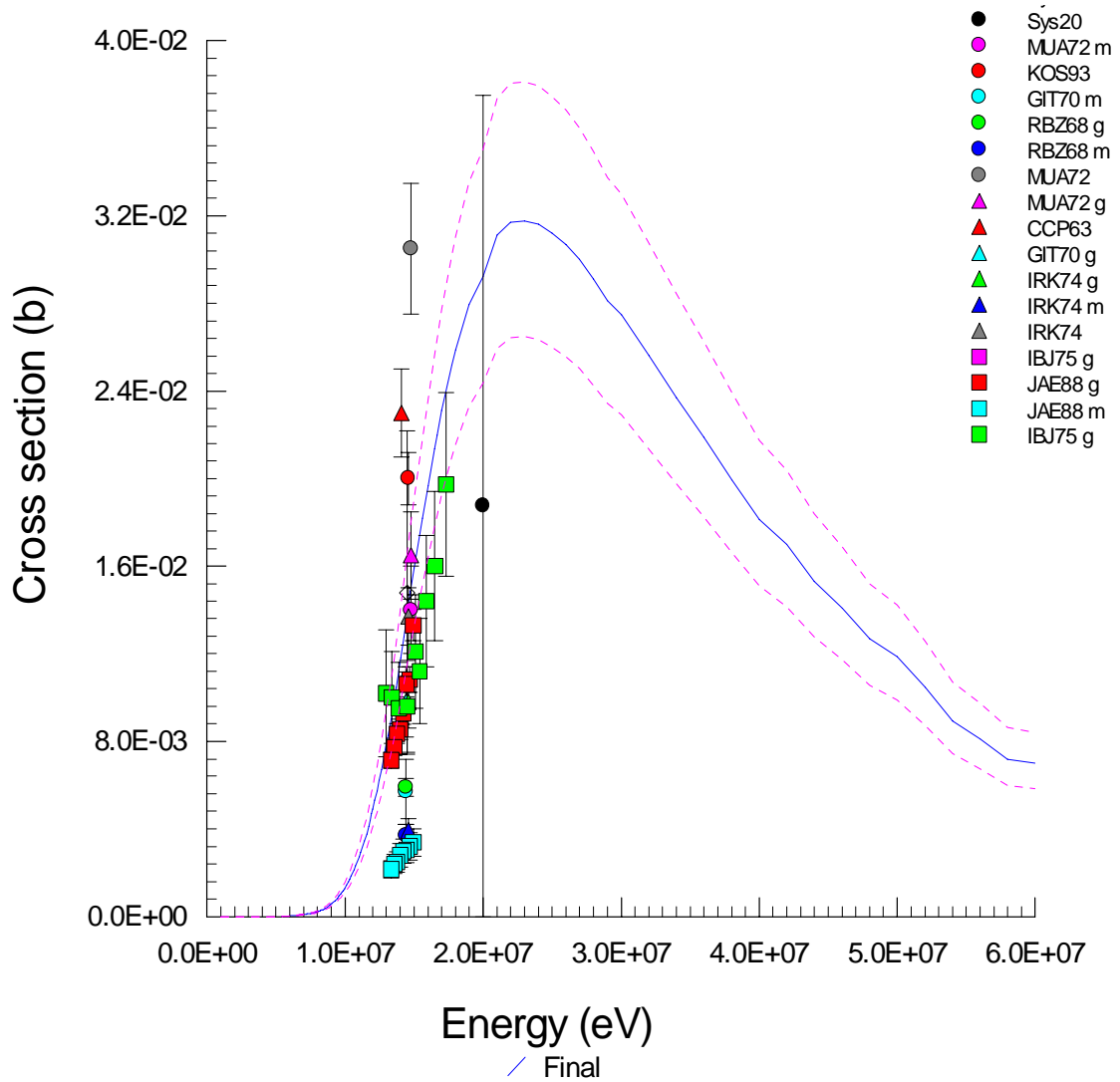
$^{117}\text{Sn}(n,p)^{117\text{m}}\text{In}$



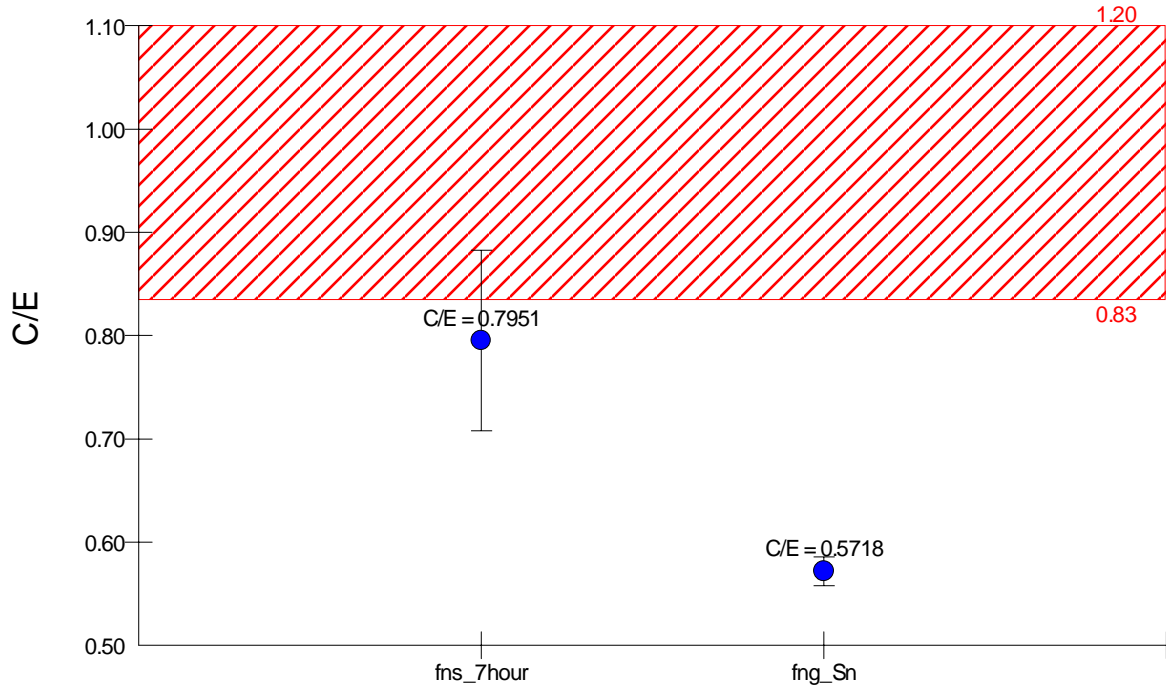
# $^{117}\text{Sn}(n,p)^{117}\text{In}$



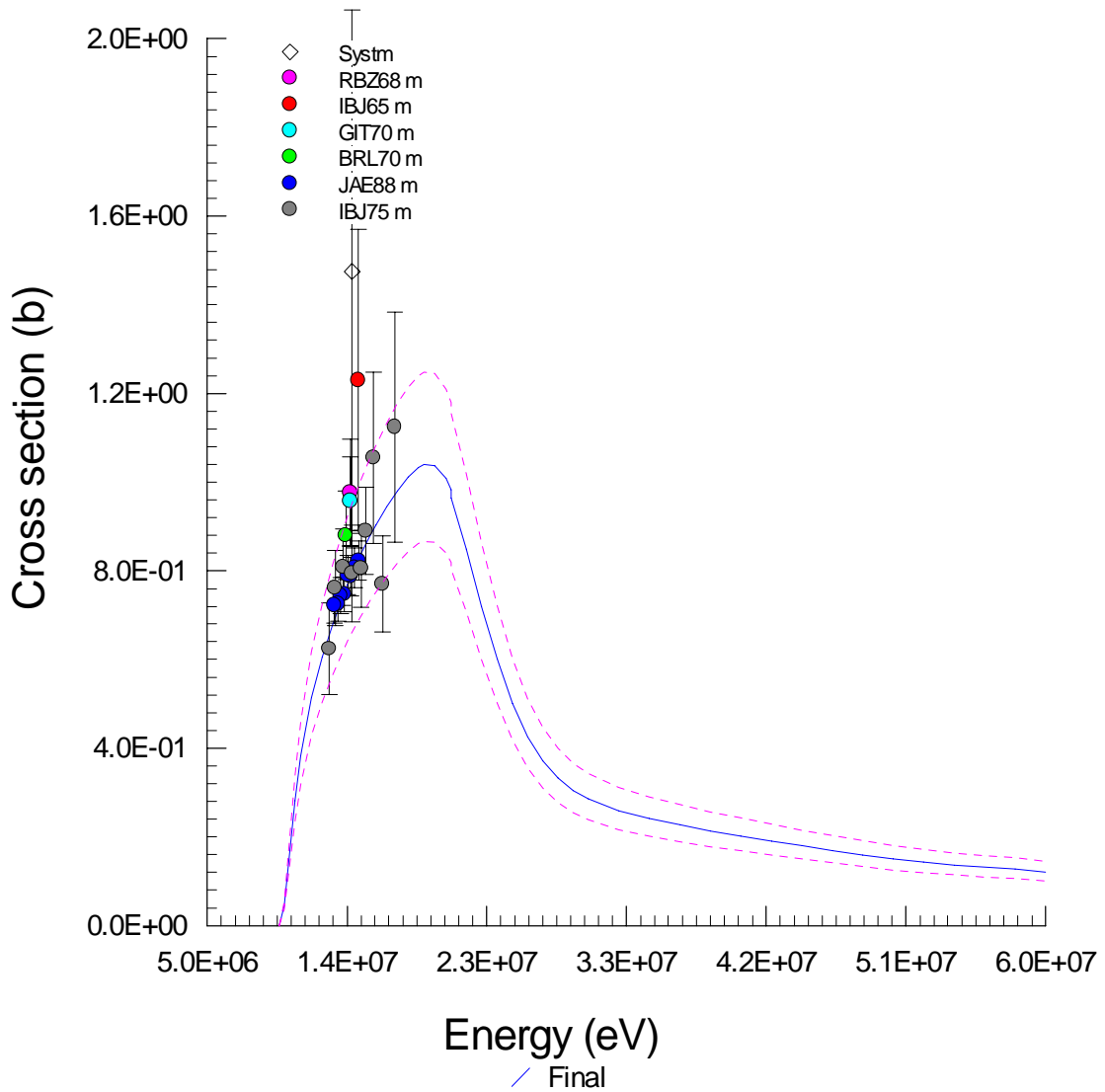
## Neutron Spectrum



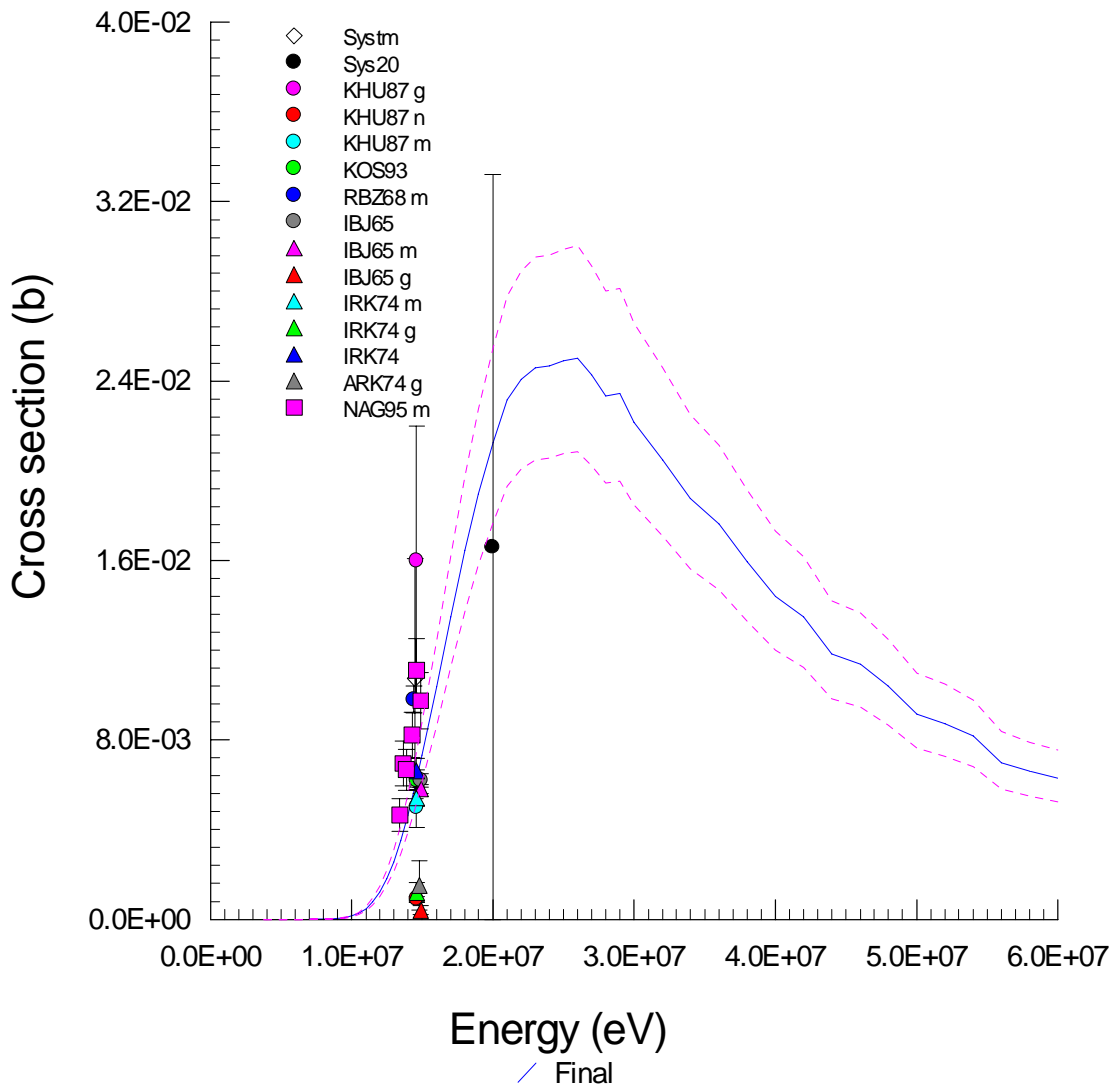
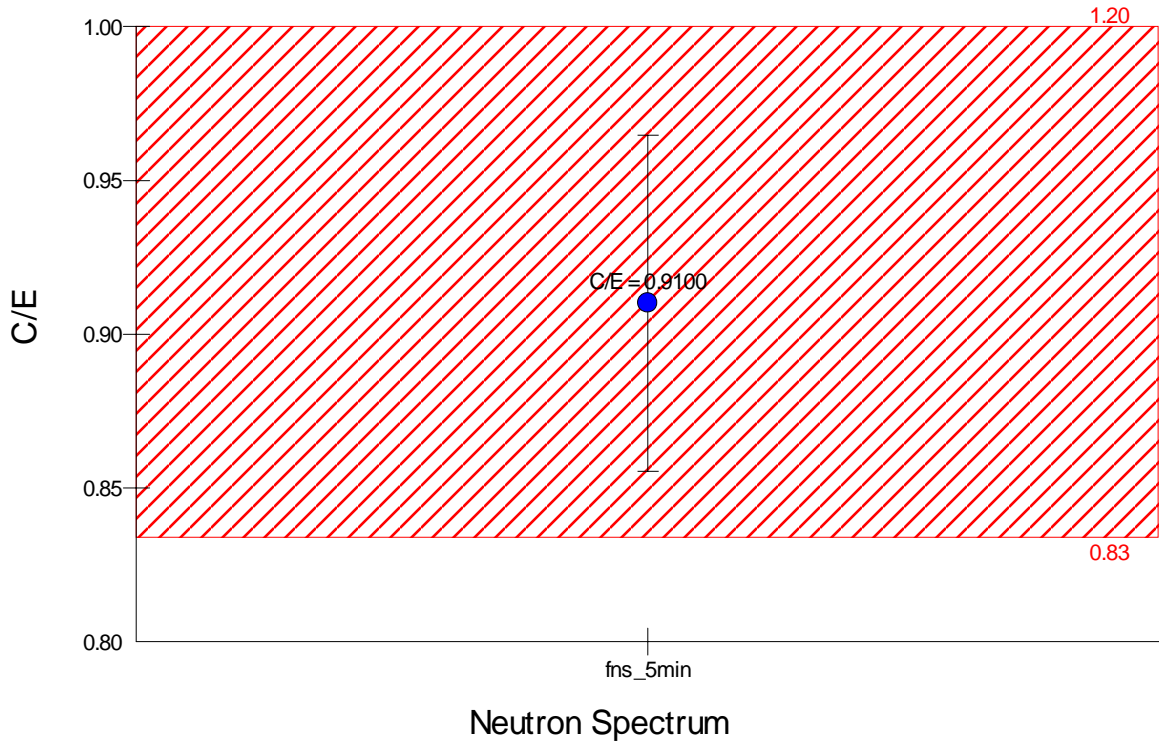
$^{118}\text{Sn}(n,2n)^{117\text{m}}\text{Sn}$

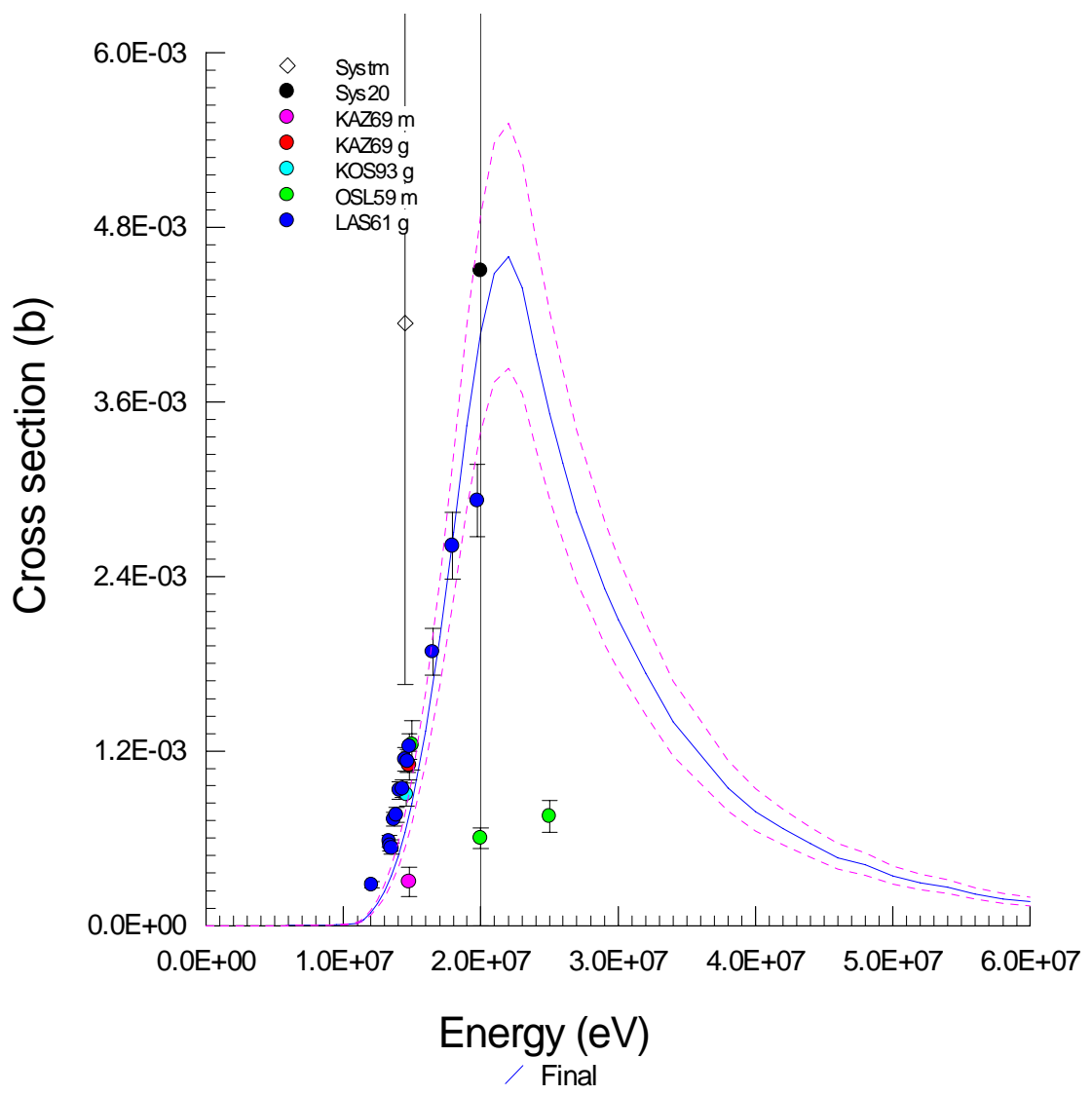
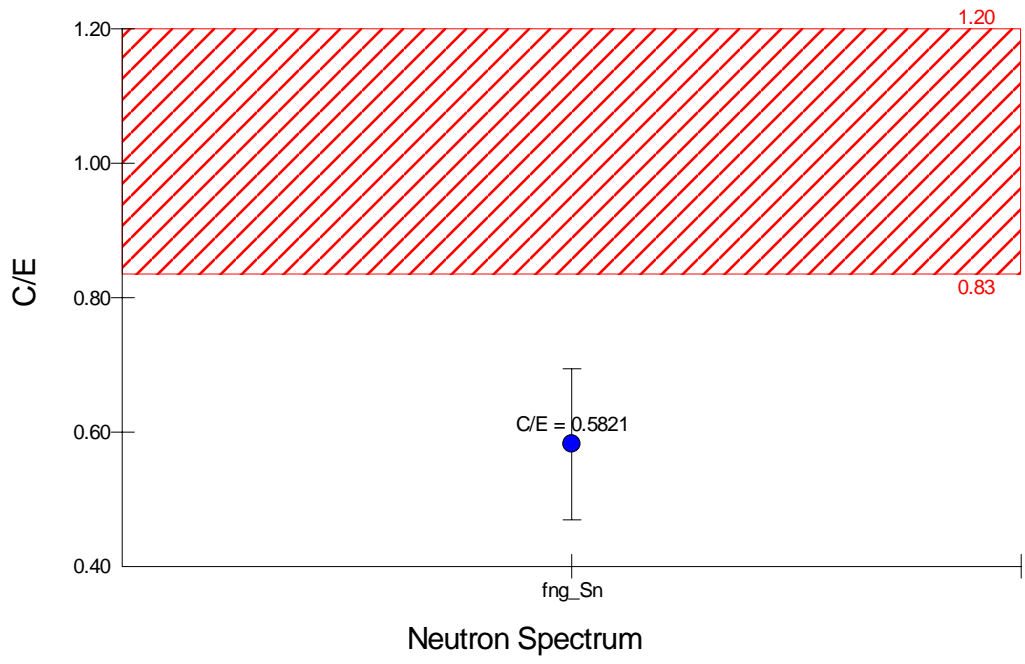
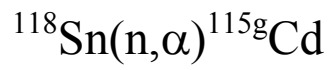


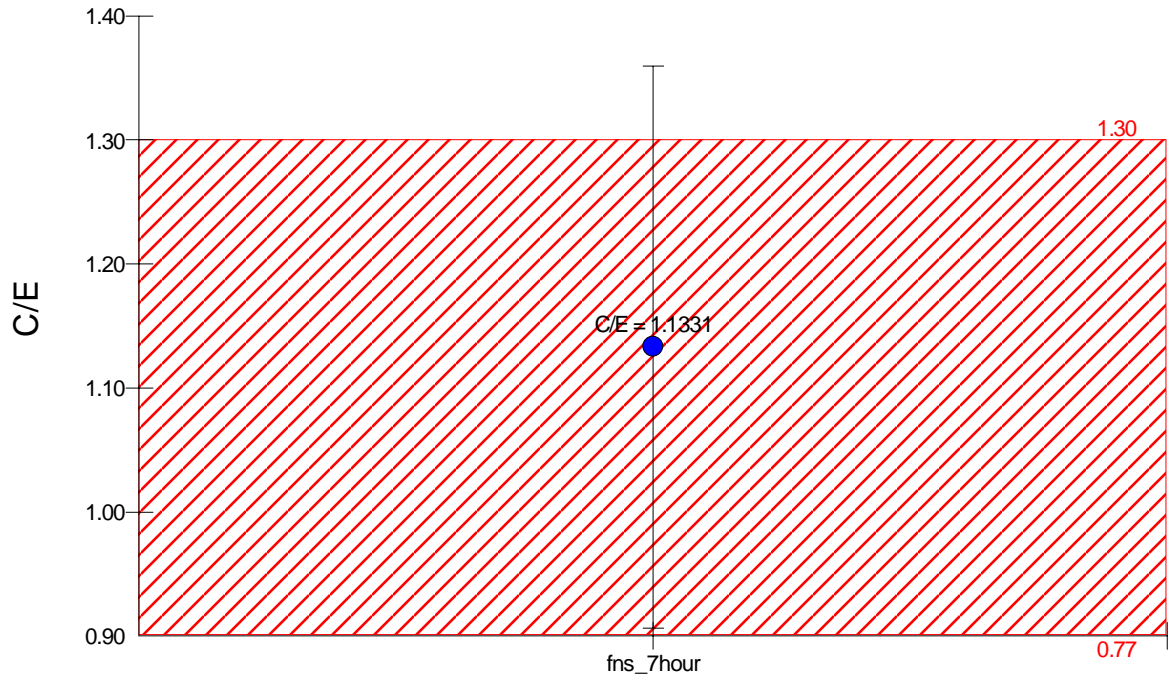
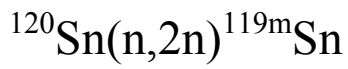
Neutron Spectrum



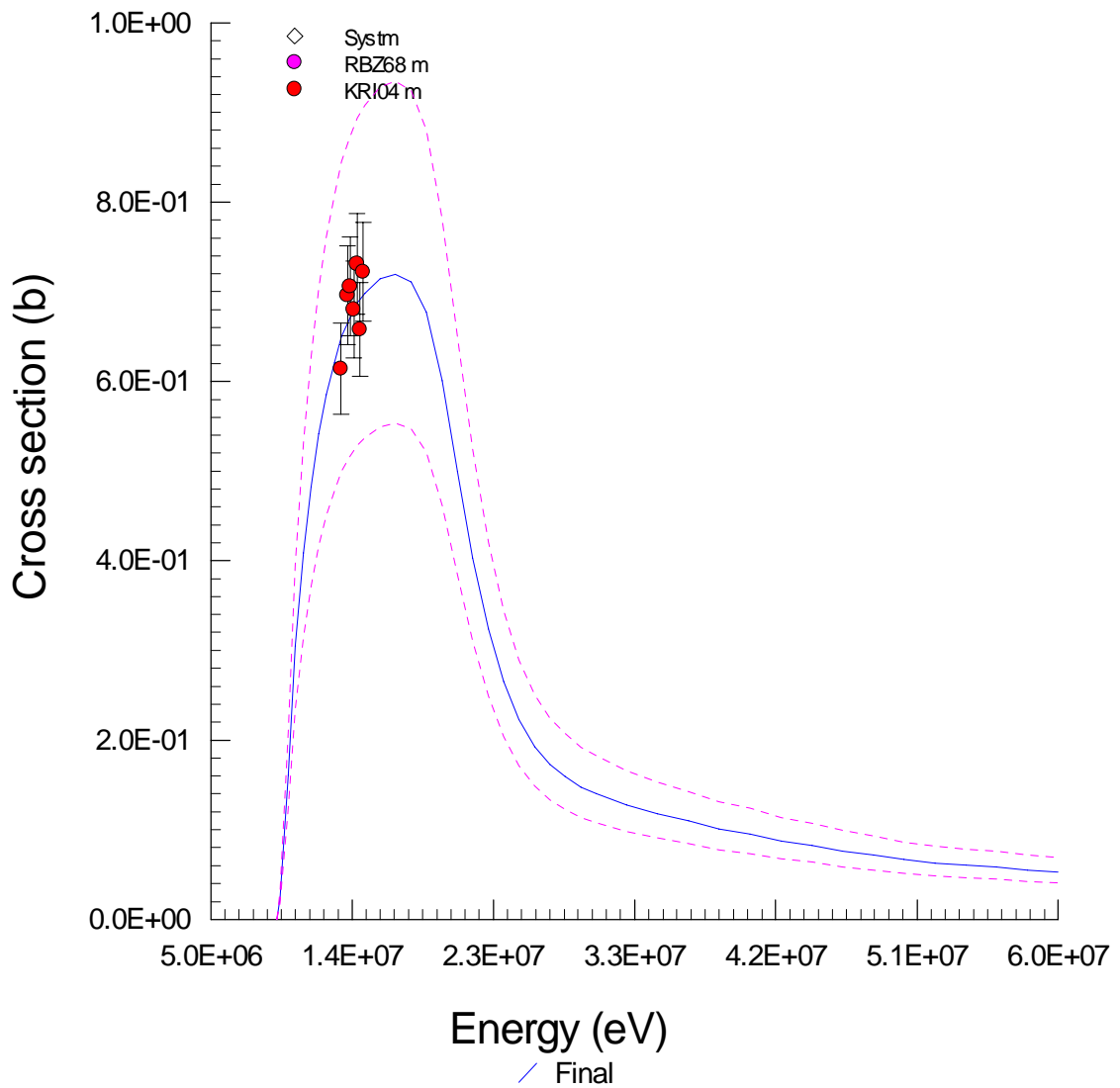
# $^{118}\text{Sn}(n,p)^{118\text{m}}\text{In}$





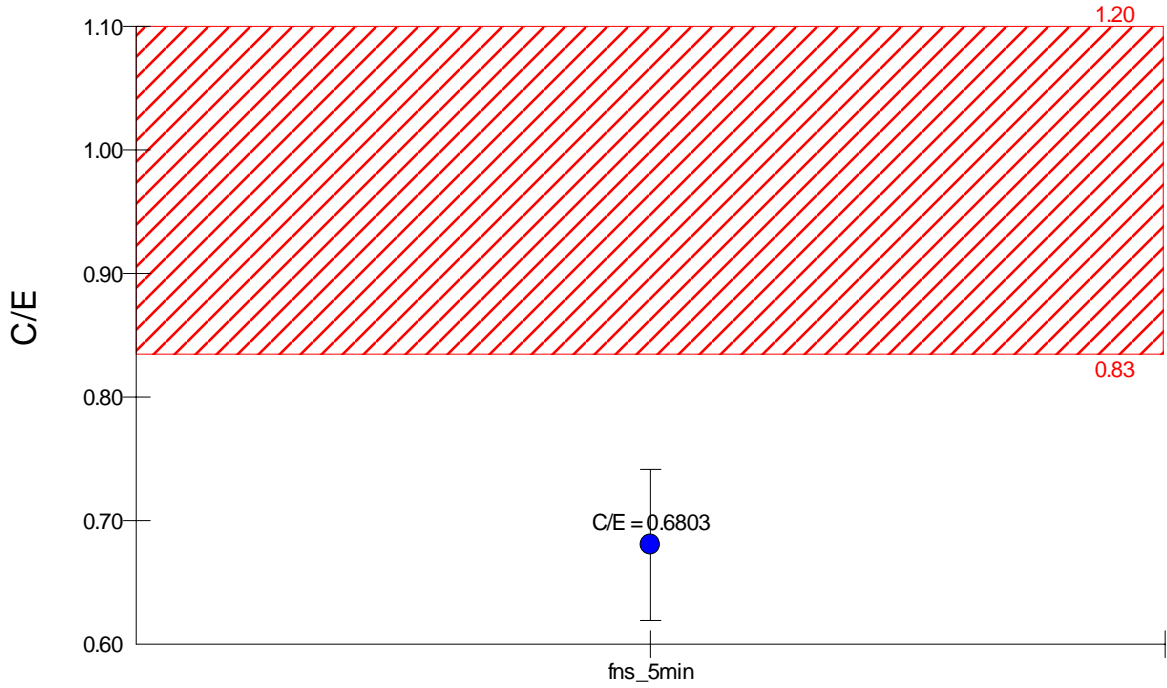


Neutron Spectrum

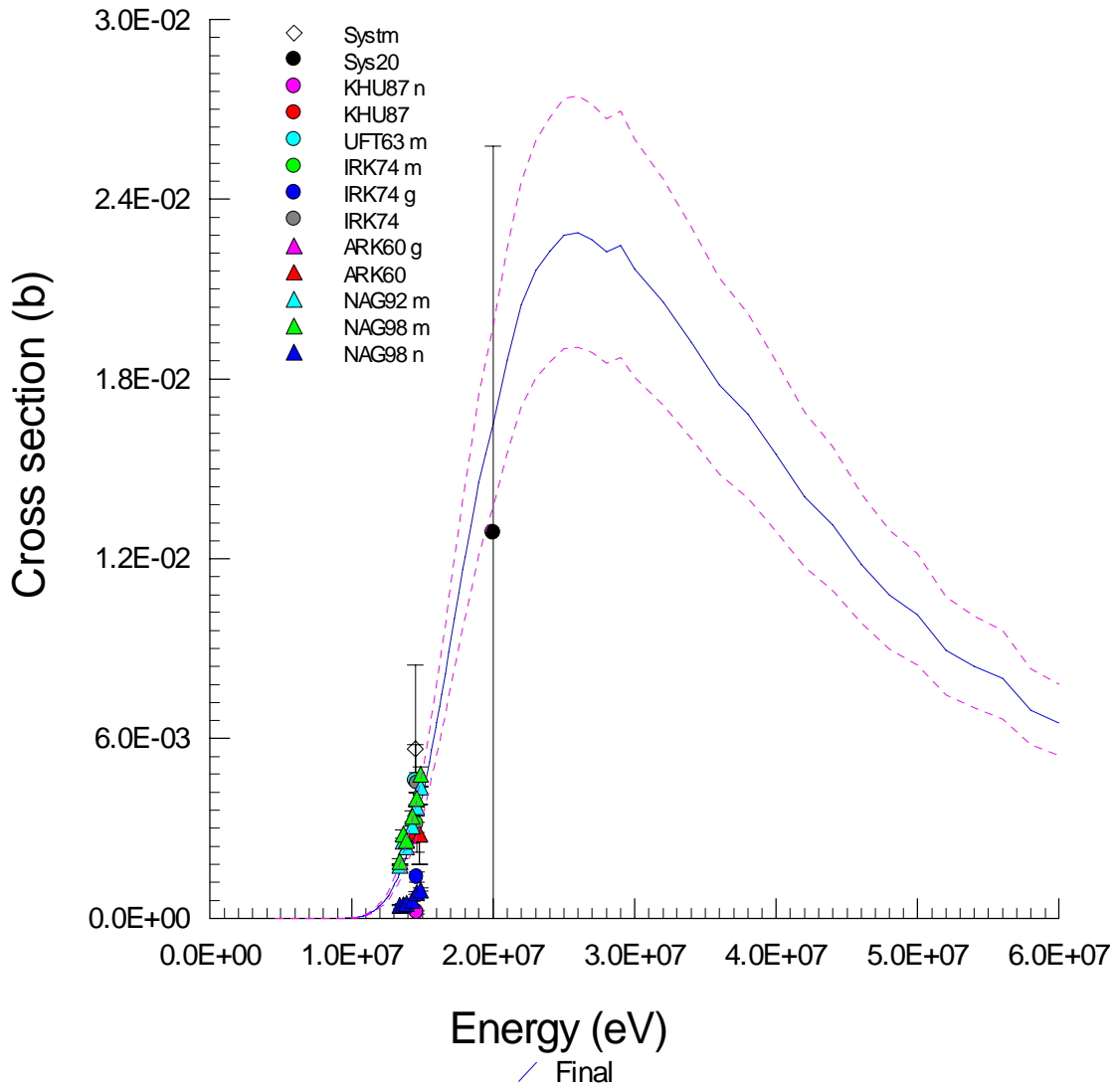


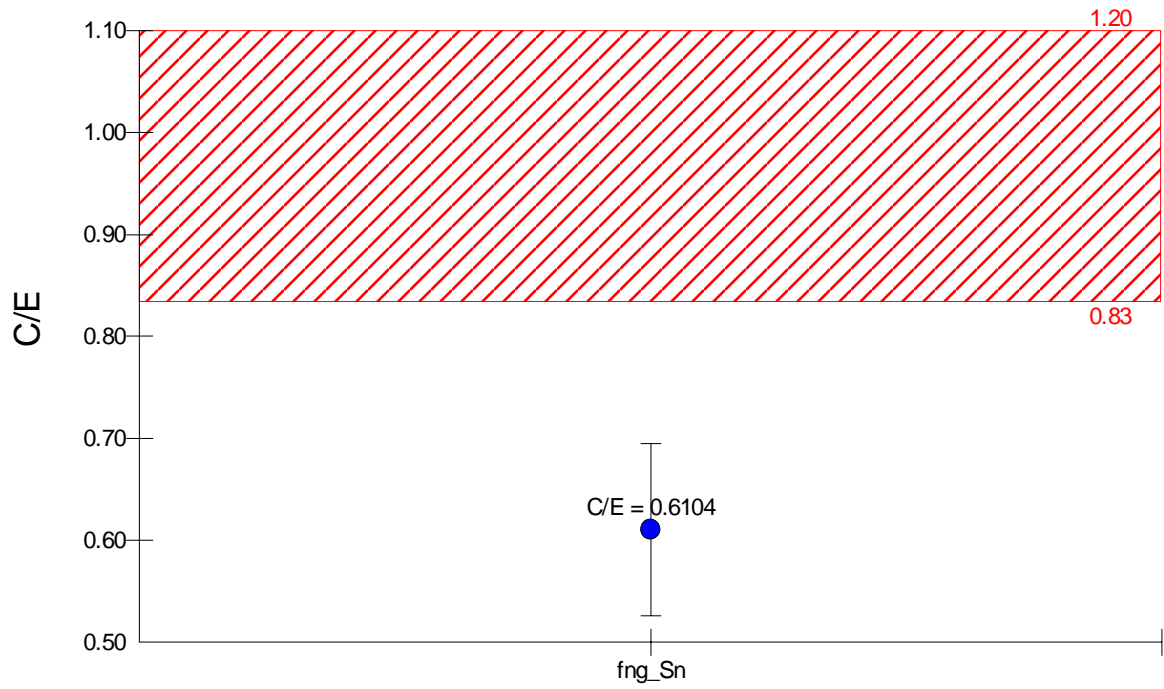
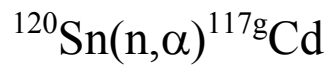


$^{120}\text{Sn}(n,p)^{120\text{m}}\text{In}$

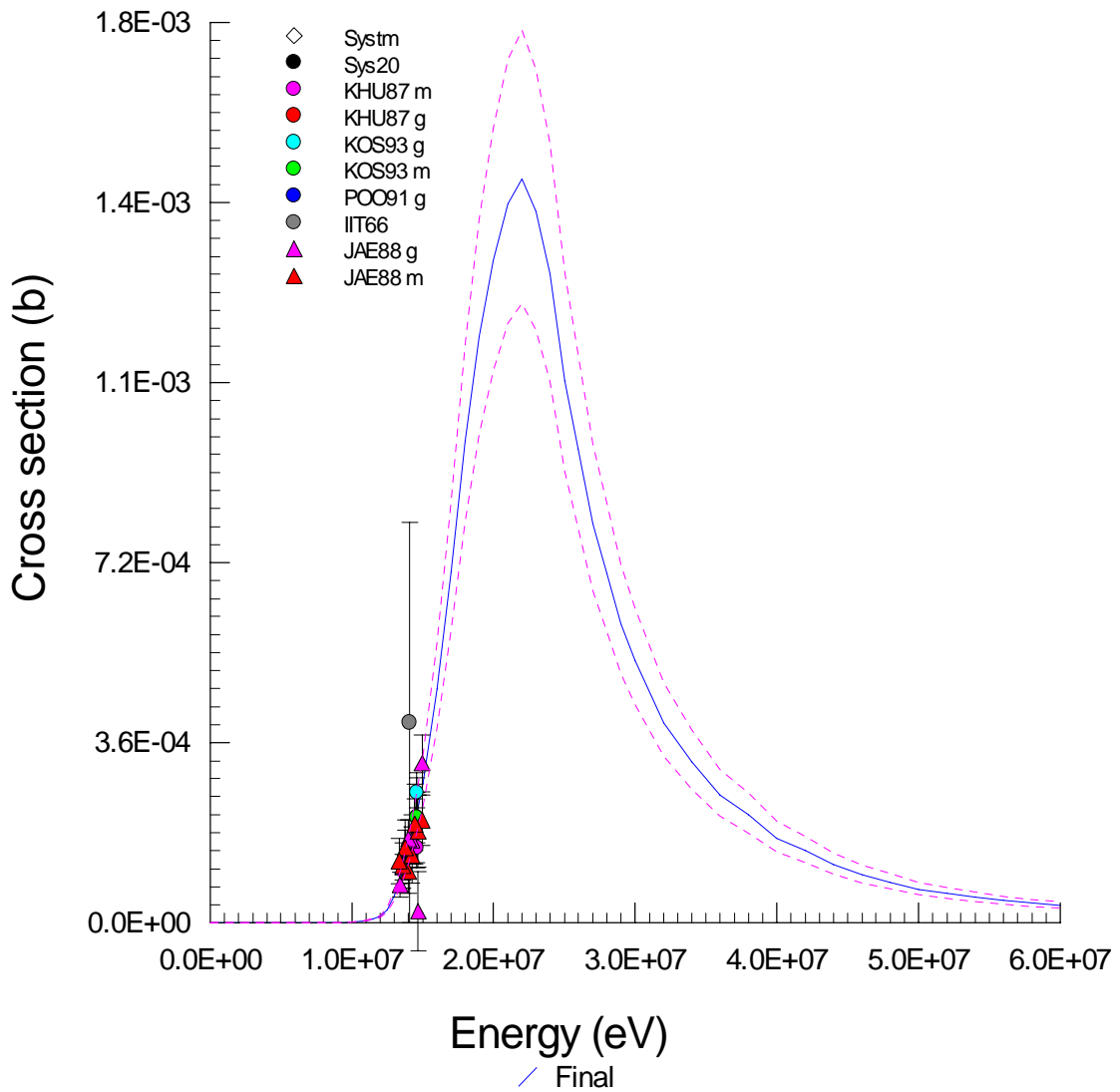


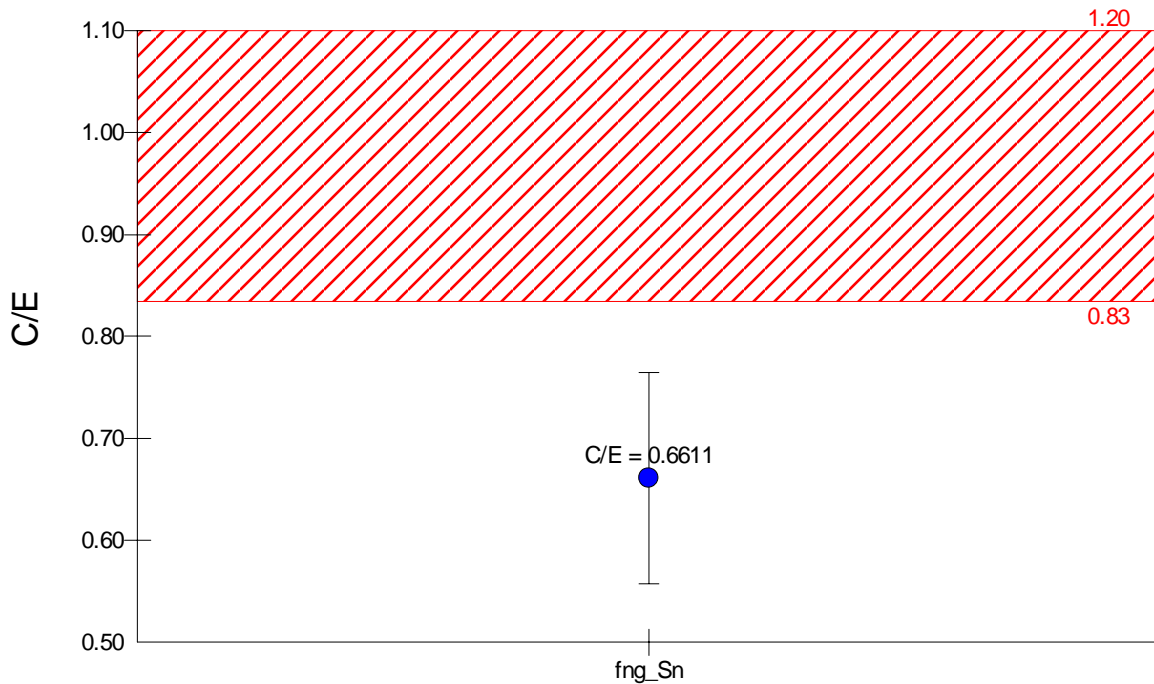
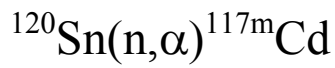
Neutron Spectrum



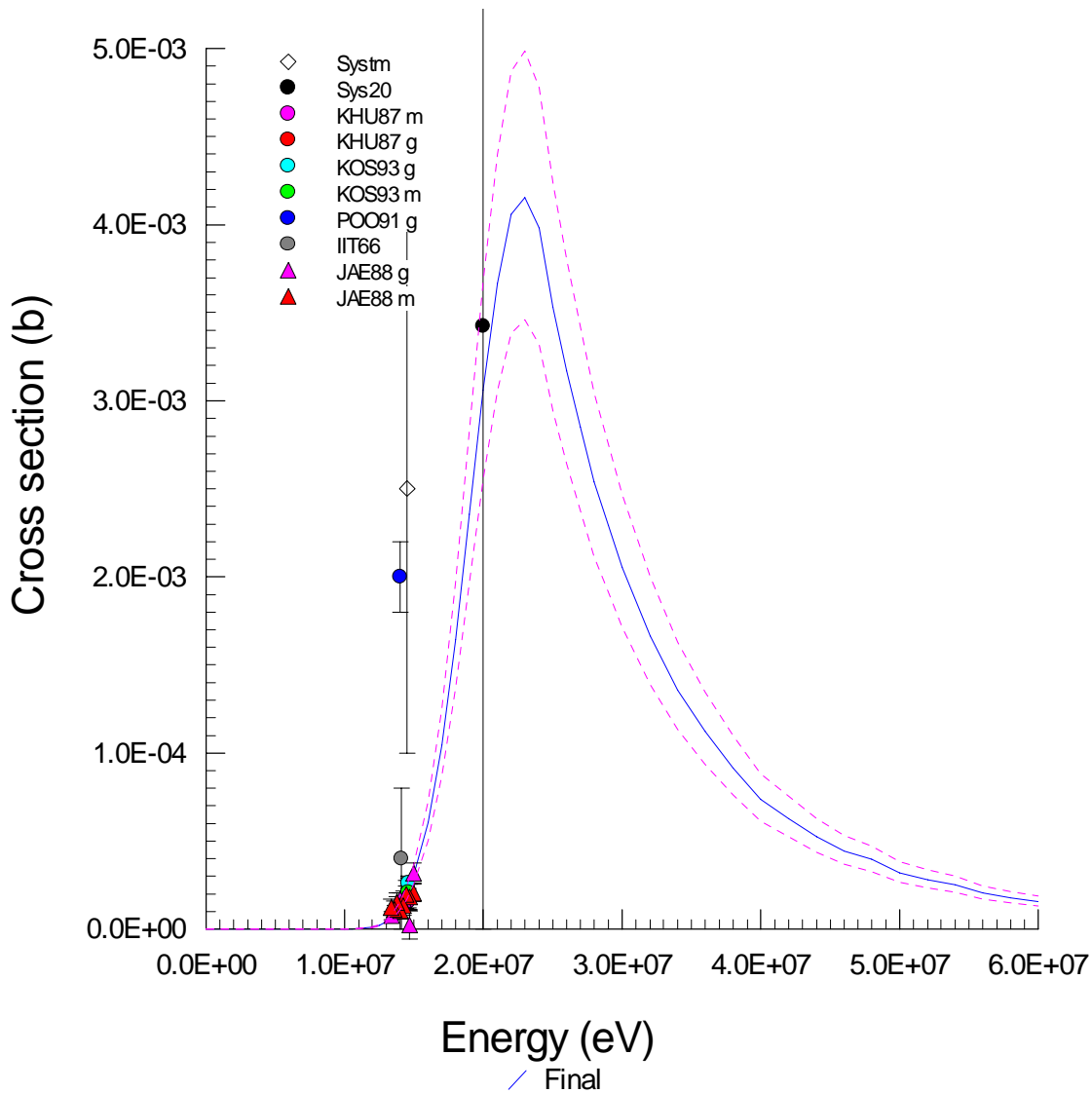


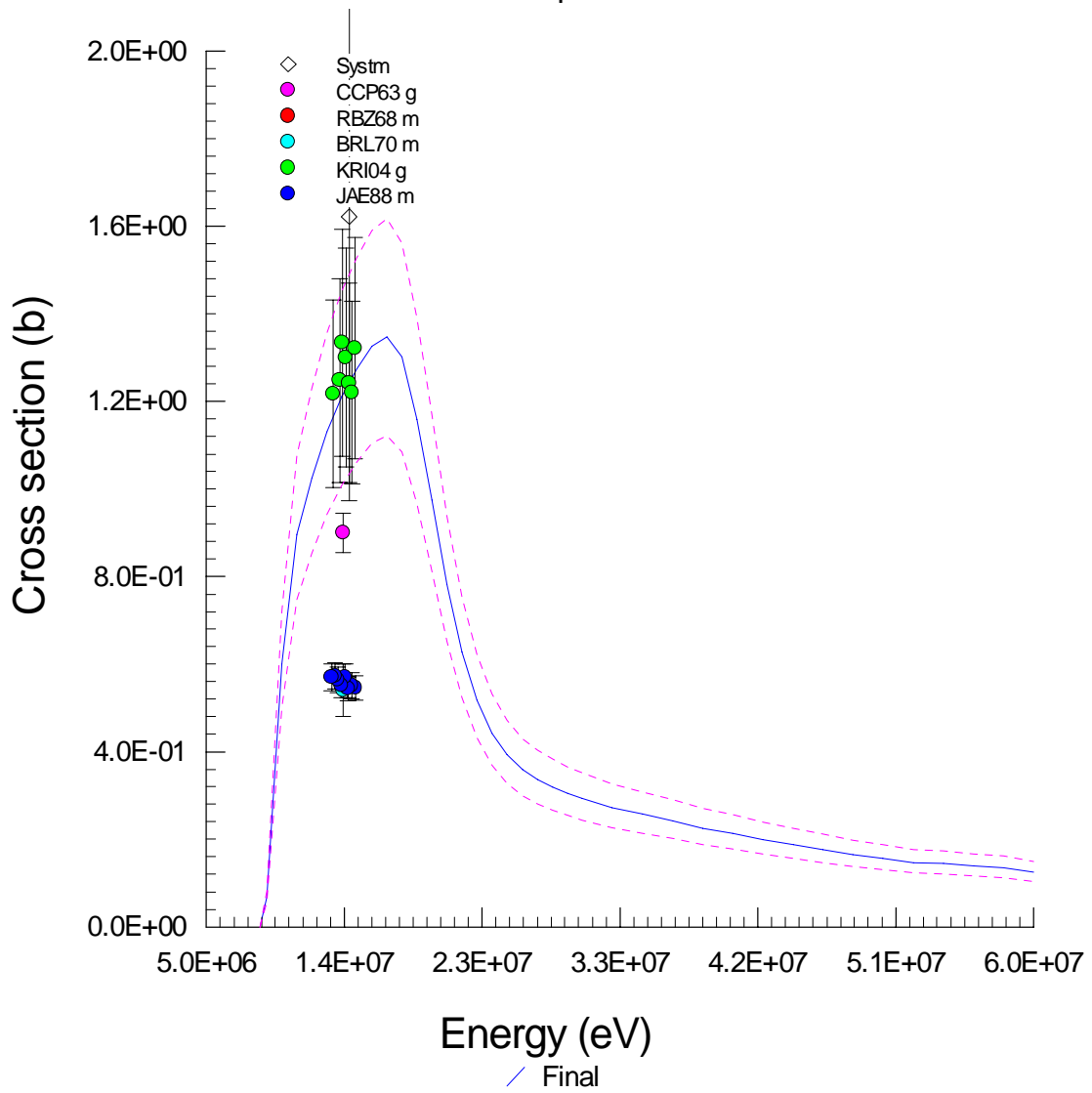
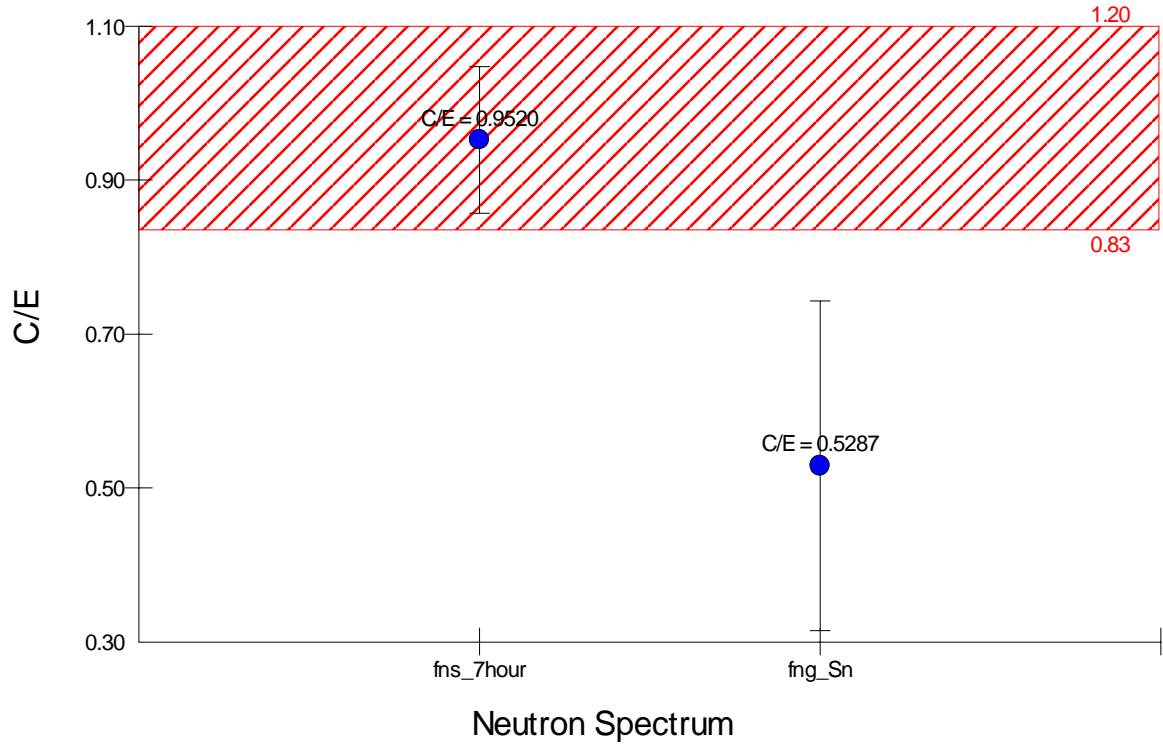
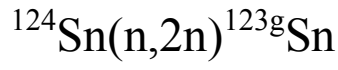
Neutron Spectrum

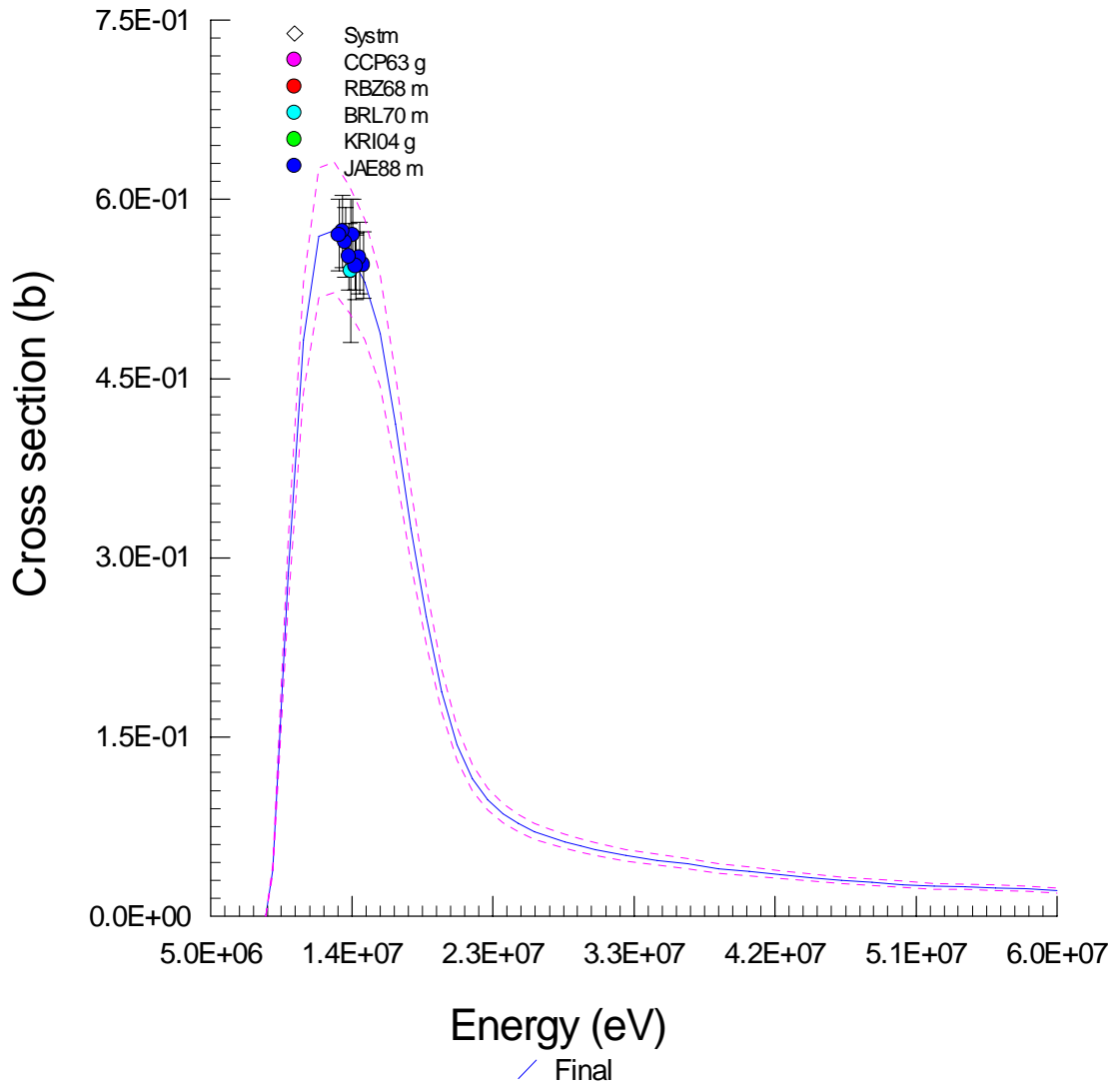
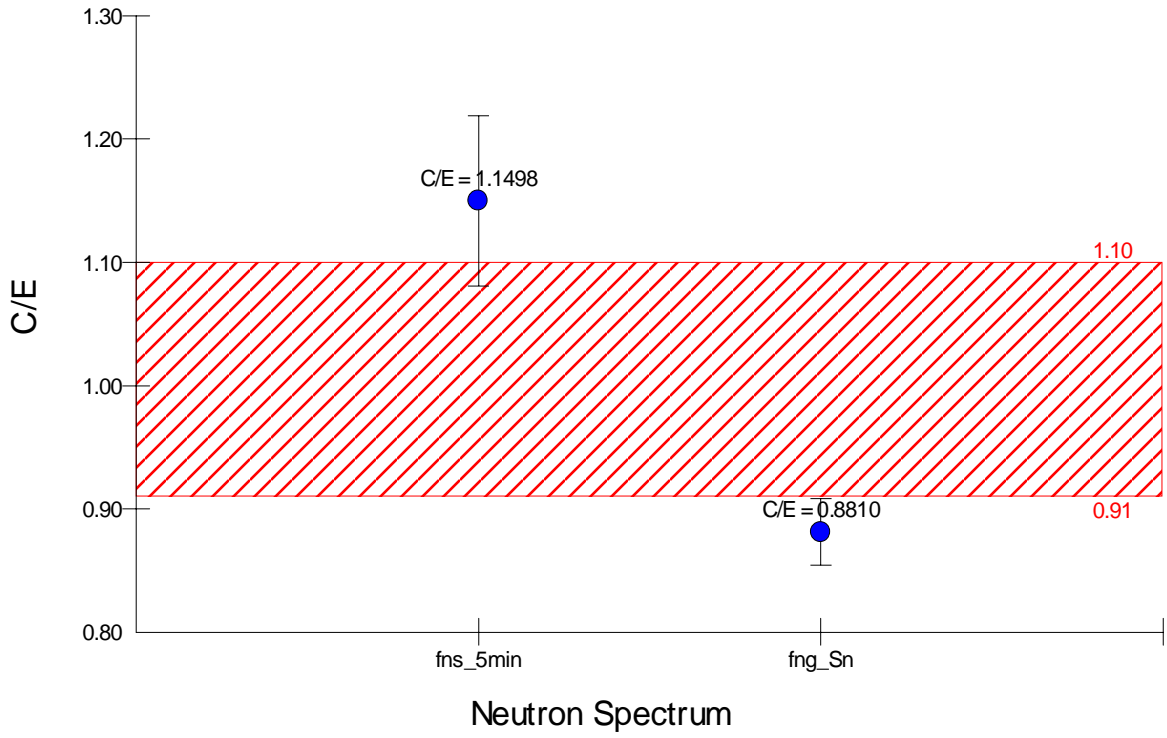
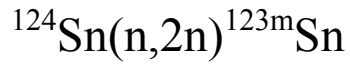




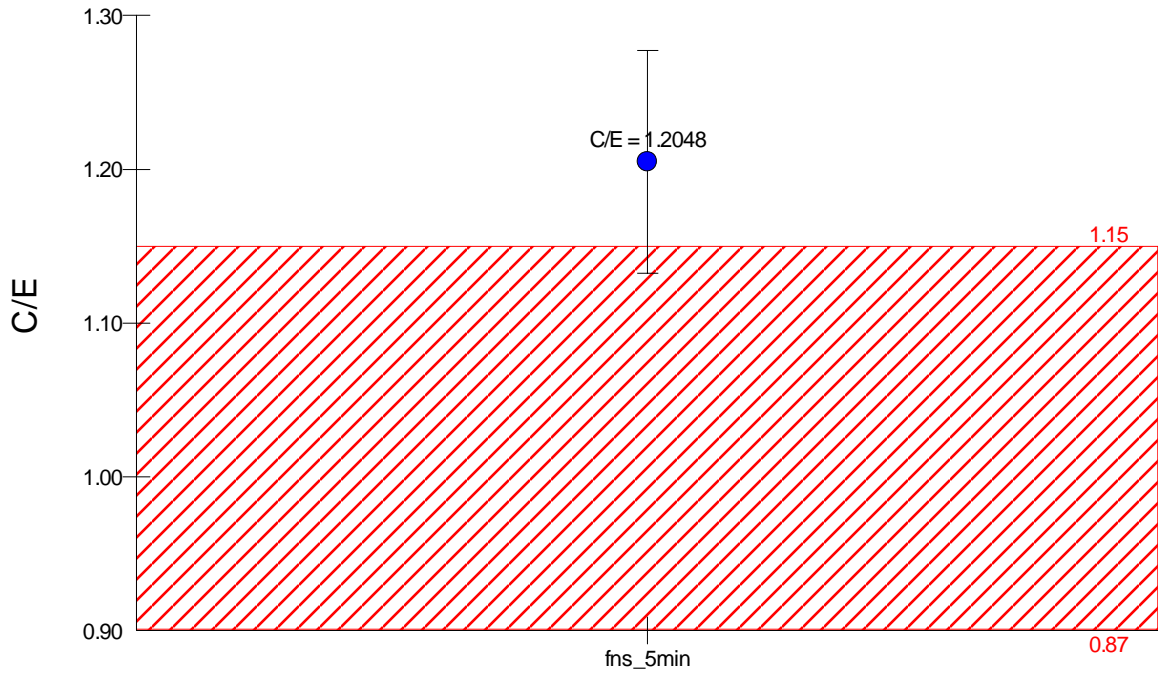
Neutron Spectrum



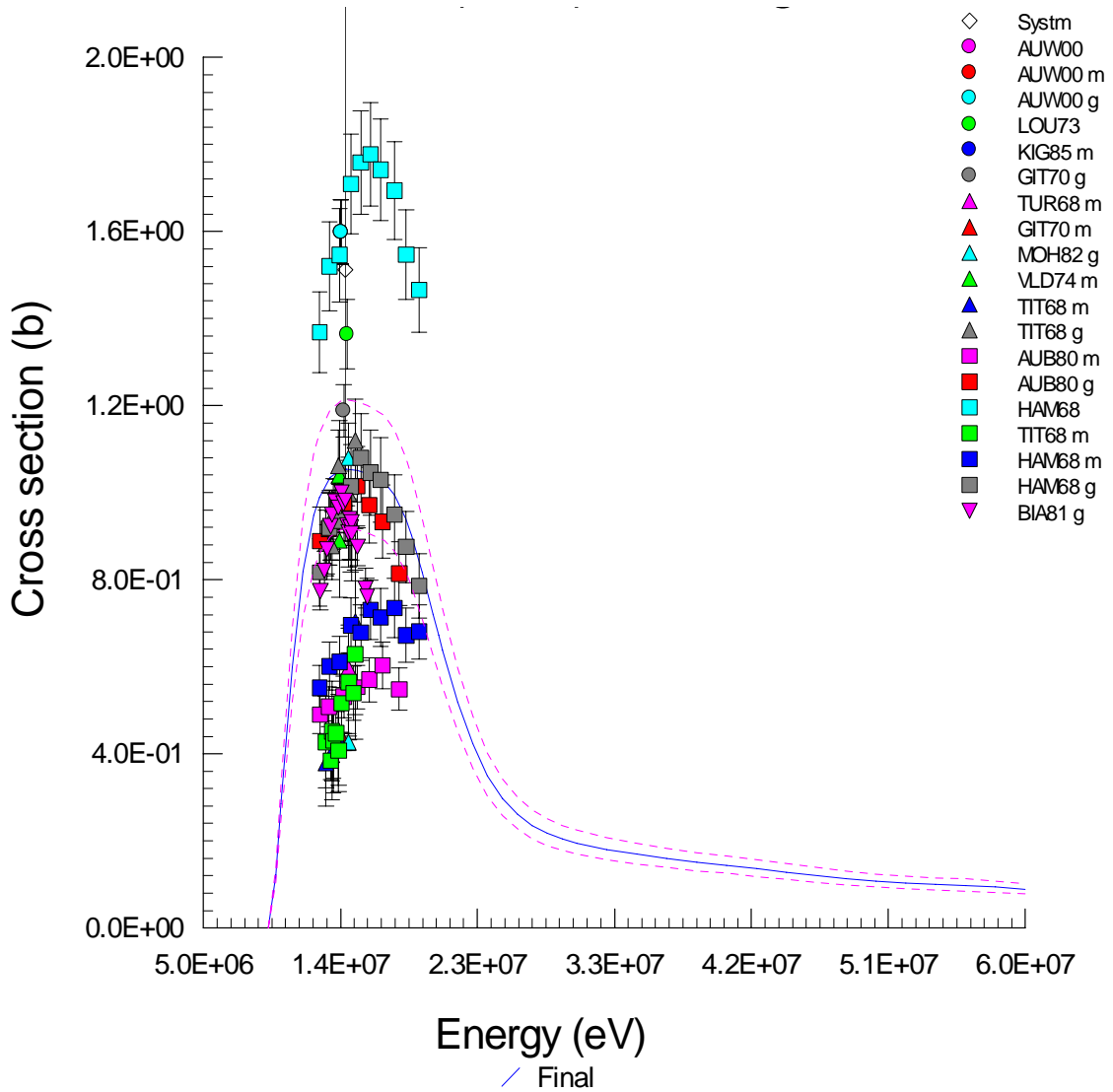


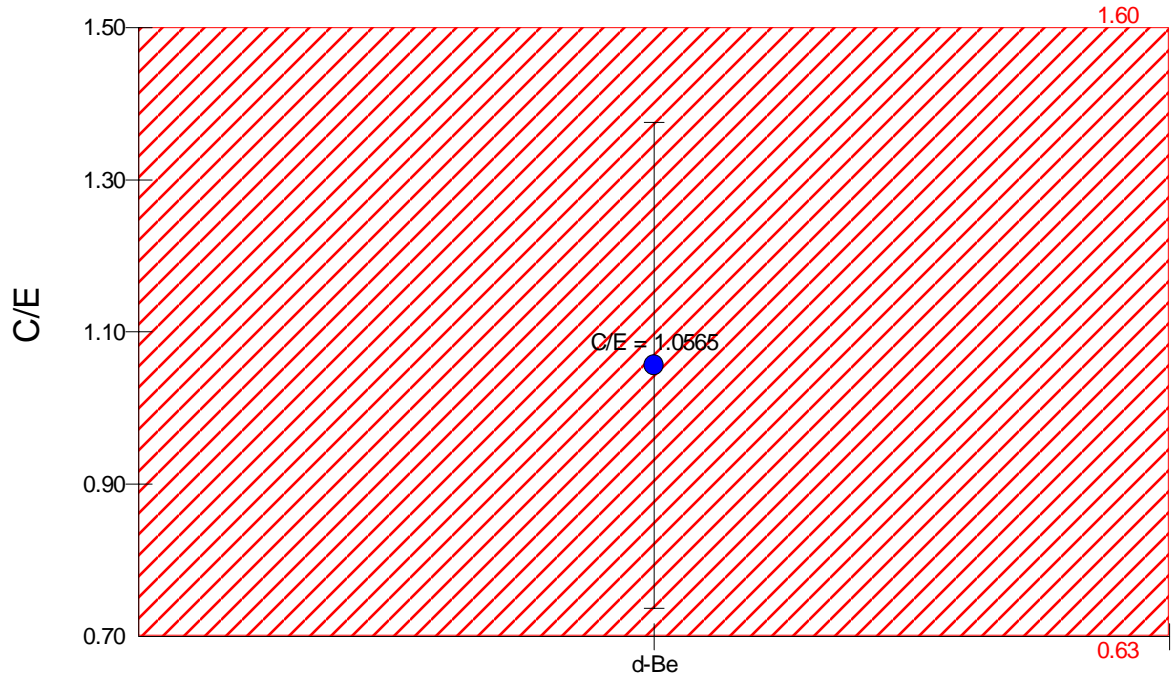
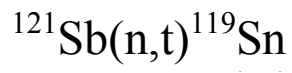


$^{121}\text{Sb}(n,2n)^{120g}\text{Sb}$

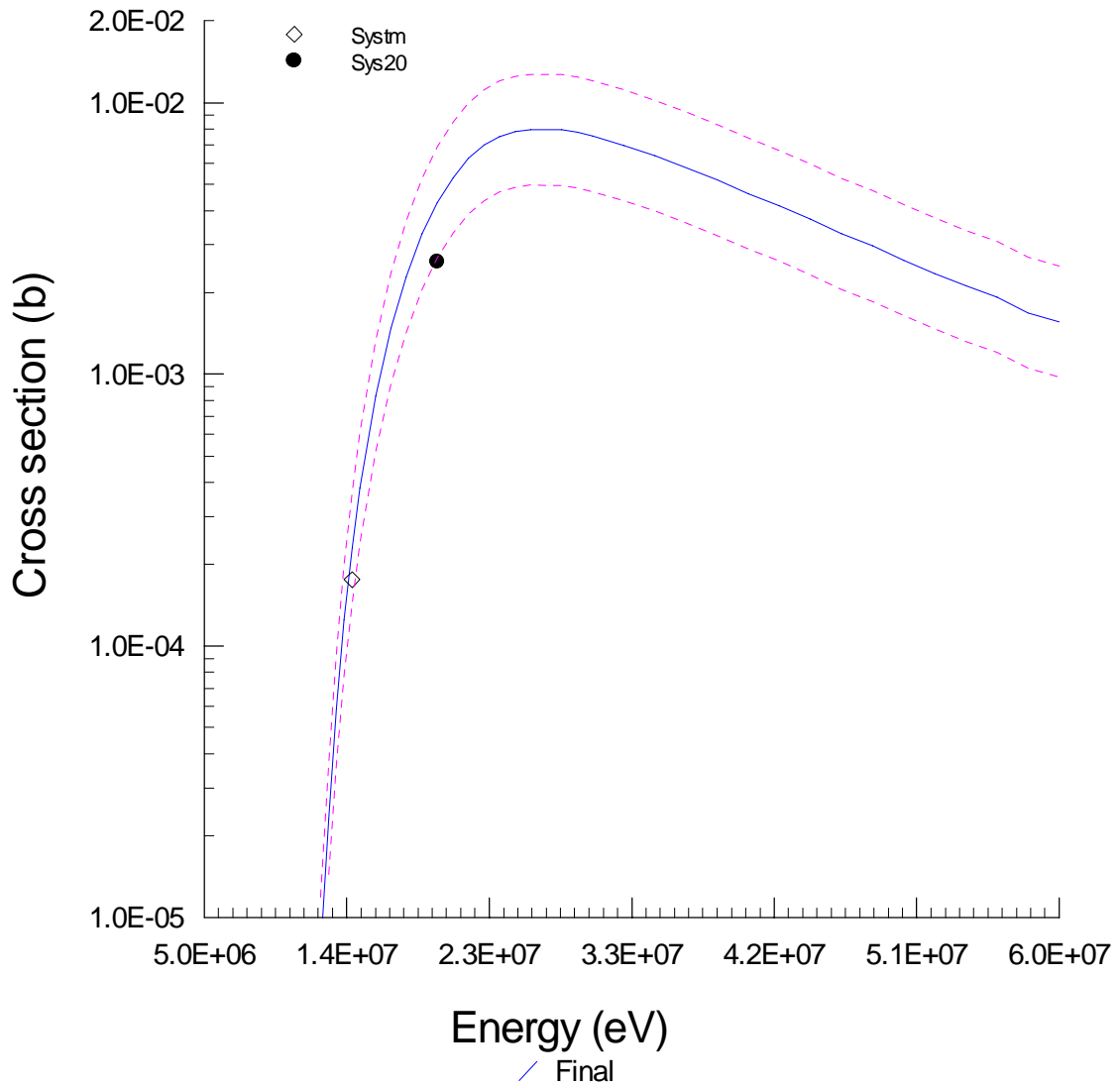


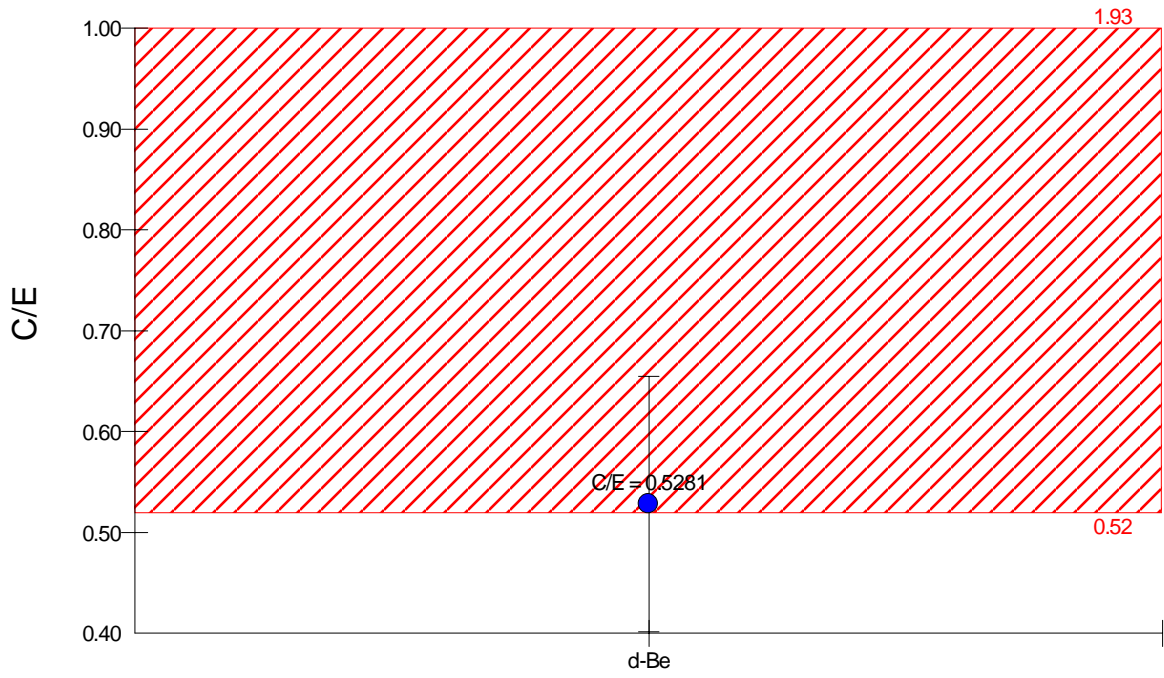
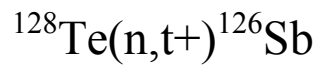
Neutron Spectrum



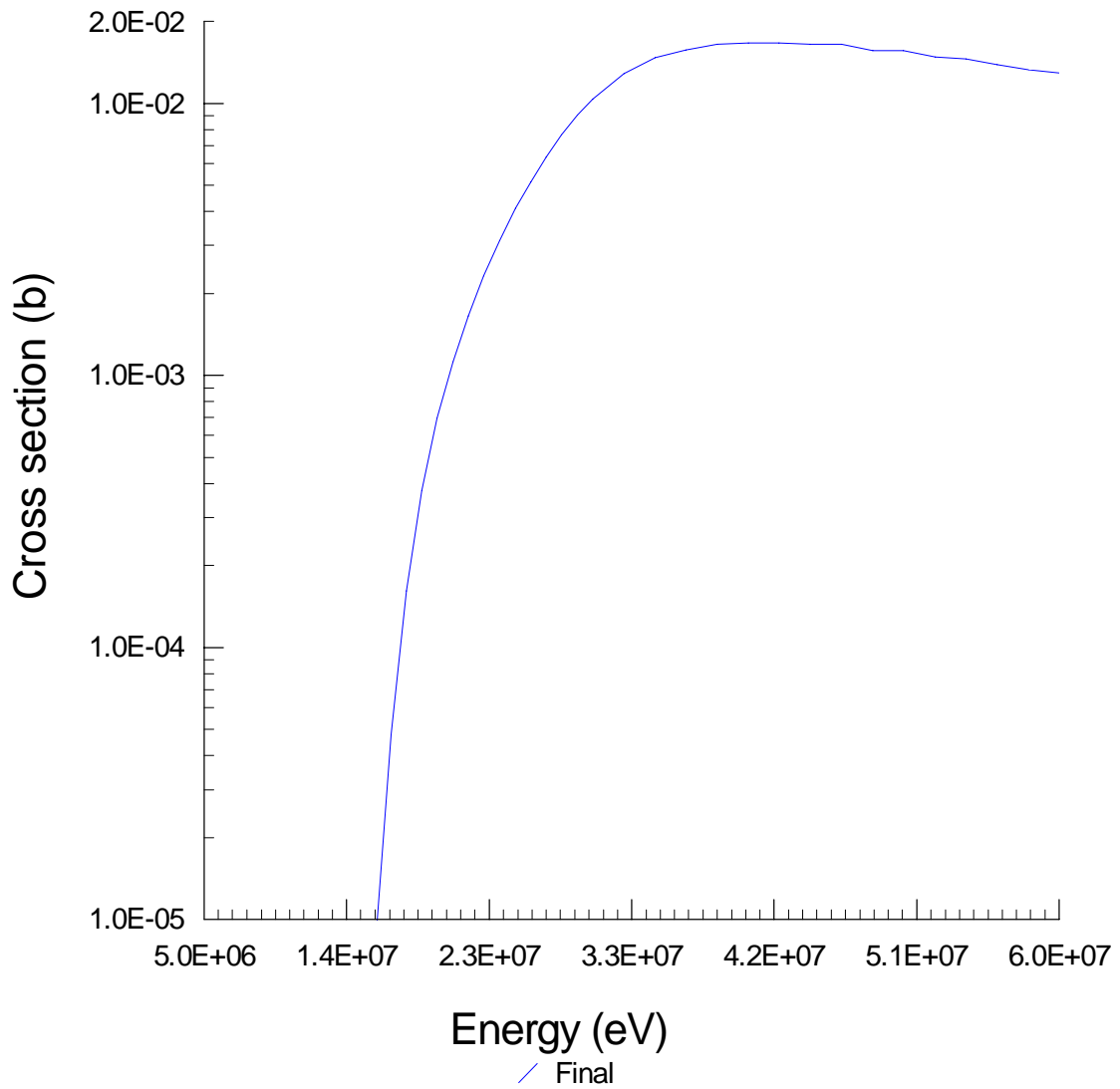


Neutron Spectrum



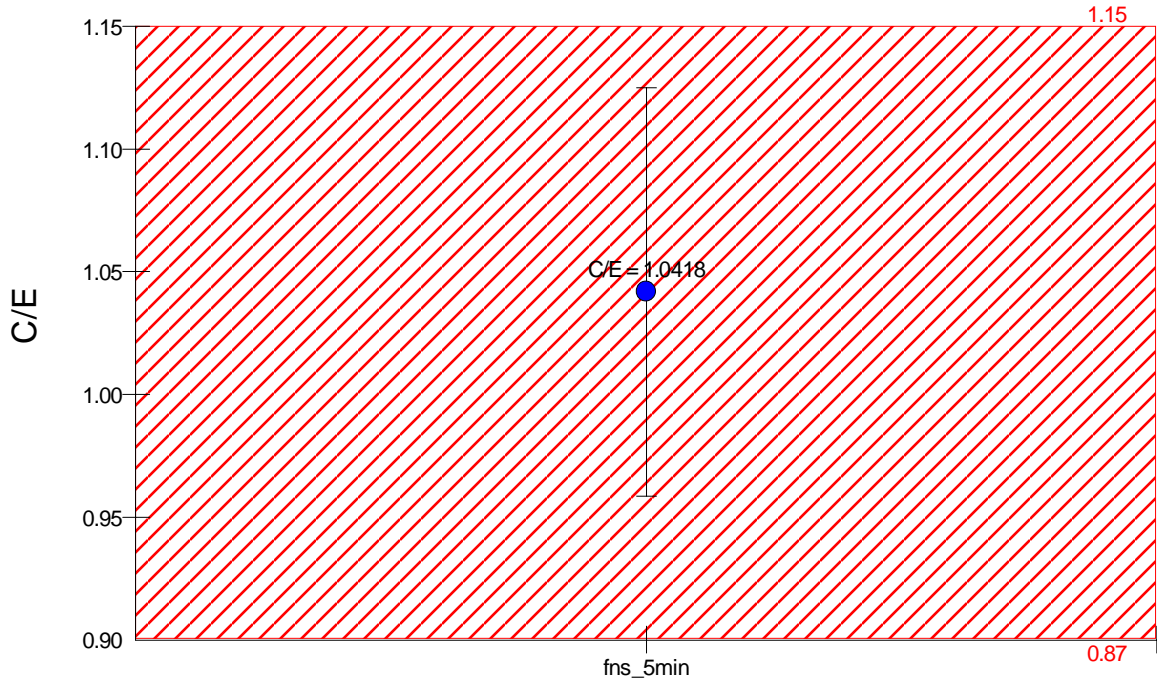


Neutron Spectrum

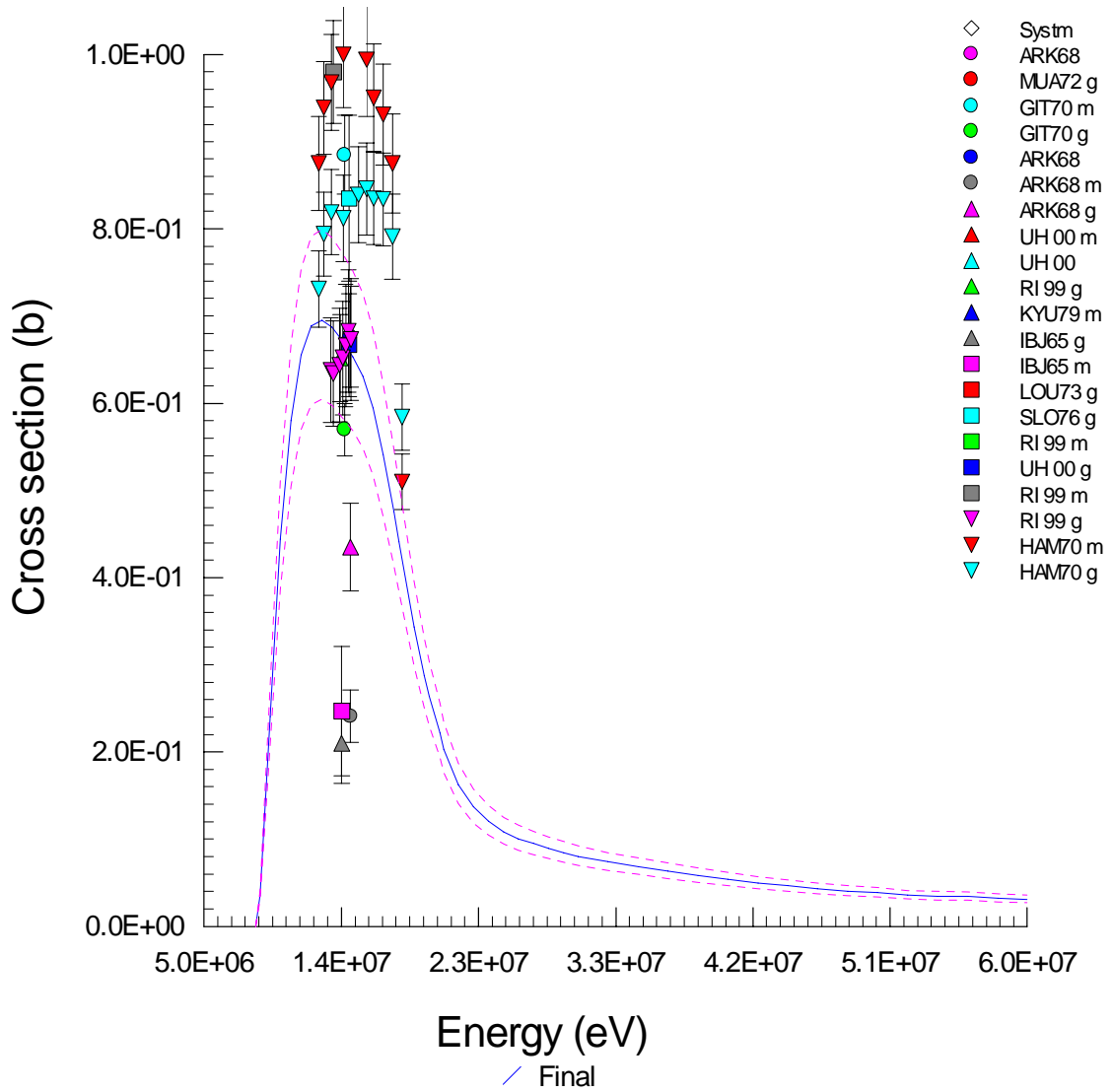




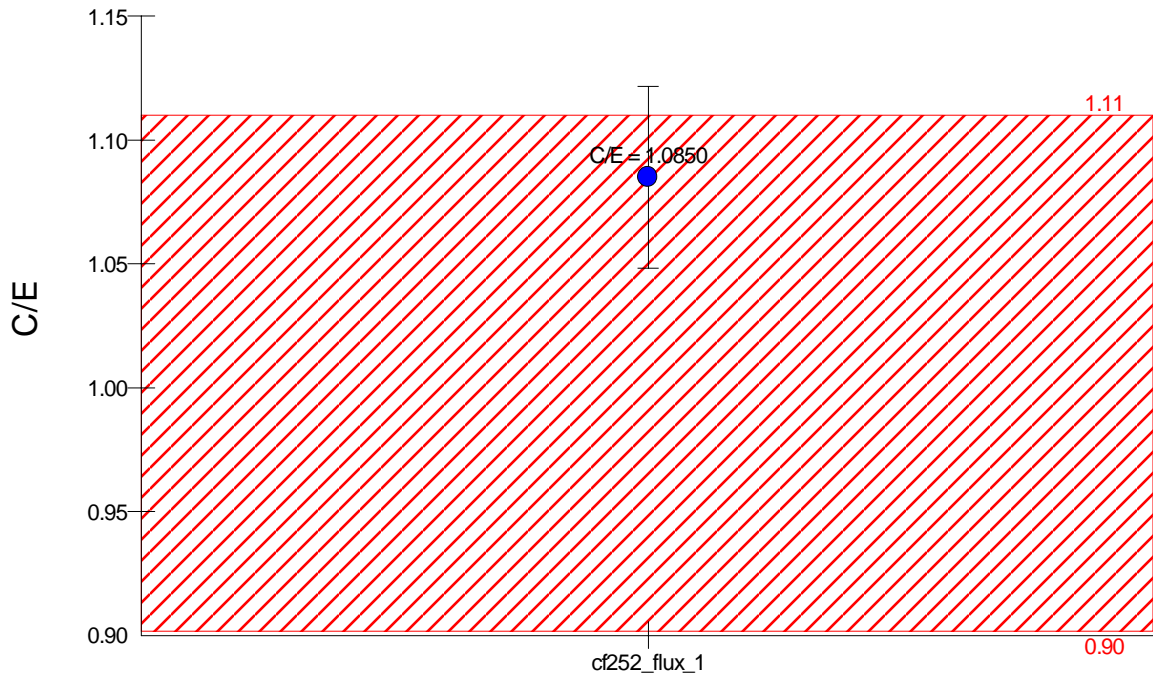
$^{130}\text{Te}(n,2n)^{129}\text{gTe}$



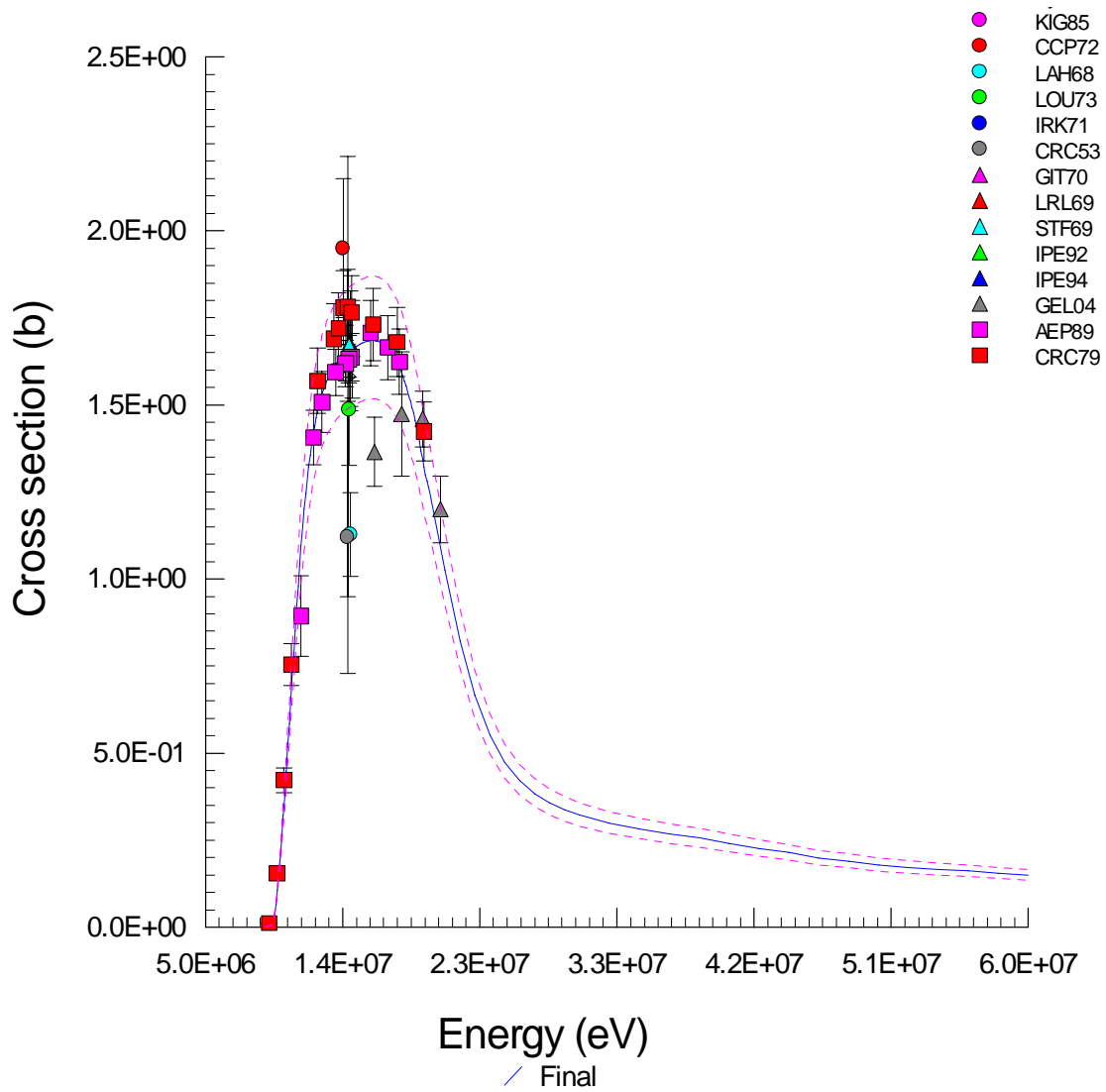
Neutron Spectrum

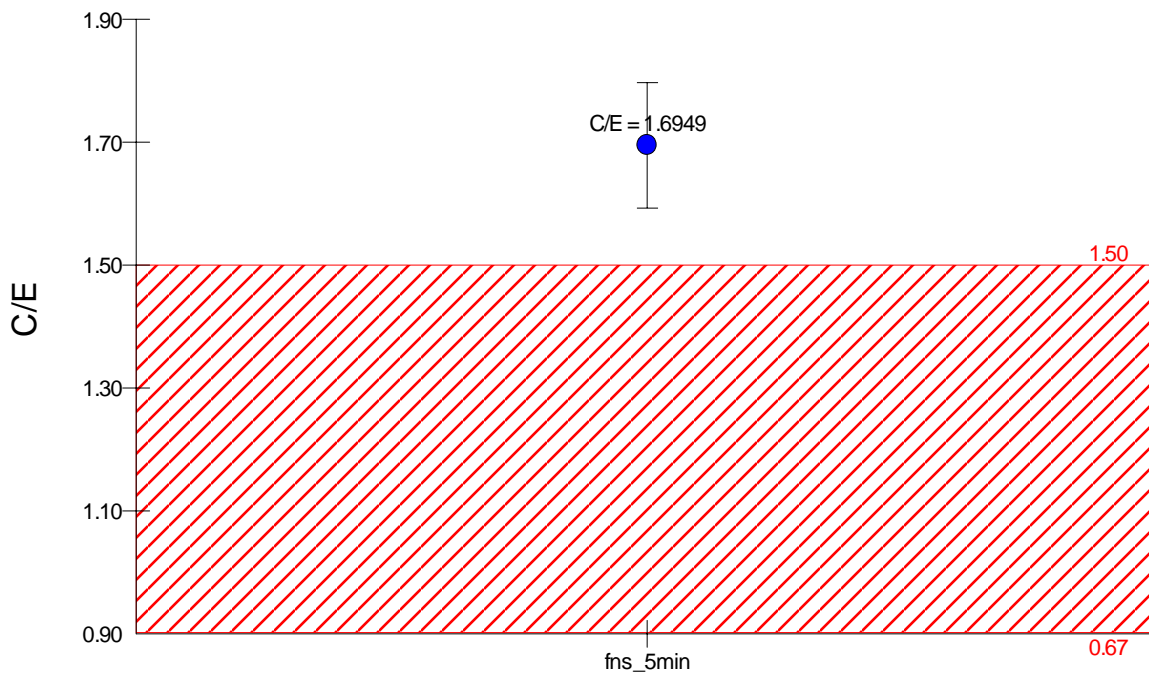
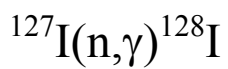


$^{127}\text{I}(n,2n)^{126}\text{I}$

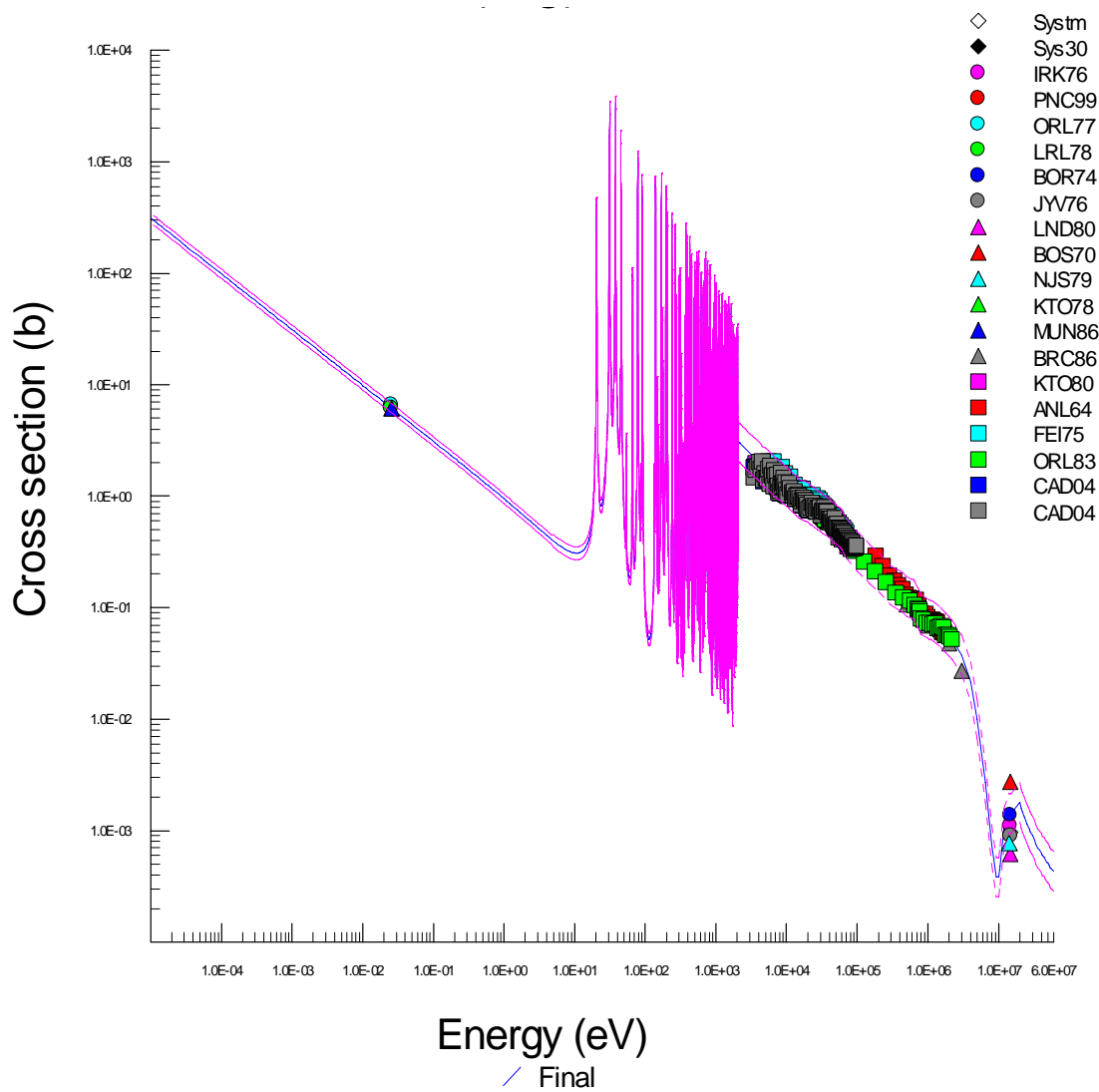


Neutron Spectrum

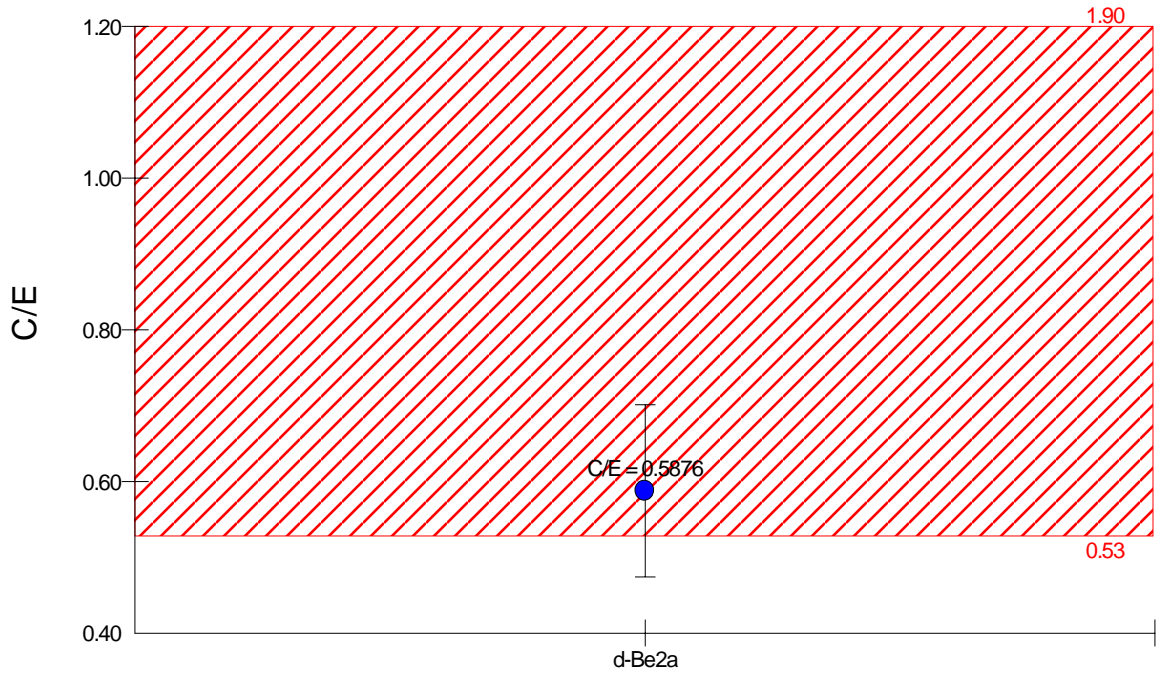




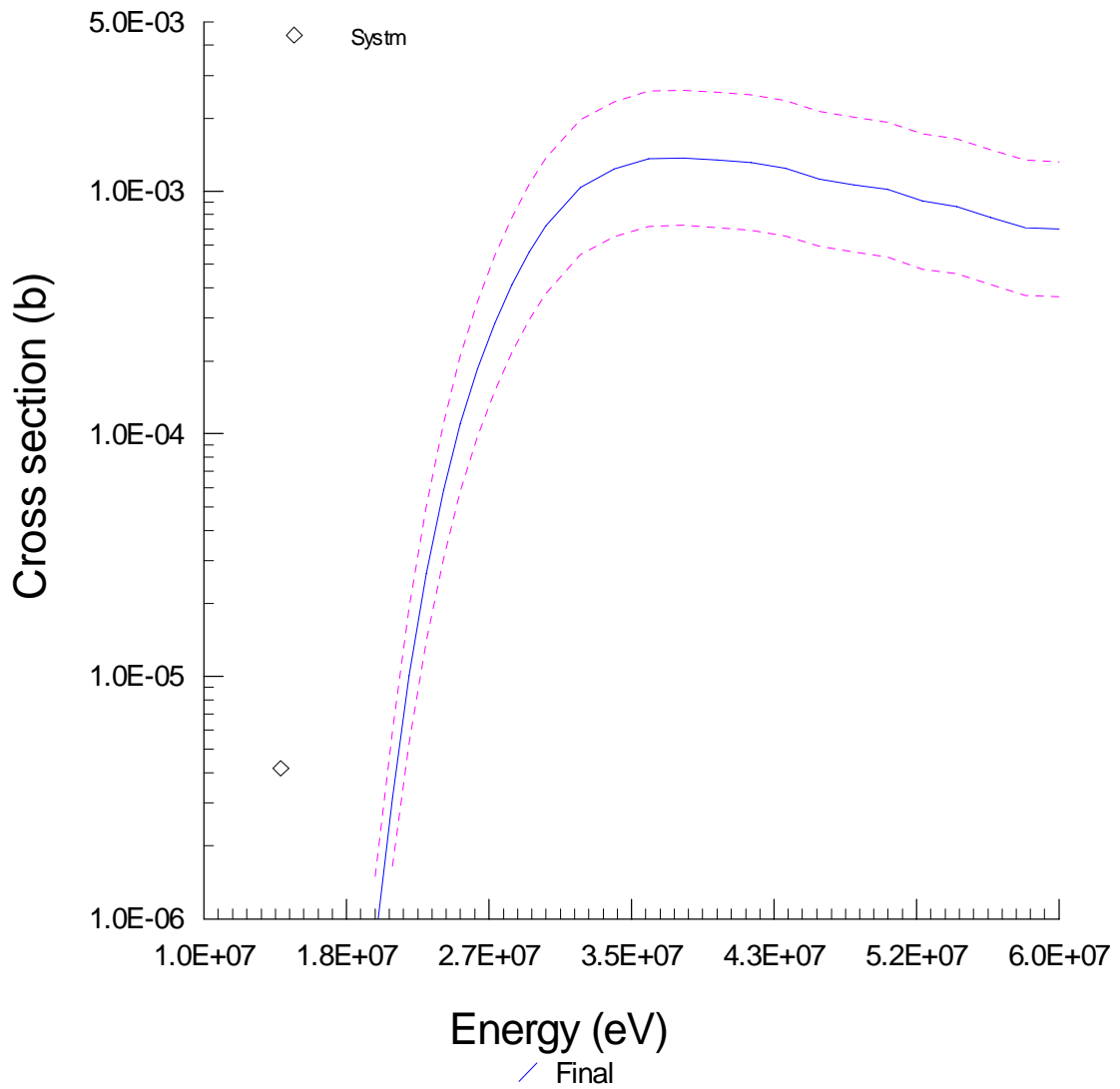
Neutron Spectrum

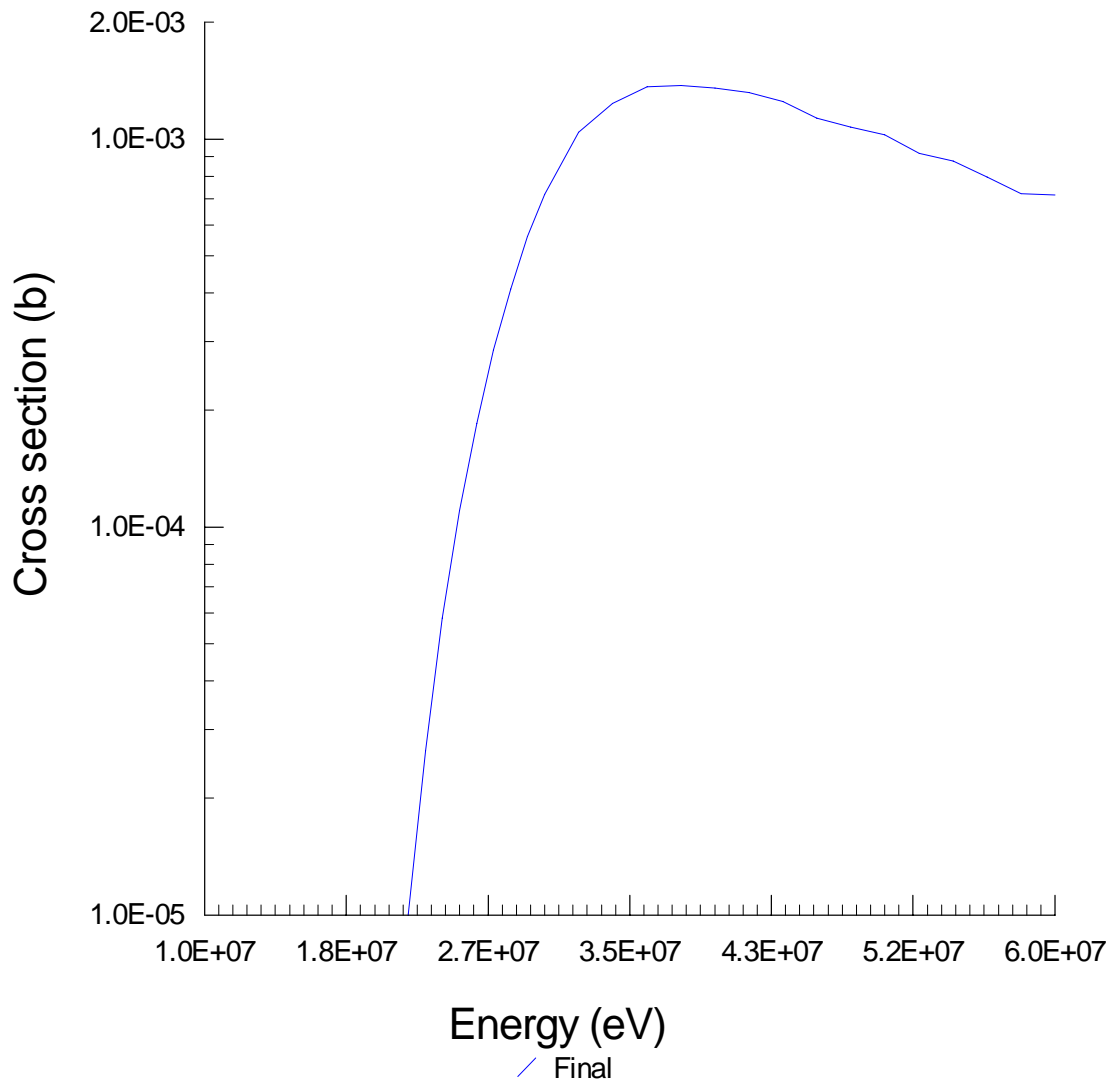
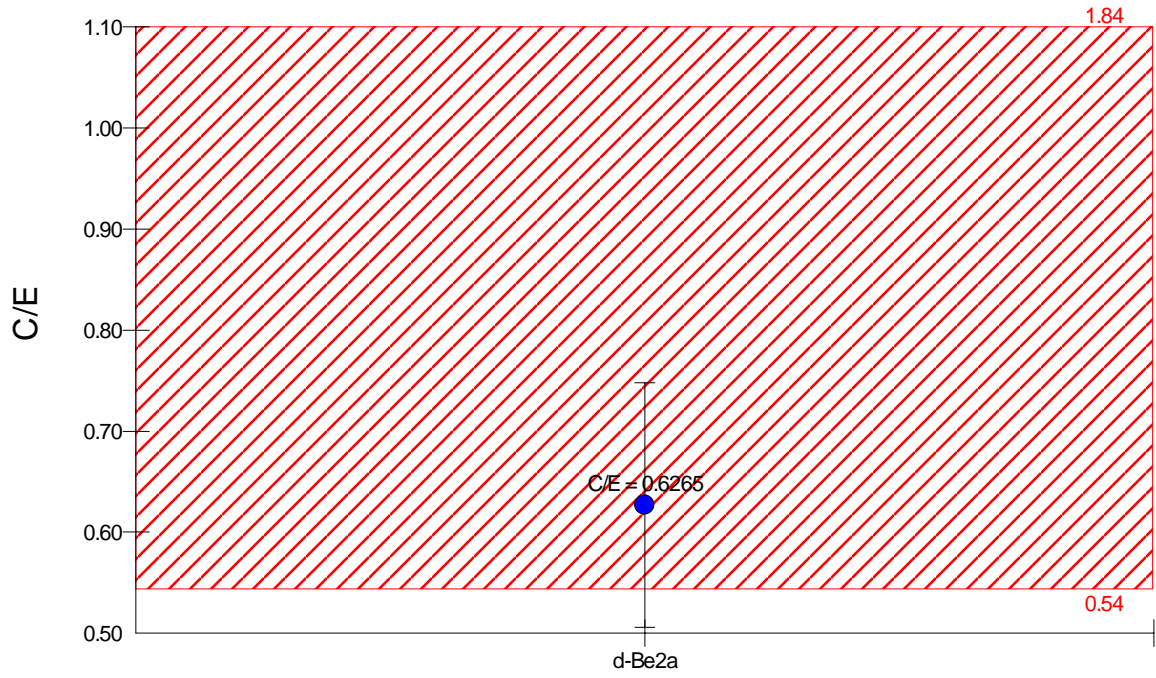
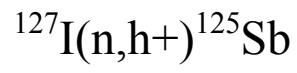


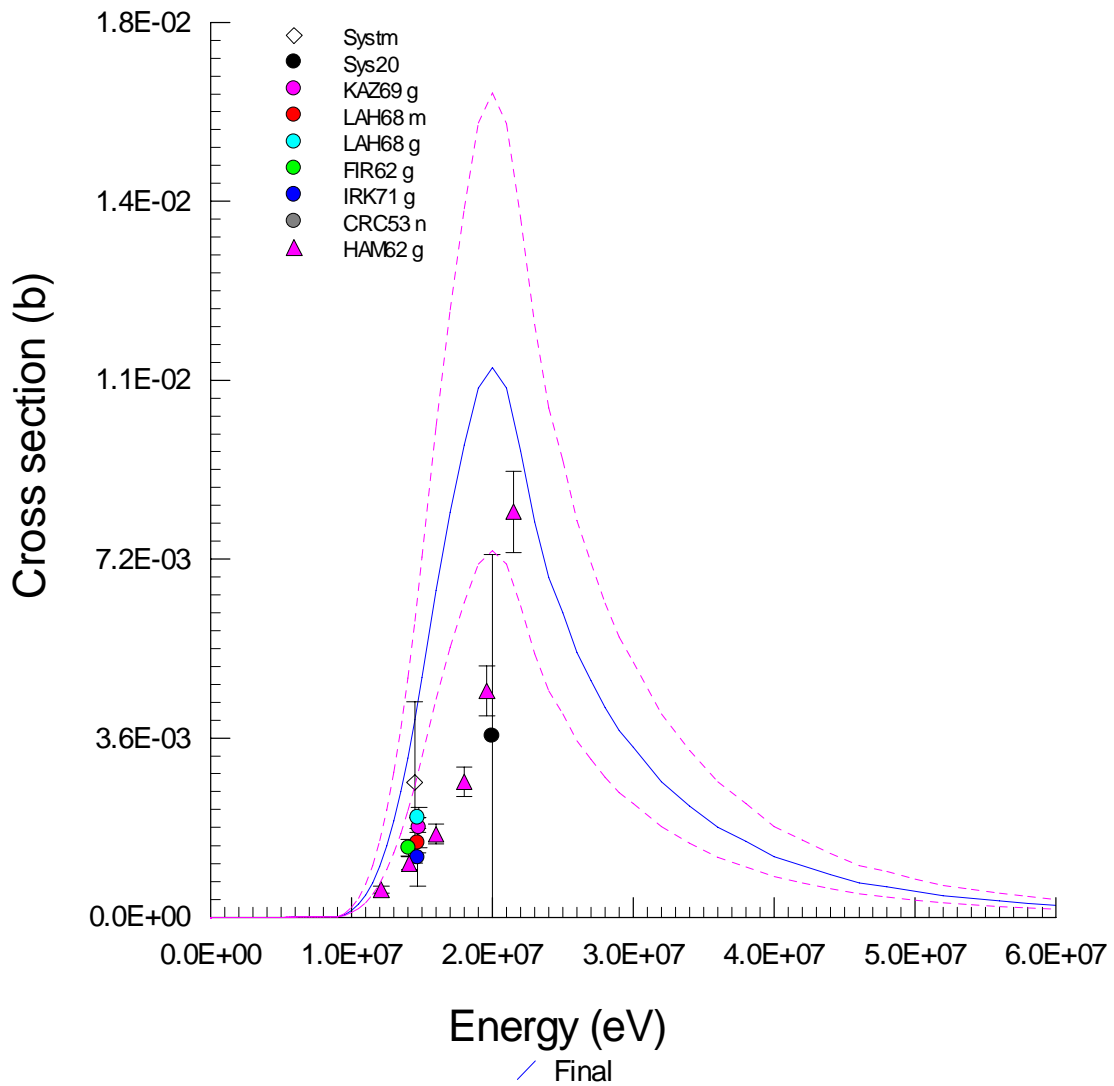
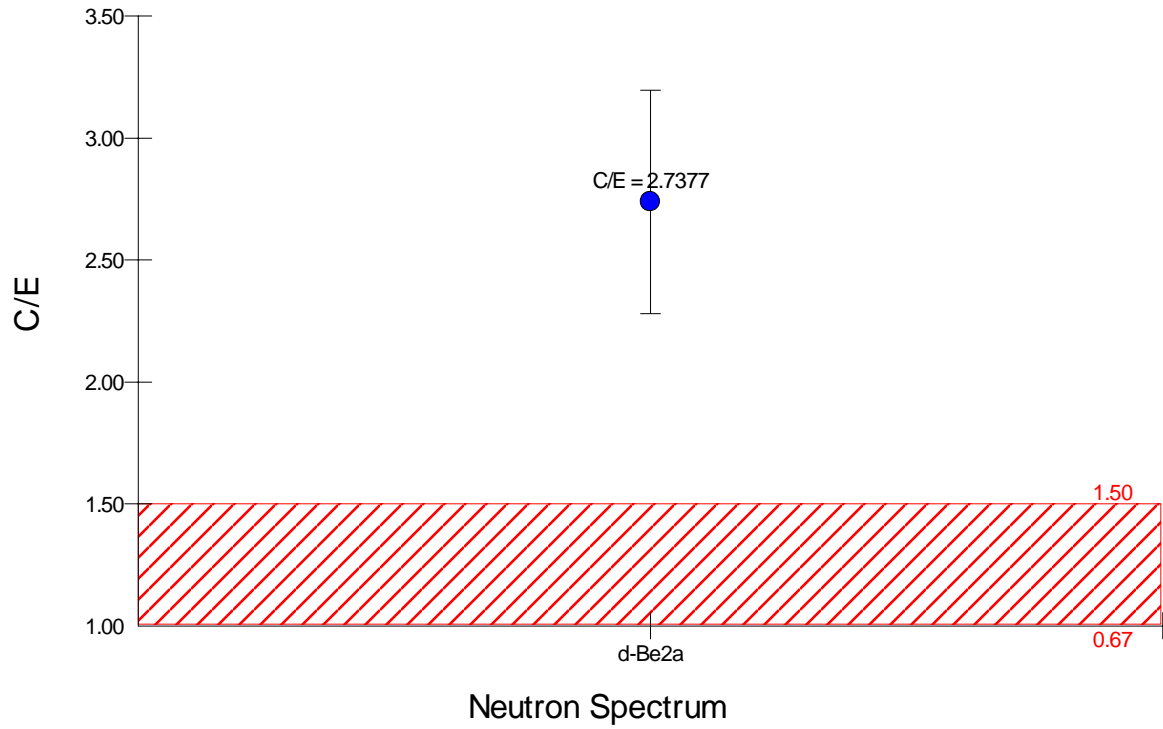
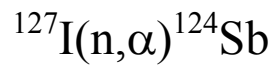
# $^{127}\text{I}(n,h)^{125}\text{Sb}$

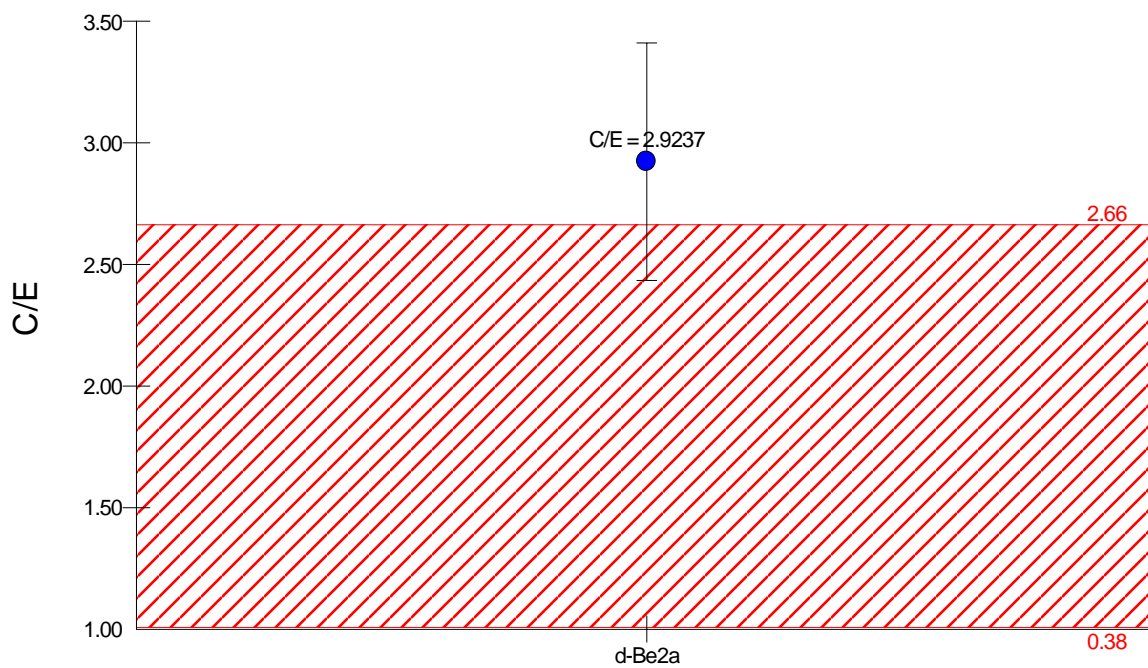
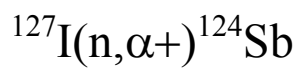


Neutron Spectrum

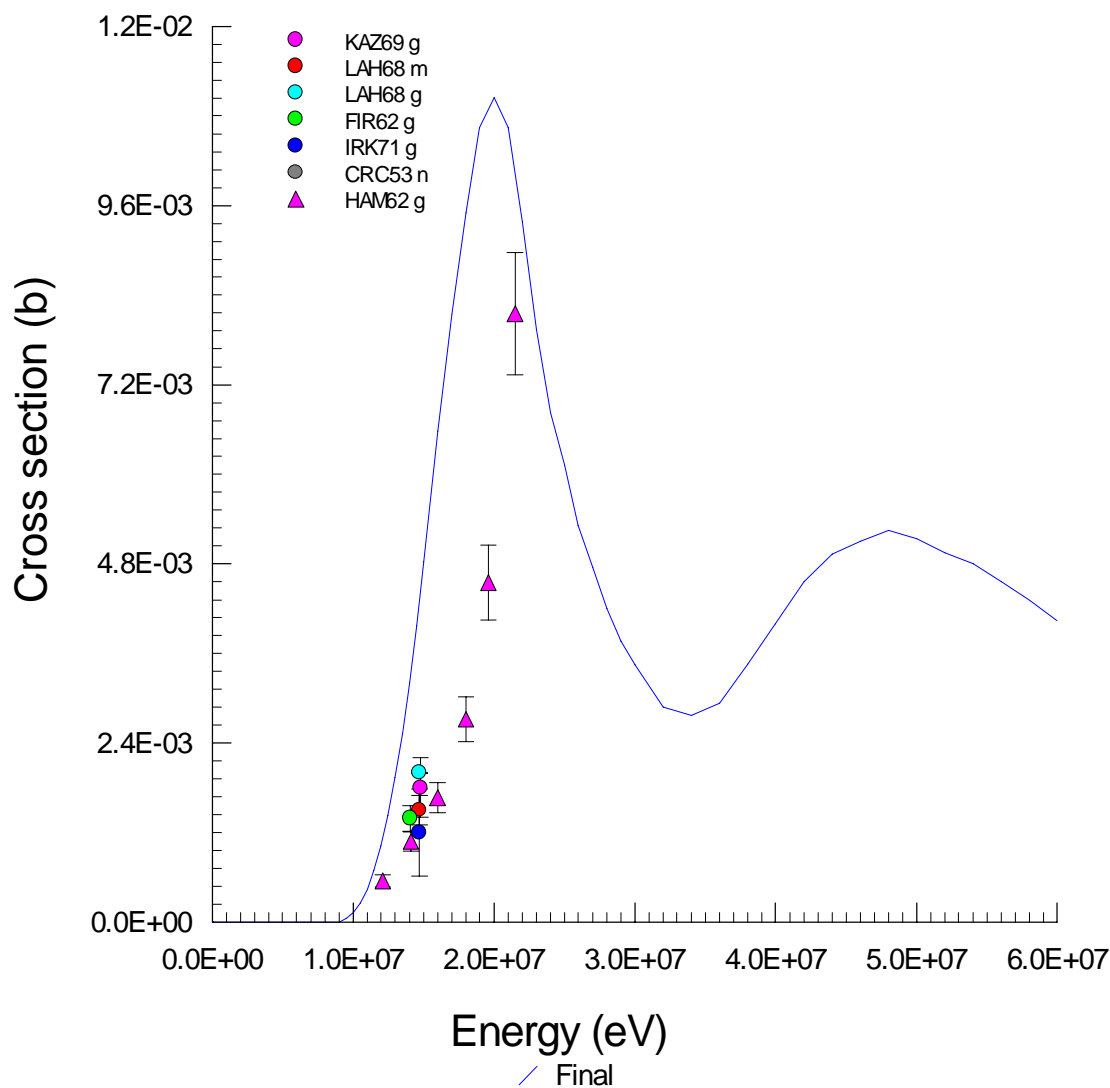


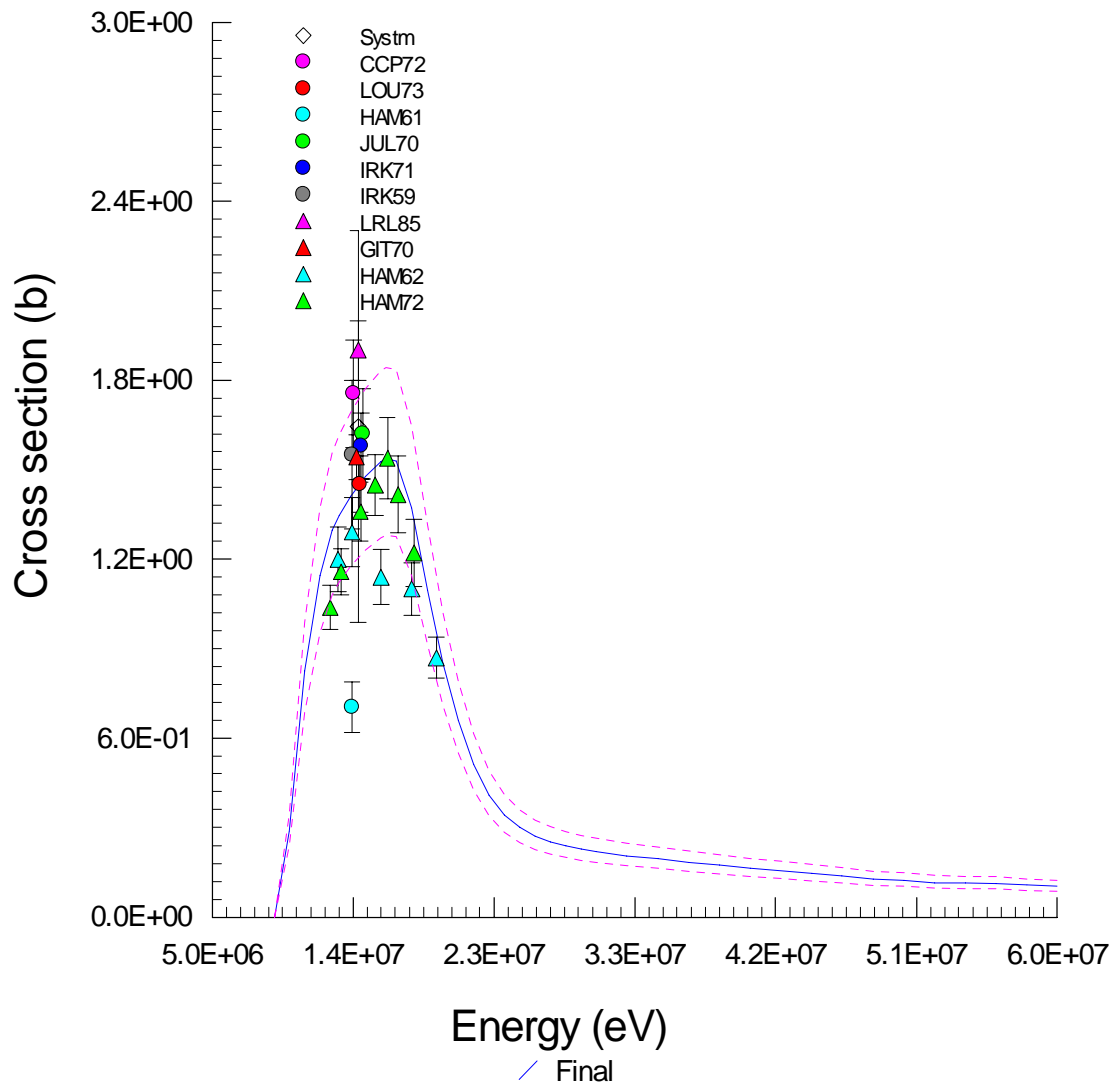
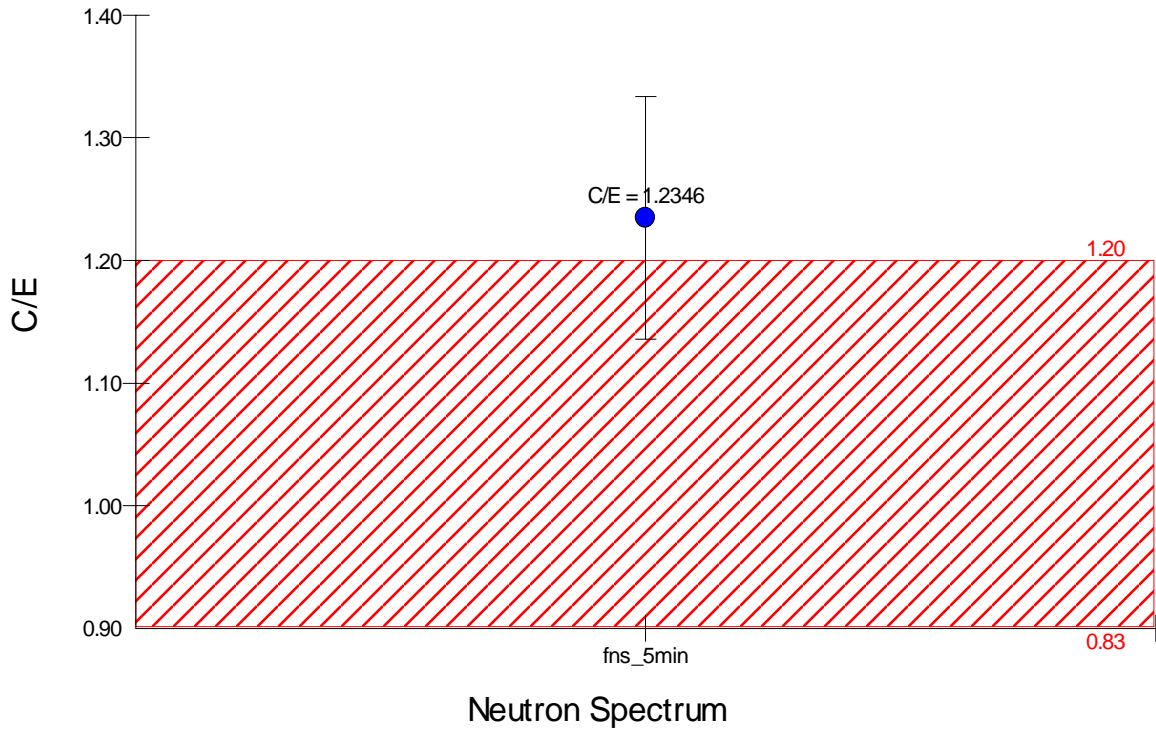
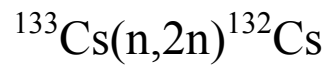






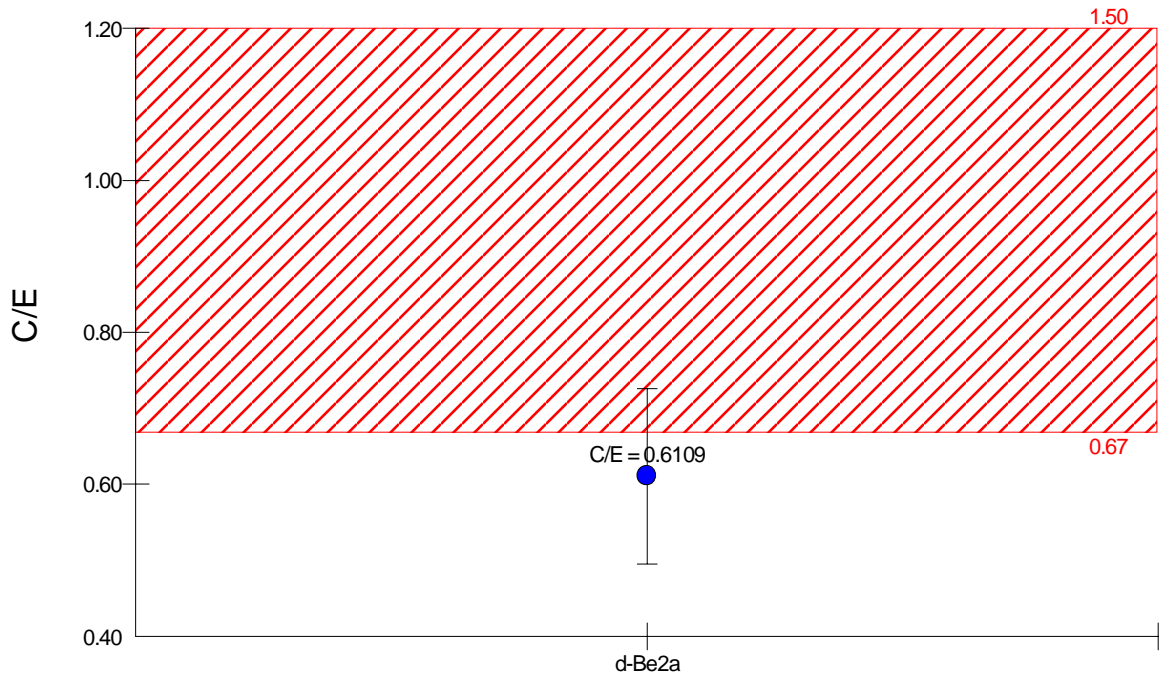
Neutron Spectrum



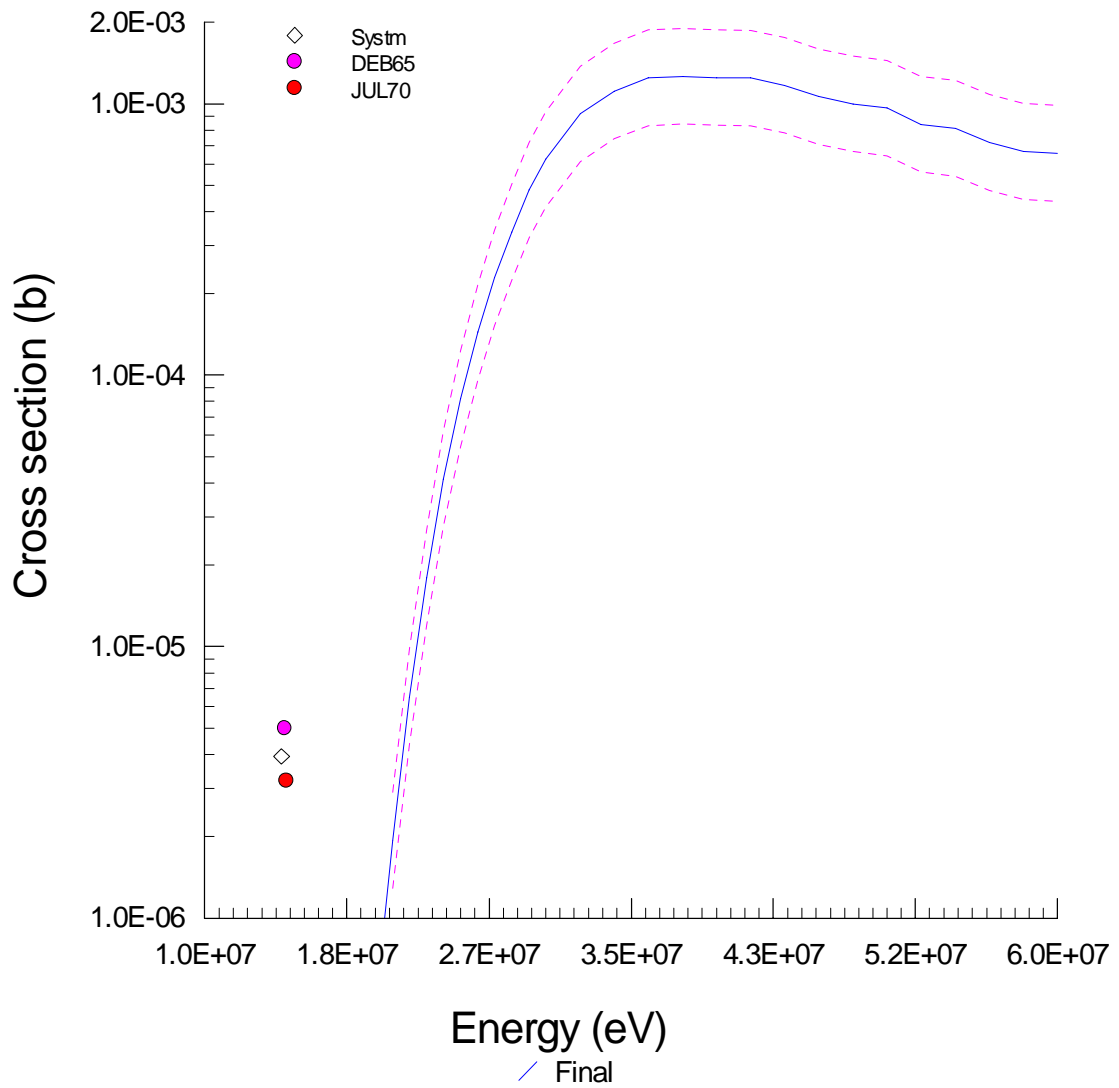


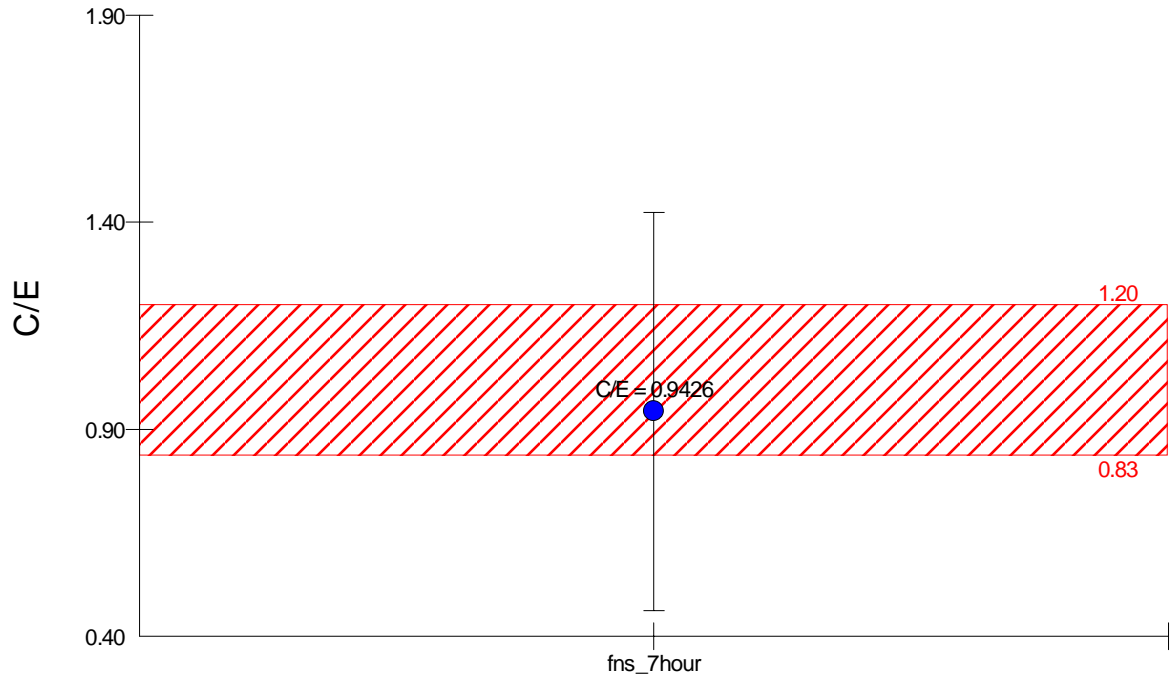
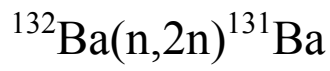


$^{133}\text{Cs}(n,h)^{131}\text{I}$

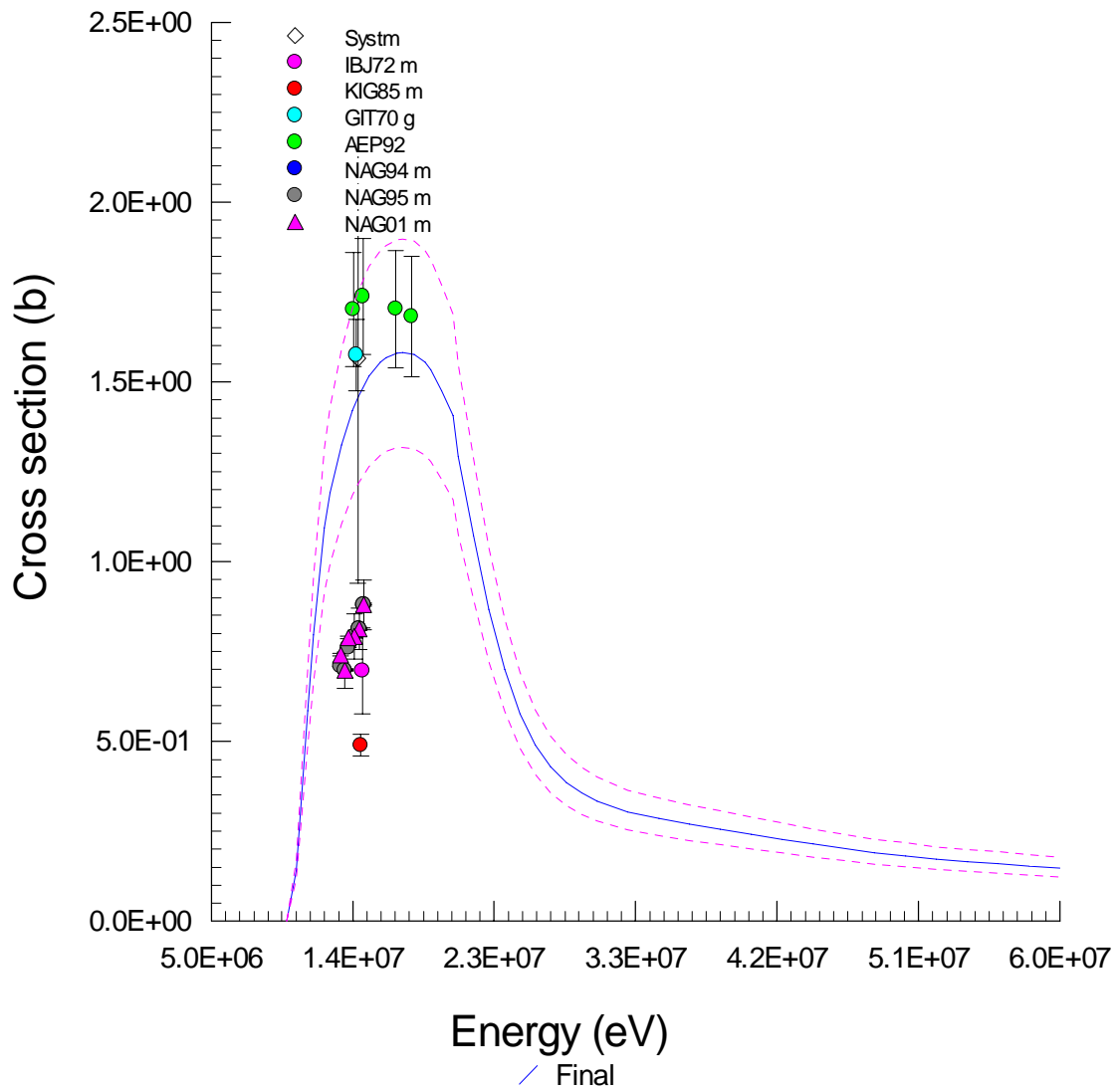


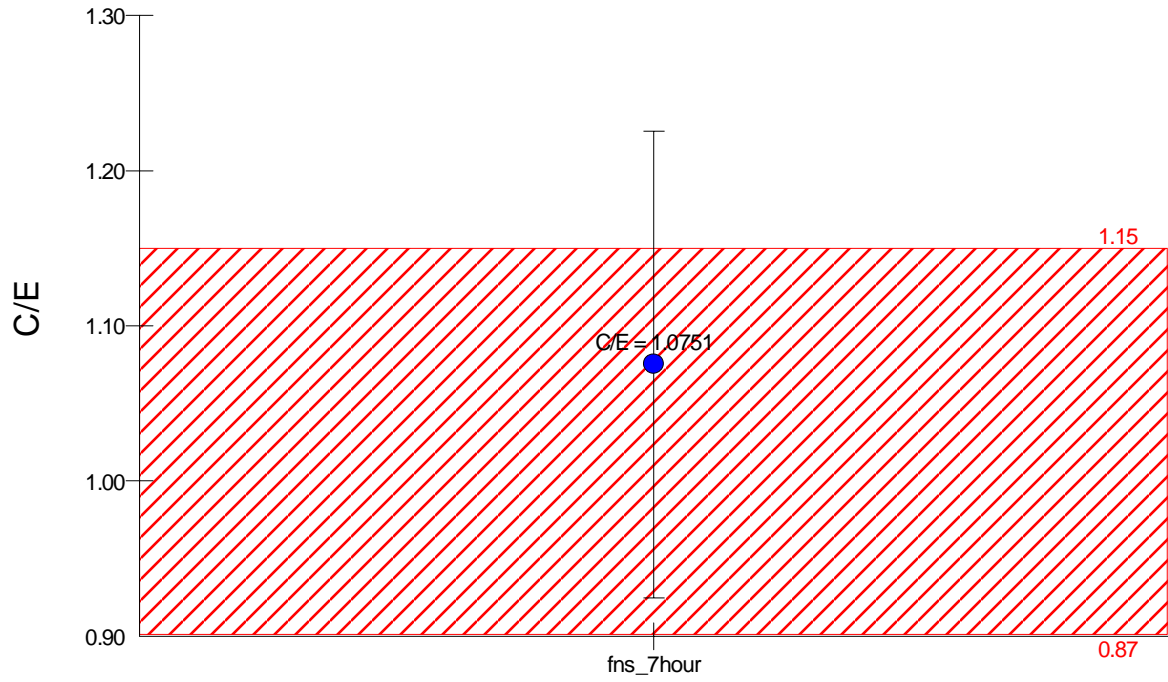
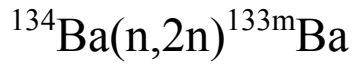
Neutron Spectrum



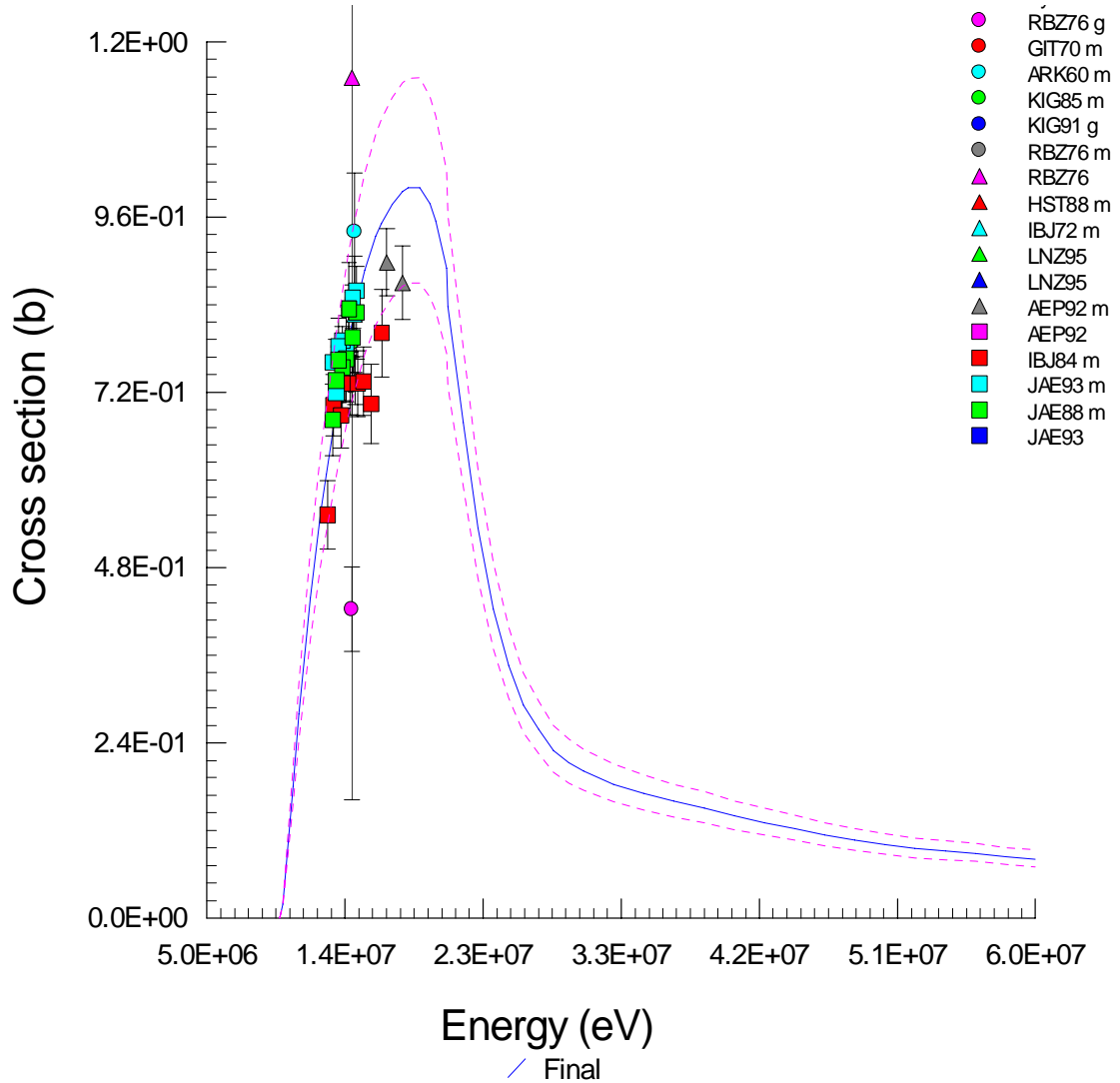


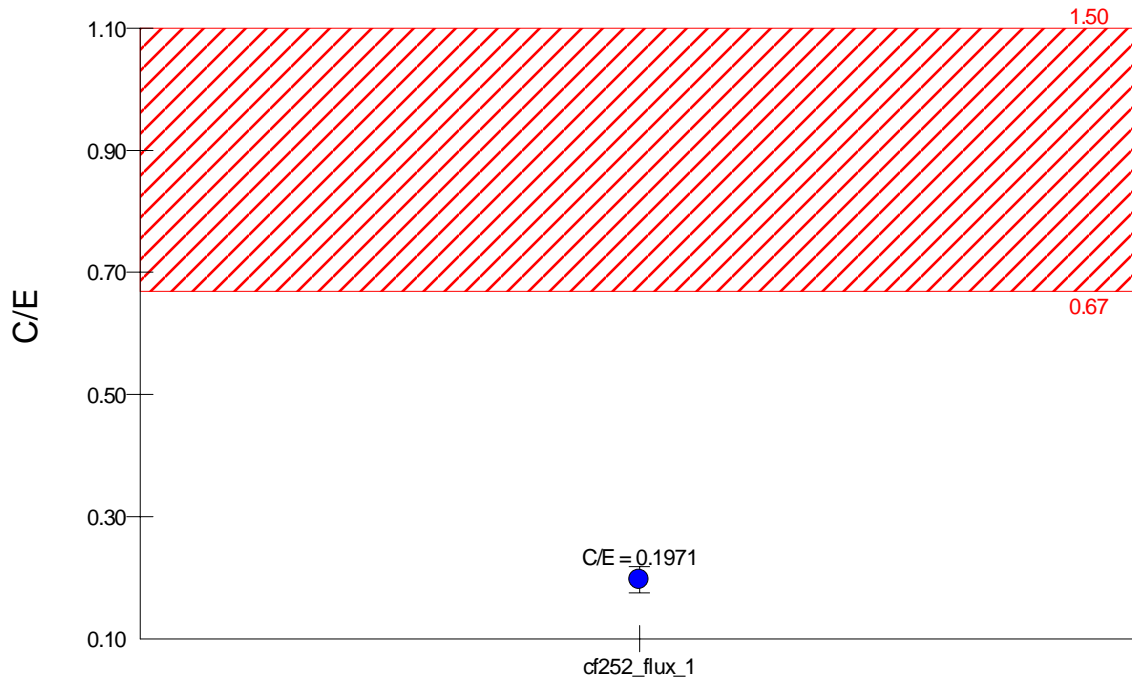
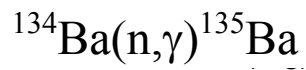
Neutron Spectrum



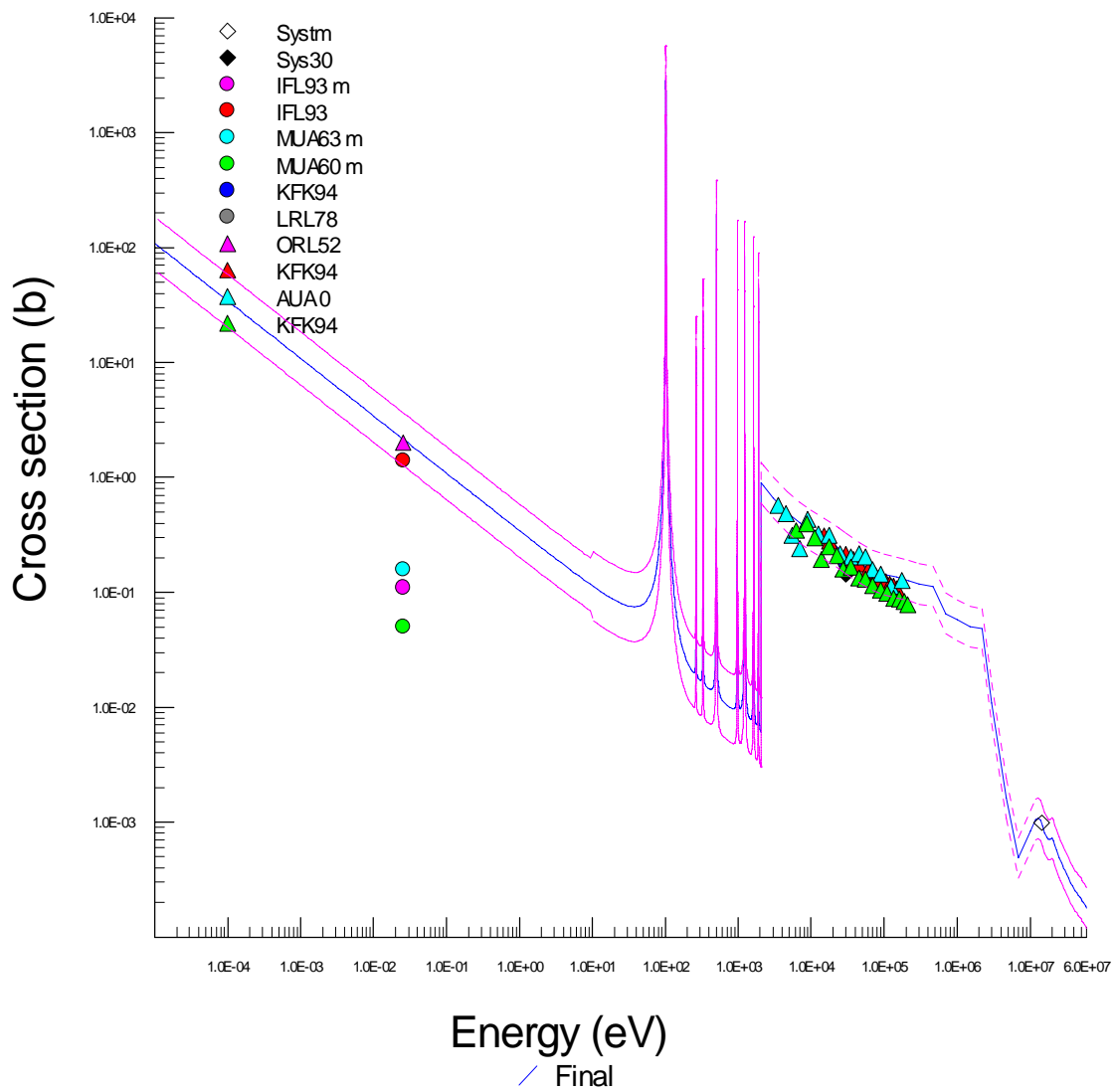


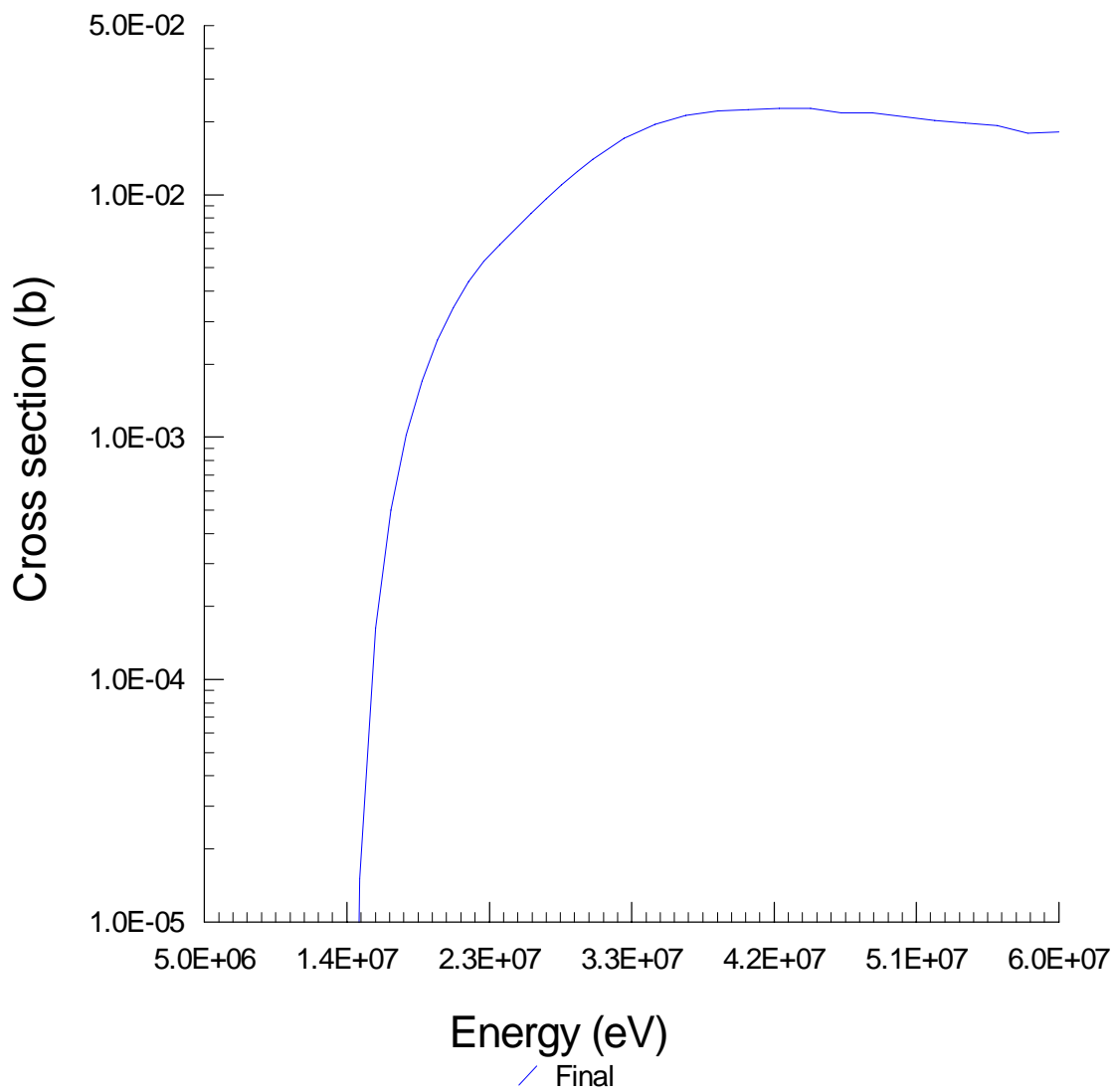
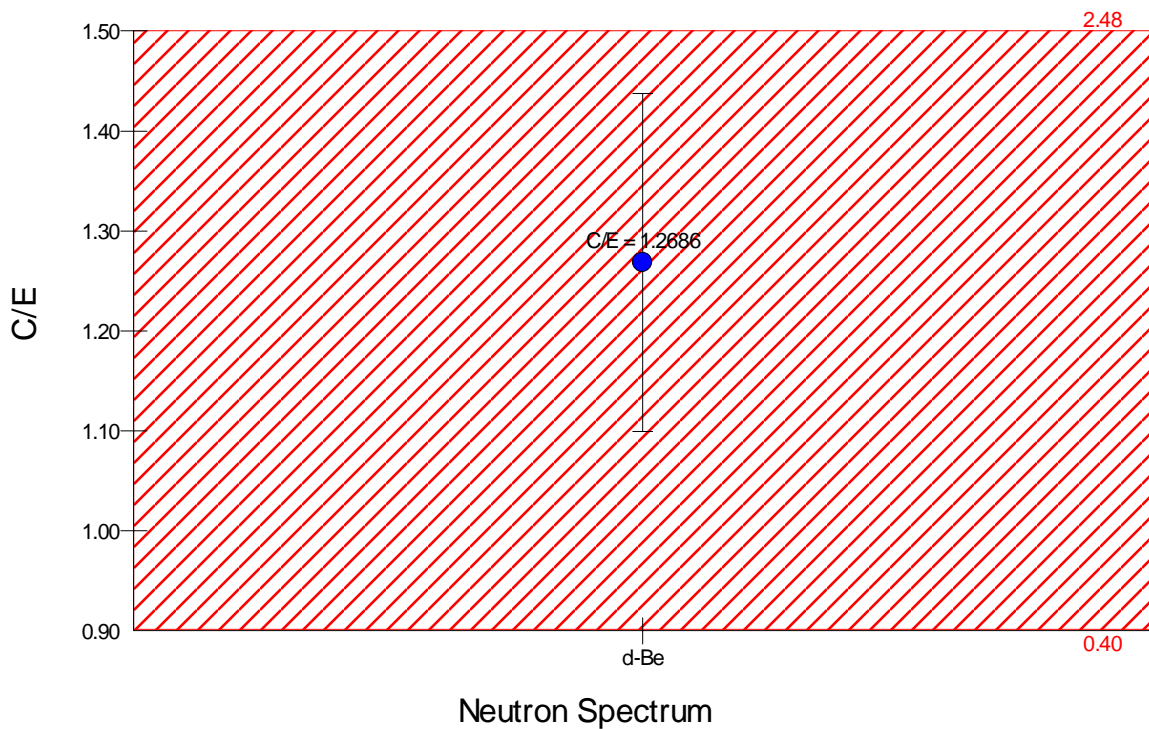
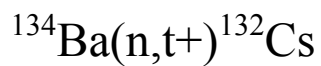
Neutron Spectrum

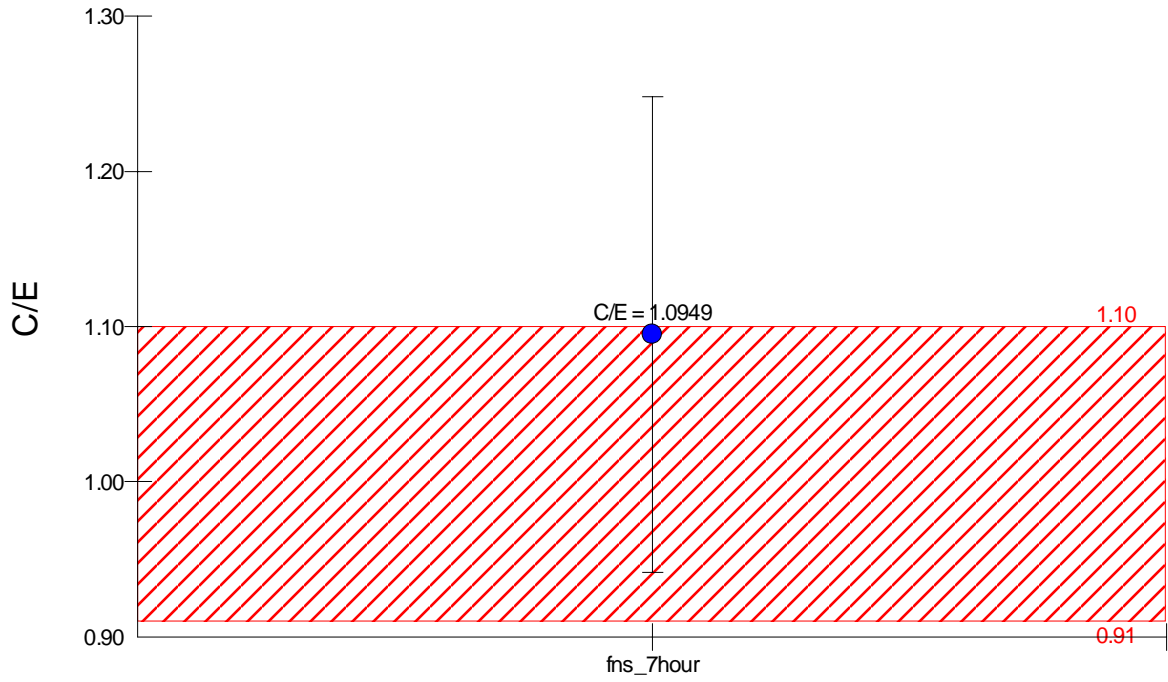
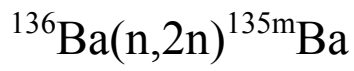




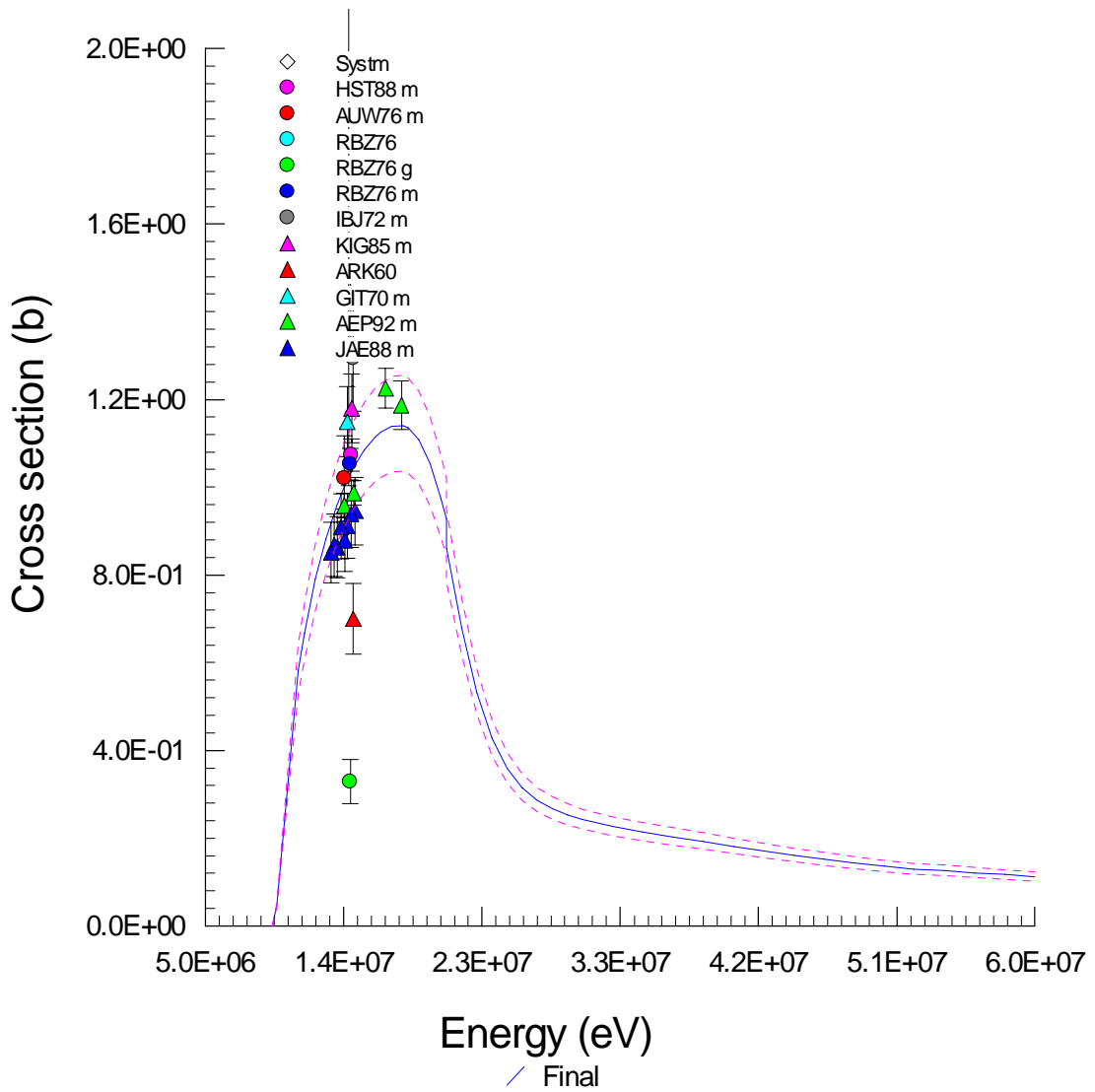
Neutron Spectrum

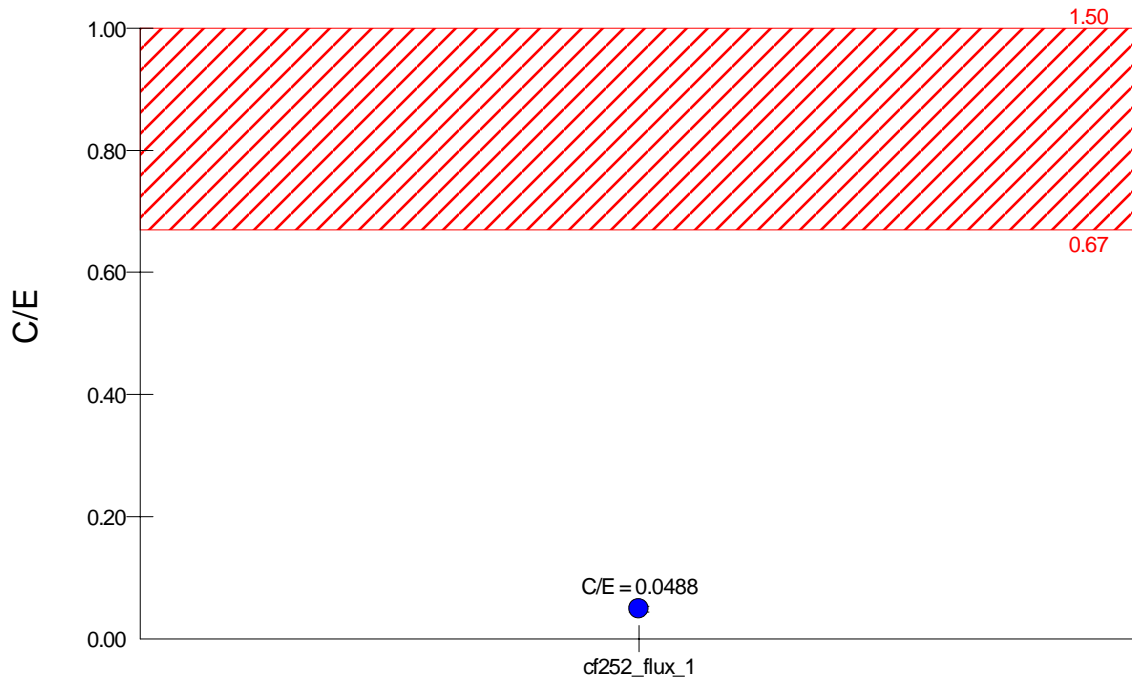
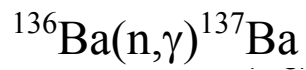




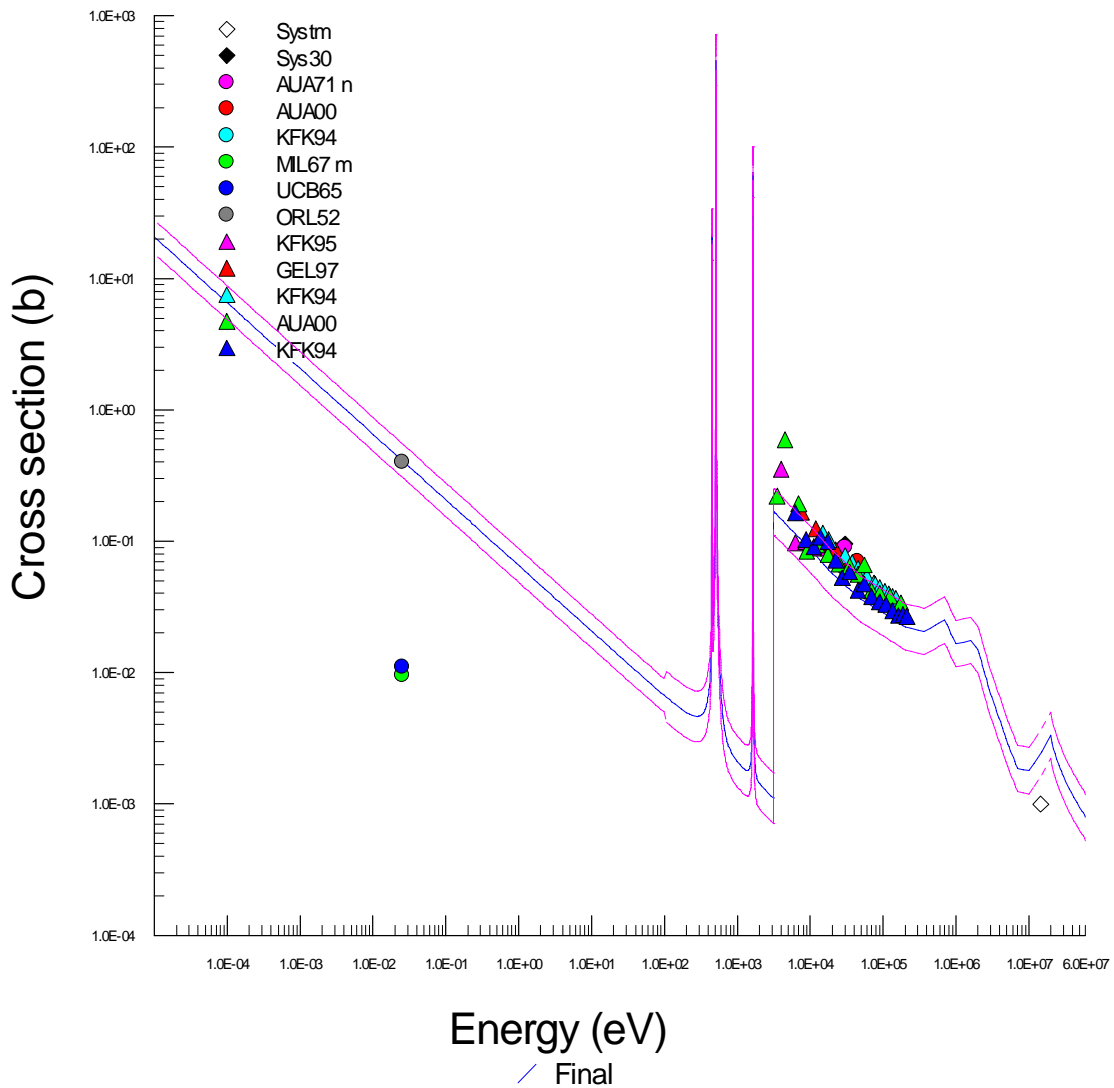


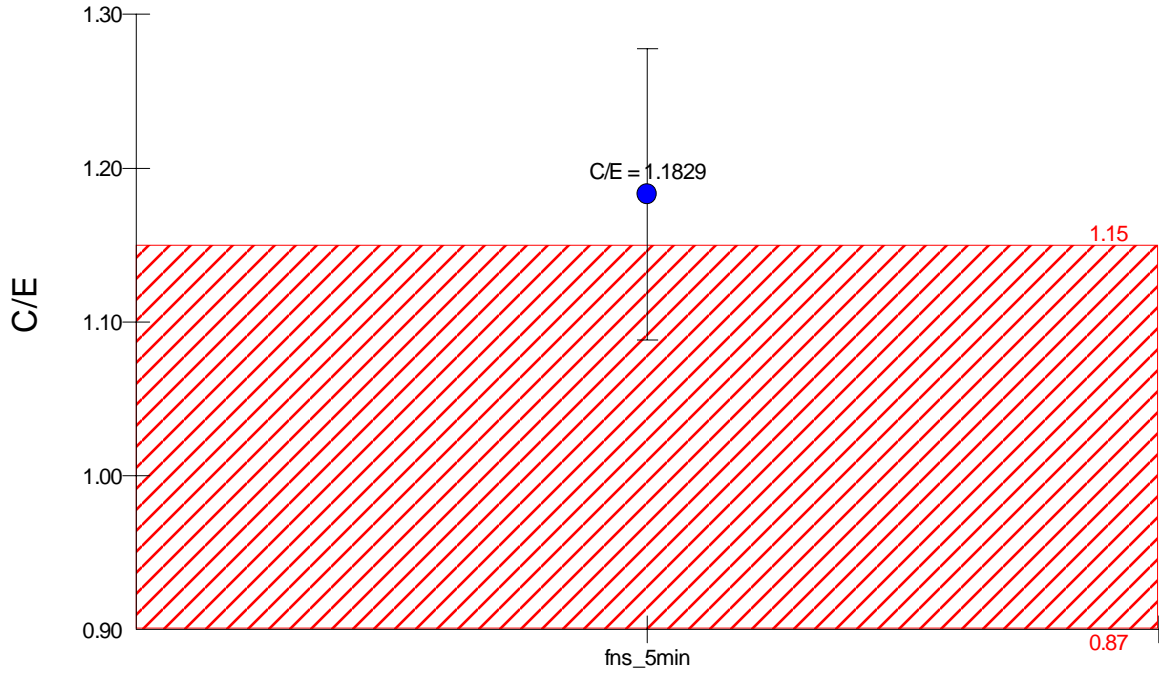
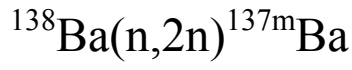
Neutron Spectrum



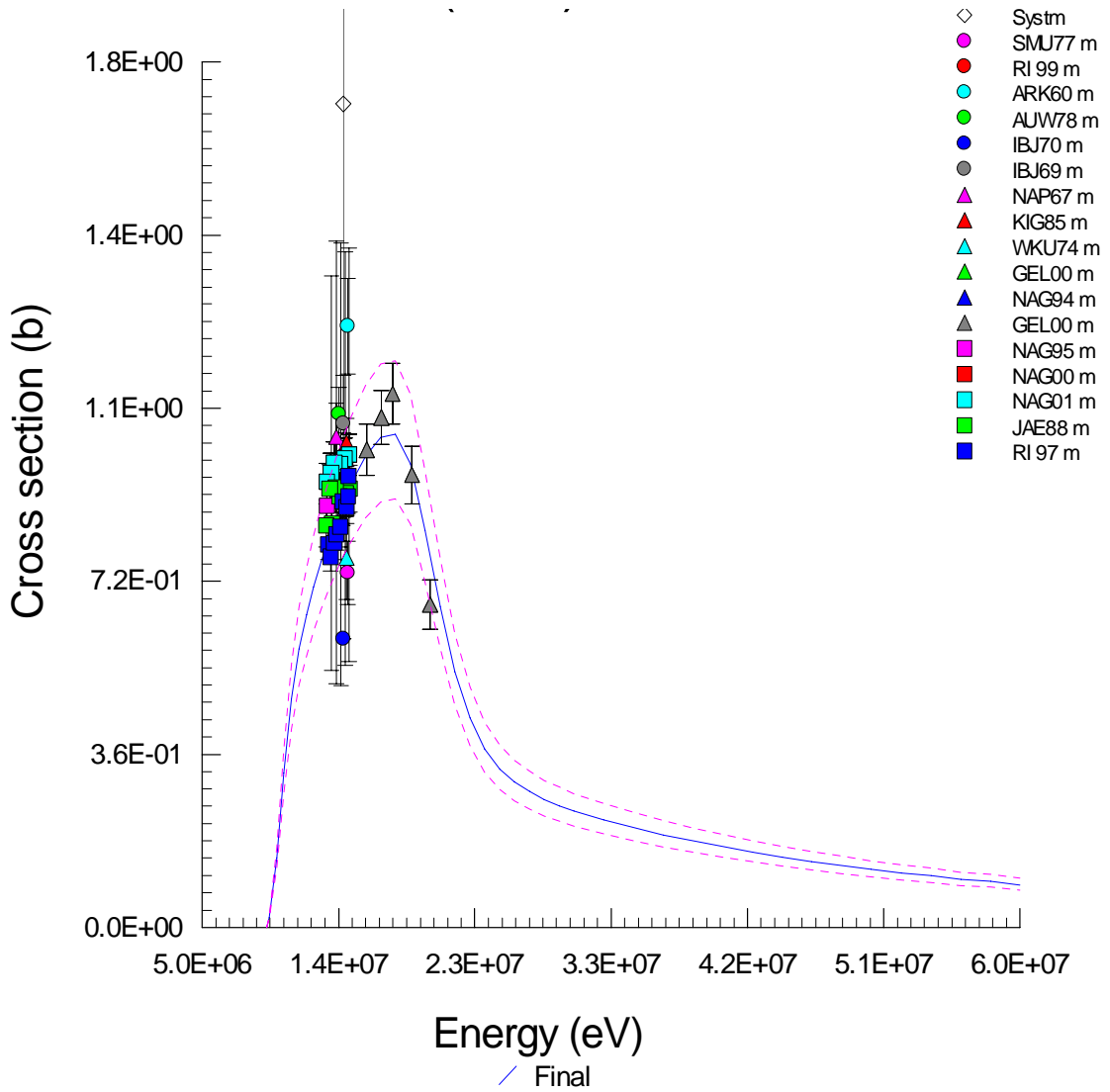


Neutron Spectrum

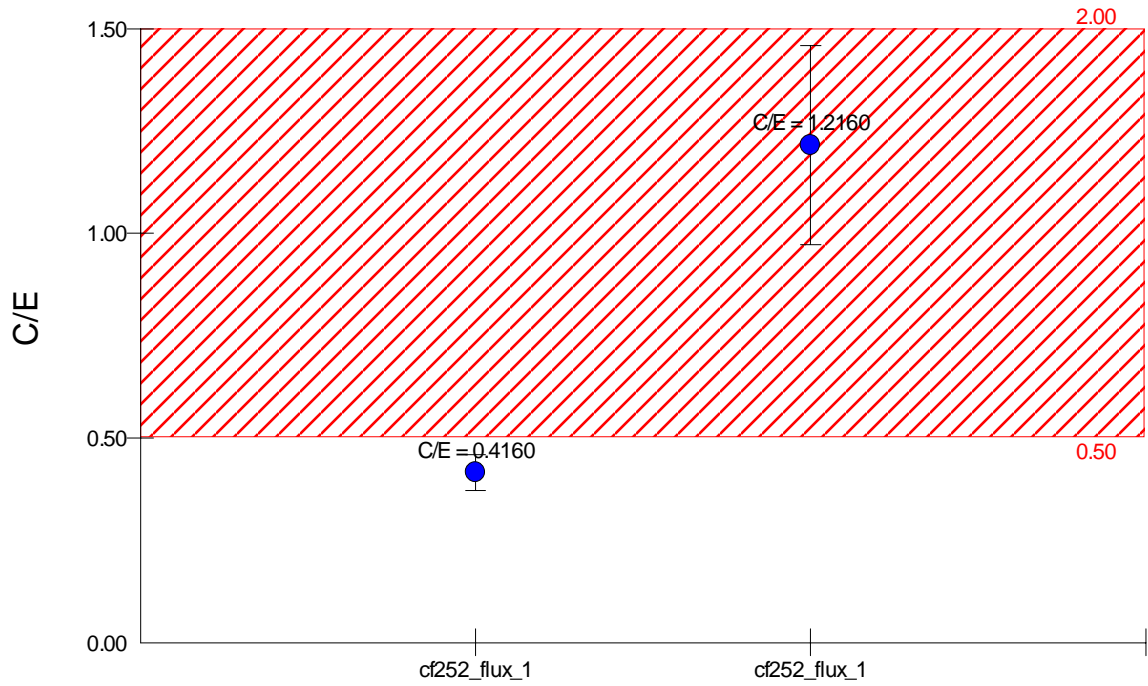
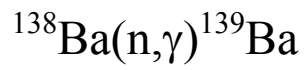




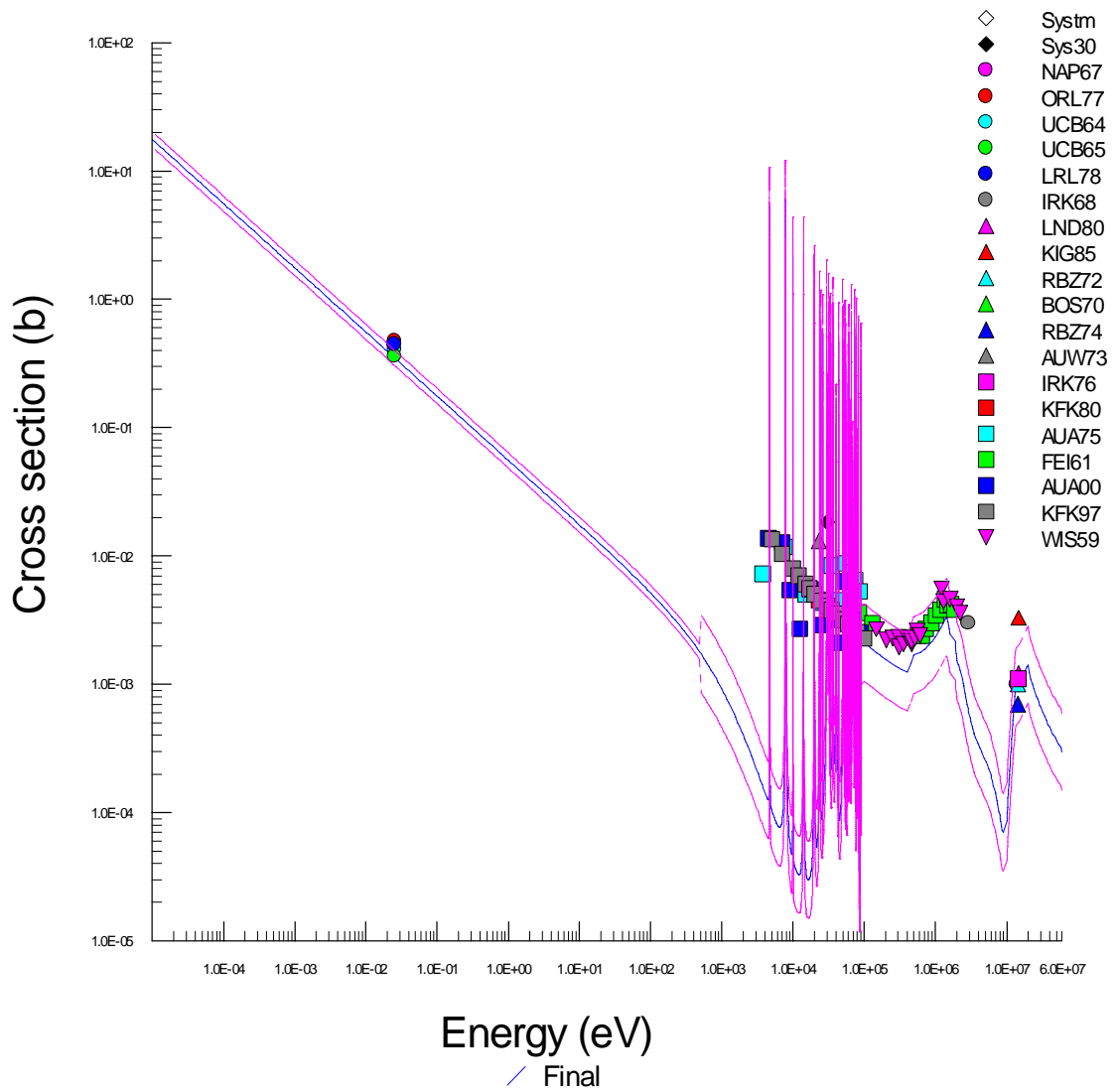
Neutron Spectrum

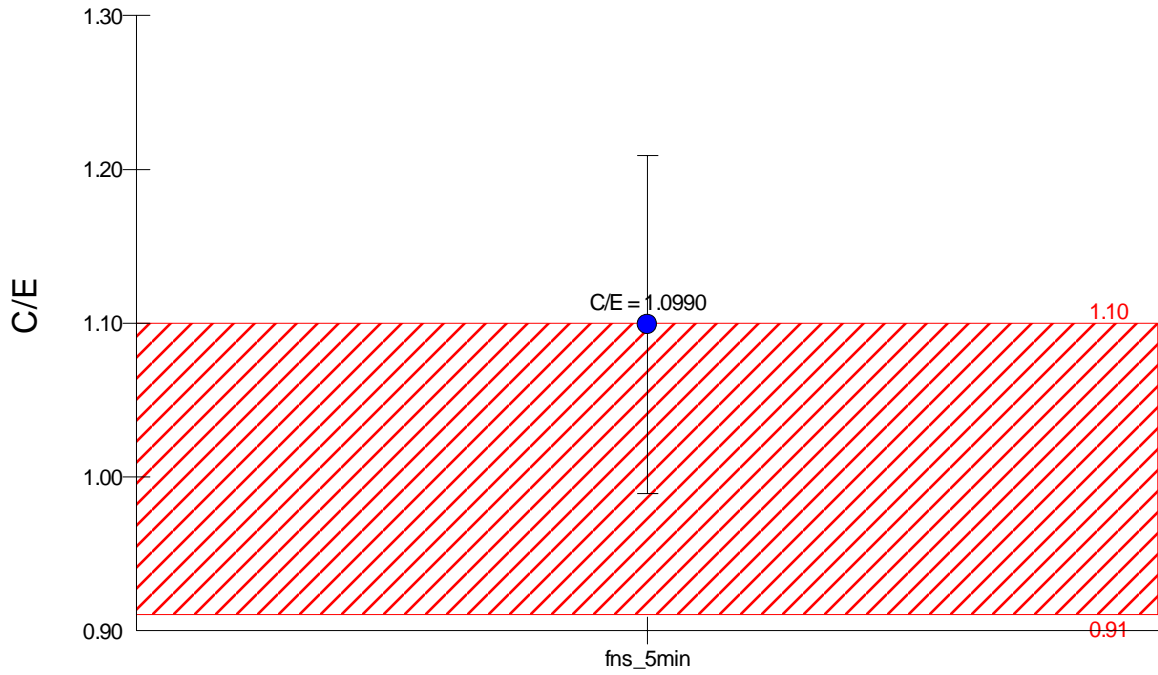
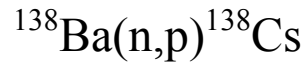




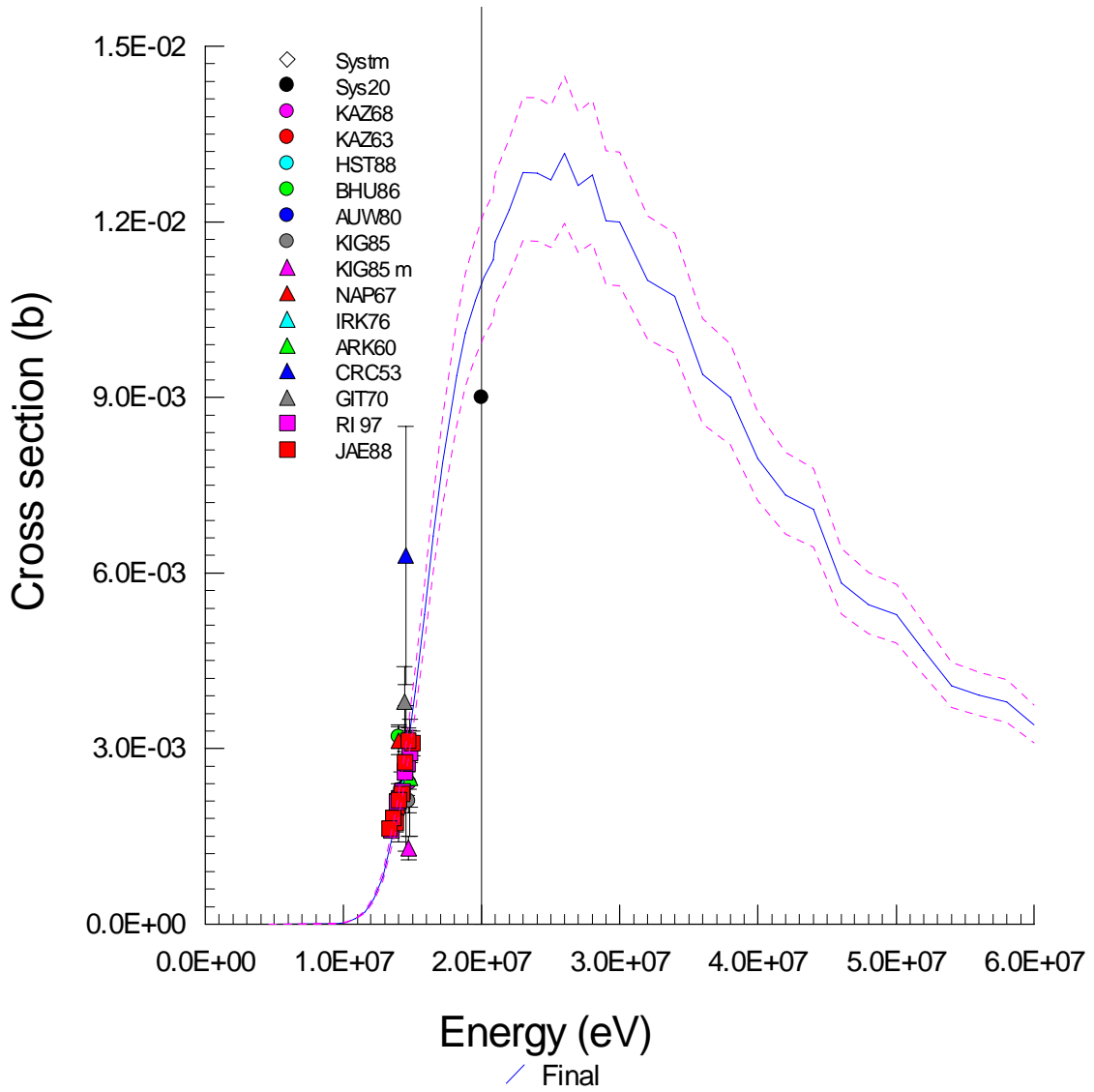


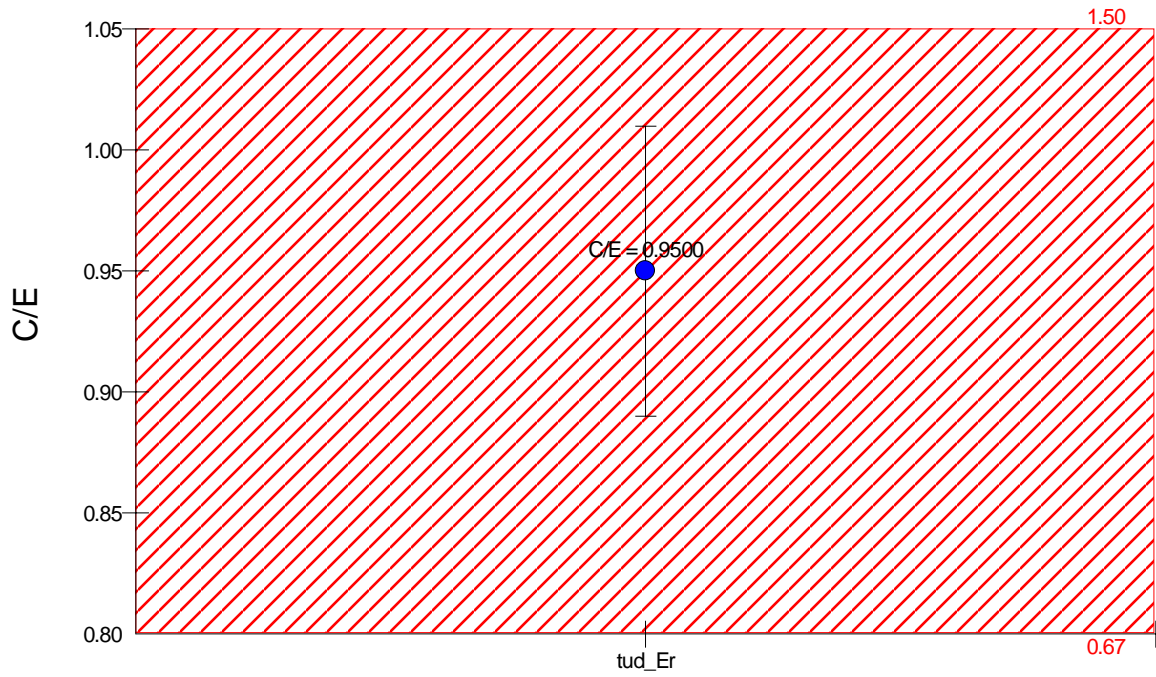
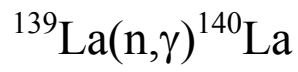
Neutron Spectrum



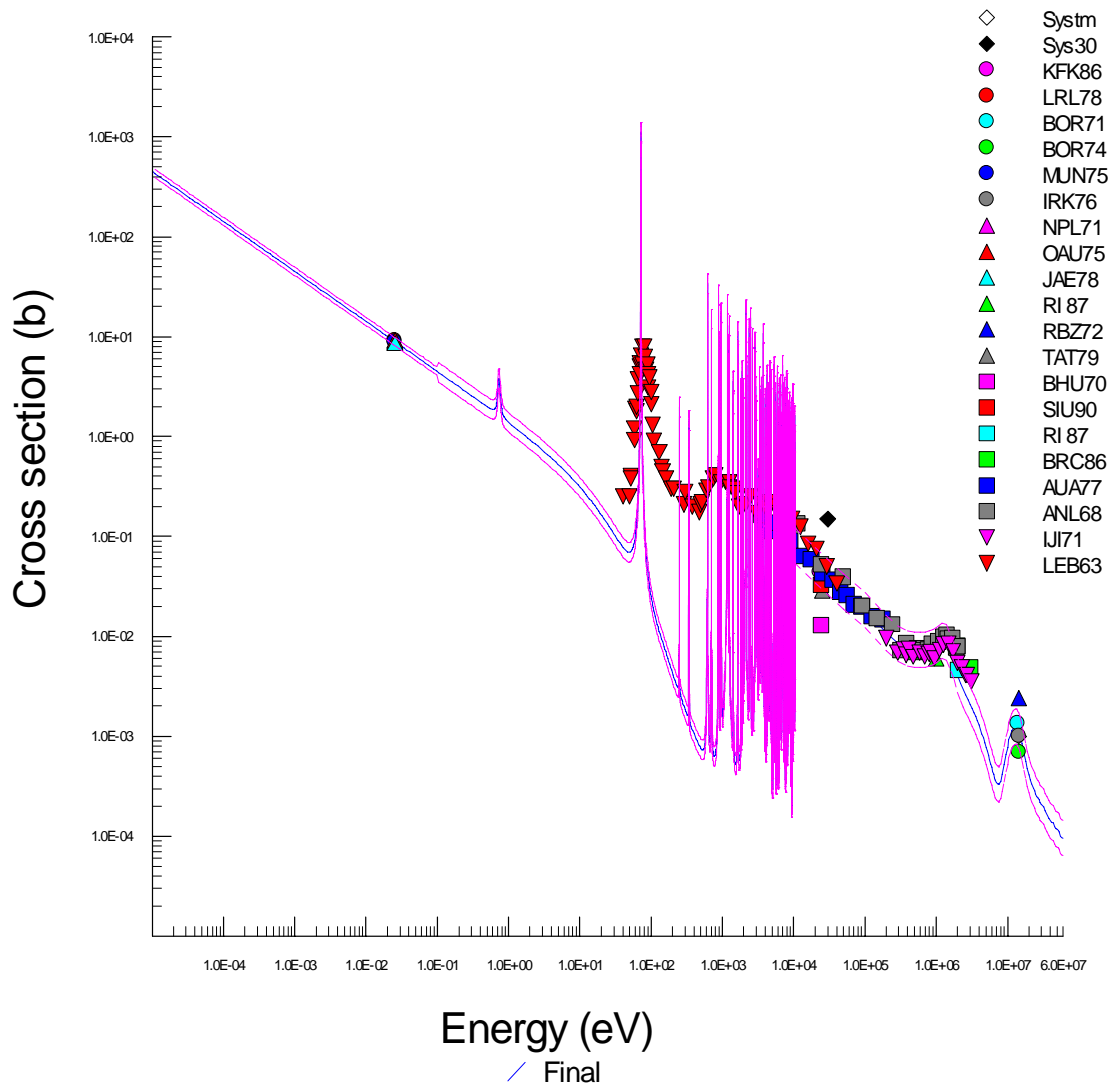


Neutron Spectrum

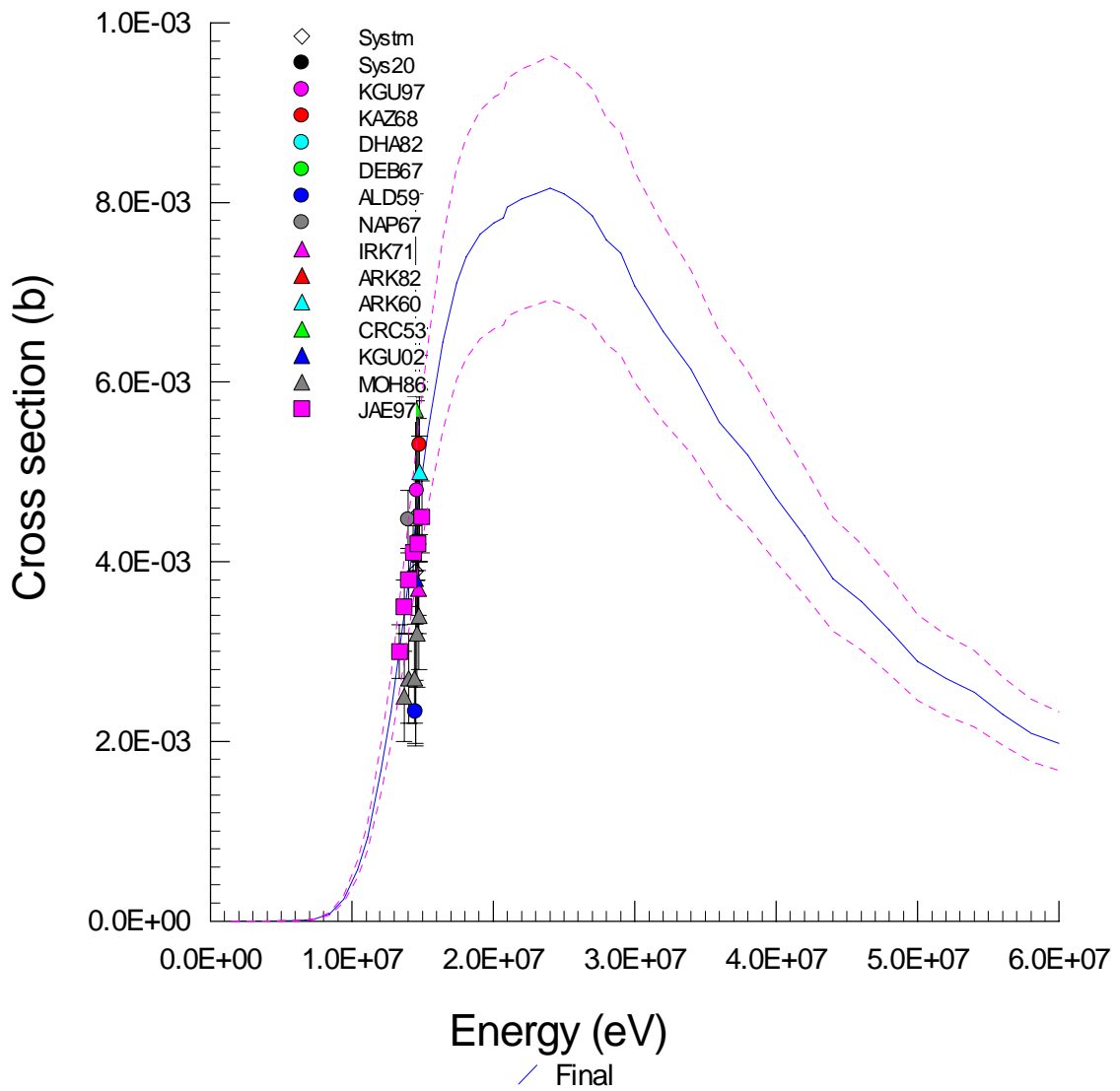
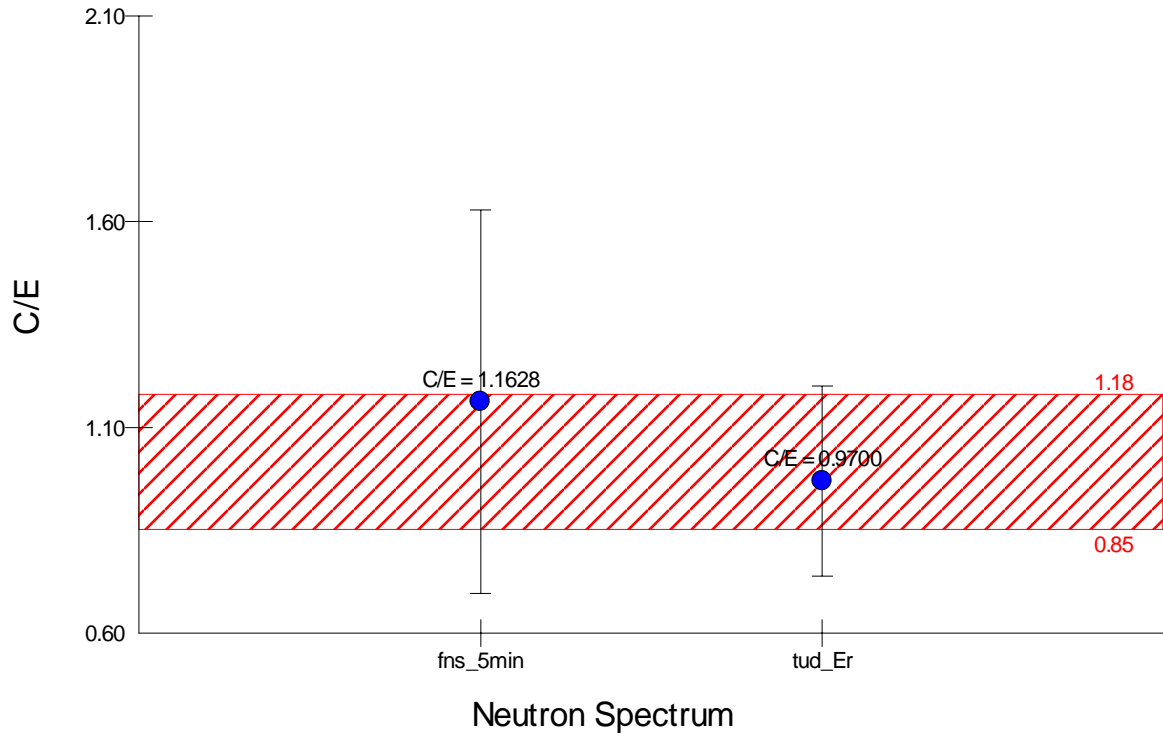




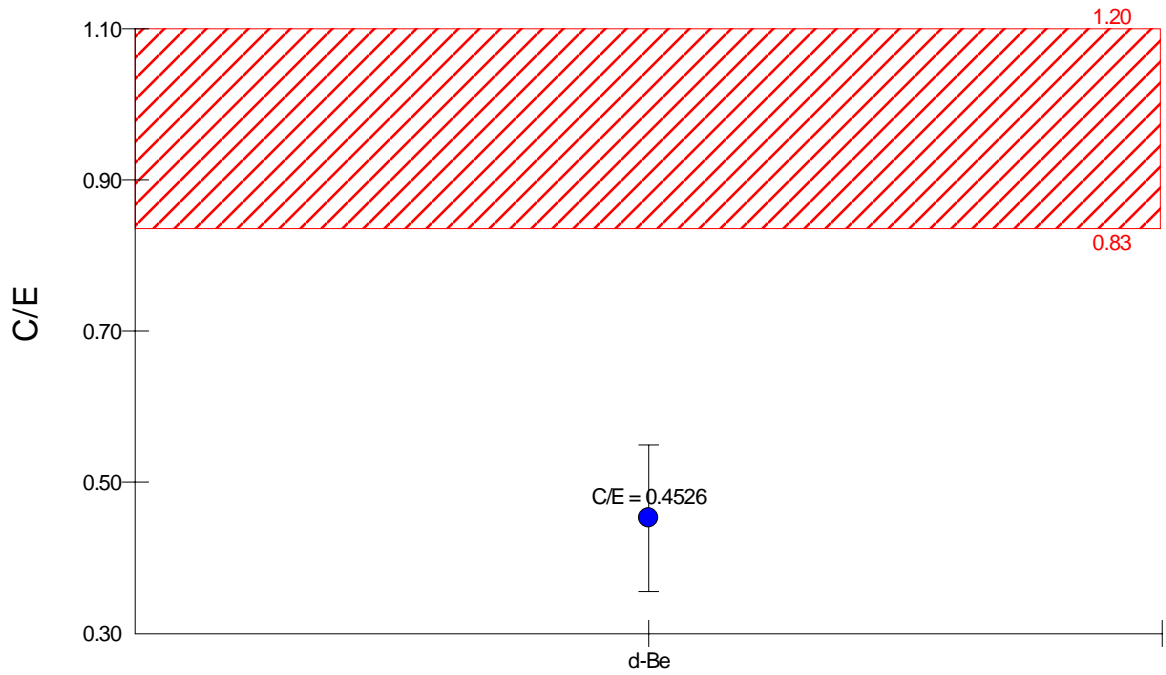
Neutron Spectrum



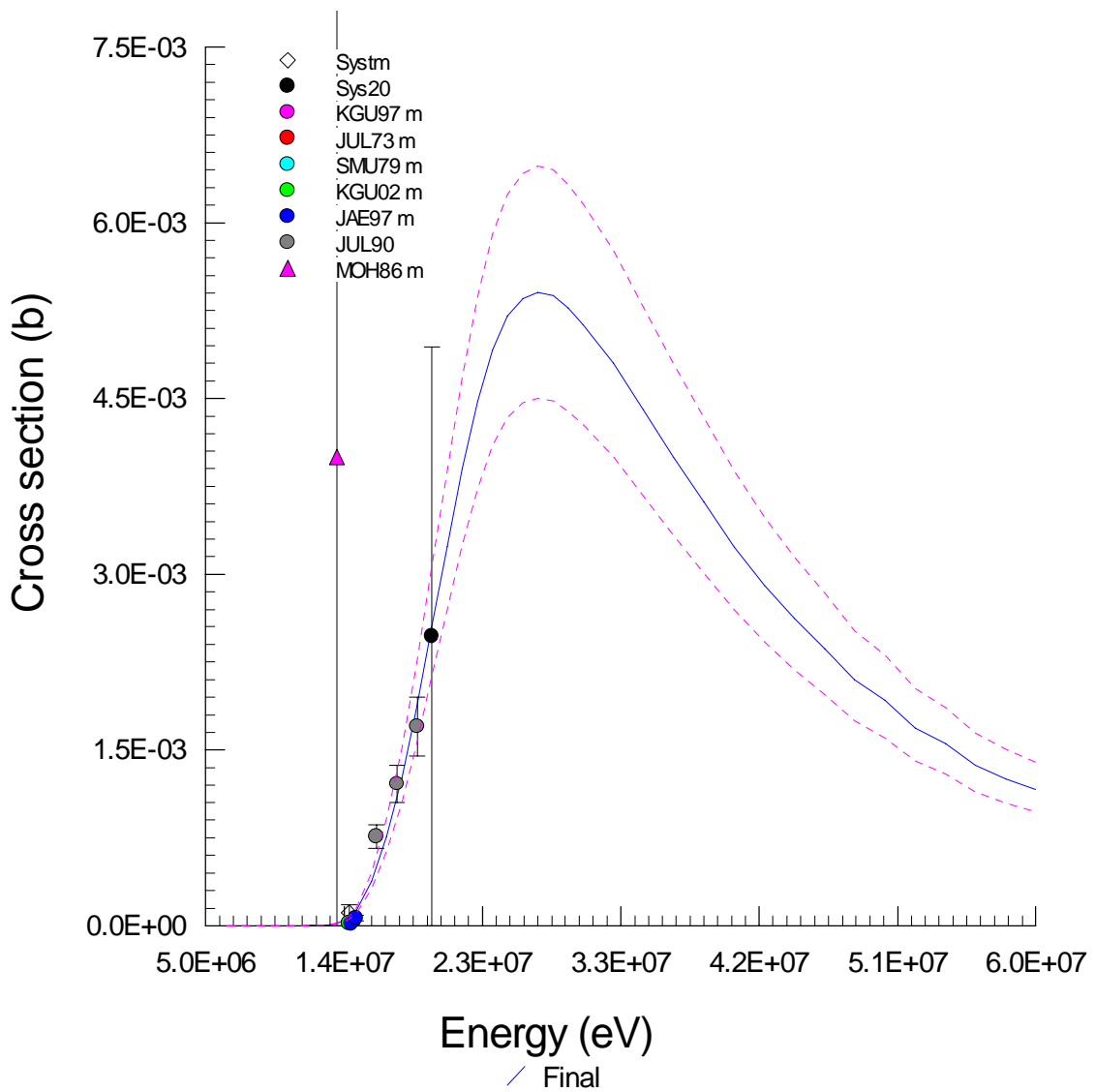
$^{139}\text{La}(n,p)^{139}\text{Ba}$



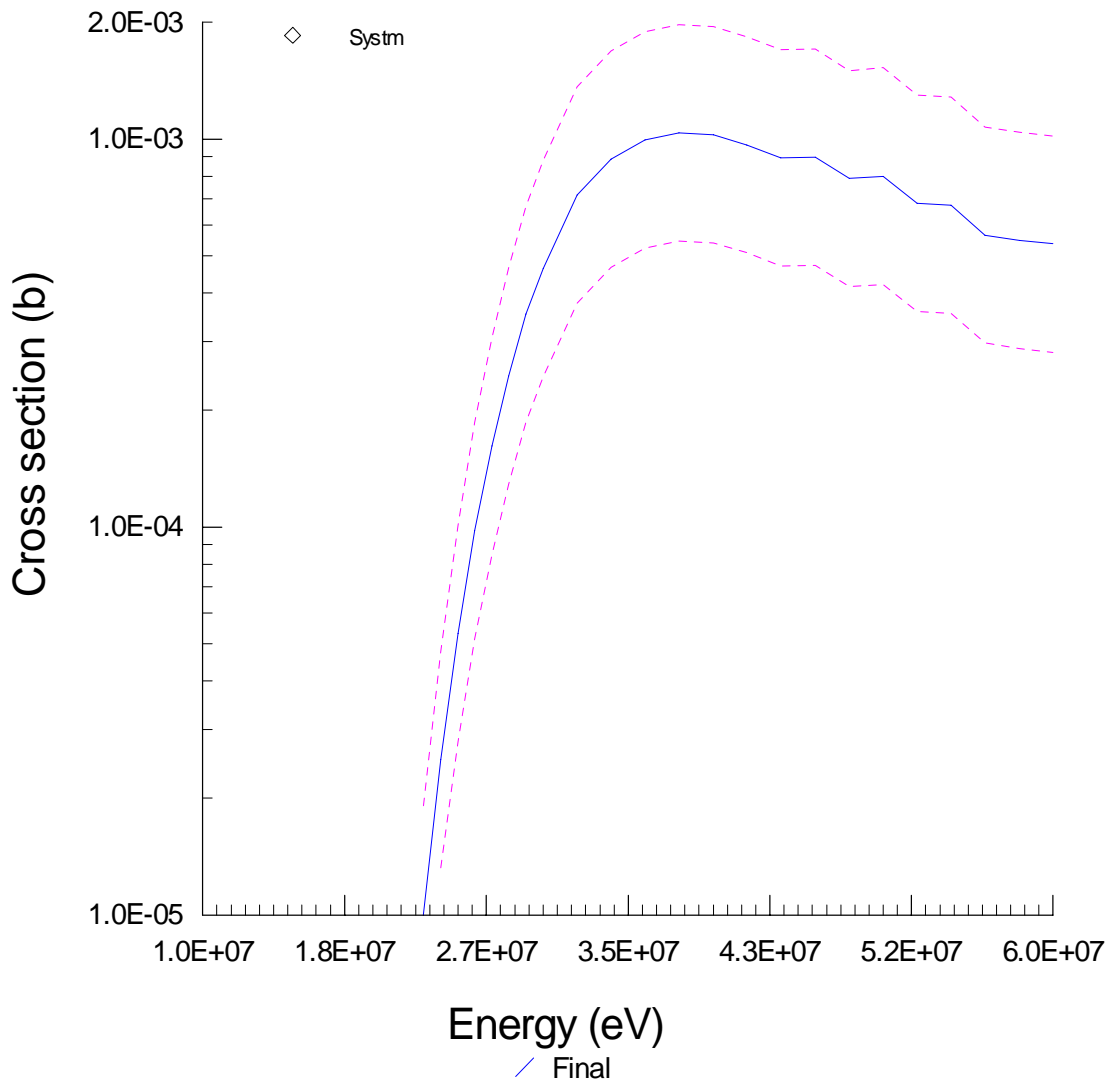
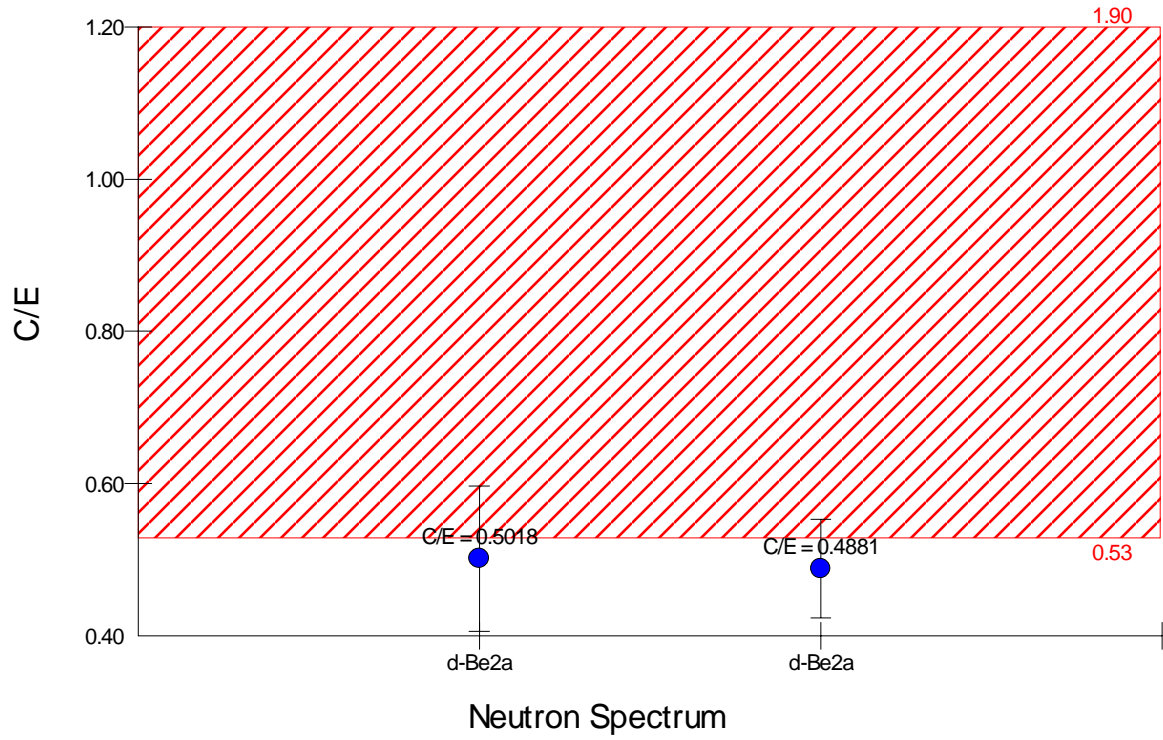
# $^{139}\text{La}(n,t)^{137}\text{Ba}$



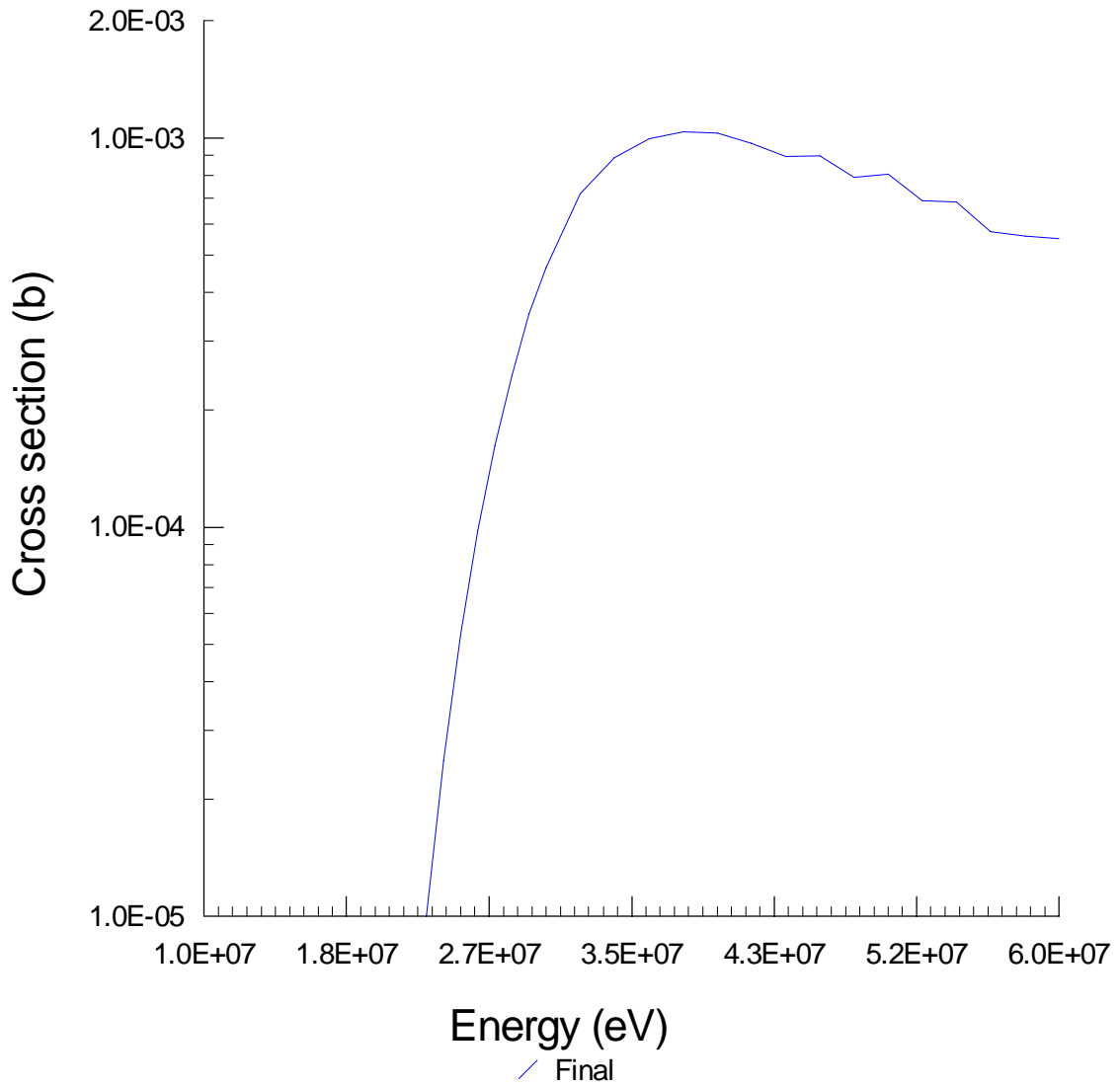
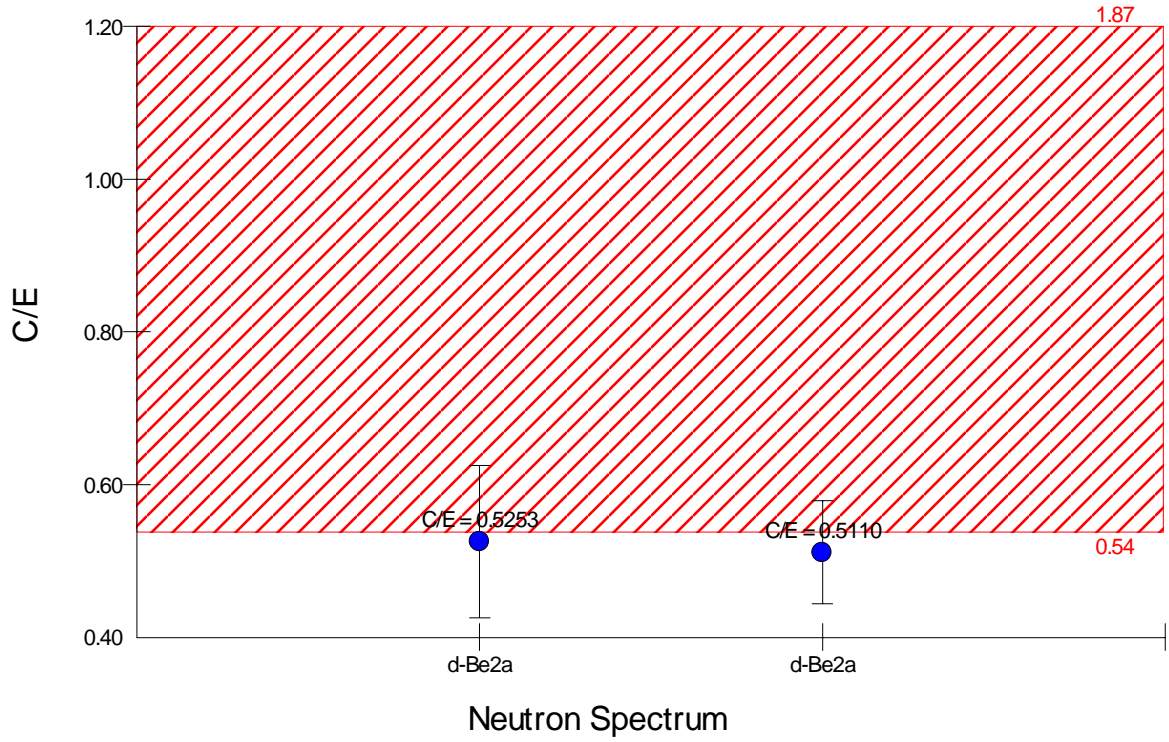
## Neutron Spectrum

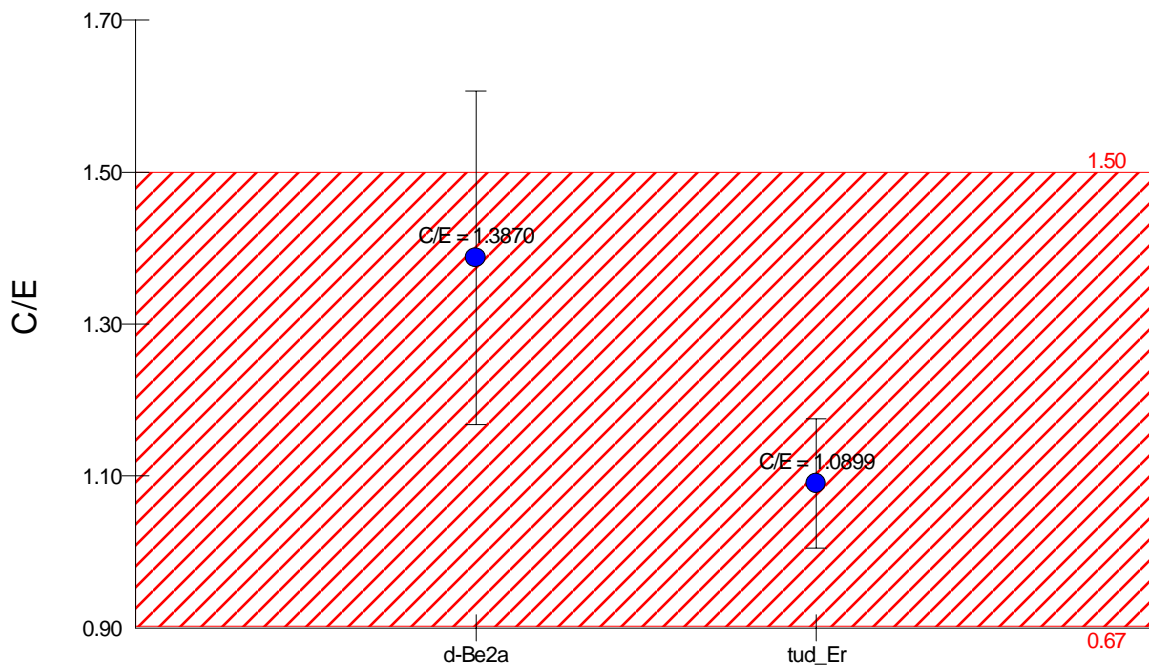
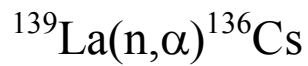


$^{139}\text{La}(n,h)^{137}\text{Cs}$

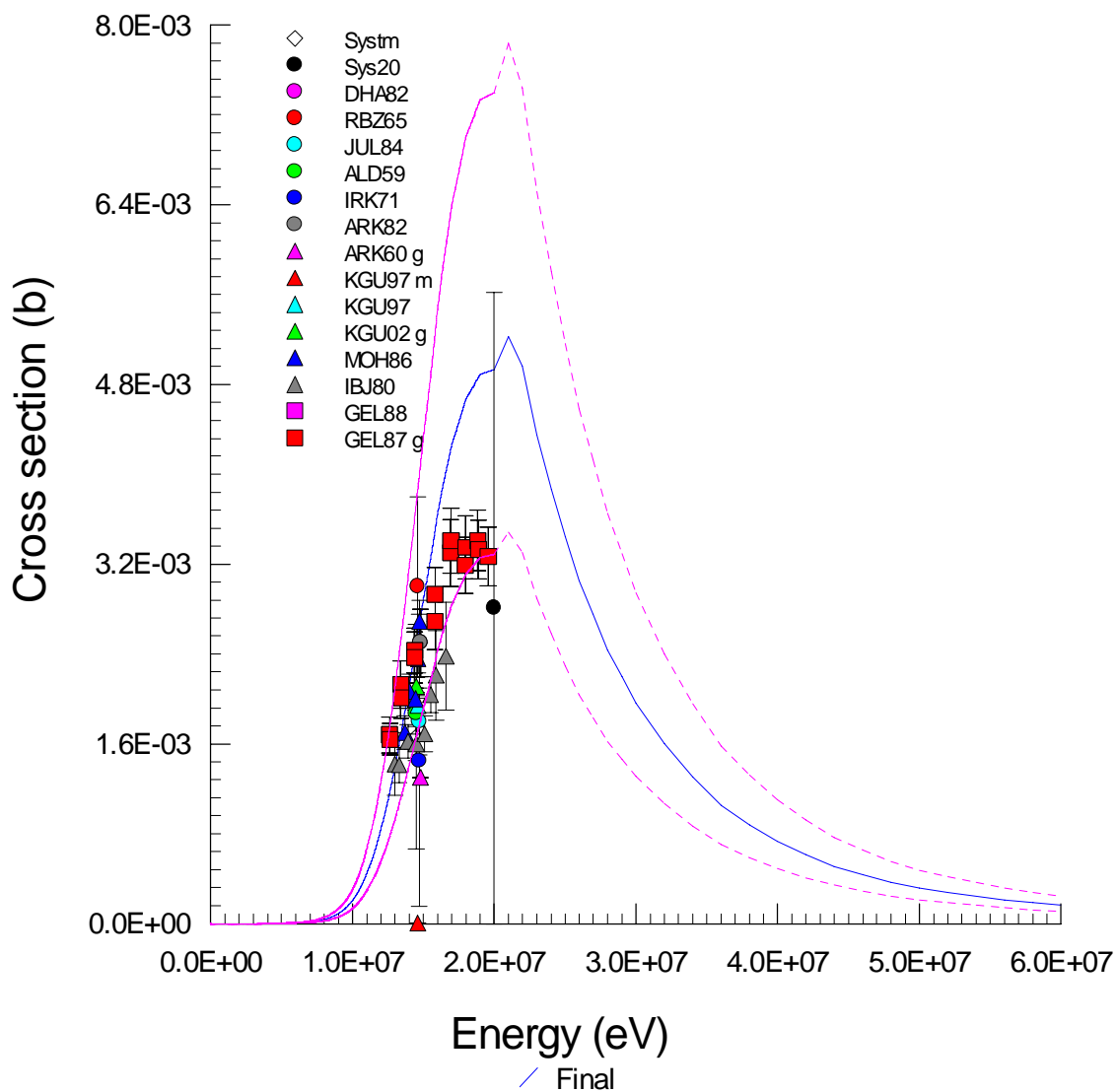


$^{139}\text{La}(n,h+)^{137}\text{Cs}$



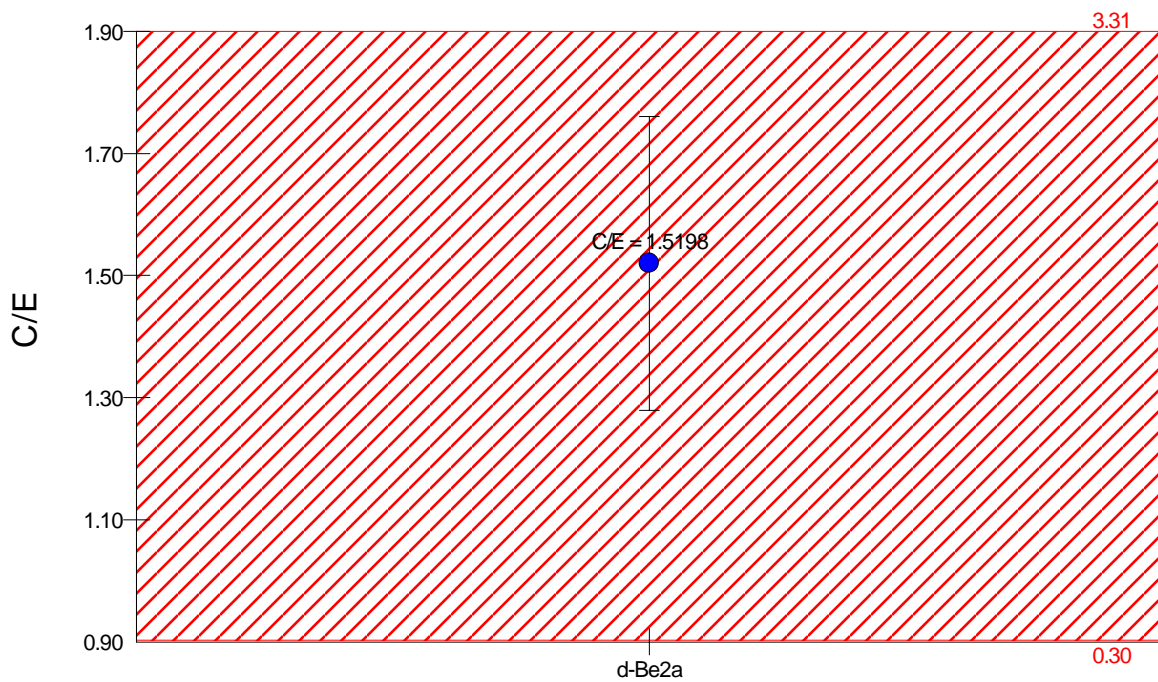


Neutron Spectrum

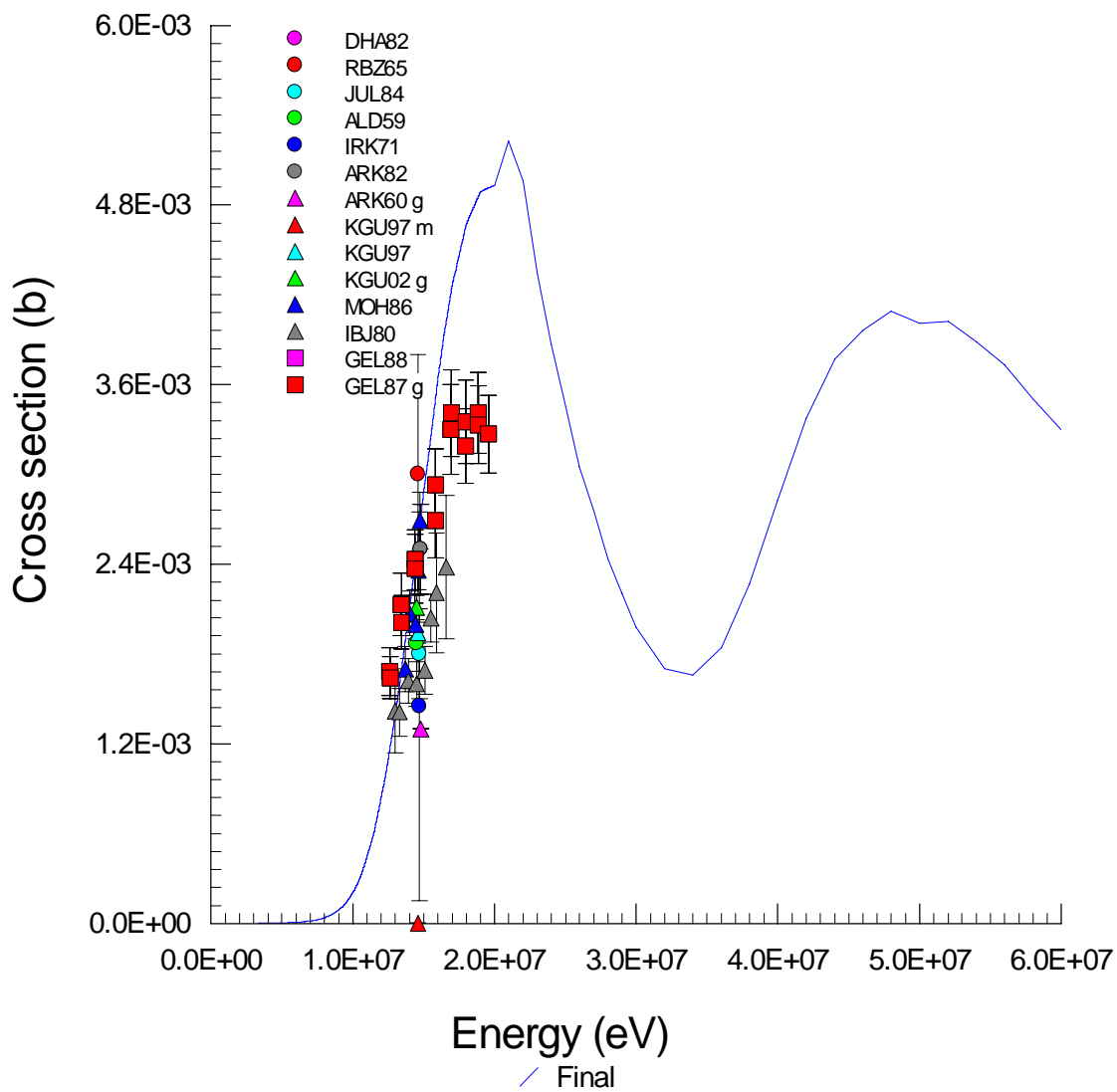


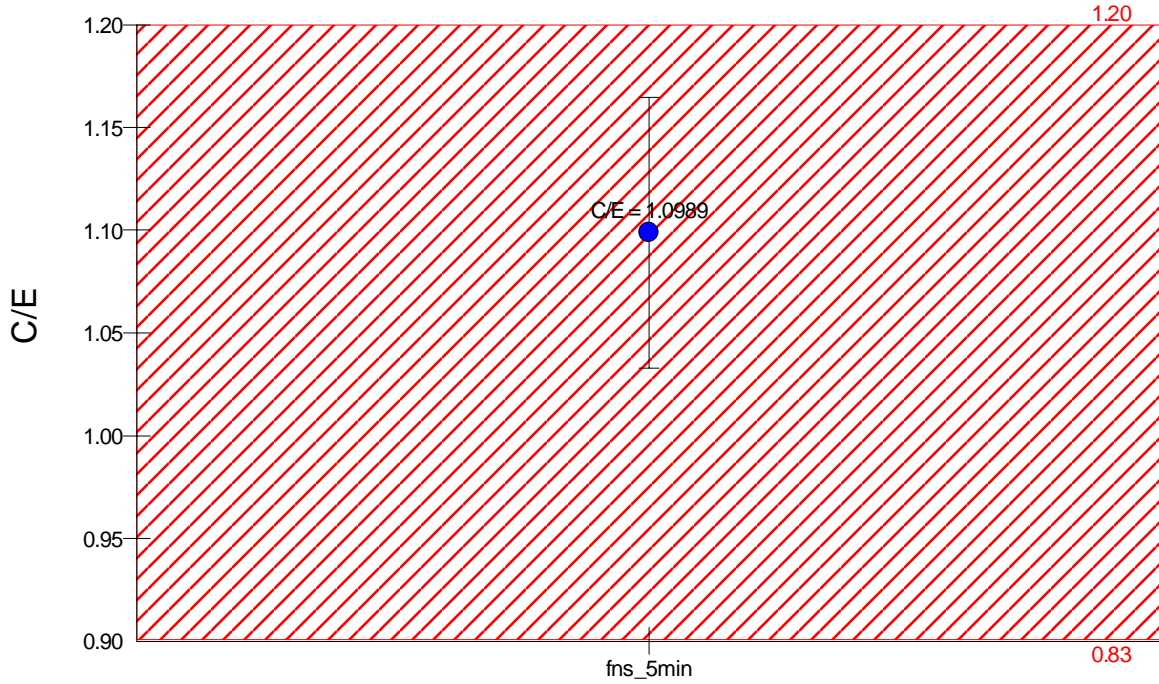
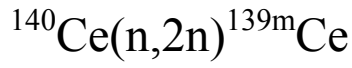


$^{139}\text{La}(n,\alpha)^{136}\text{Cs}$

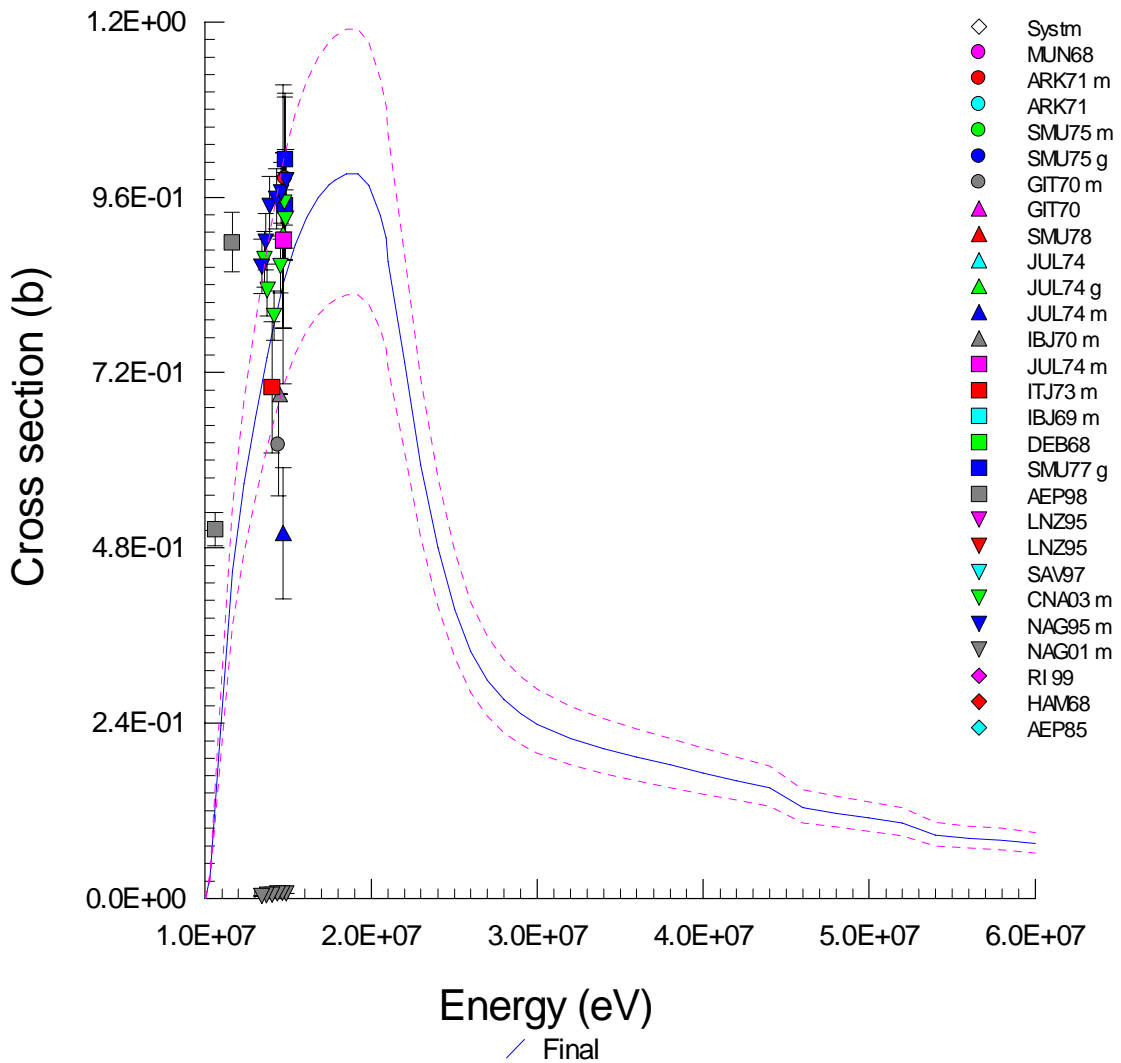


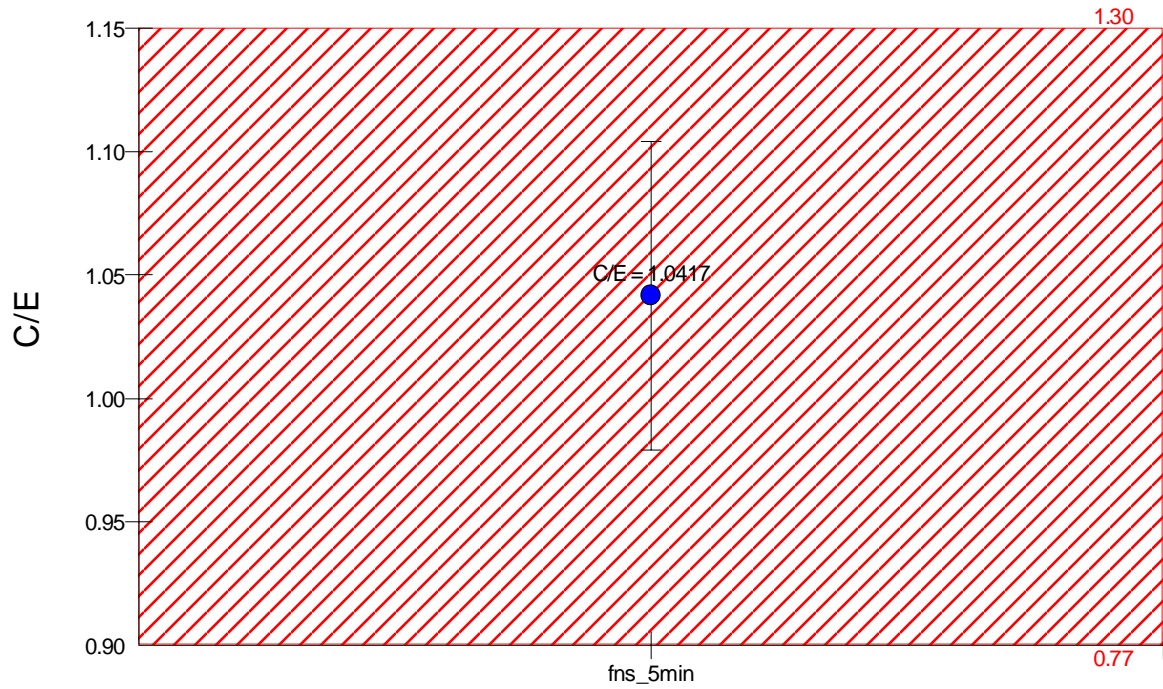
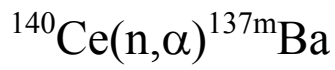
Neutron Spectrum



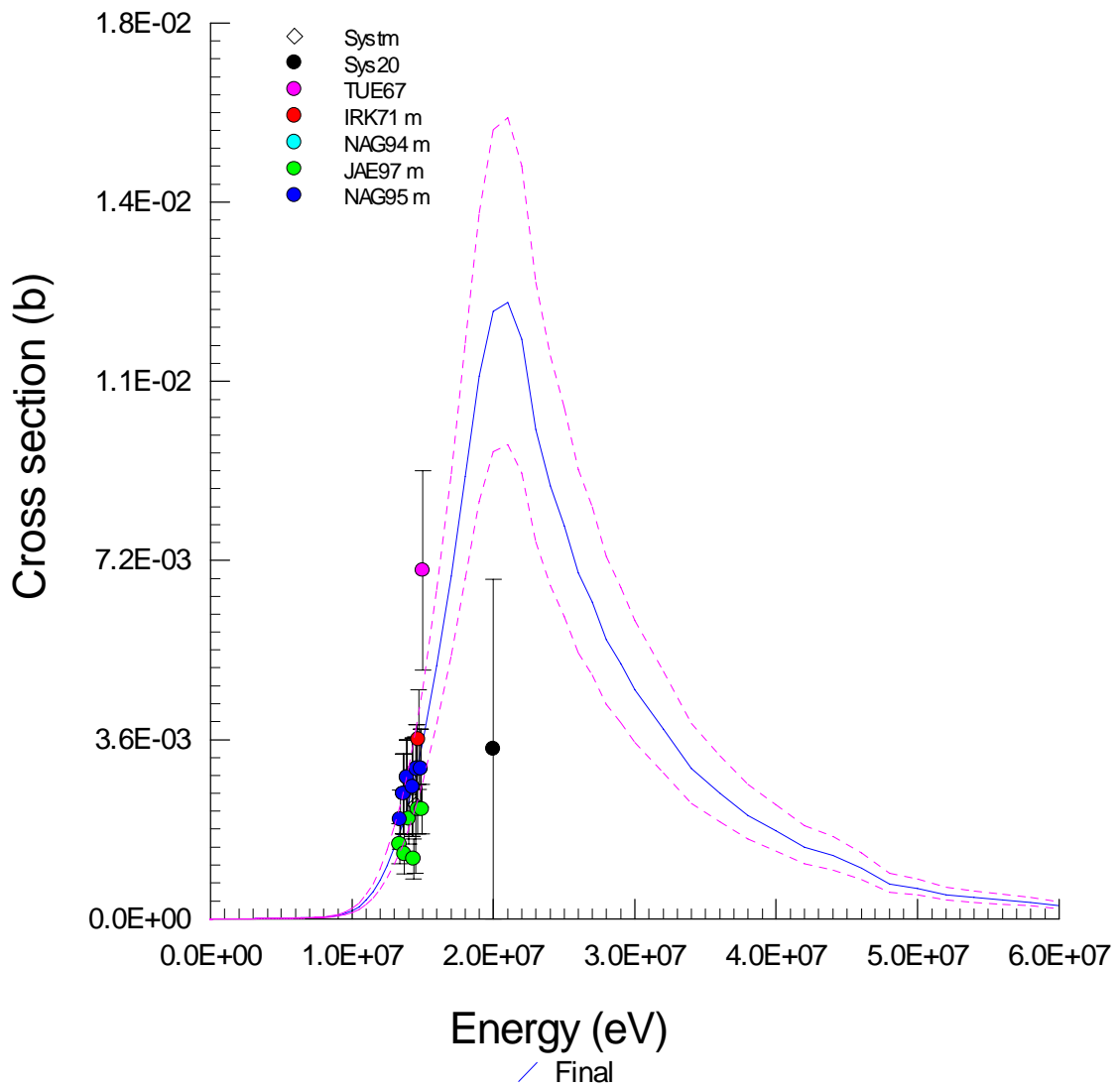


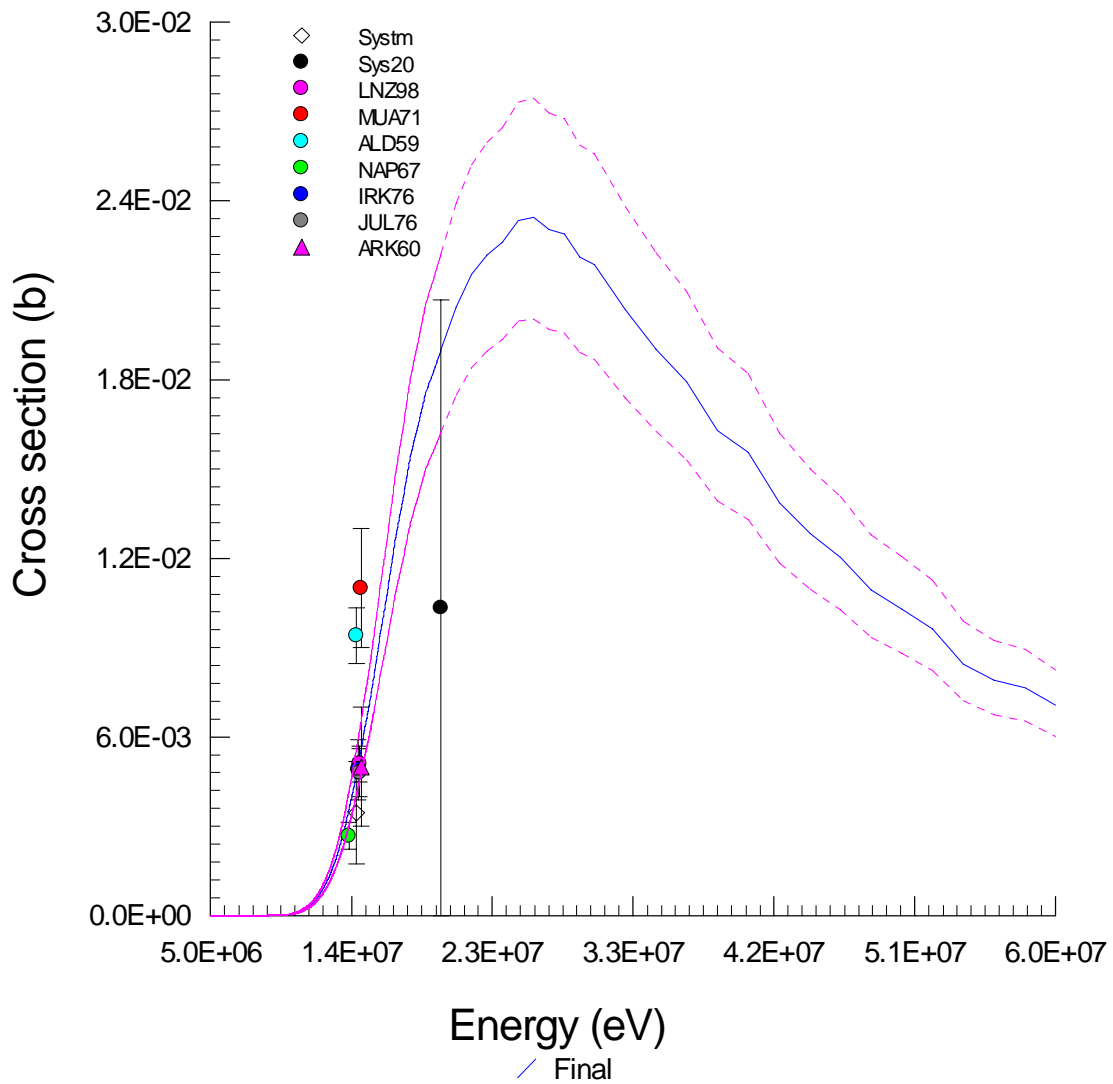
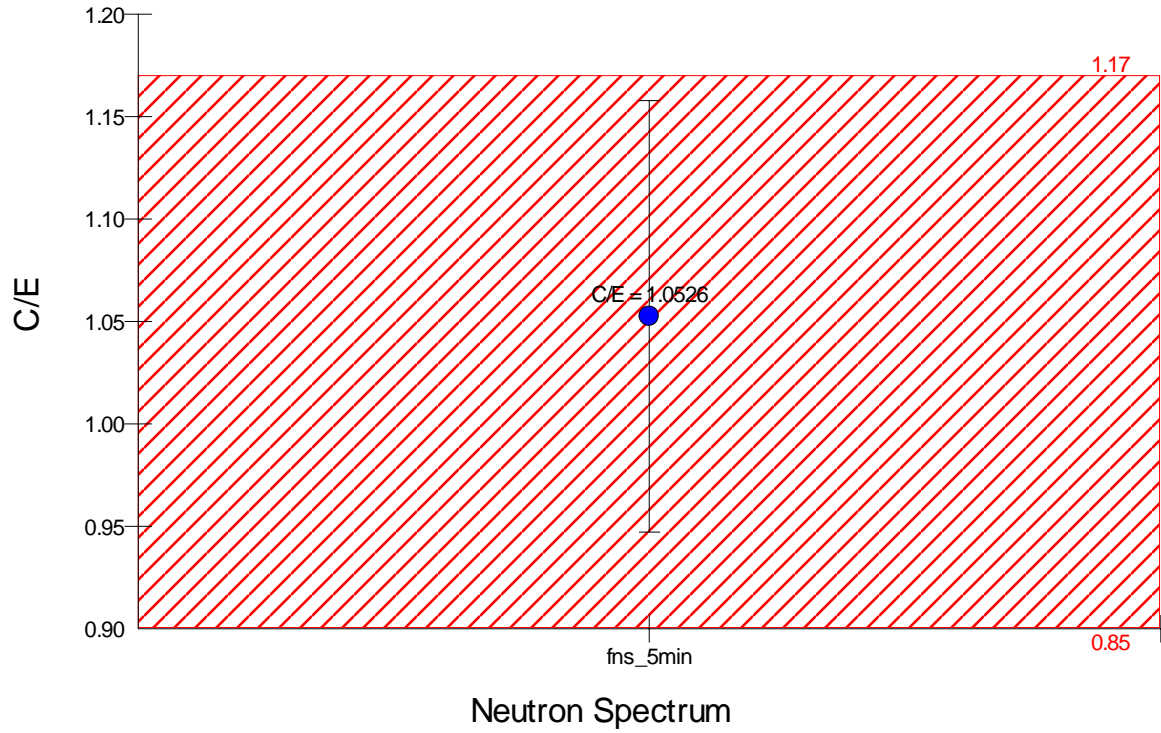
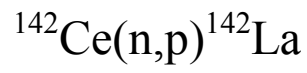
Neutron Spectrum

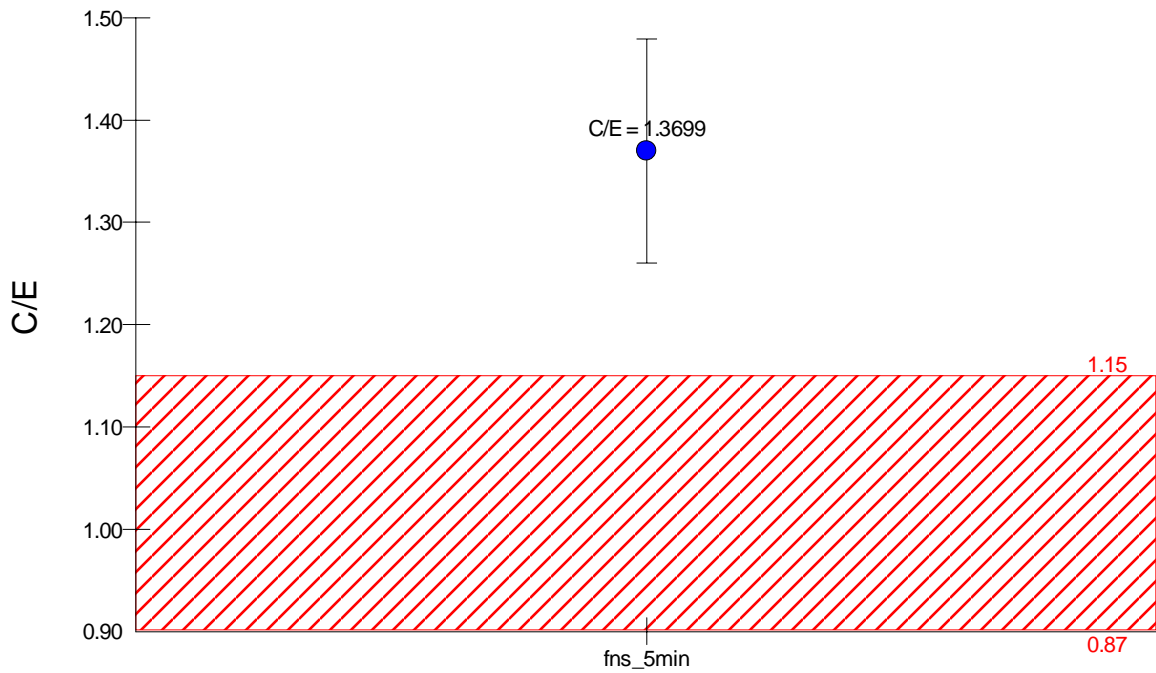
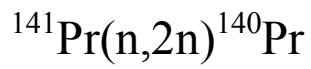




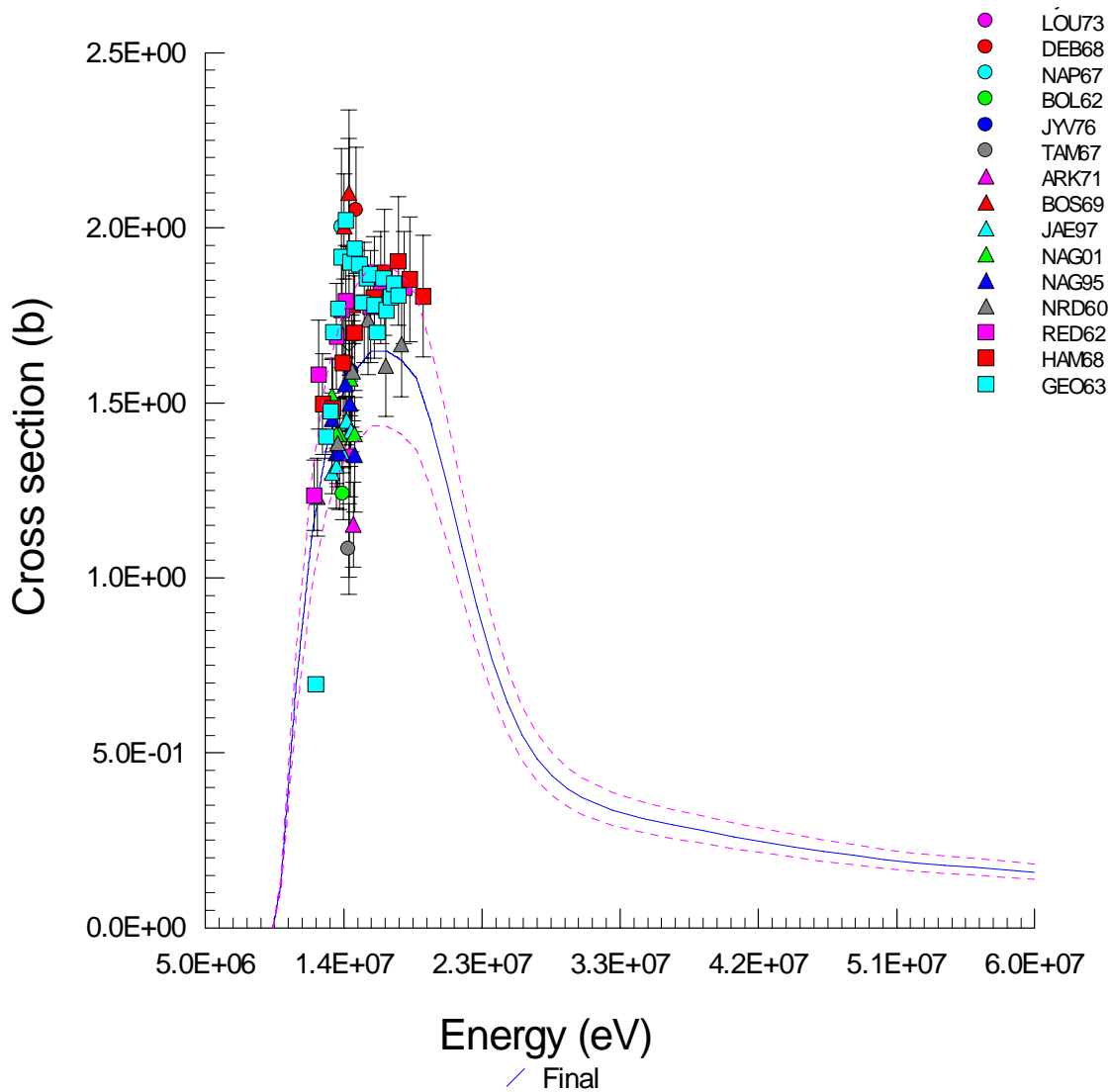
Neutron Spectrum

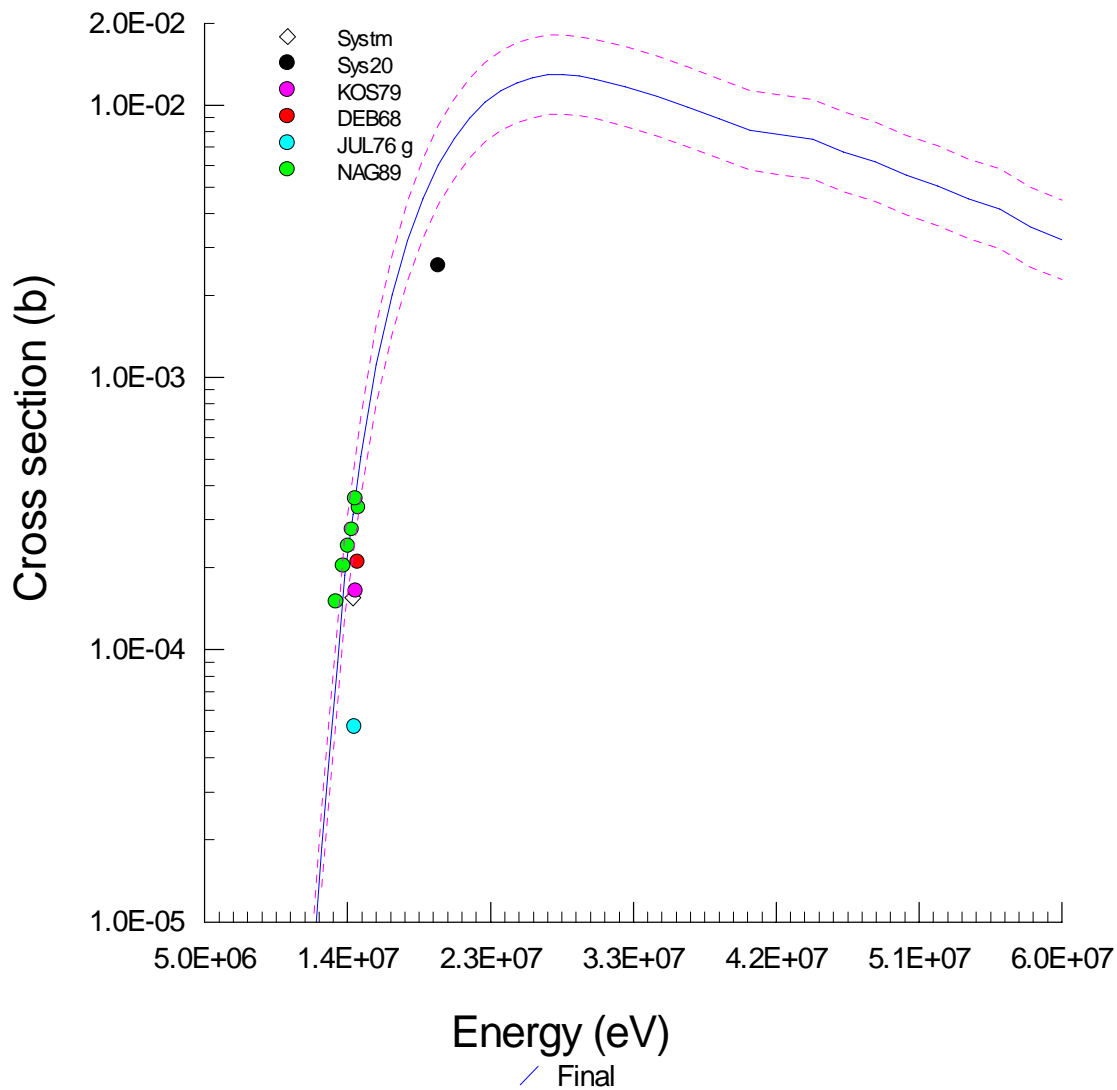
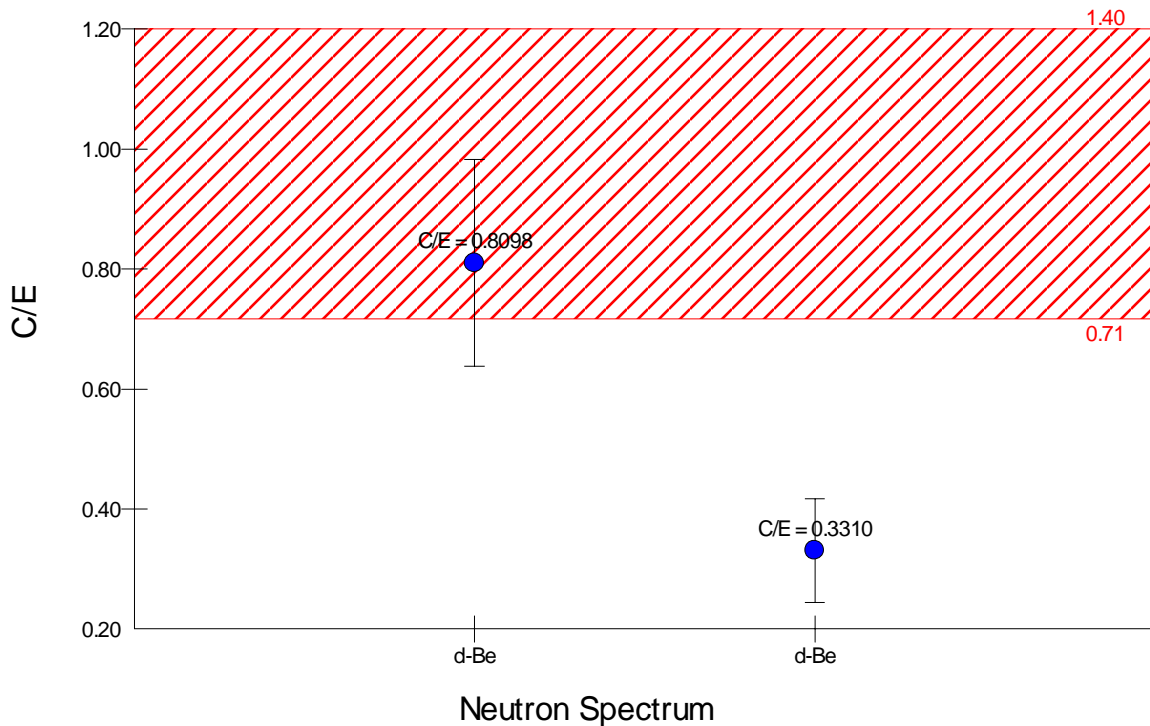
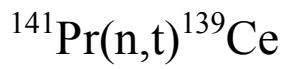


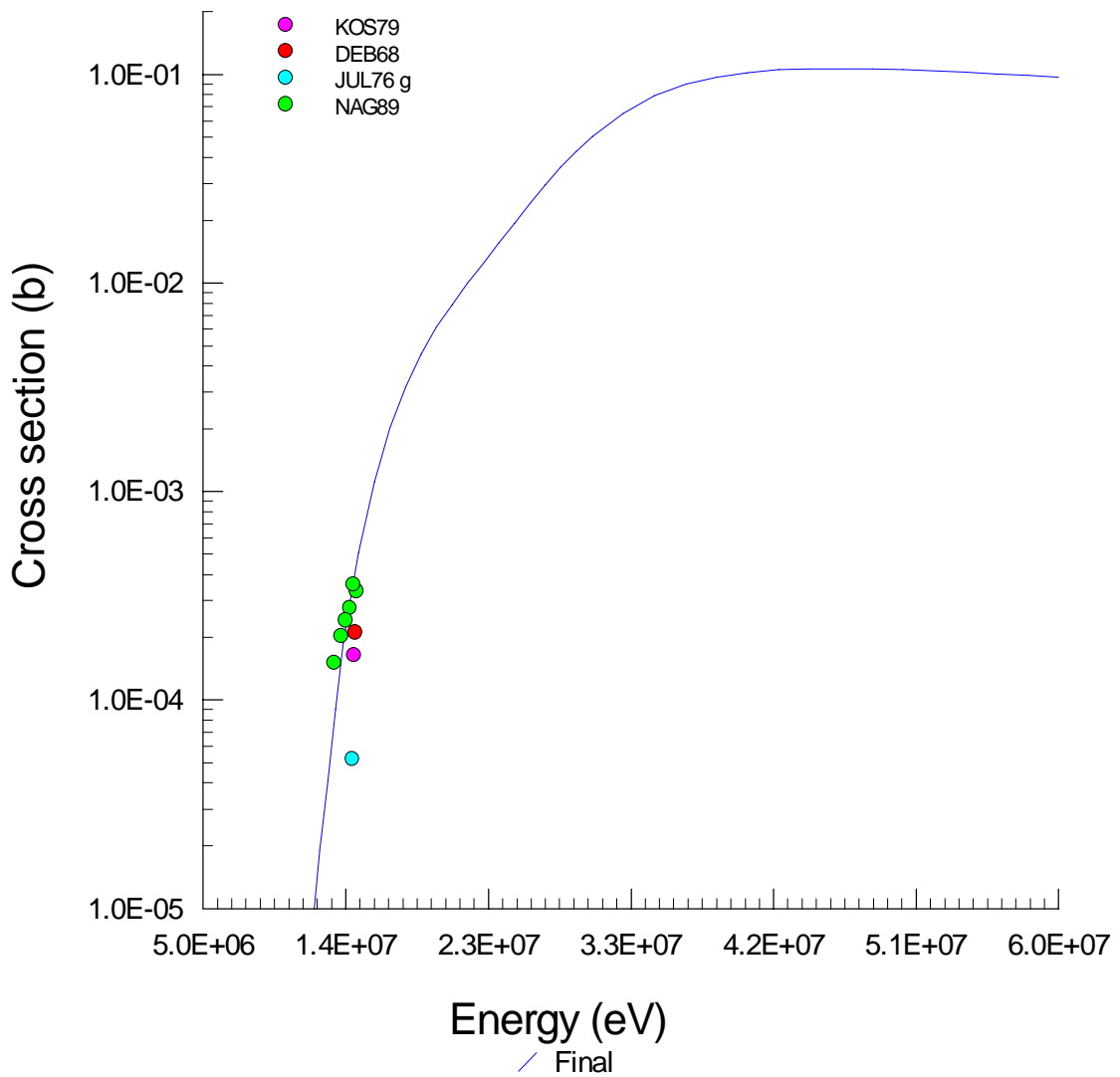
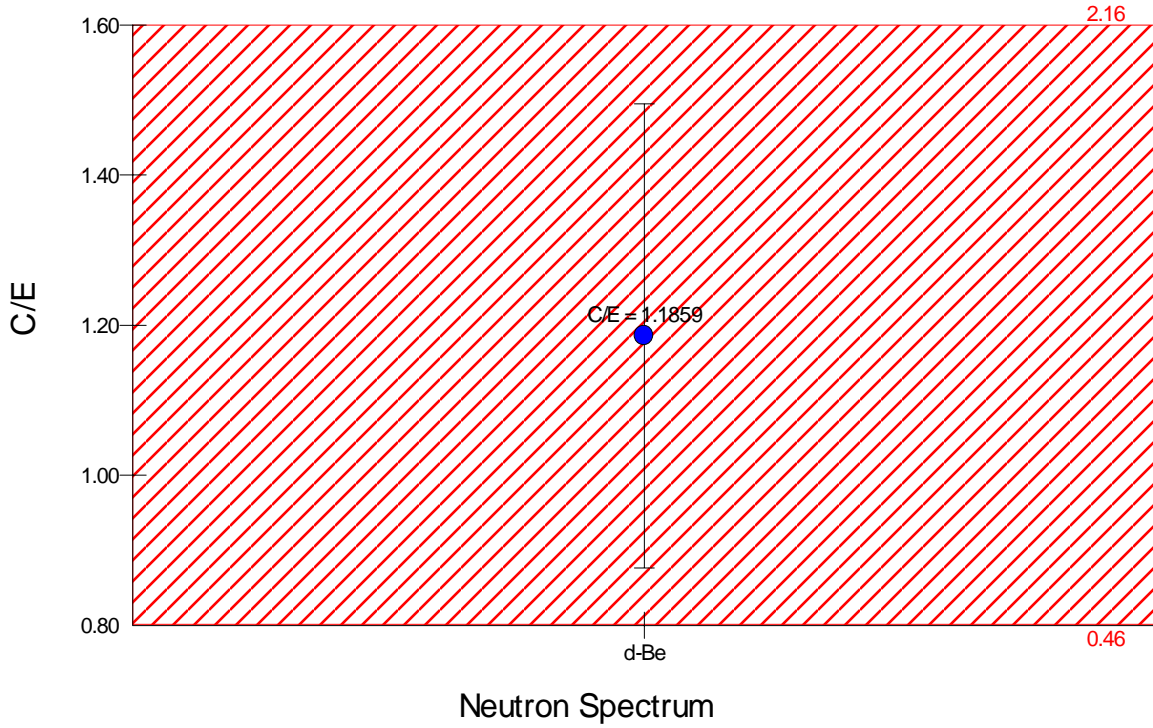
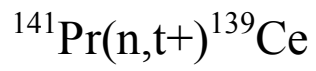




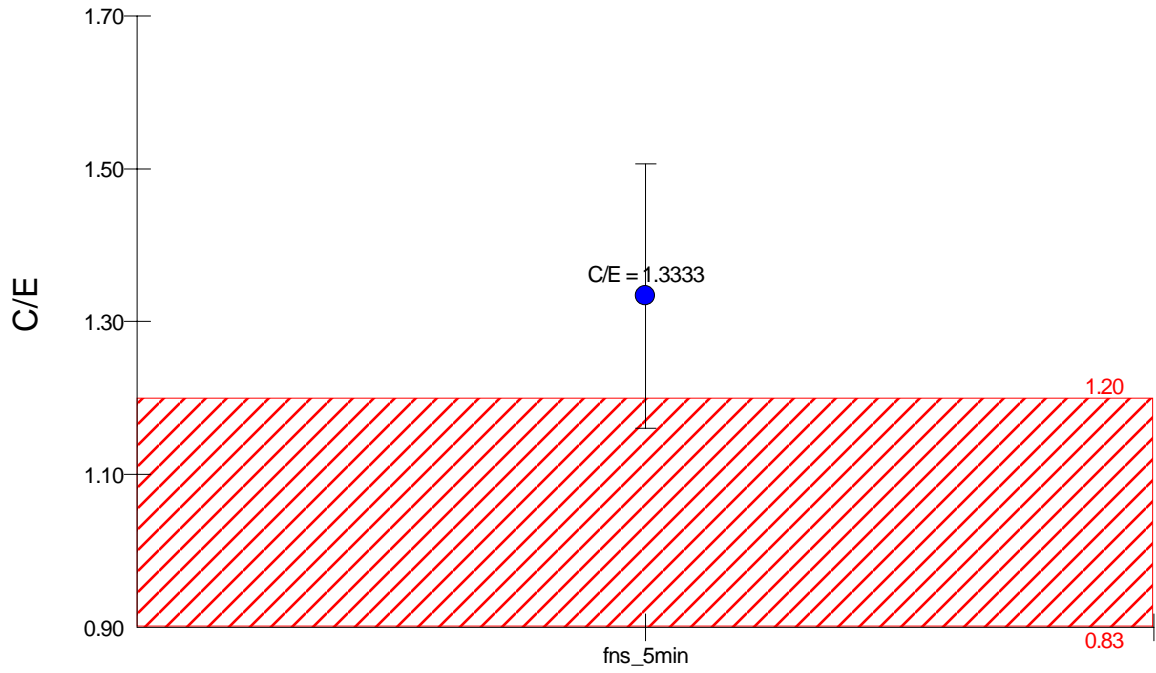
Neutron Spectrum



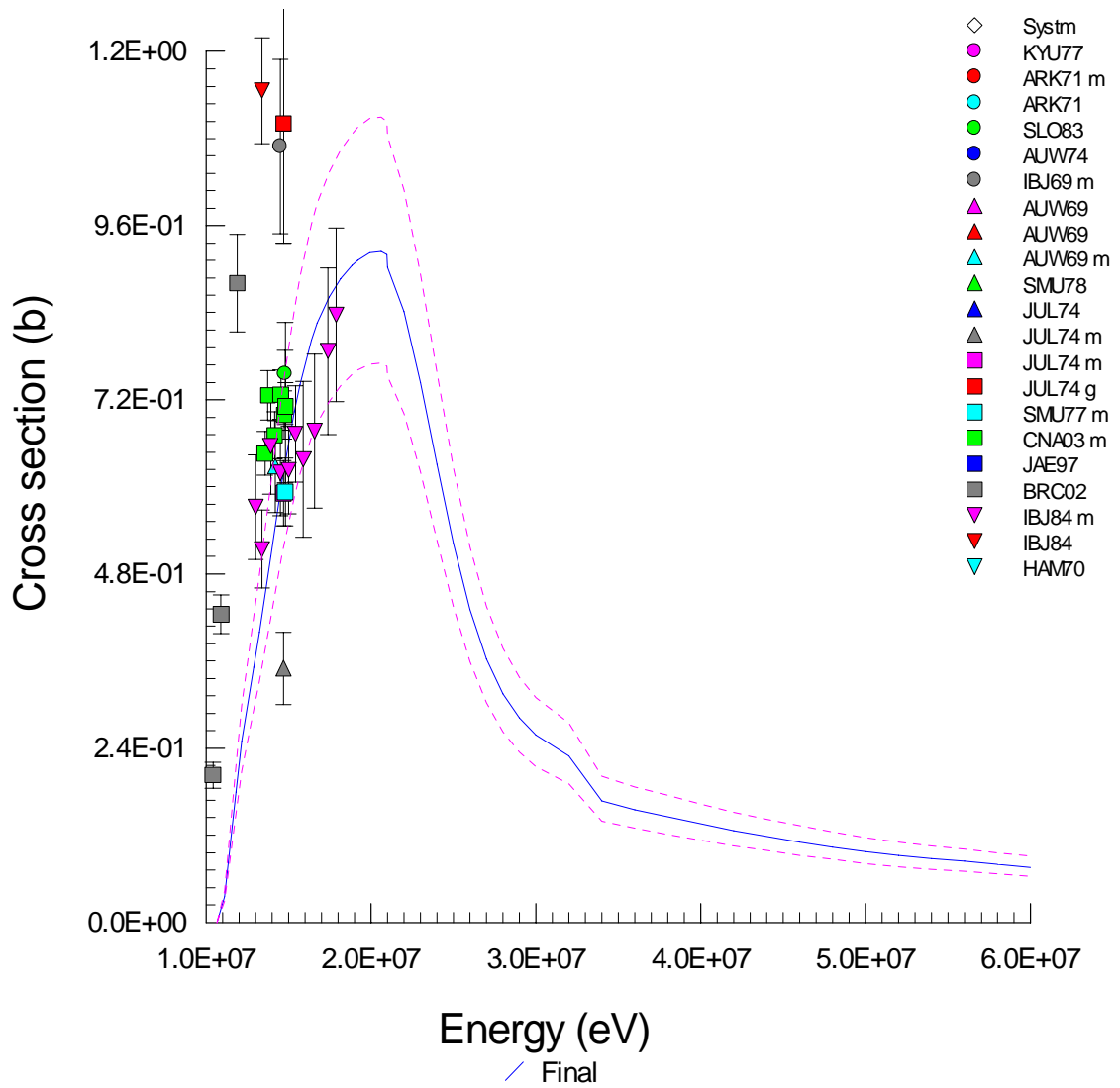




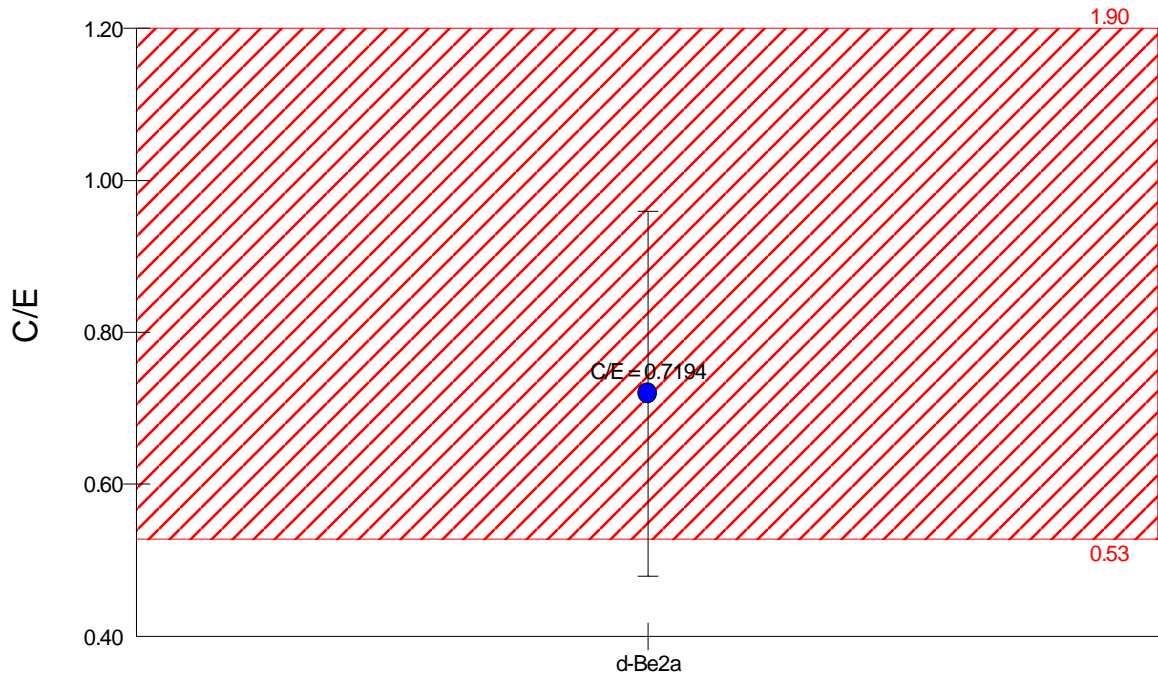
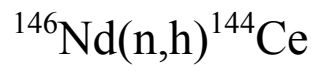
$^{142}\text{Nd}(n,2n)^{141\text{m}}\text{Nd}$



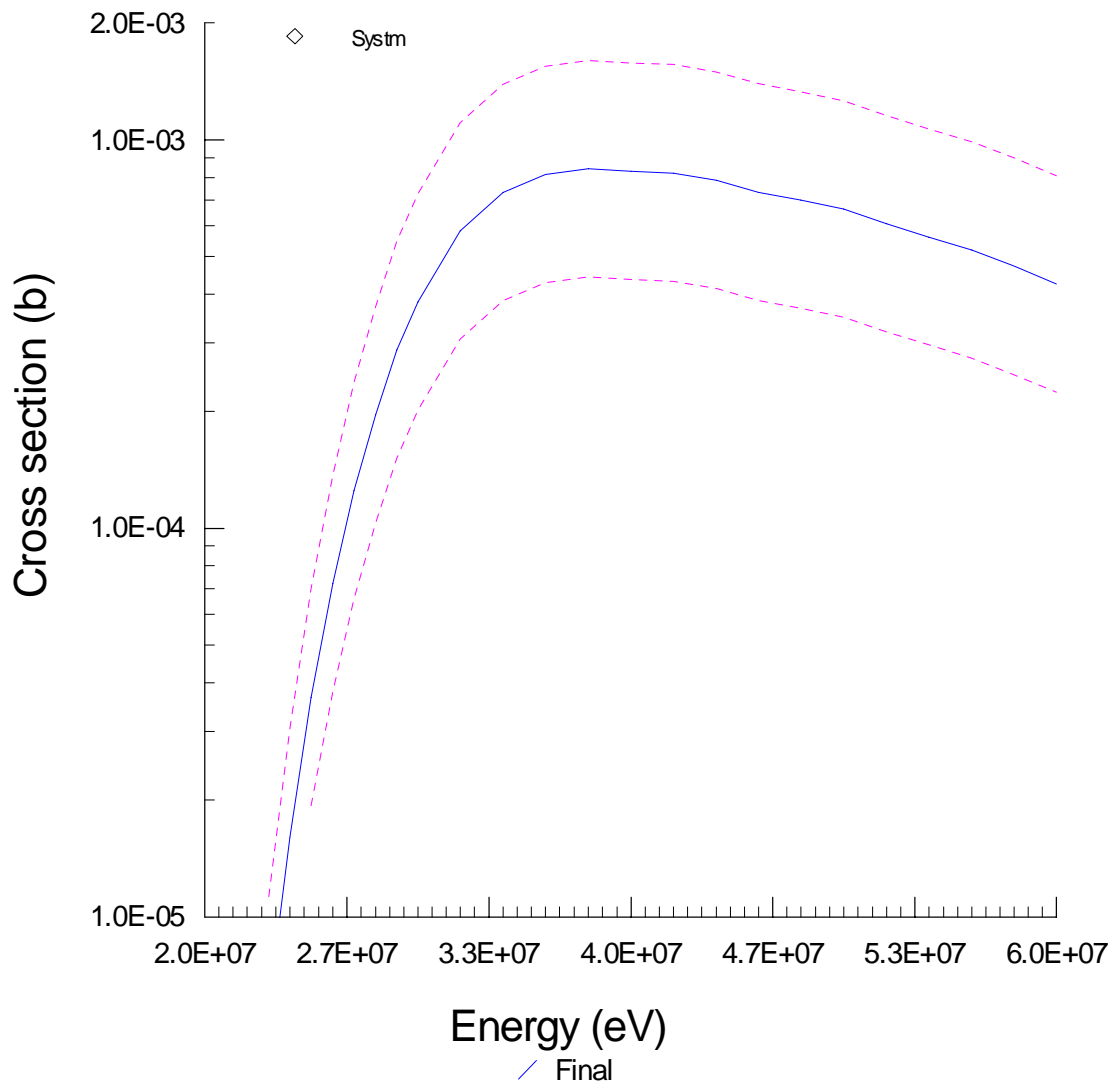
Neutron Spectrum

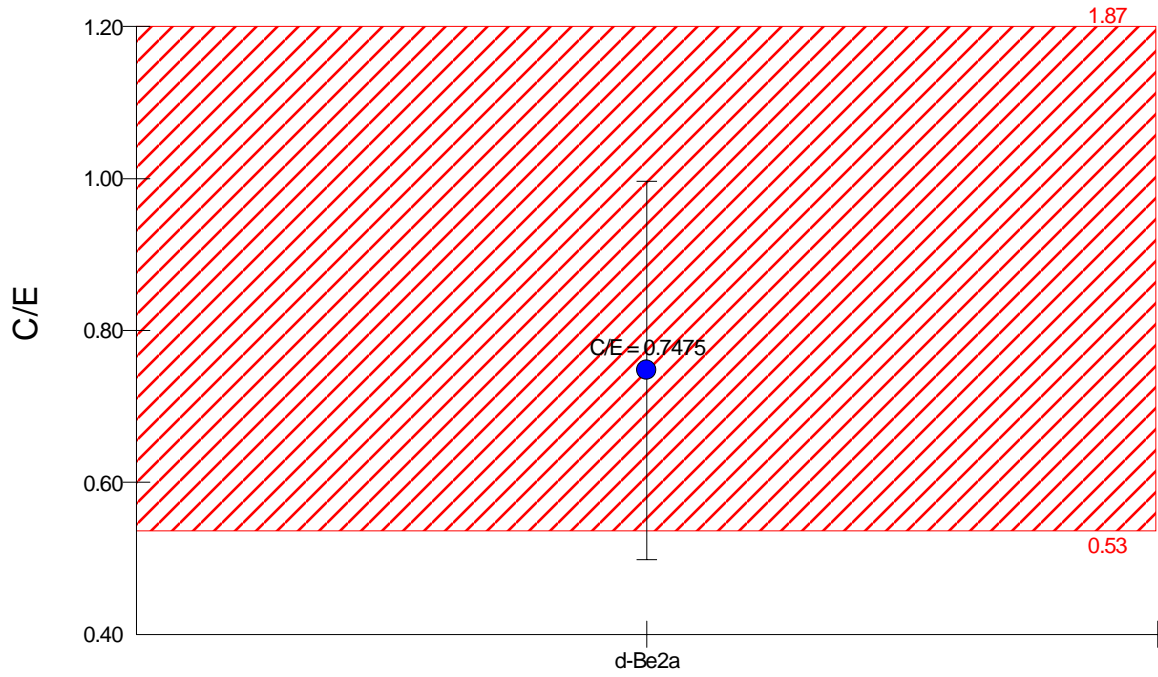
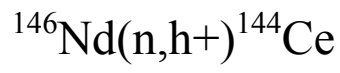




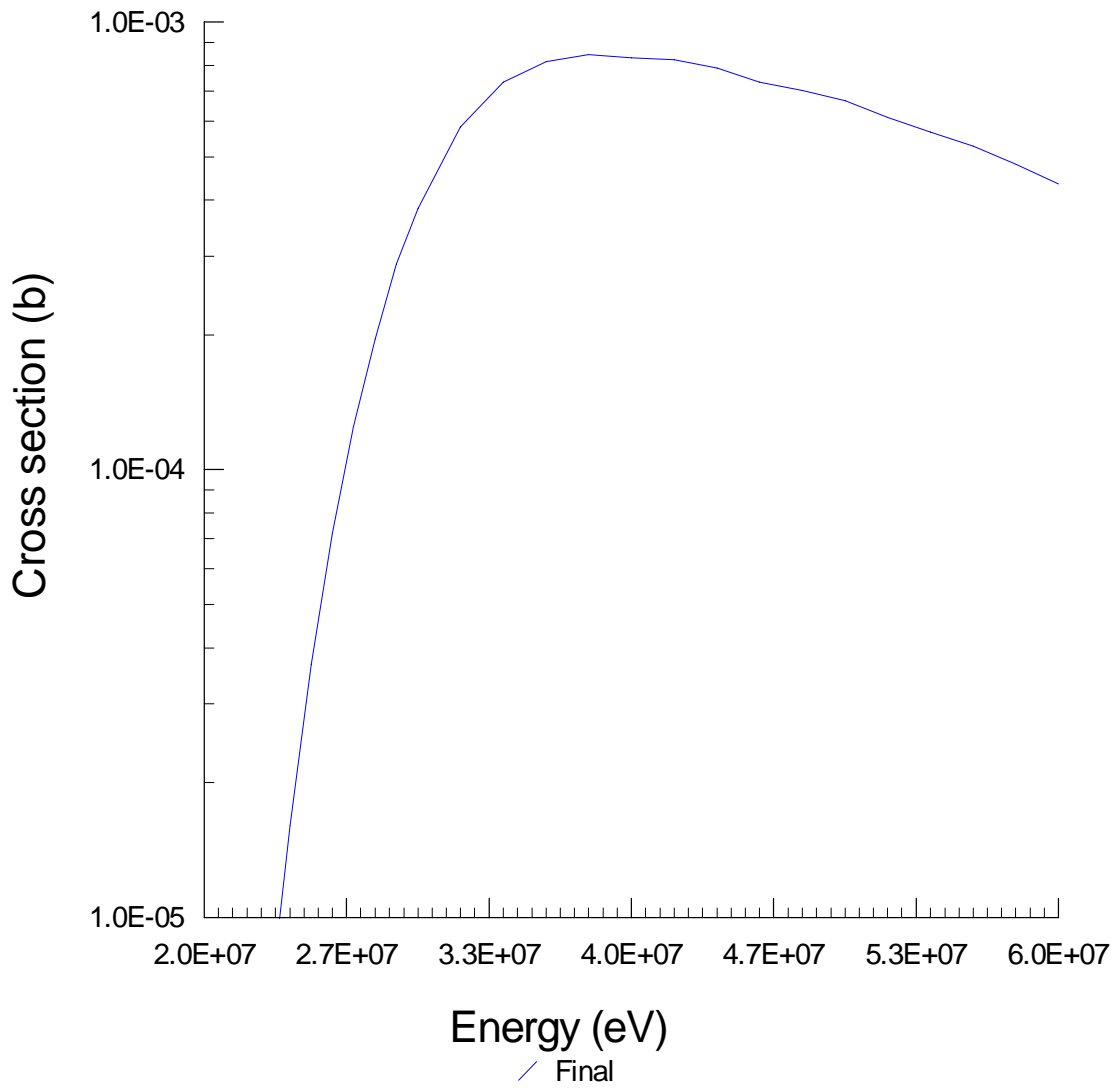


Neutron Spectrum

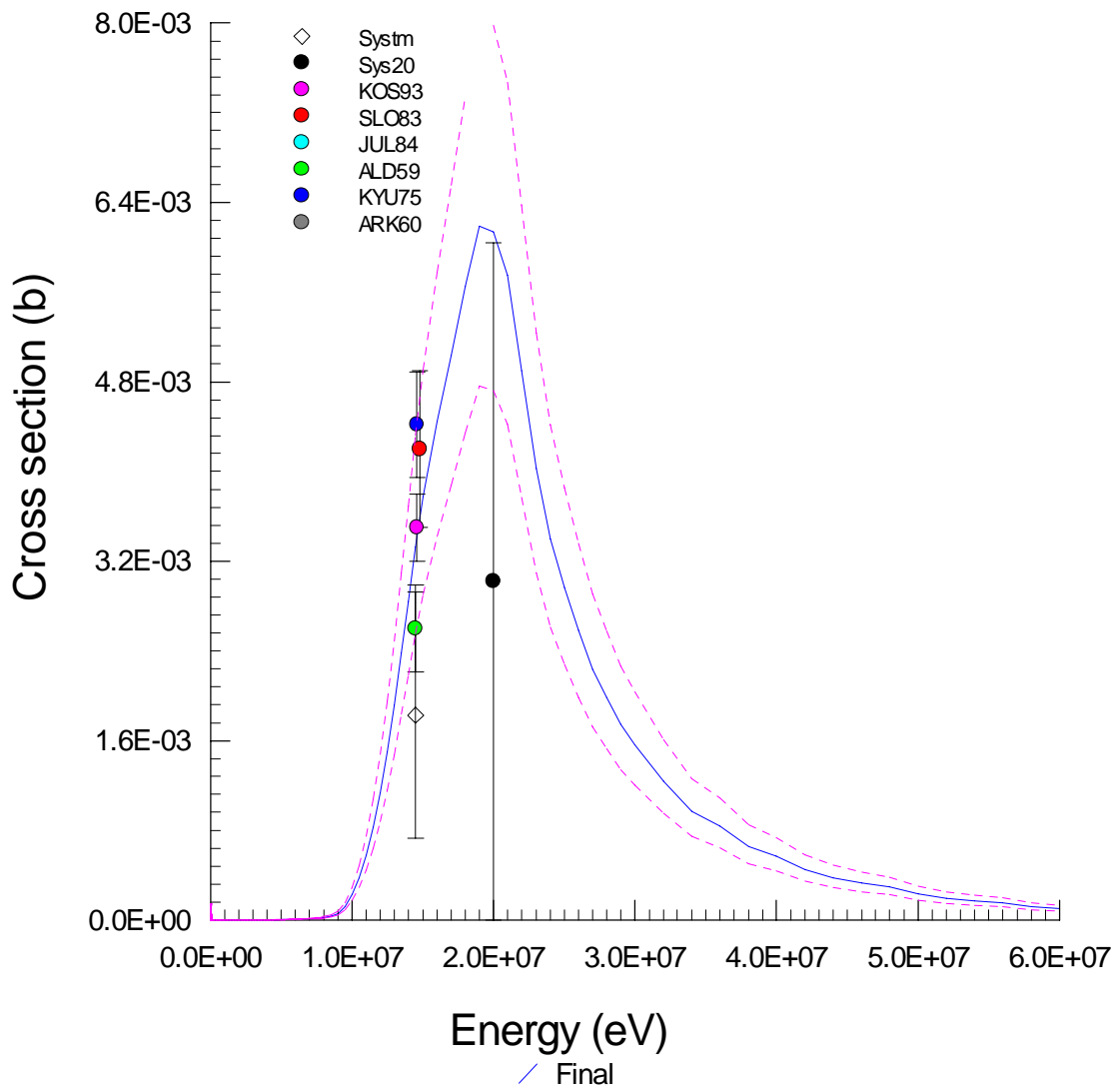
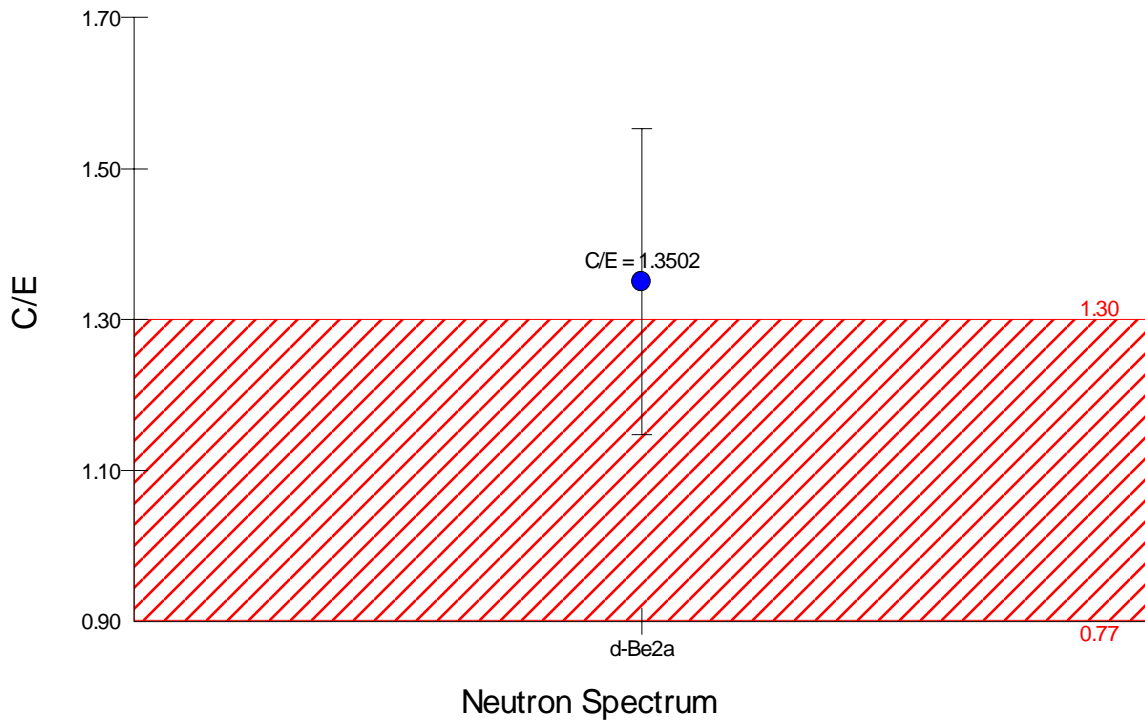
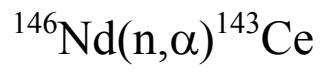


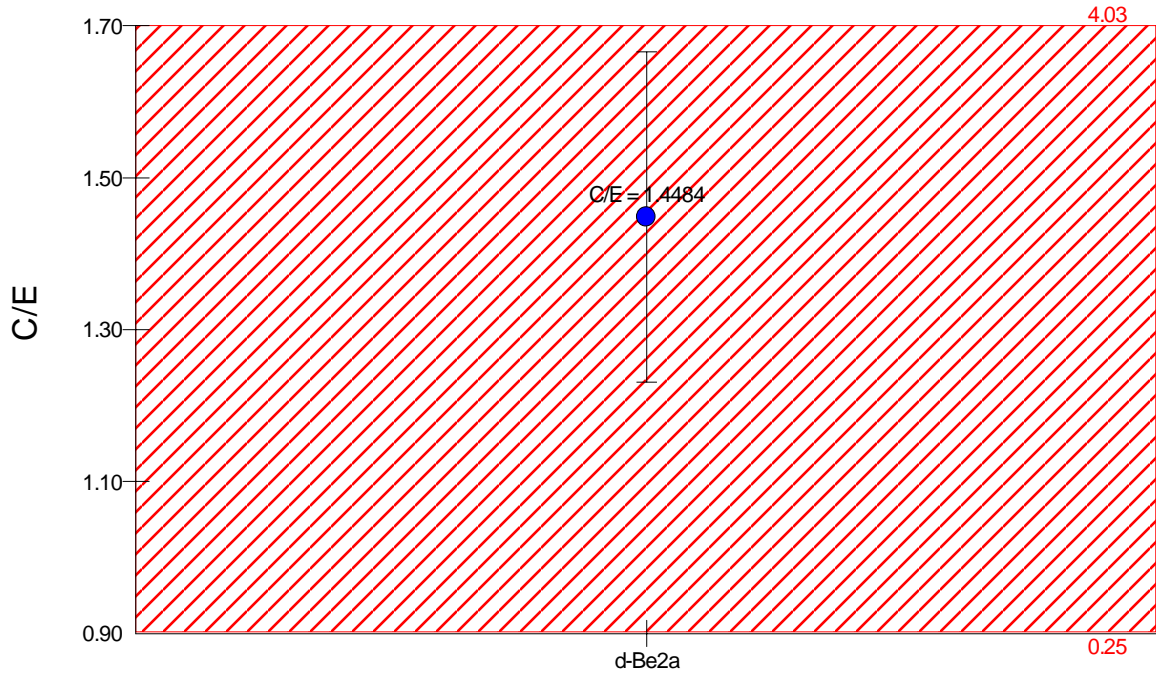
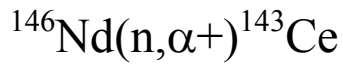


Neutron Spectrum

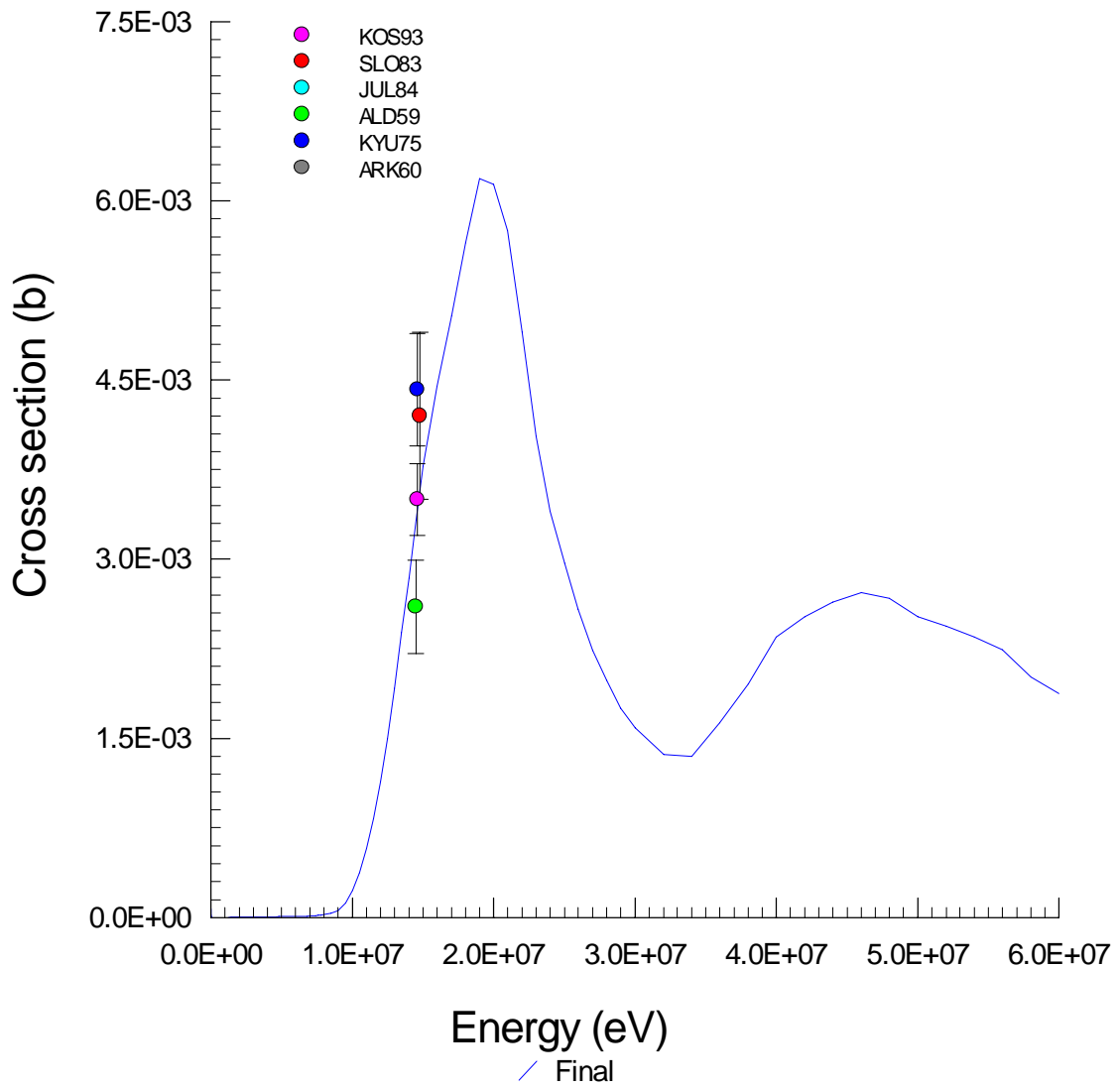


Final

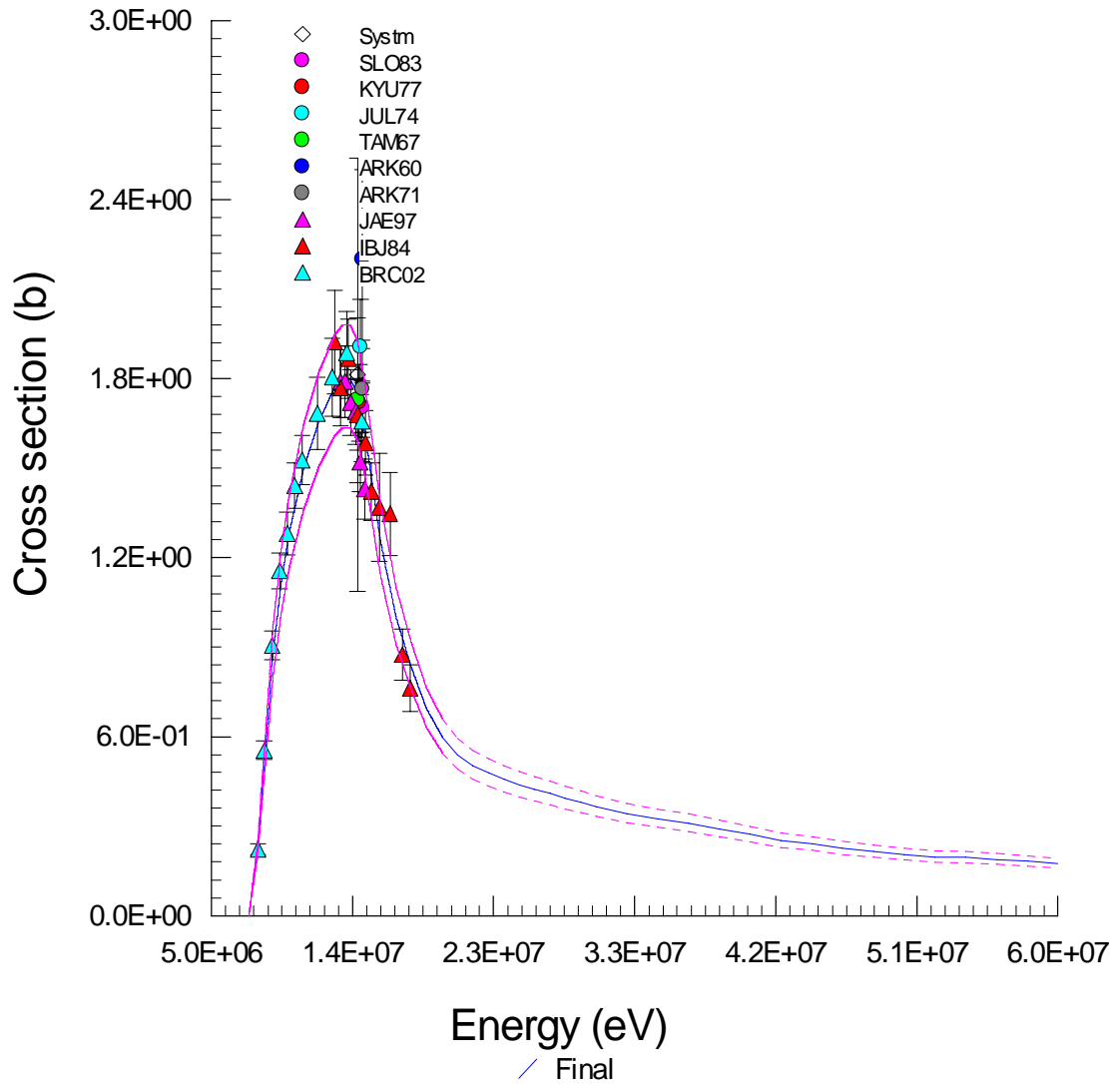
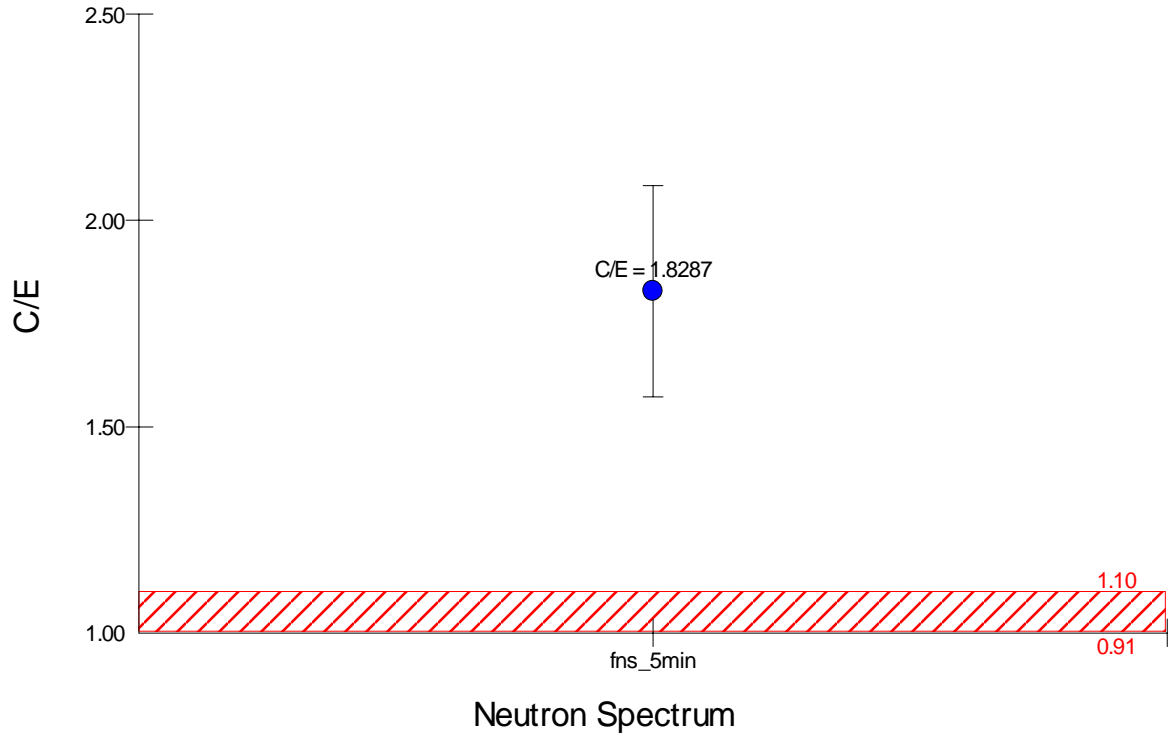


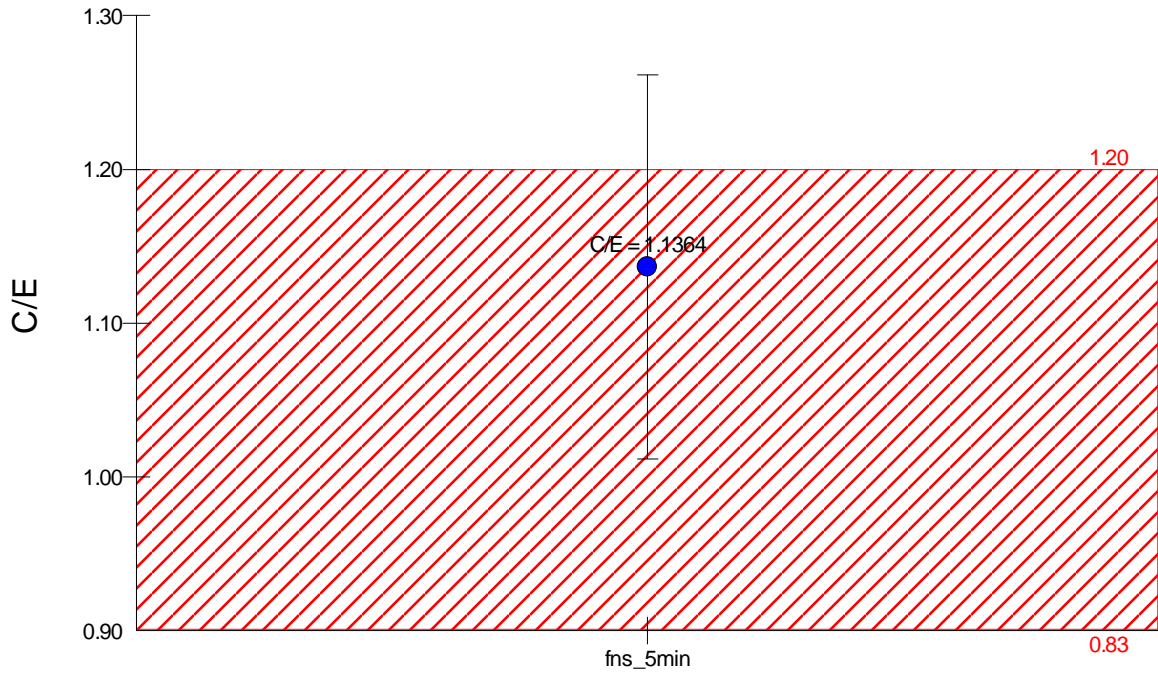
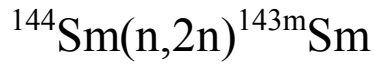


Neutron Spectrum

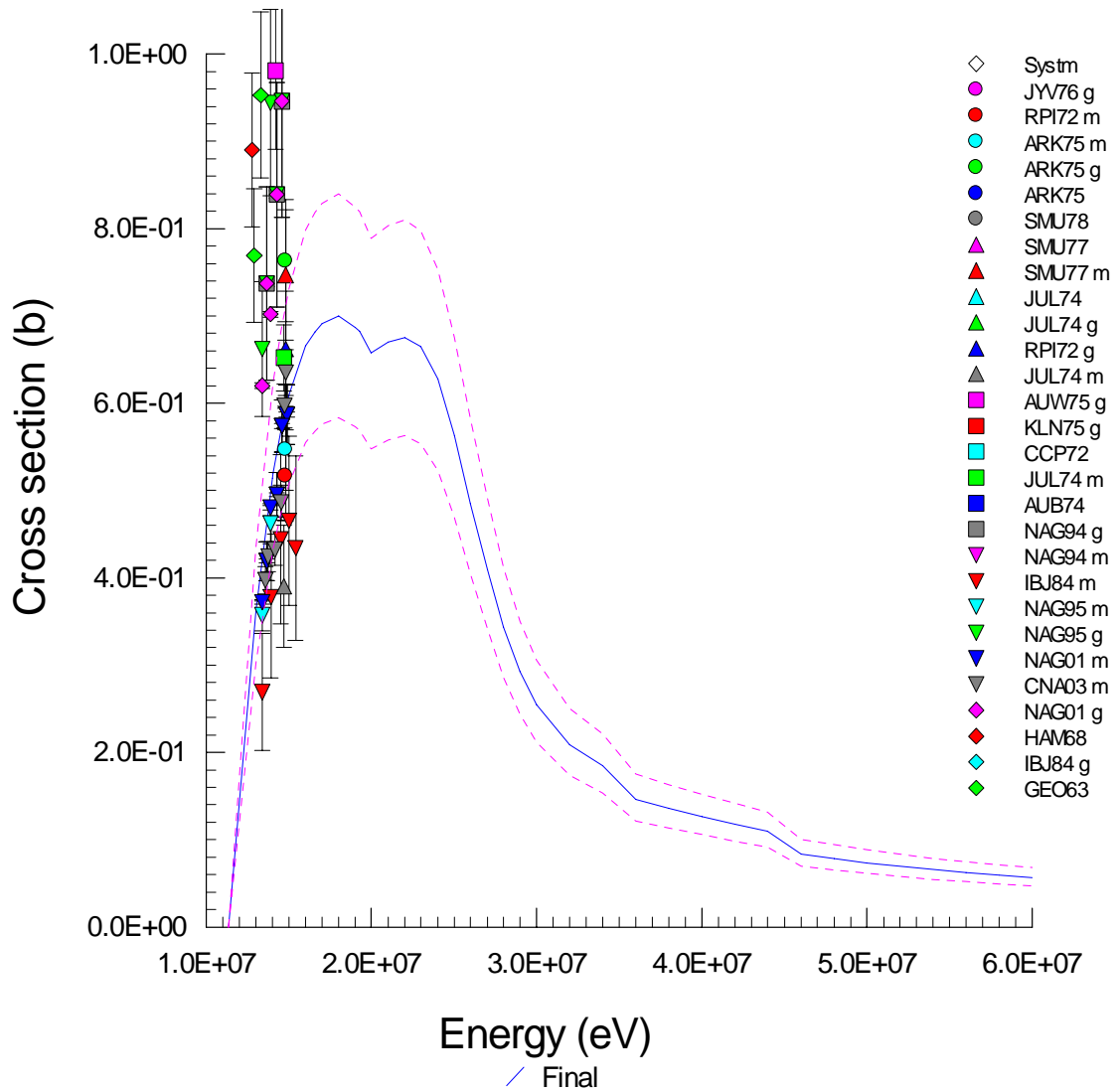


$^{150}\text{Nd}(n,2n)^{149}\text{Nd}$

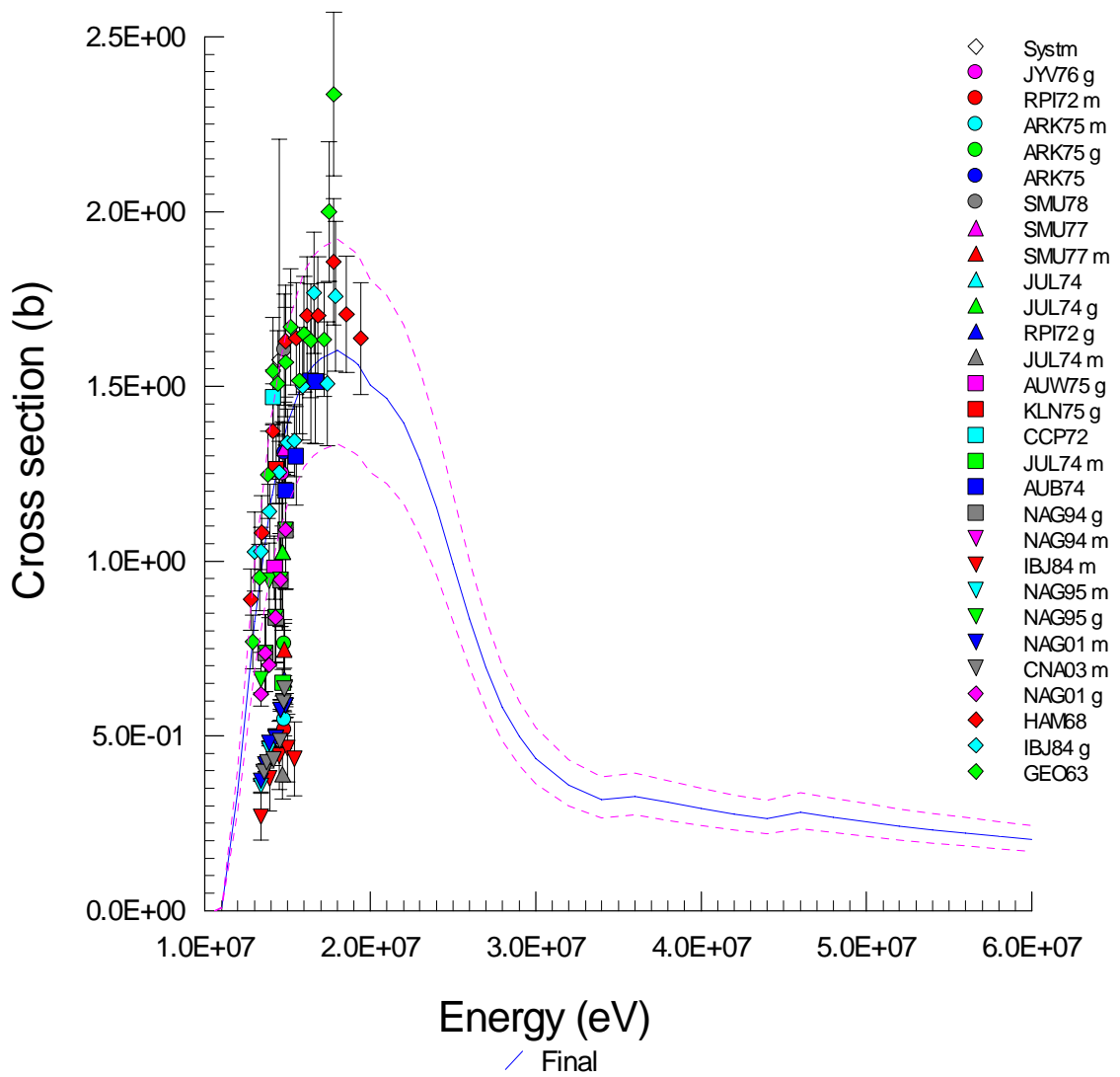
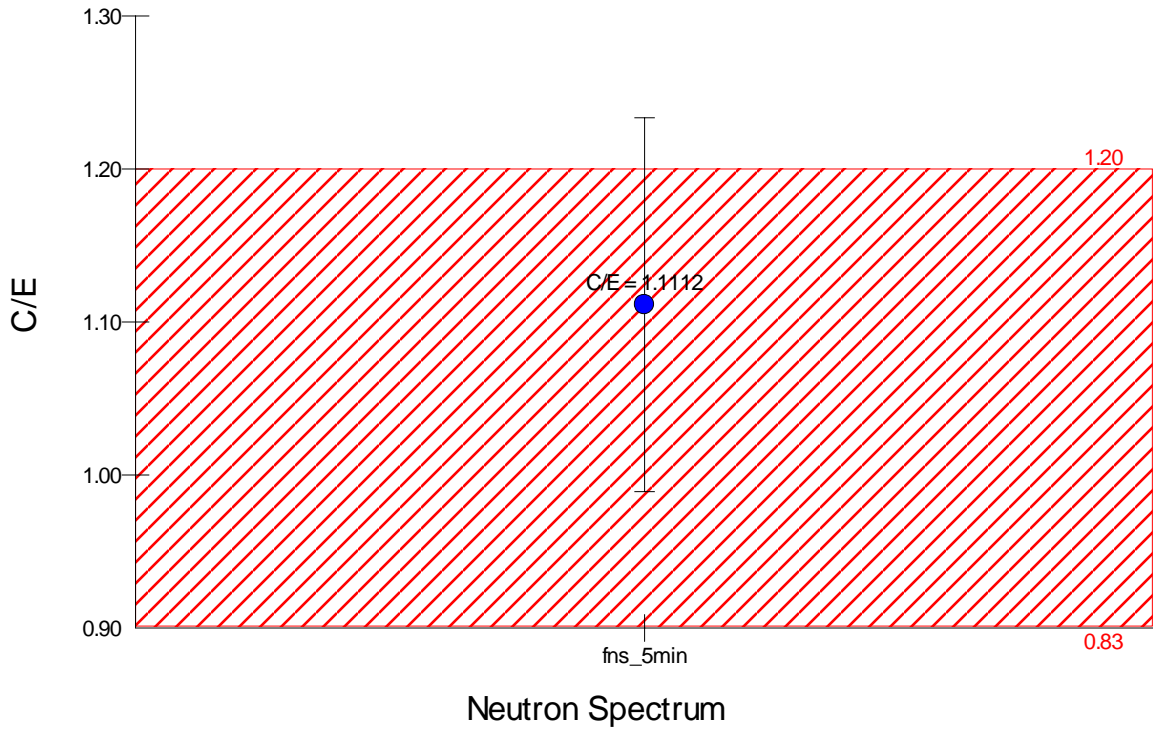




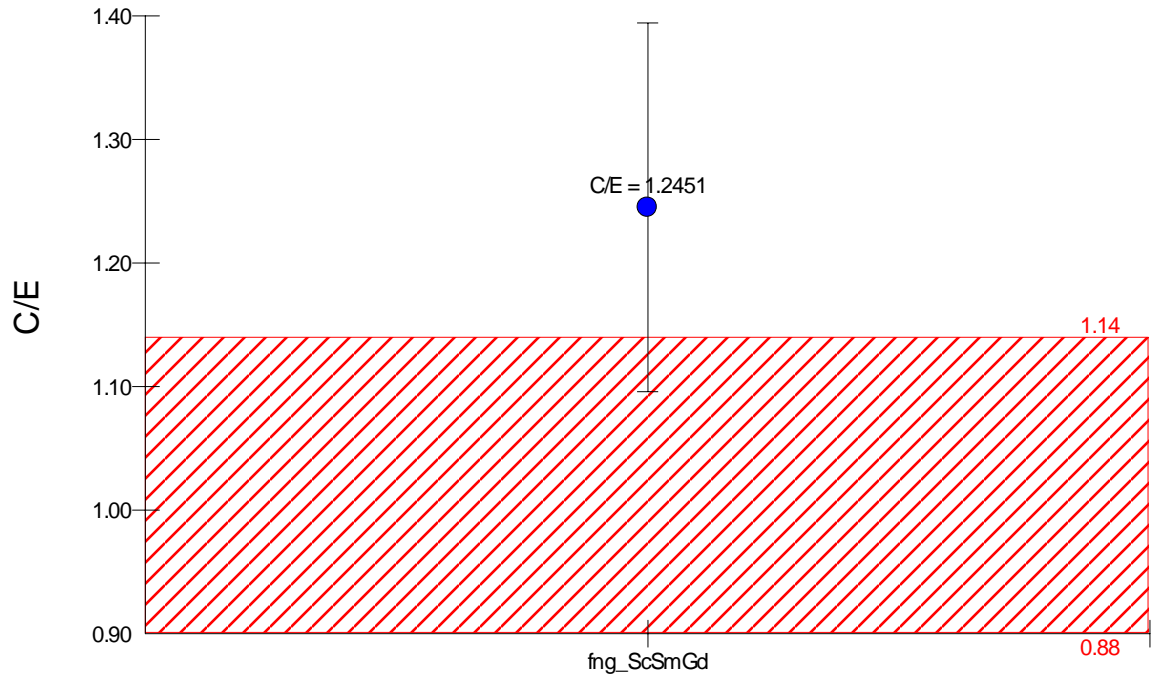
Neutron Spectrum



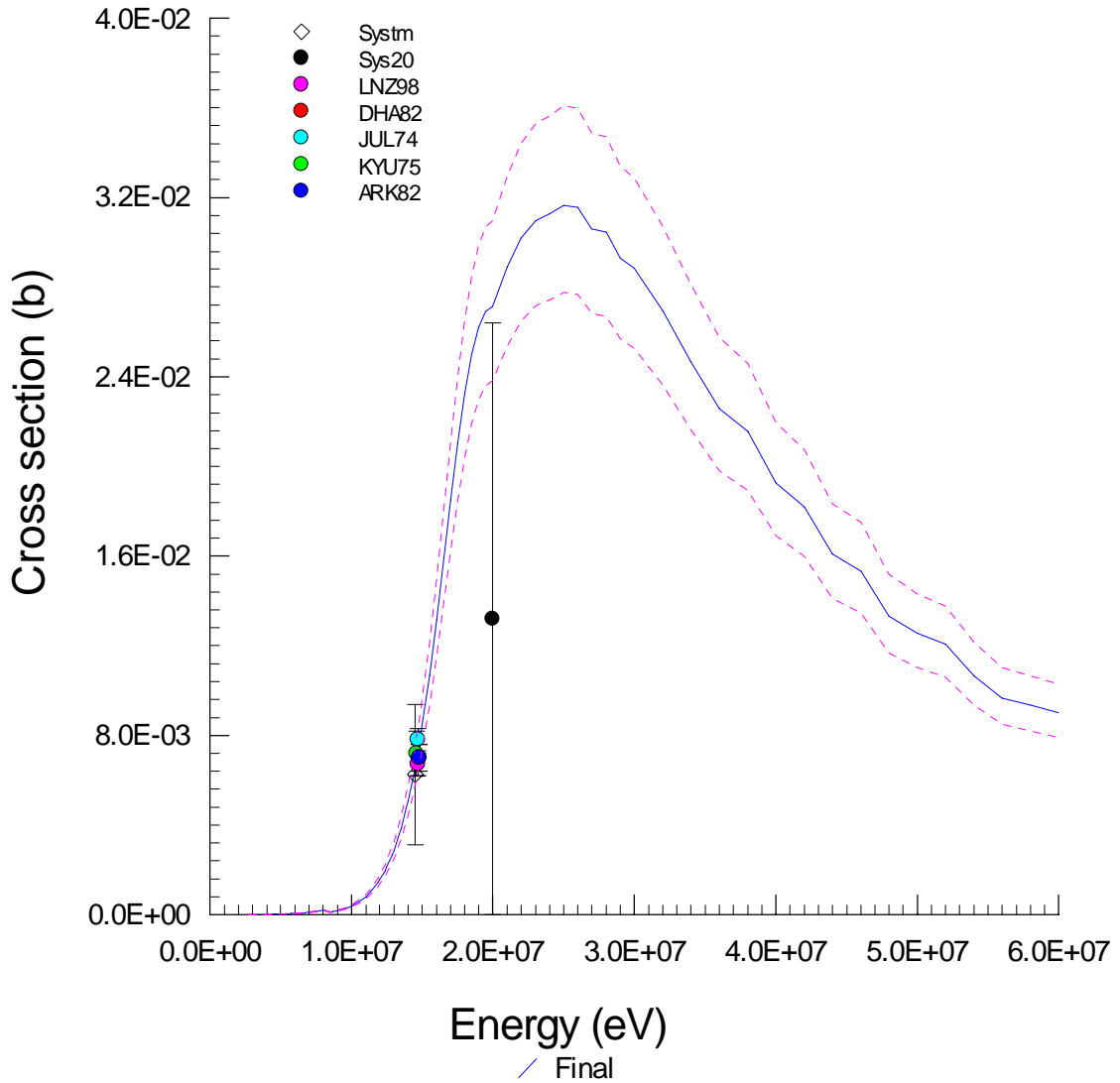
$^{144}\text{Sm}(n,2n)^{143}\text{Sm}$



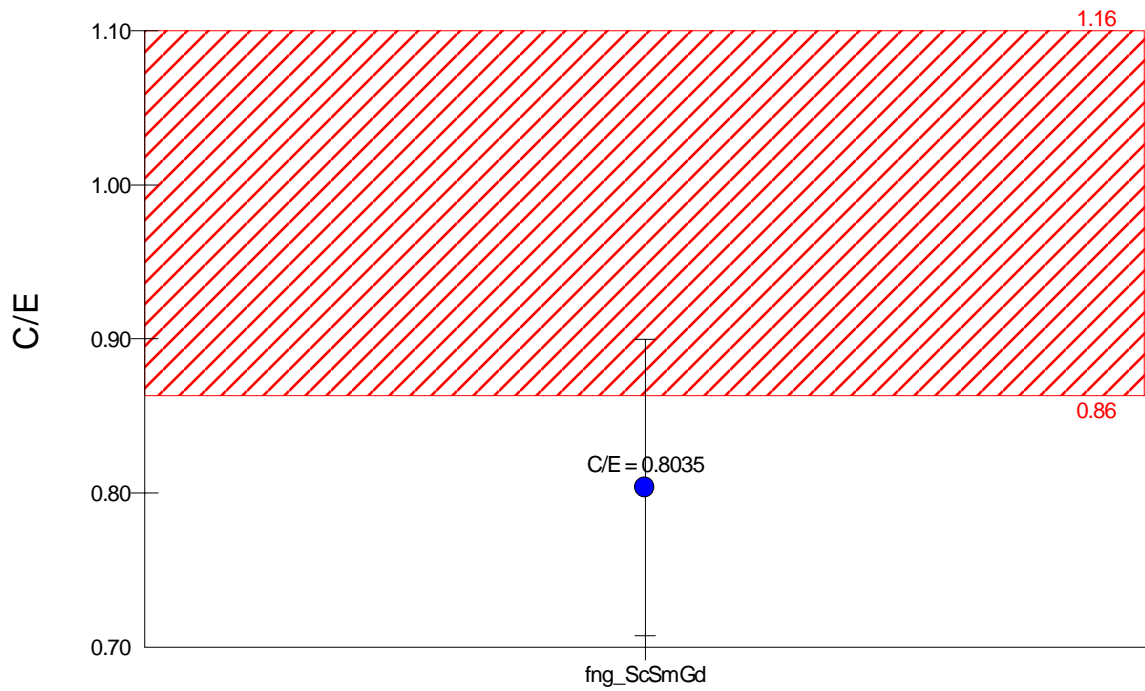
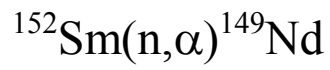
$^{150}\text{Sm}(n,p)^{150}\text{Pm}$



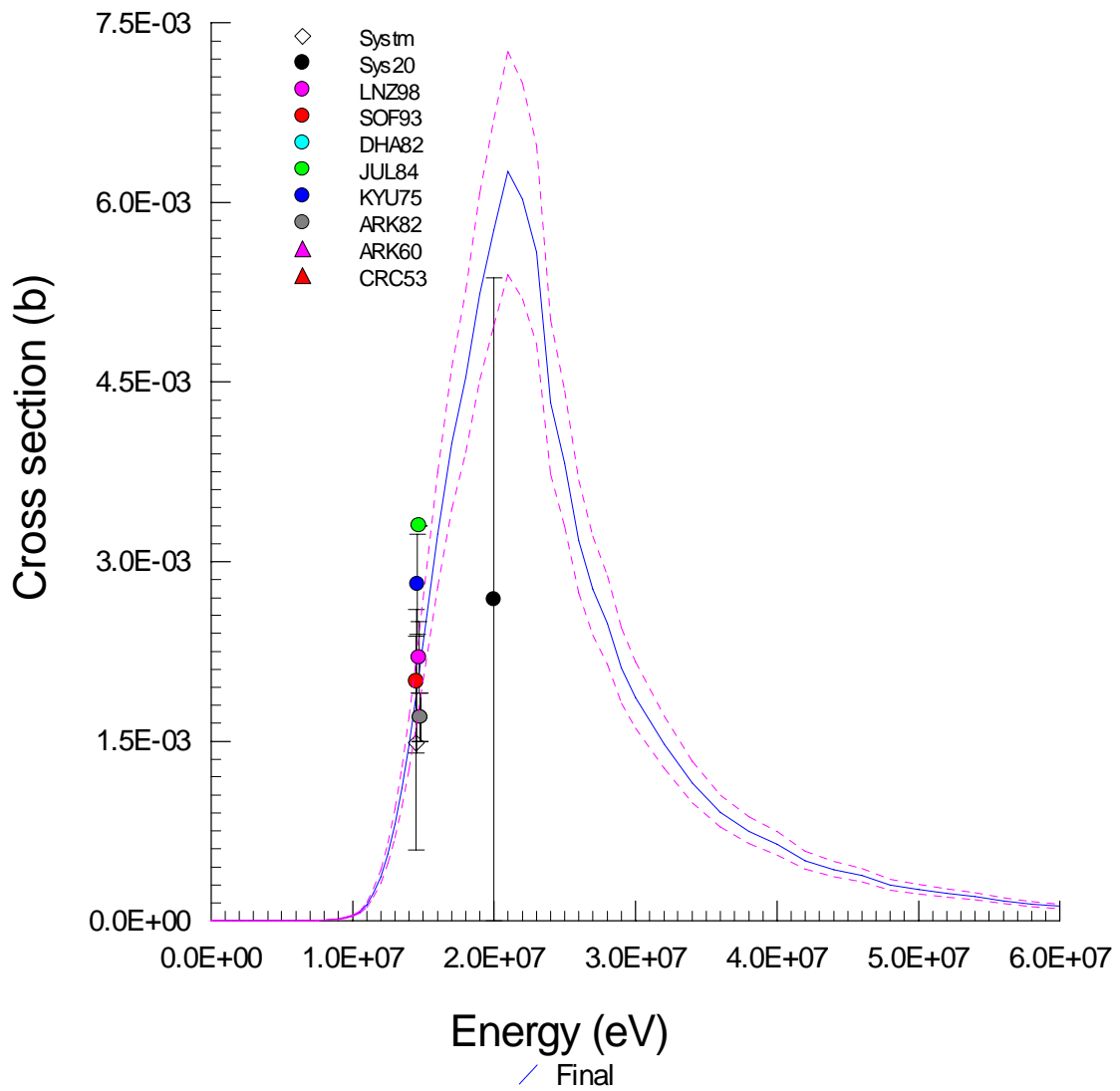
Neutron Spectrum



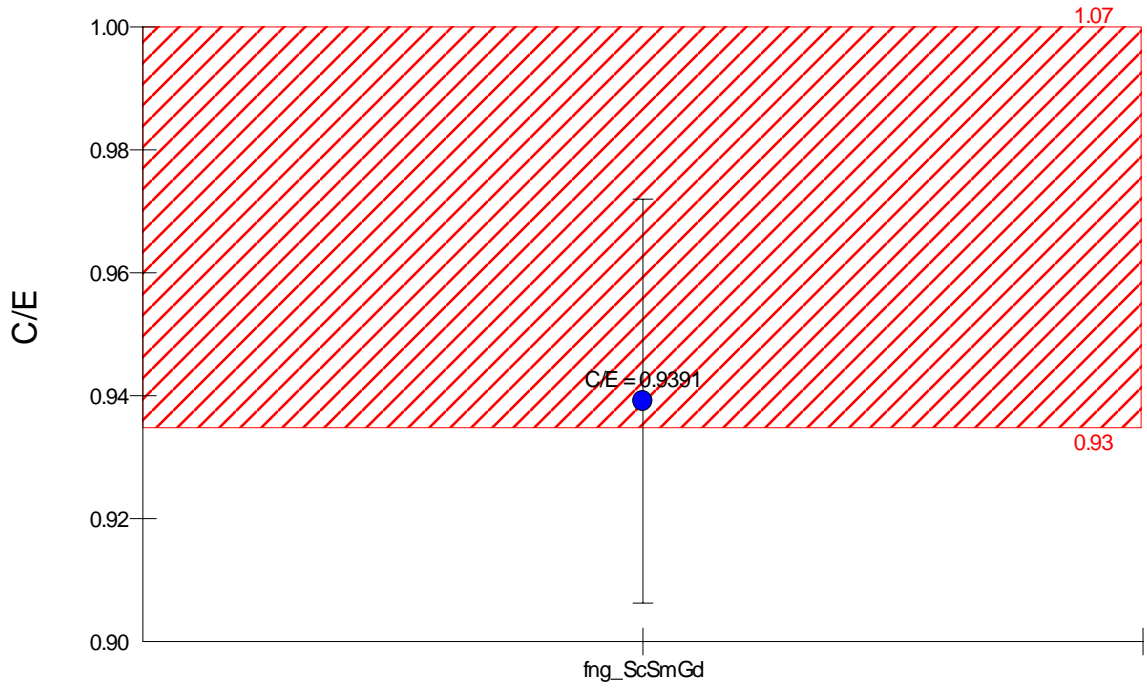




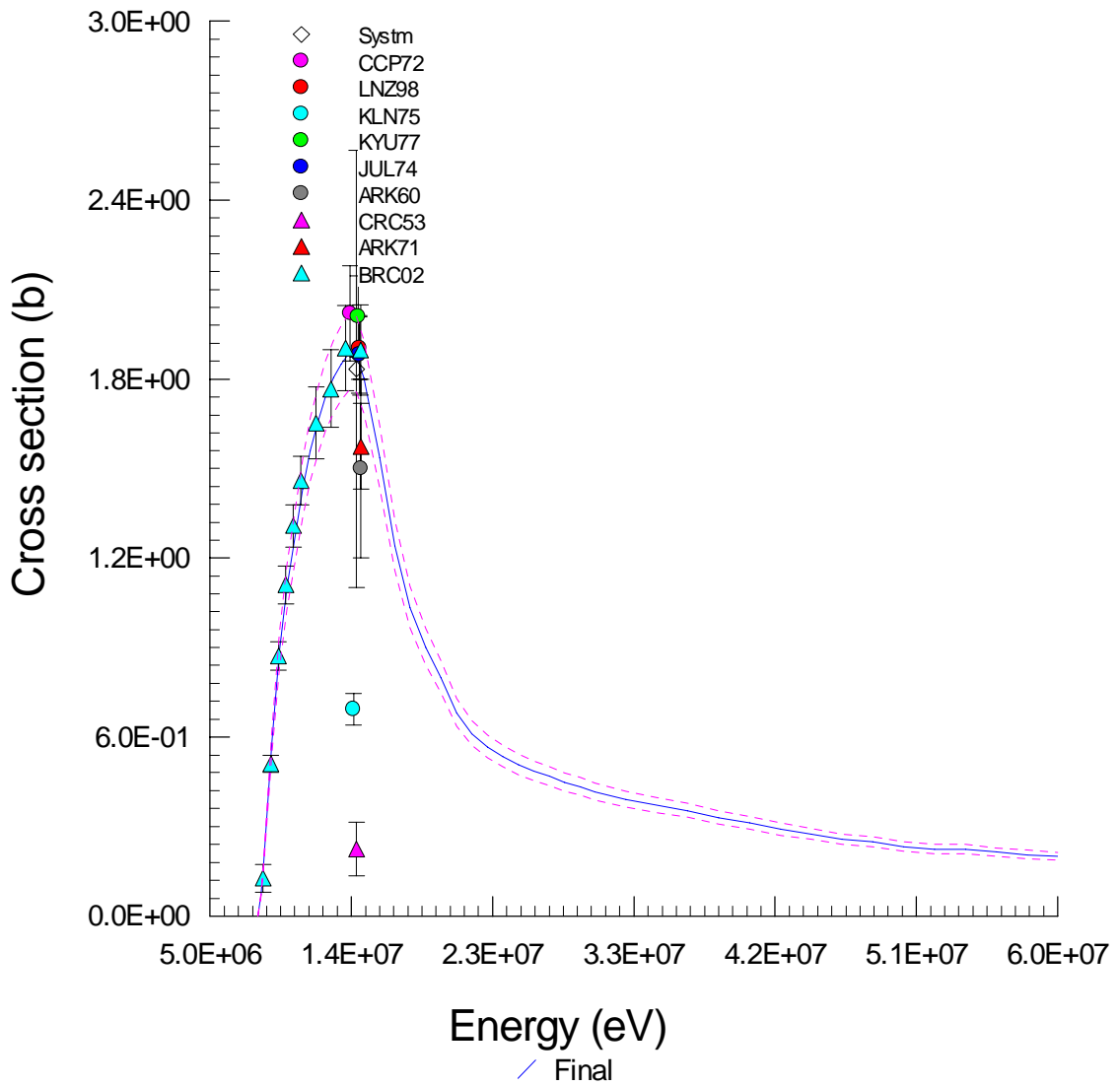
Neutron Spectrum

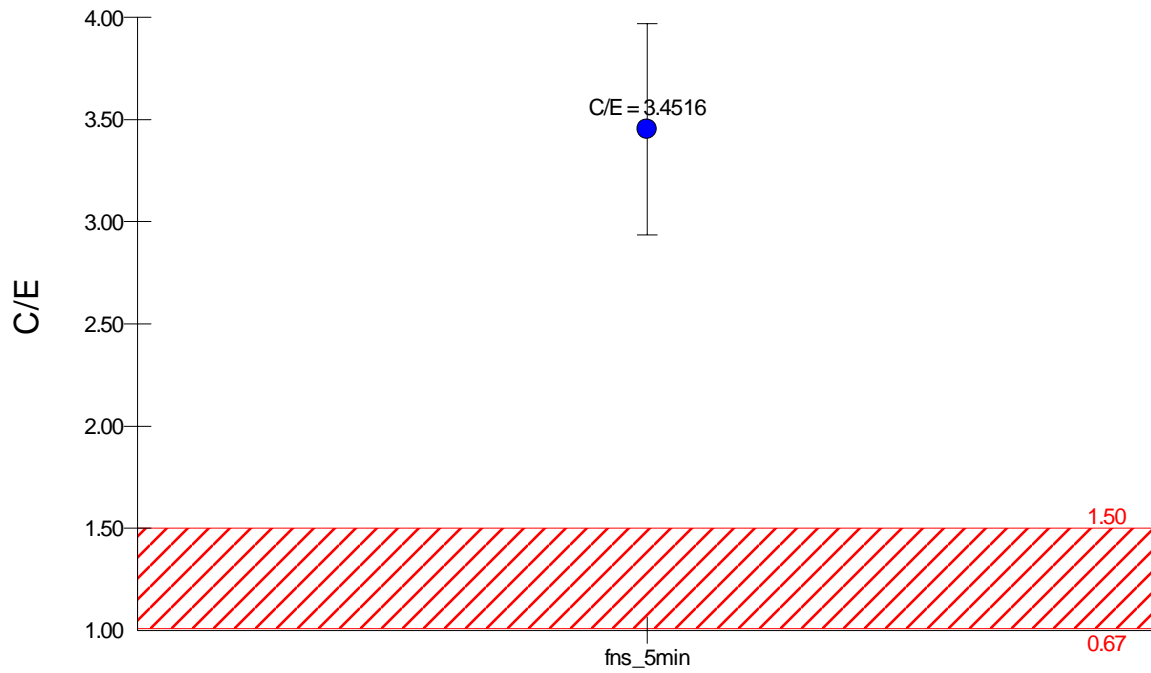
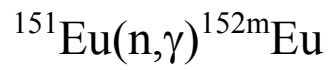


$^{154}\text{Sm}(n,2n)^{153}\text{Sm}$

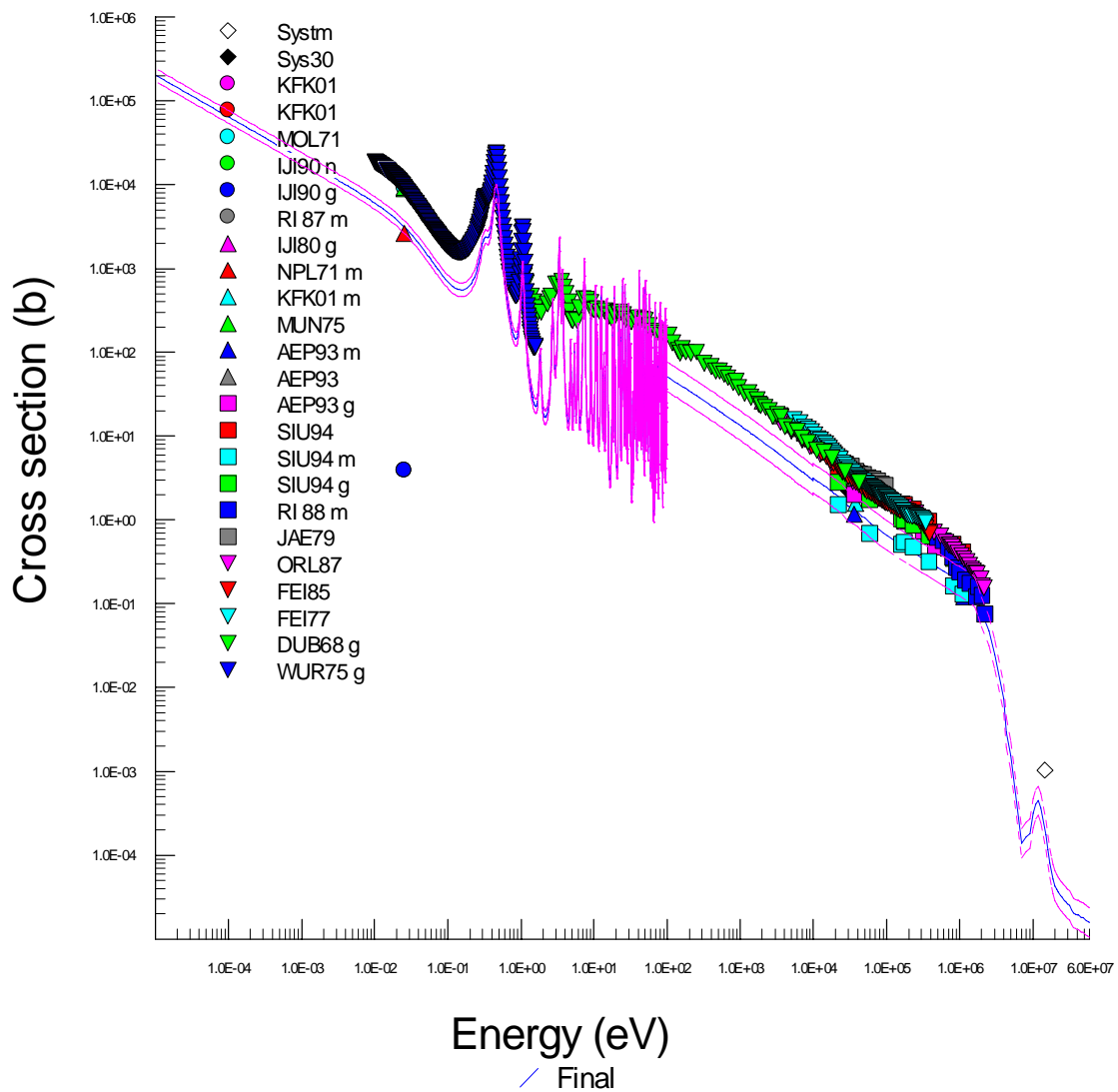


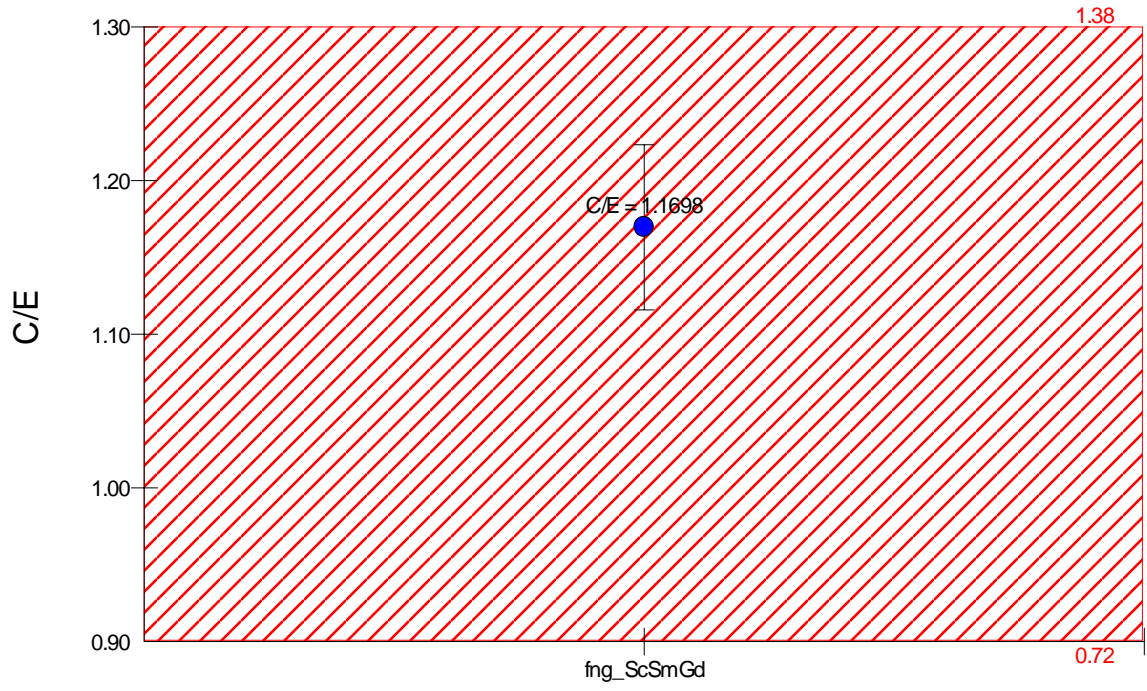
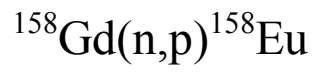
Neutron Spectrum



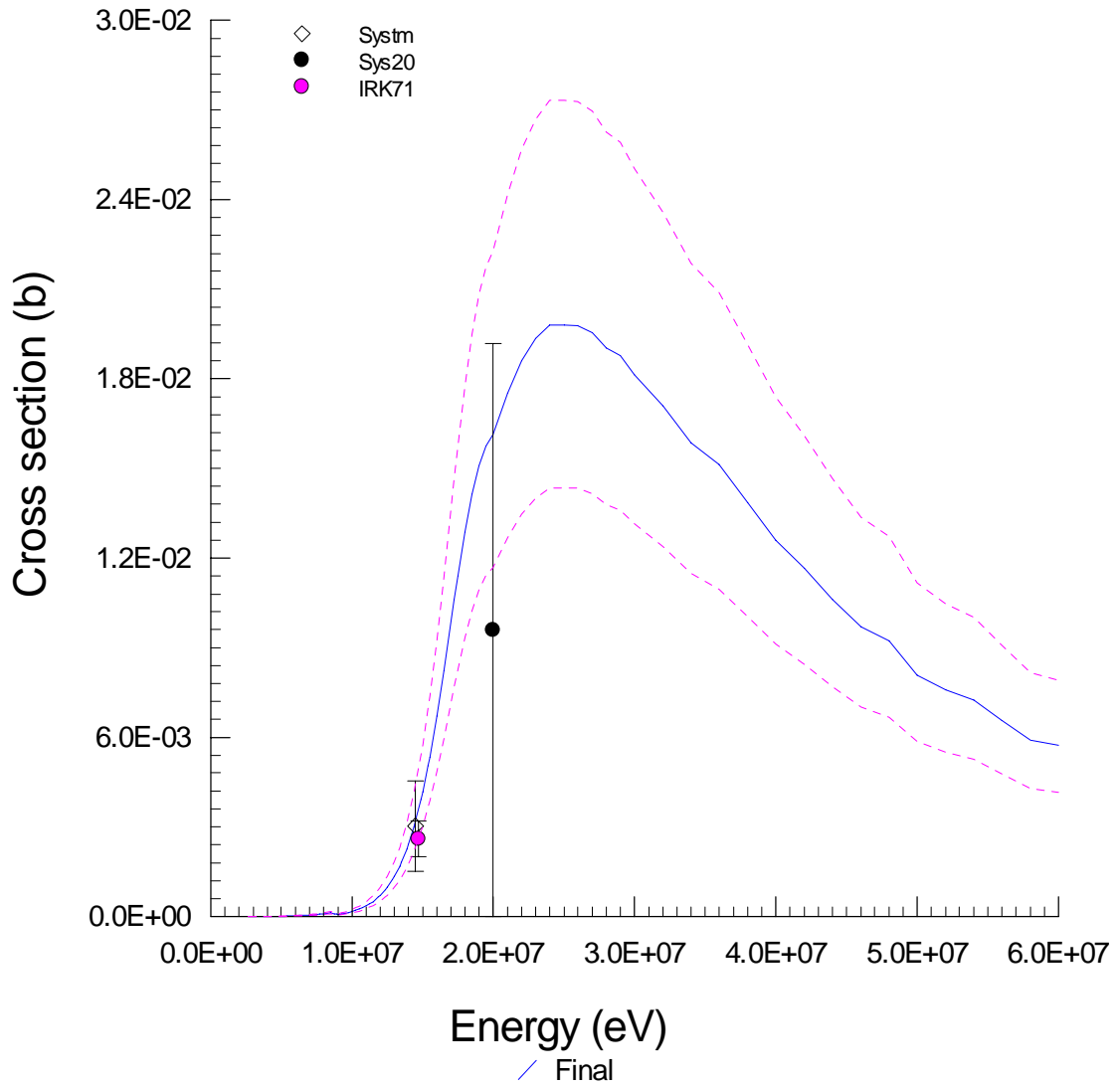


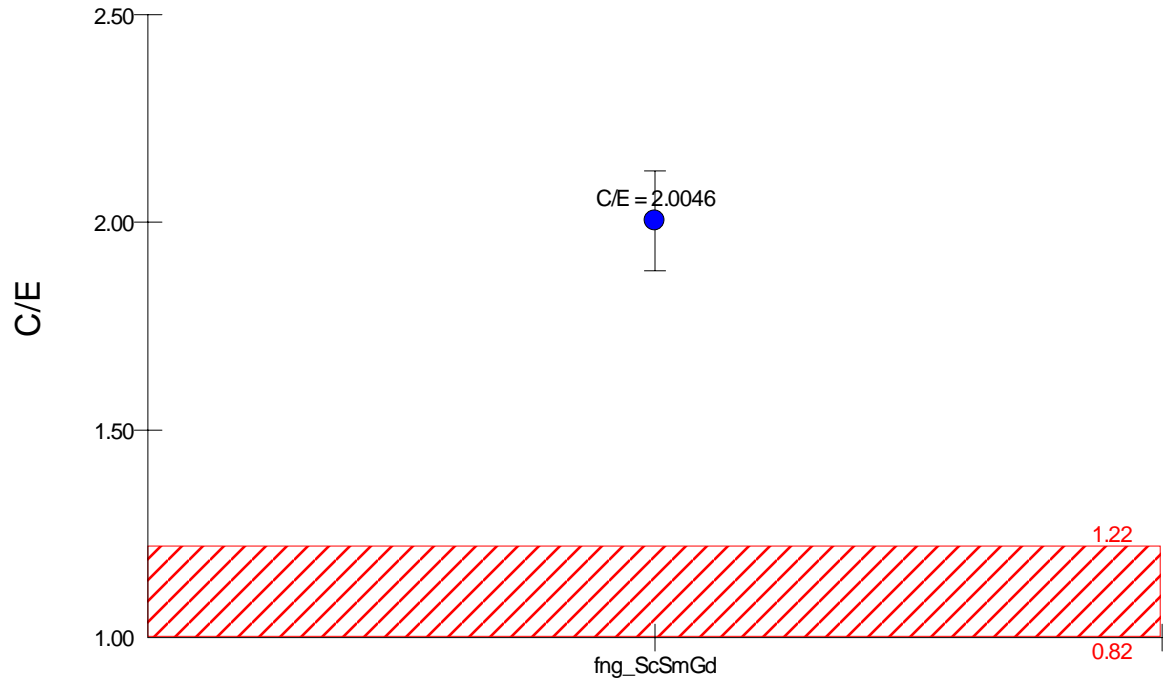
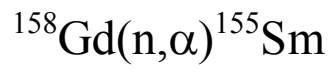
Neutron Spectrum



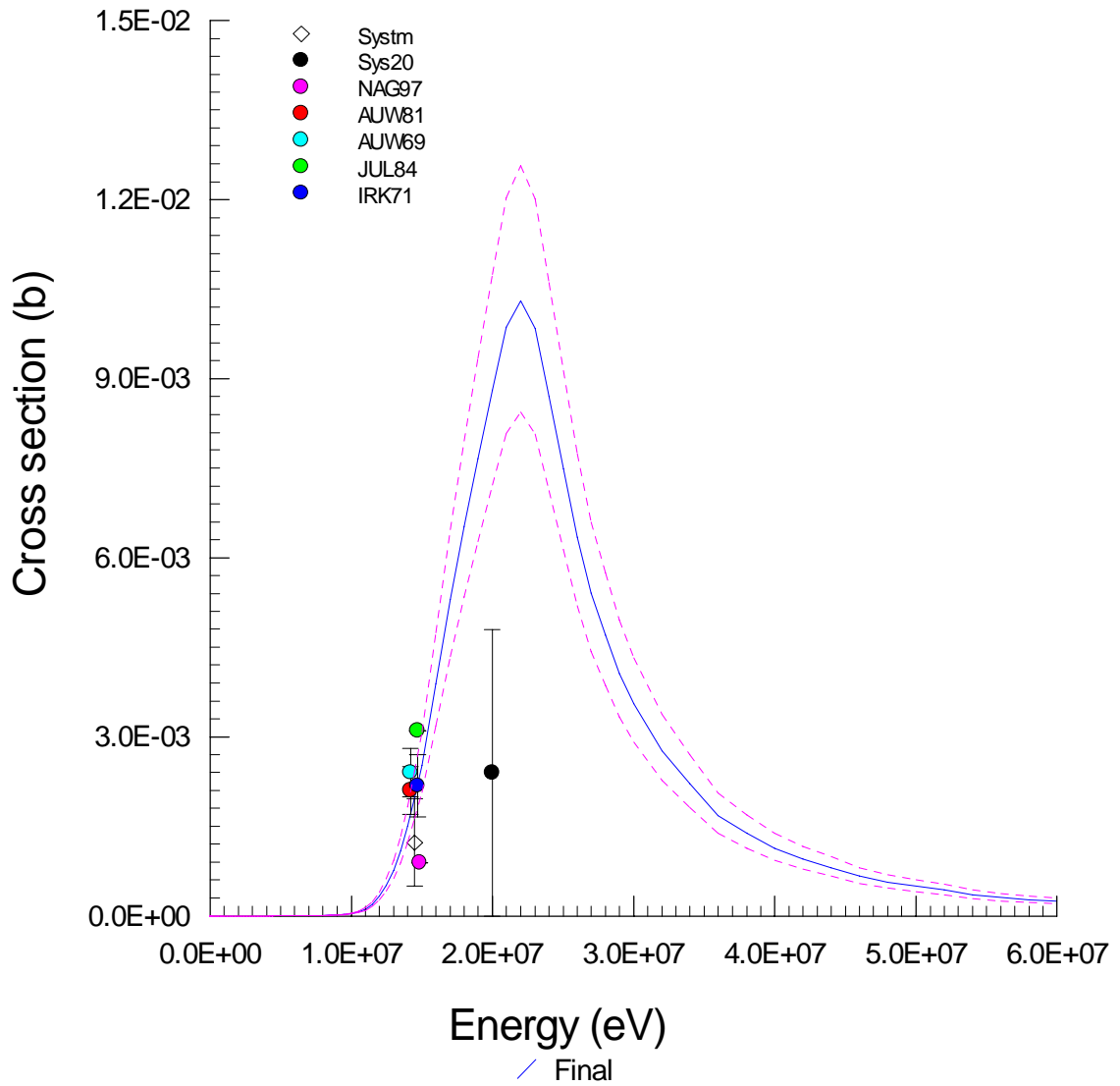


Neutron Spectrum

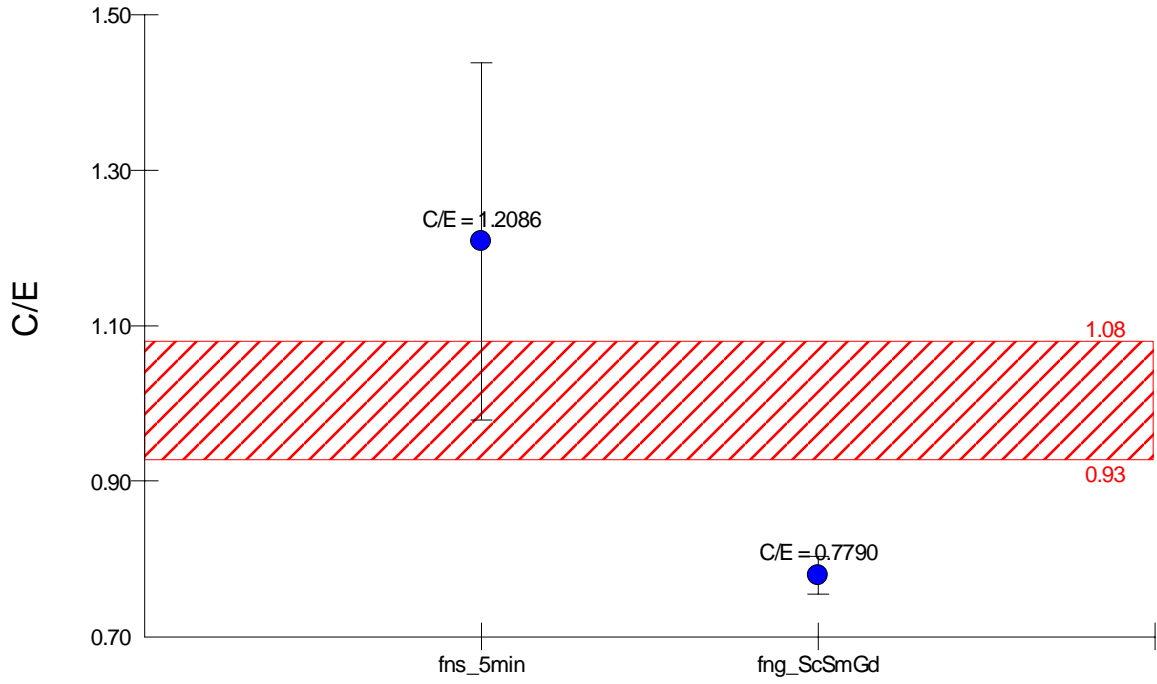




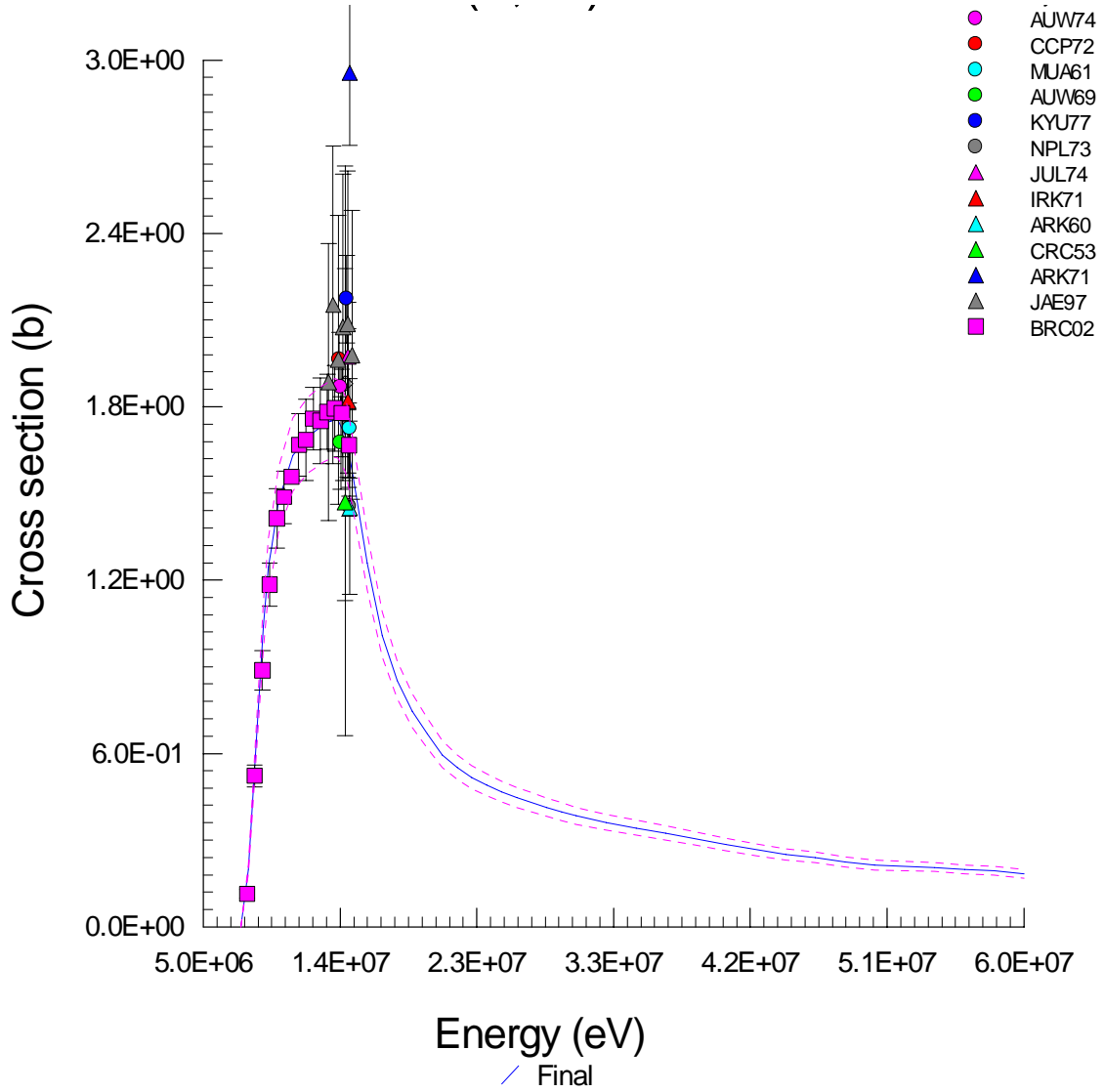
Neutron Spectrum

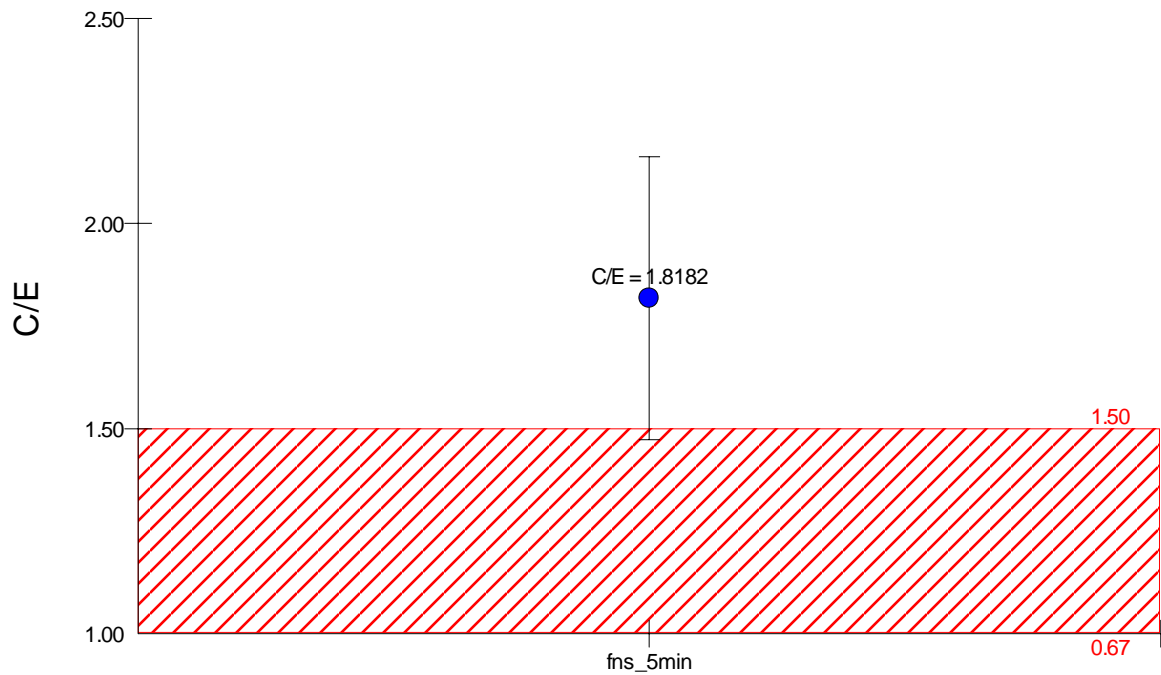
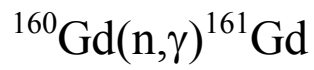


$^{160}\text{Gd}(n,2n)^{159}\text{Gd}$

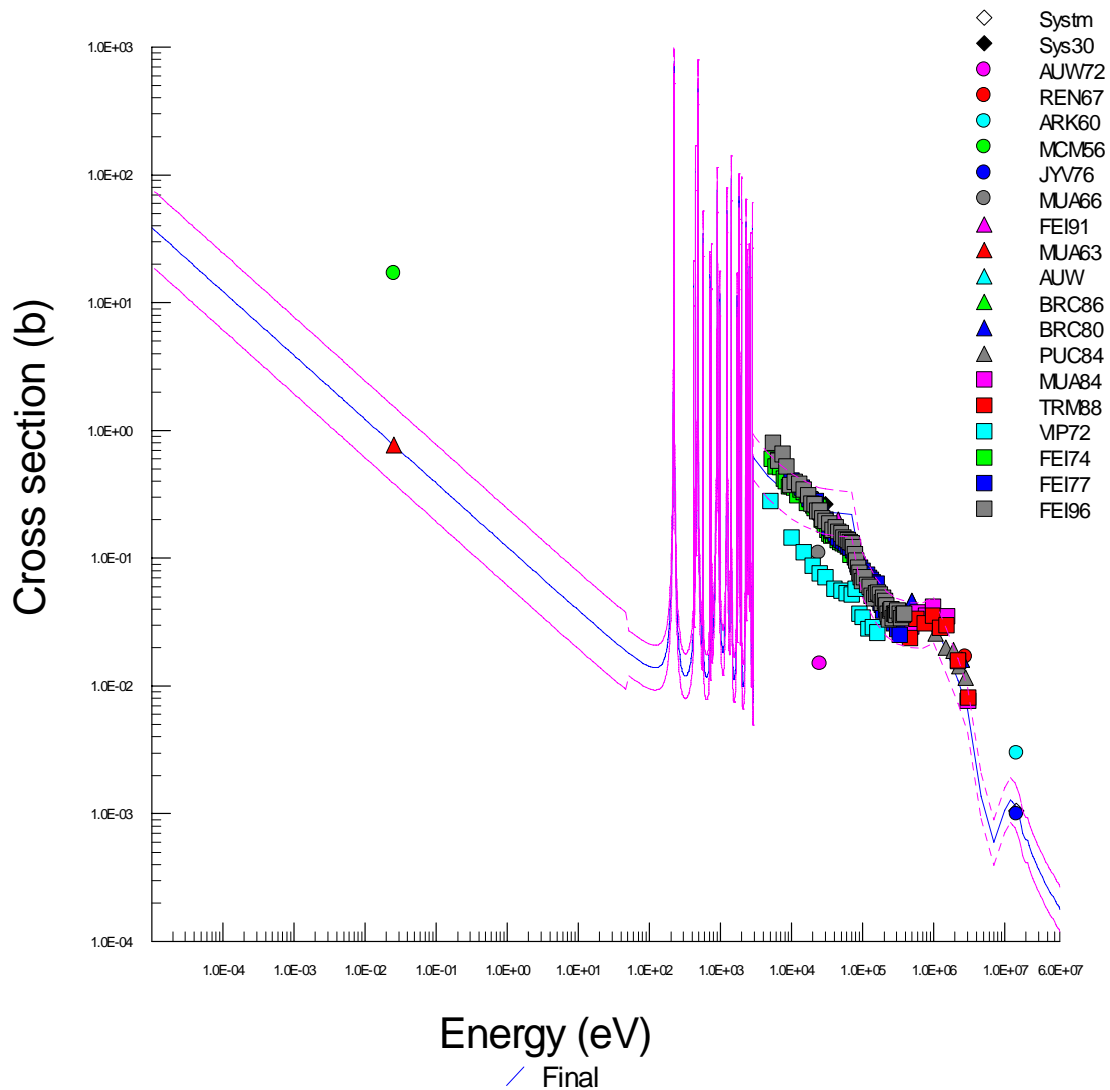


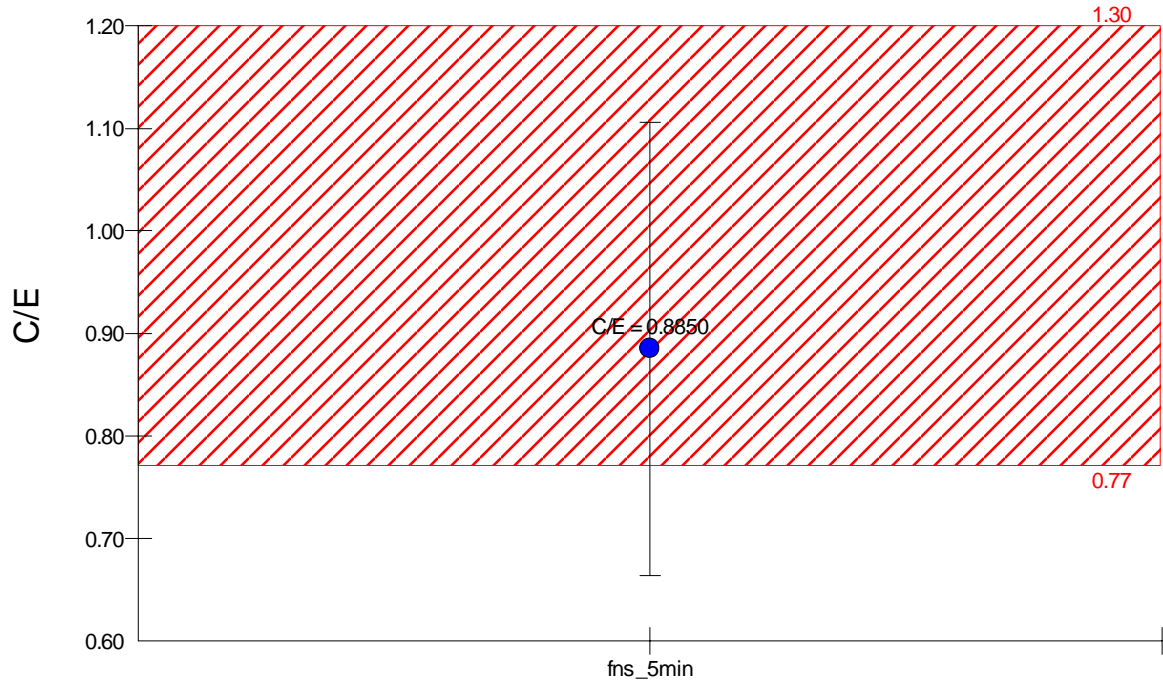
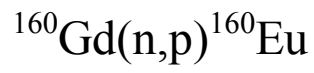
Neutron Spectrum



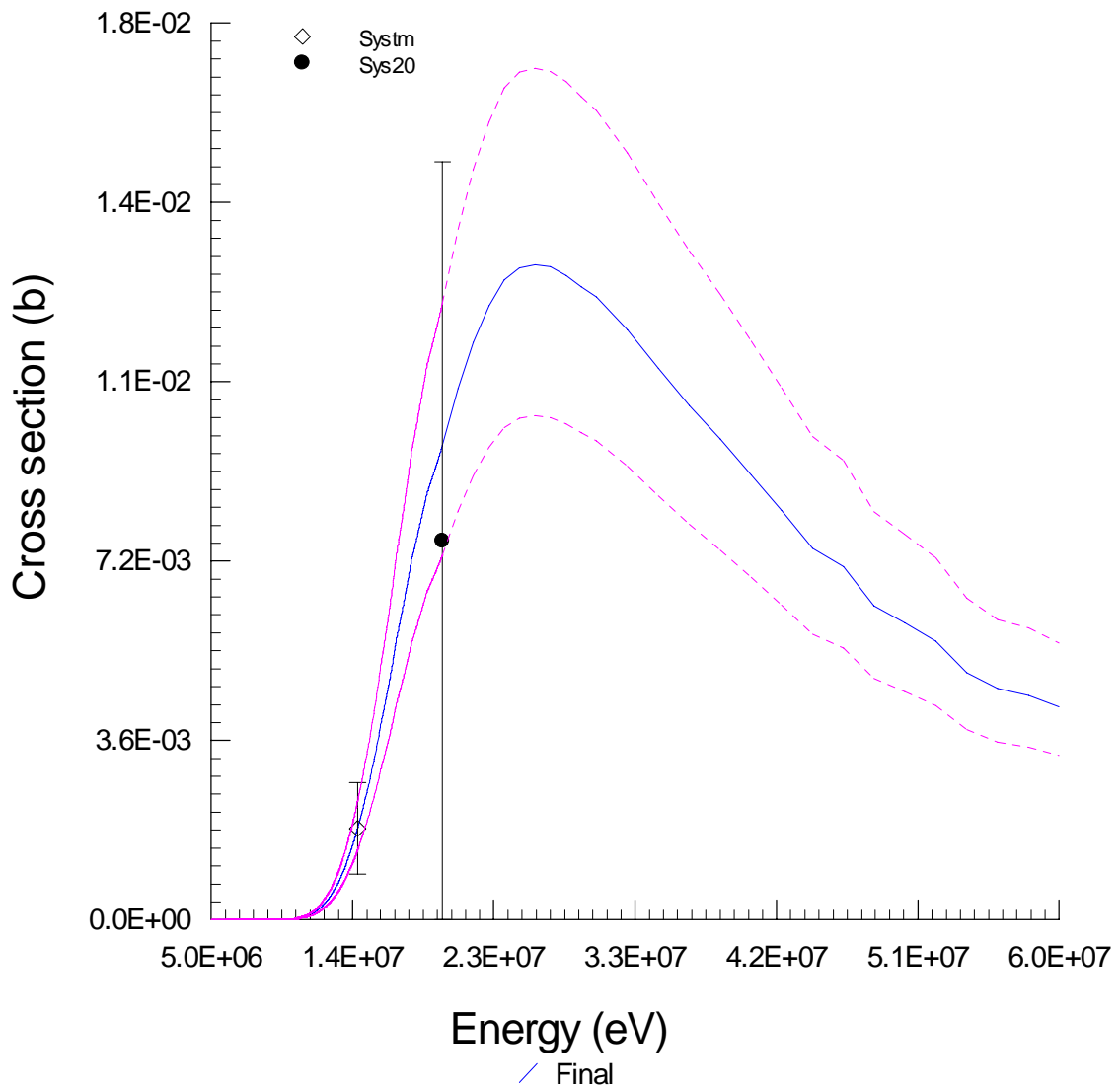


Neutron Spectrum



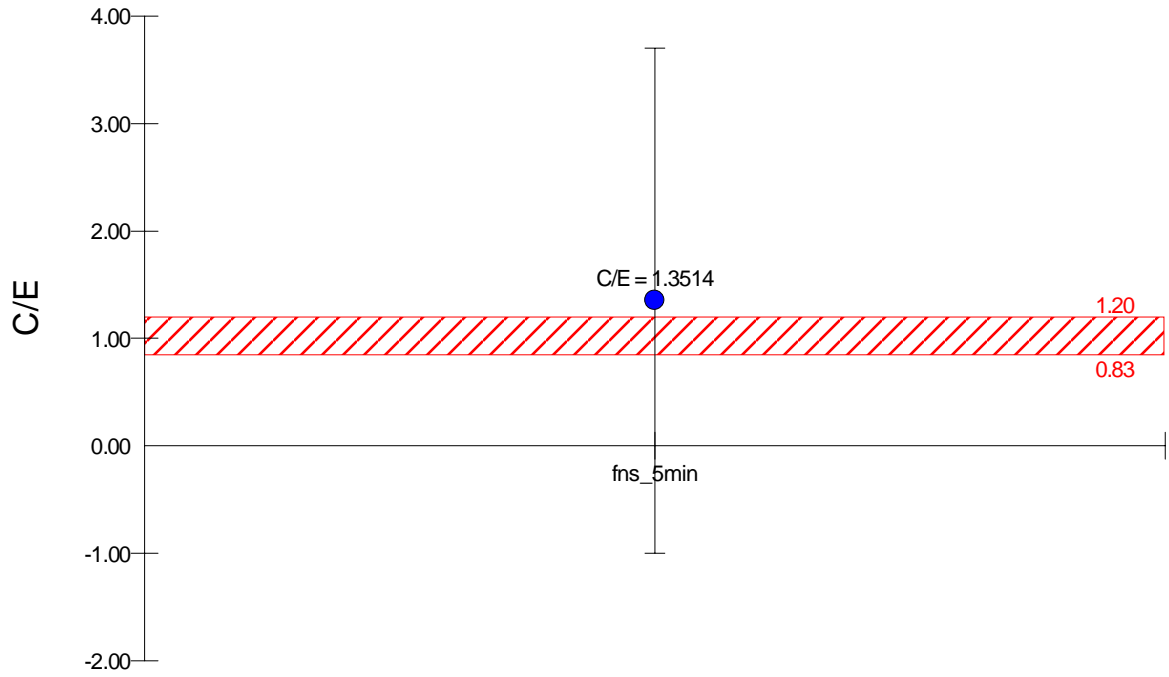


Neutron Spectrum

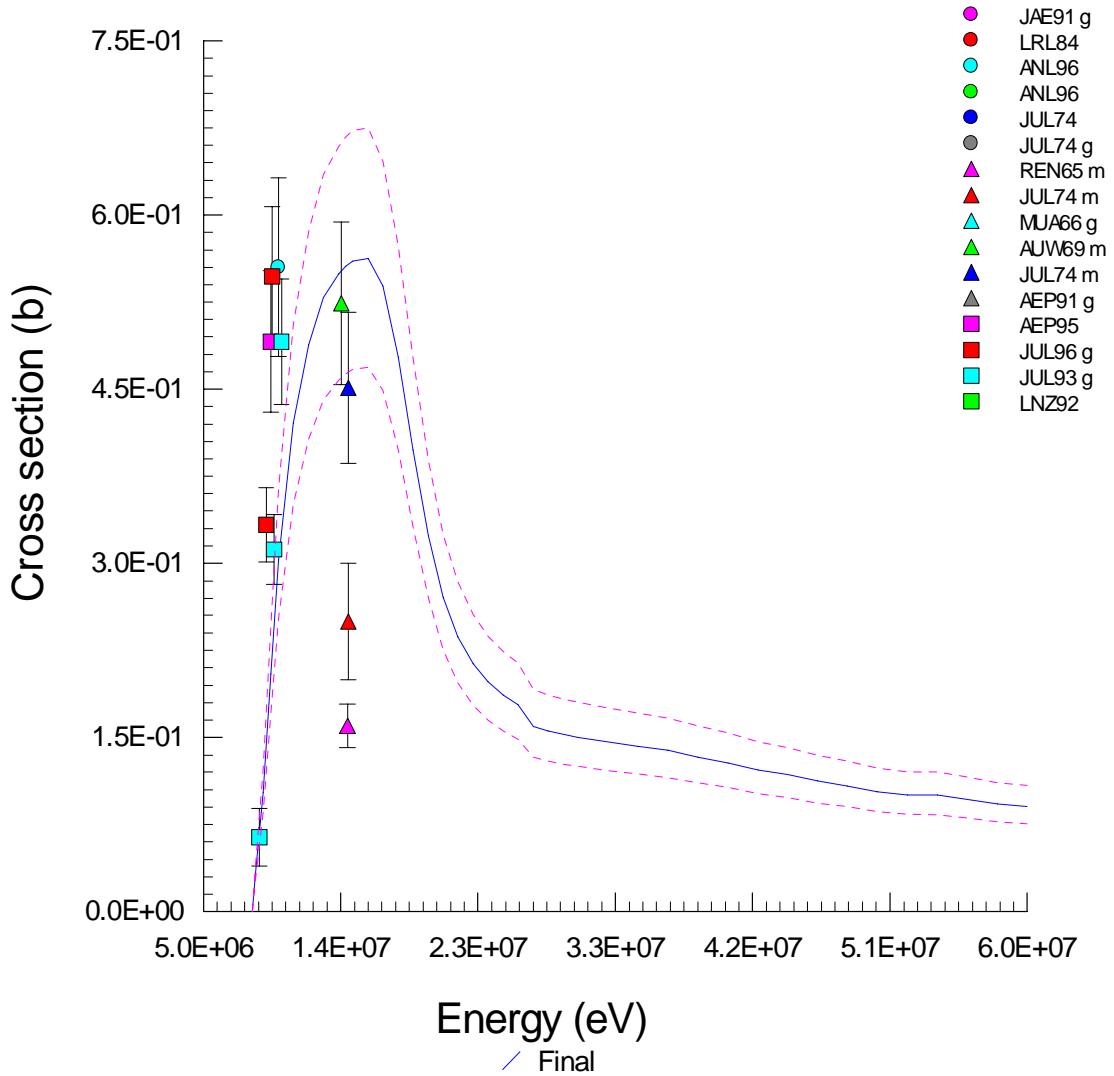




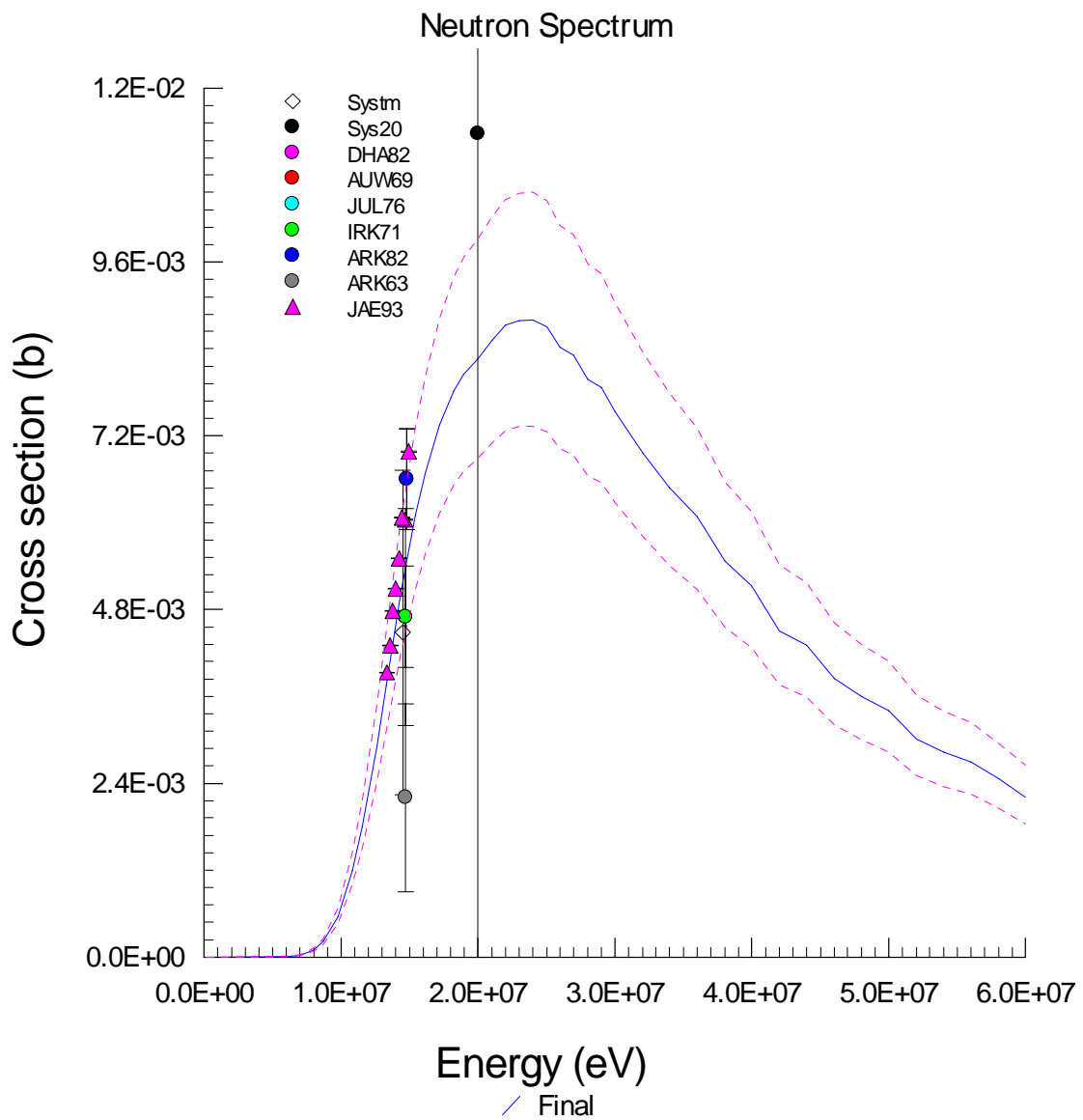
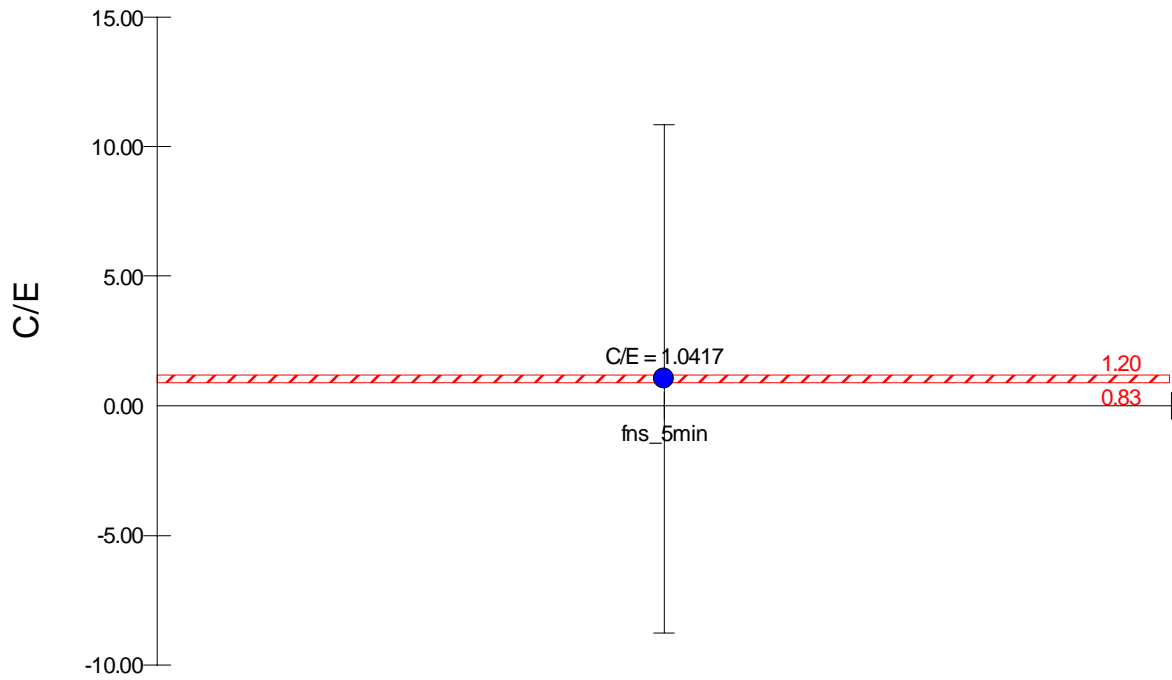
$^{159}\text{Tb}(n,2n)^{158\text{m}}\text{Tb}$

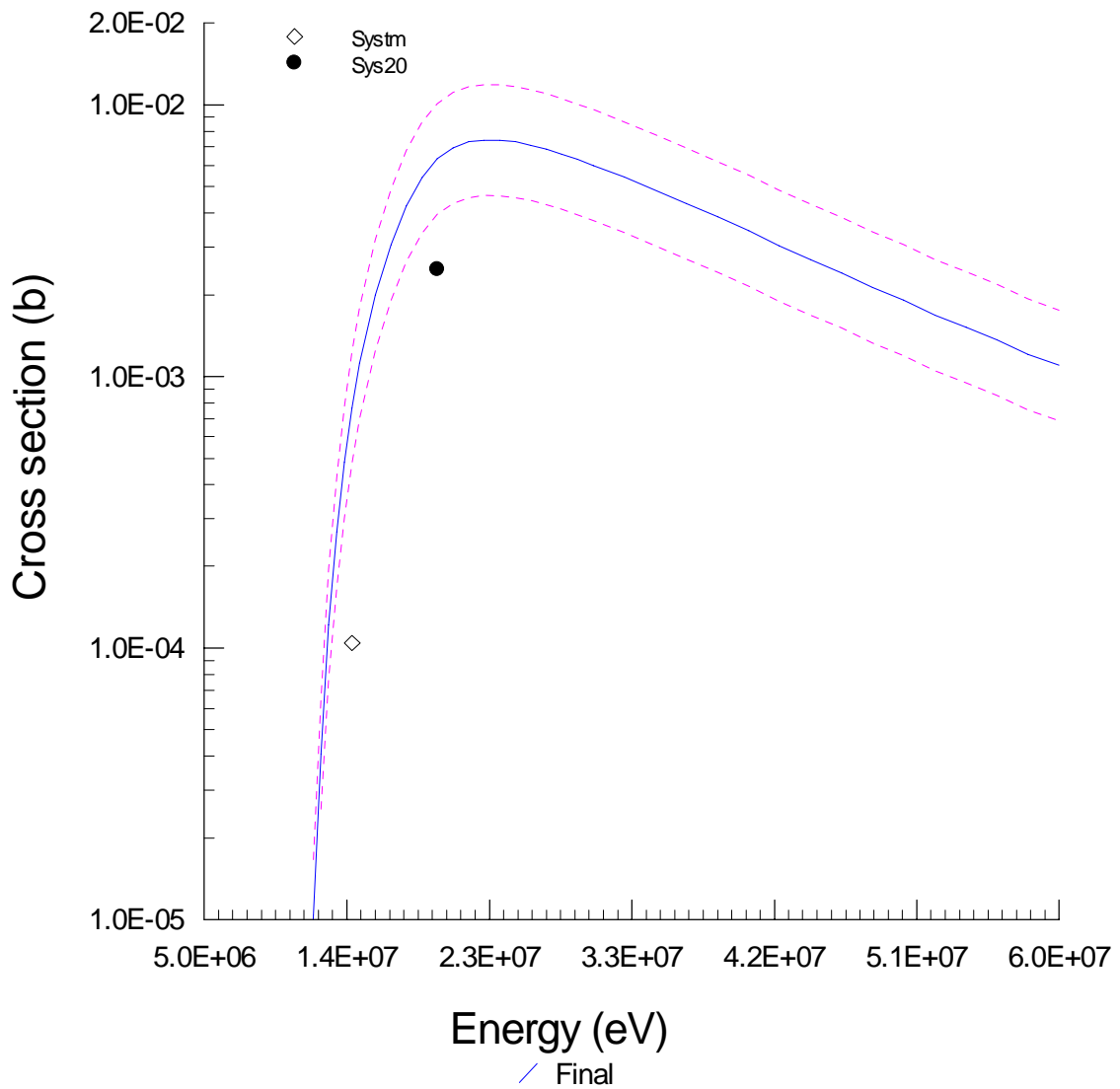
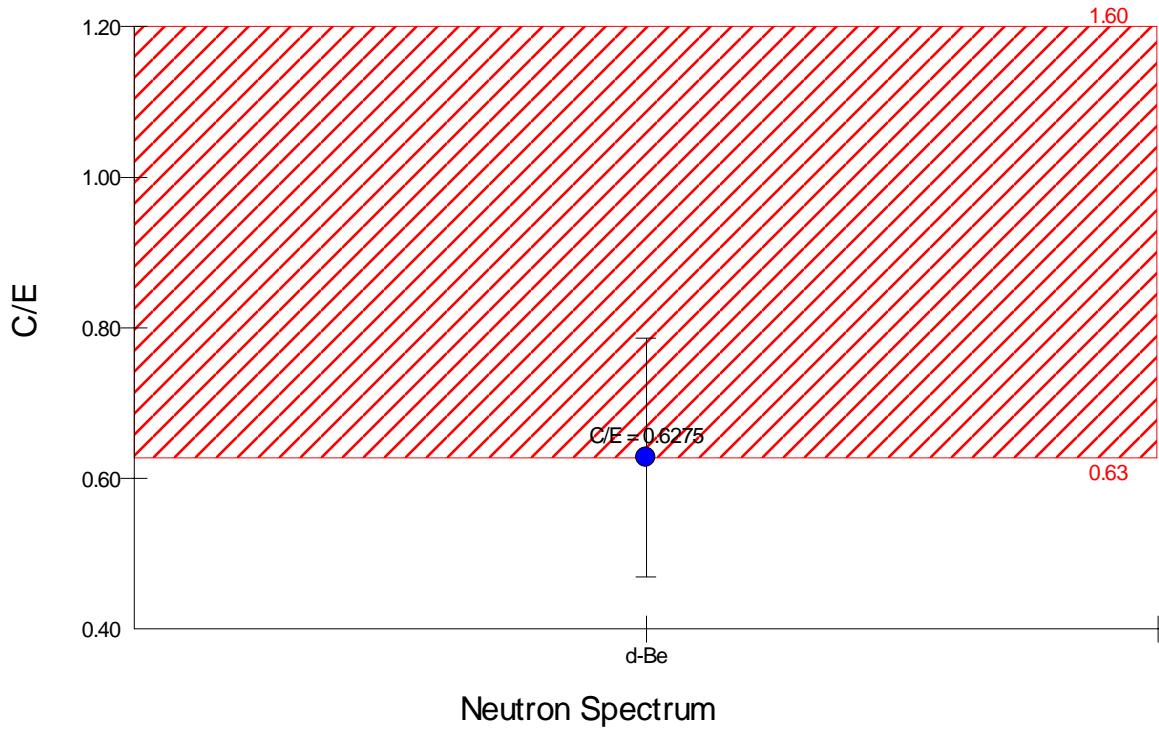
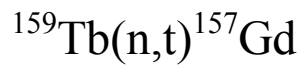


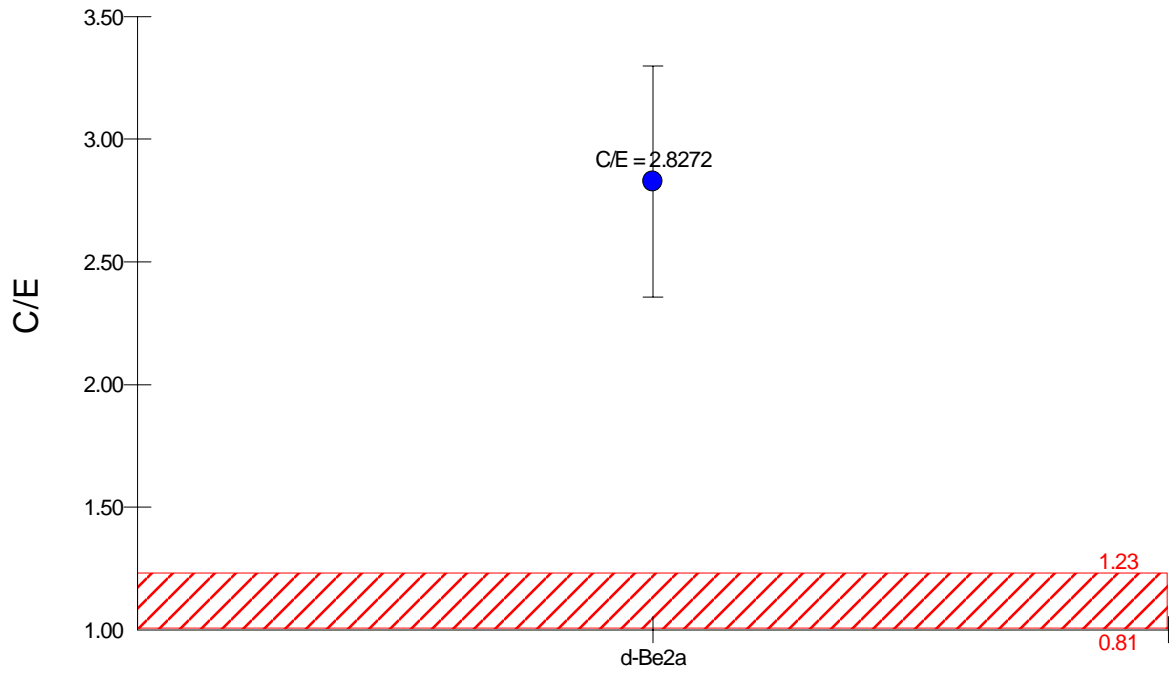
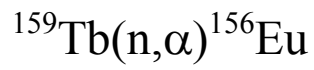
Neutron Spectrum



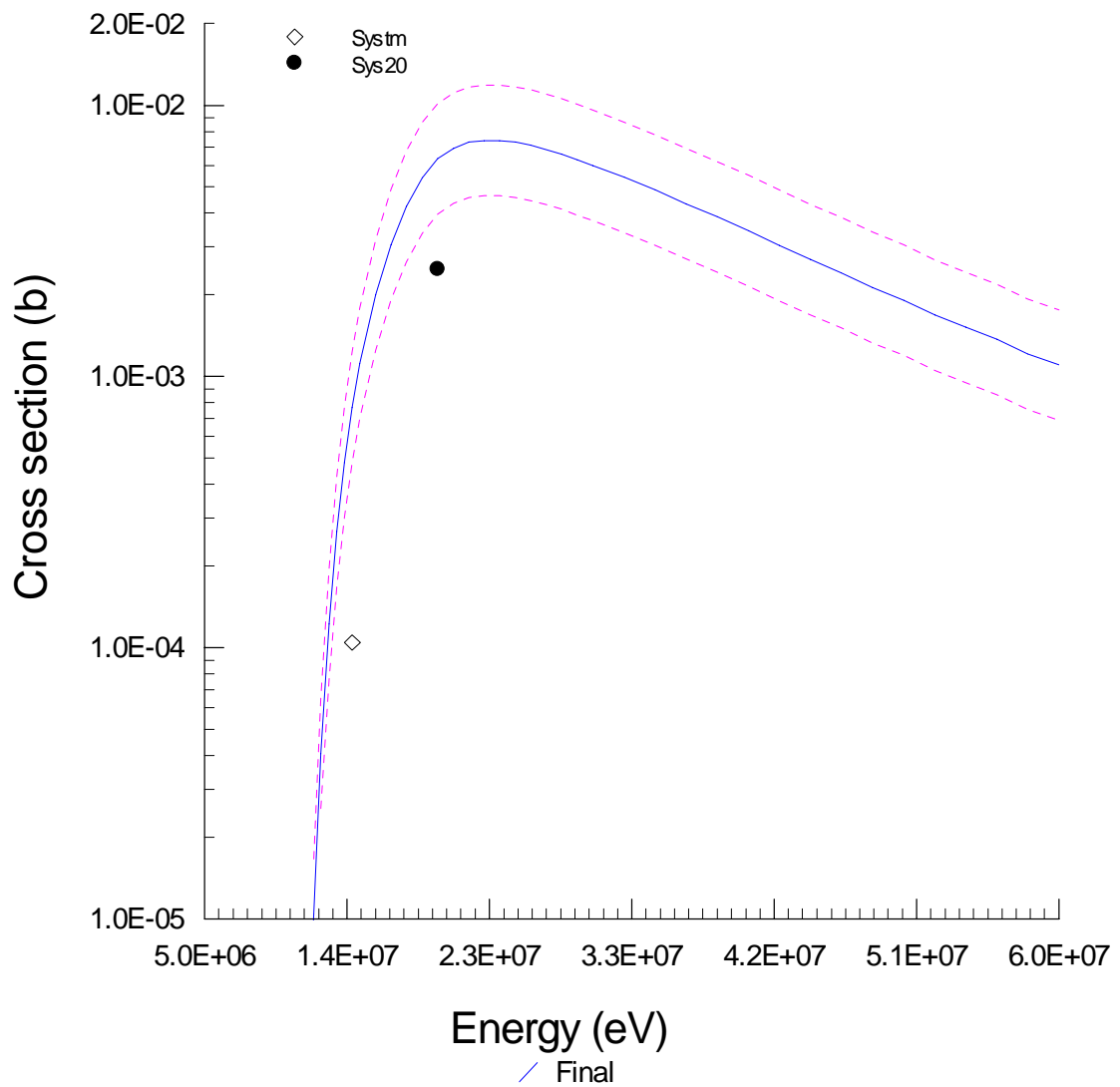
# $^{159}\text{Tb}(n,p)^{159}\text{Gd}$

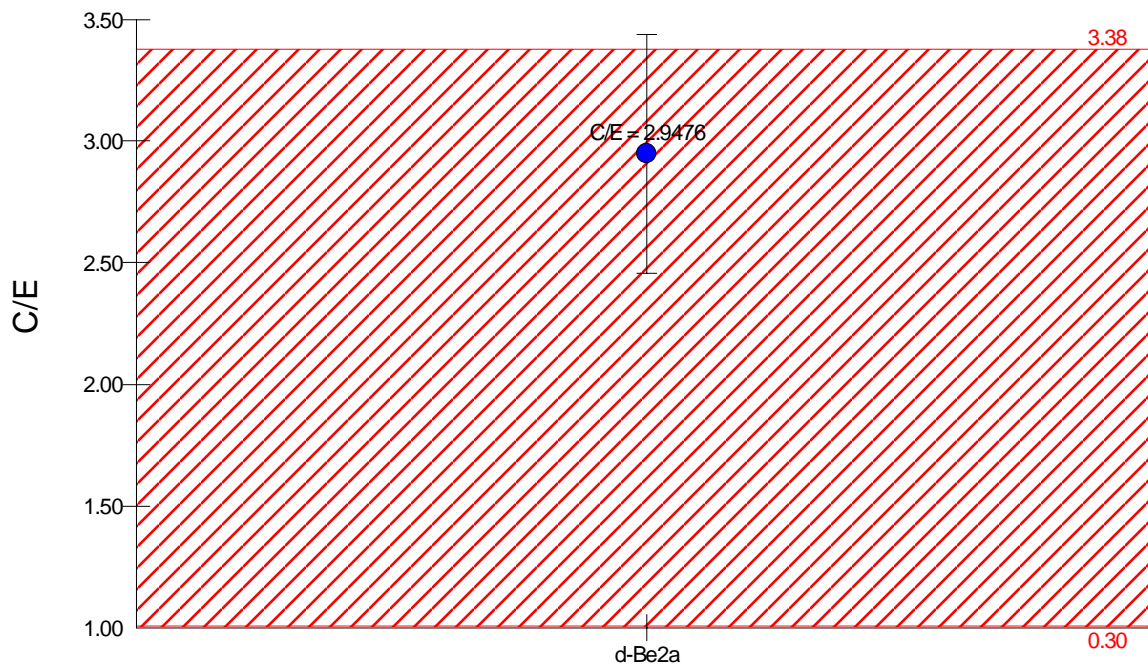
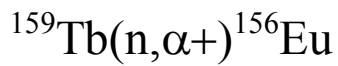




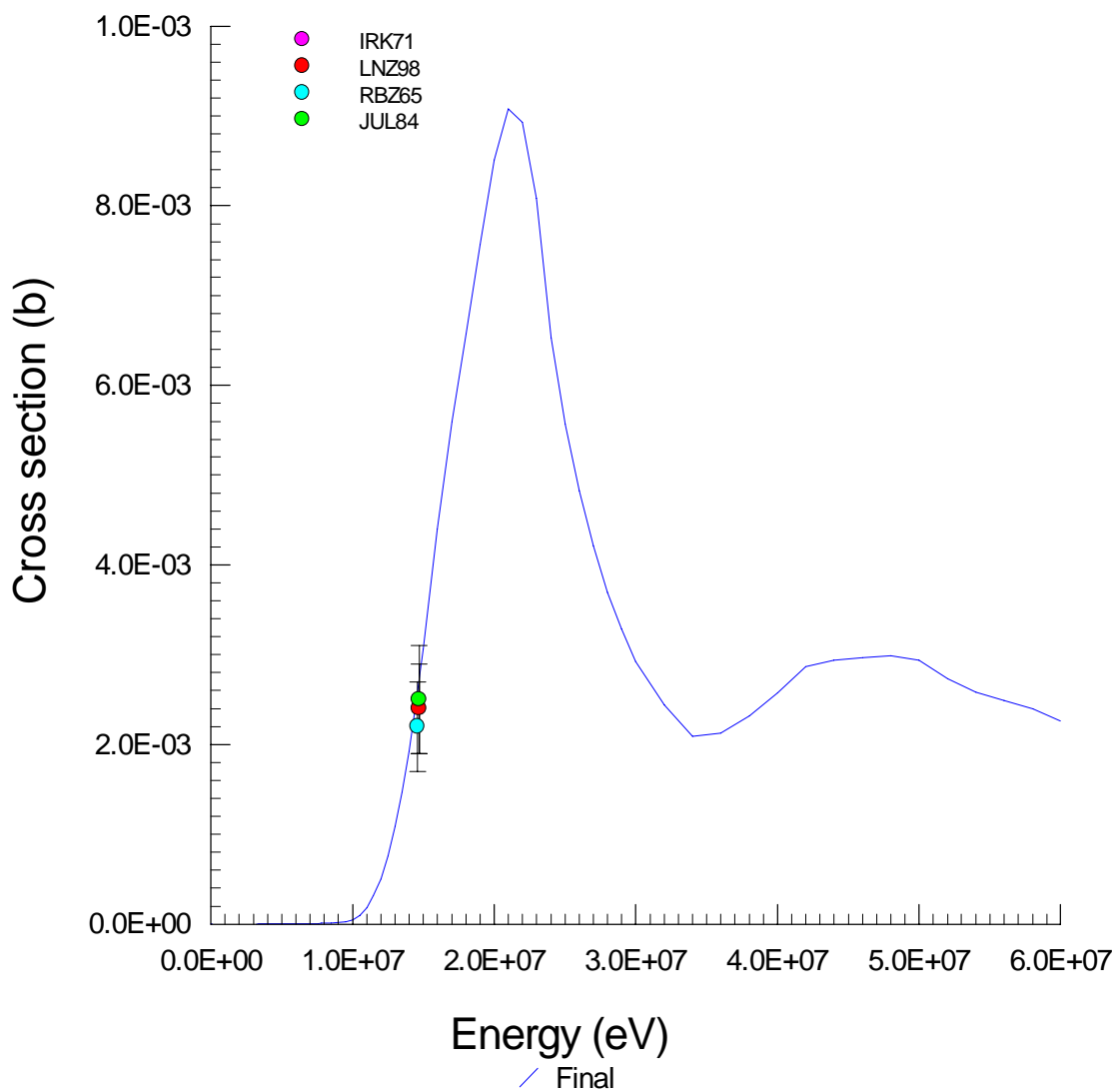


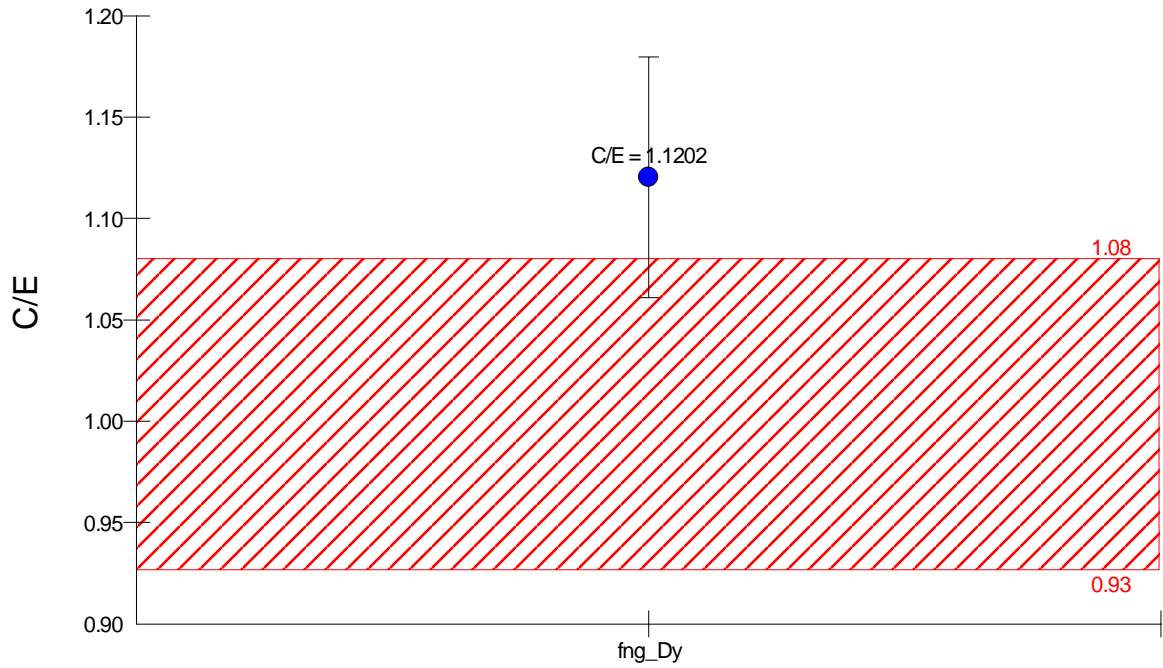
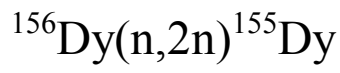
Neutron Spectrum



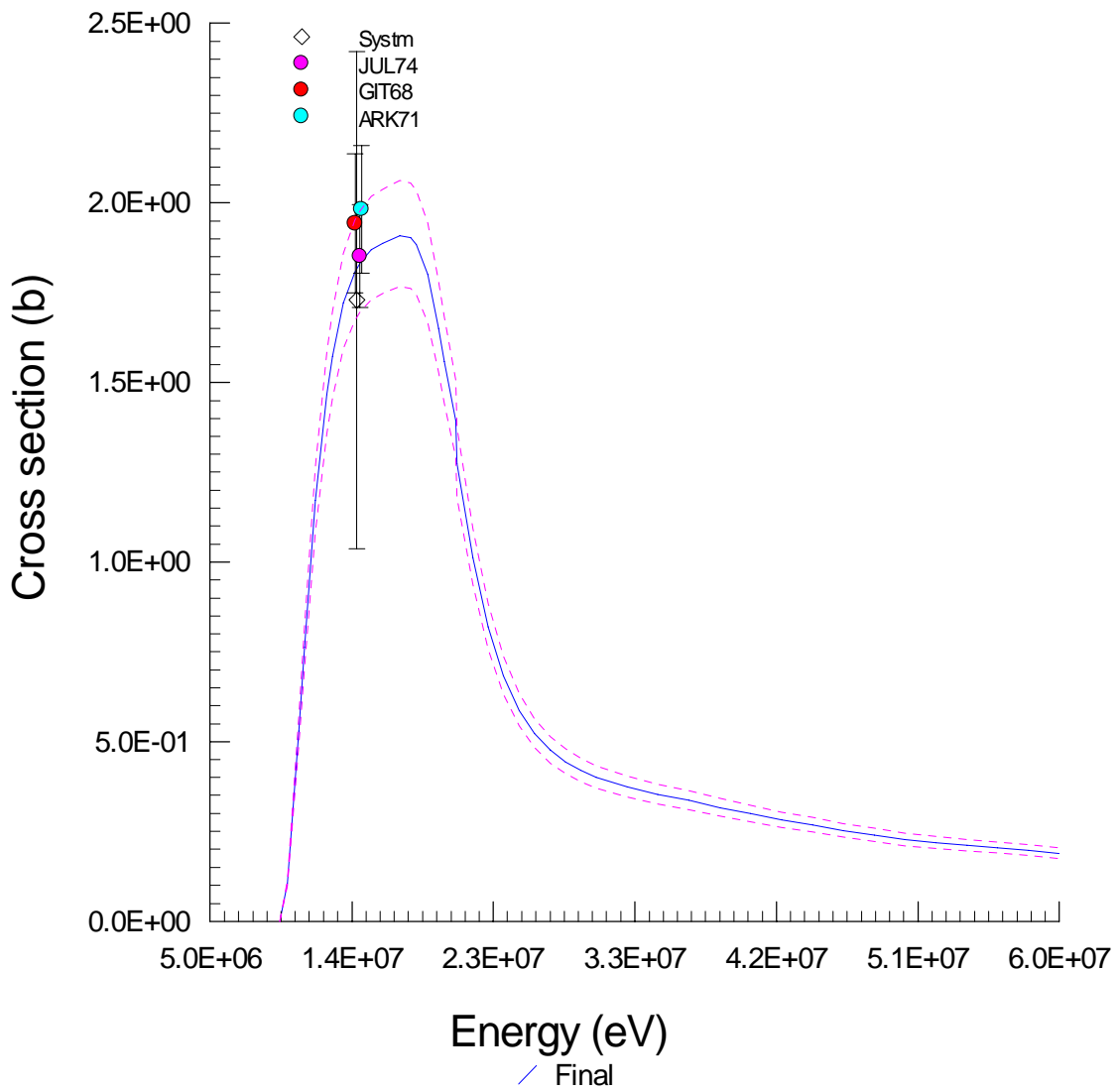


Neutron Spectrum

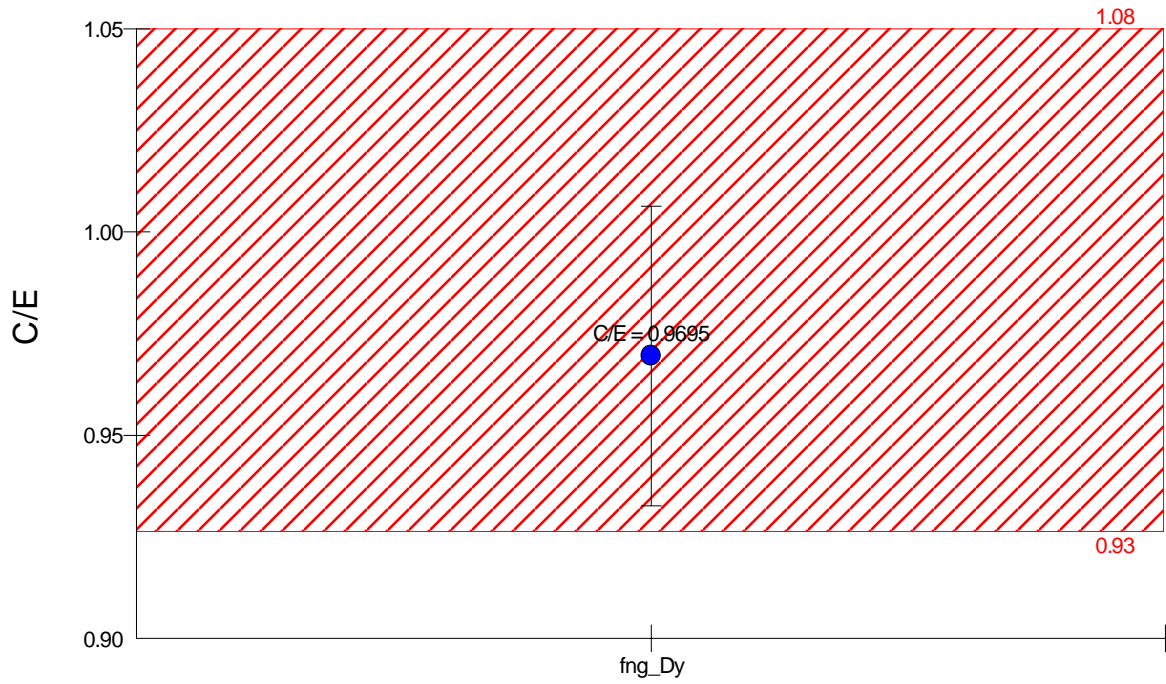




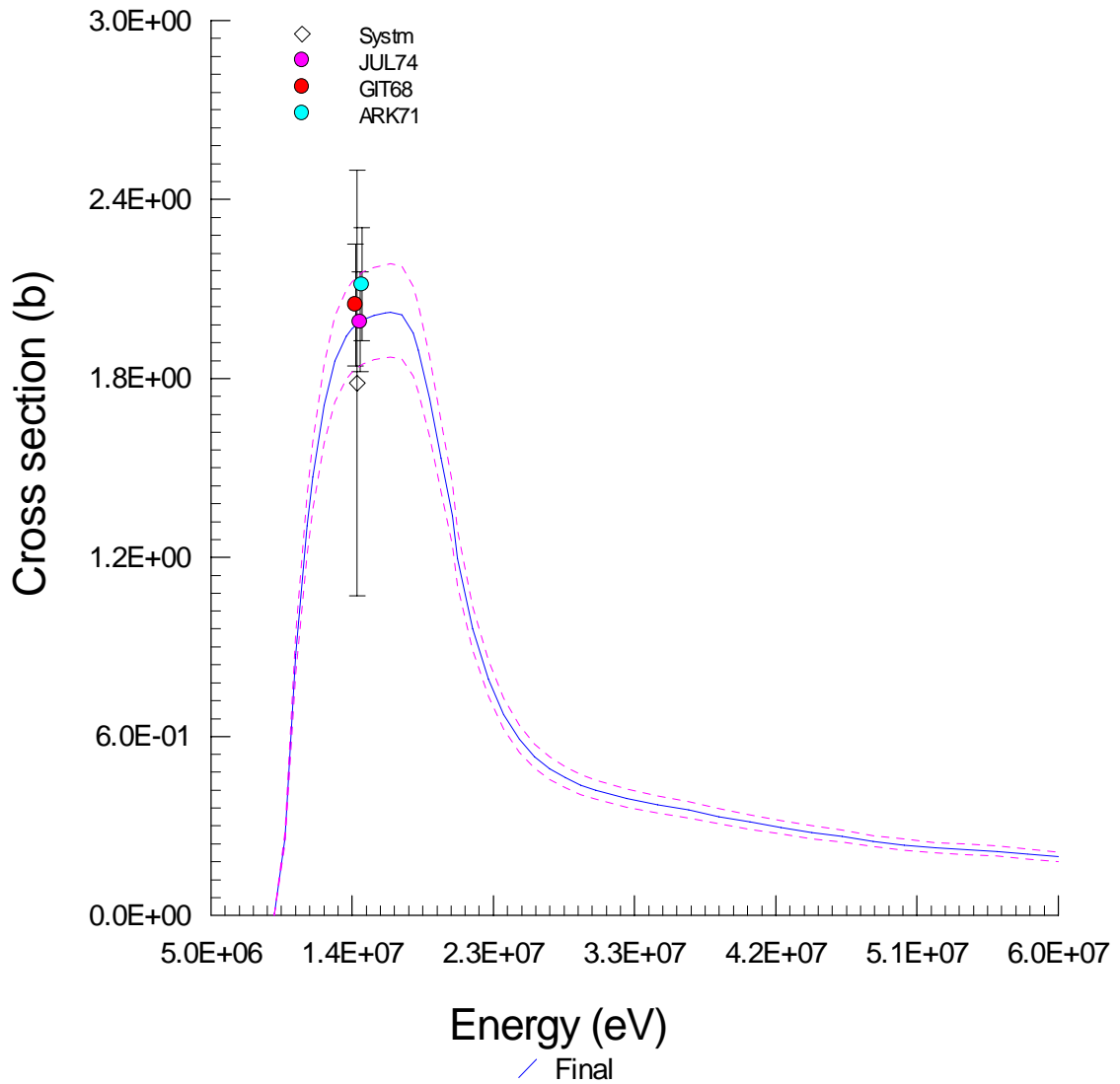
Neutron Spectrum



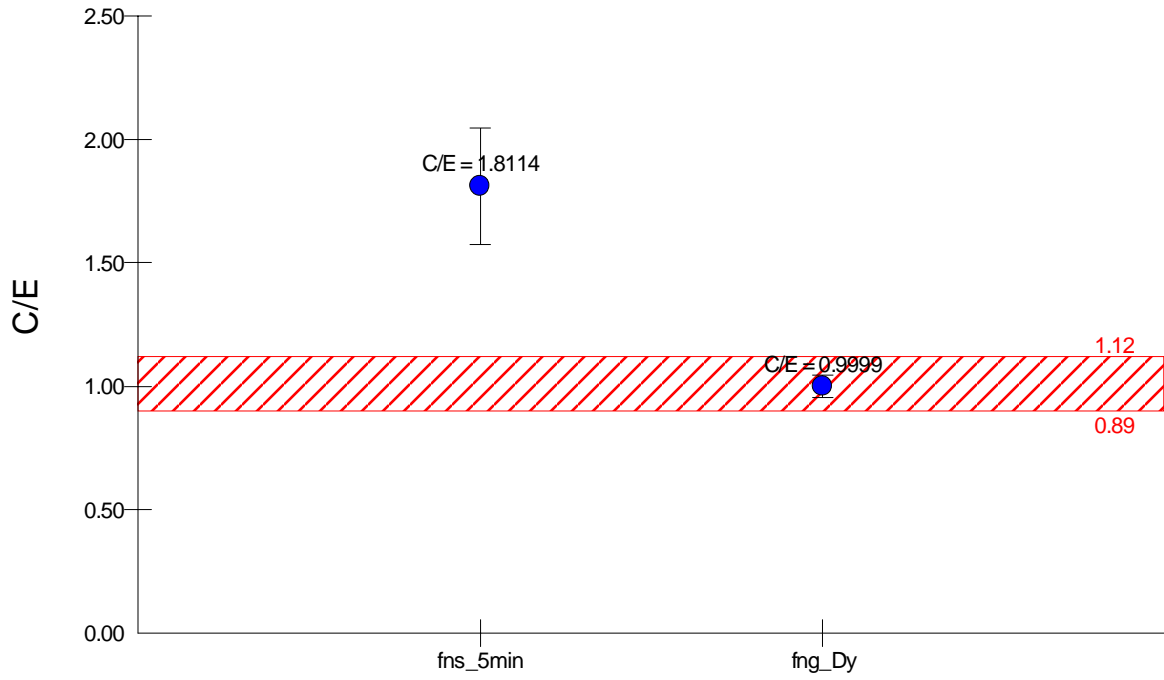
$^{158}\text{Dy}(n,2n)^{157}\text{Dy}$



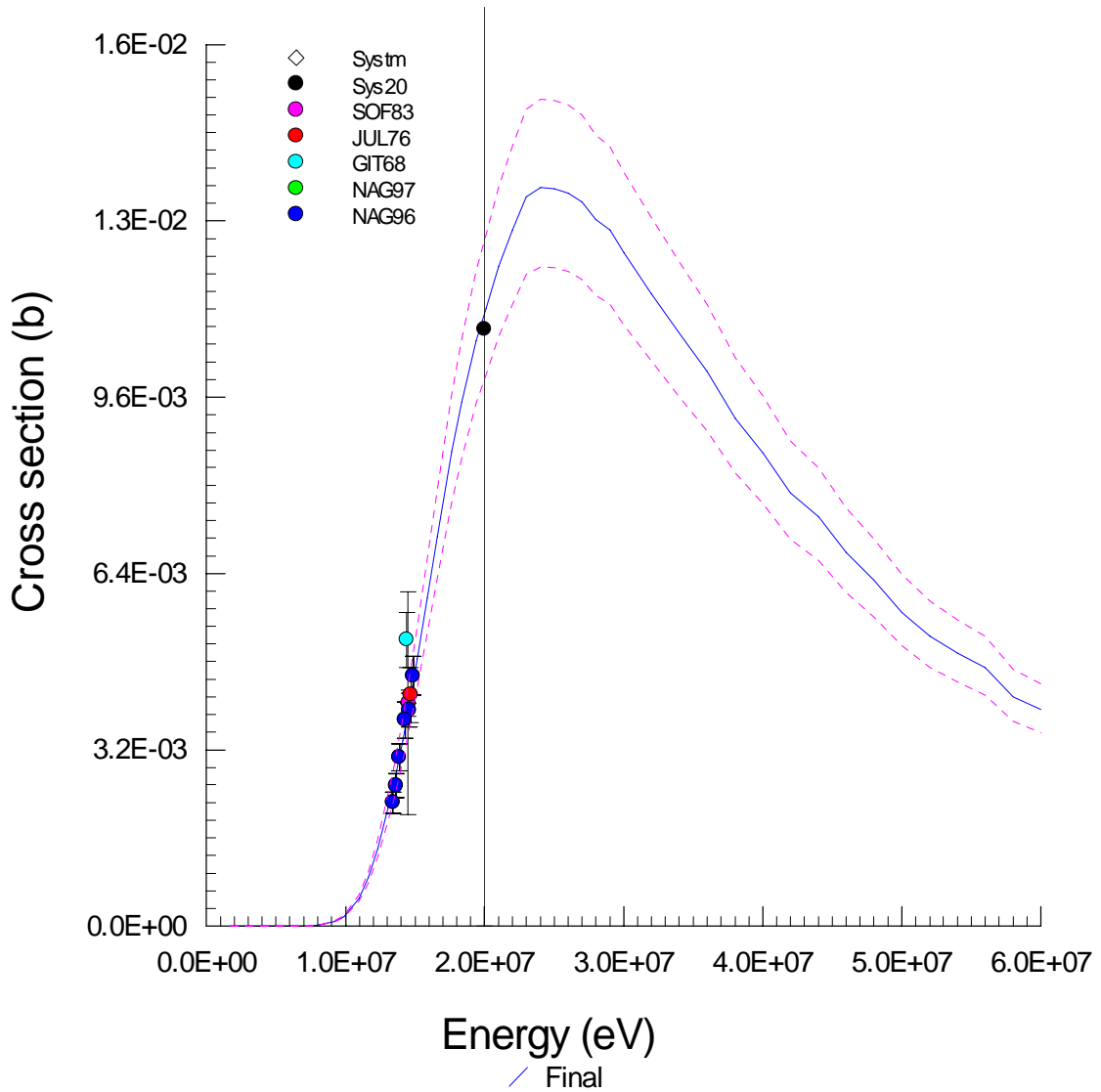
Neutron Spectrum



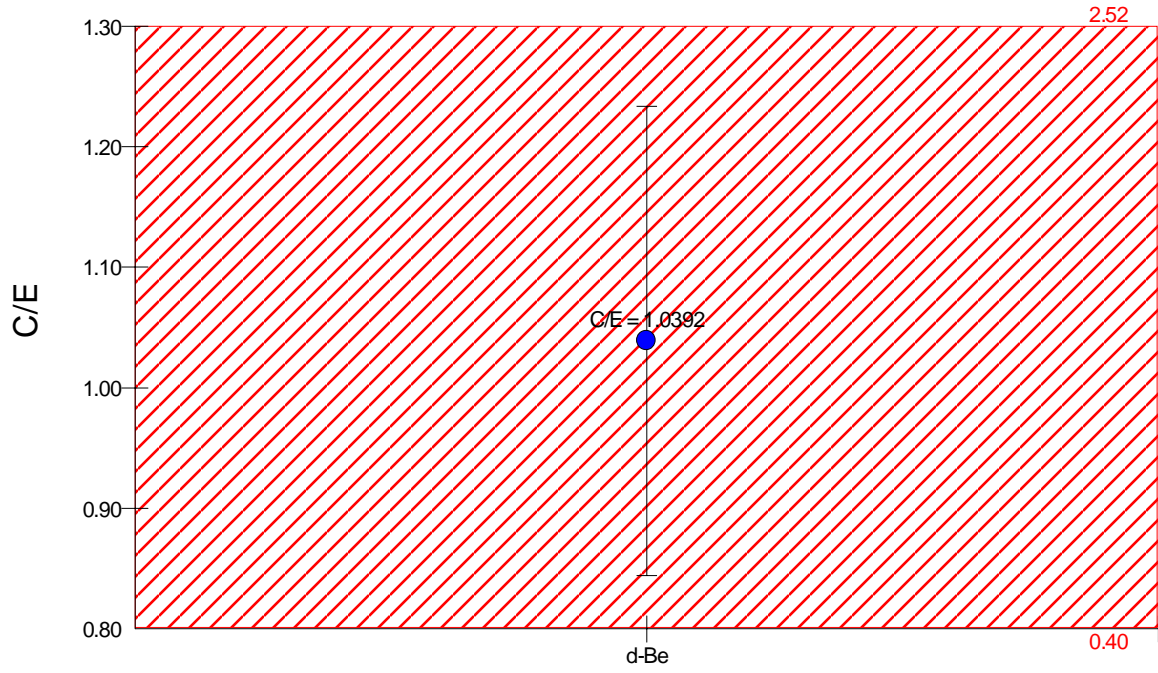
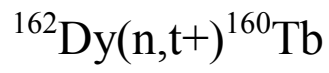
$^{162}\text{Dy}(n,p)^{162}\text{Tb}$



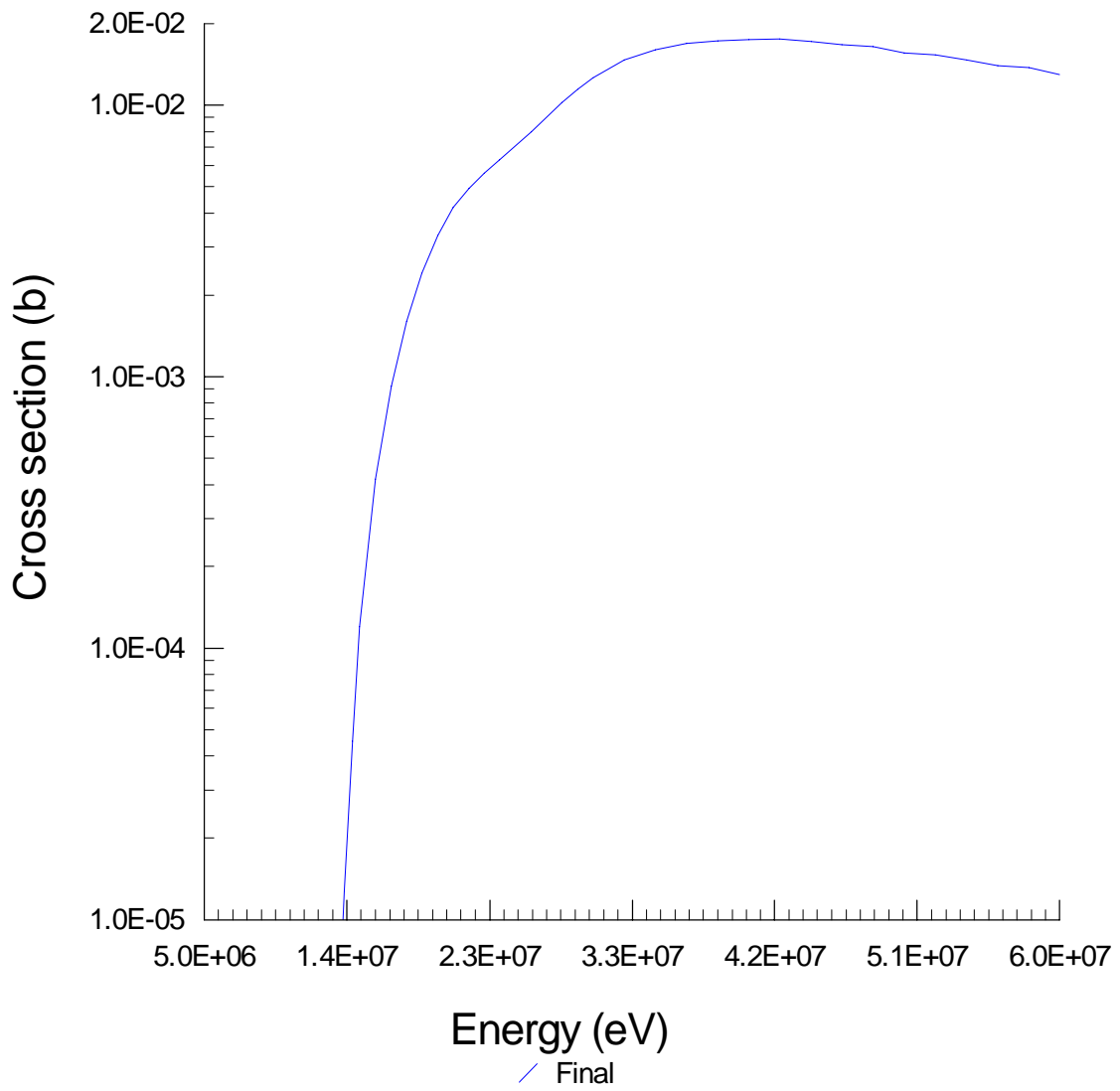
Neutron Spectrum



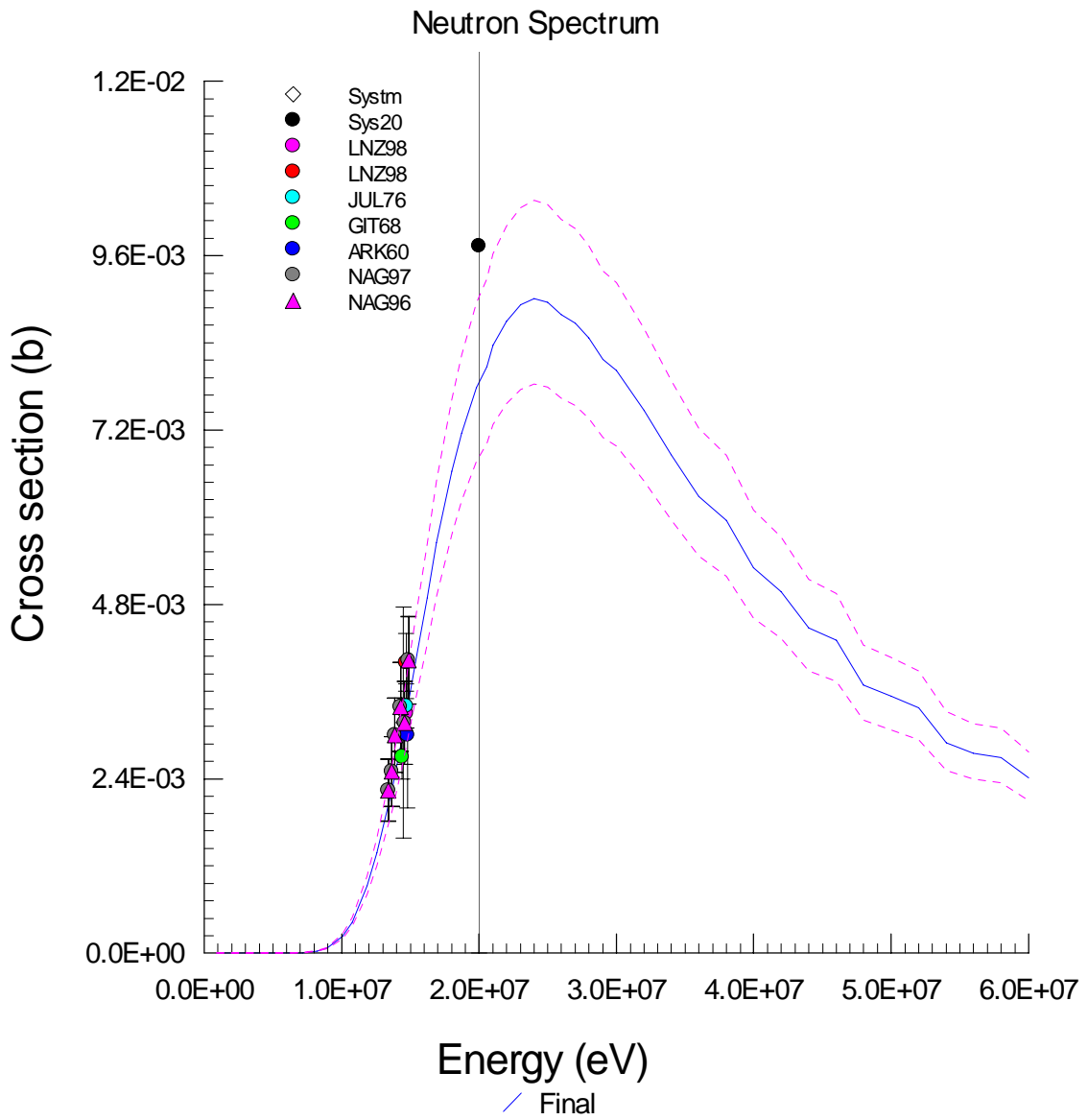
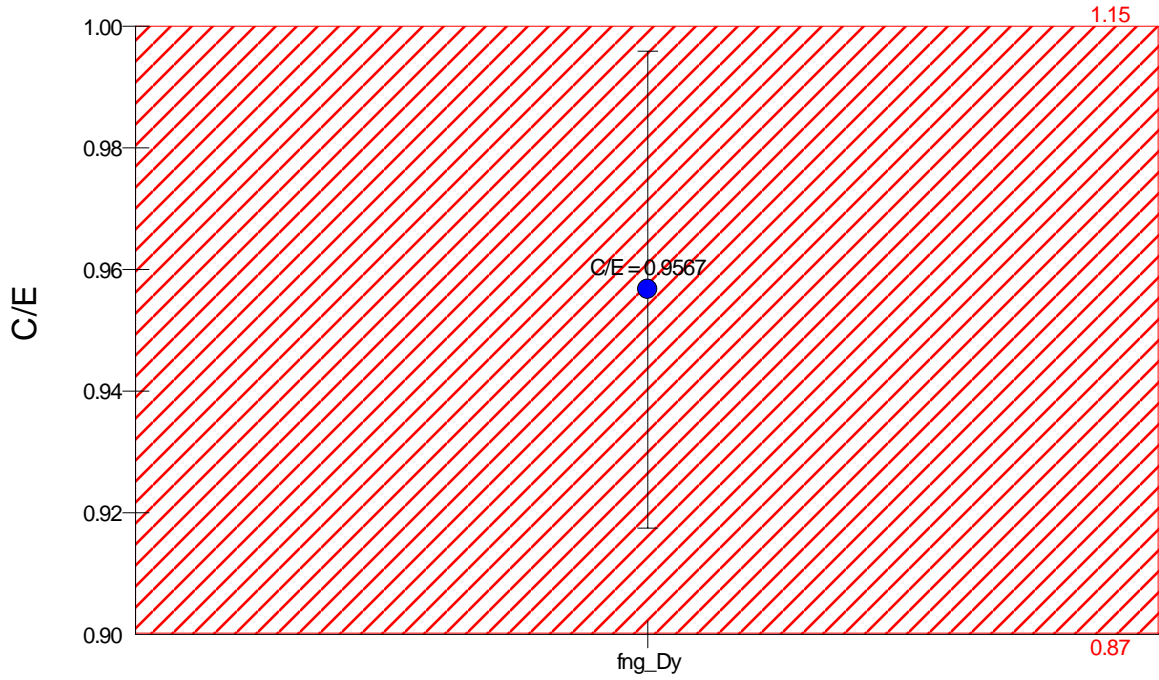


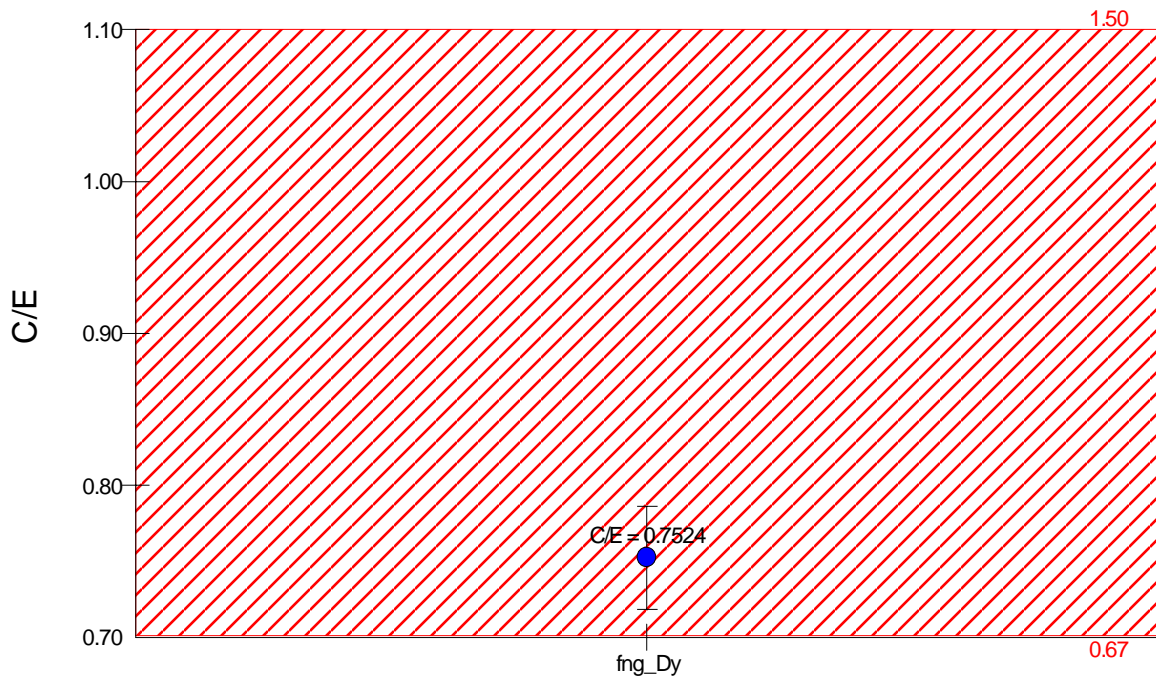
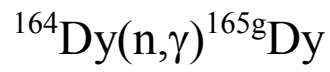


Neutron Spectrum

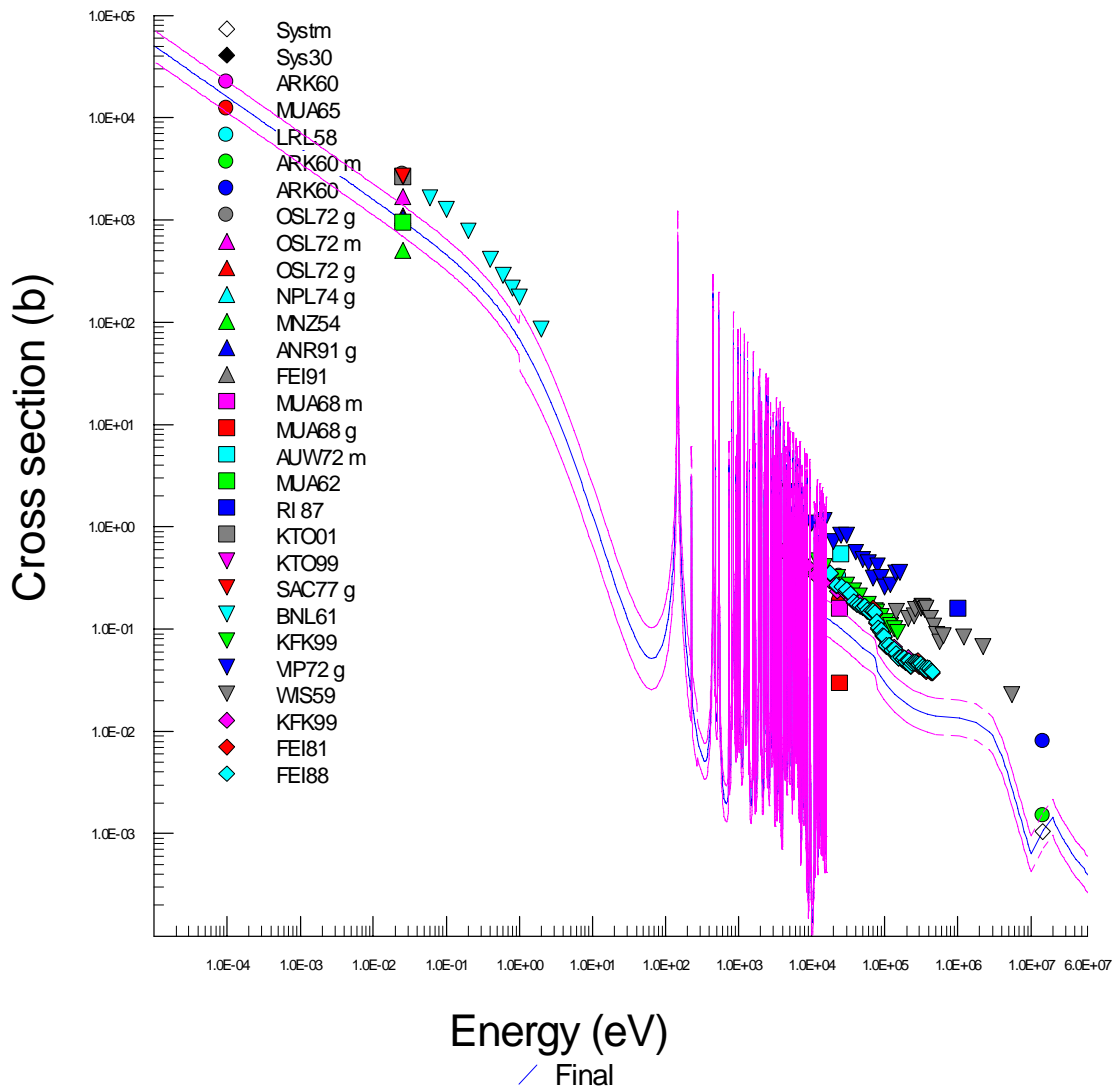


# $^{163}\text{Dy}(n,p)^{163}\text{Tb}$

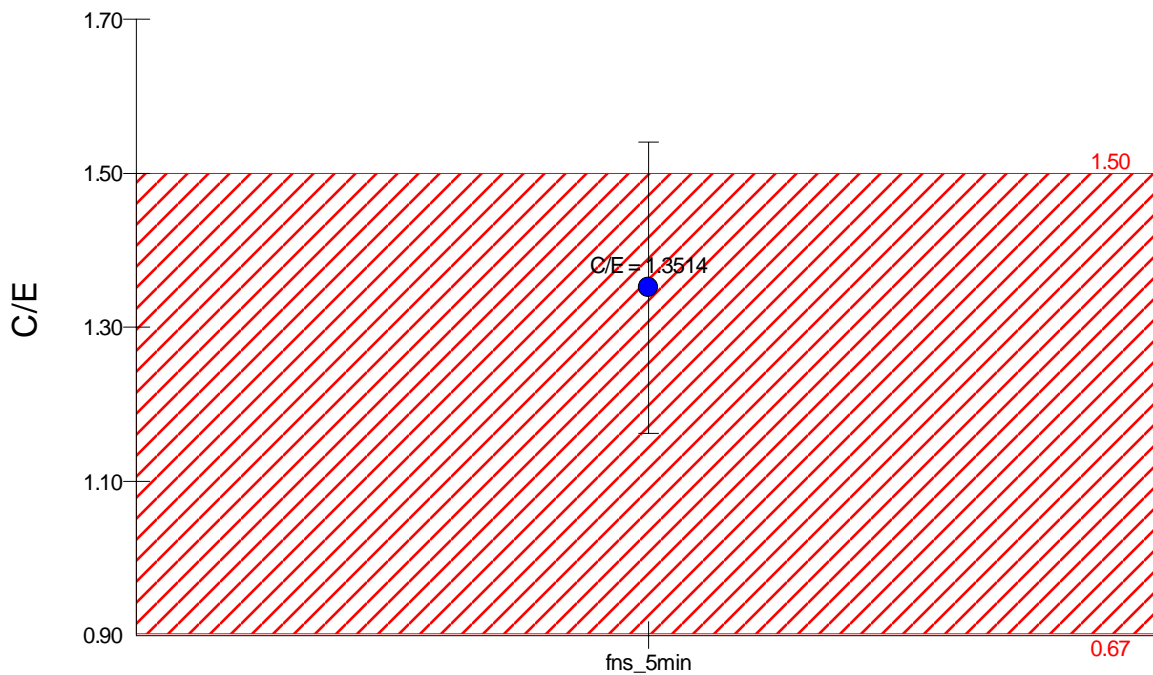




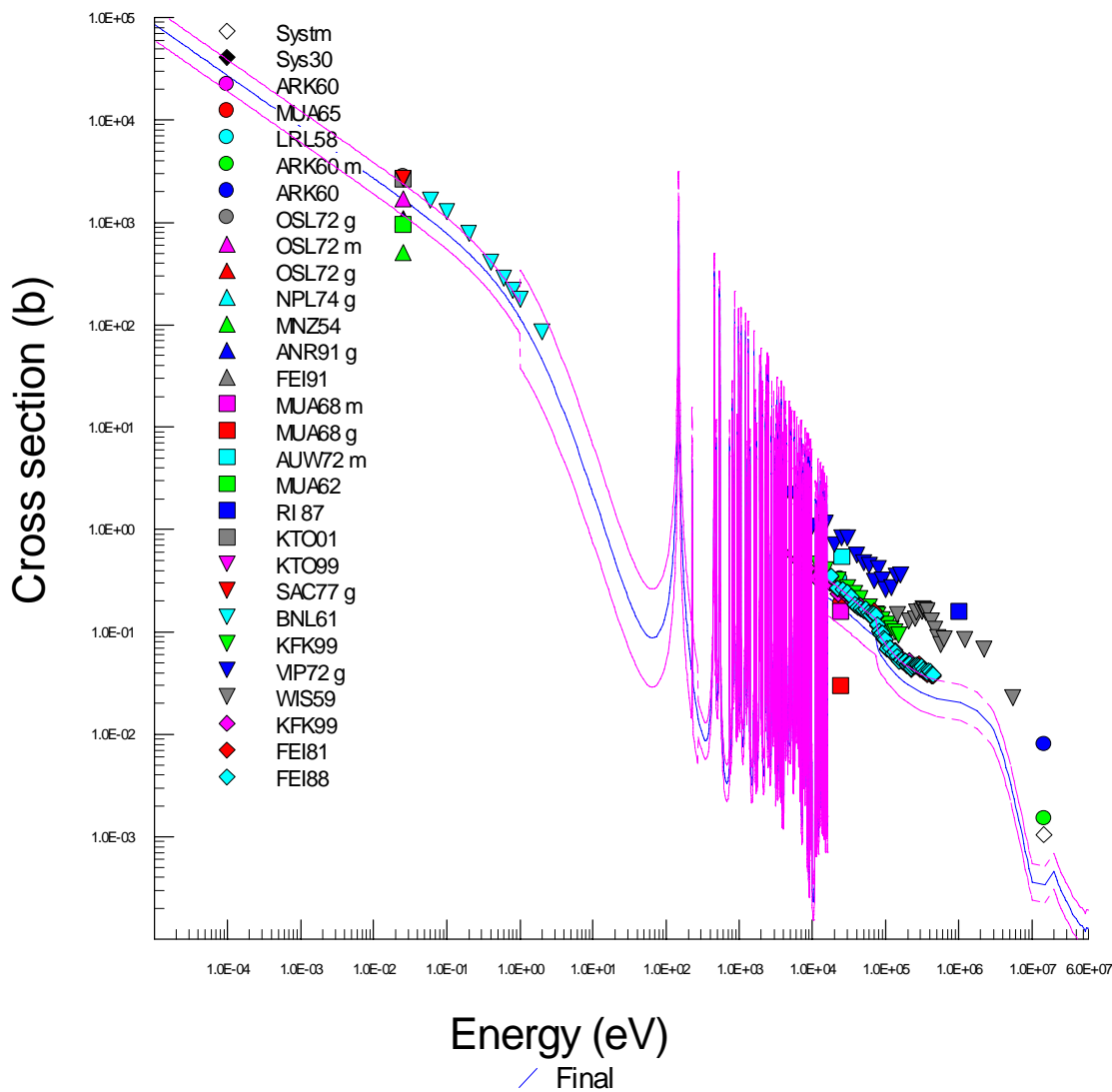
Neutron Spectrum

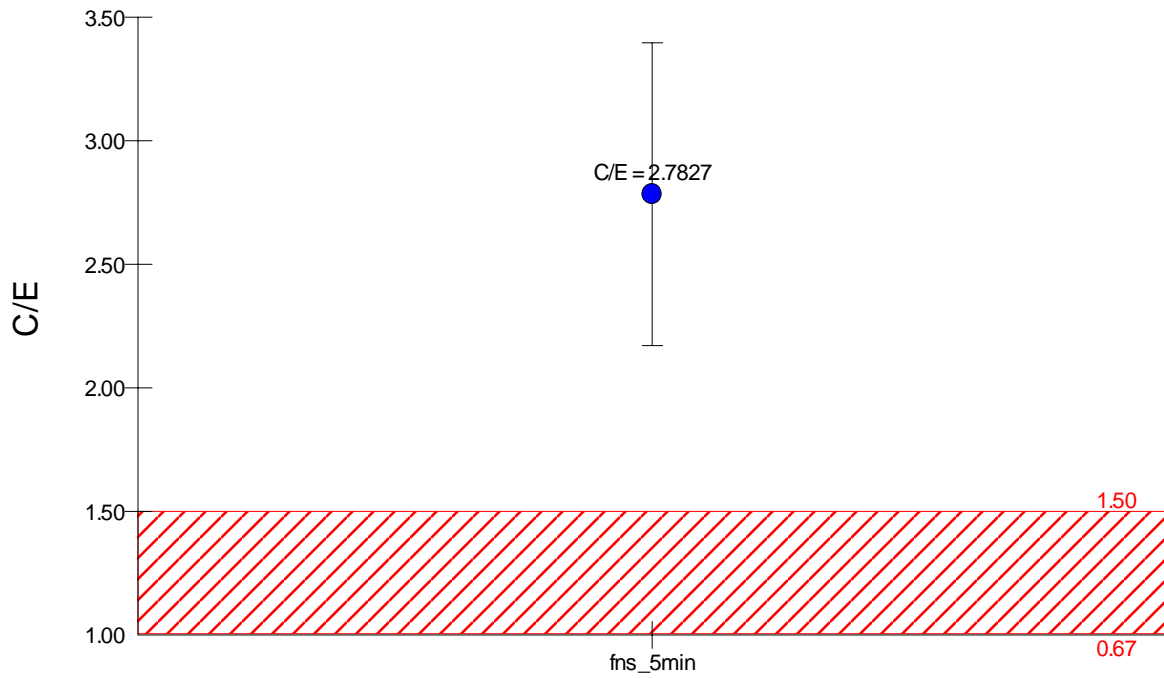
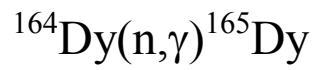


$^{164}\text{Dy}(n,\gamma)^{165\text{m}}\text{Dy}$

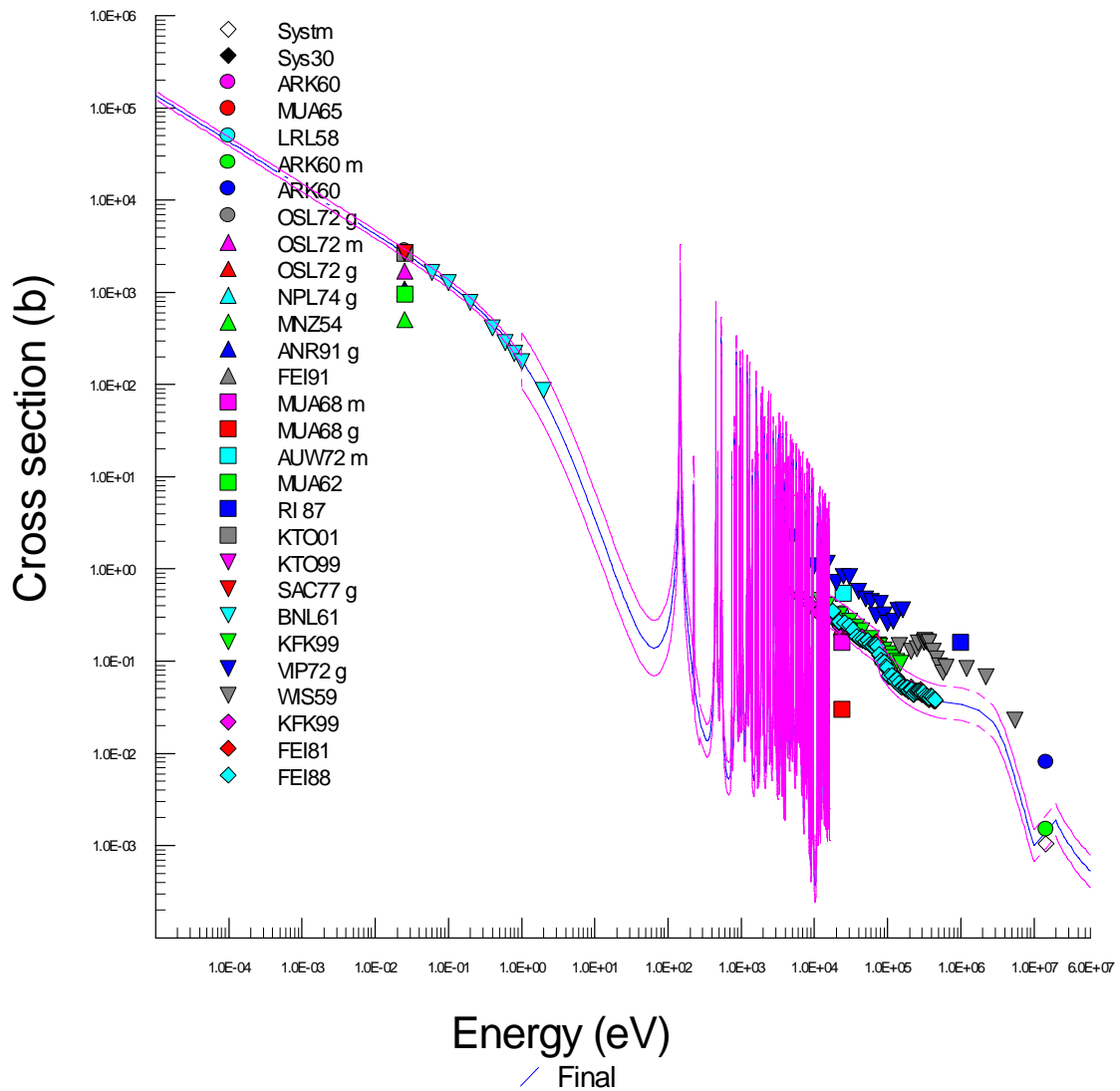


Neutron Spectrum

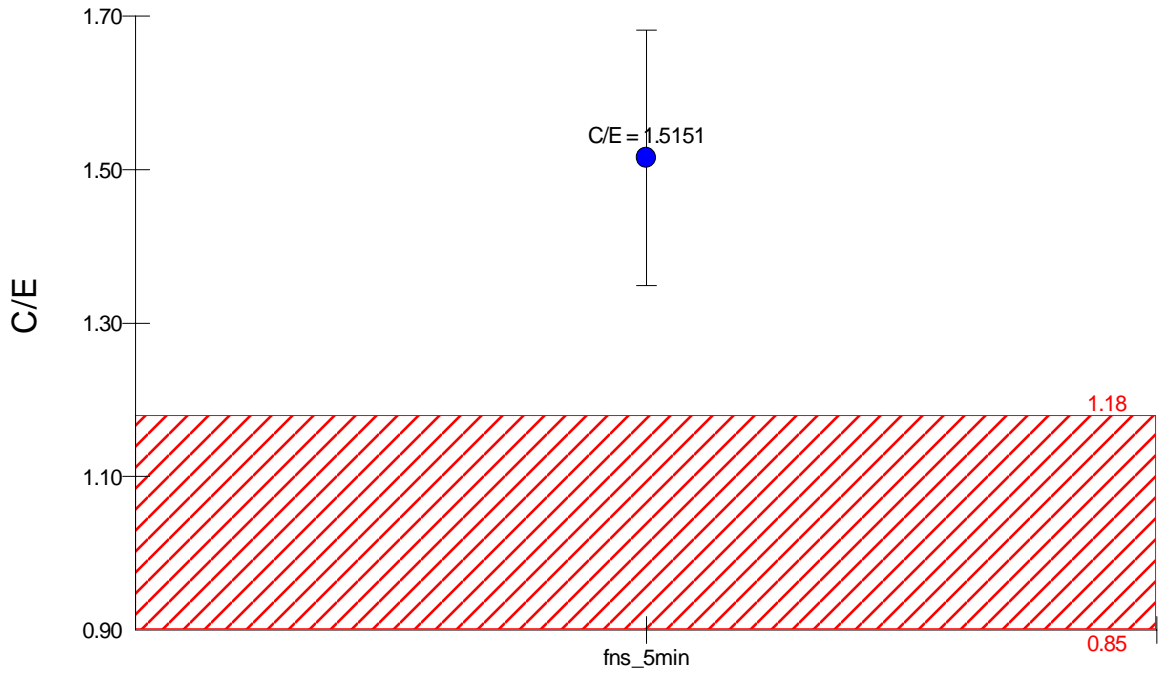




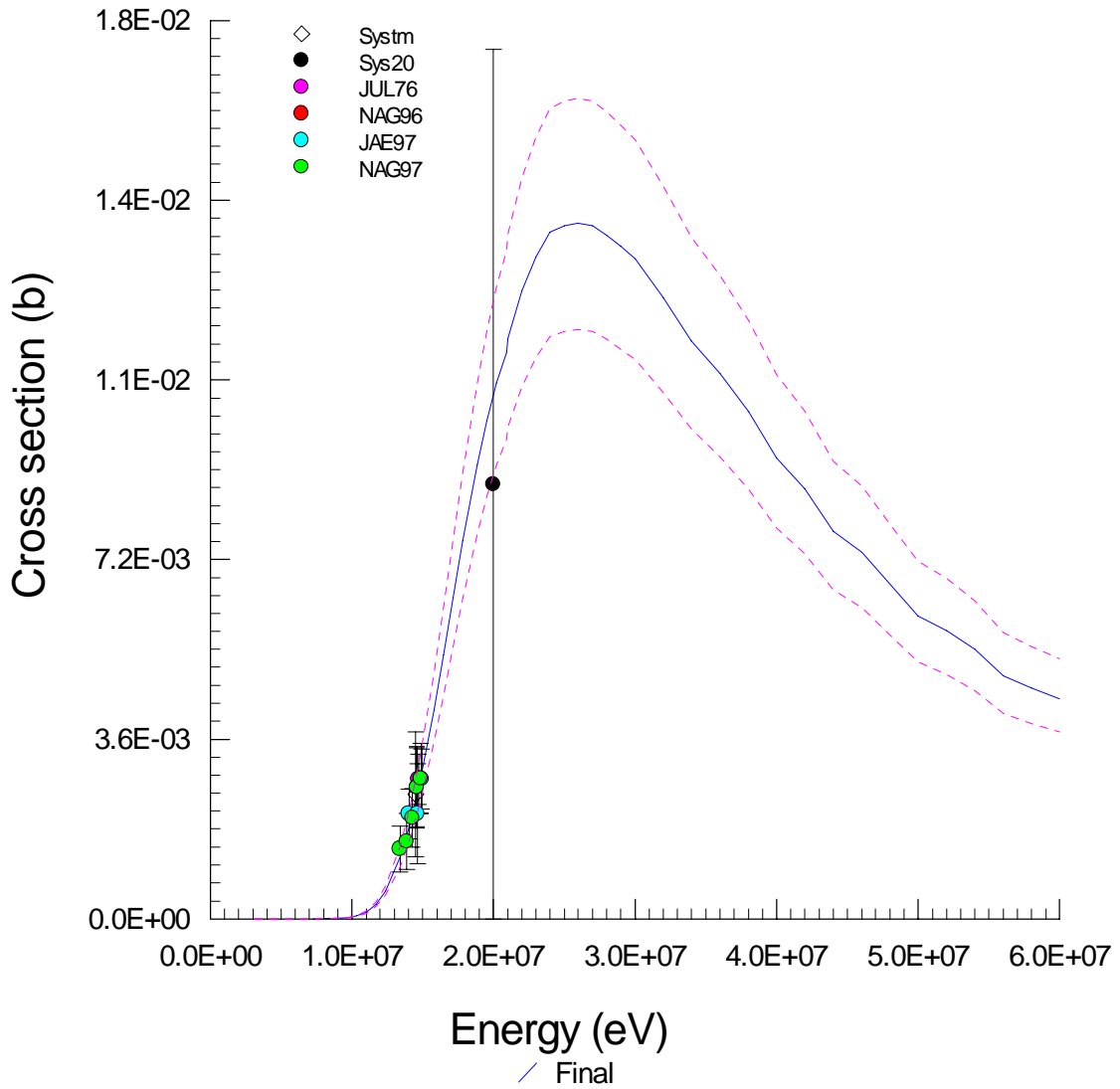
Neutron Spectrum



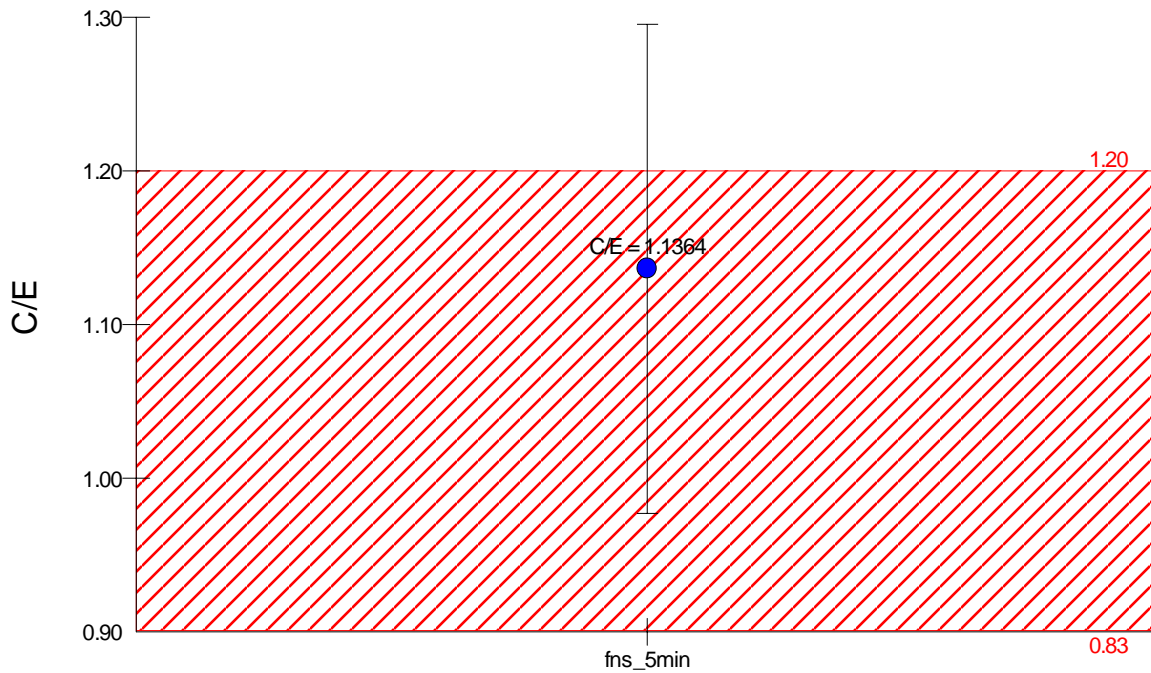
$^{164}\text{Dy}(n,p)^{164}\text{Tb}$



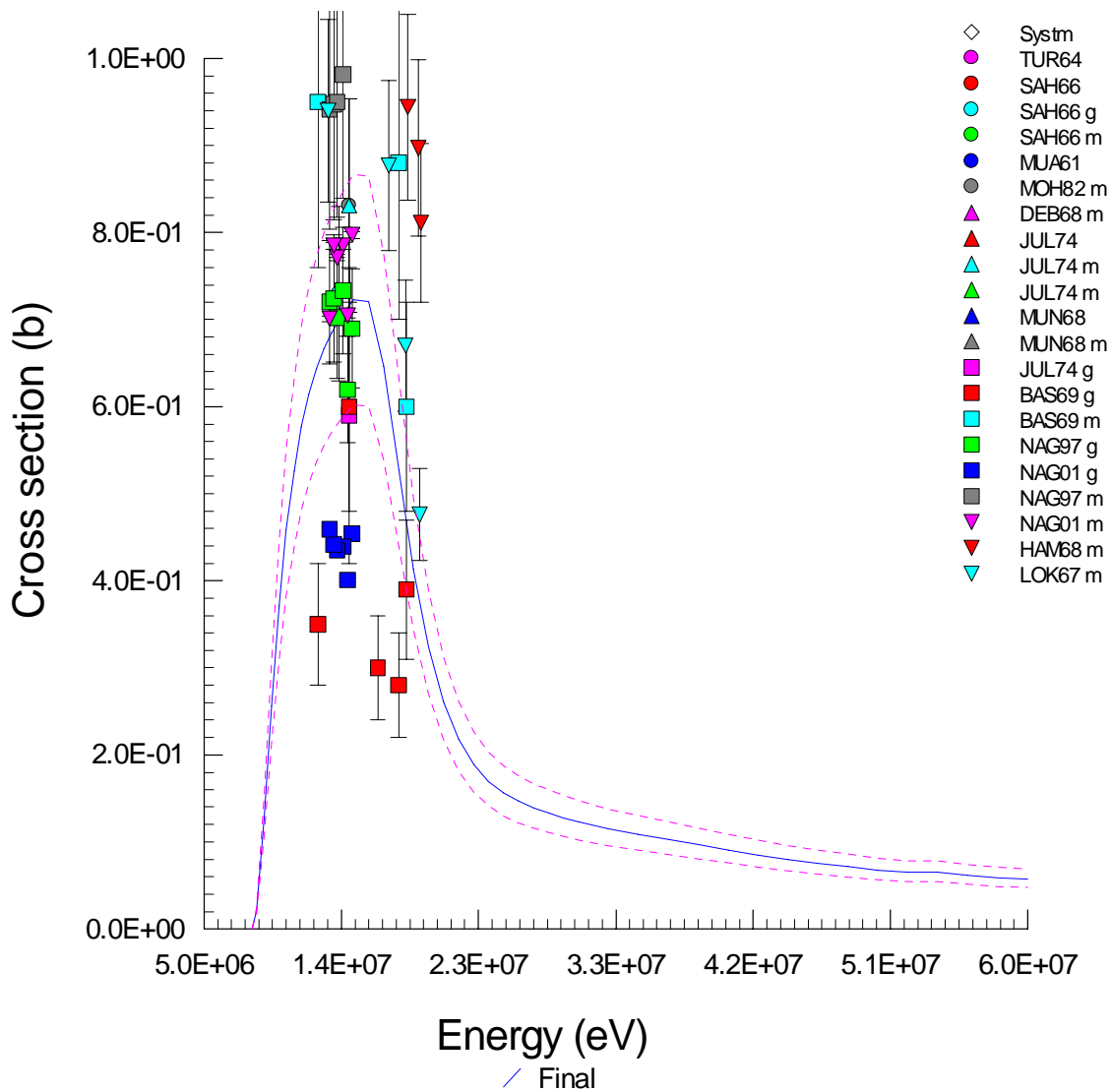
Neutron Spectrum



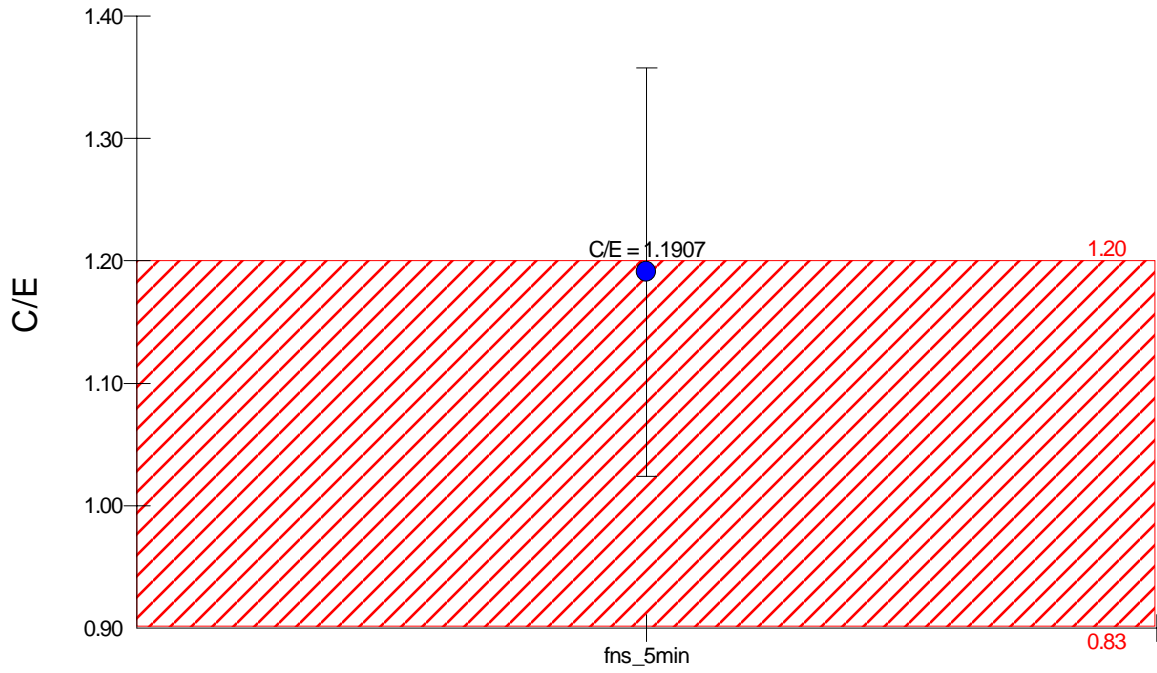
$^{165}\text{Ho}(n,2n)^{164\text{m}}\text{Ho}$



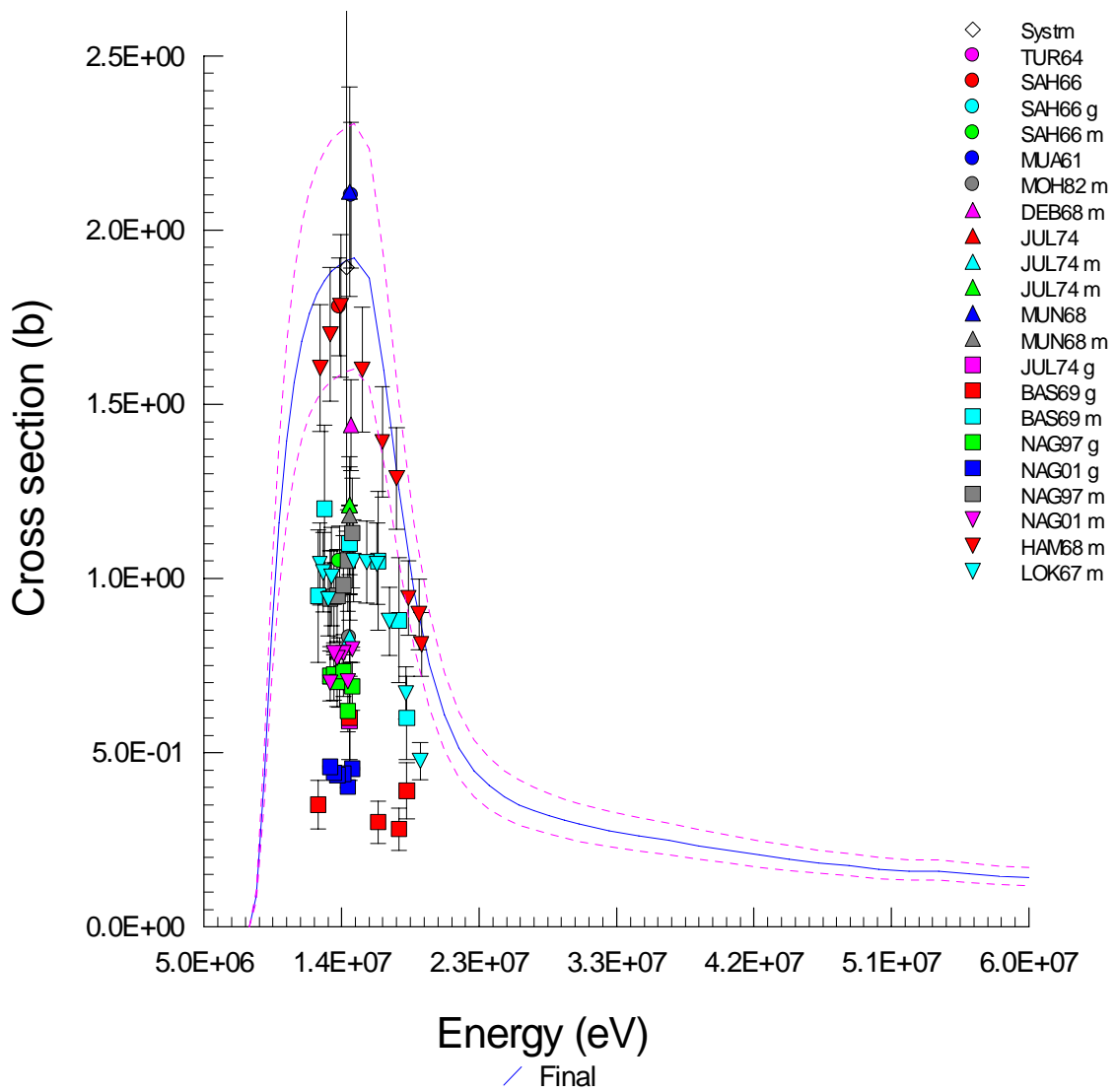
Neutron Spectrum



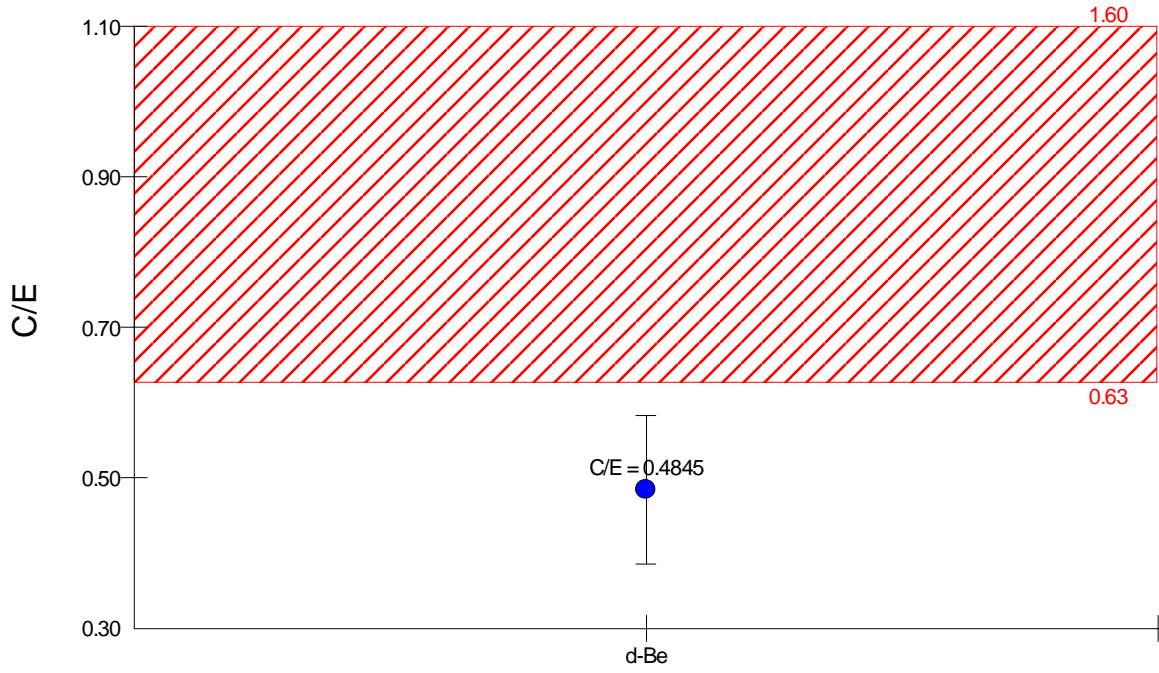
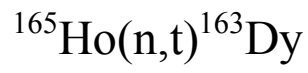
$^{165}\text{Ho}(n,2n)^{164}\text{Ho}$



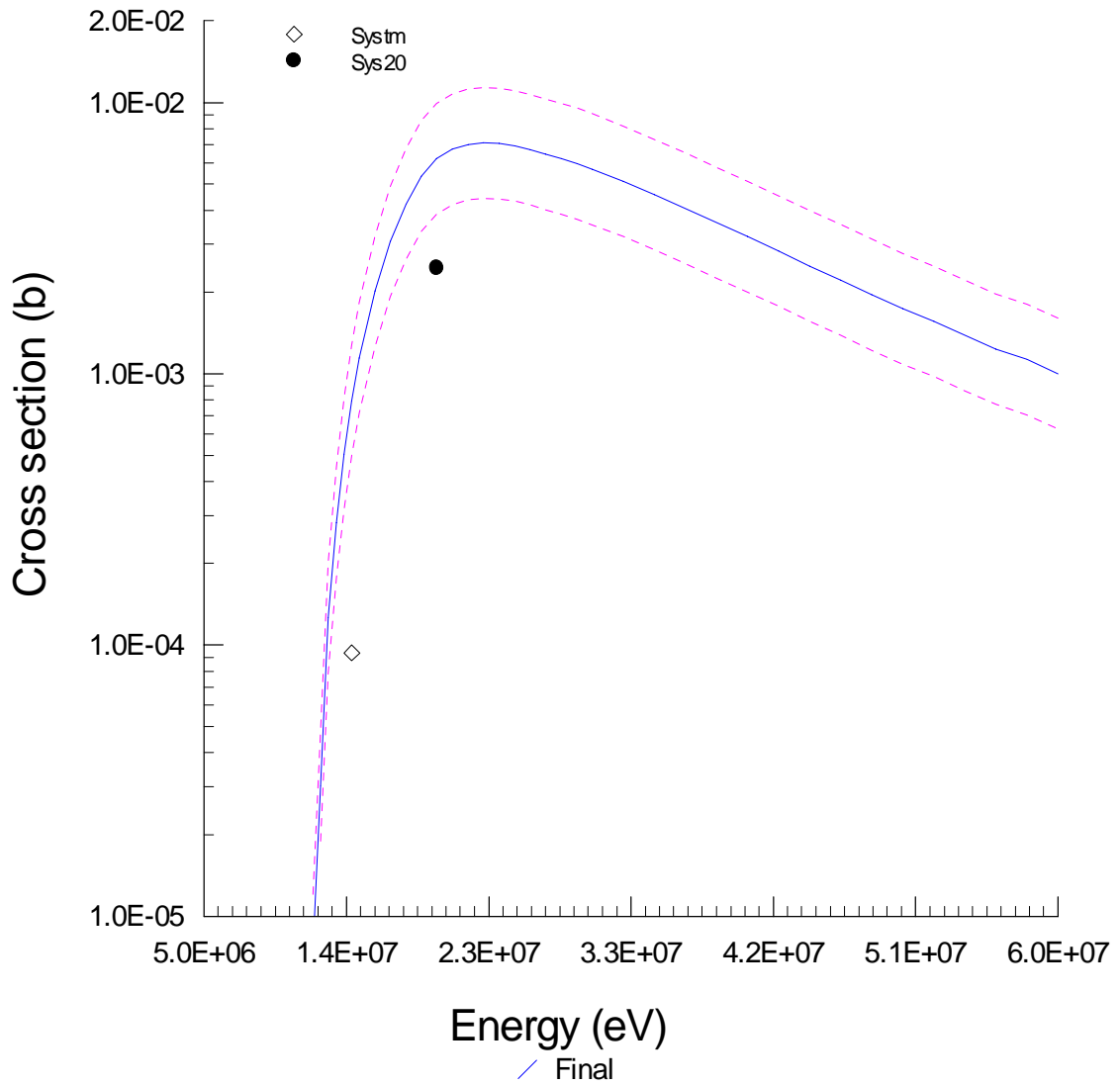
Neutron Spectrum

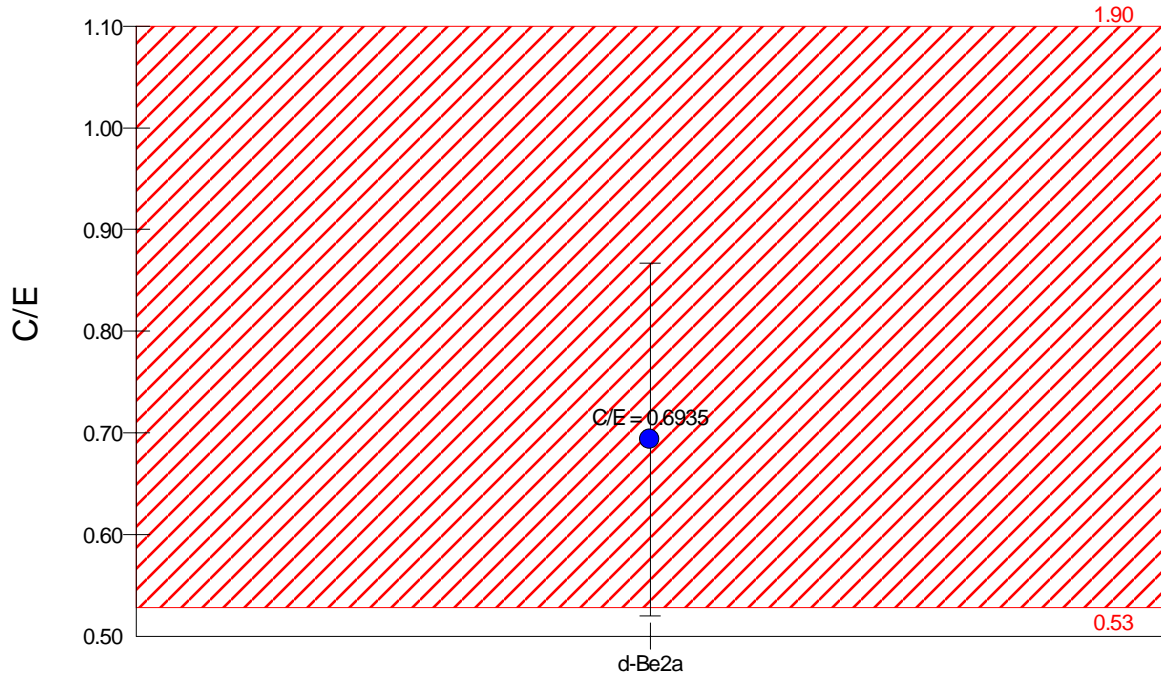
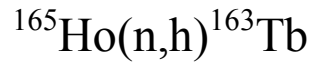




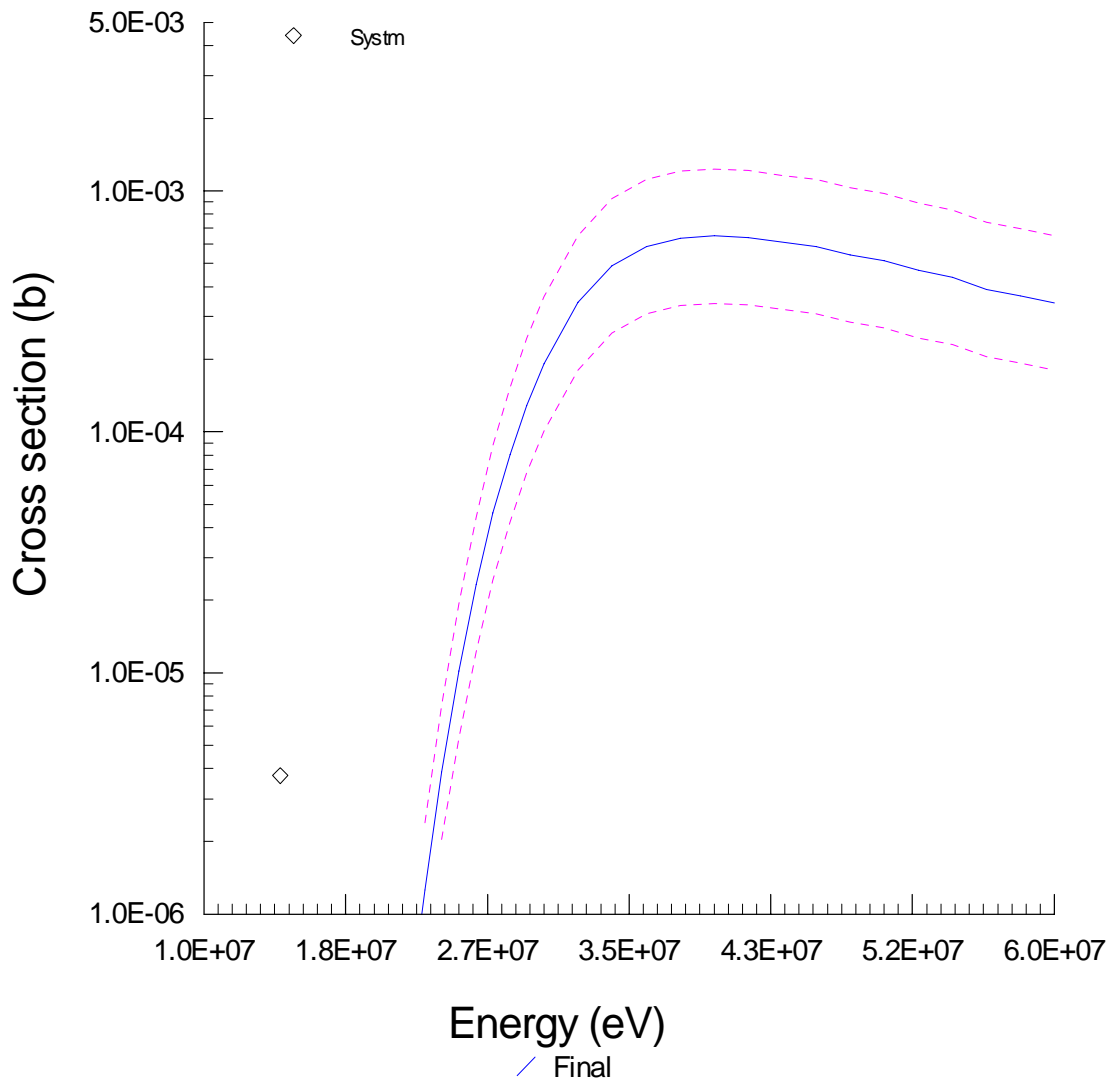


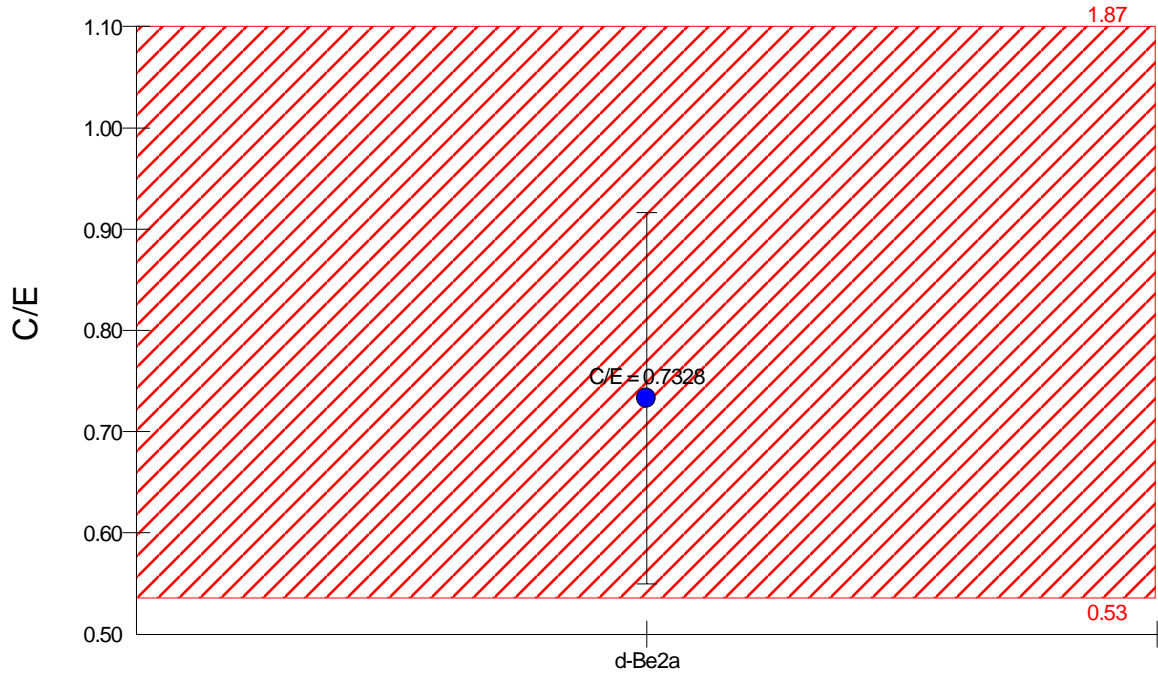
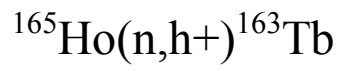
Neutron Spectrum



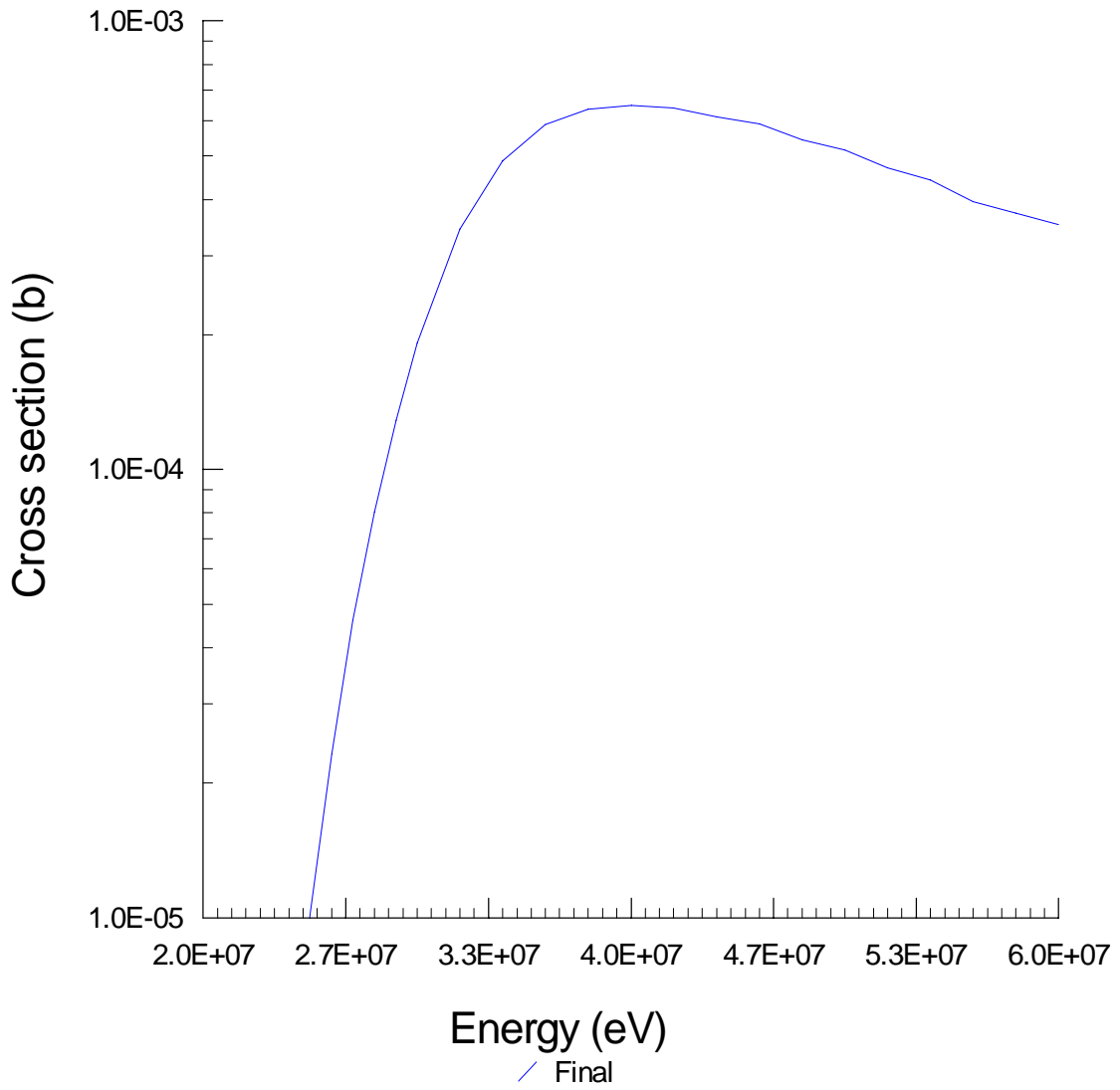


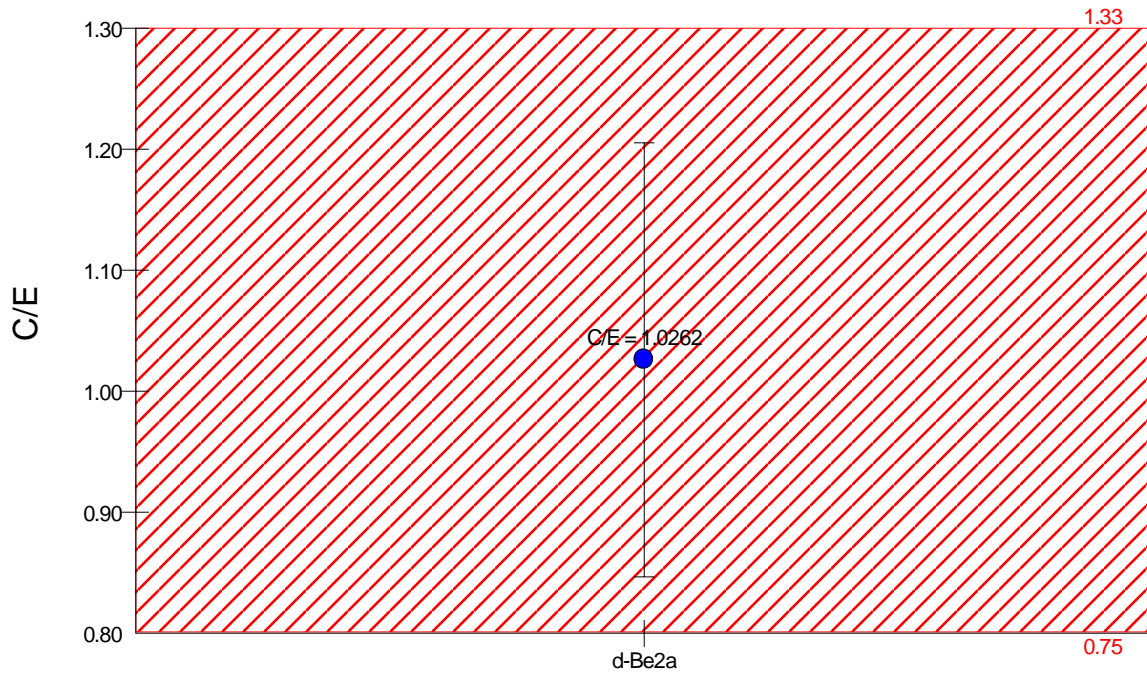
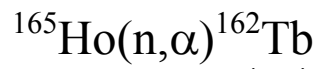
Neutron Spectrum



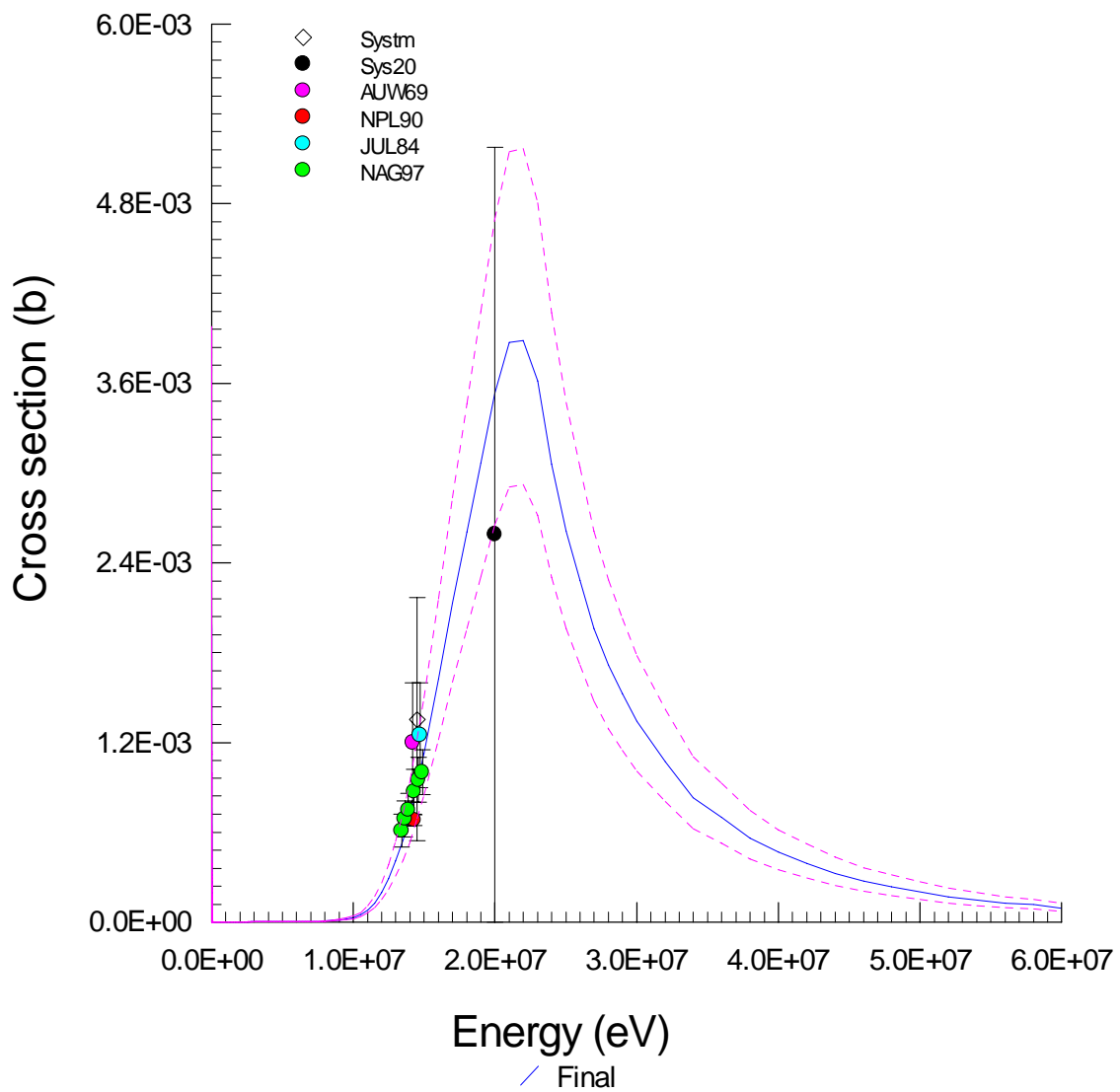


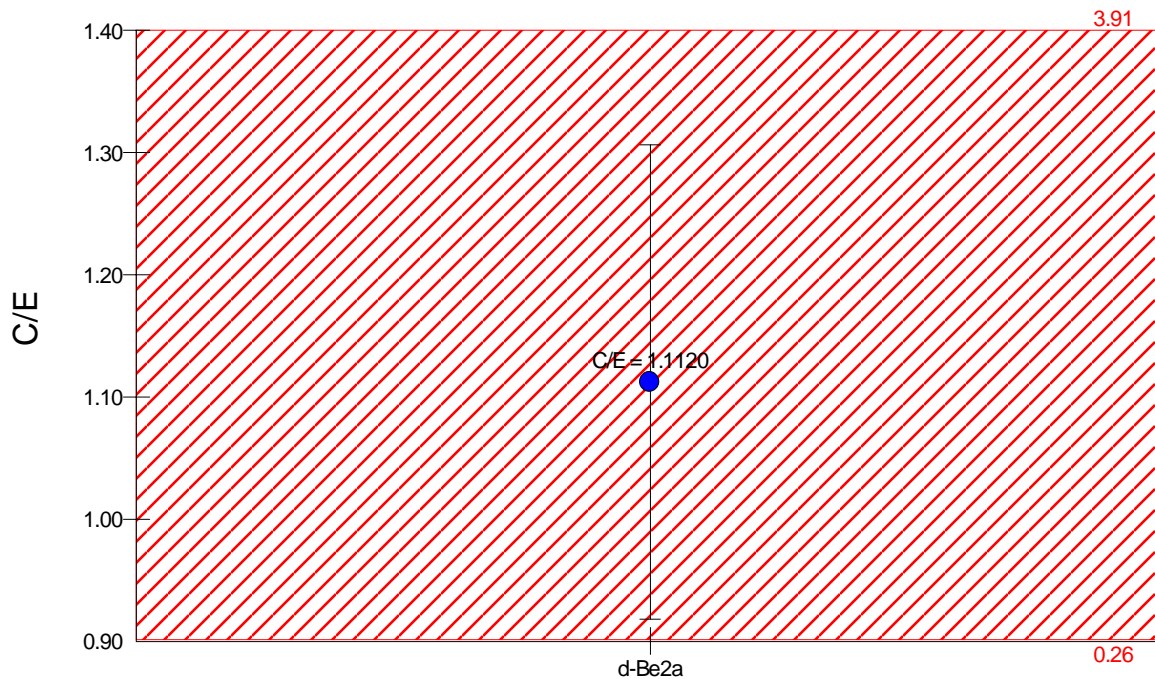
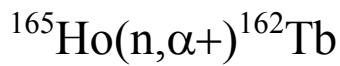
Neutron Spectrum



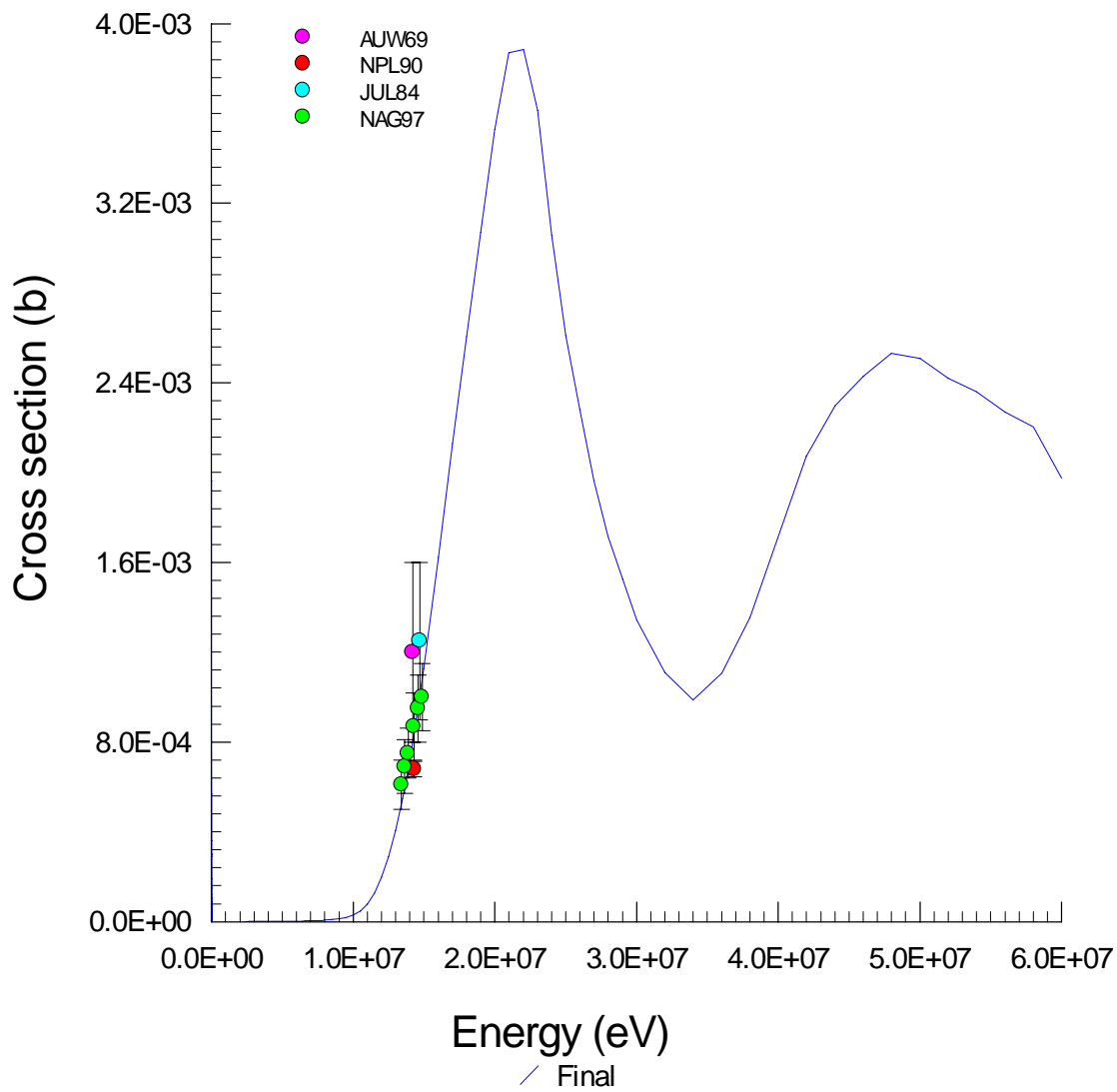


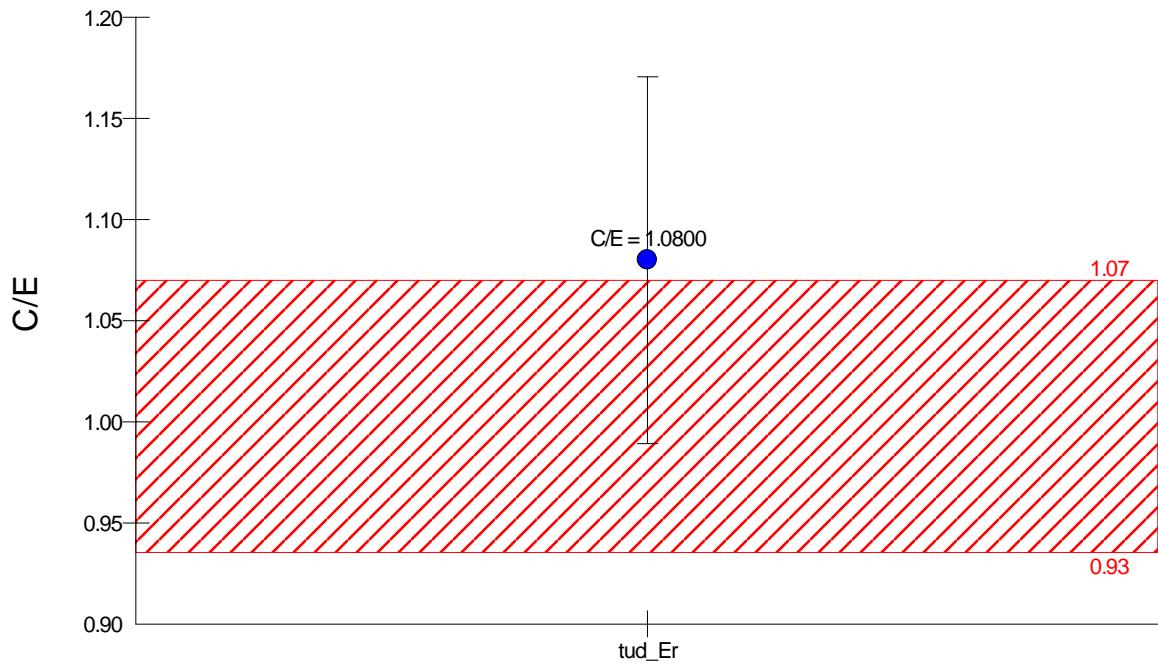
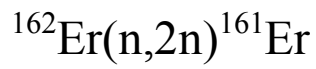
Neutron Spectrum



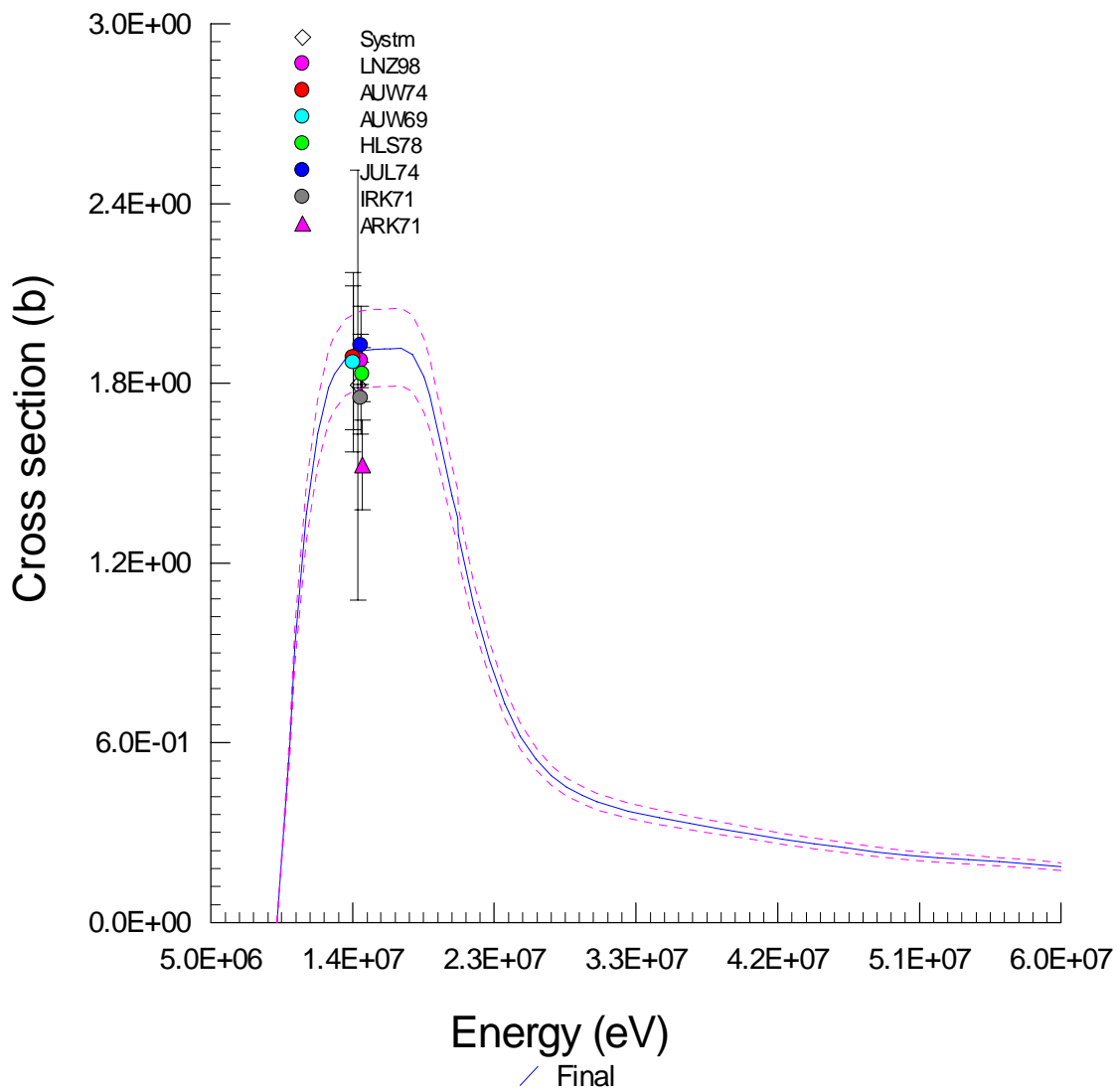


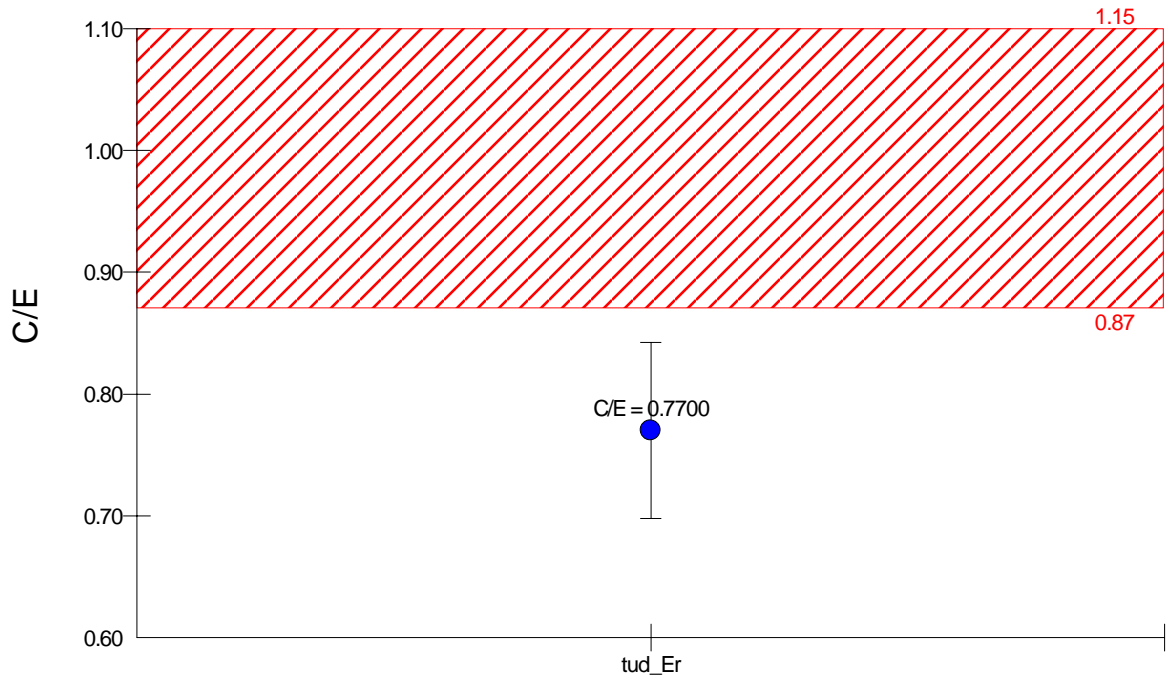
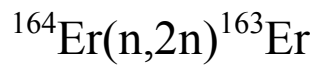
Neutron Spectrum



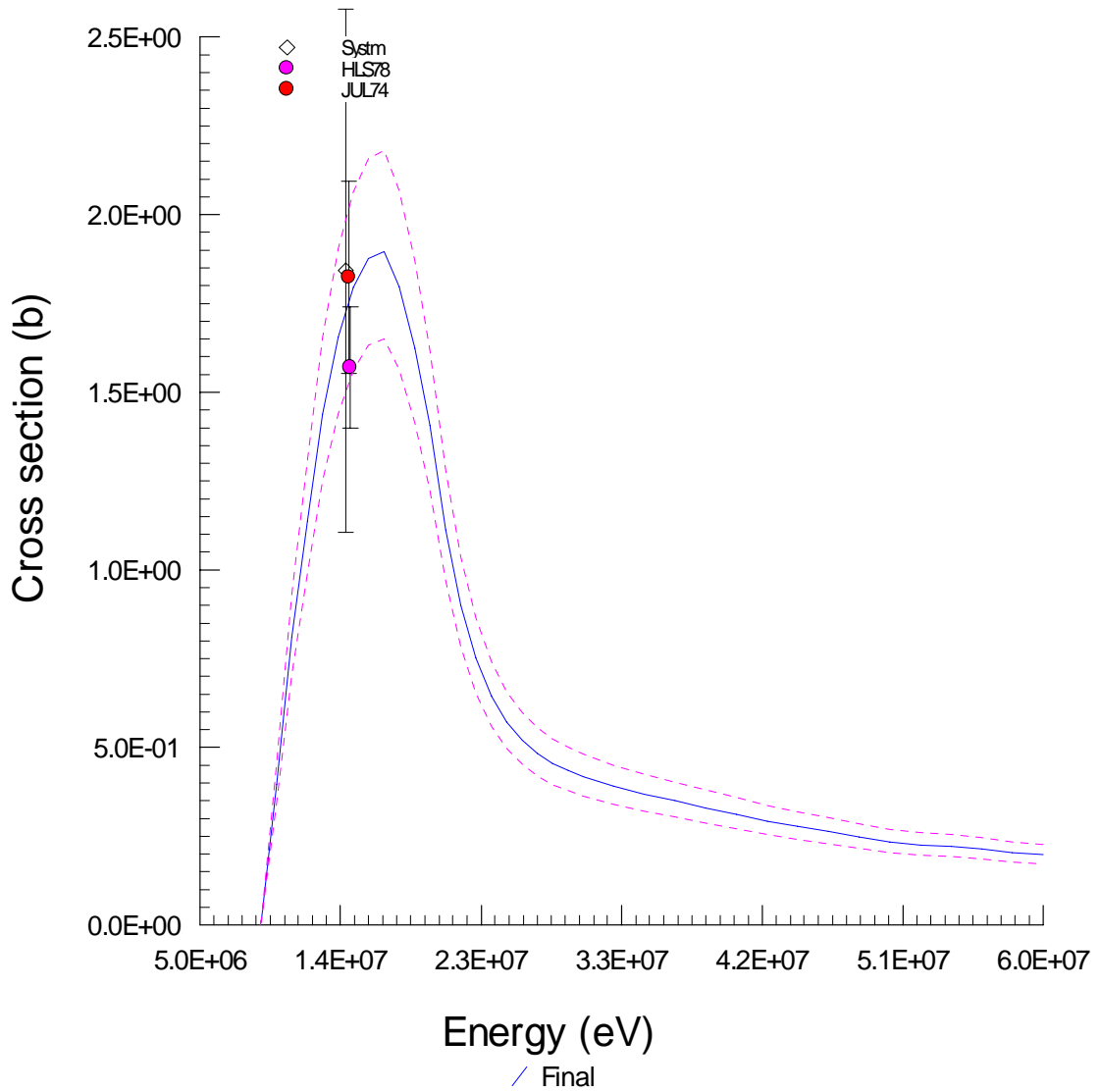


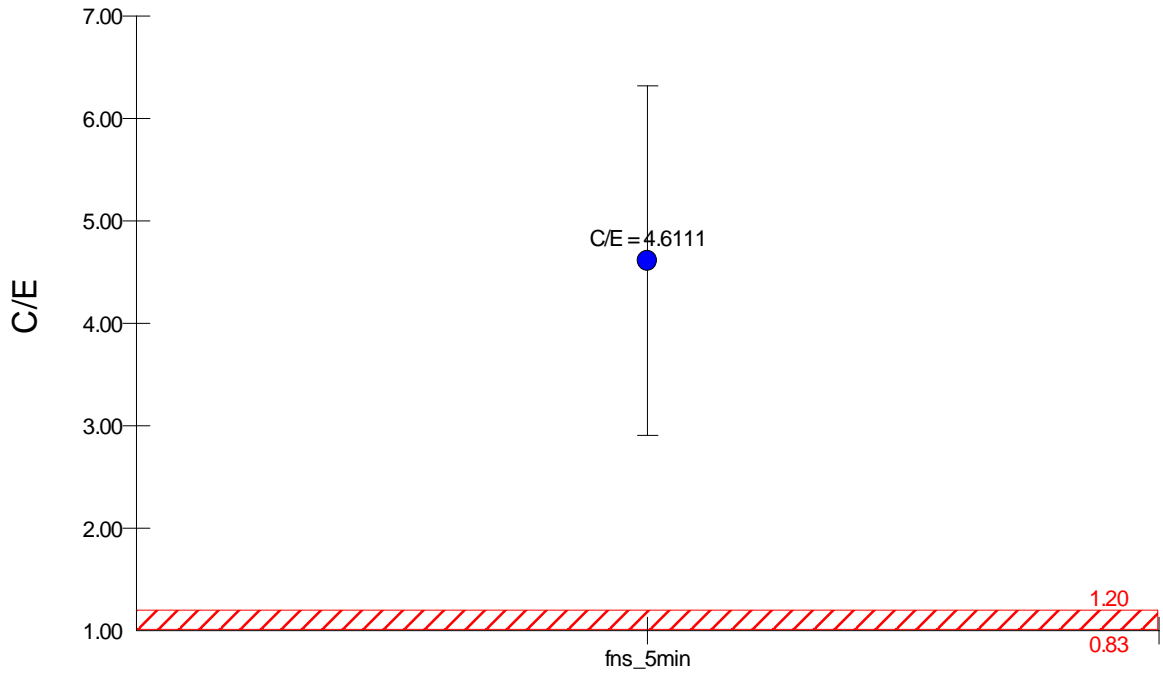
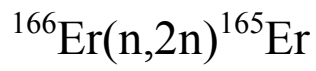
Neutron Spectrum



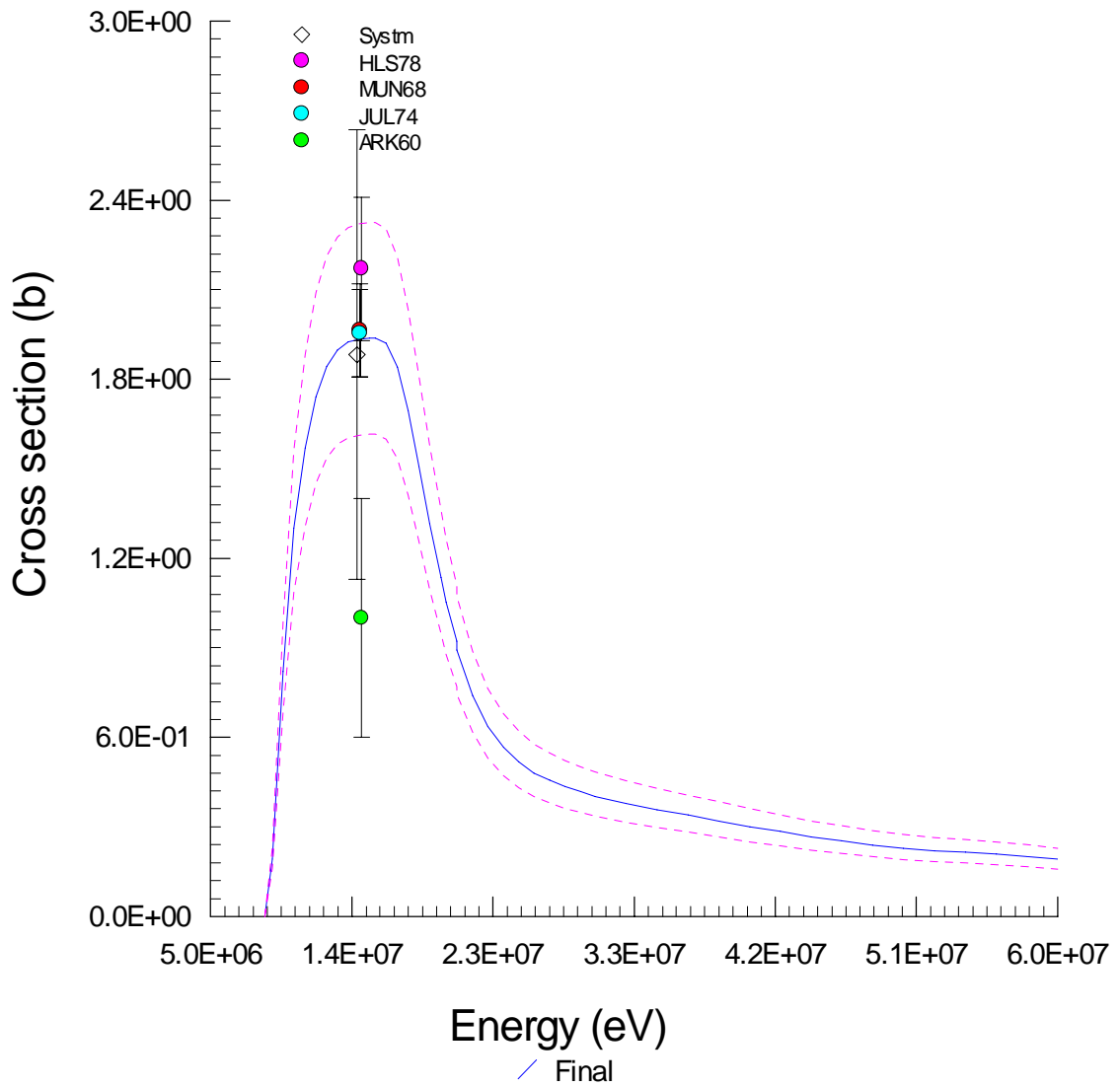


Neutron Spectrum



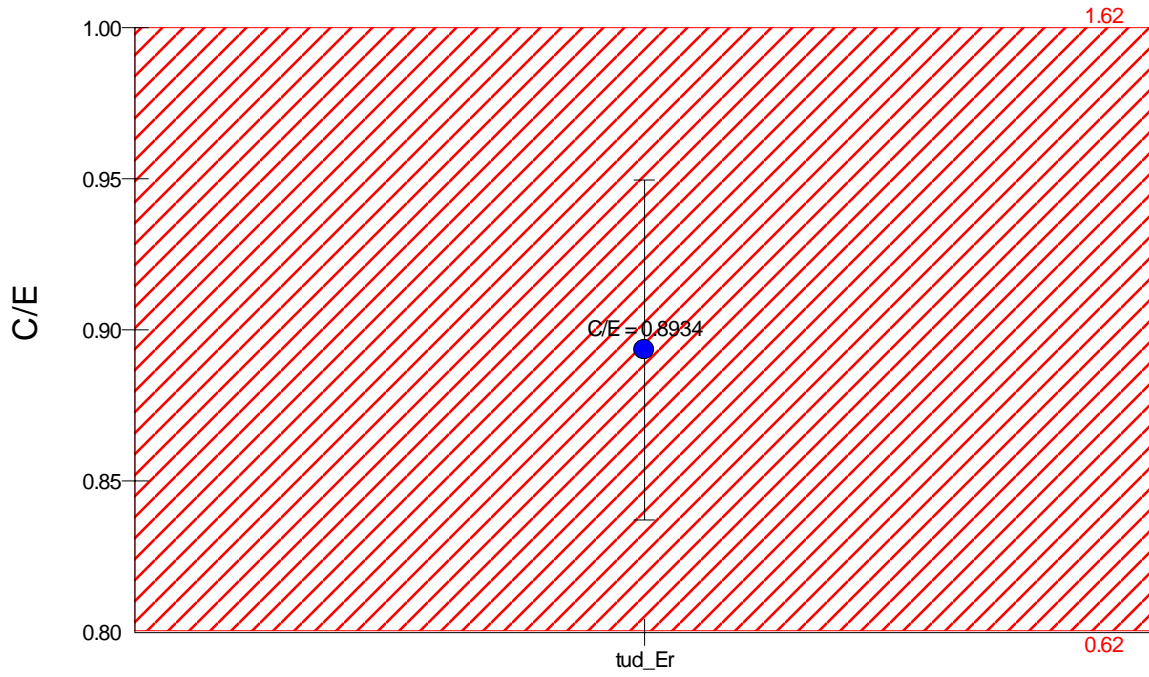


Neutron Spectrum

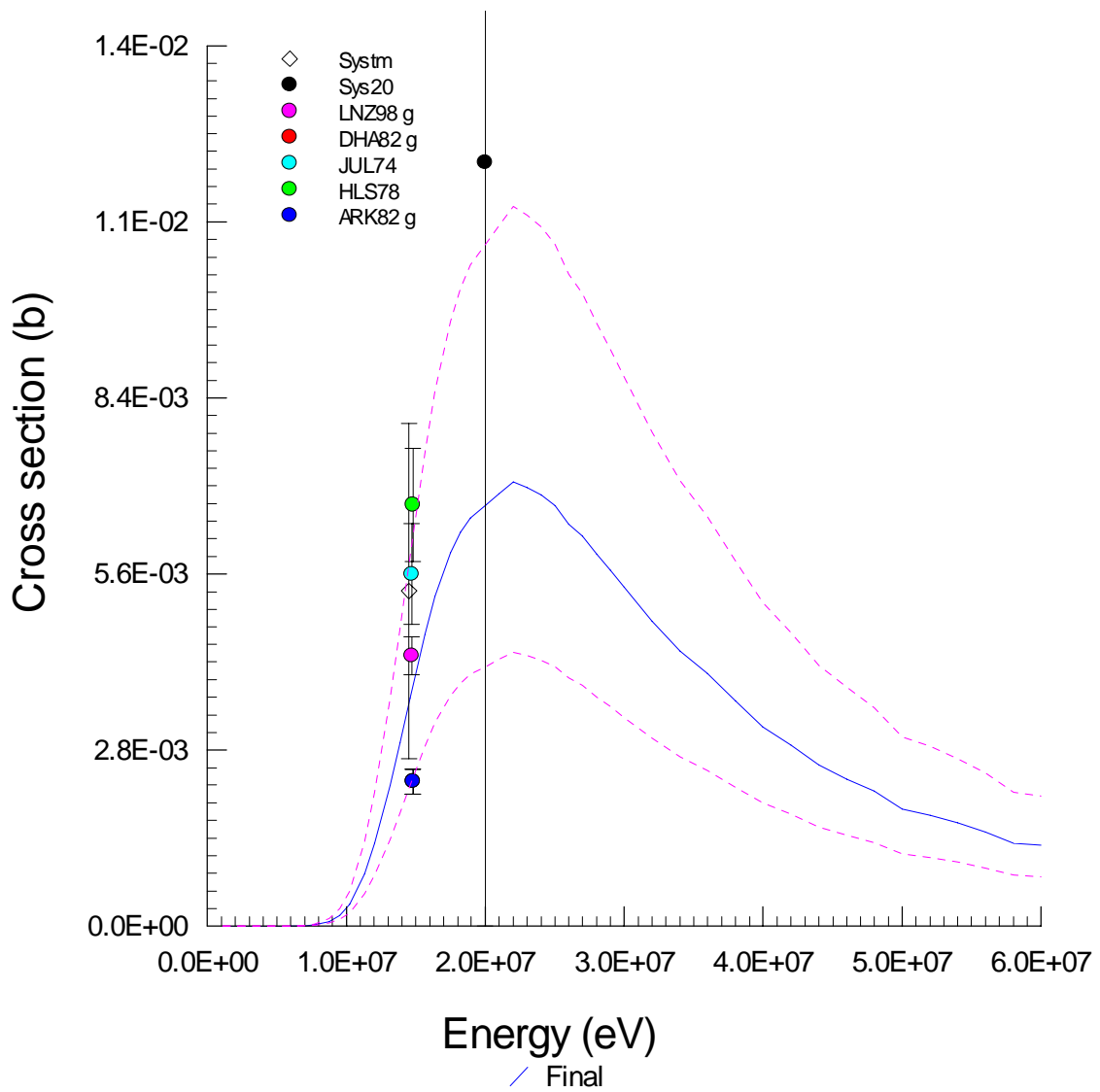




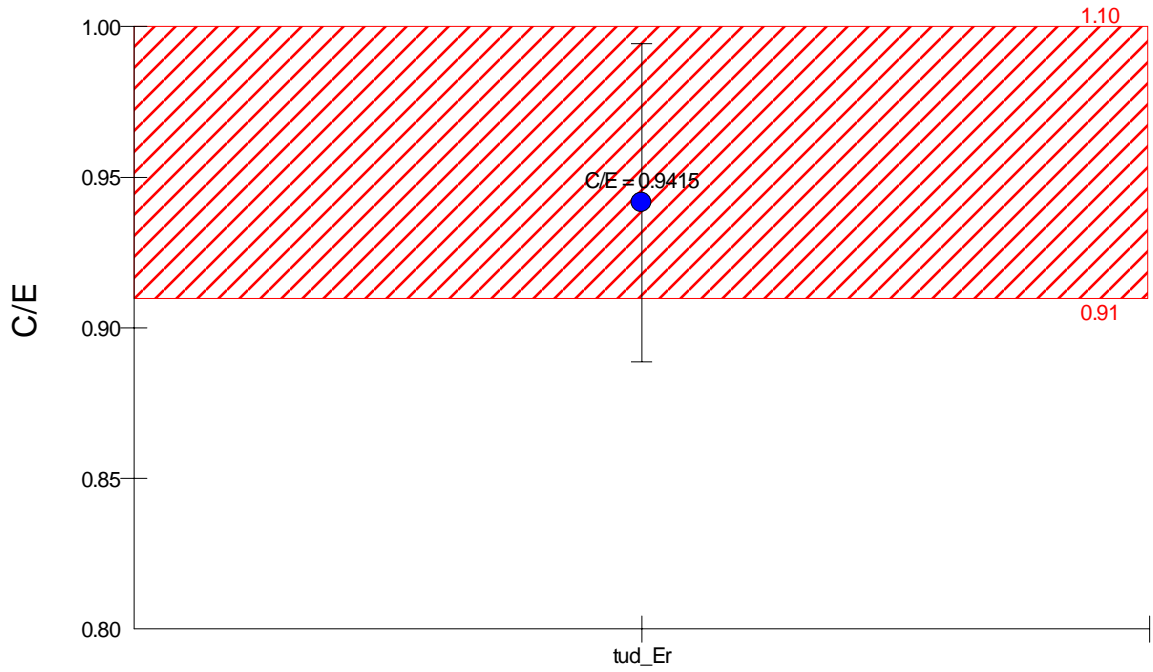
$^{166}\text{Er}(n,p)^{166g}\text{Ho}$



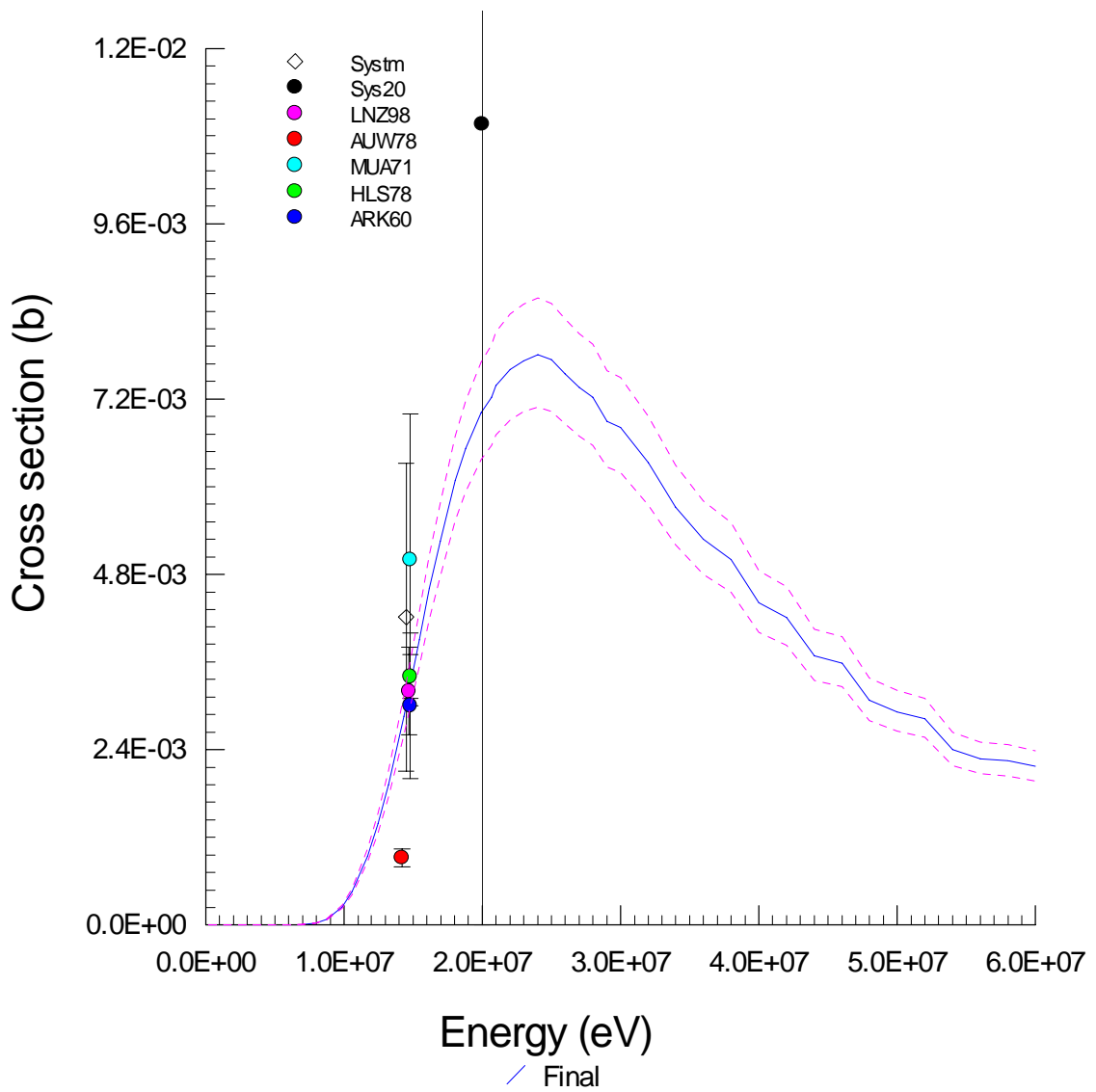
Neutron Spectrum



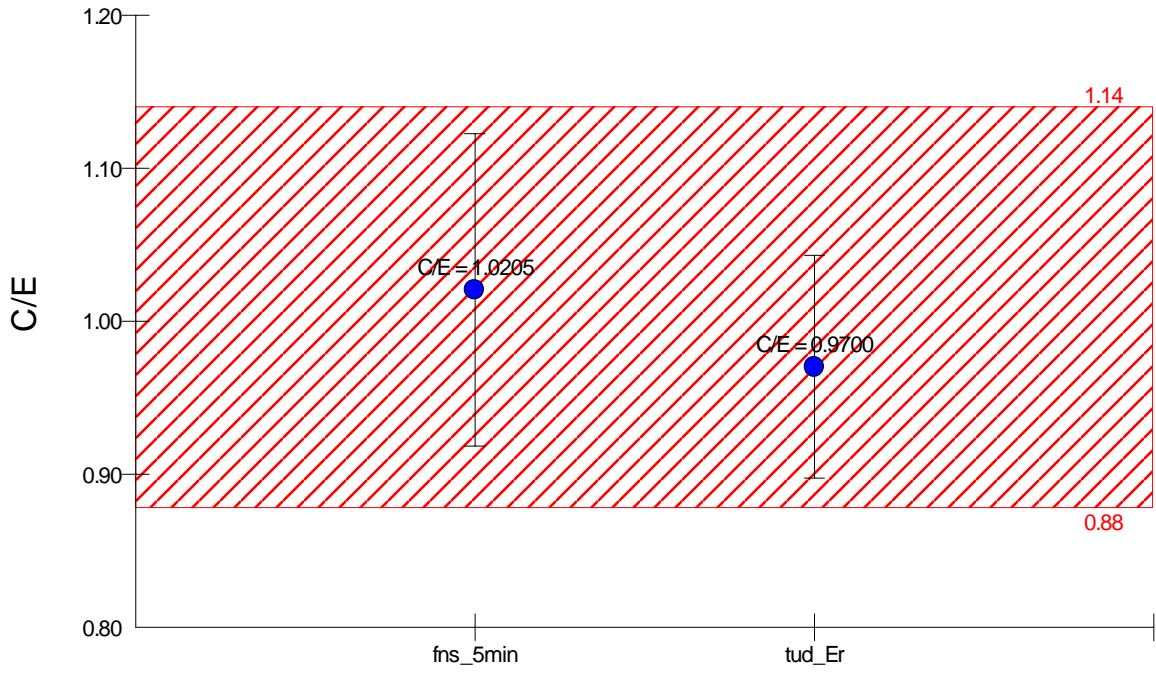
# $^{167}\text{Er}(n,p)^{167}\text{Ho}$



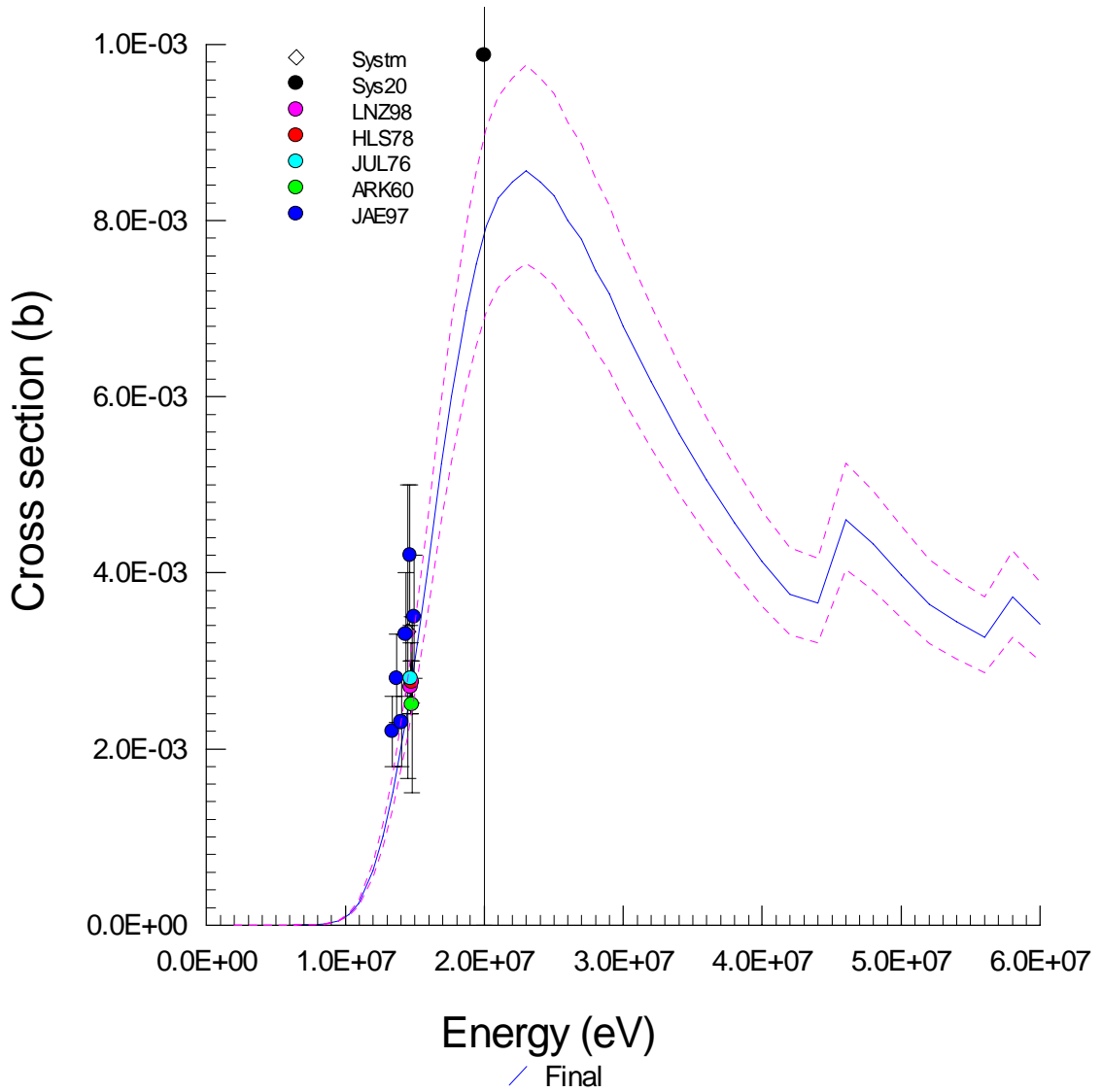
## Neutron Spectrum

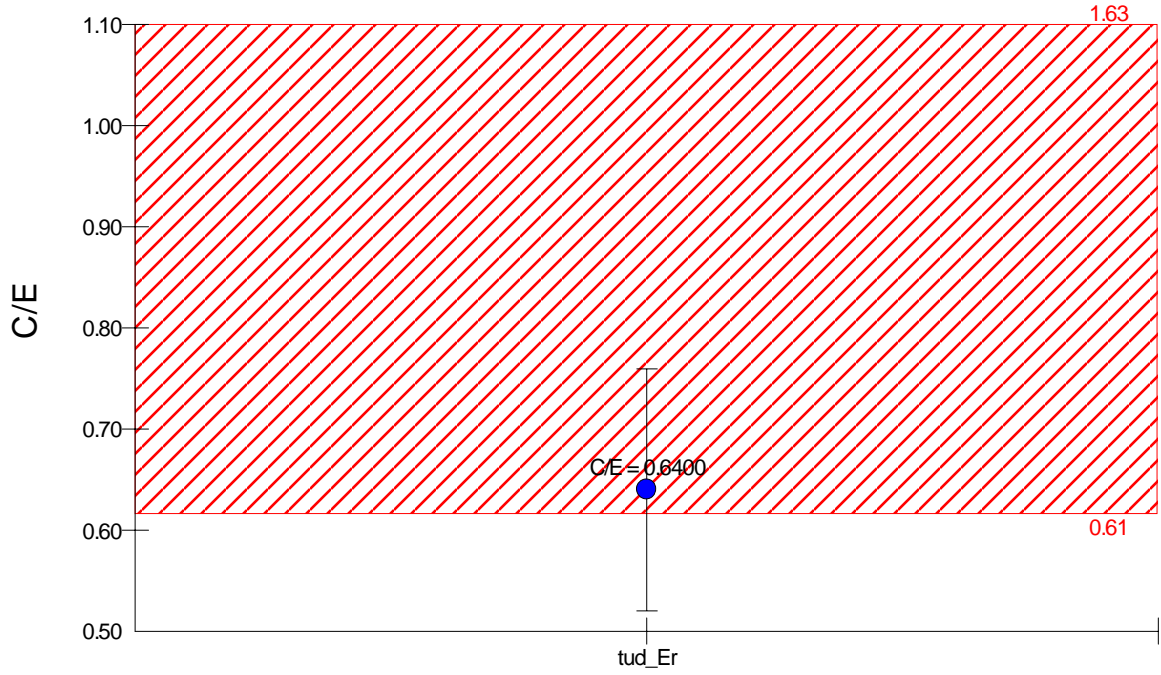
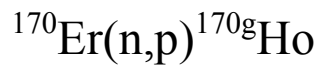


$^{168}\text{Er}(n,p)^{168}\text{Ho}$

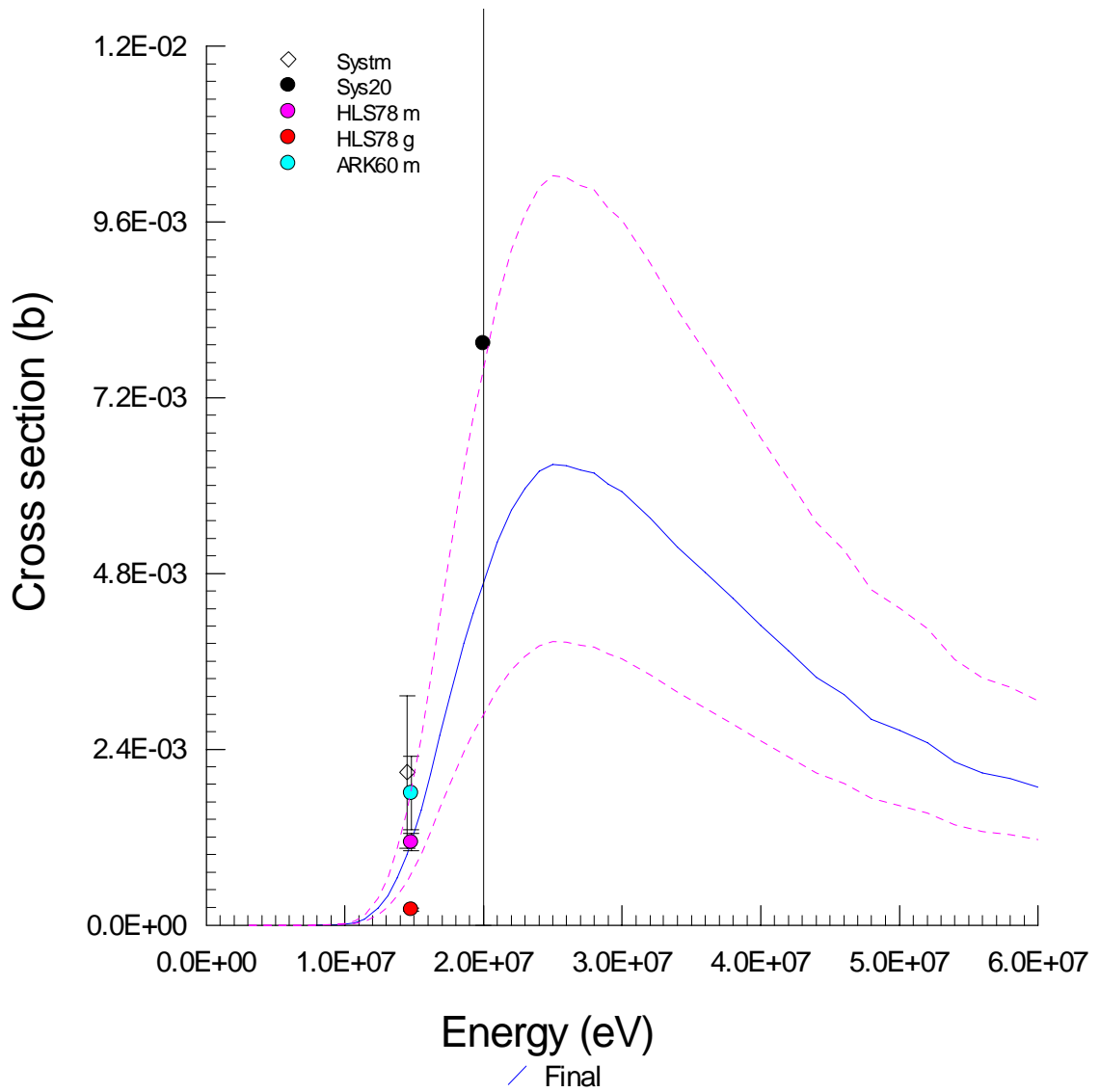


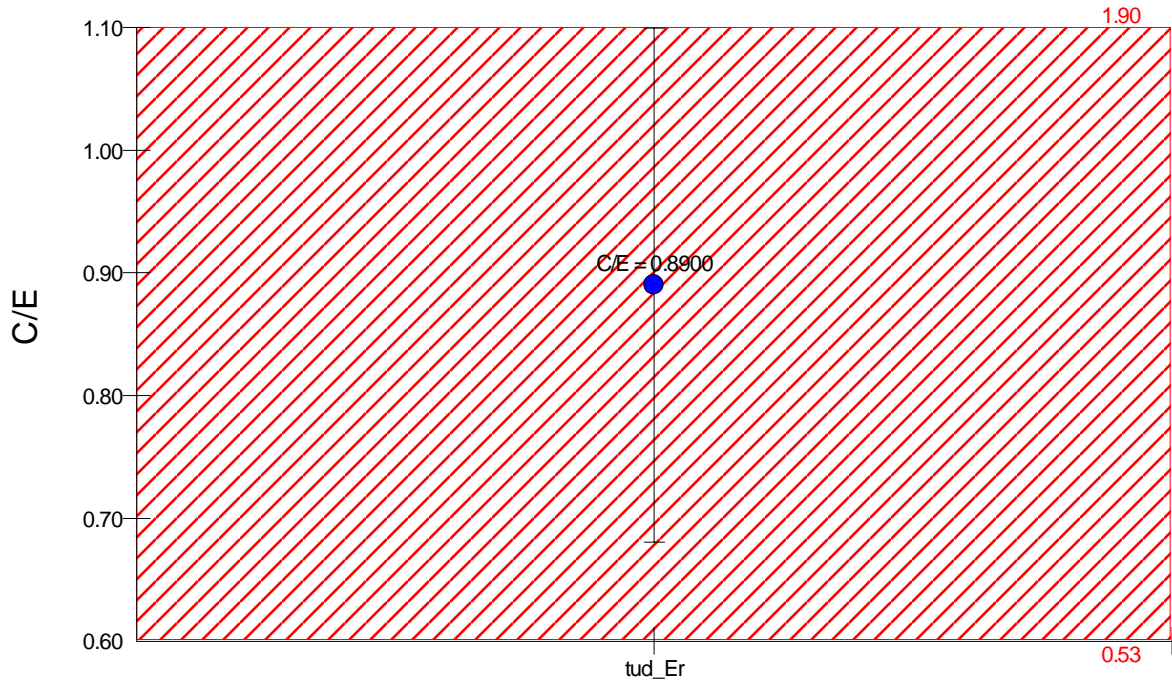
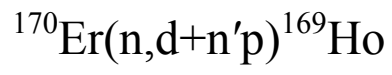
Neutron Spectrum



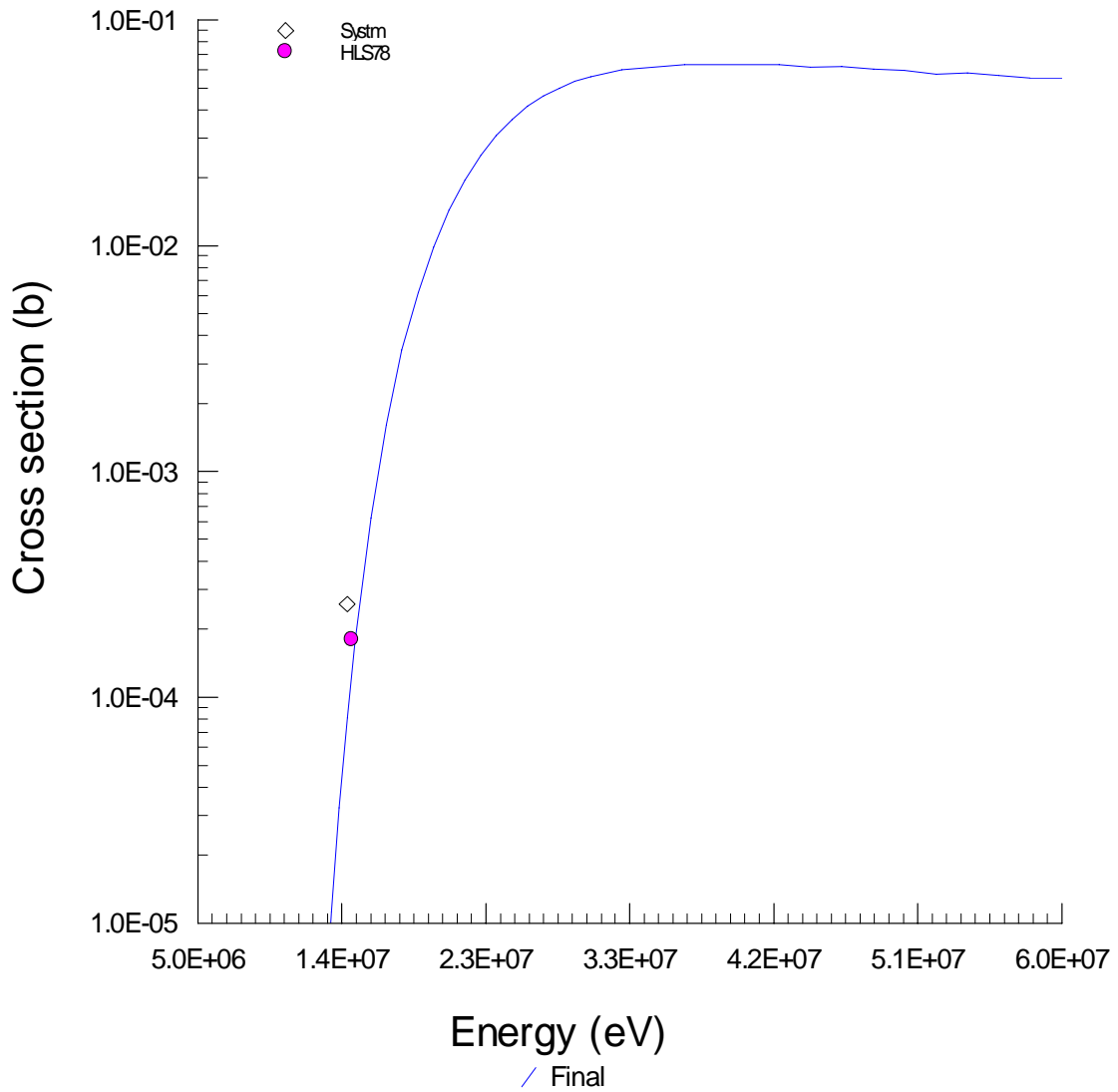


Neutron Spectrum

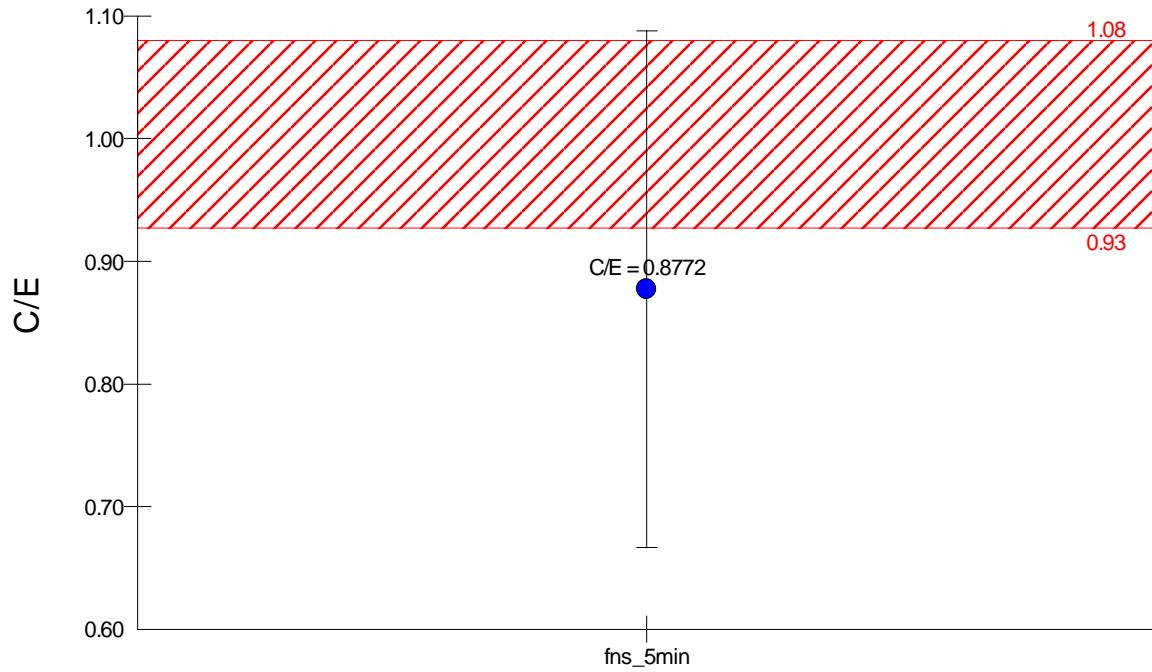




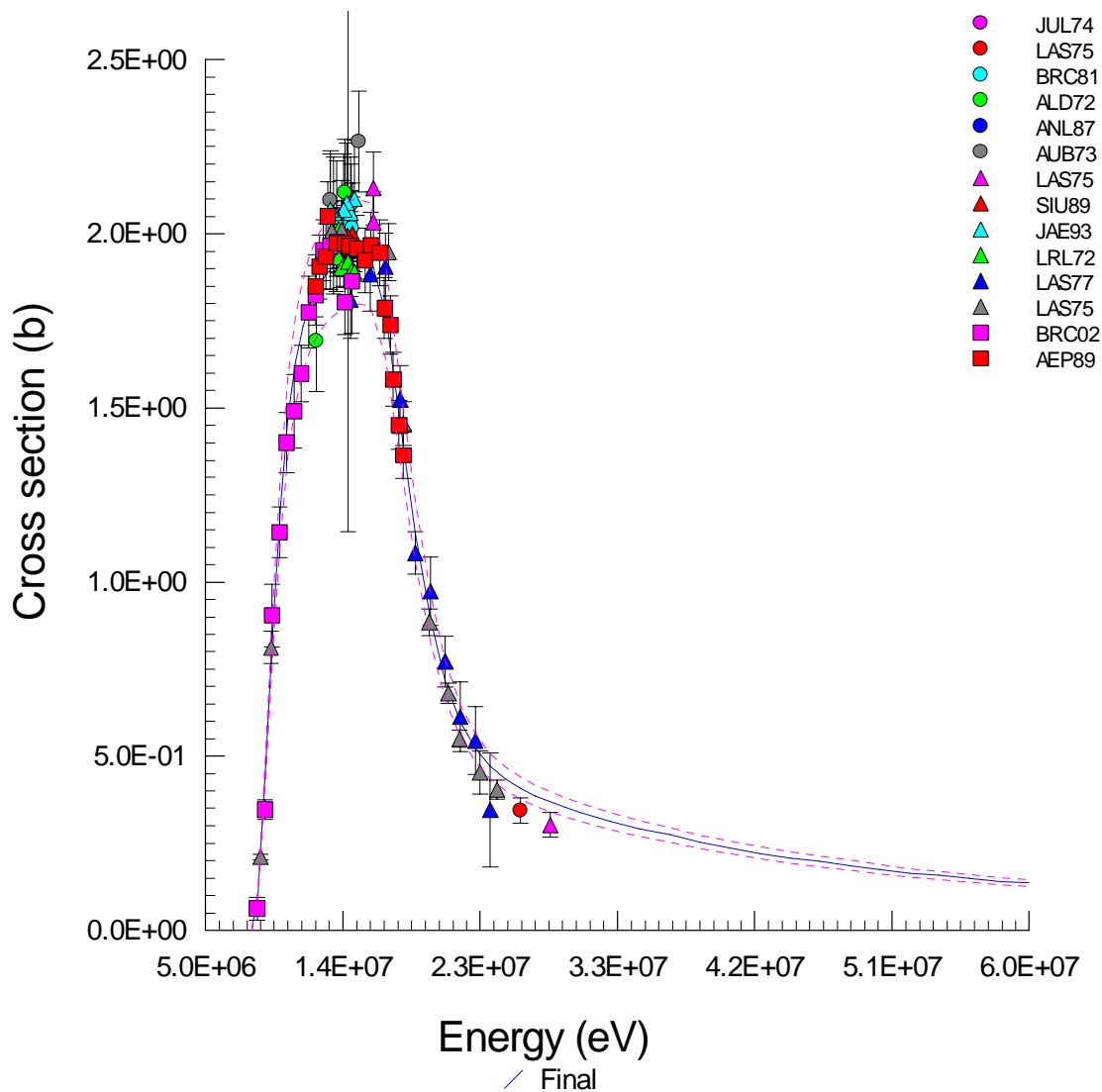
Neutron Spectrum

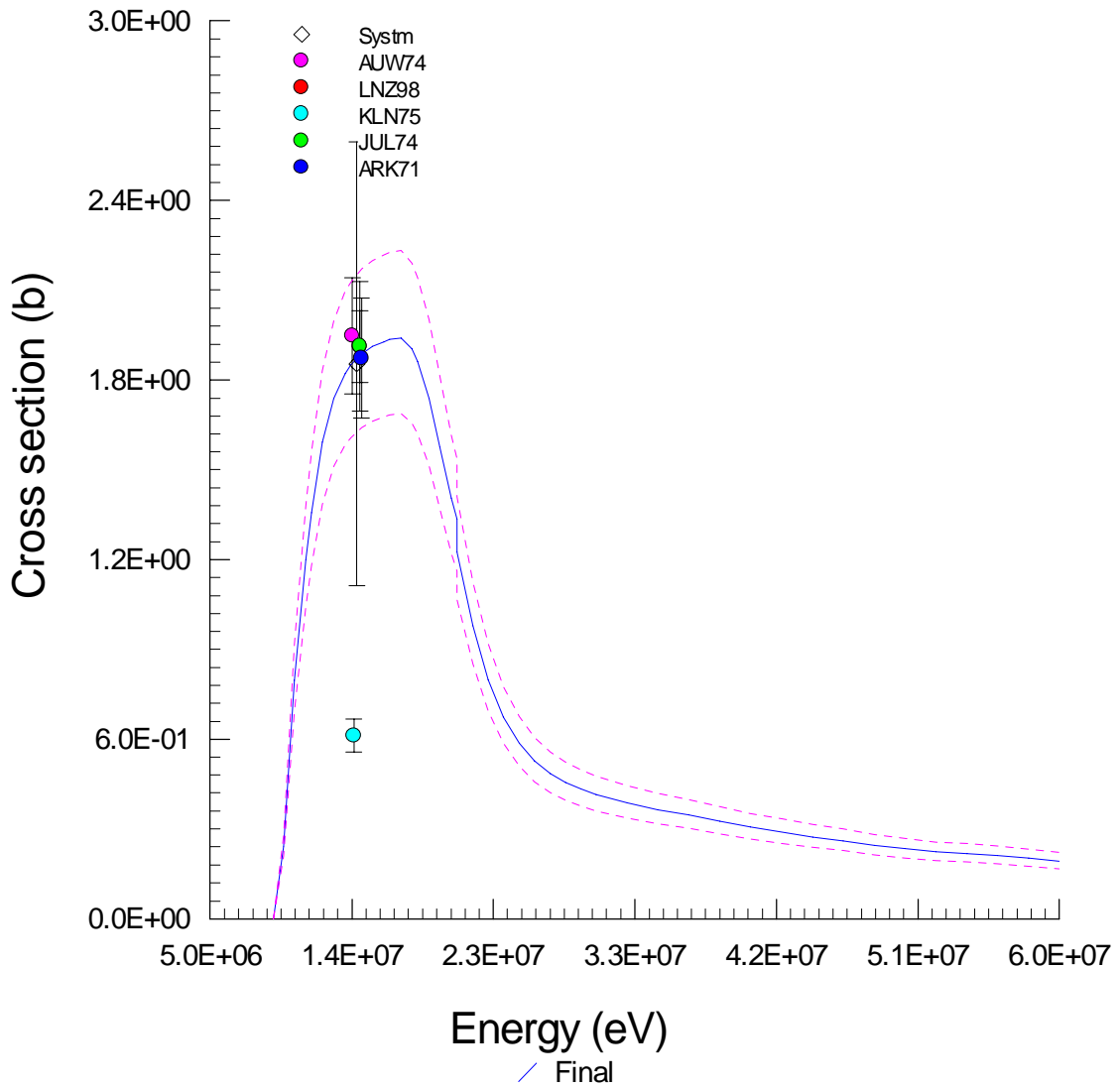
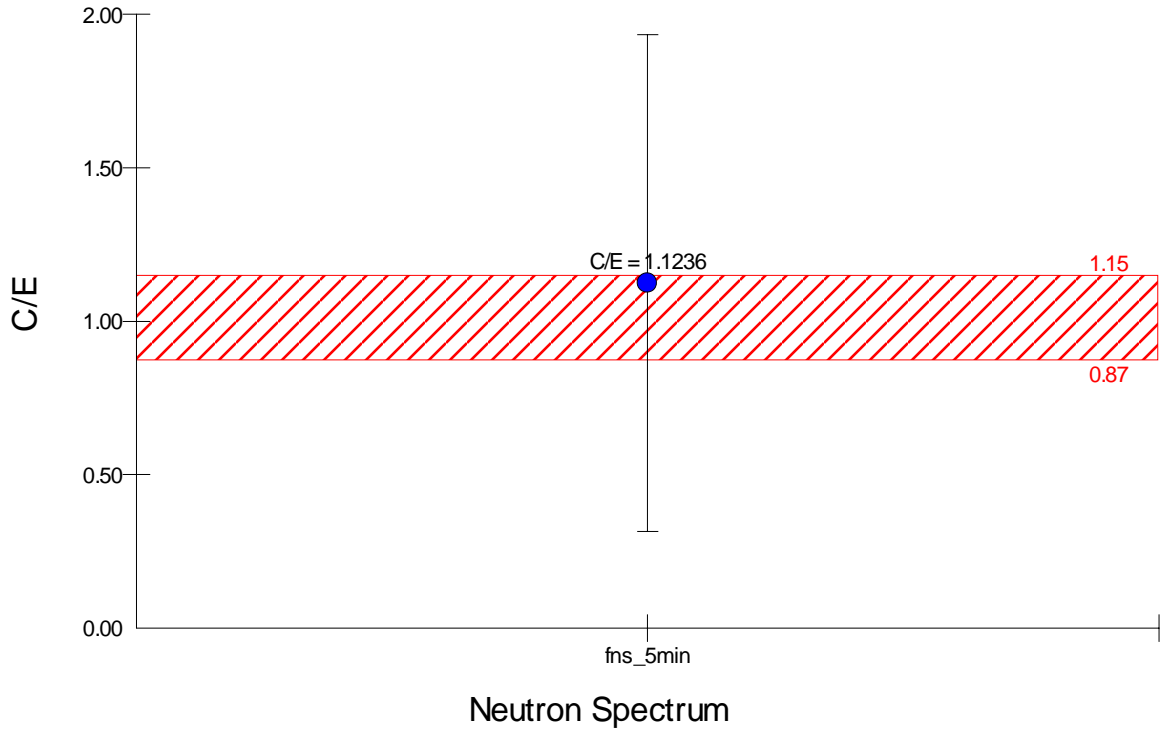
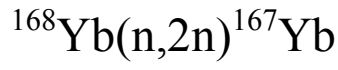


$^{169}\text{Tm}(n,2n)^{168}\text{Tm}$

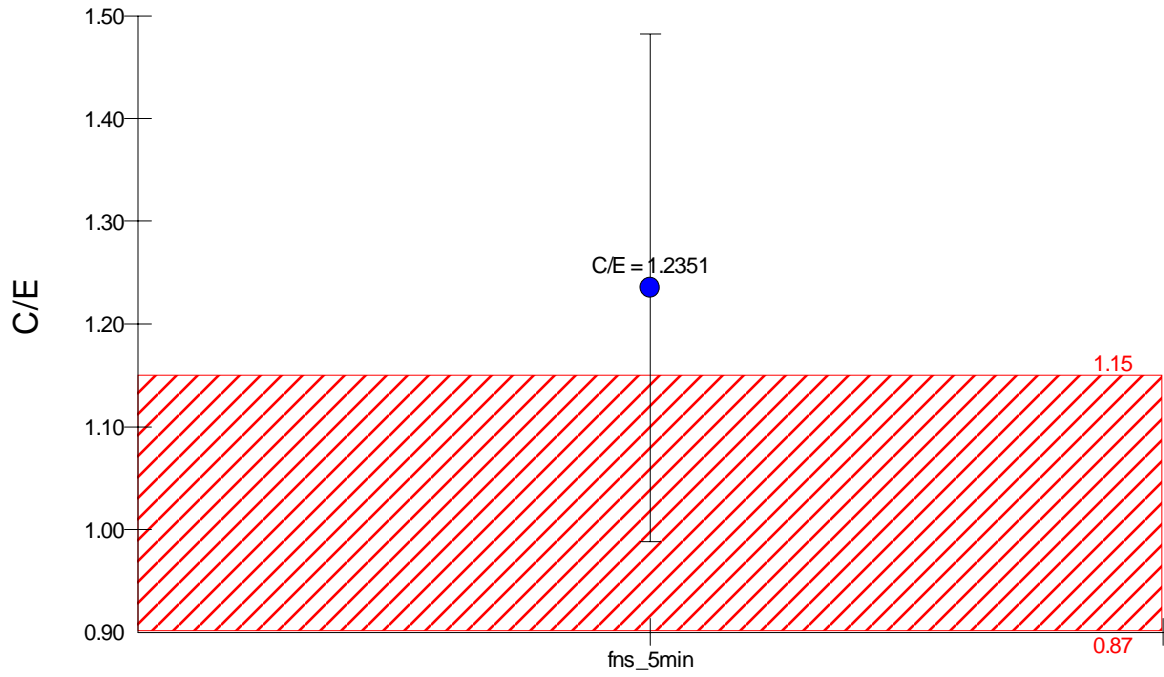


Neutron Spectrum

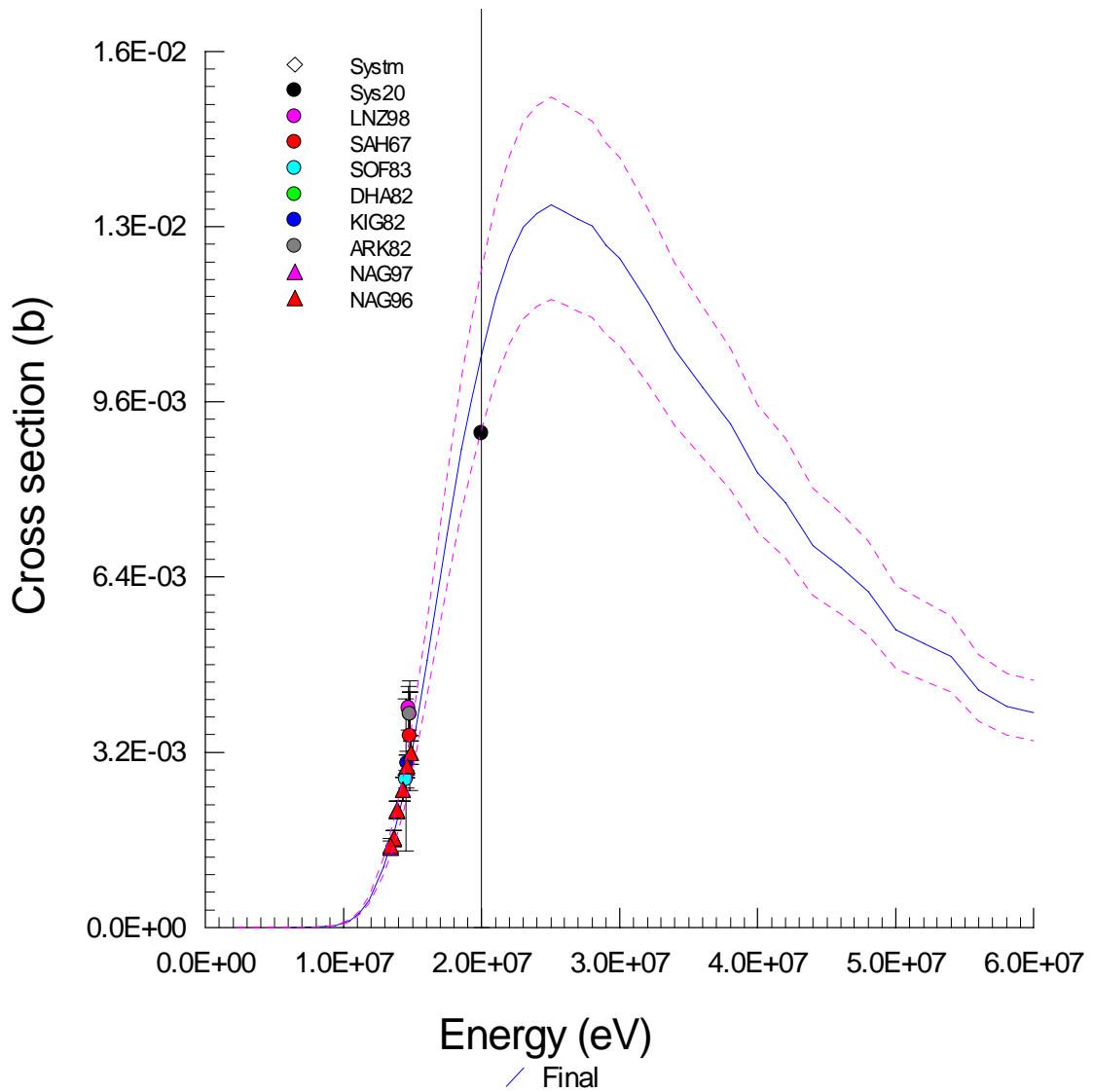




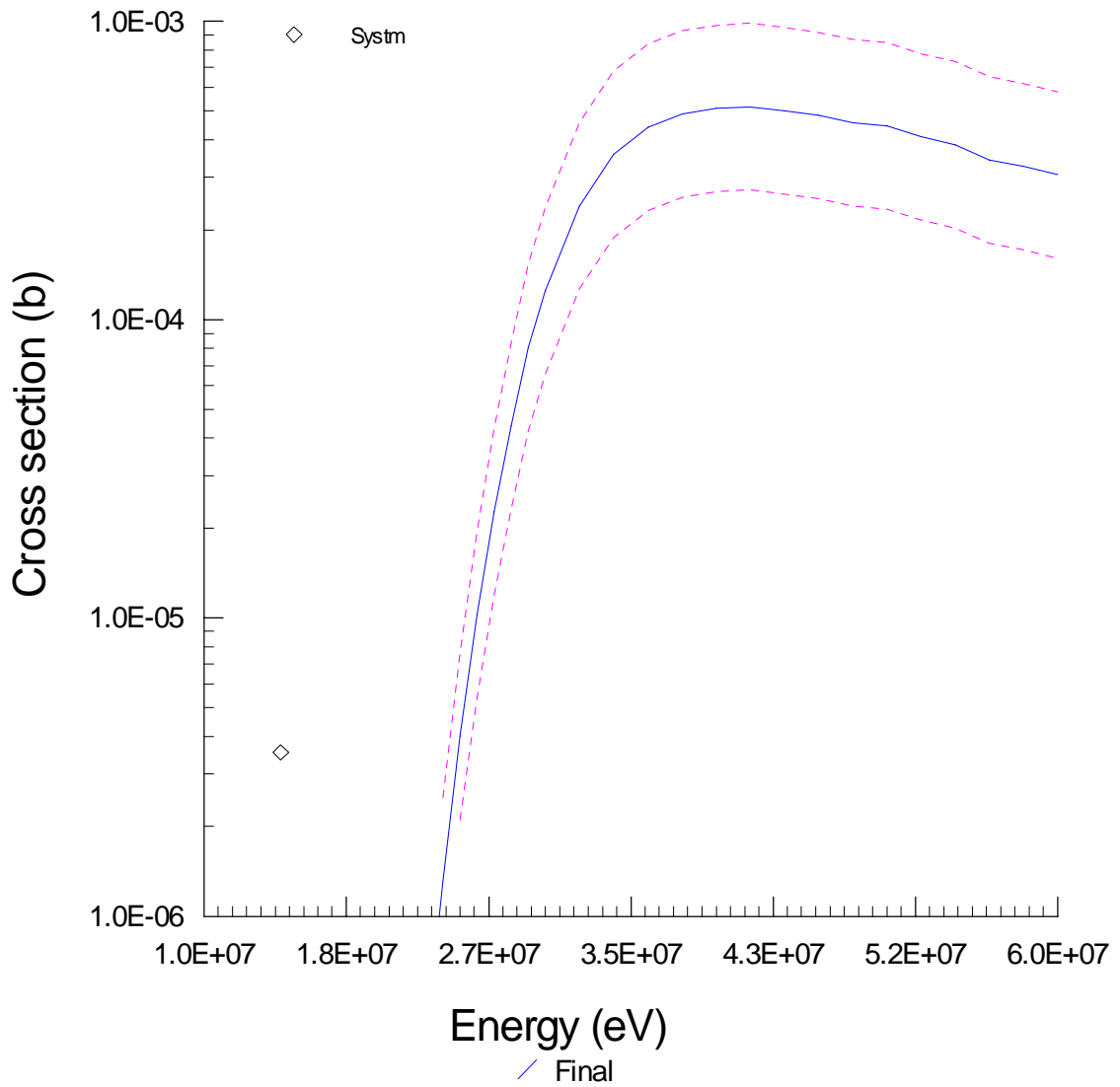
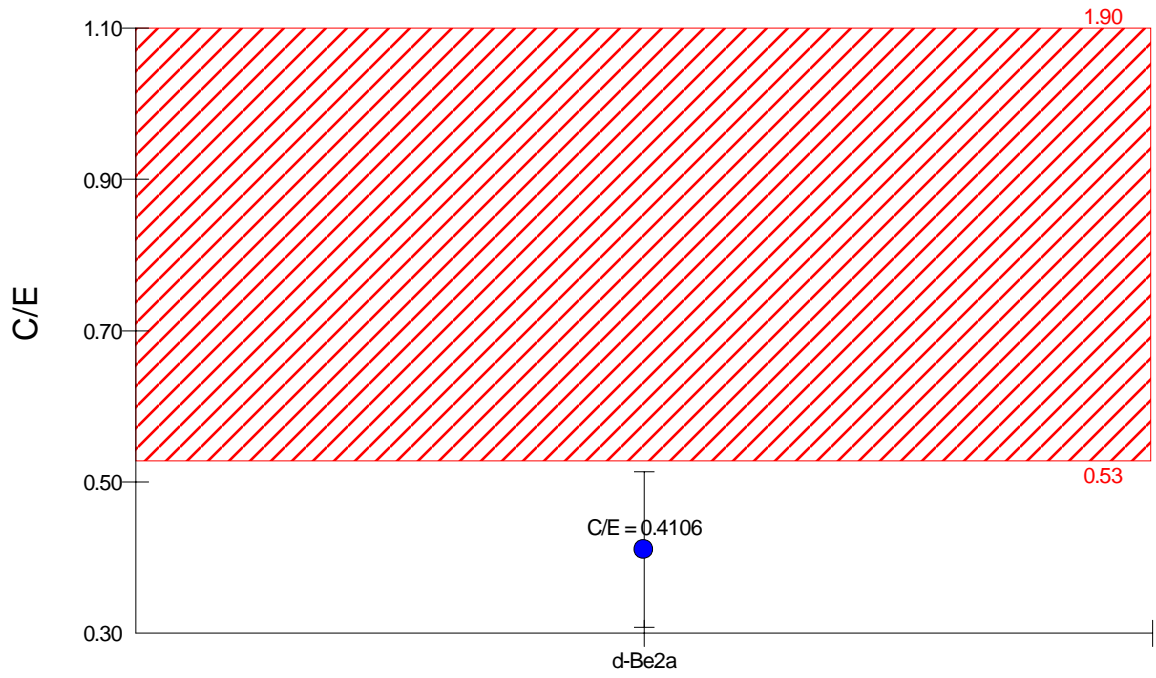
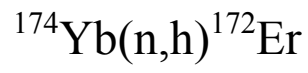
$^{174}\text{Yb}(n,p)^{174}\text{Tm}$

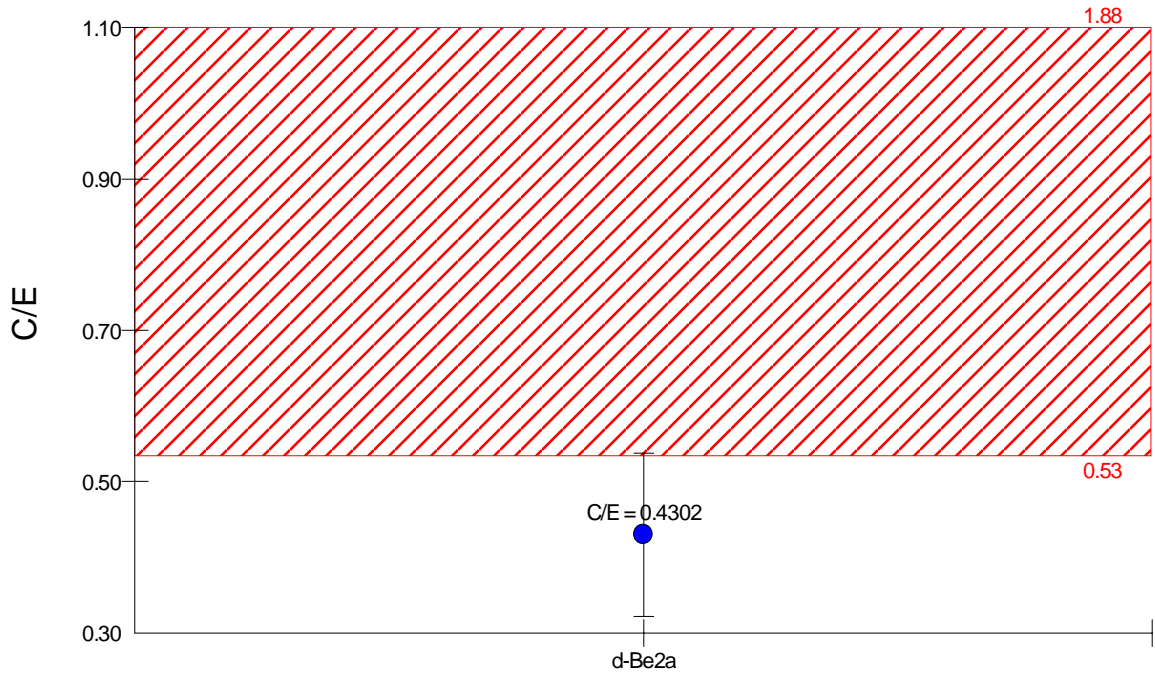
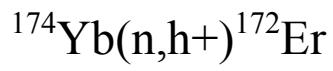


Neutron Spectrum

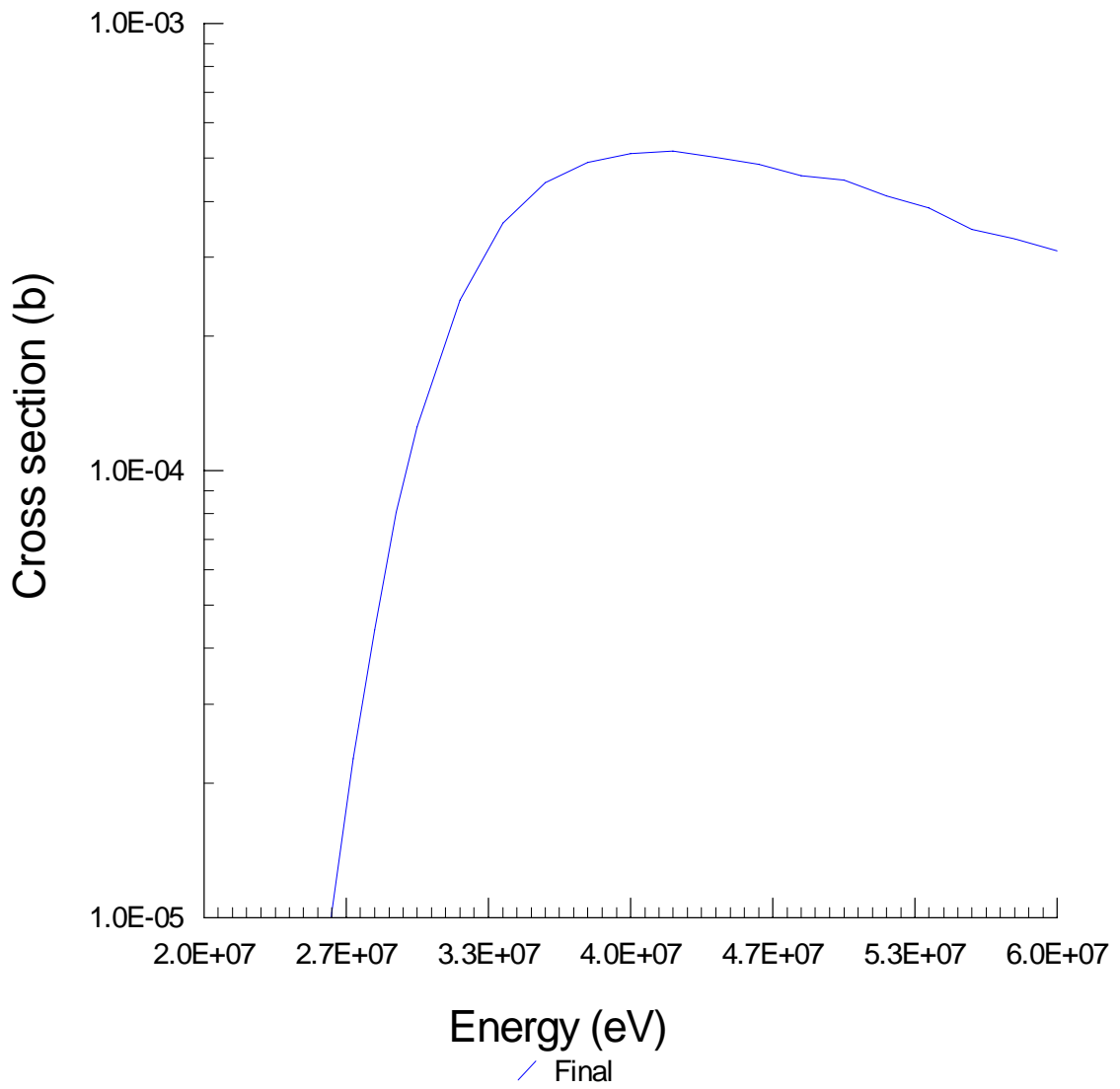


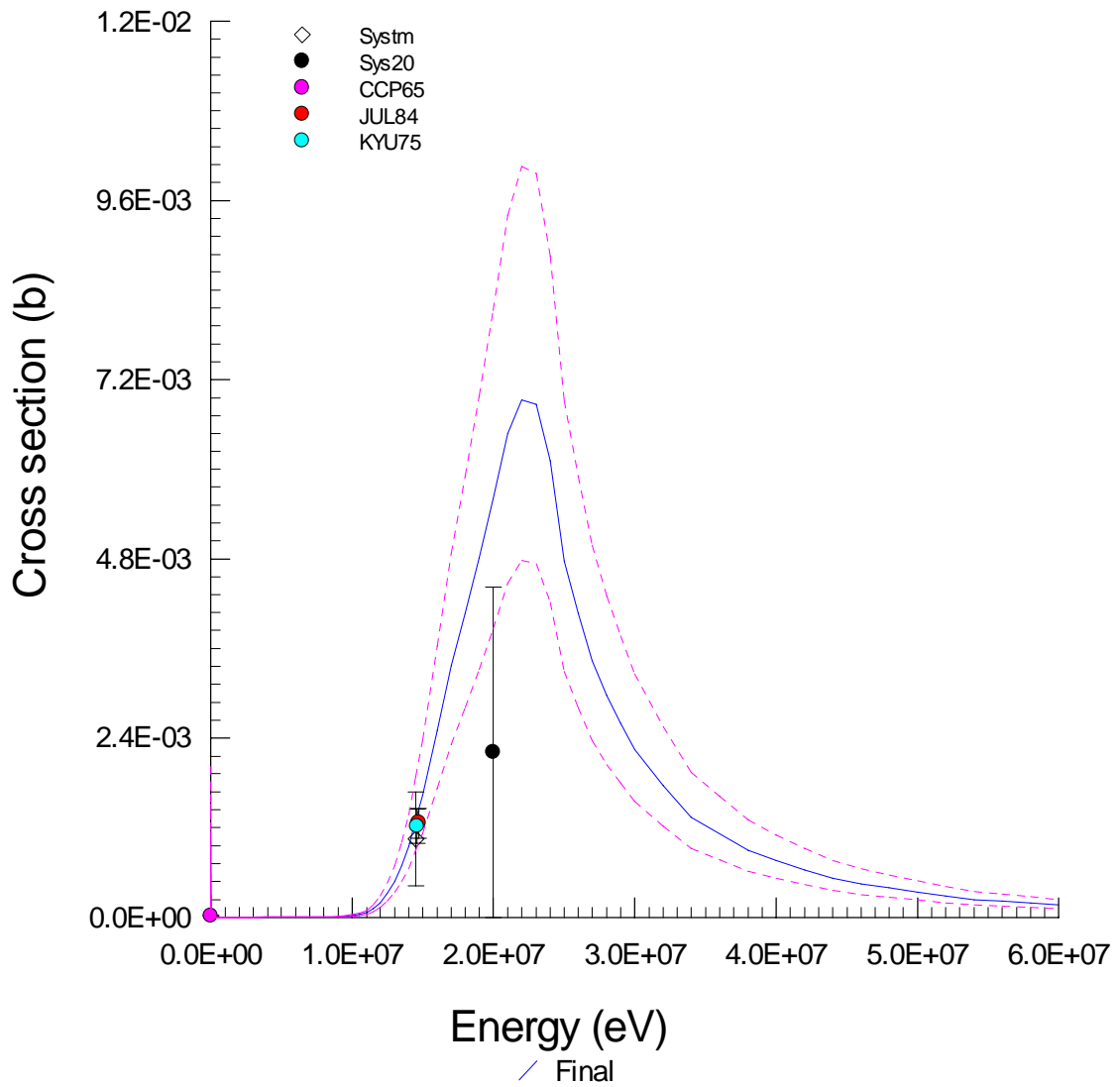
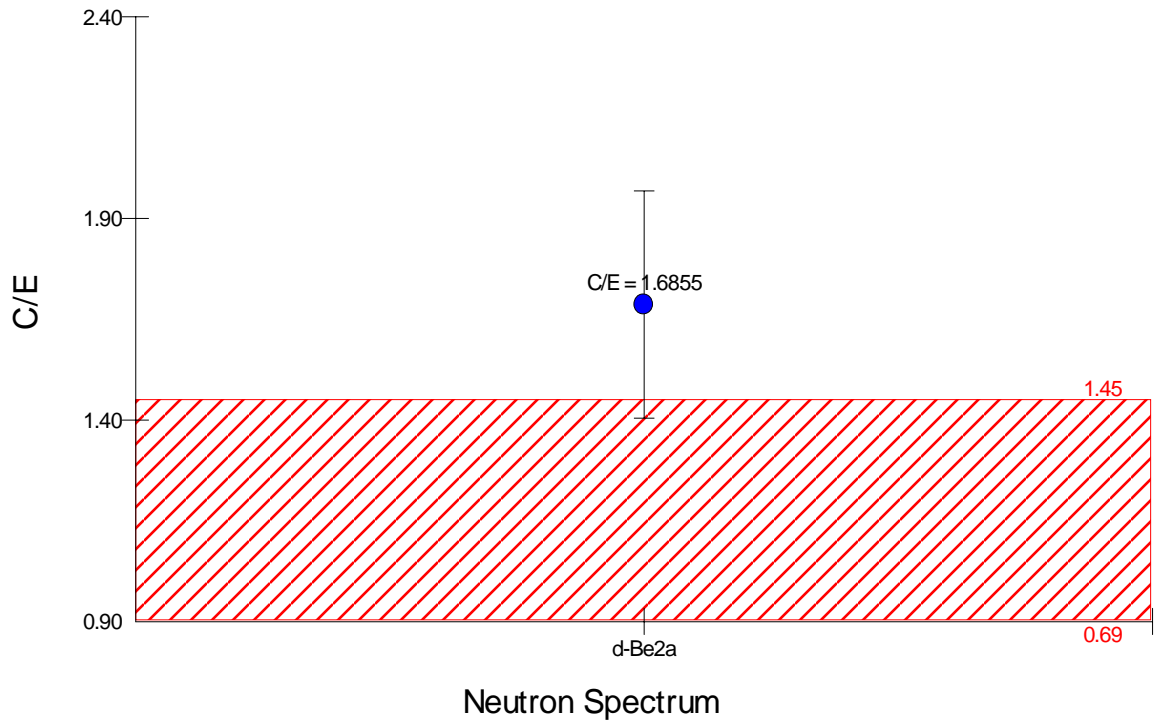
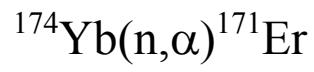


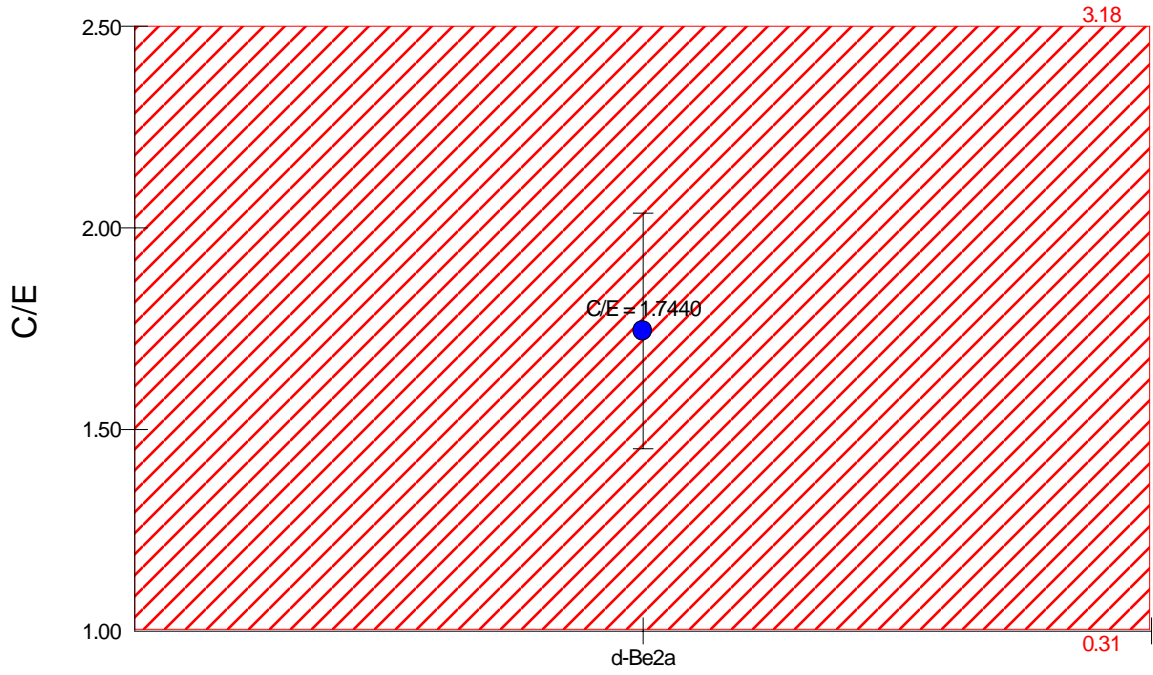
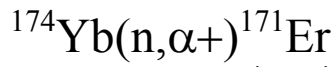




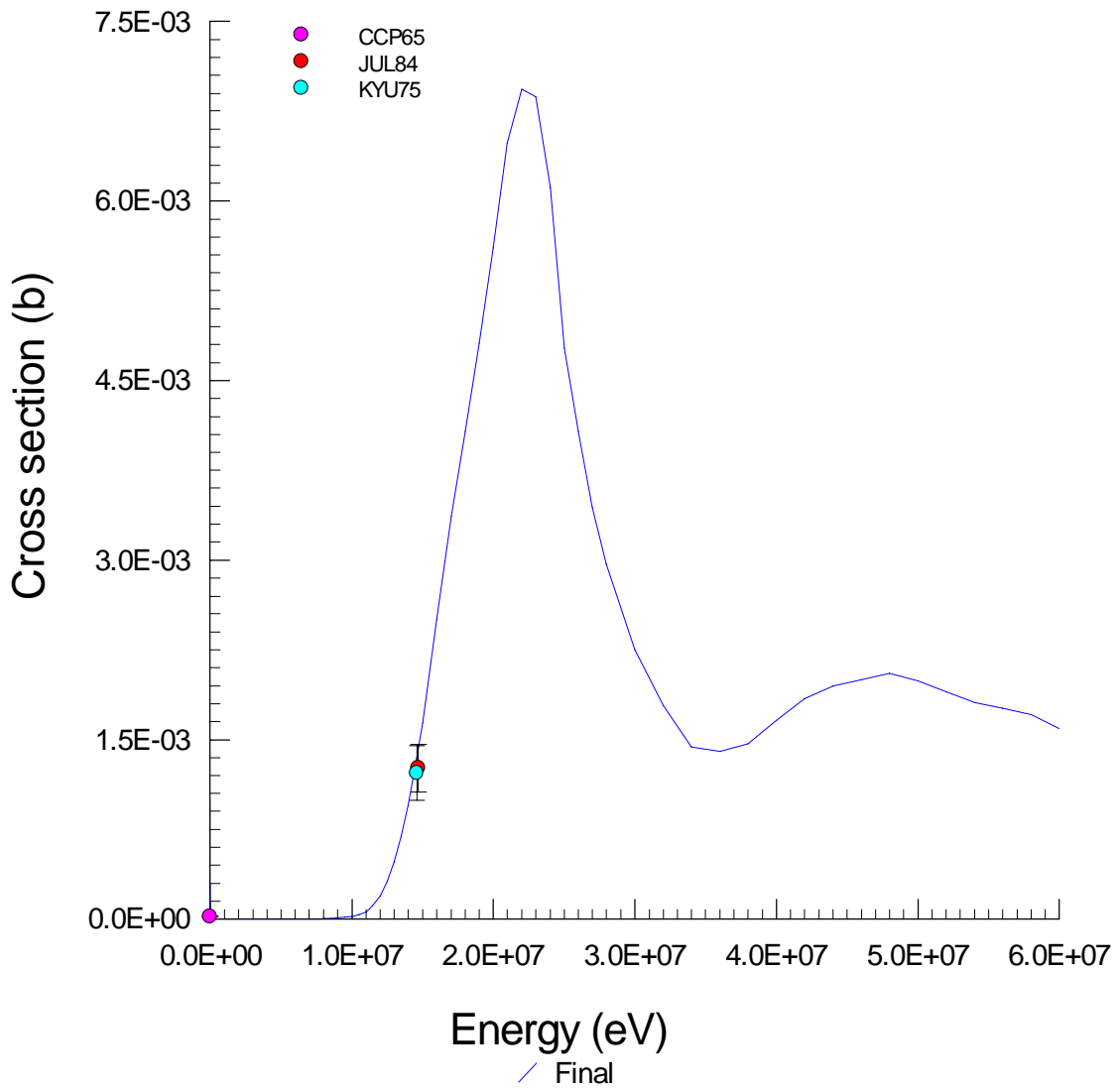
Neutron Spectrum

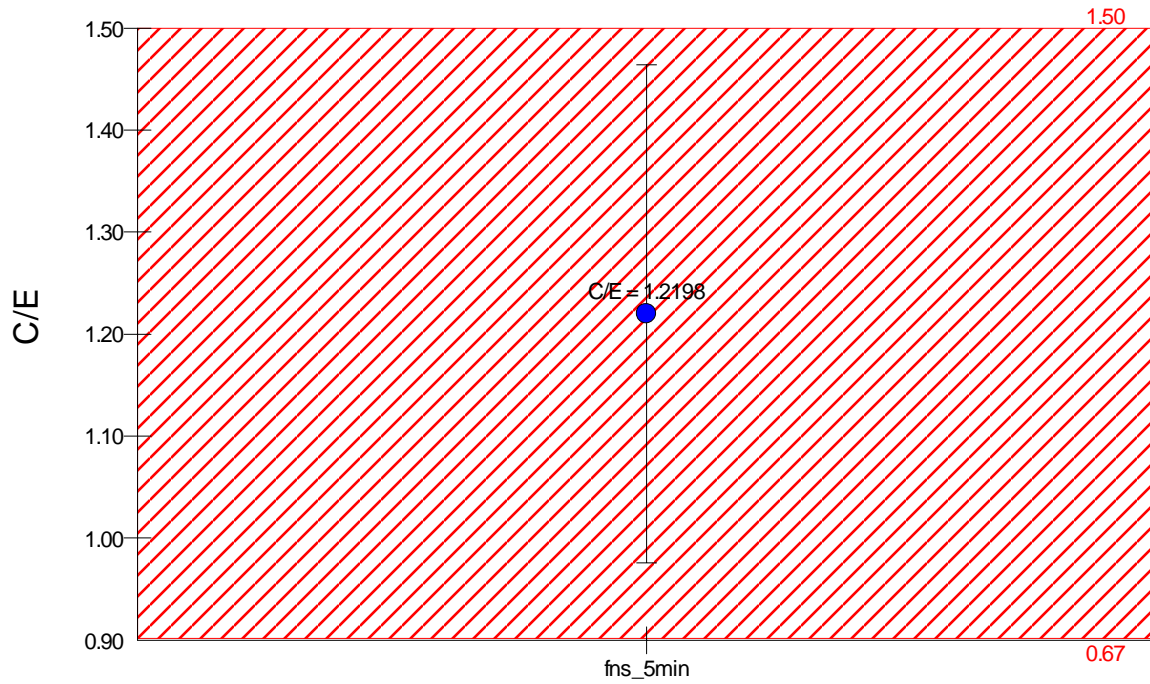
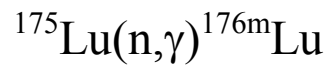




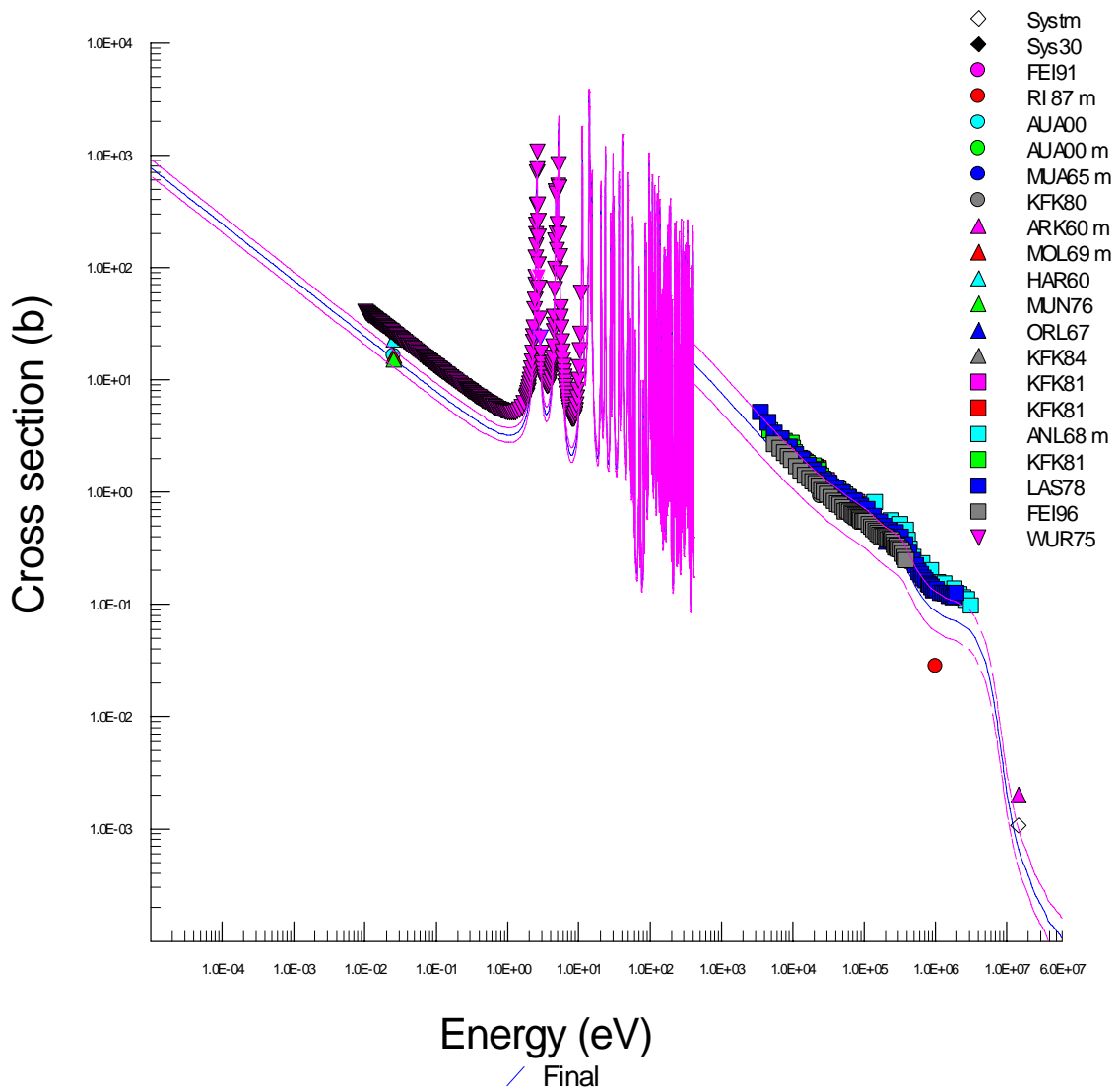


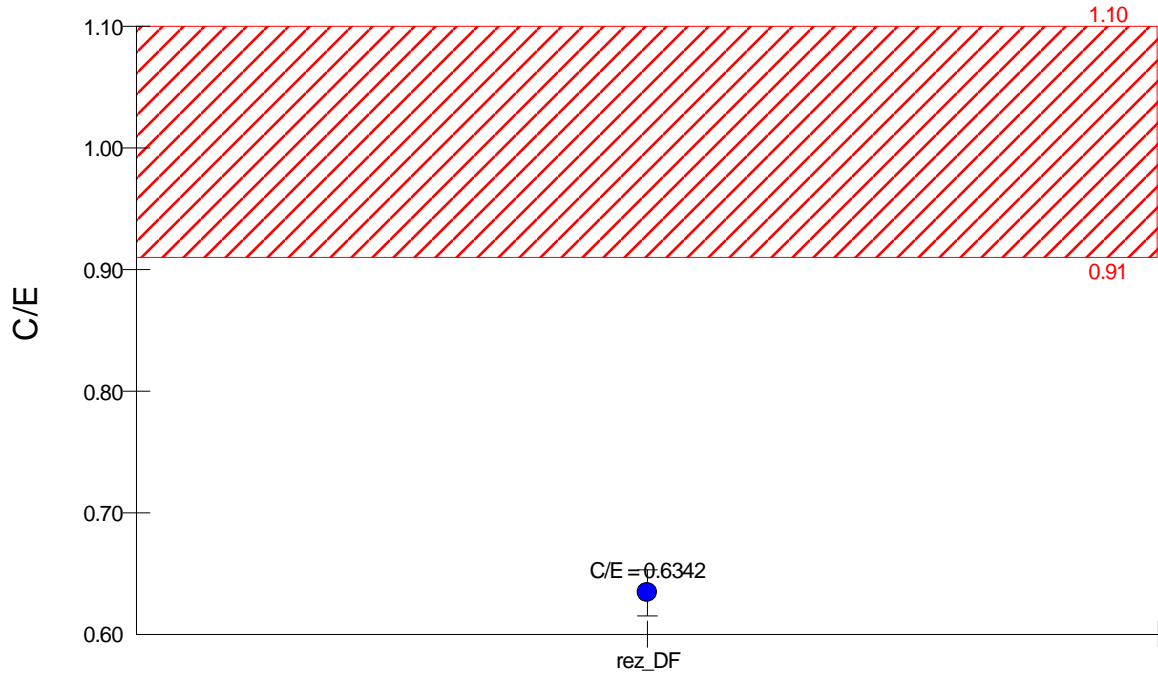
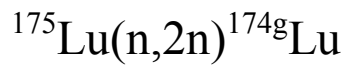
Neutron Spectrum



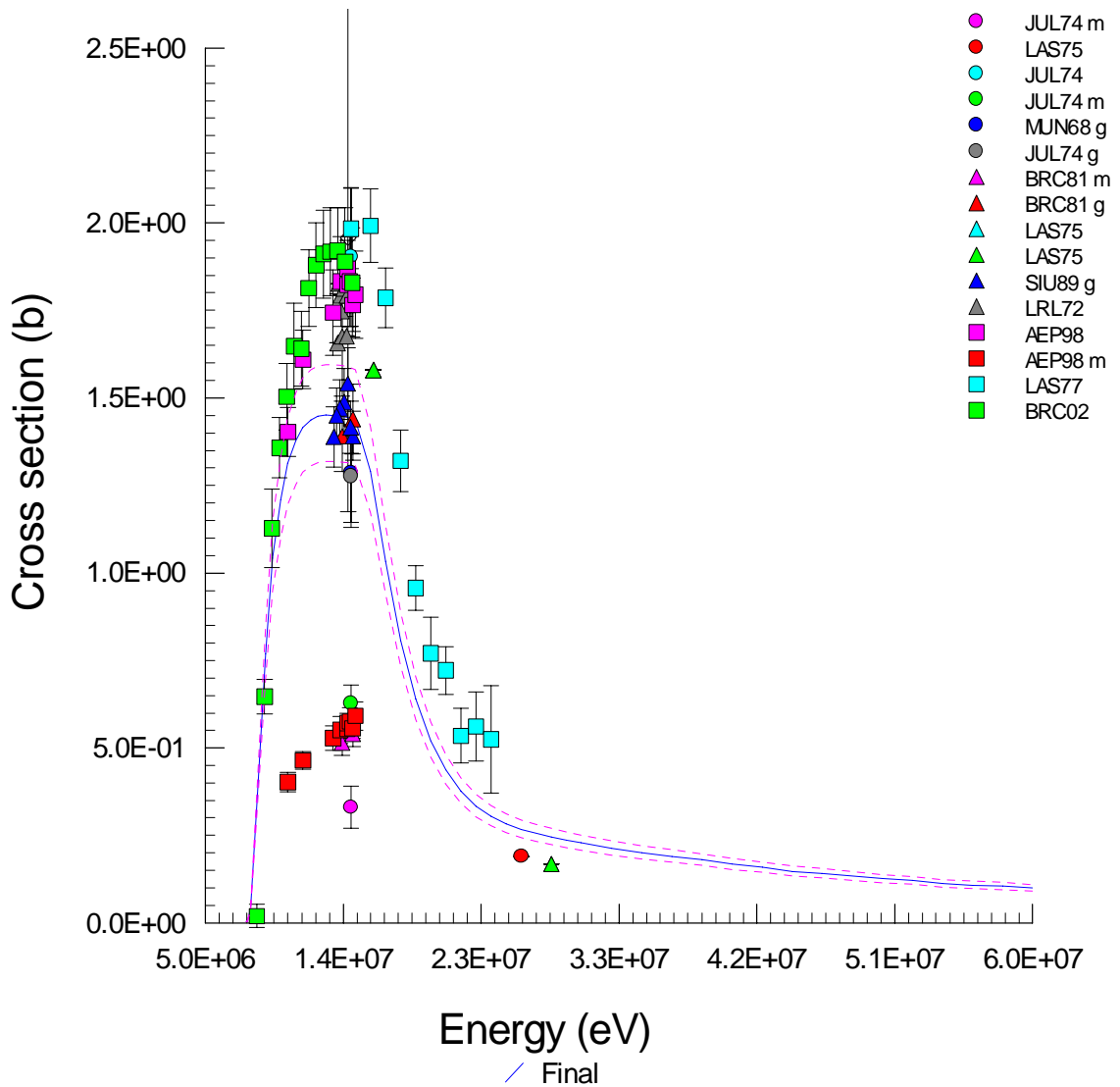


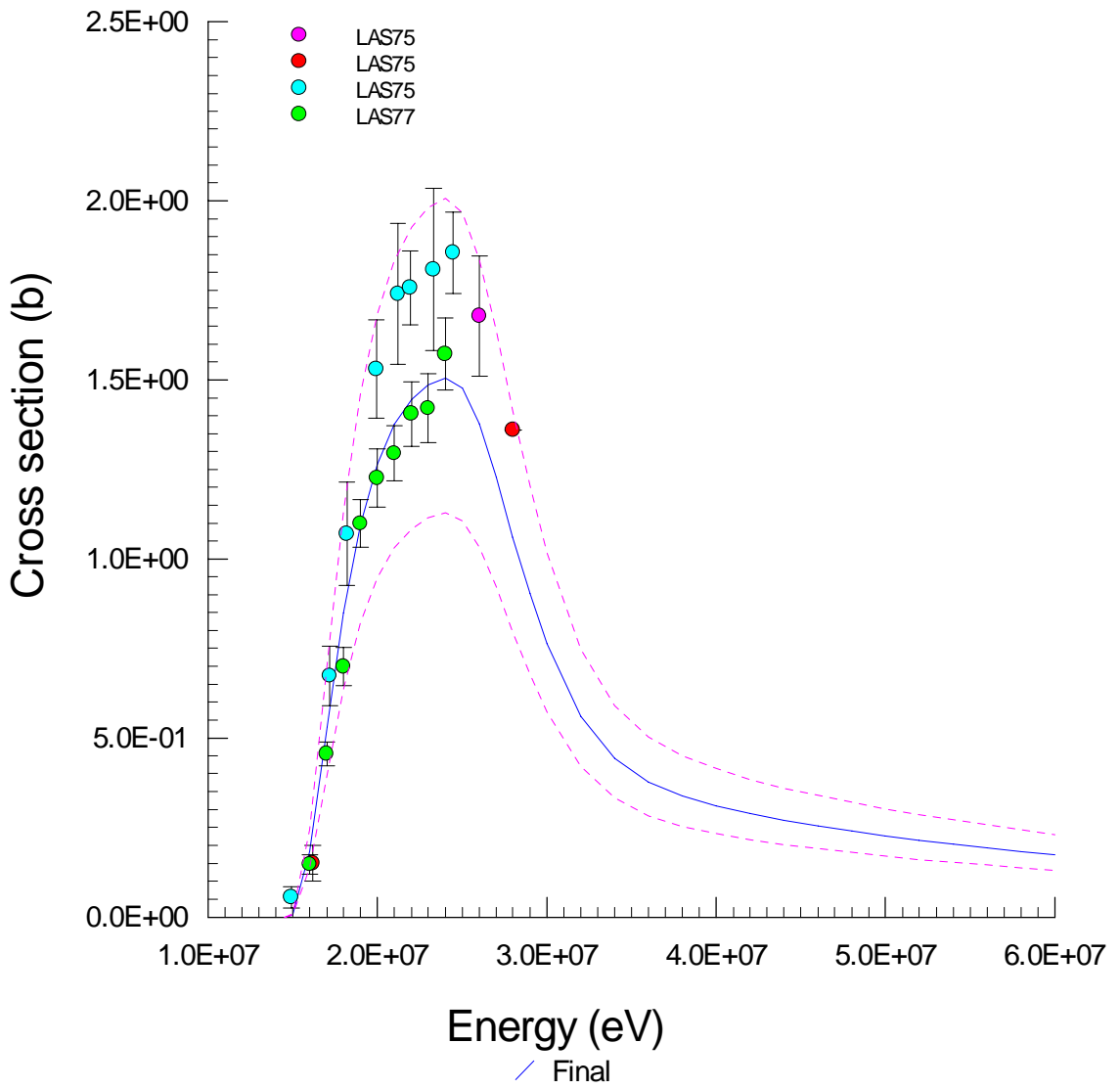
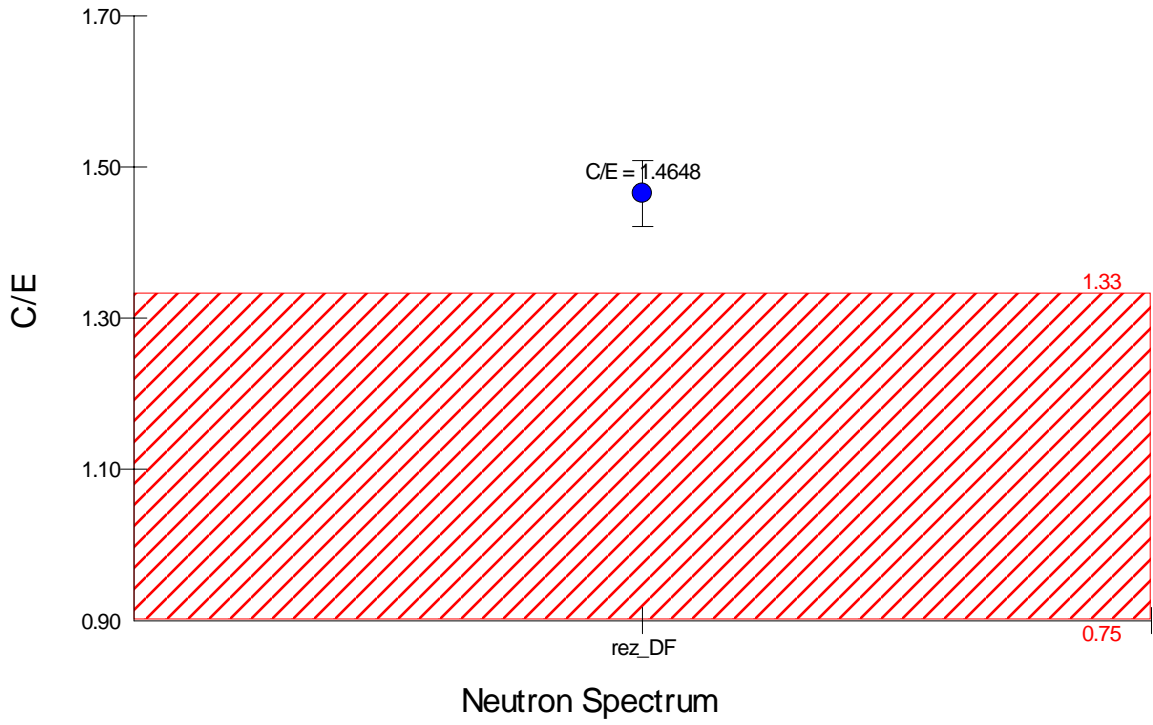
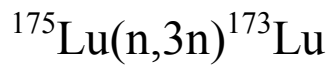
Neutron Spectrum

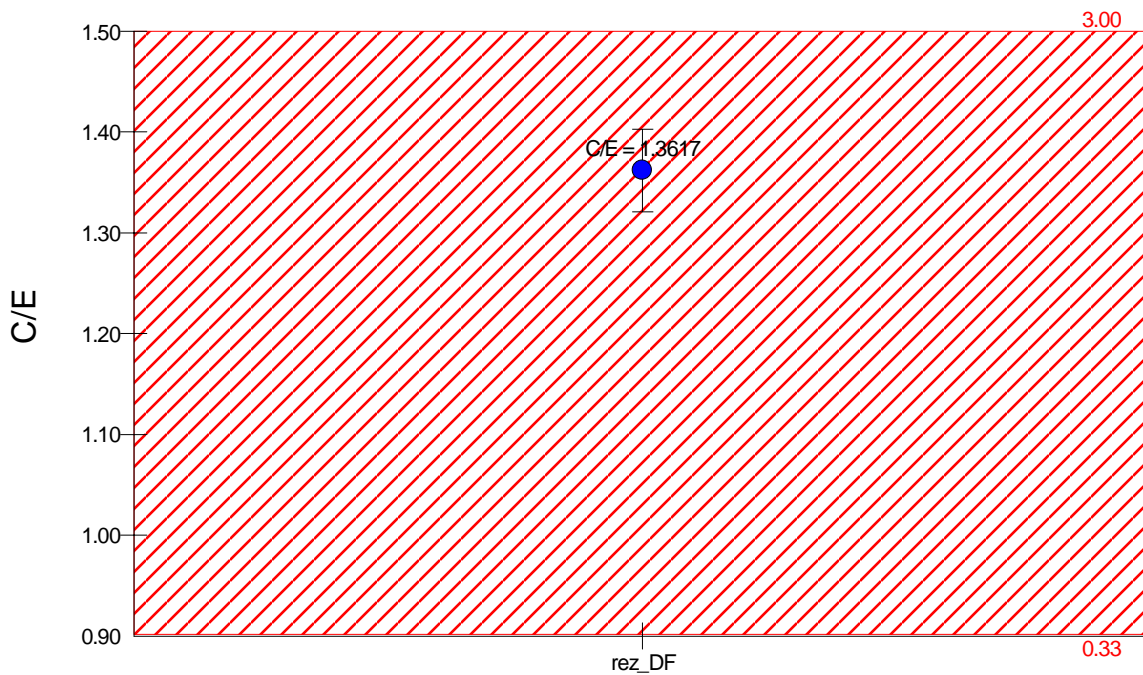
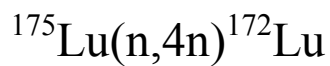




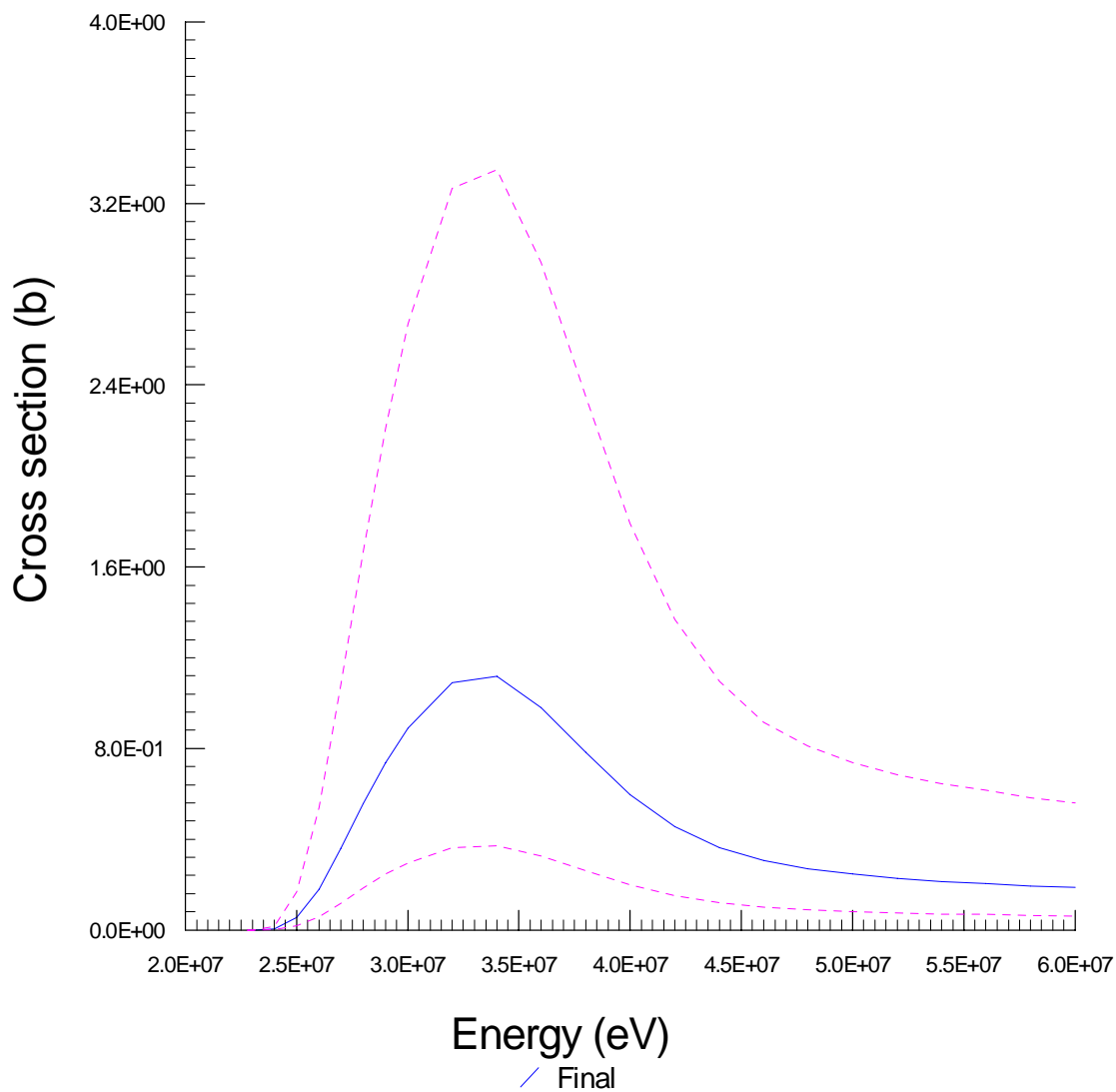
Neutron Spectrum





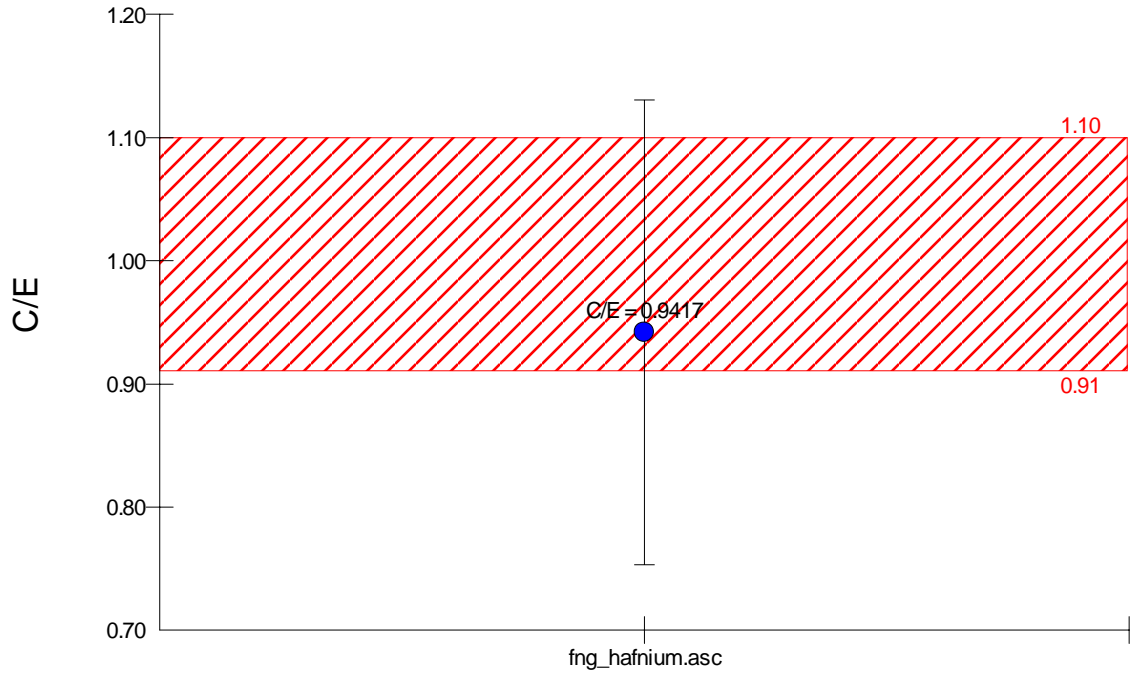


Neutron Spectrum

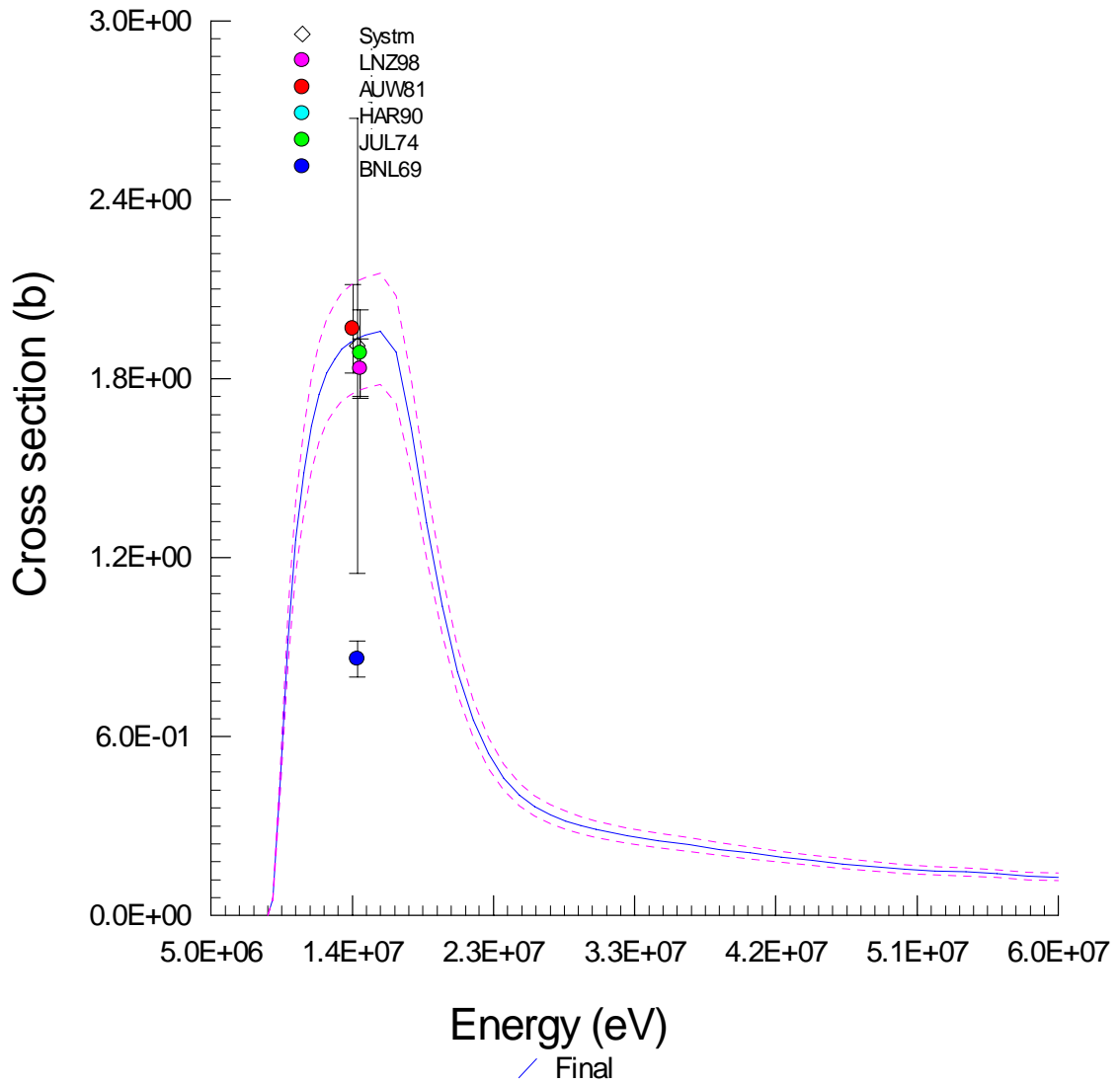


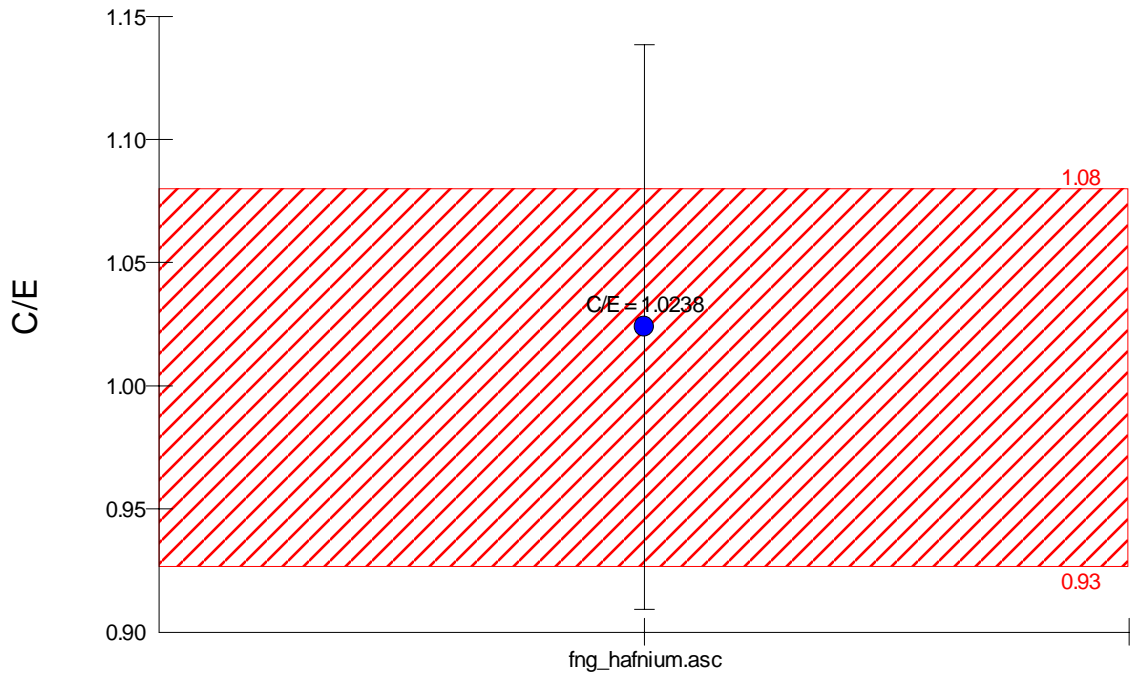
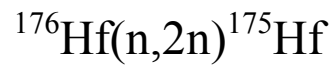


$^{174}\text{Hf}(n,2n)^{173}\text{Hf}$

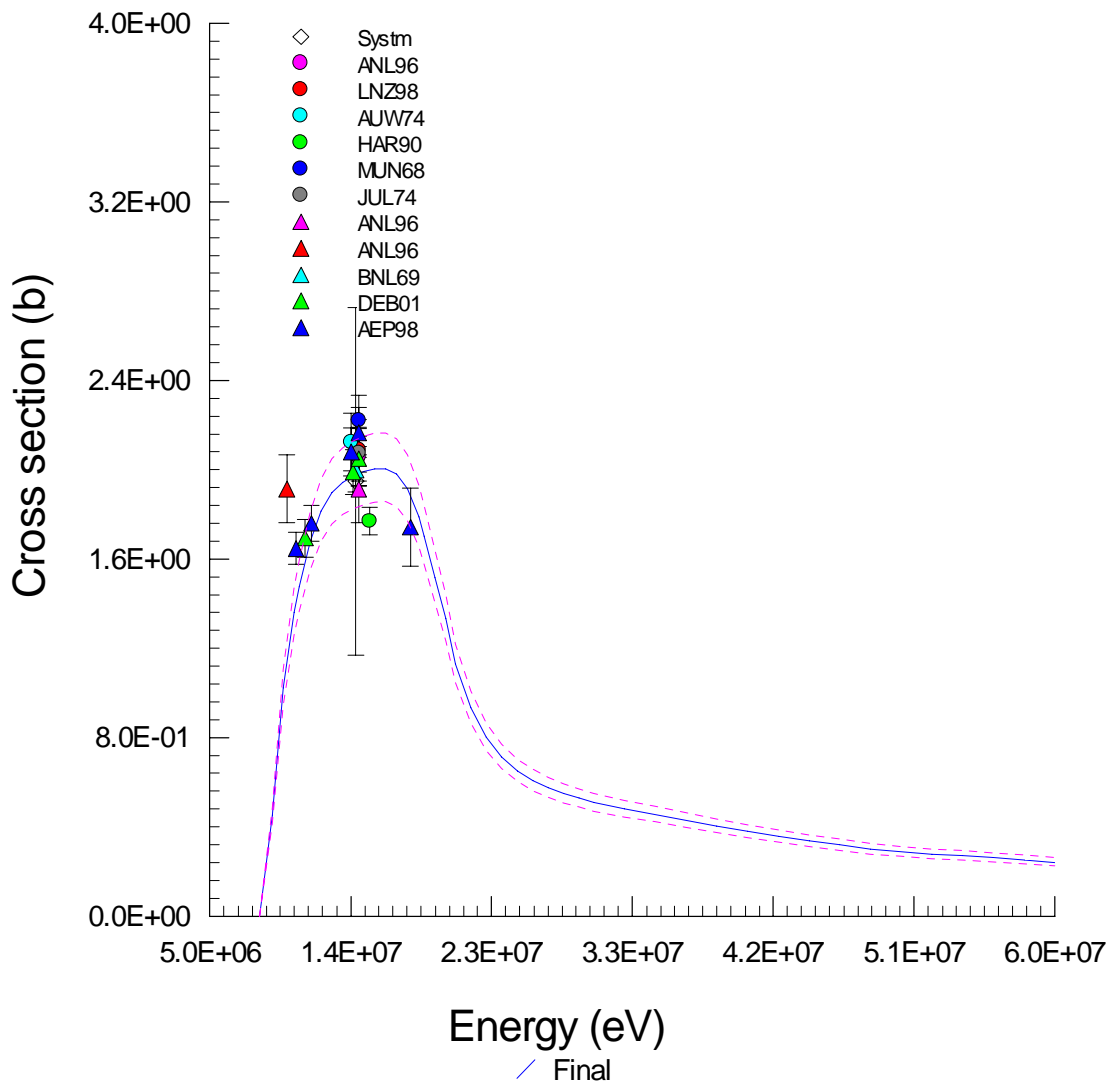


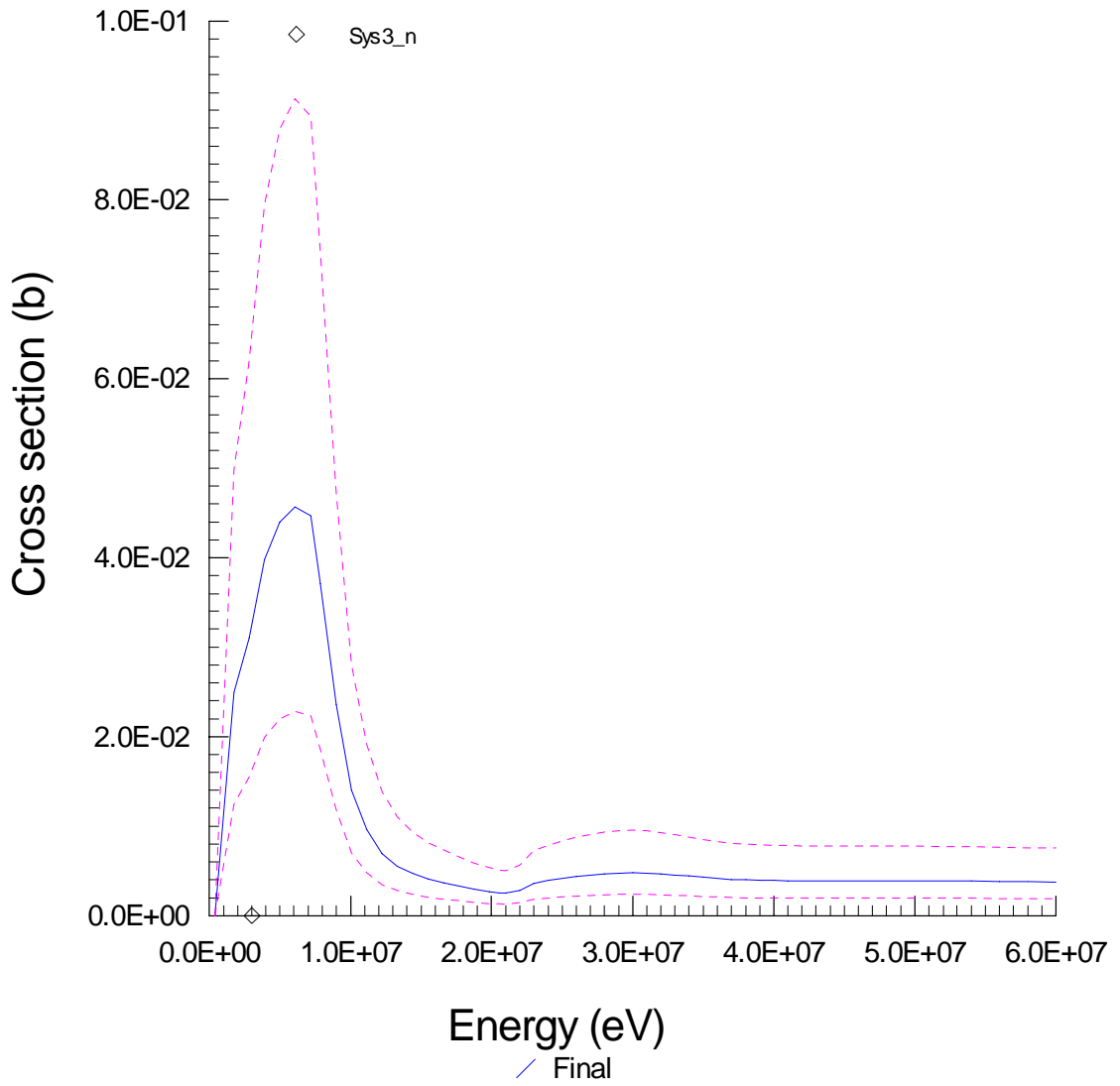
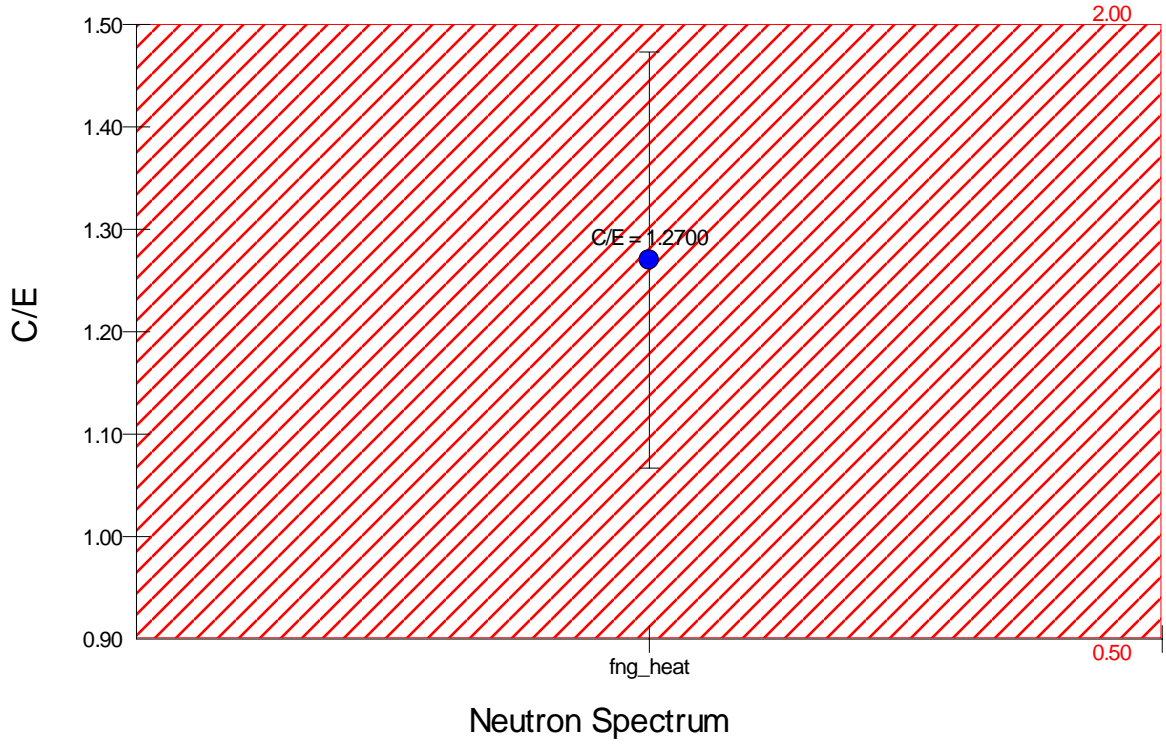
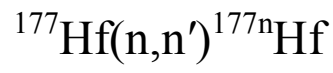
Neutron Spectrum



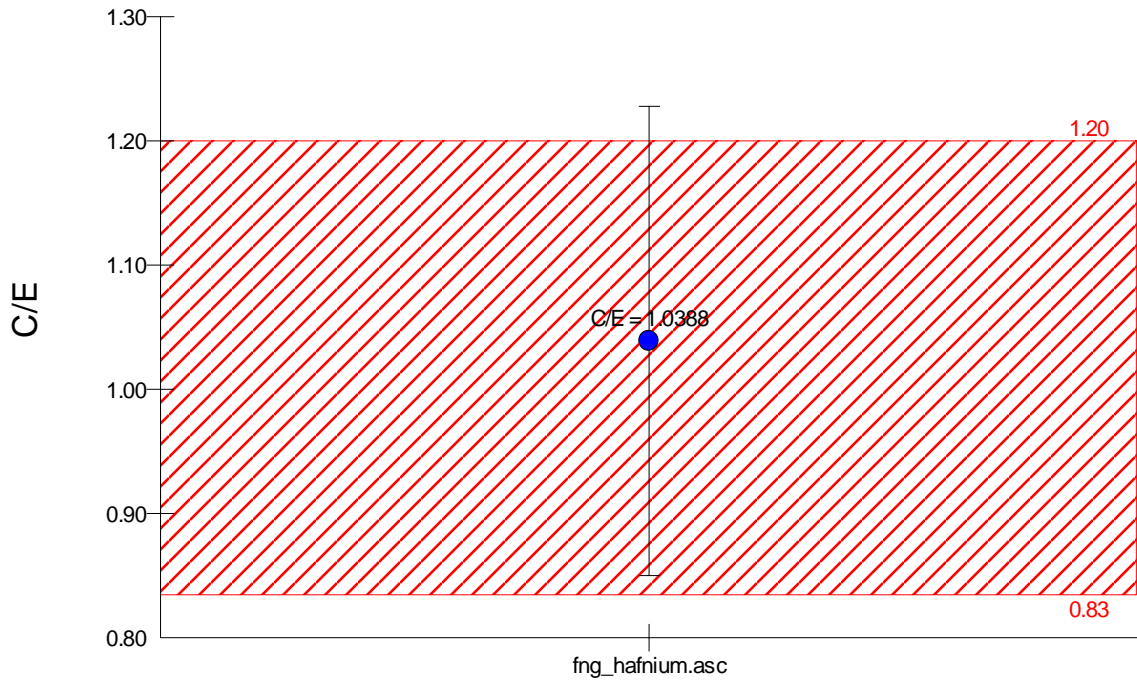


Neutron Spectrum

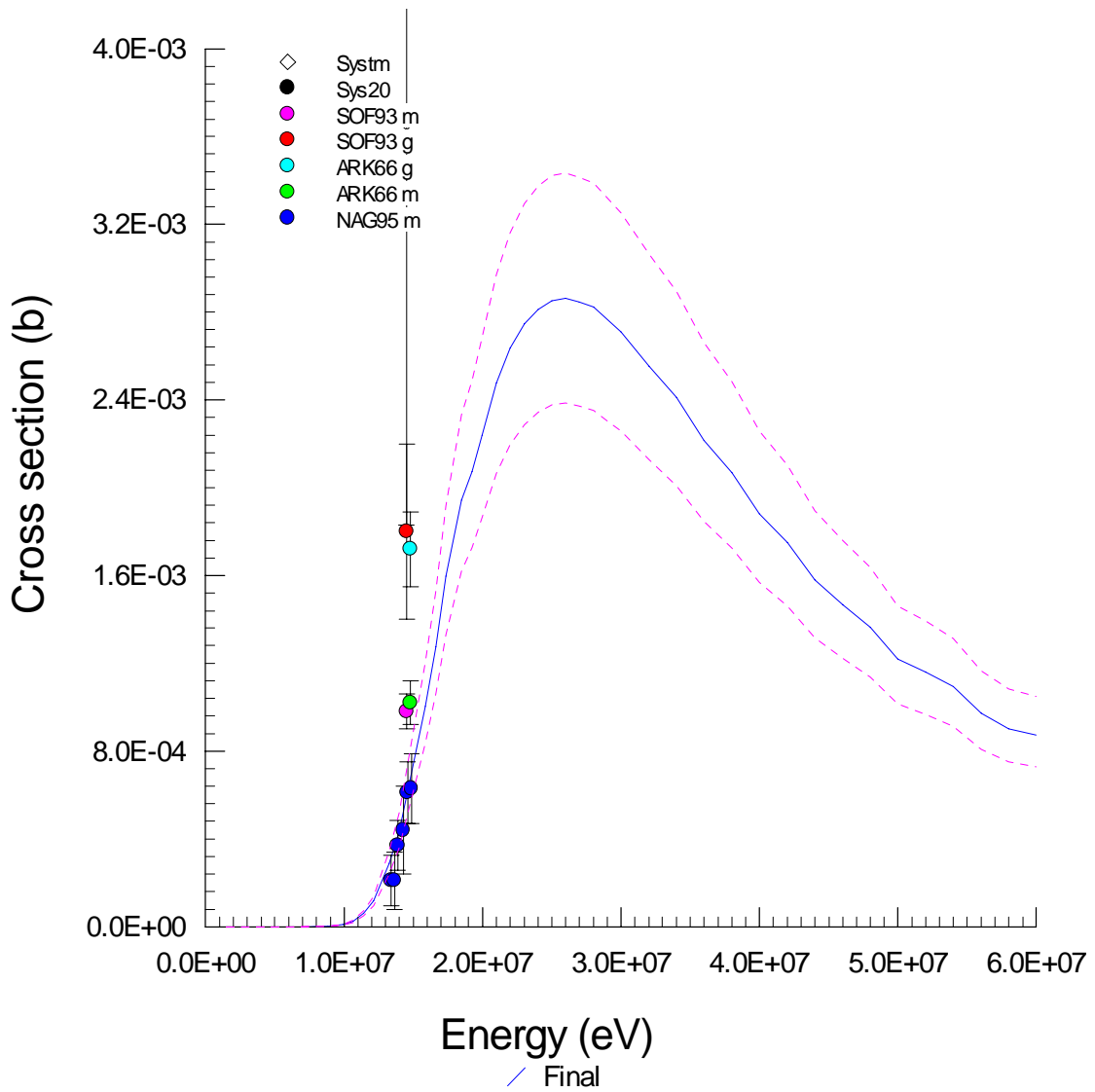




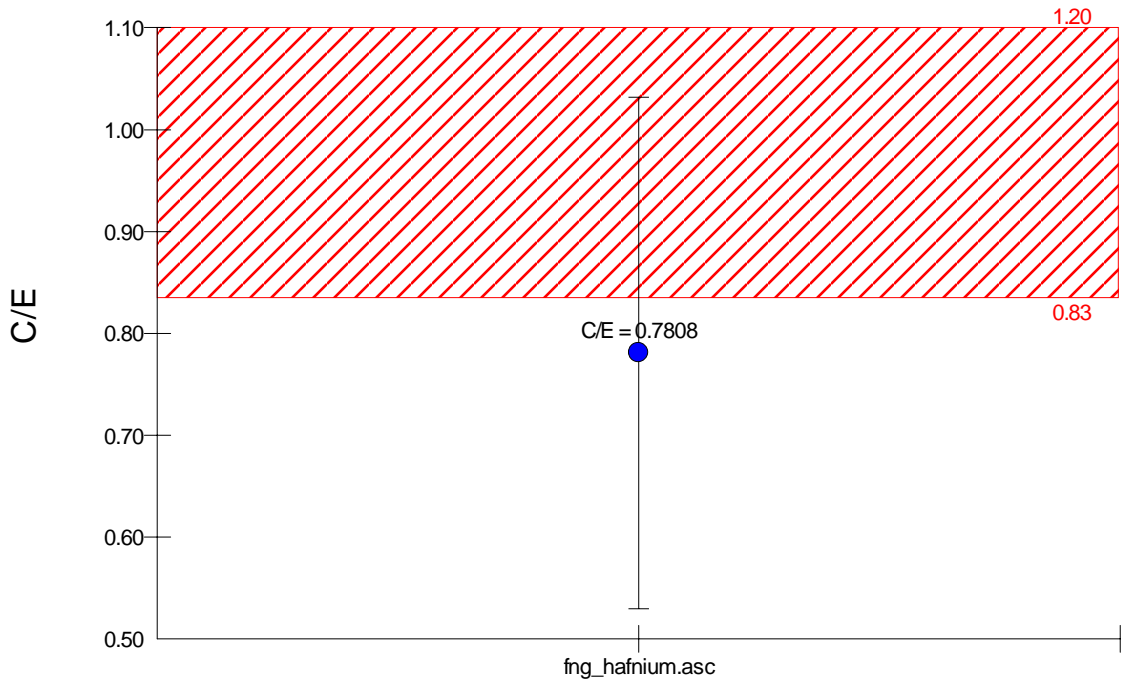
$^{178}\text{Hf}(n,p)^{178\text{m}}\text{Lu}$



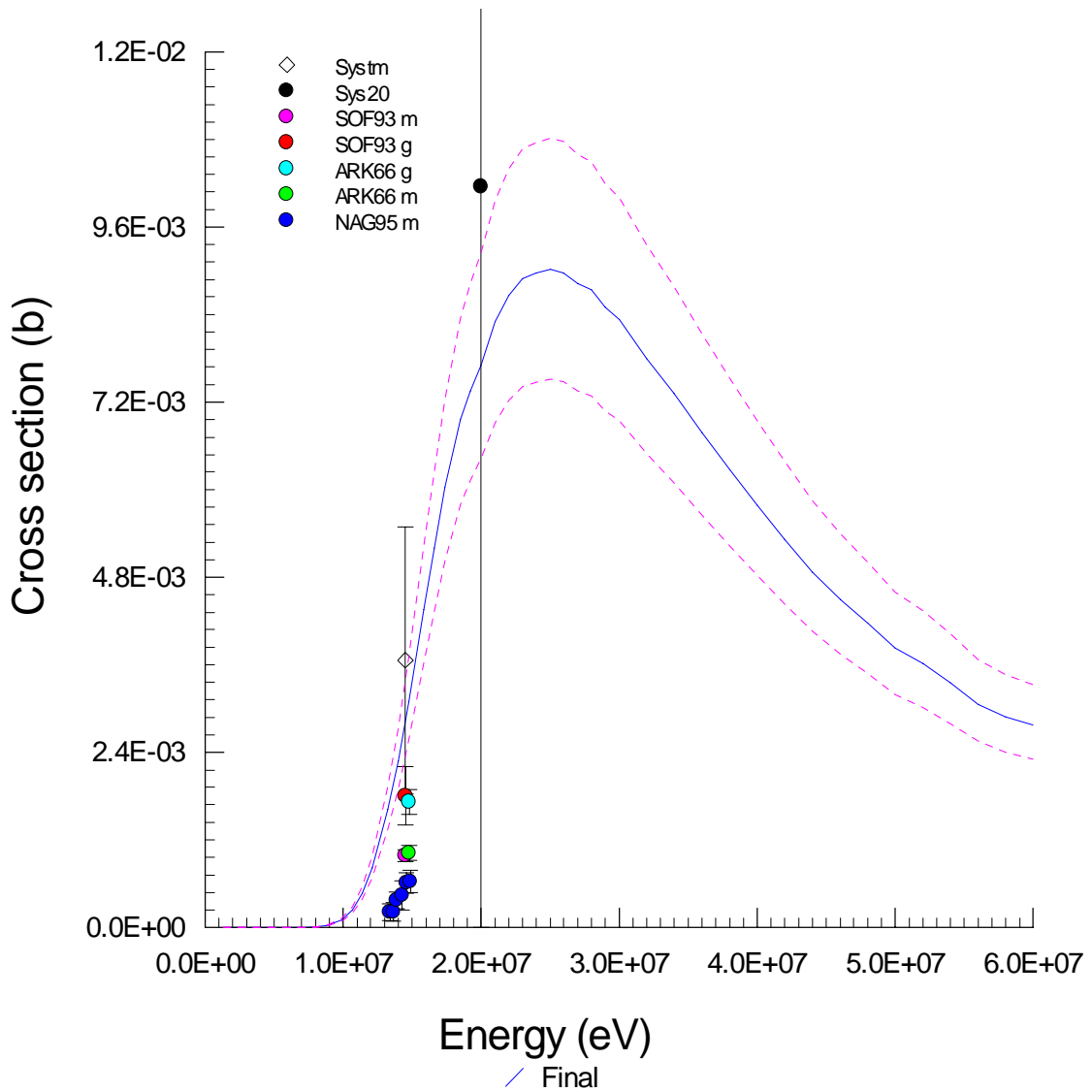
Neutron Spectrum



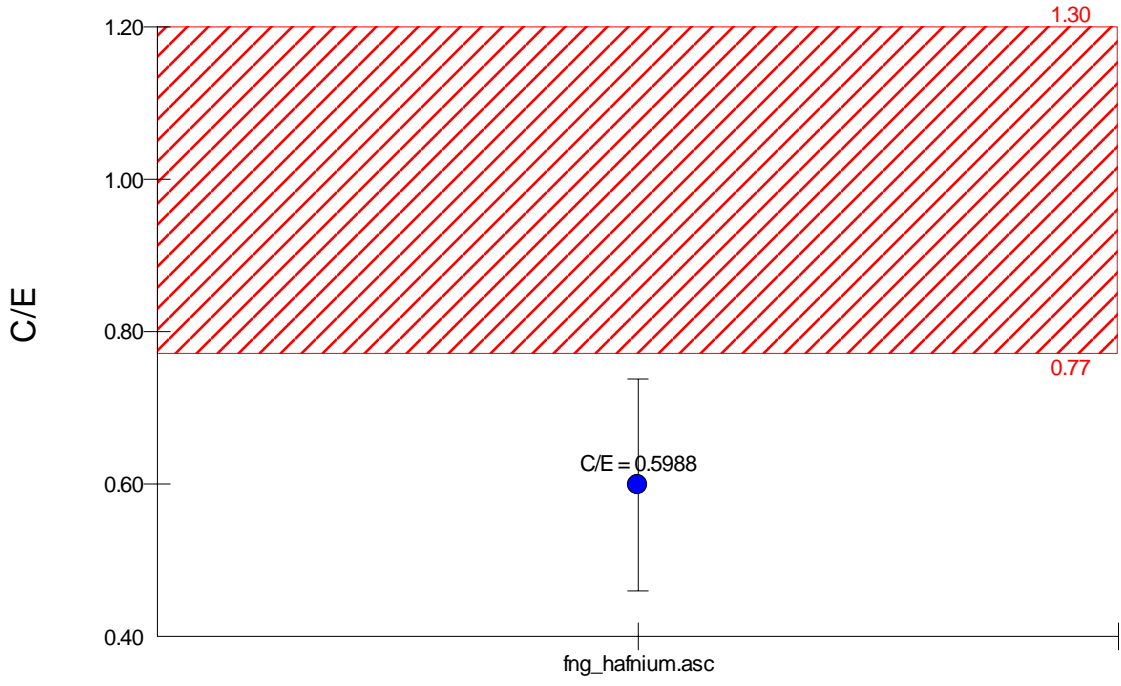
$^{178}\text{Hf}(n,p)^{178}\text{Lu}$



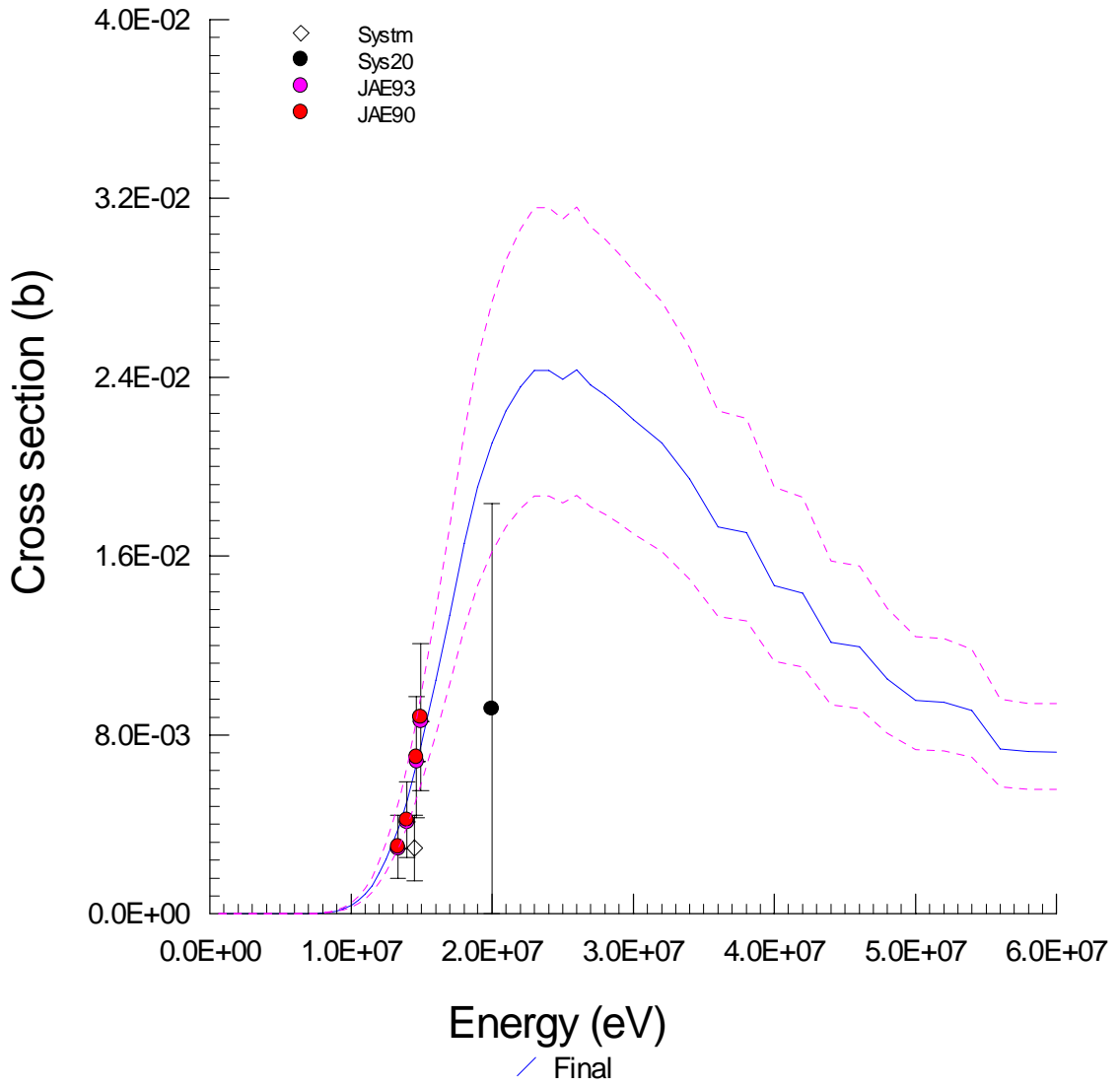
Neutron Spectrum



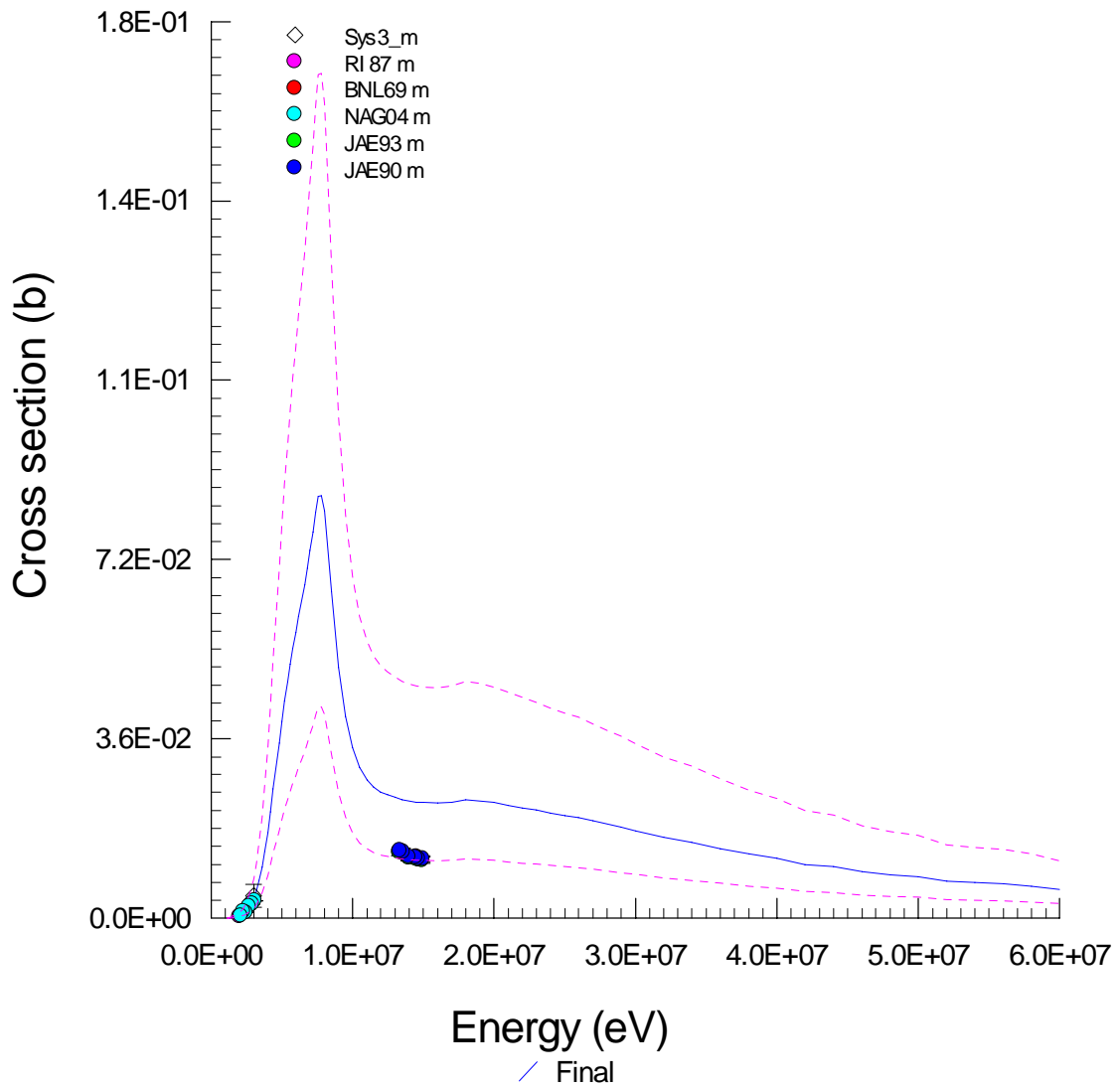
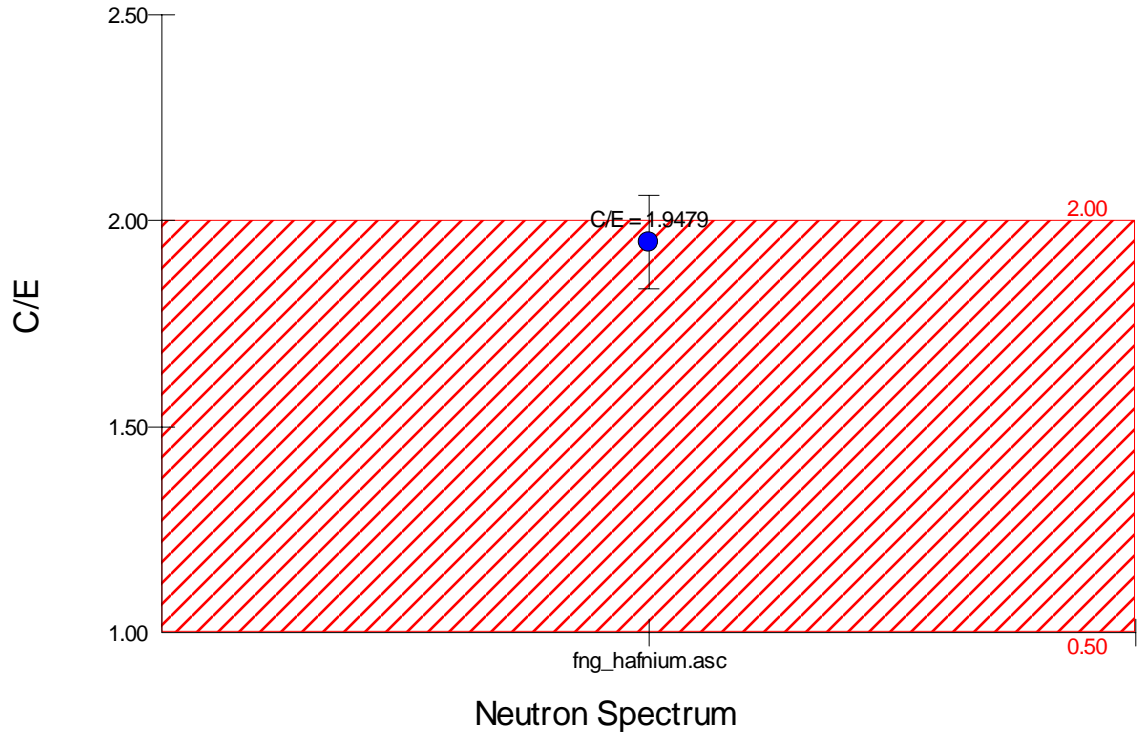
$^{179}\text{Hf}(n,p)^{179}\text{Lu}$

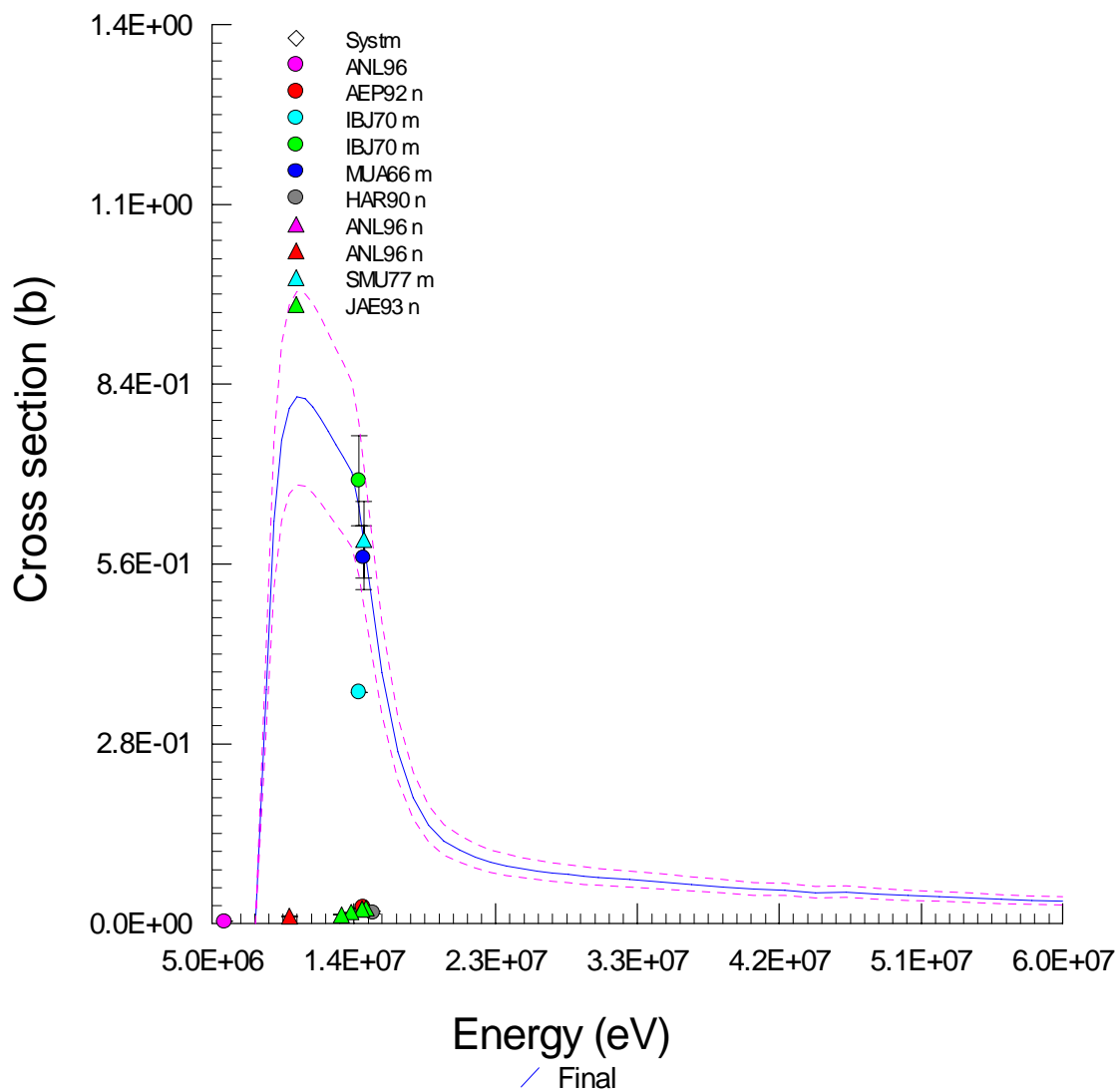
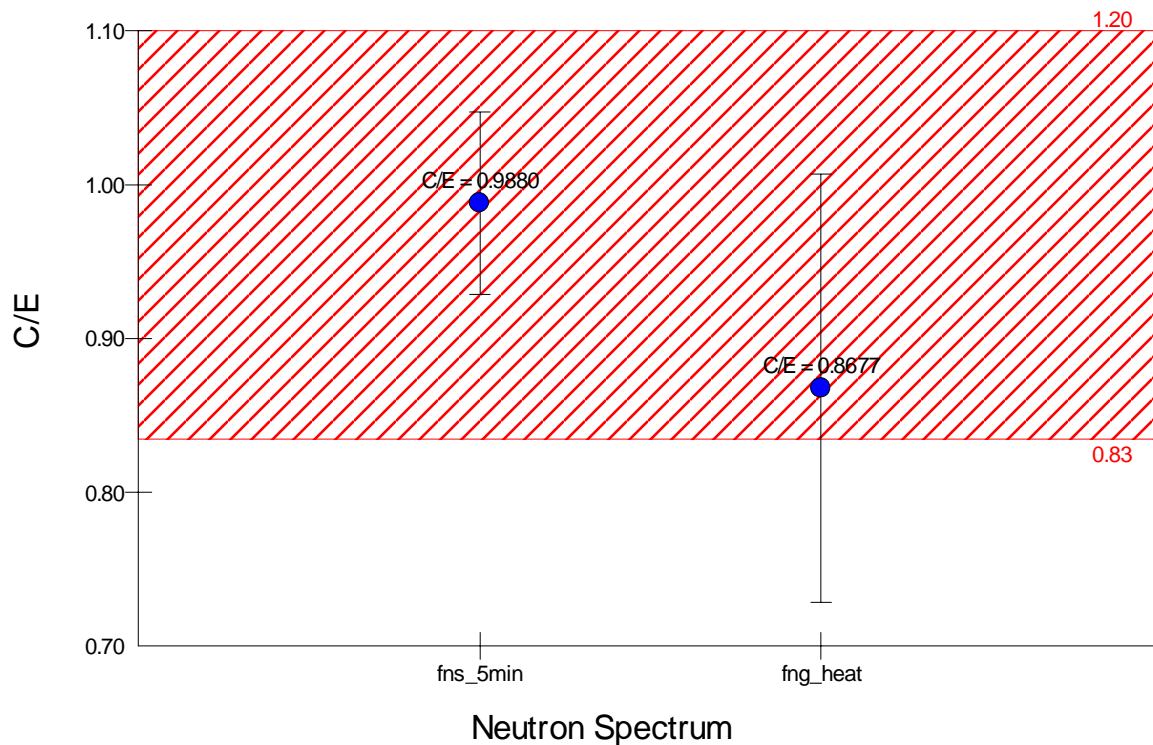
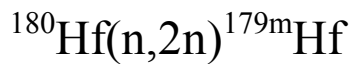


Neutron Spectrum

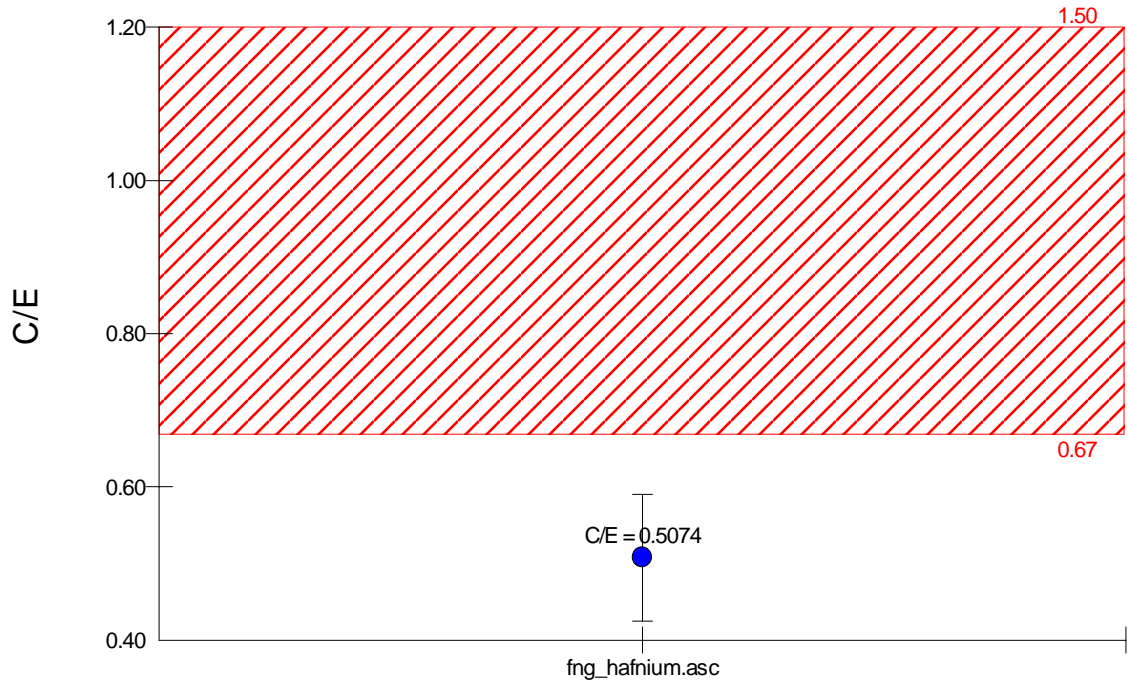
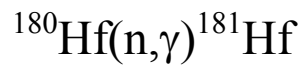


$^{180}\text{Hf}(n,n')^{180\text{m}}\text{Hf}$

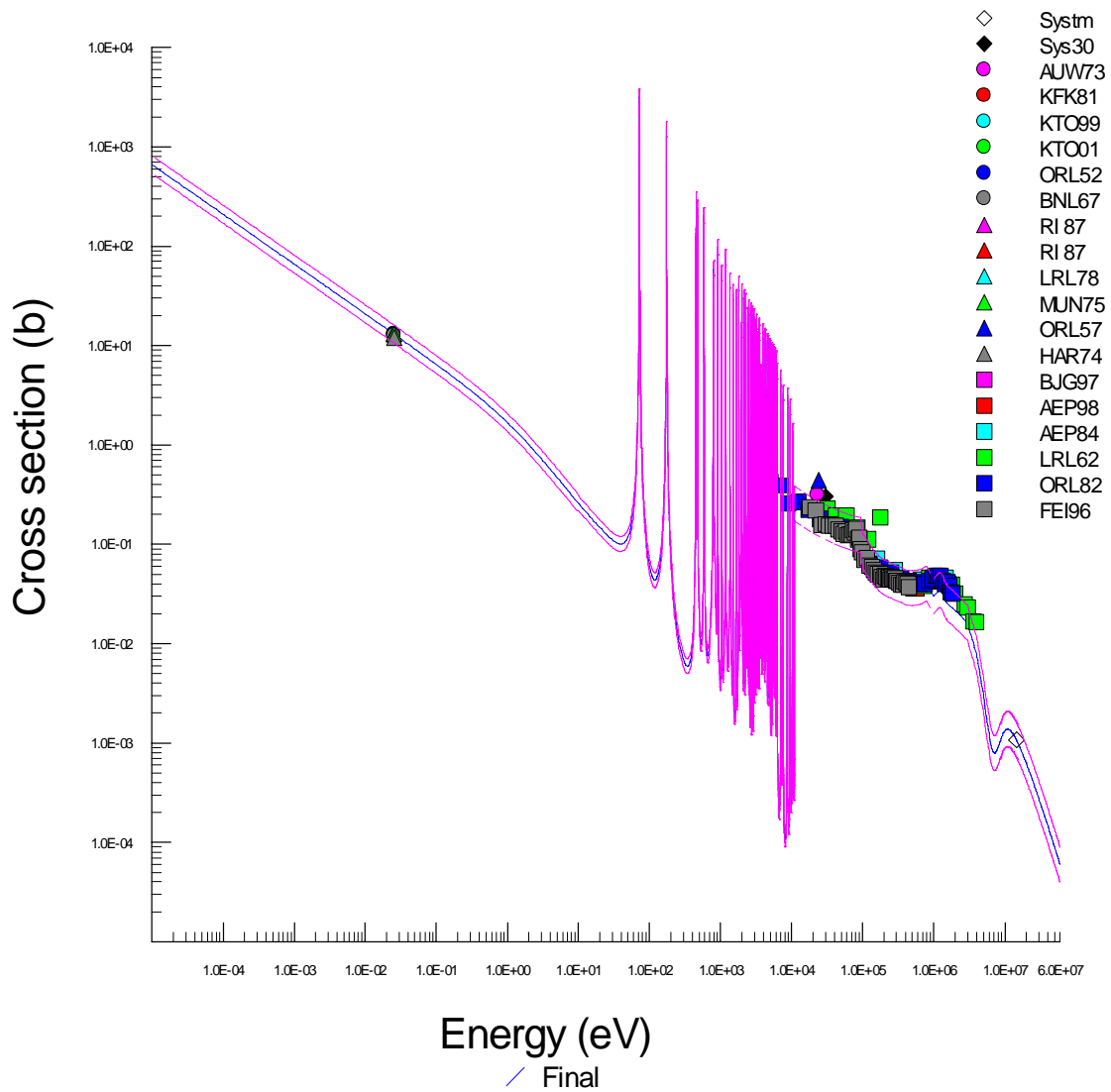




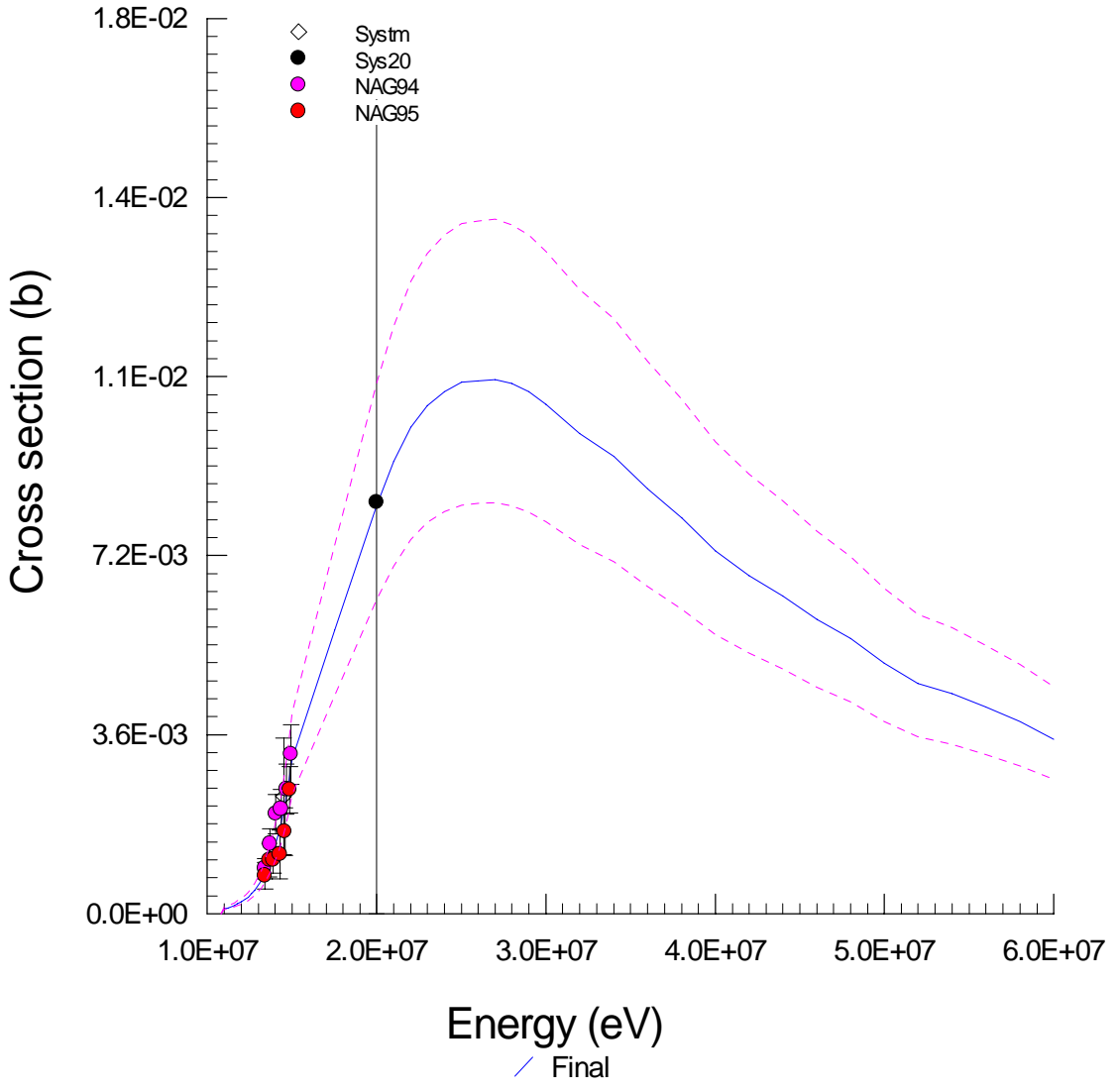
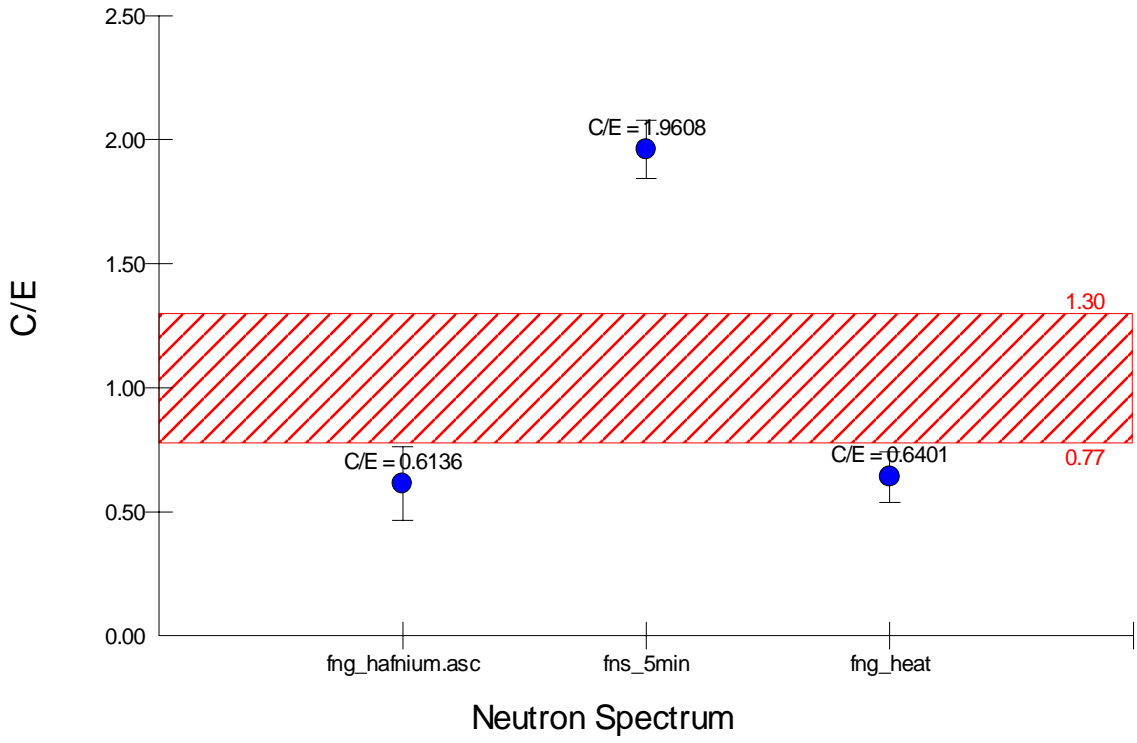




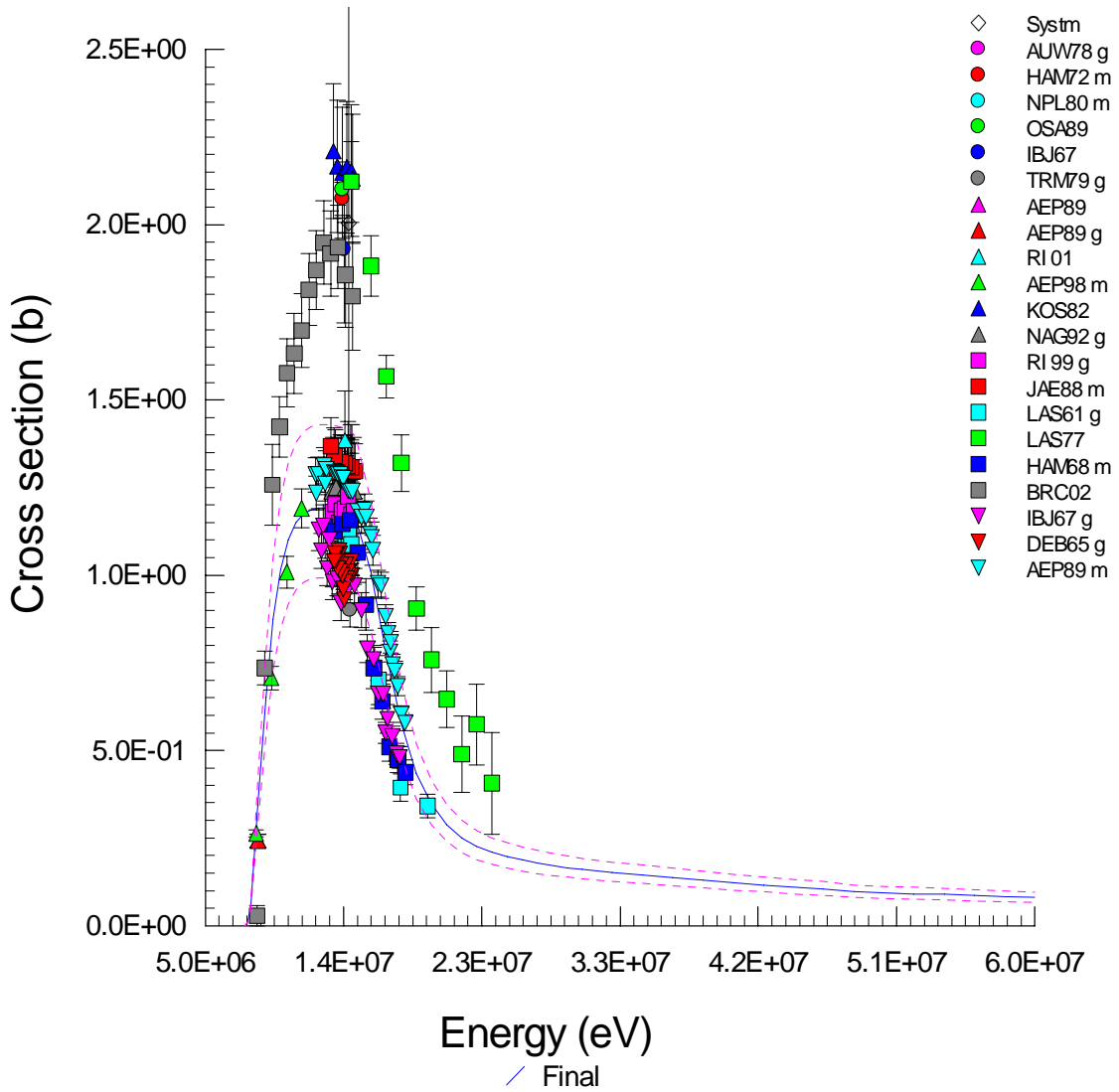
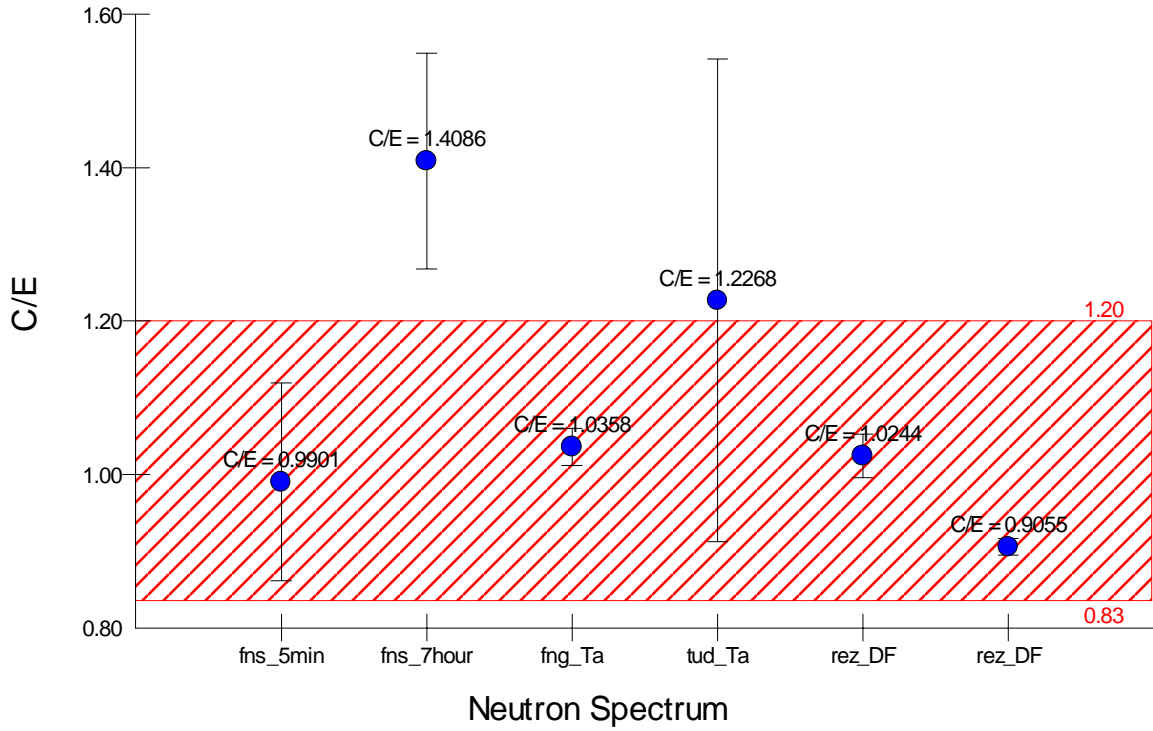
### Neutron Spectrum

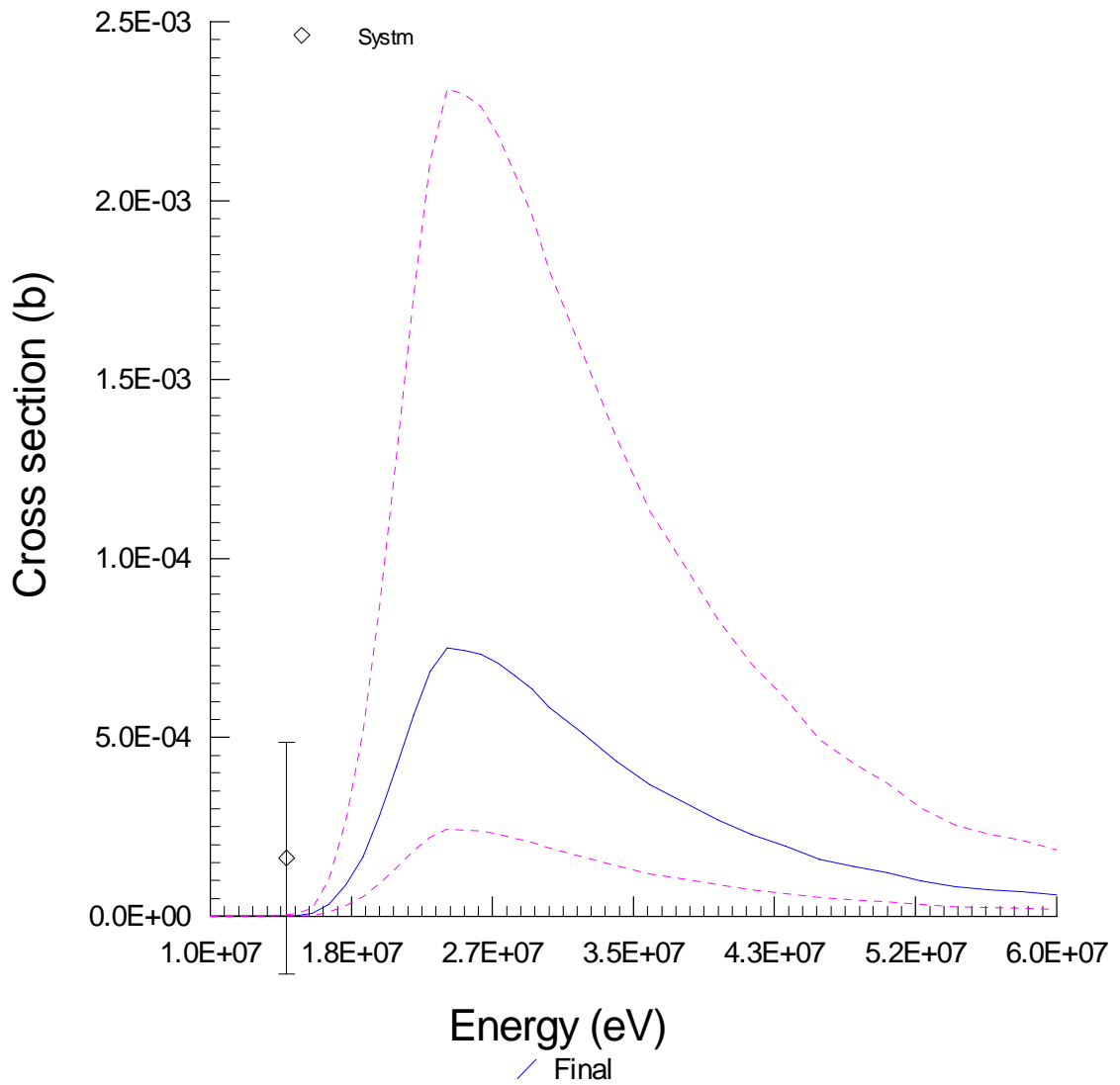
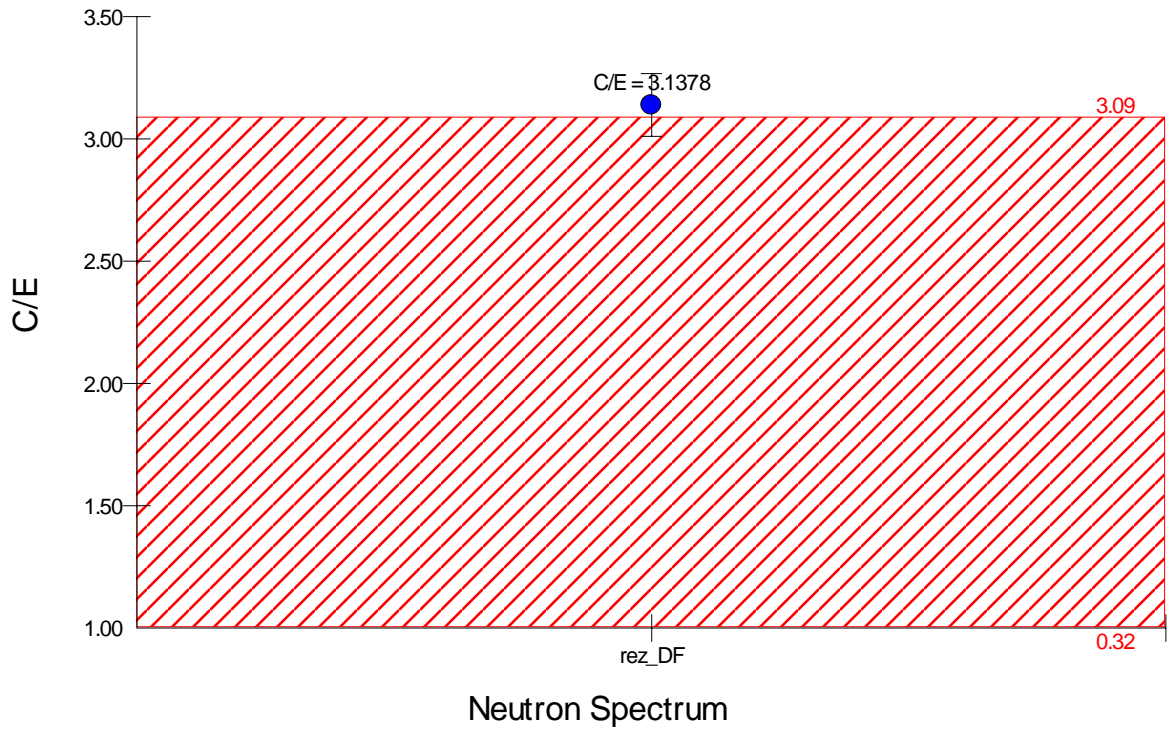
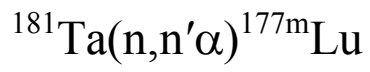


$^{180}\text{Hf}(n,p)^{180}\text{Lu}$

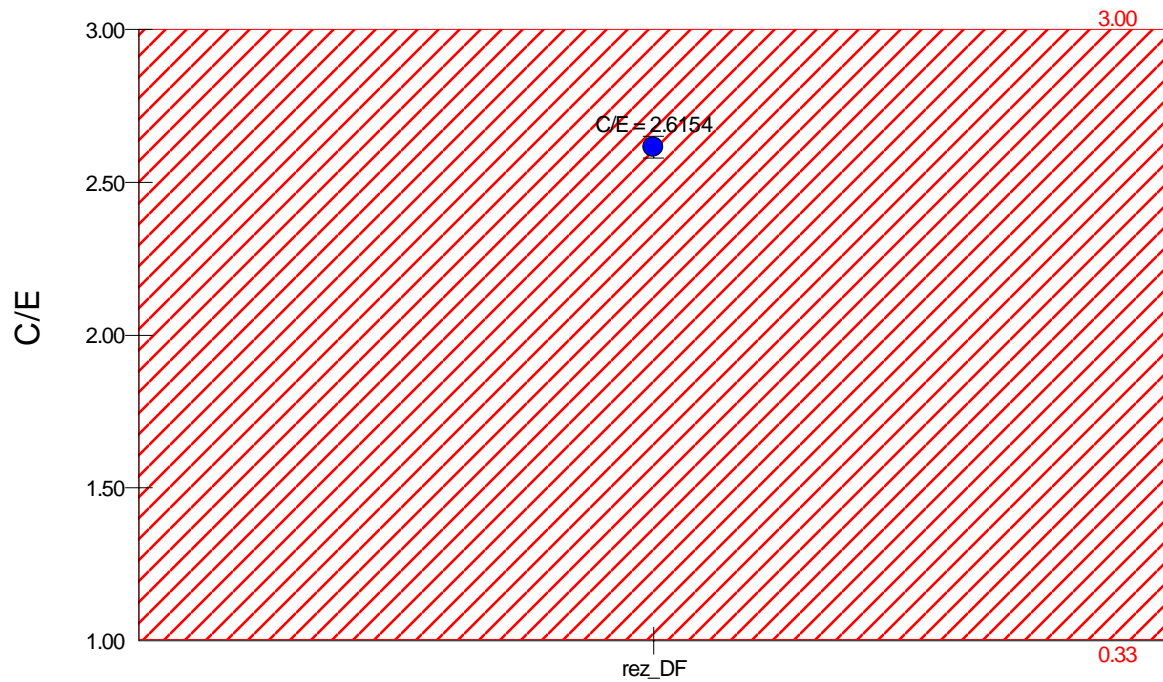


$^{181}\text{Ta}(n,2n)^{180g}\text{Ta} \blacktriangleright 554$

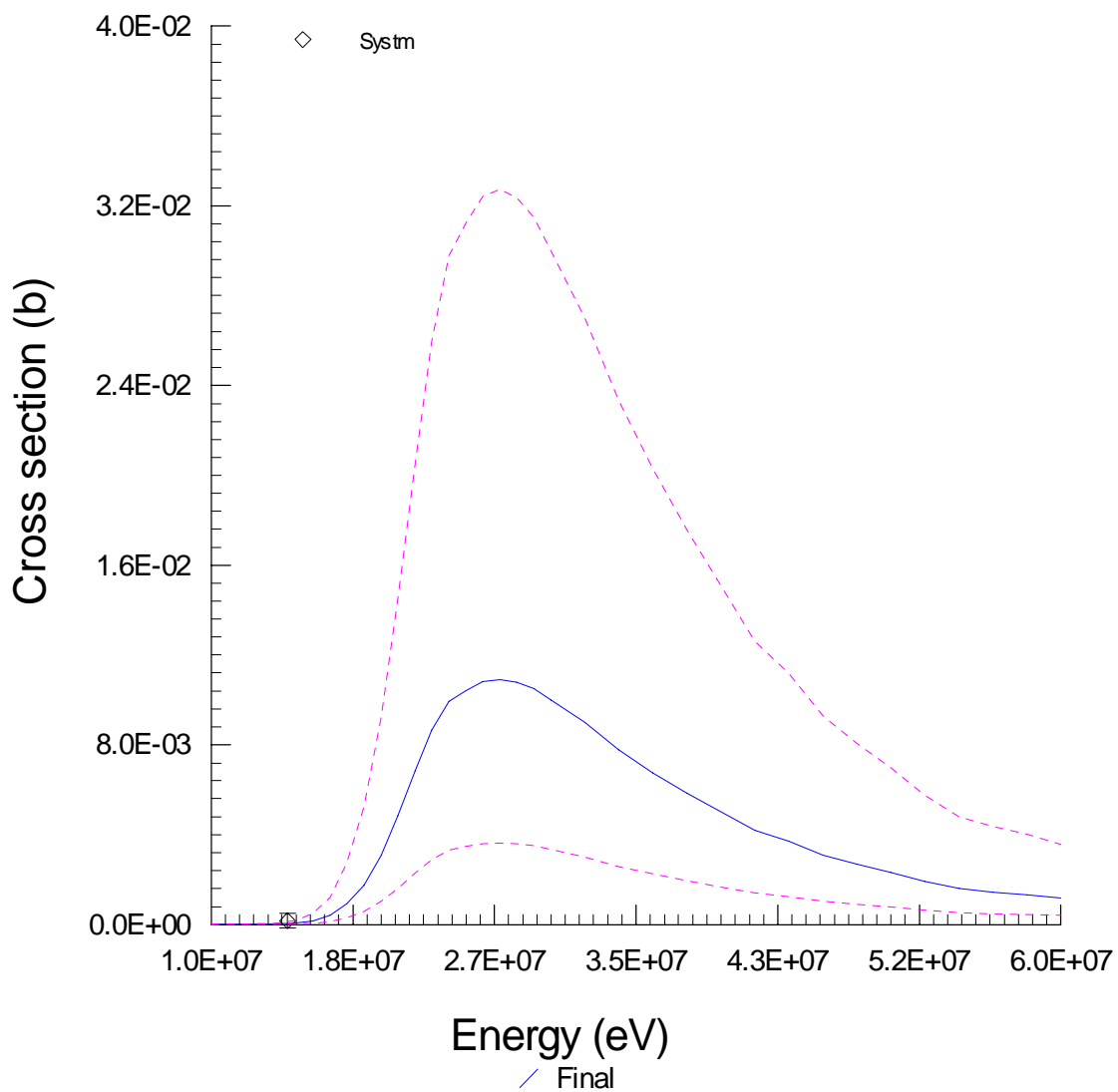


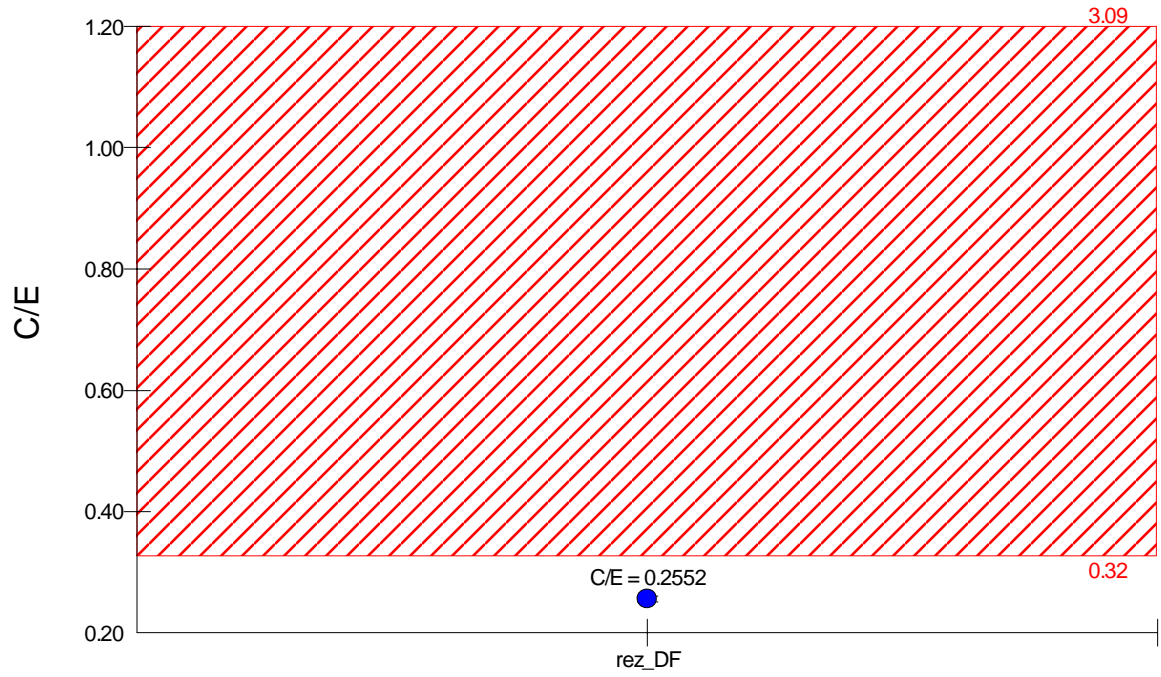
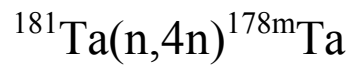


# $^{181}\text{Ta}(n,n'\alpha)^{177}\text{Lu}$

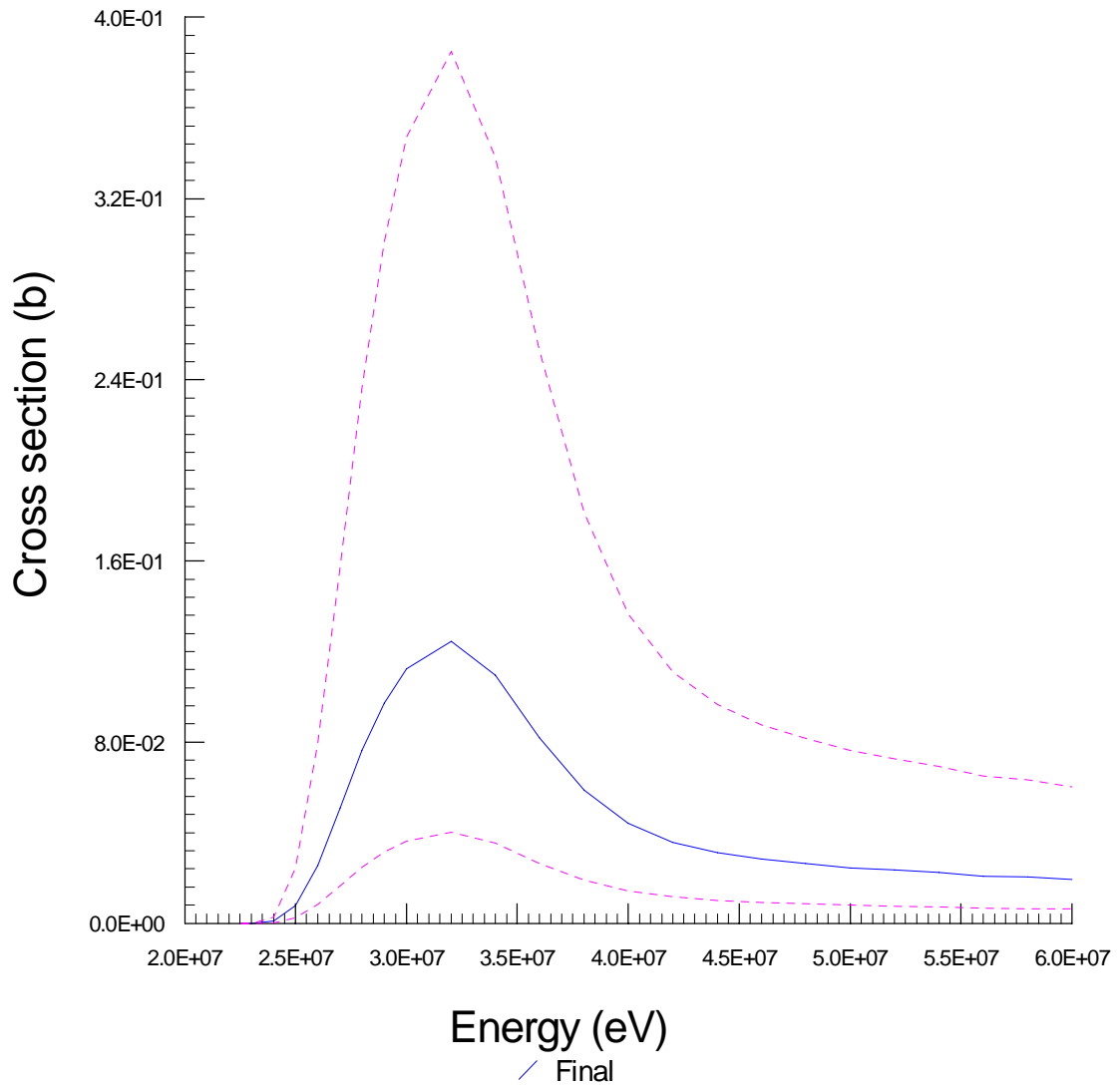


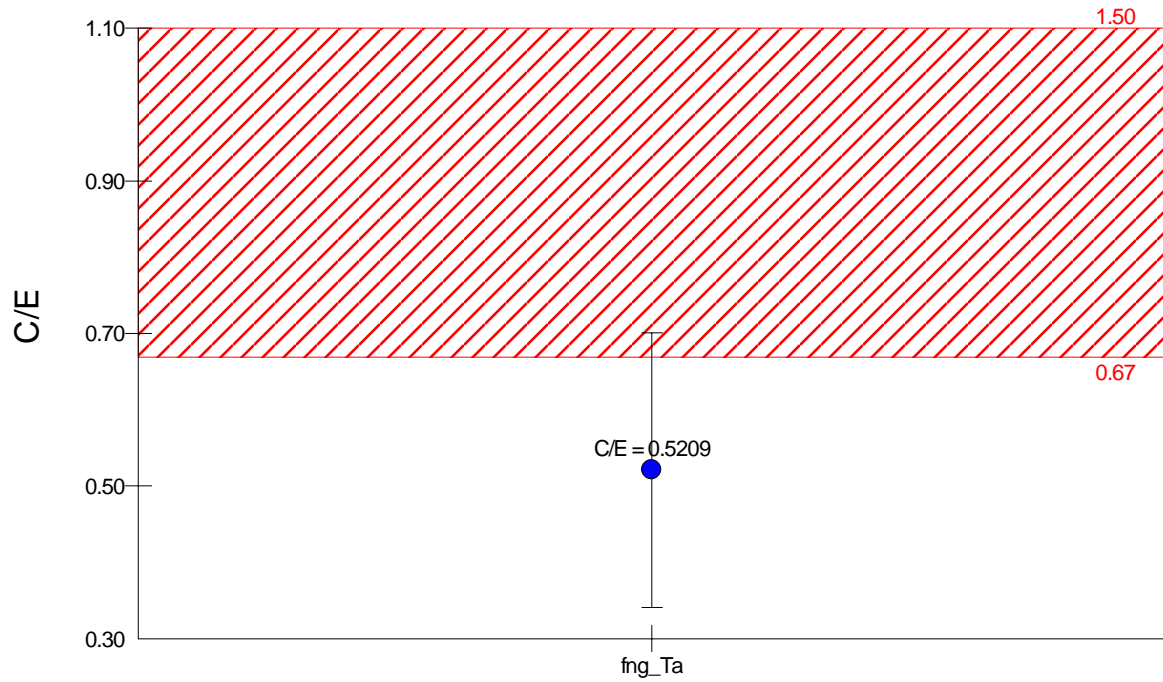
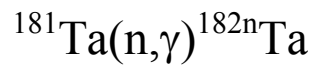
Neutron Spectrum



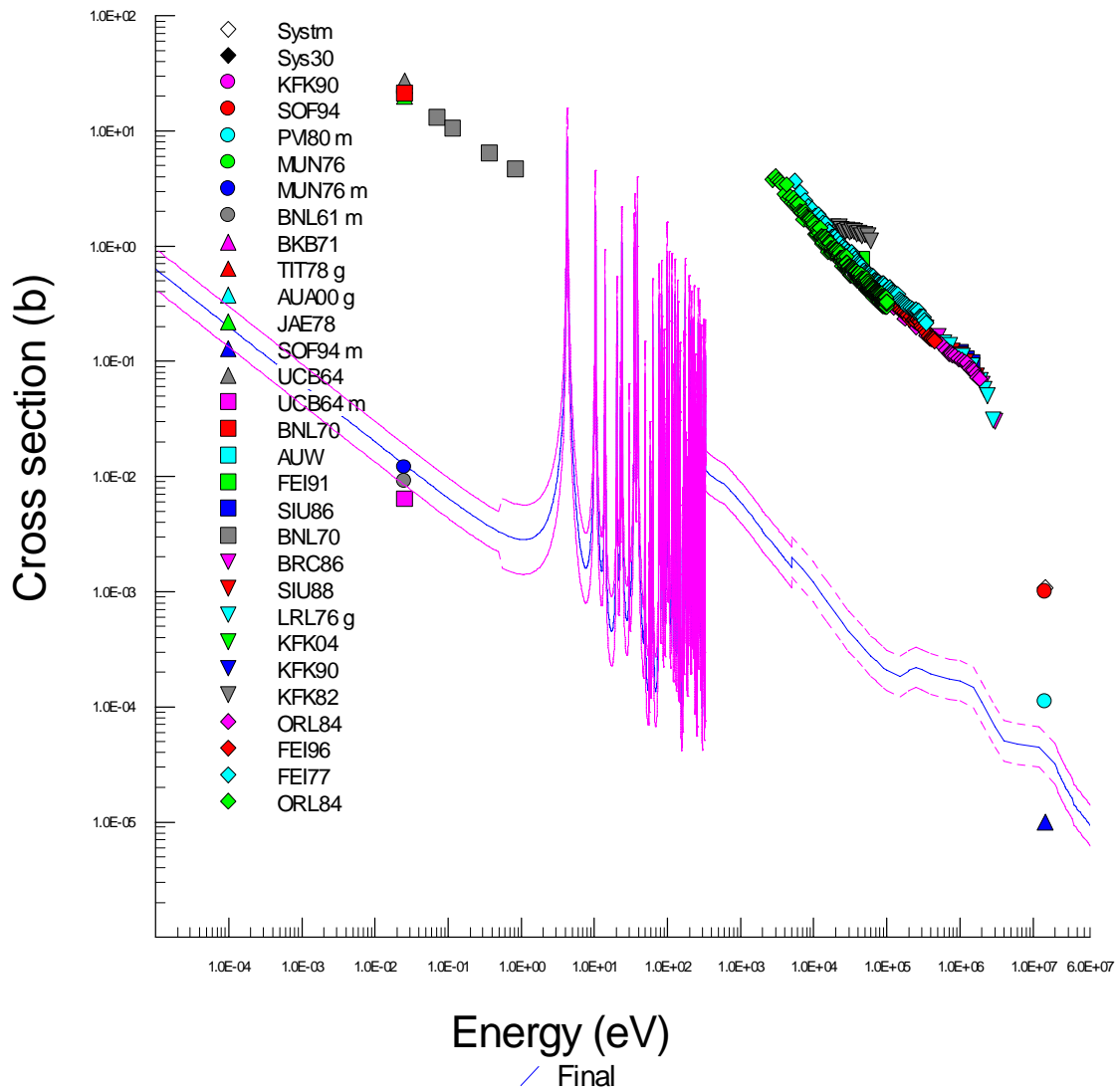


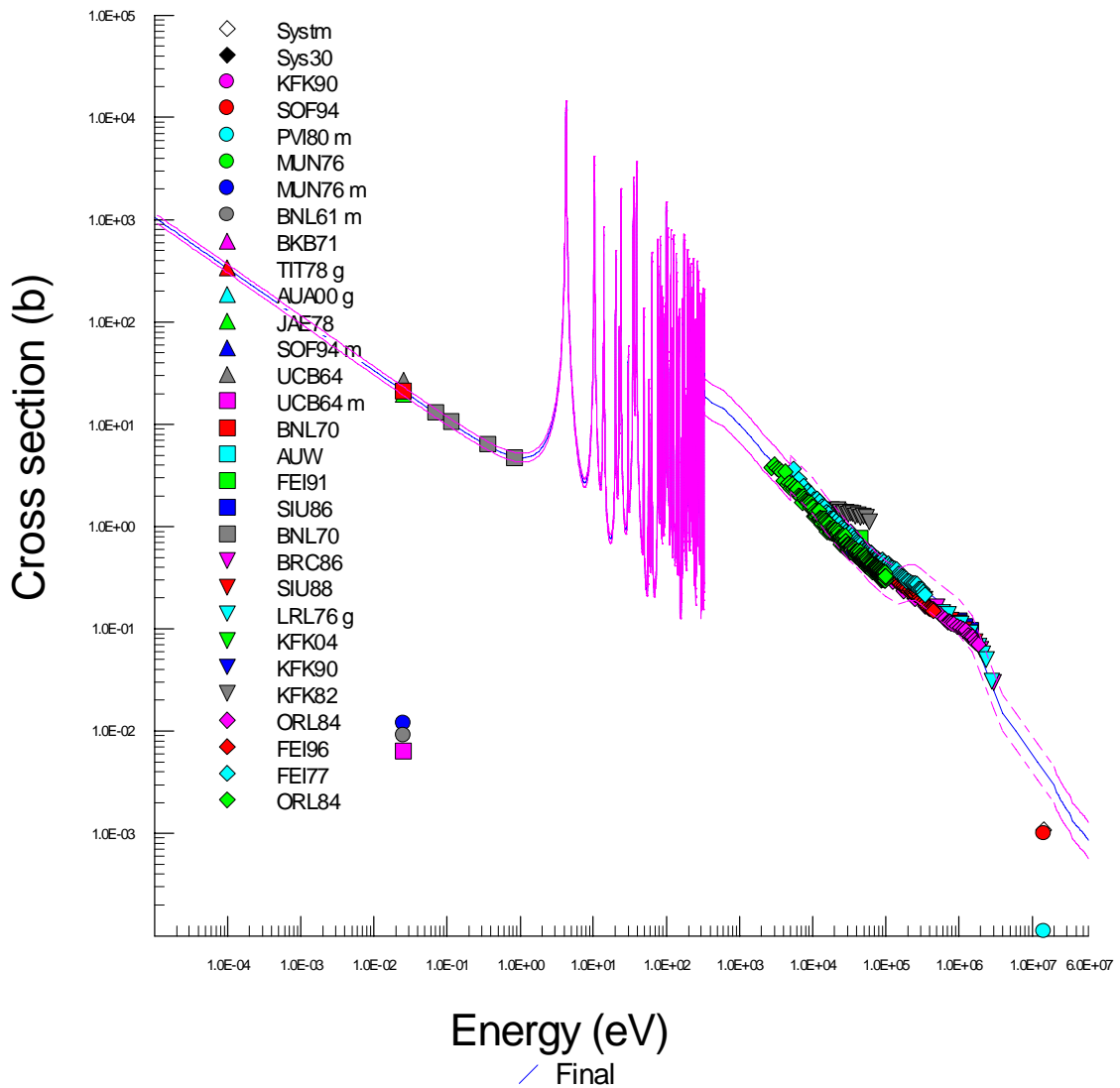
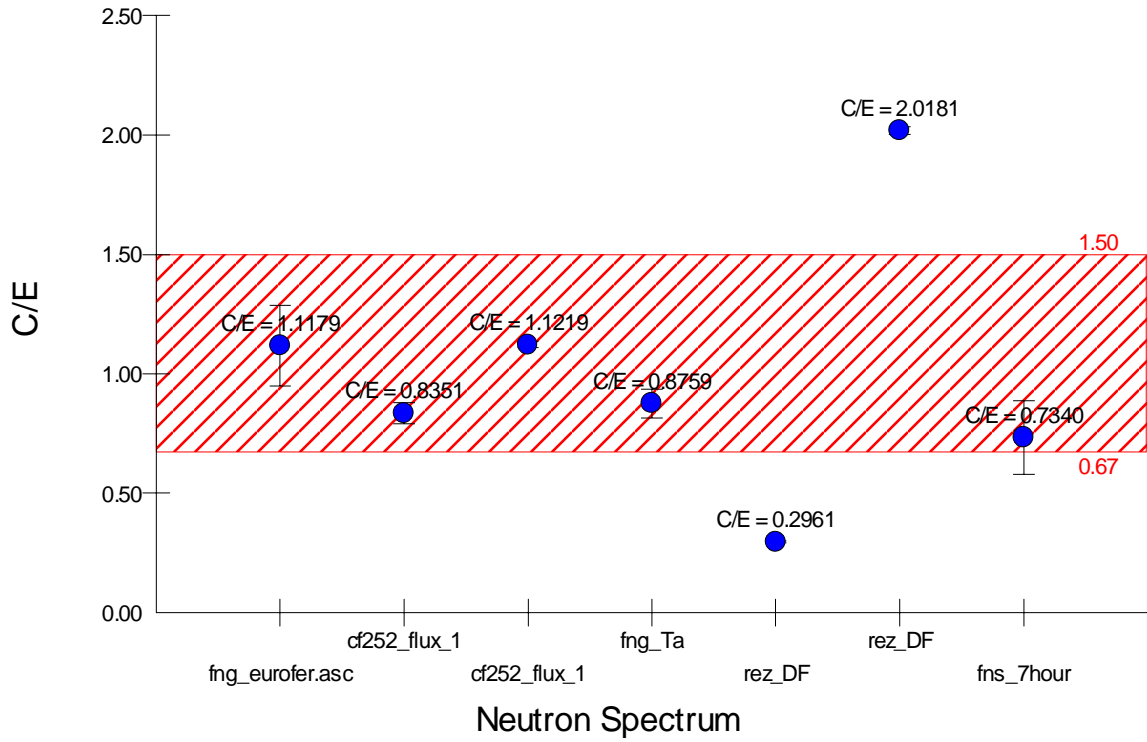
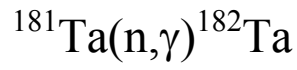
Neutron Spectrum





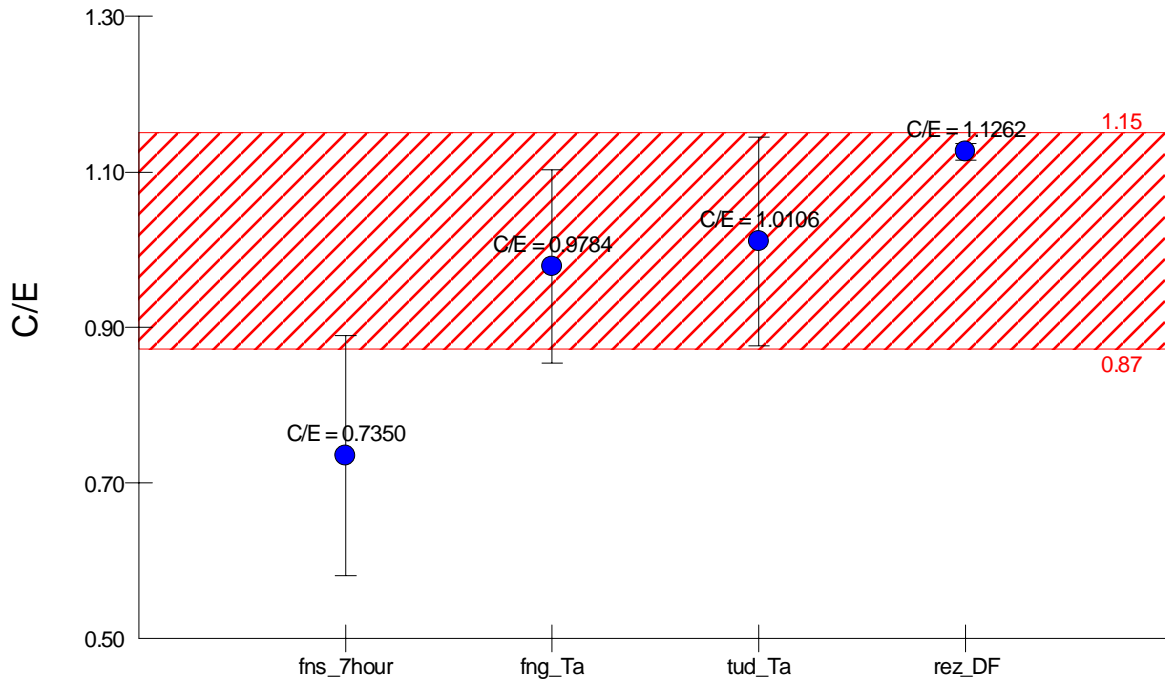
Neutron Spectrum



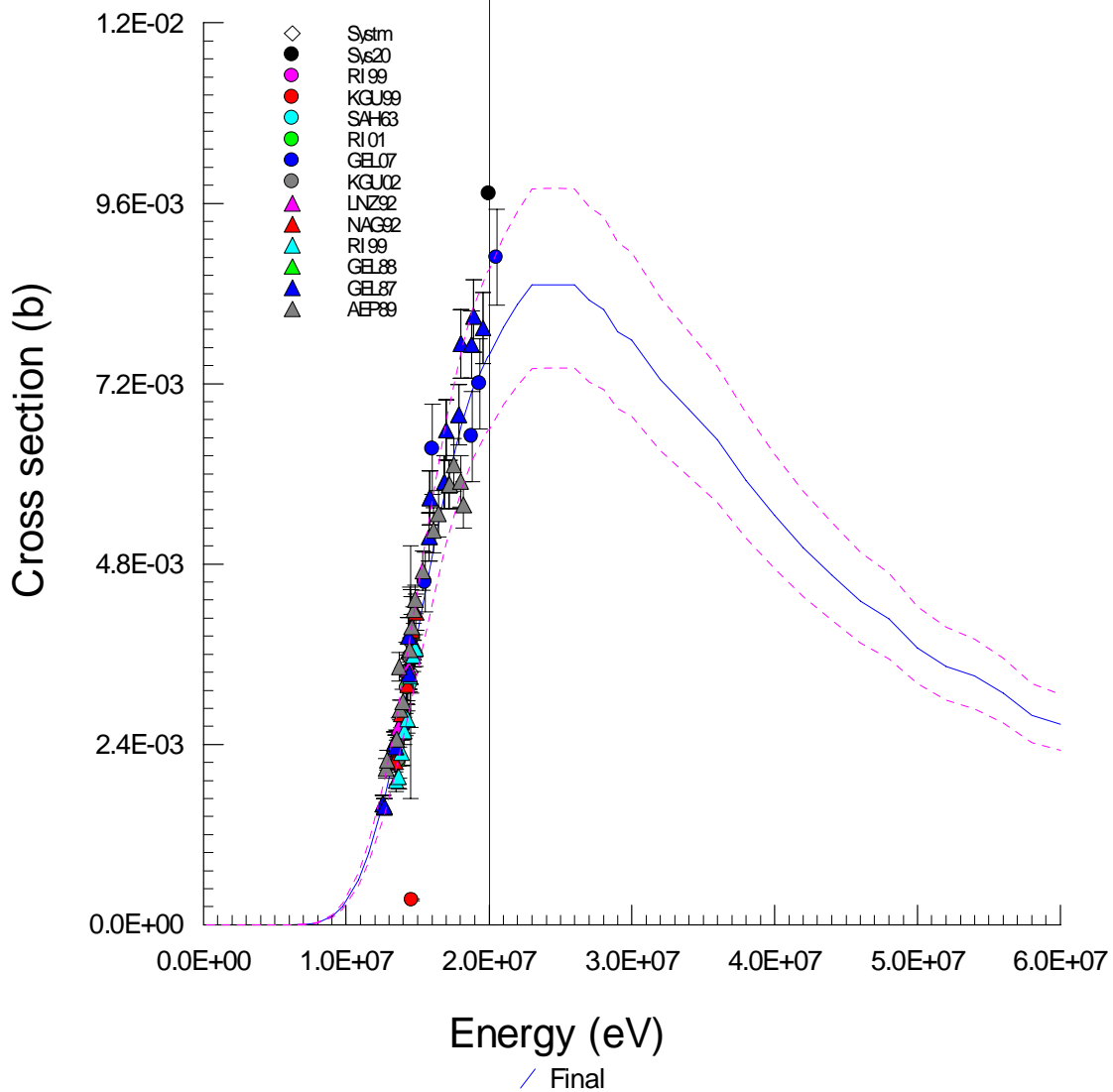


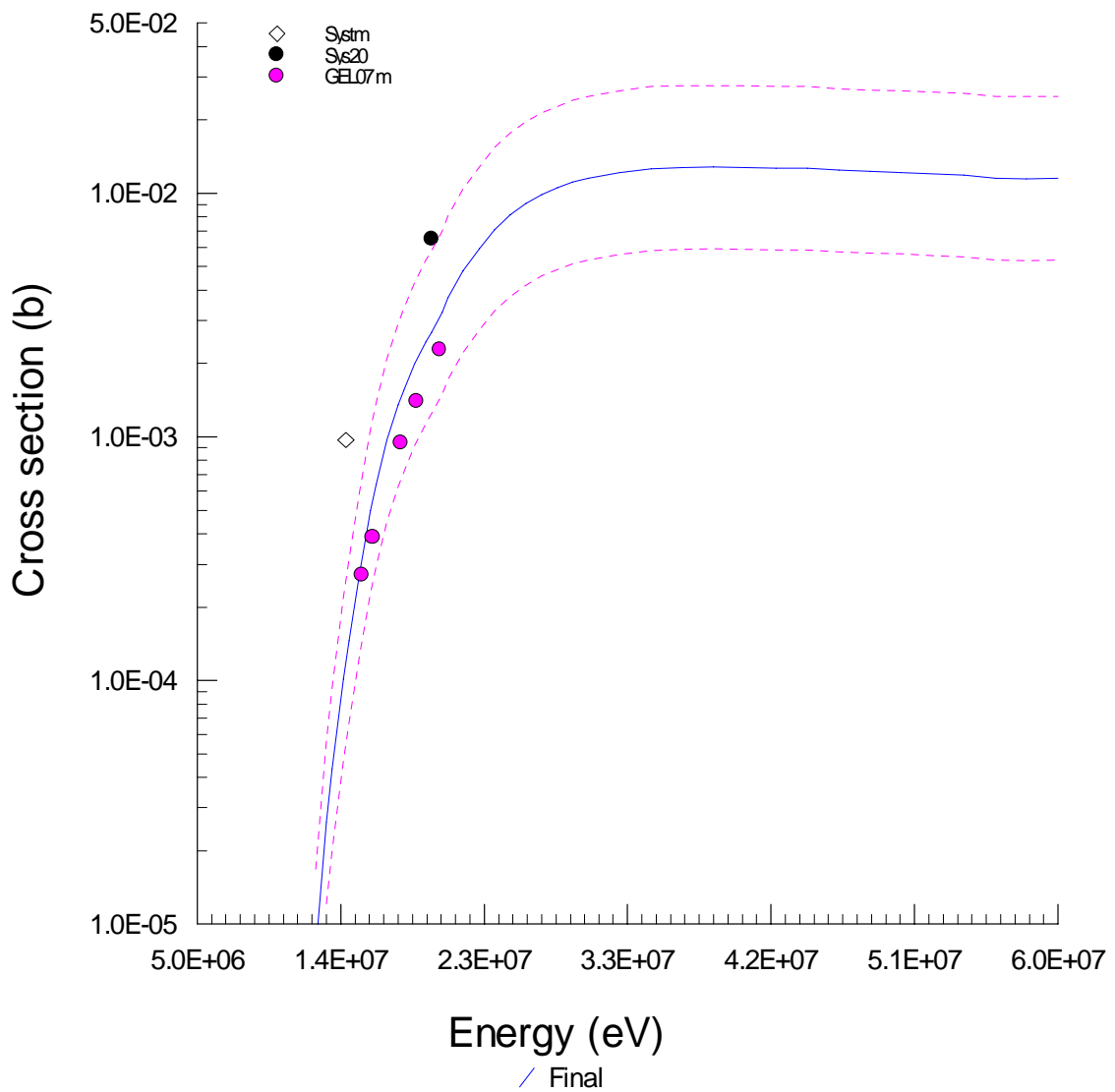
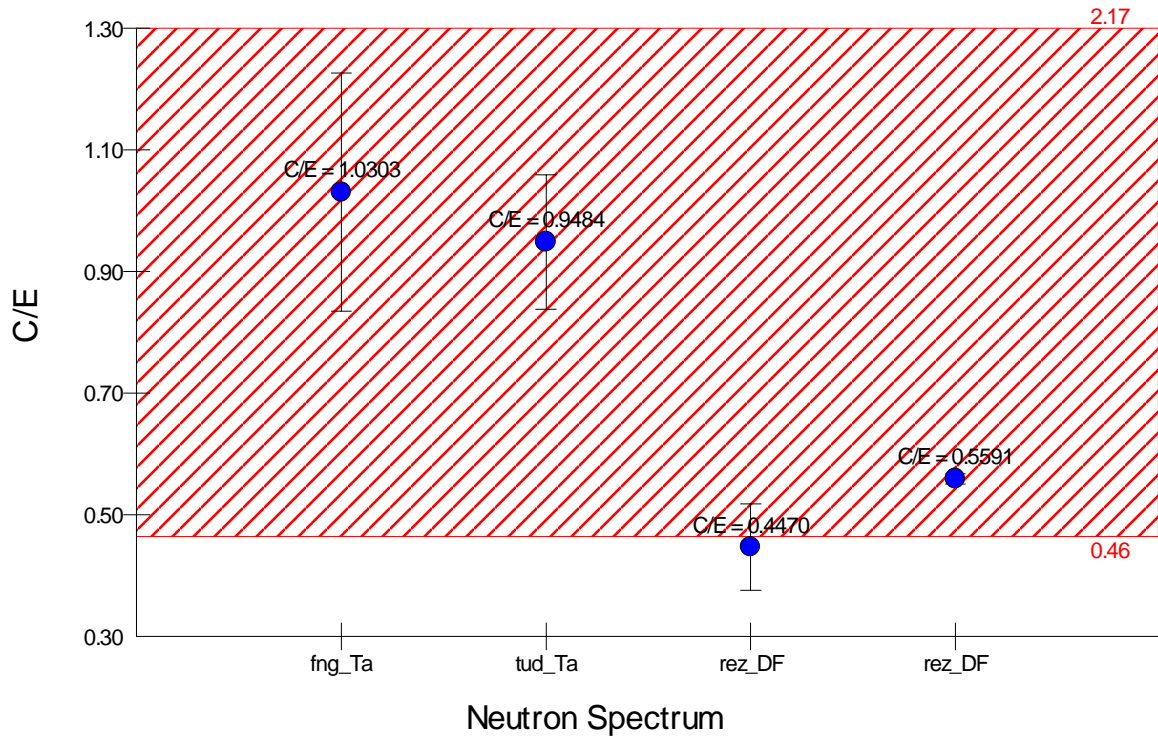
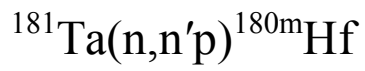


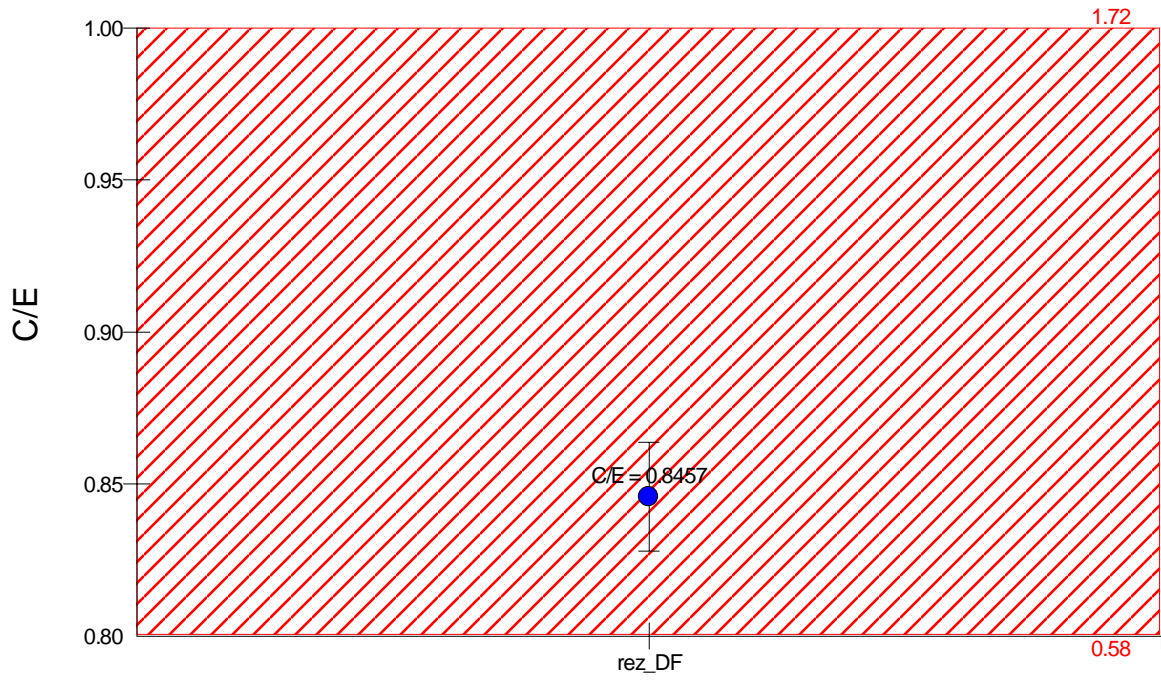
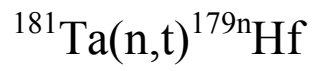
# $^{181}\text{Ta}(n,p)^{181}\text{Hf}$



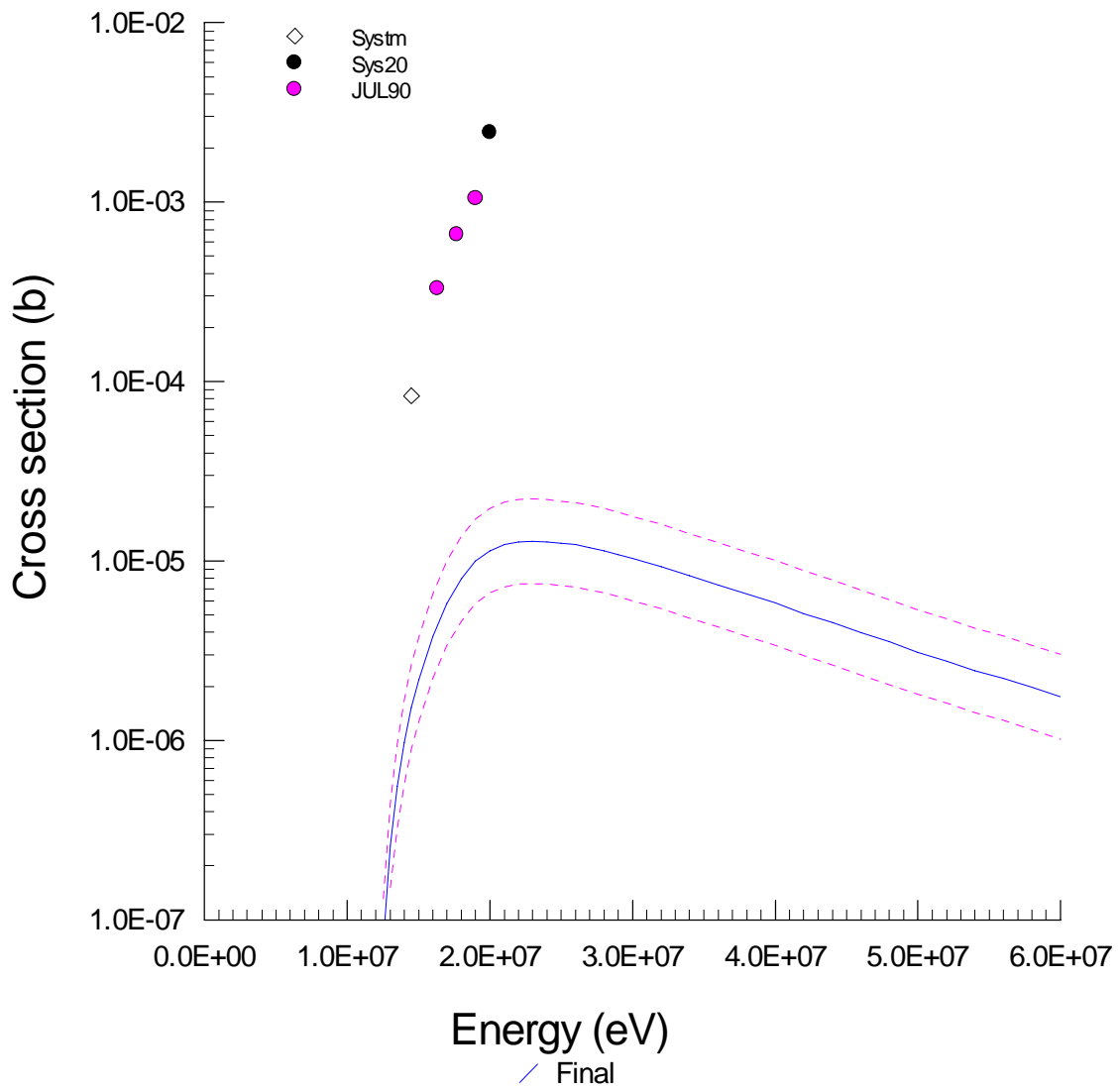
## Neutron Spectrum

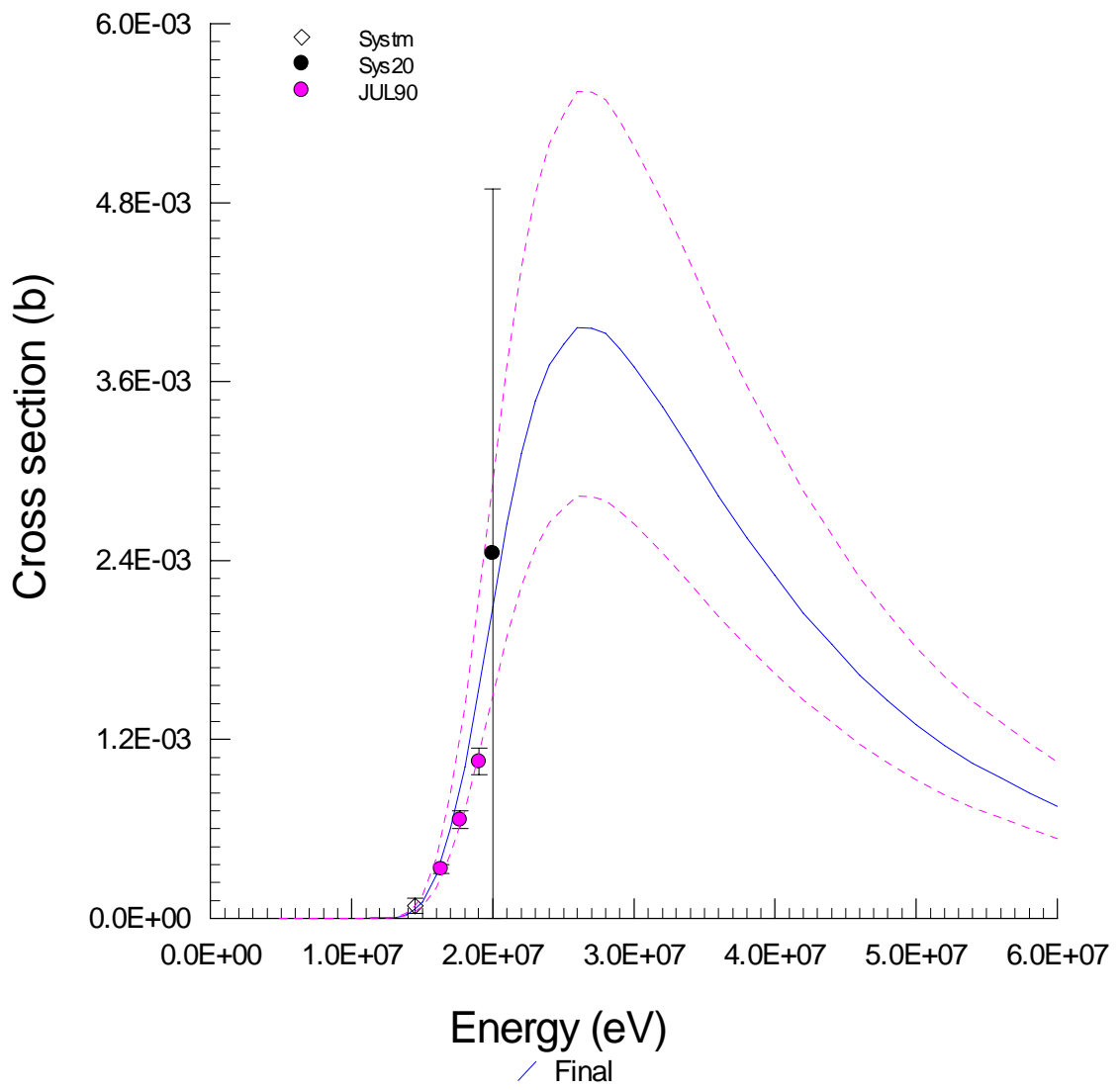
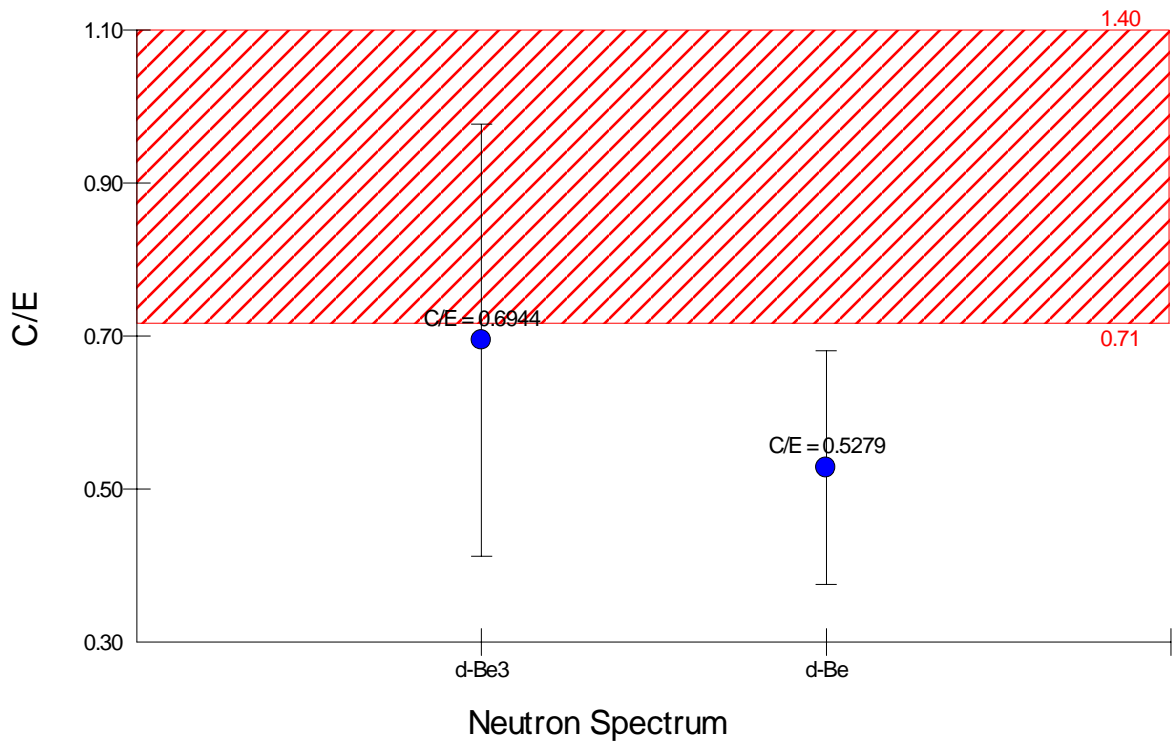
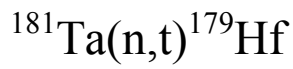




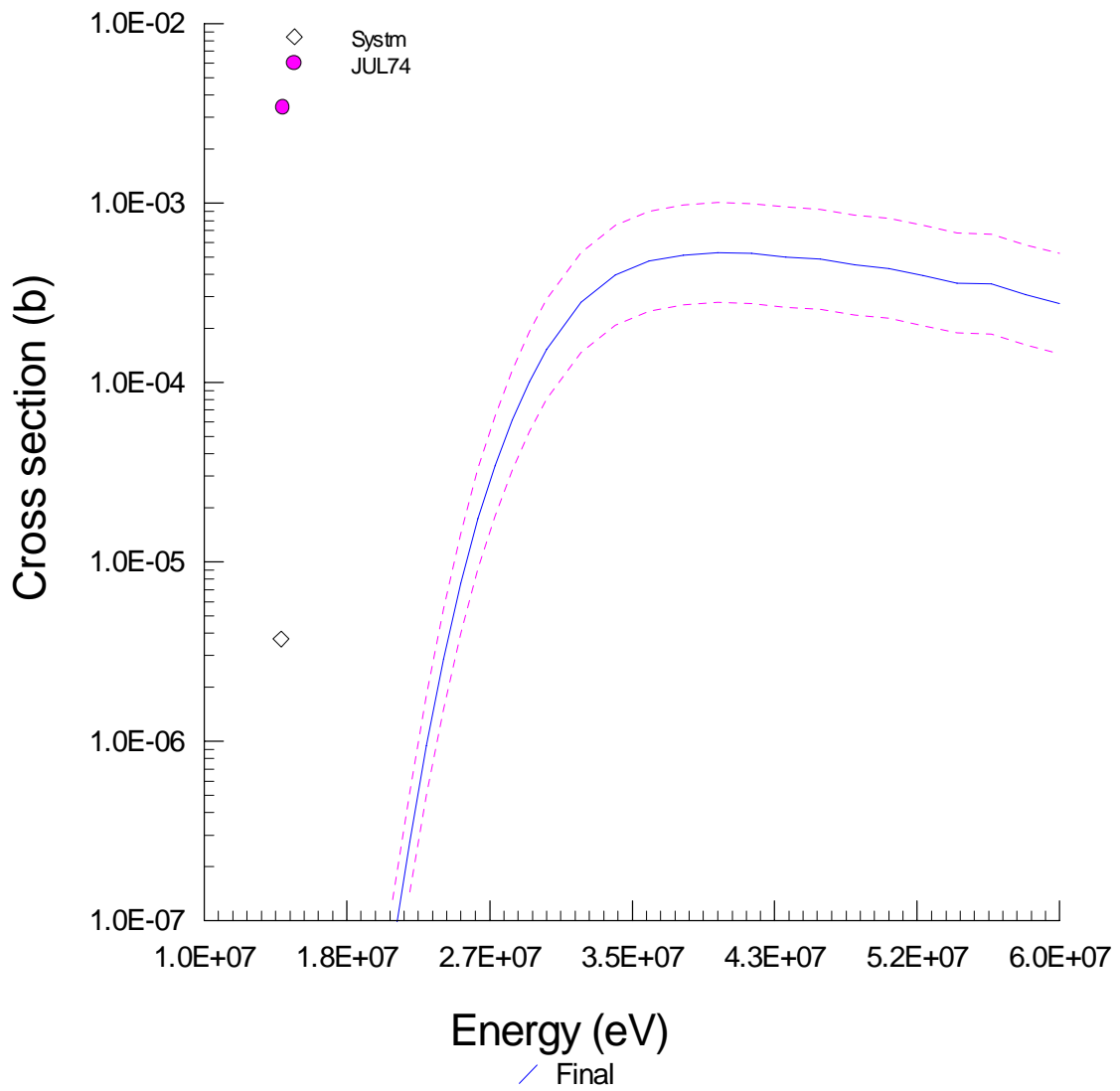
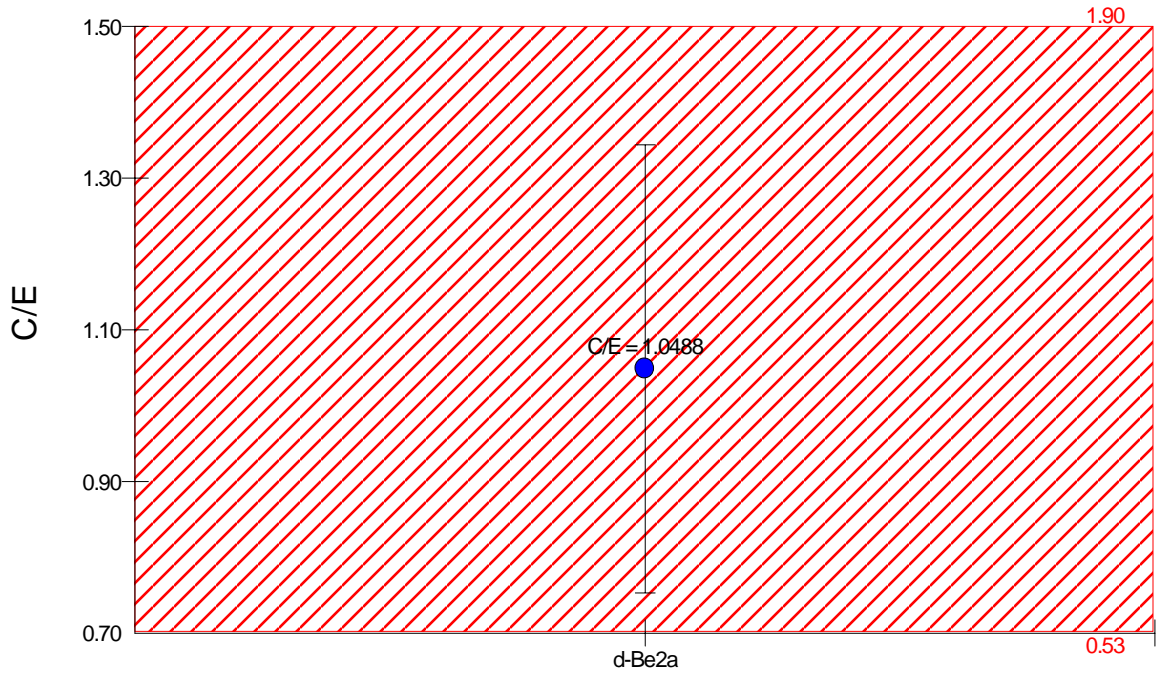


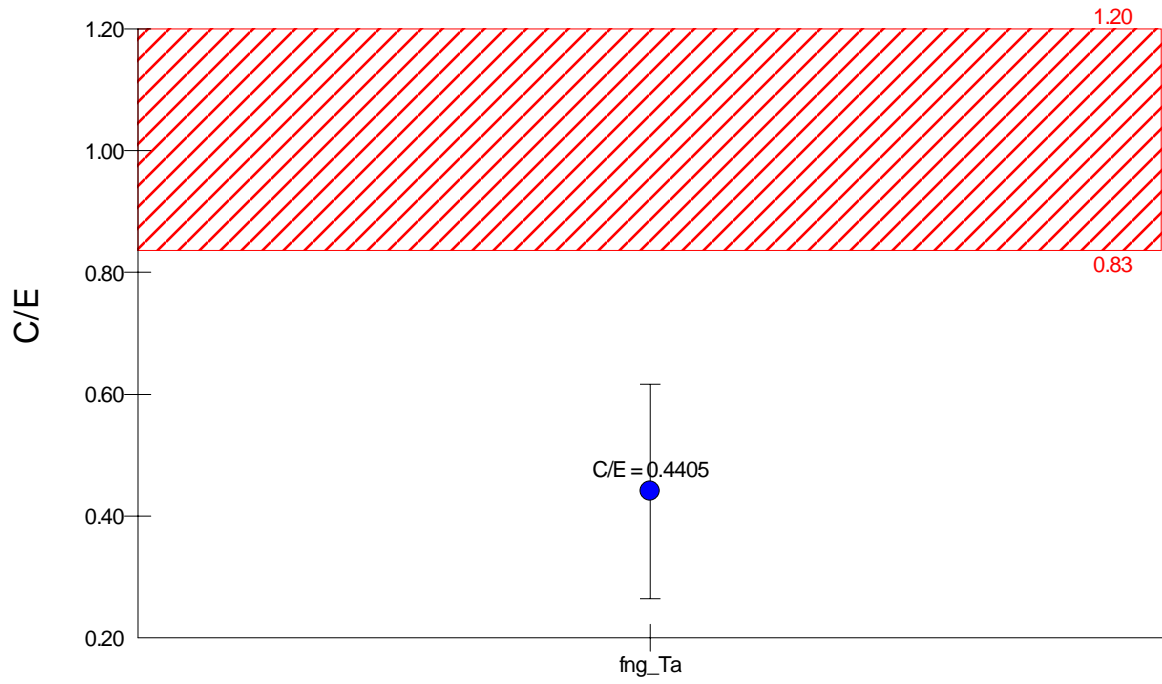
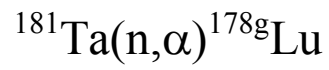
Neutron Spectrum



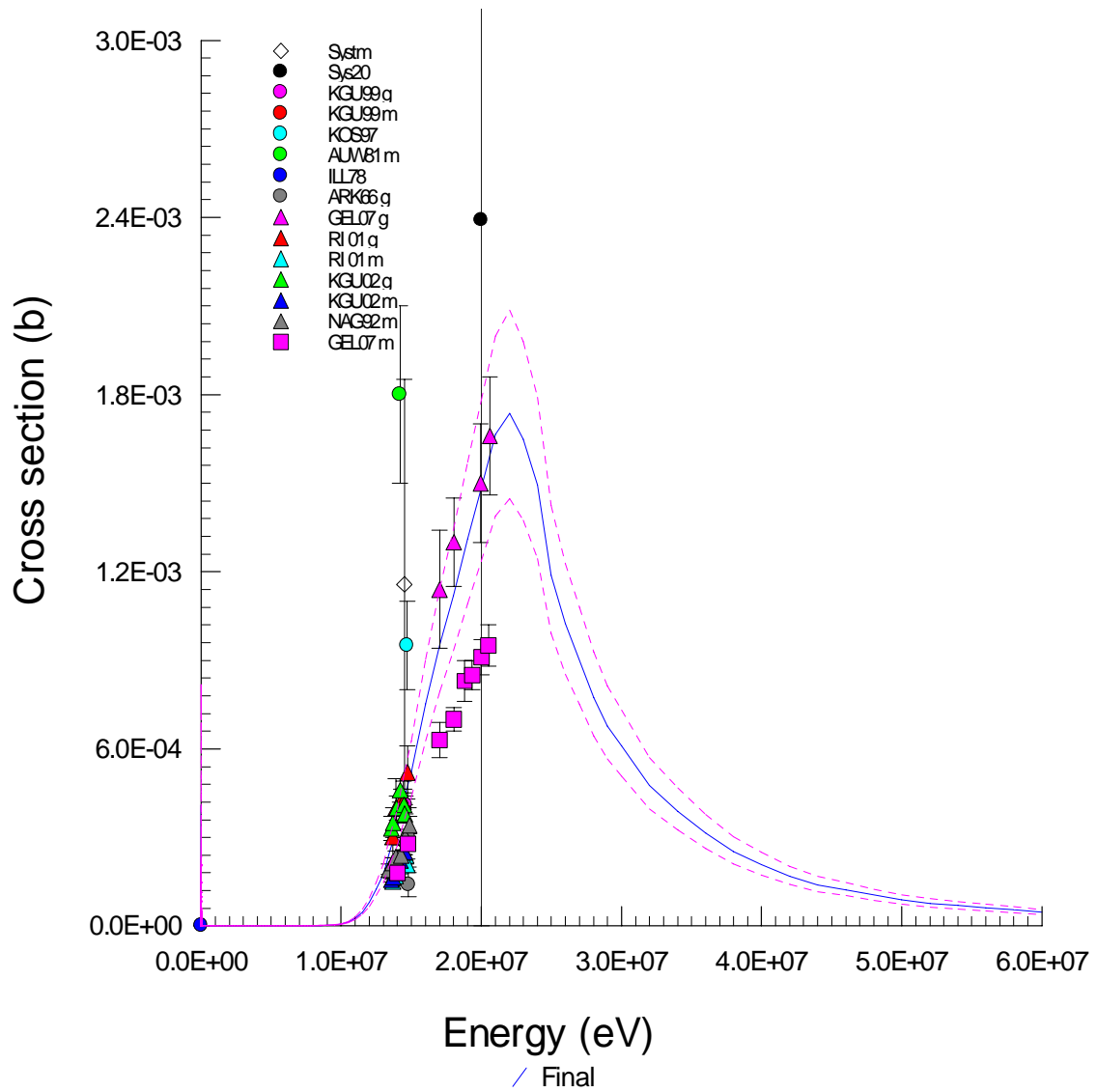


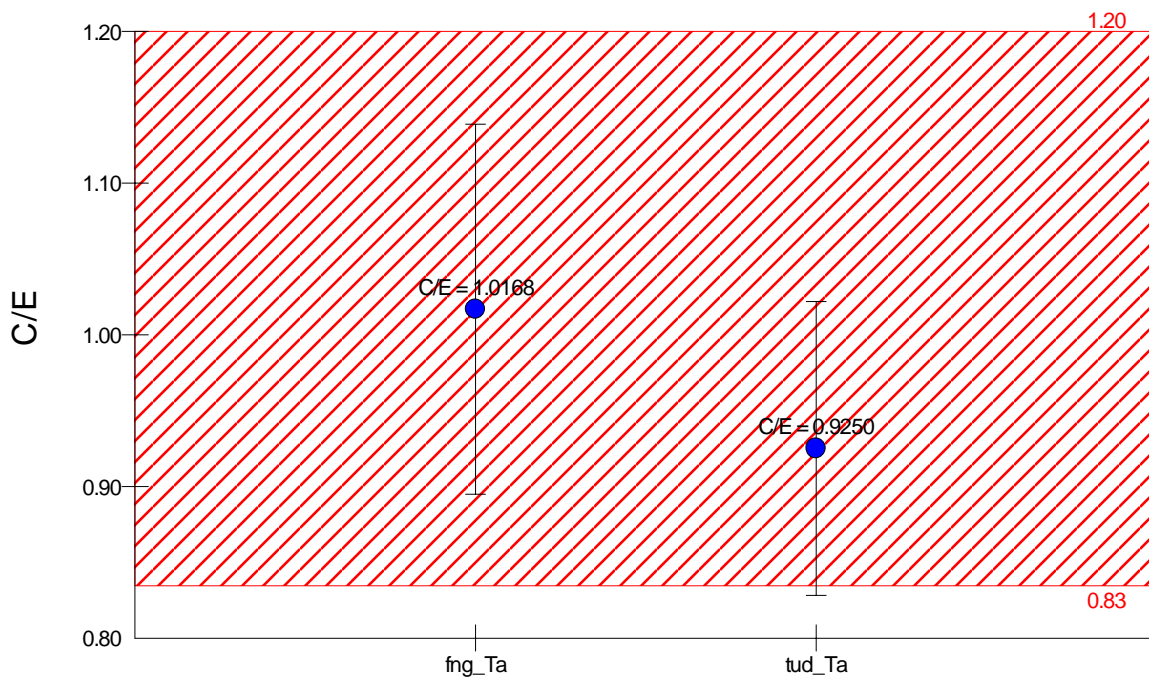
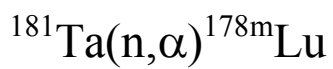
# $^{181}\text{Ta}(n,h)^{179}\text{Lu}$



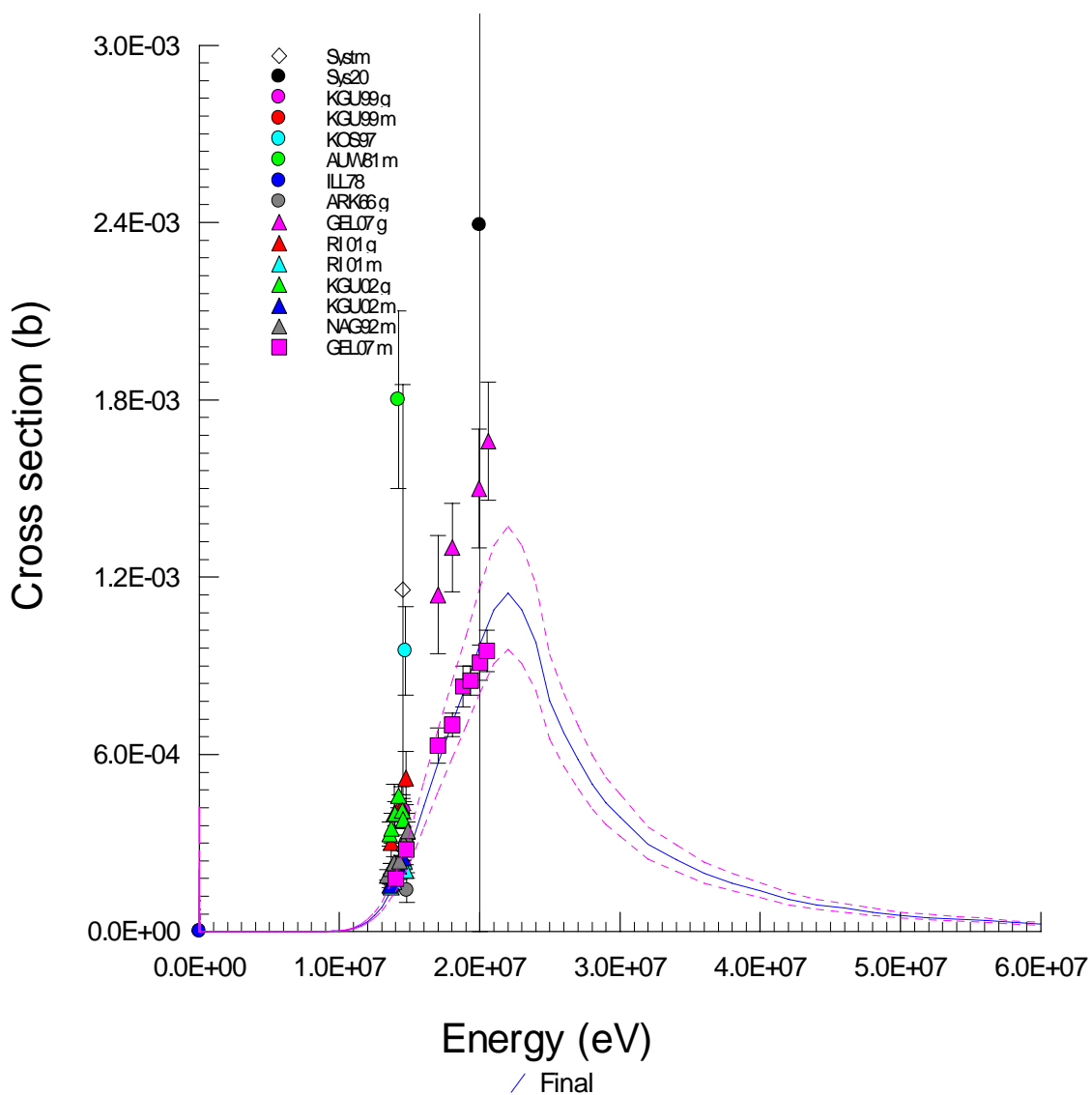


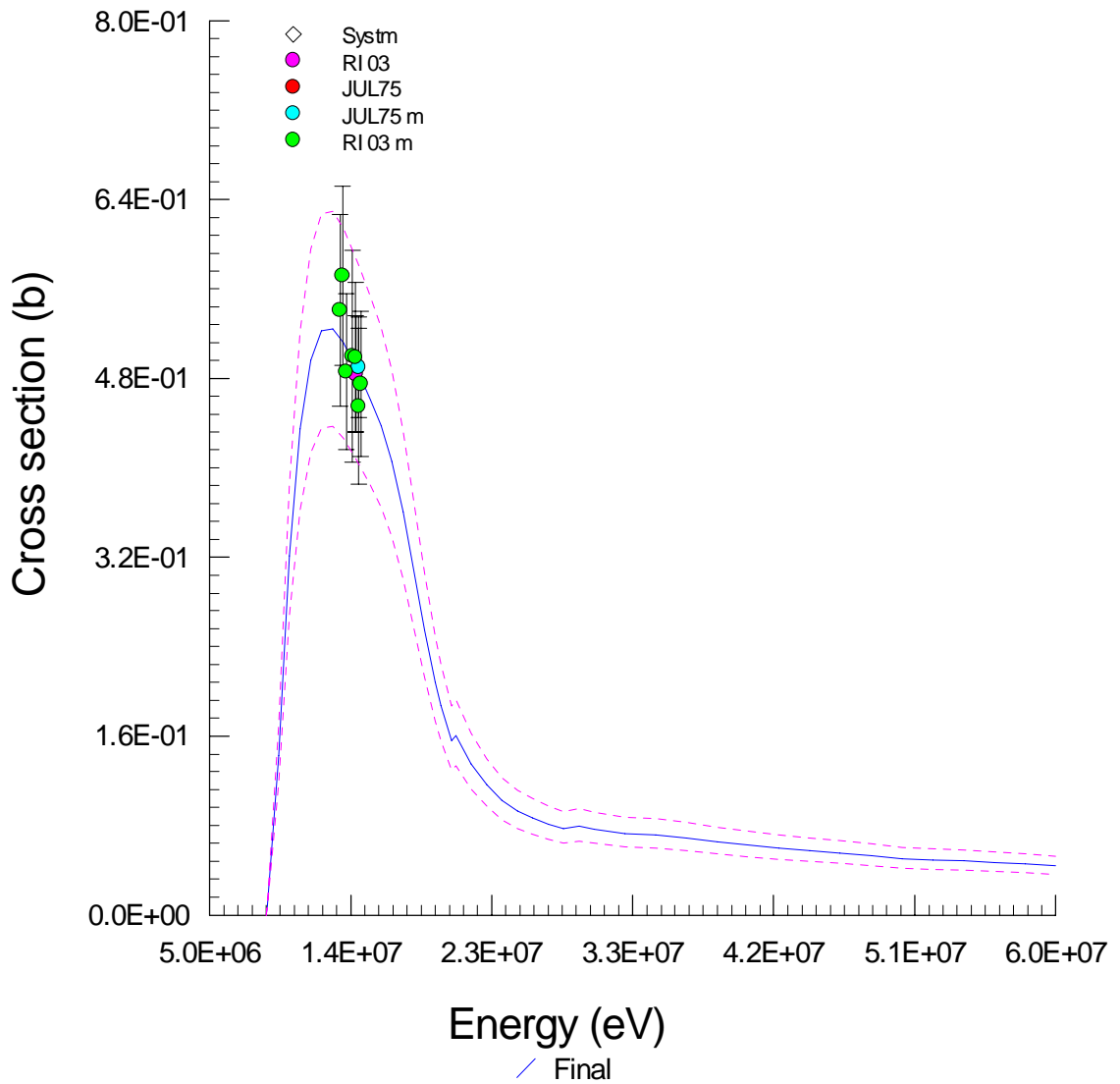
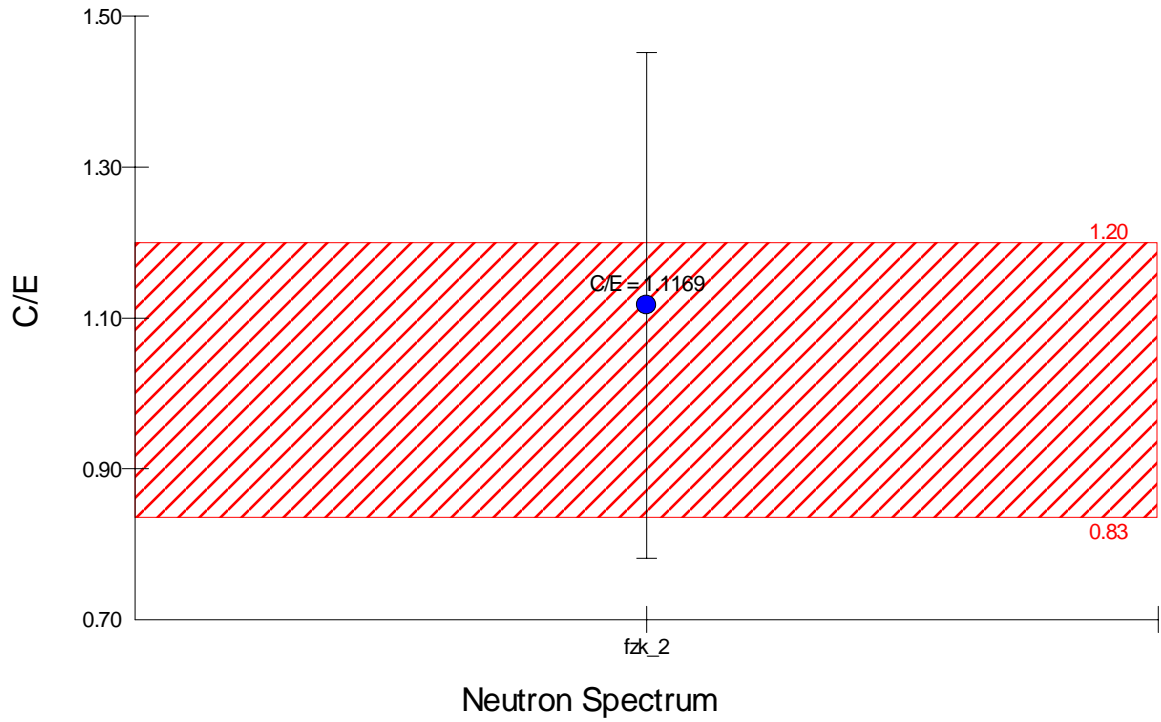
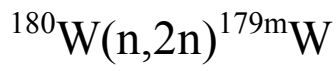
Neutron Spectrum



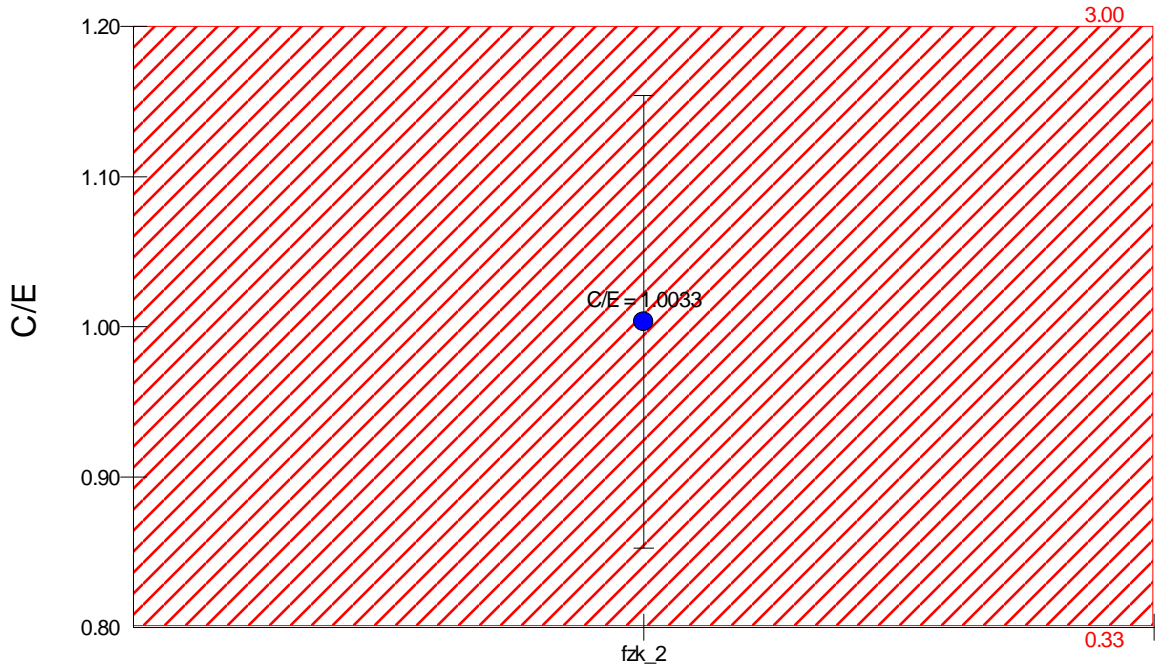
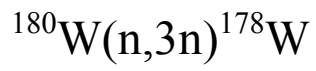


Neutron Spectrum

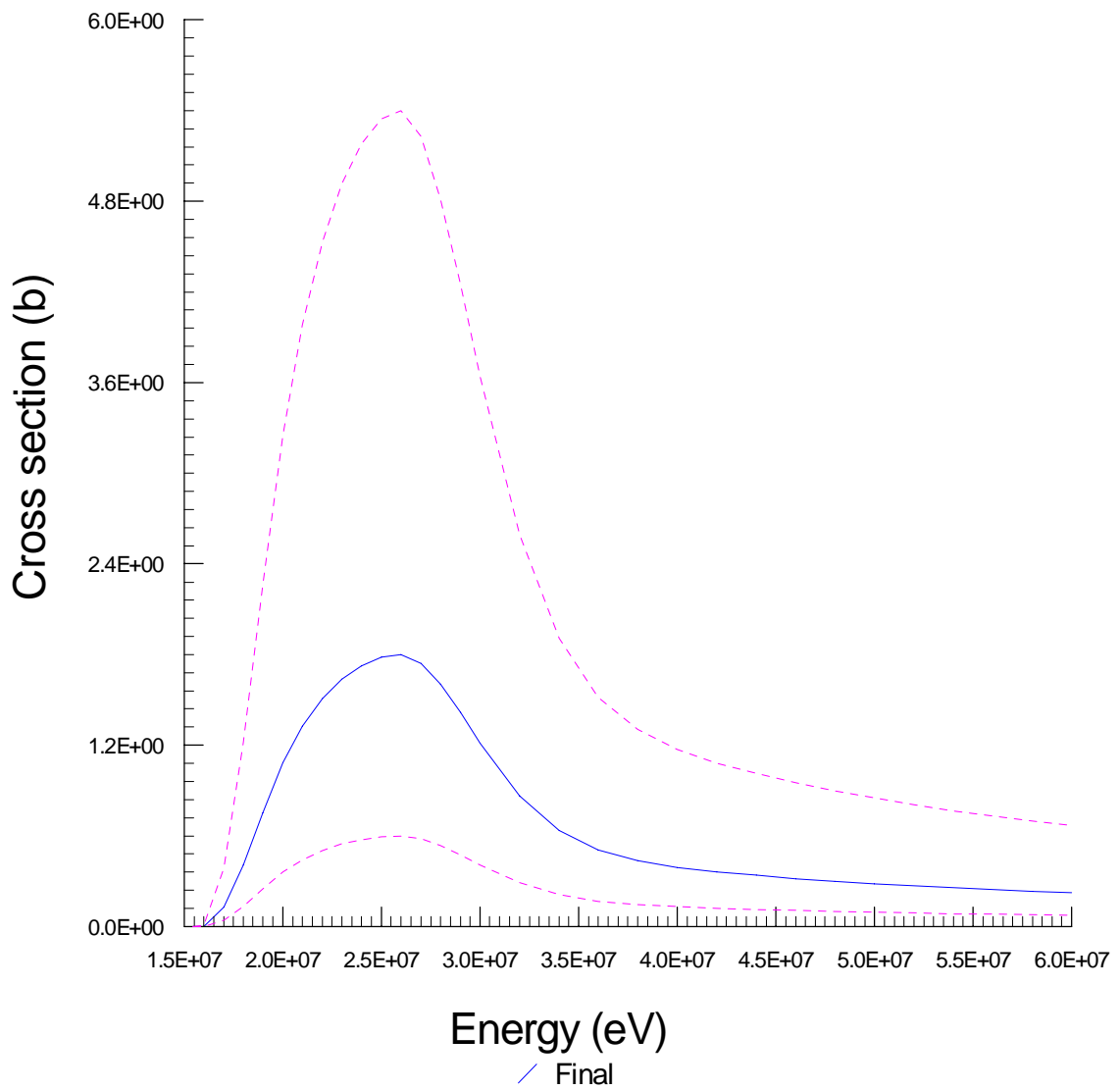




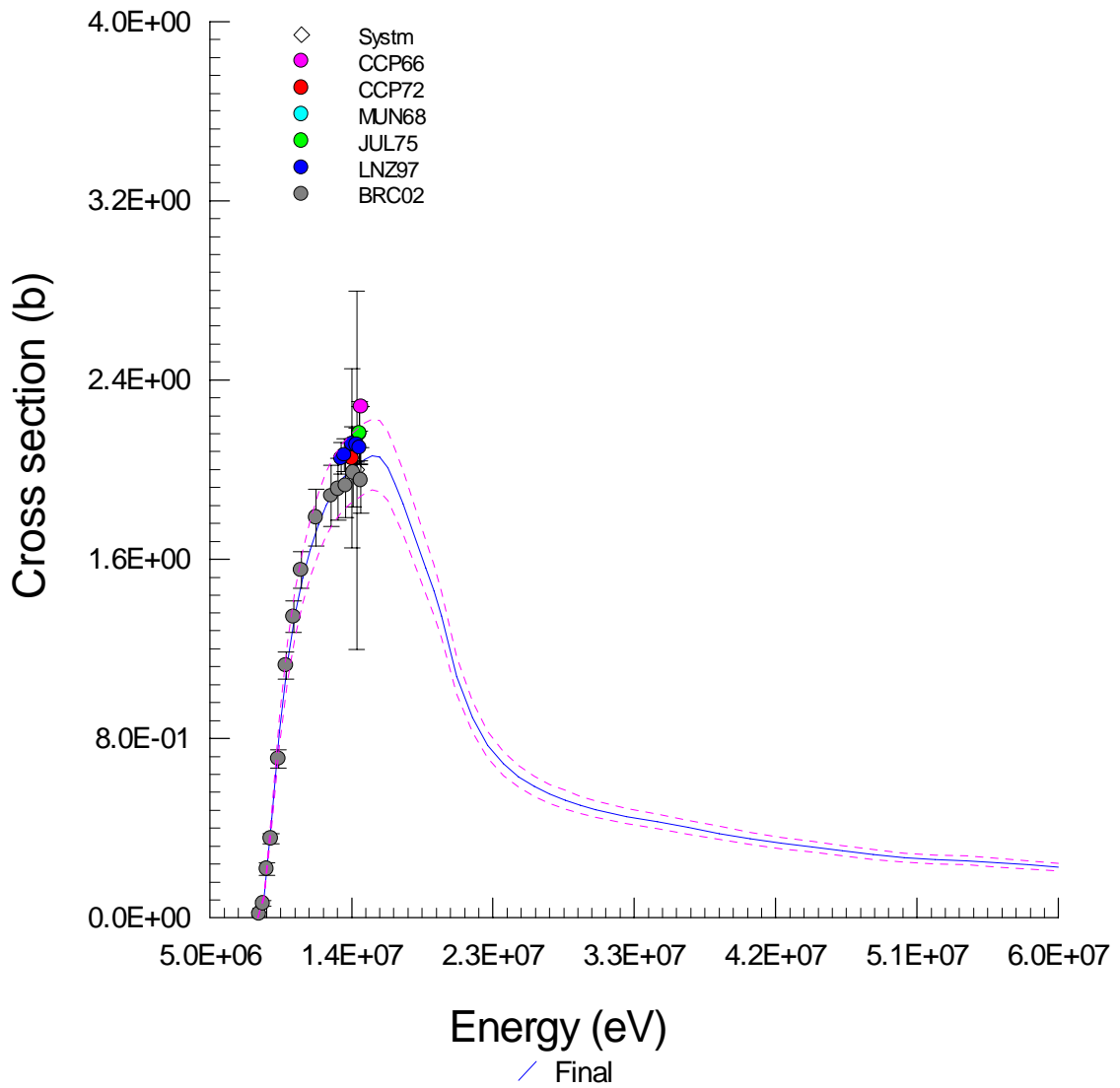
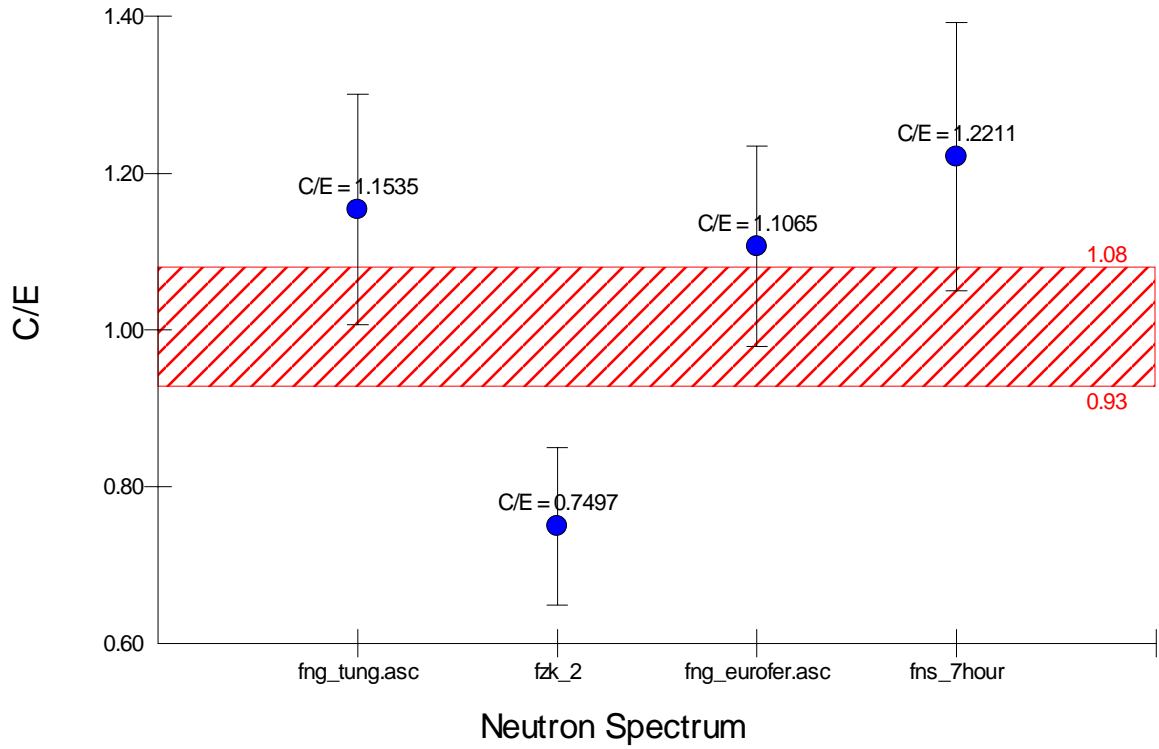




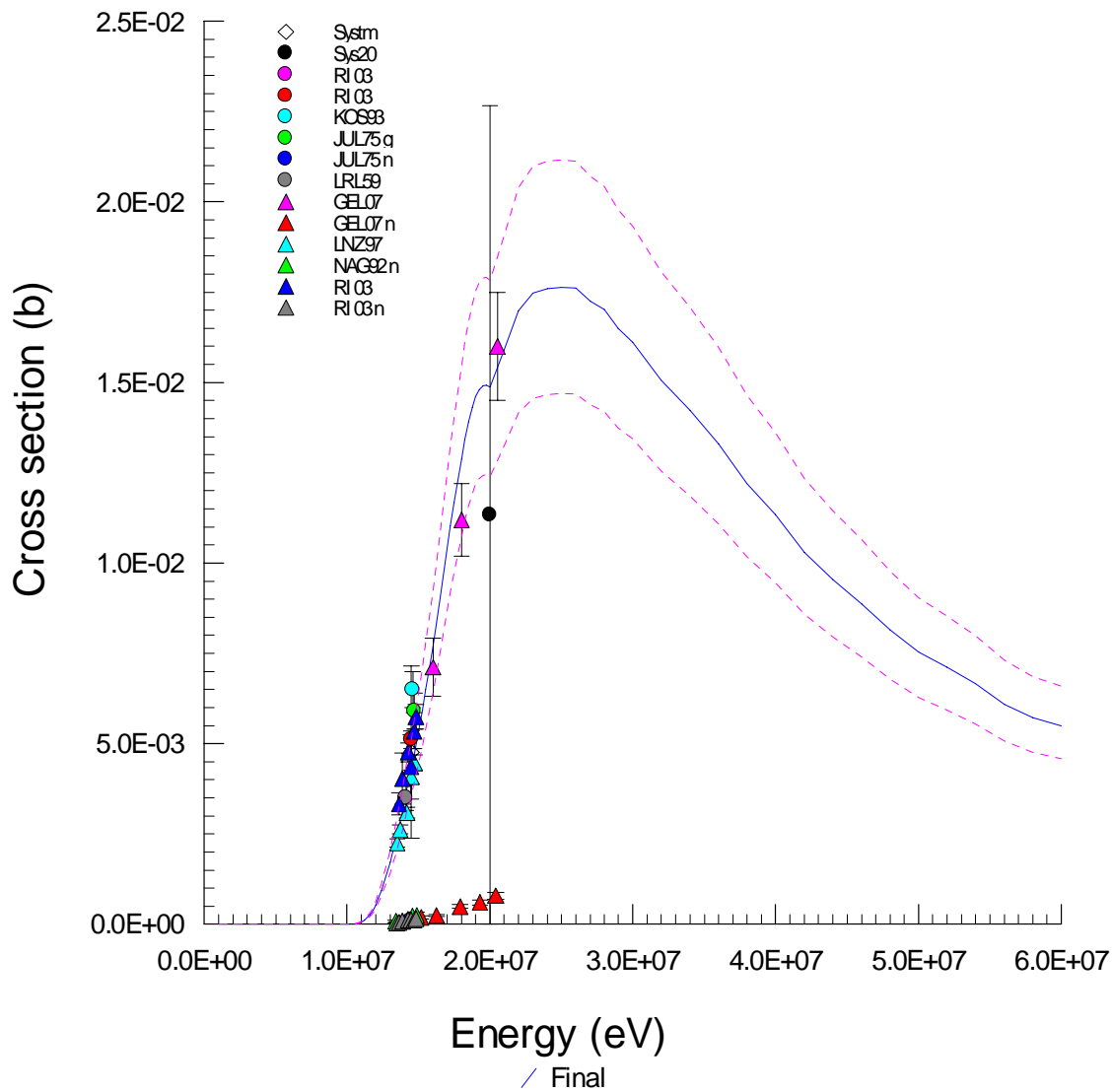
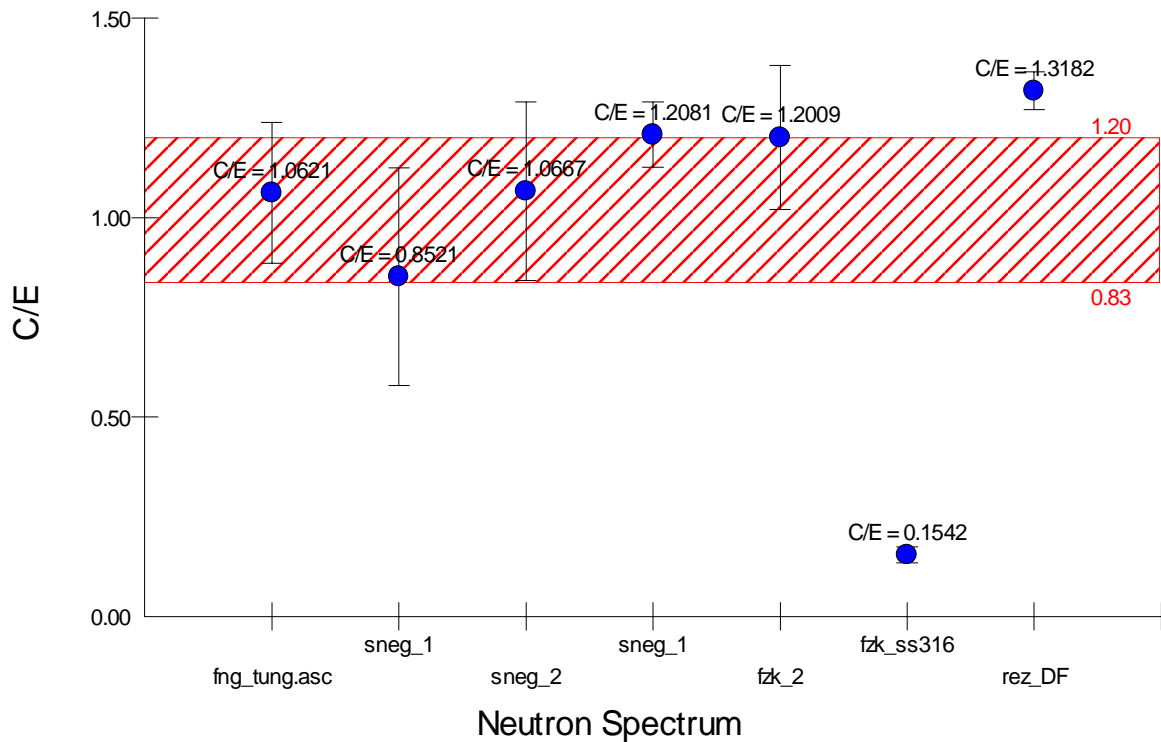
Neutron Spectrum

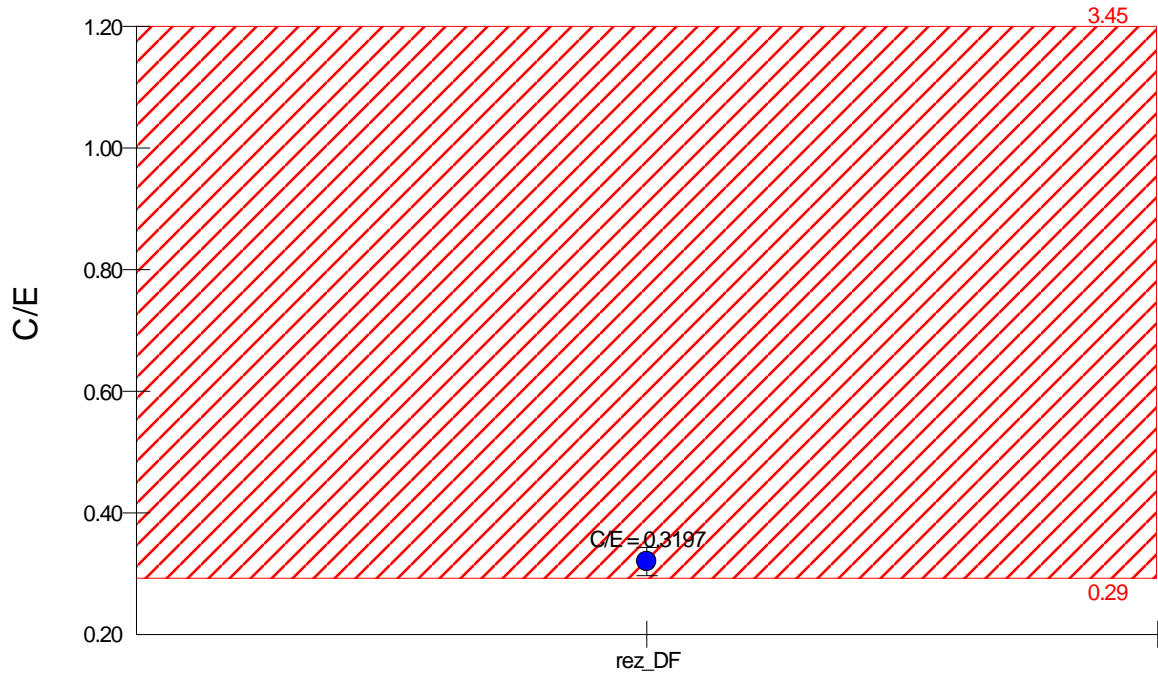
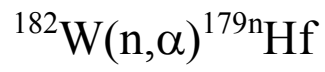


$^{182}\text{W}(n,2n)^{181}\text{W}$

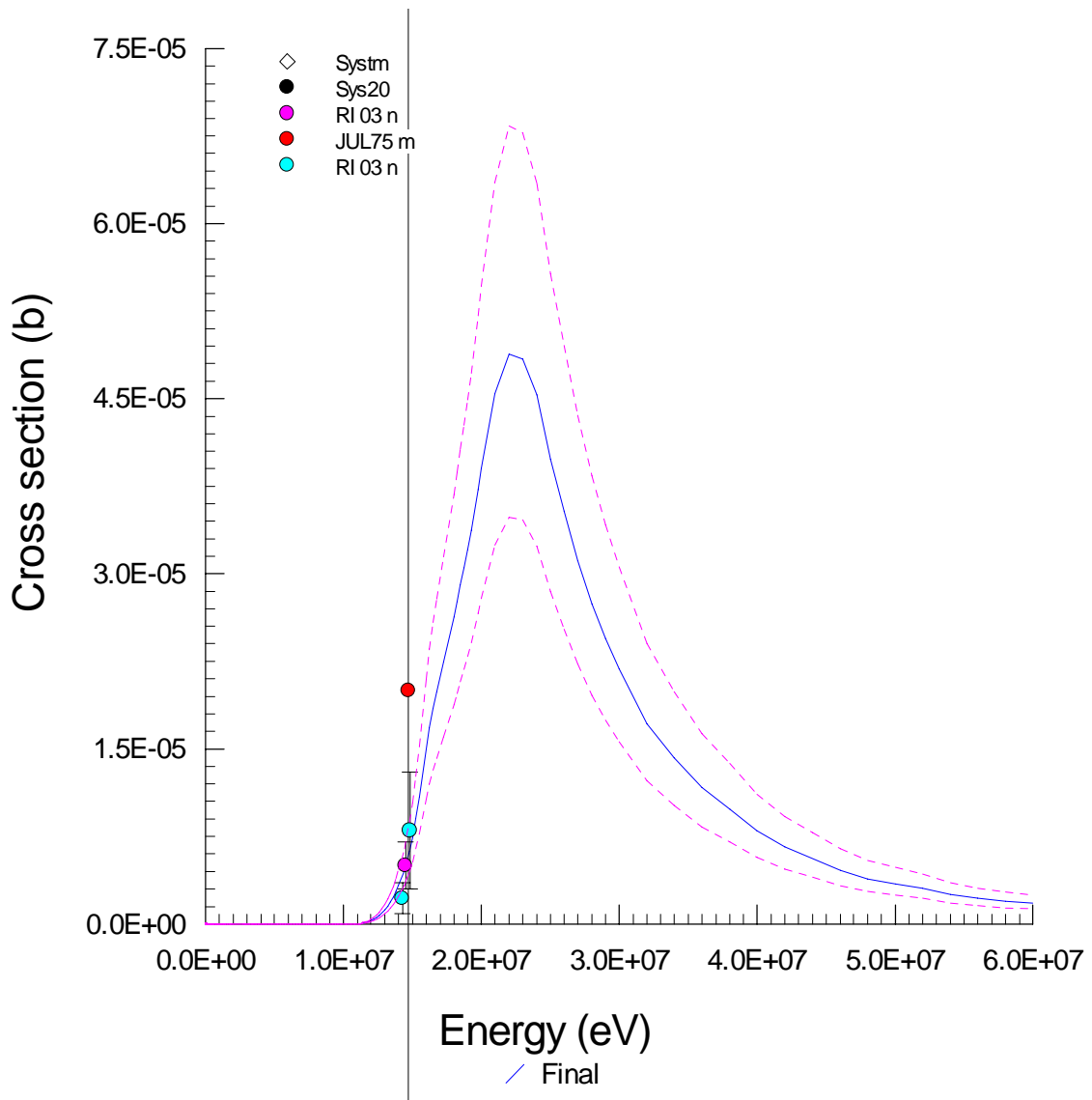


$^{182}\text{W}(n,p)^{182}\text{Ta} \blacktriangleright 555$

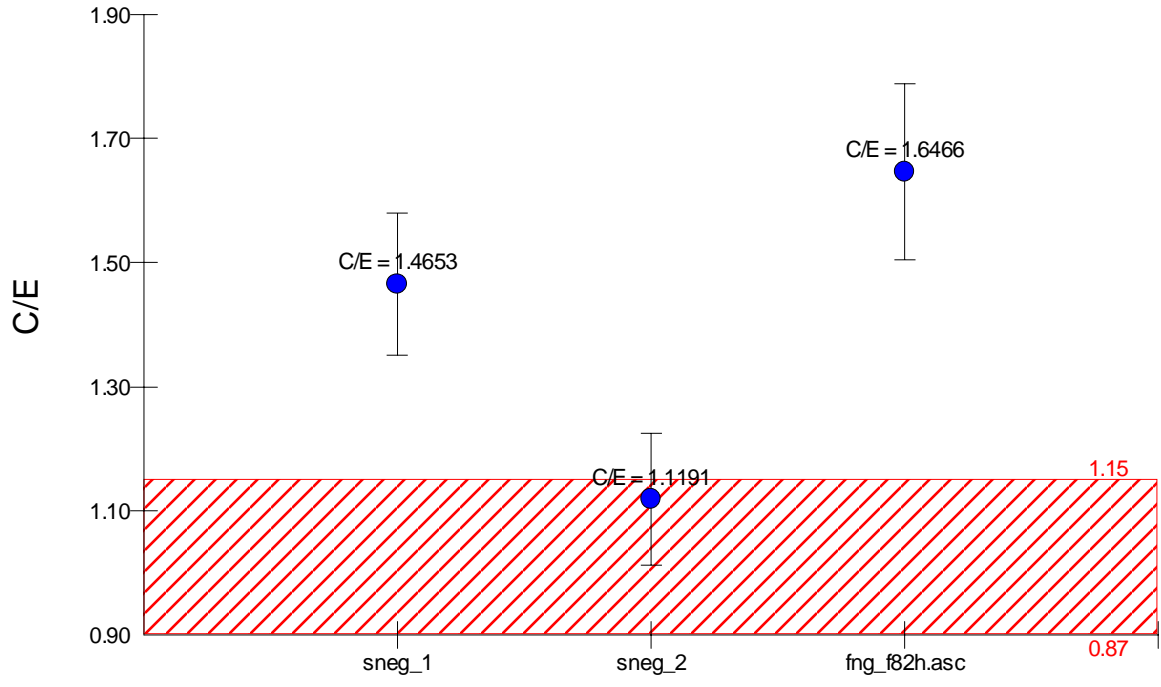




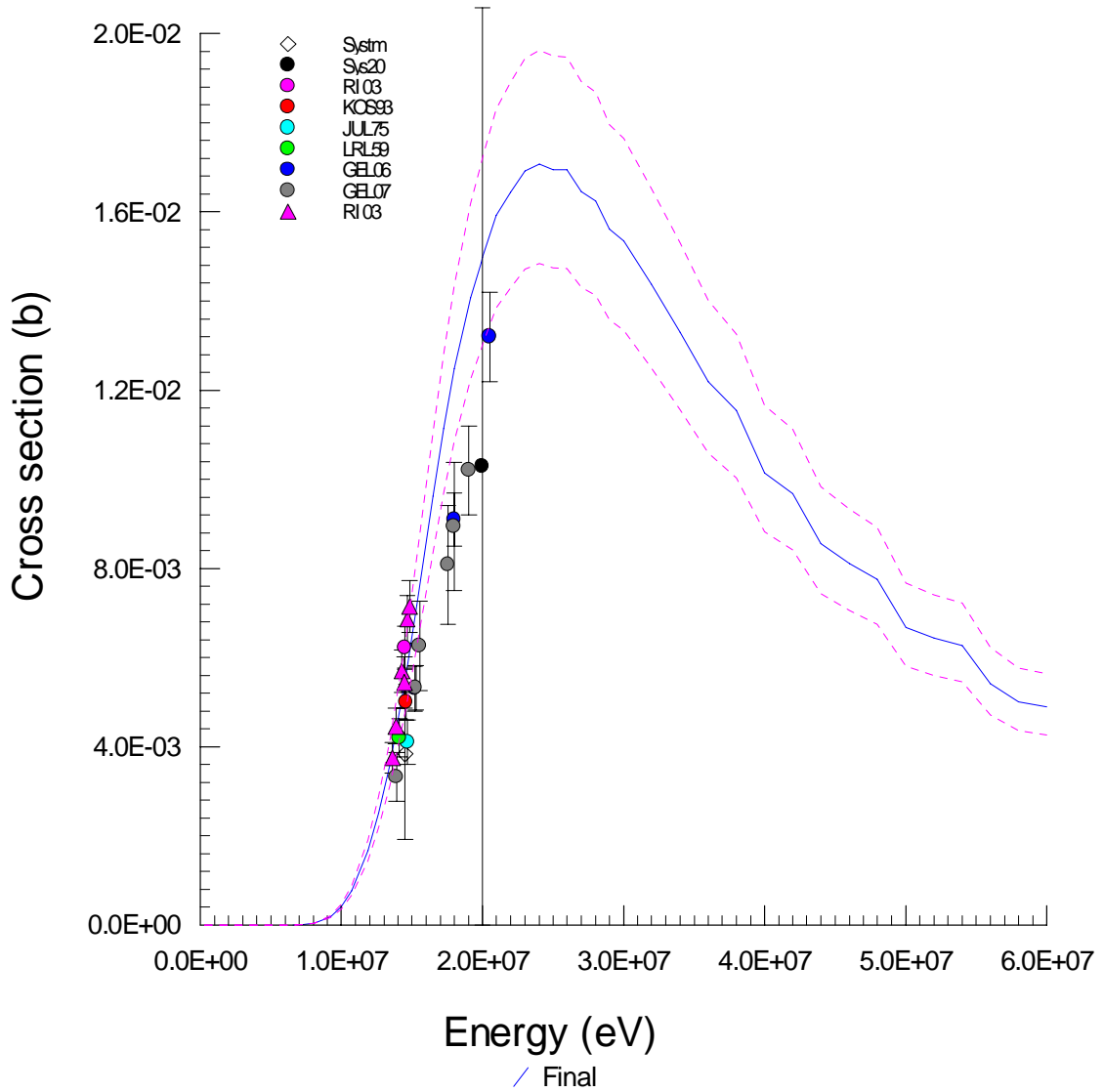
Neutron Spectrum

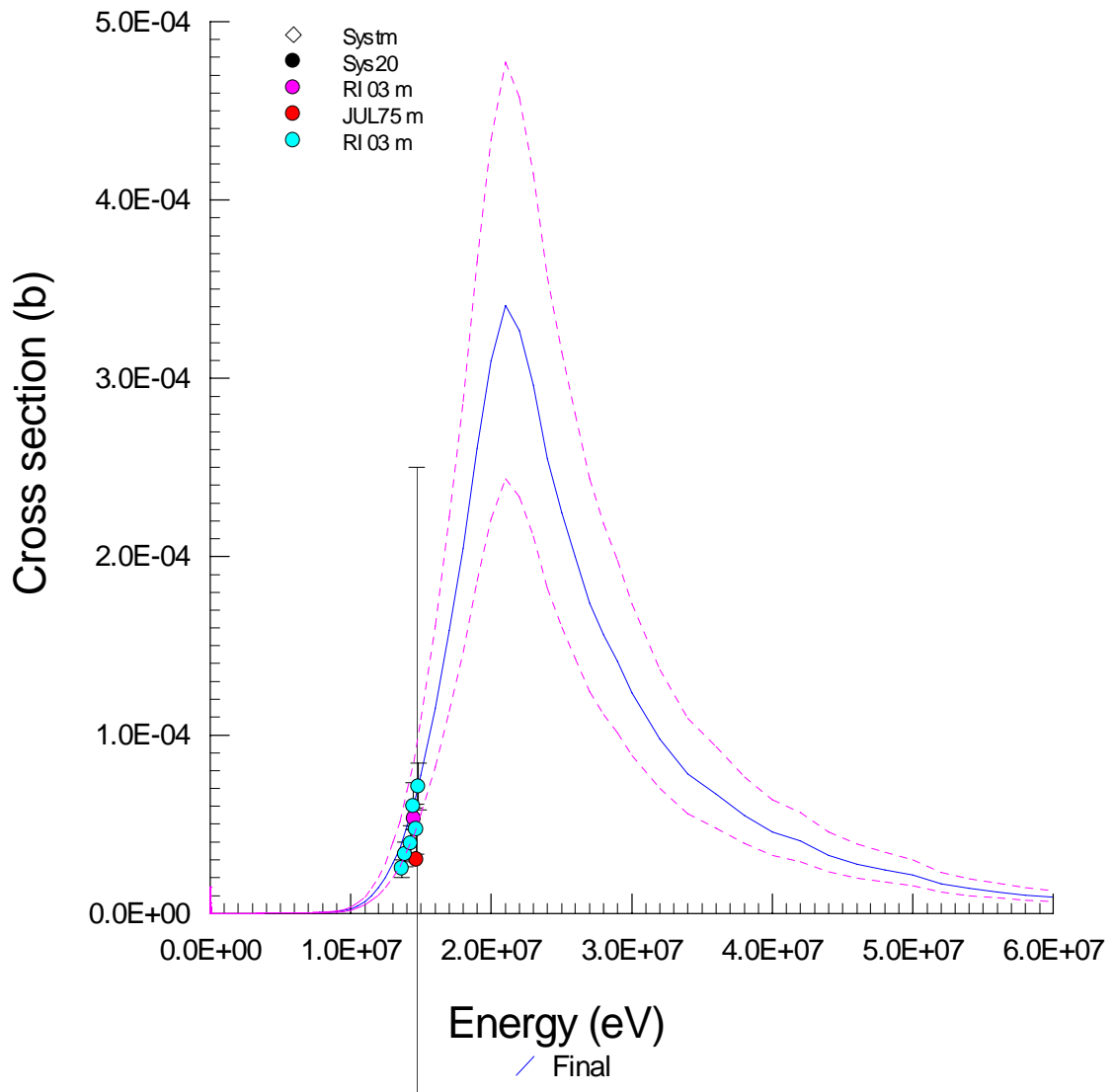
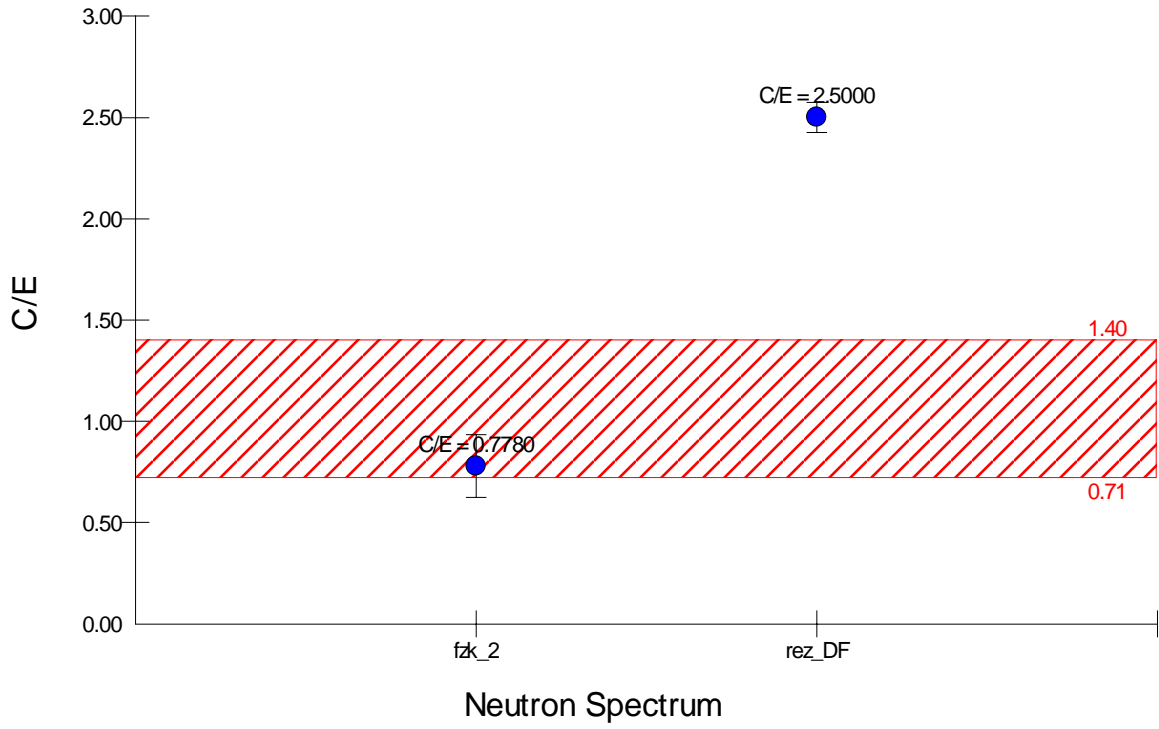
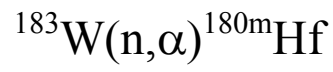


$^{183}\text{W}(n,p)^{183}\text{Ta}$

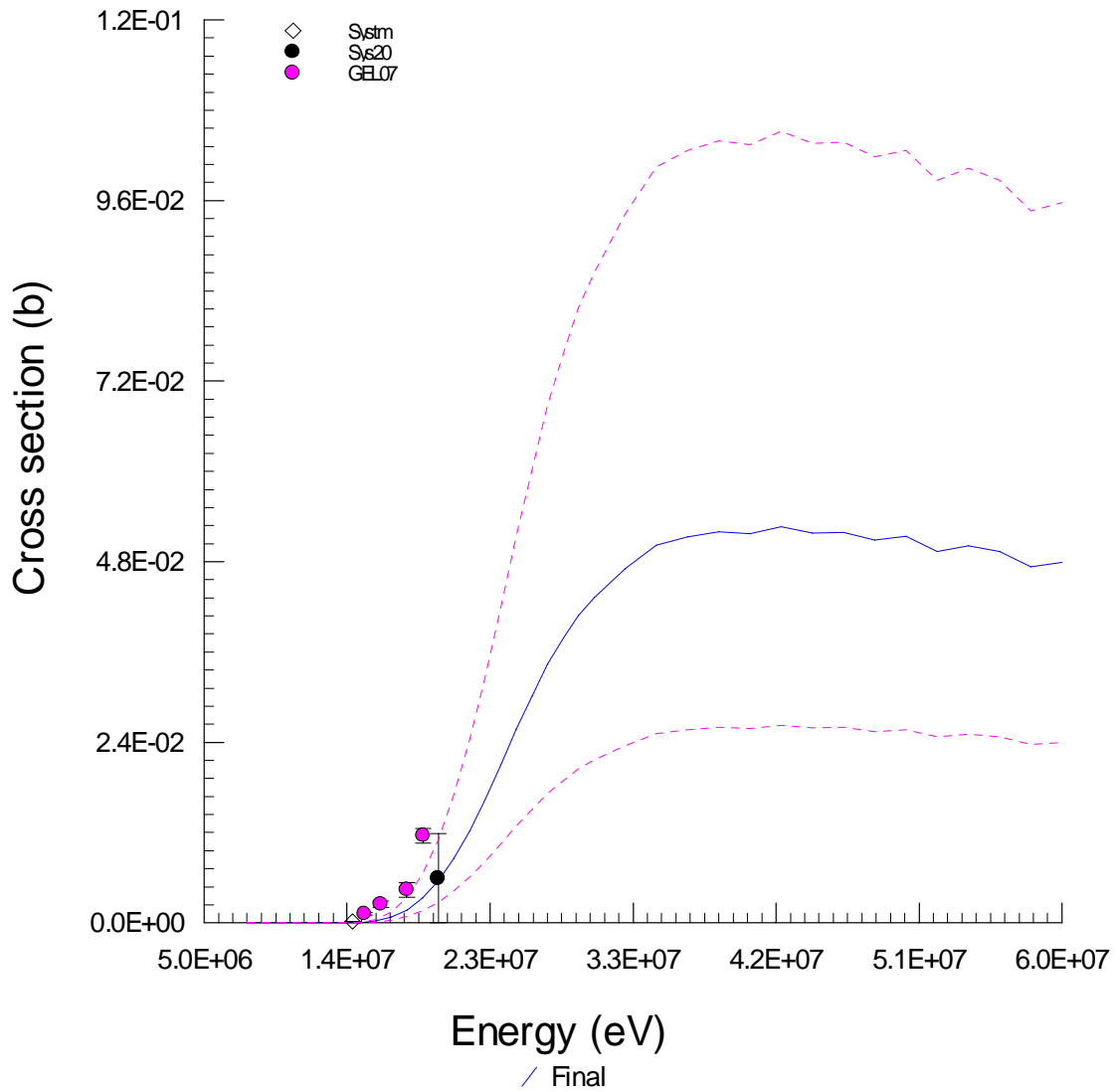
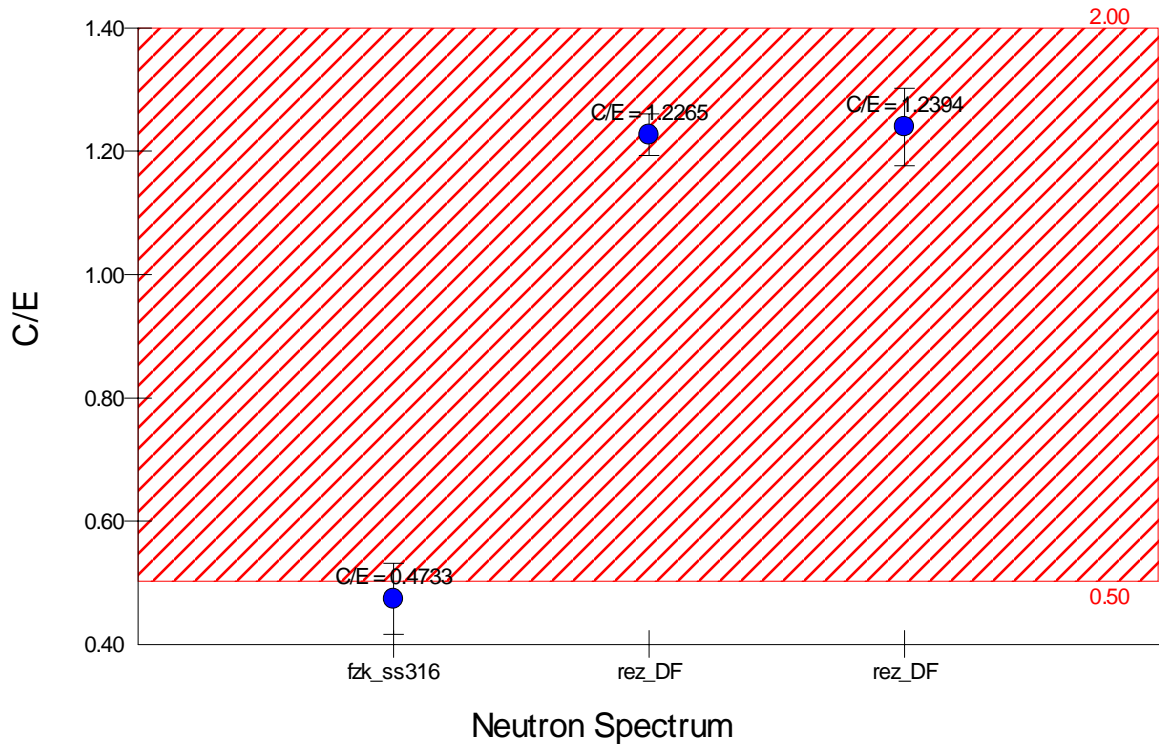


Neutron Spectrum

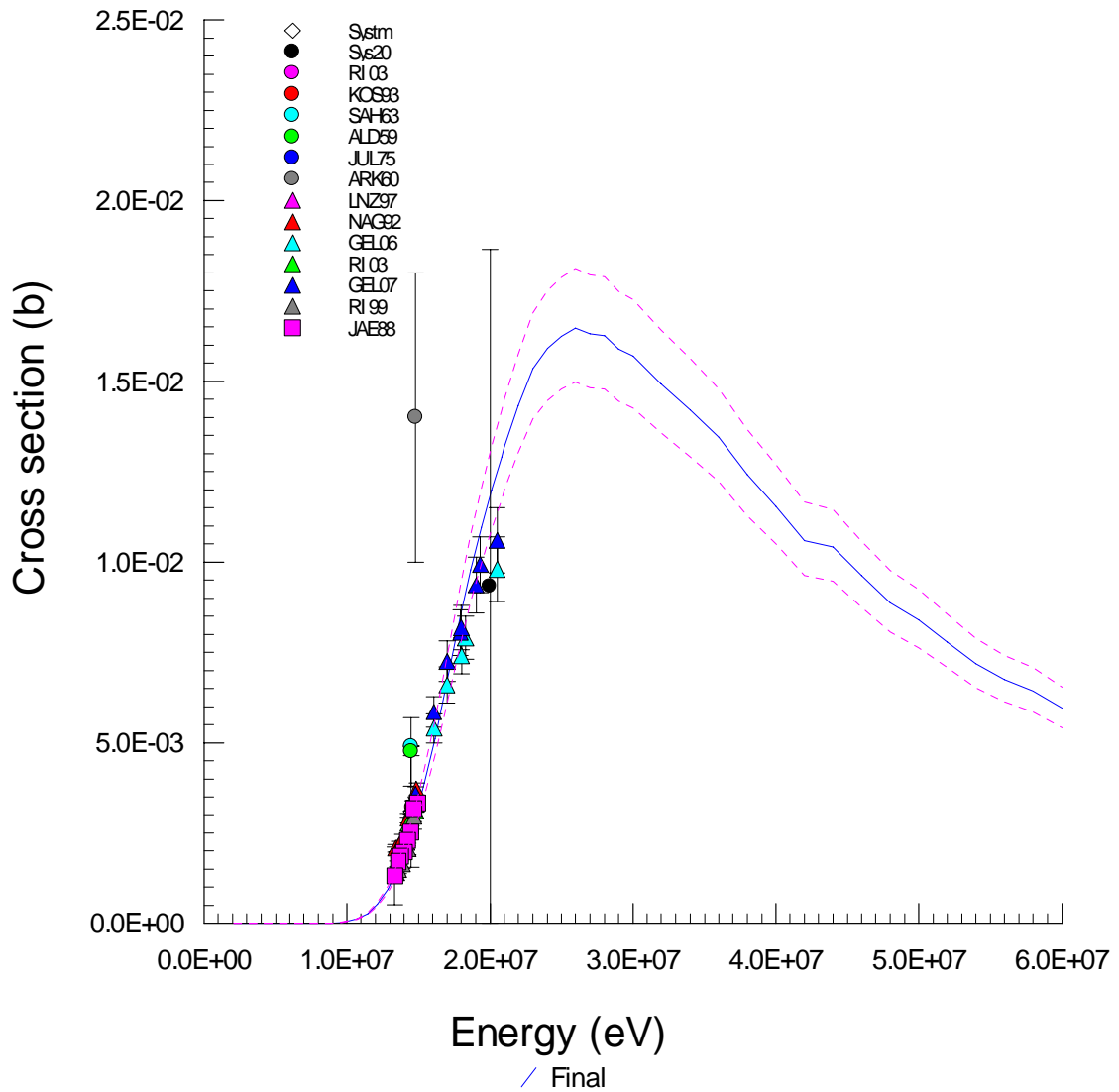
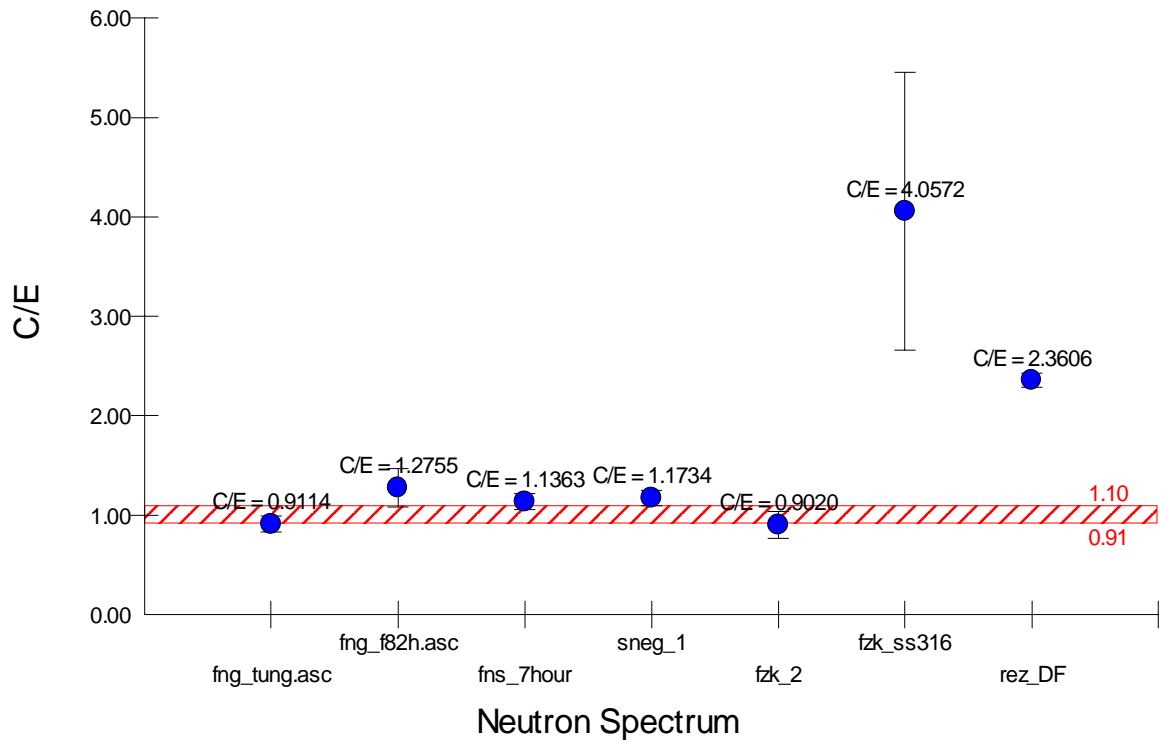




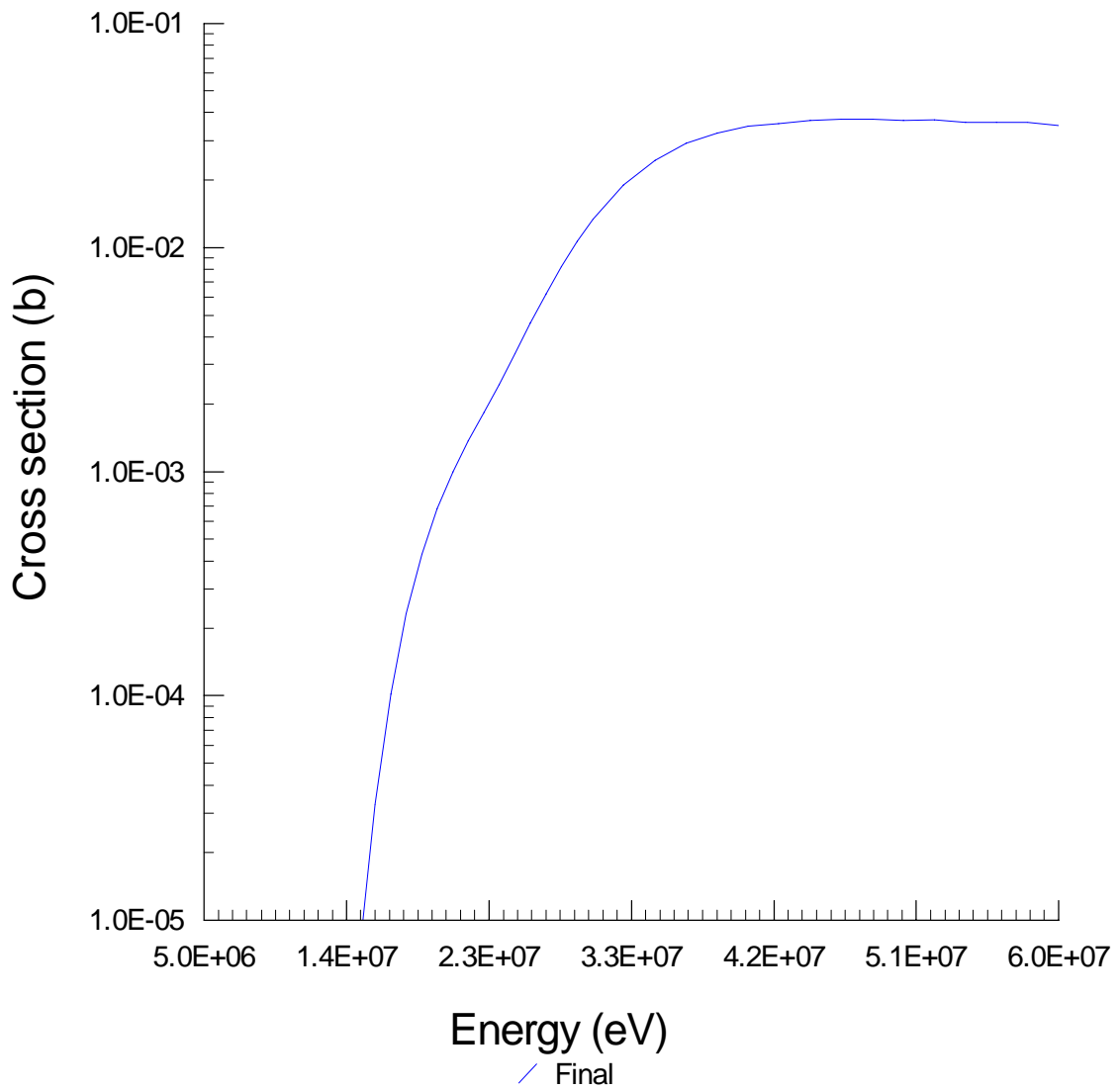
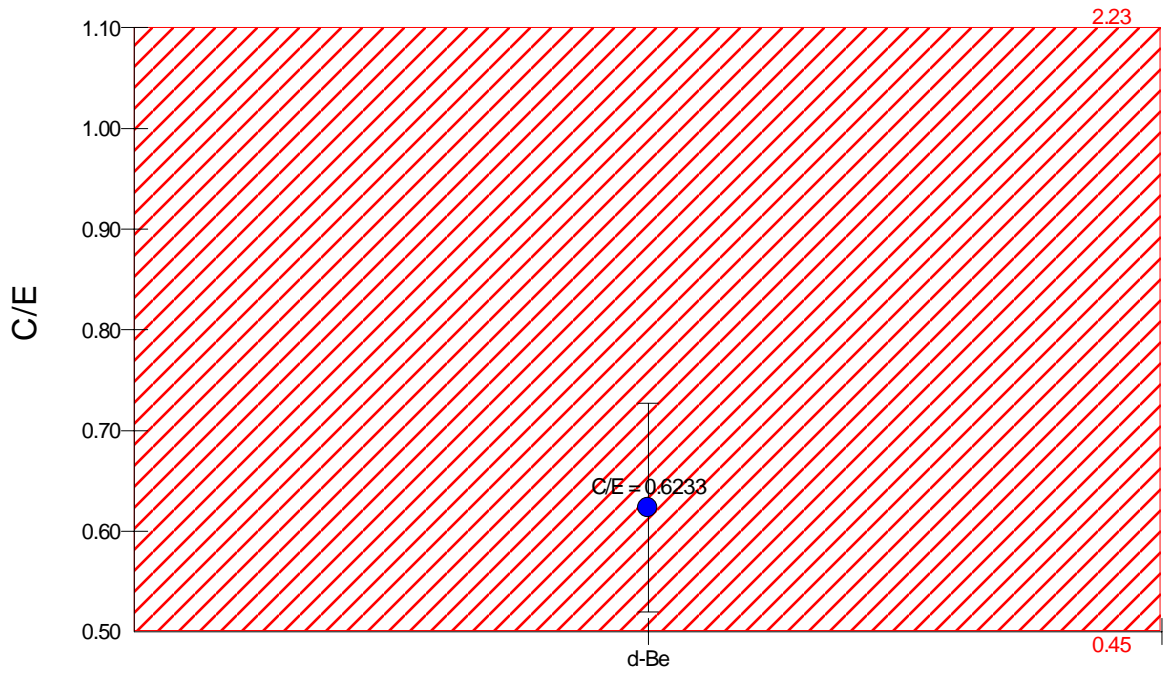
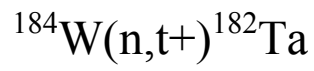
# $^{184}\text{W}(n,n'p)^{183}\text{Ta}$

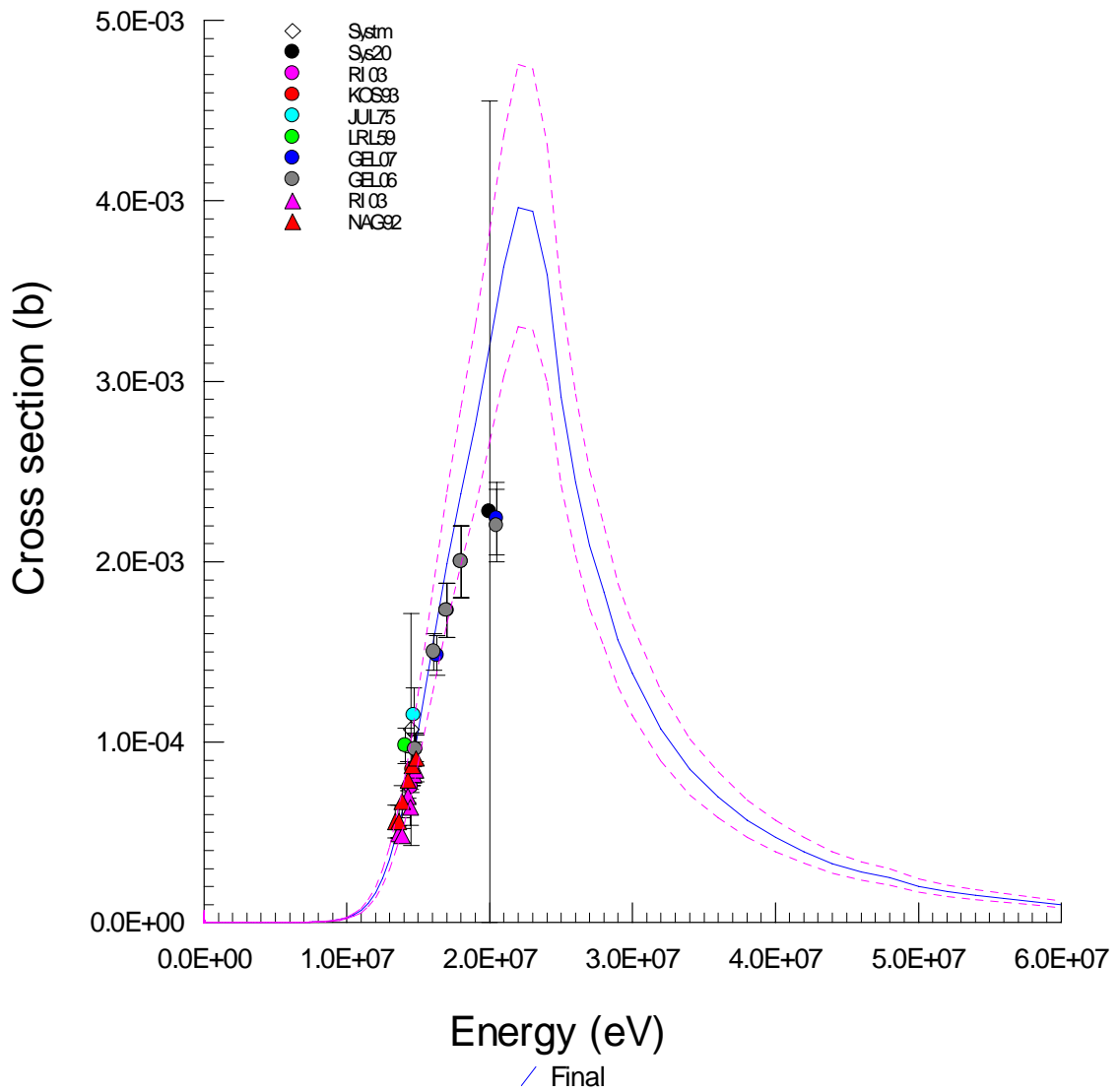
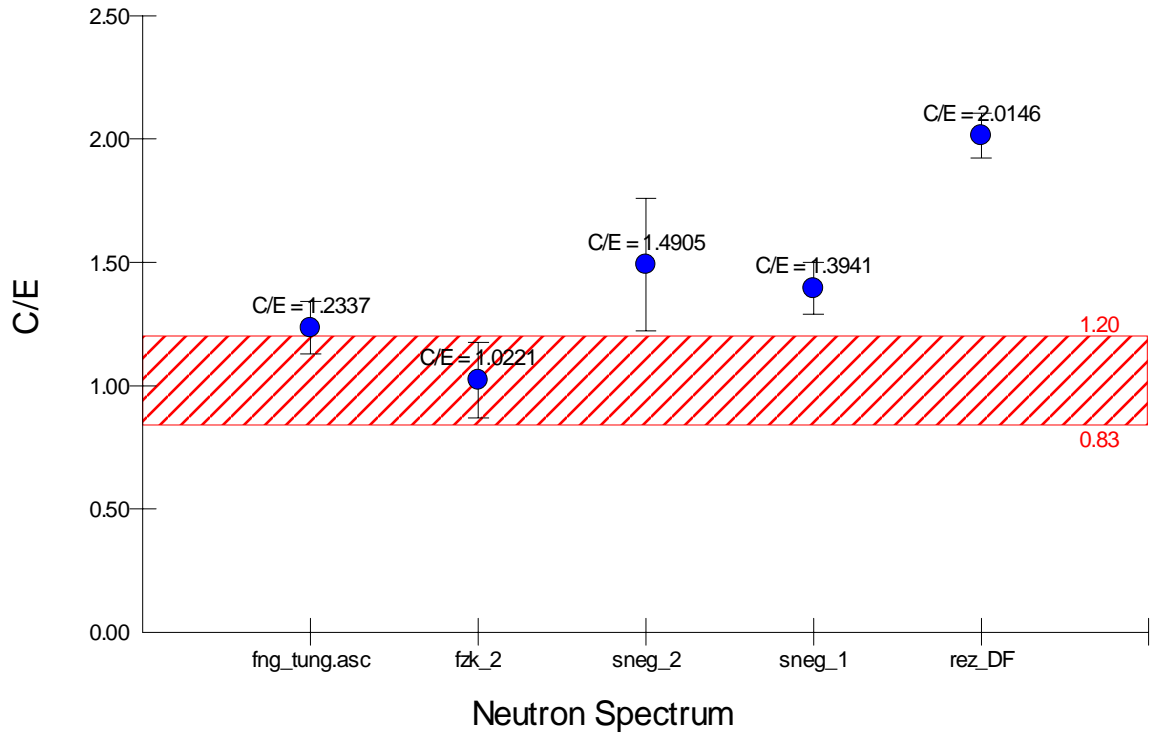
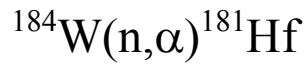


$^{184}\text{W}(n,p)^{184}\text{Ta} \blacktriangleright 555$

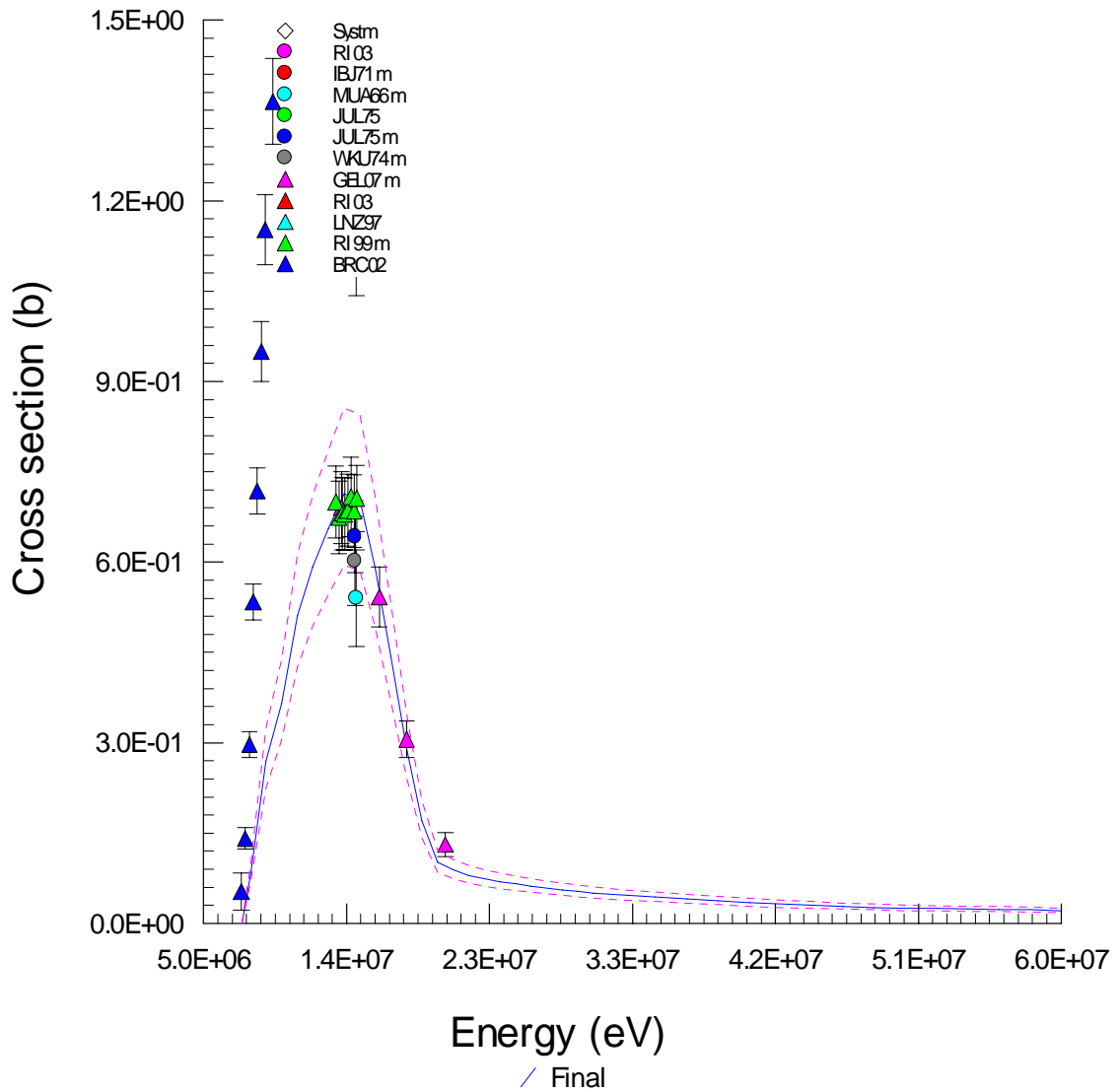
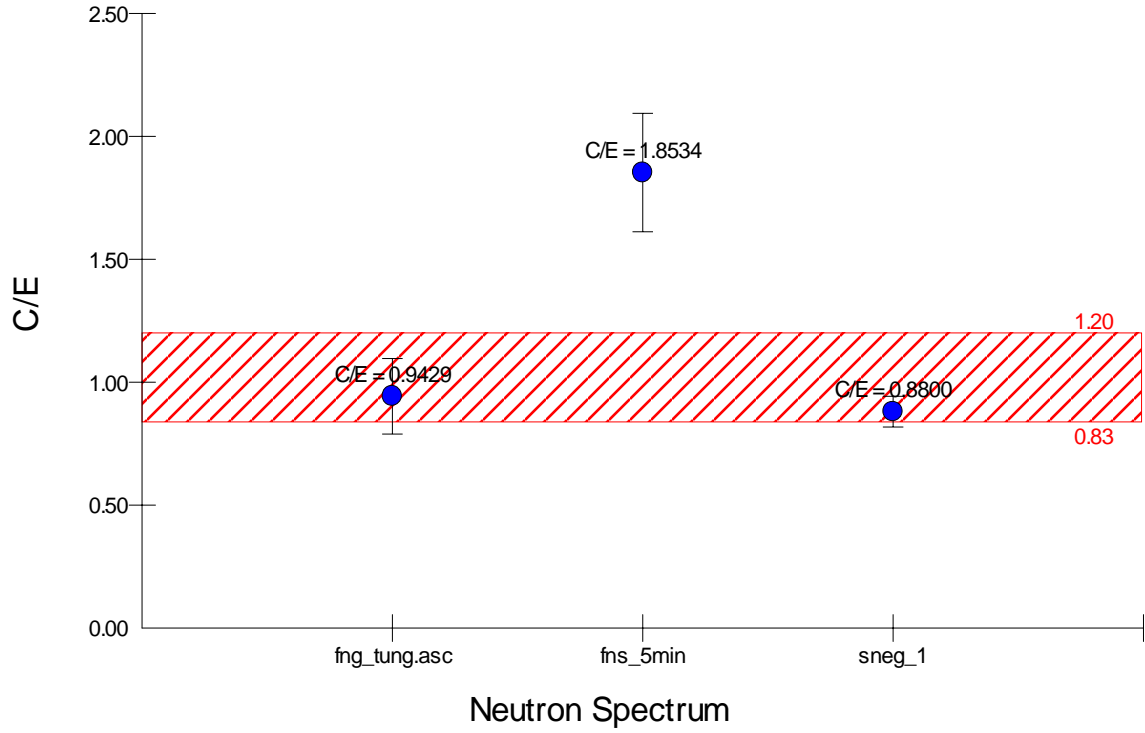




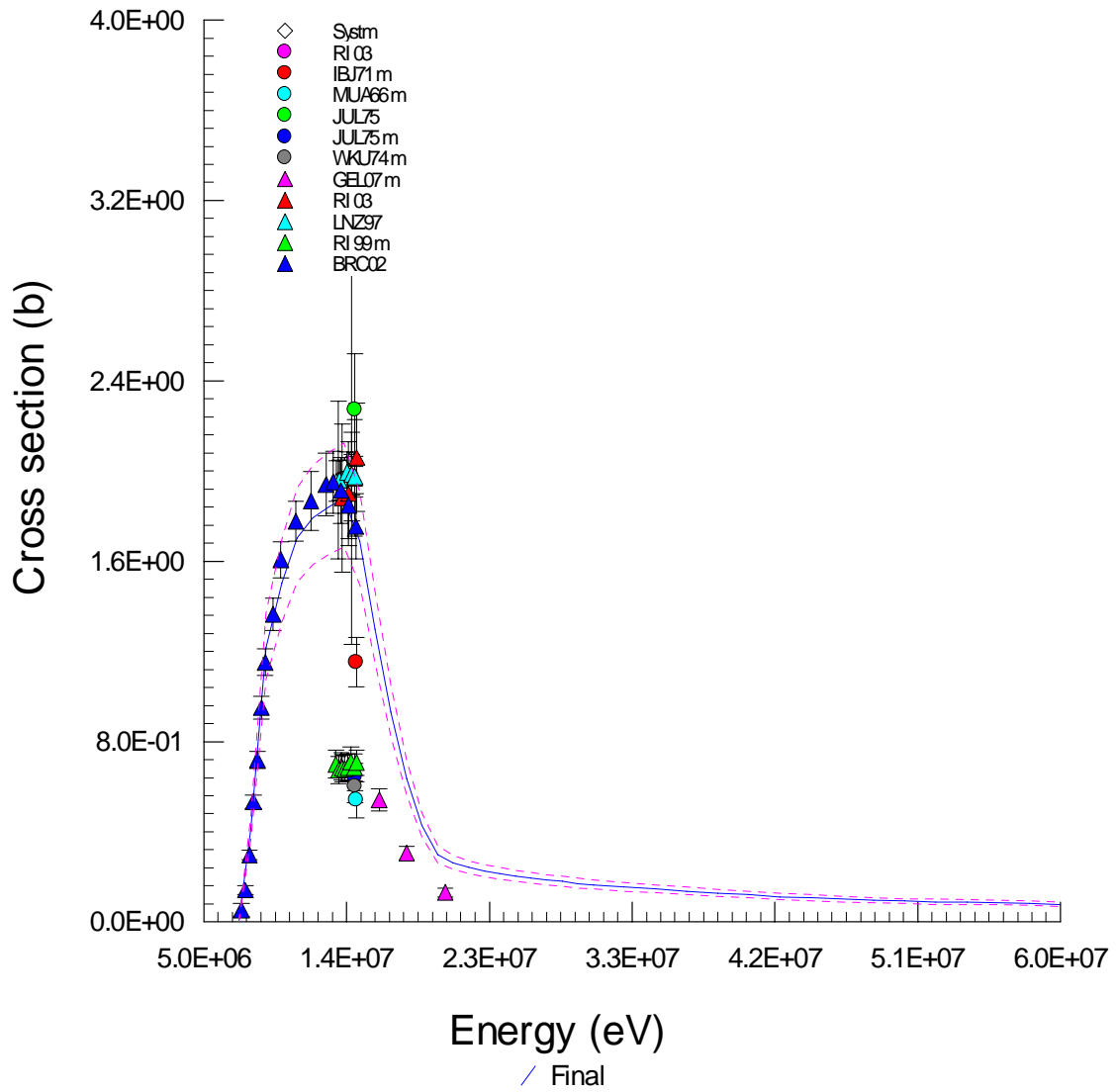
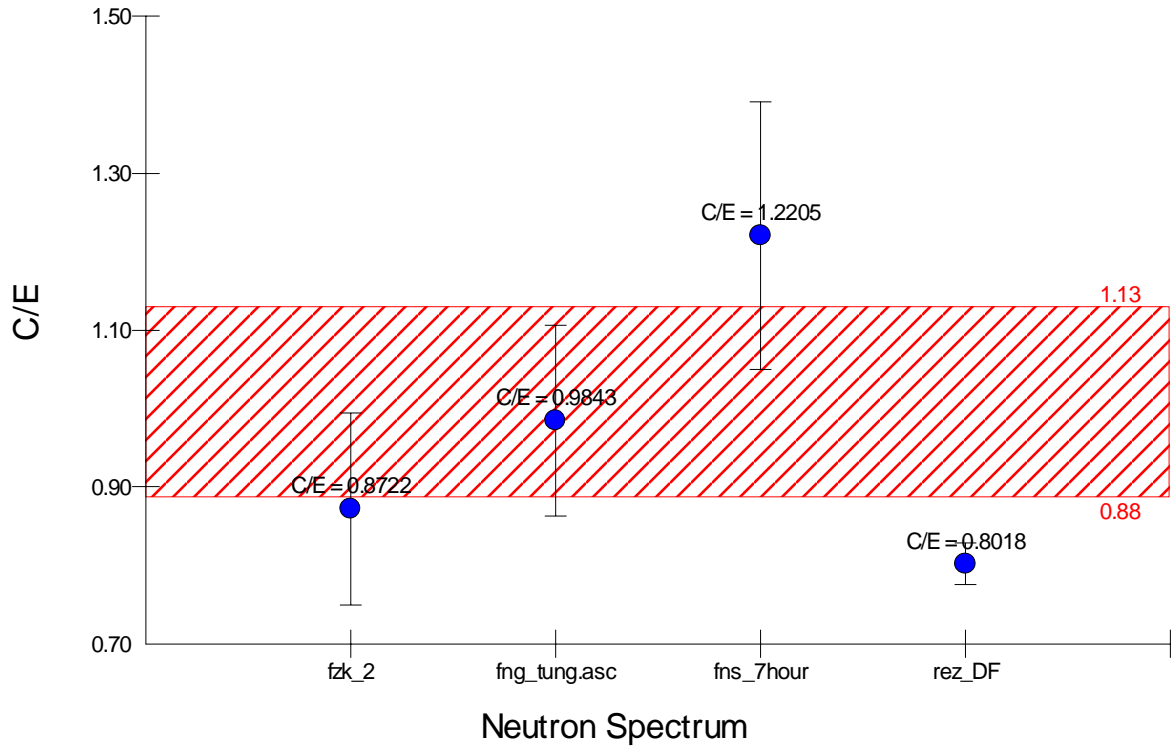




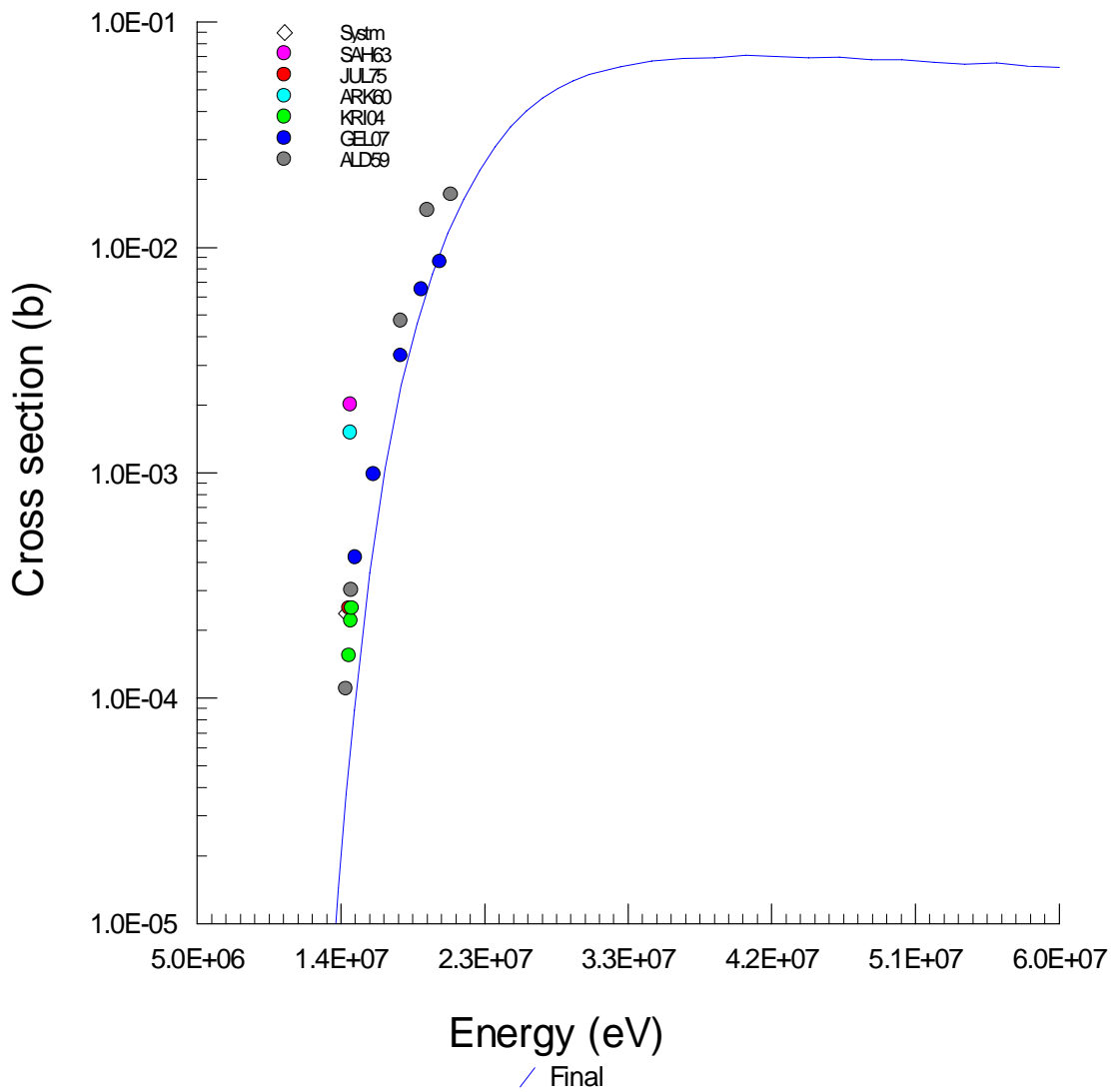
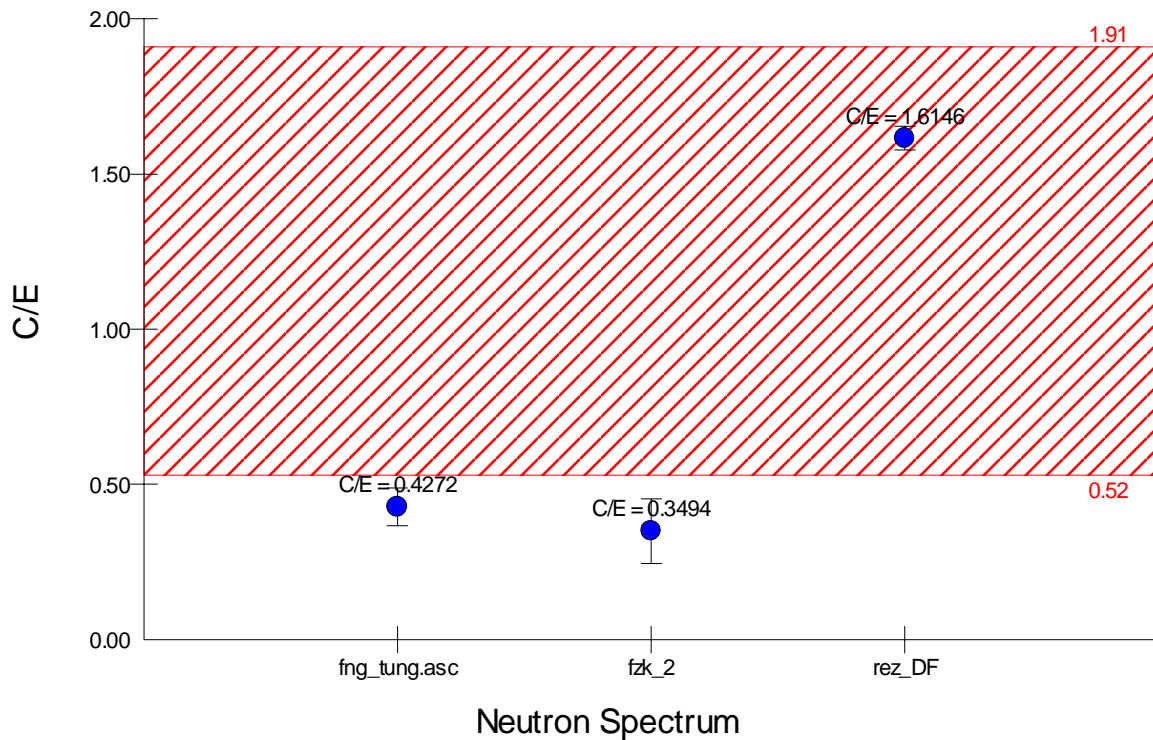
$^{186}\text{W}(n,2n)^{185\text{m}}\text{W}$

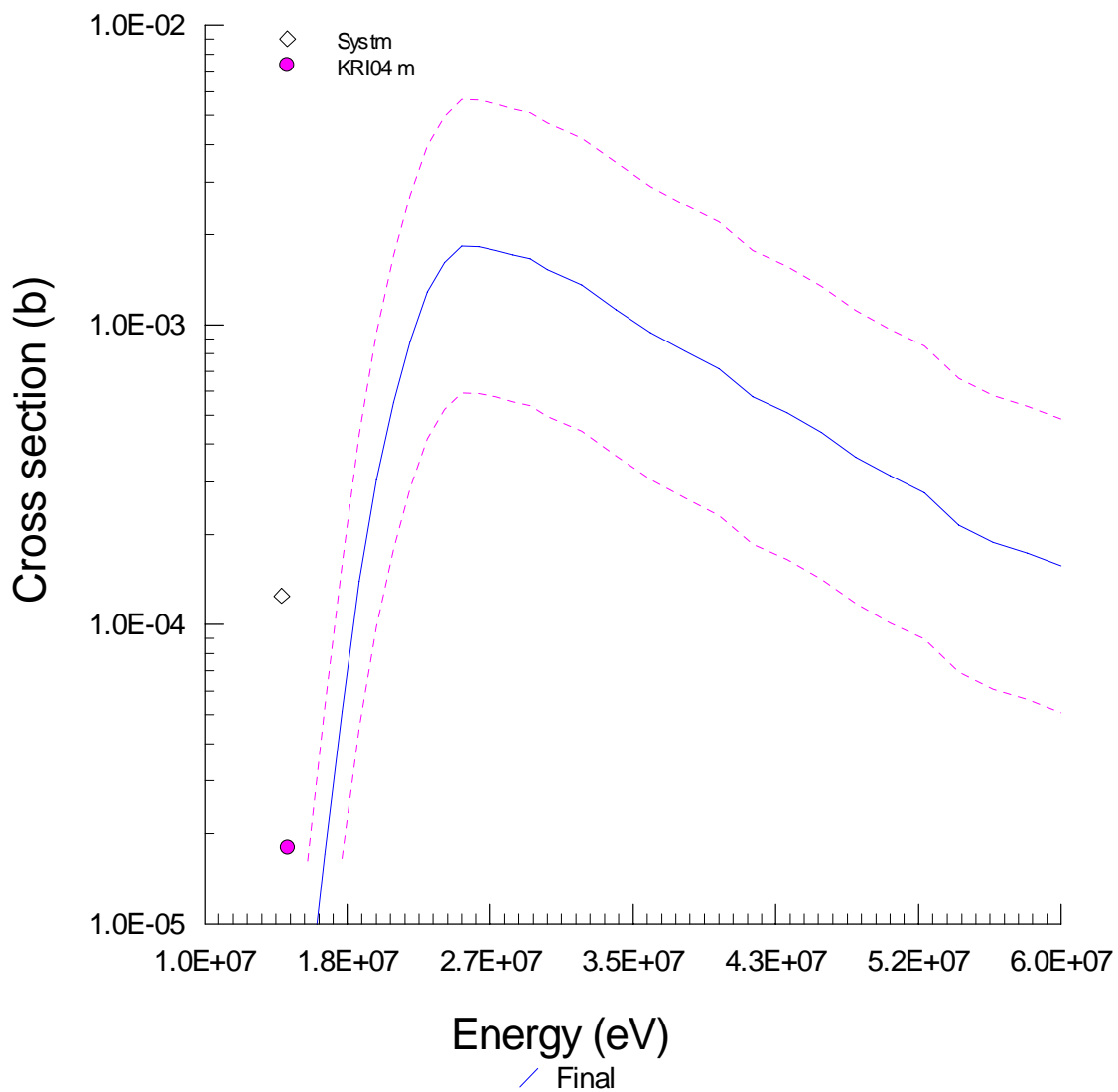
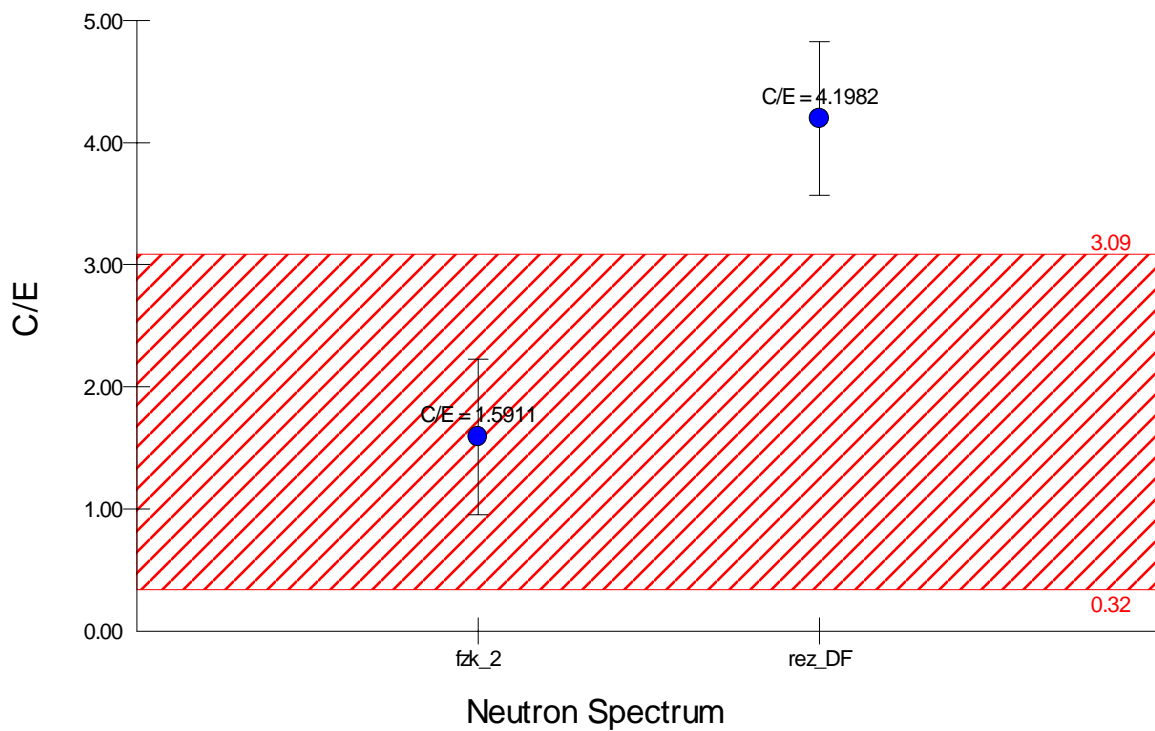
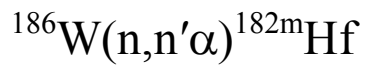


$^{186}\text{W}(n,2n)^{185}\text{W}$

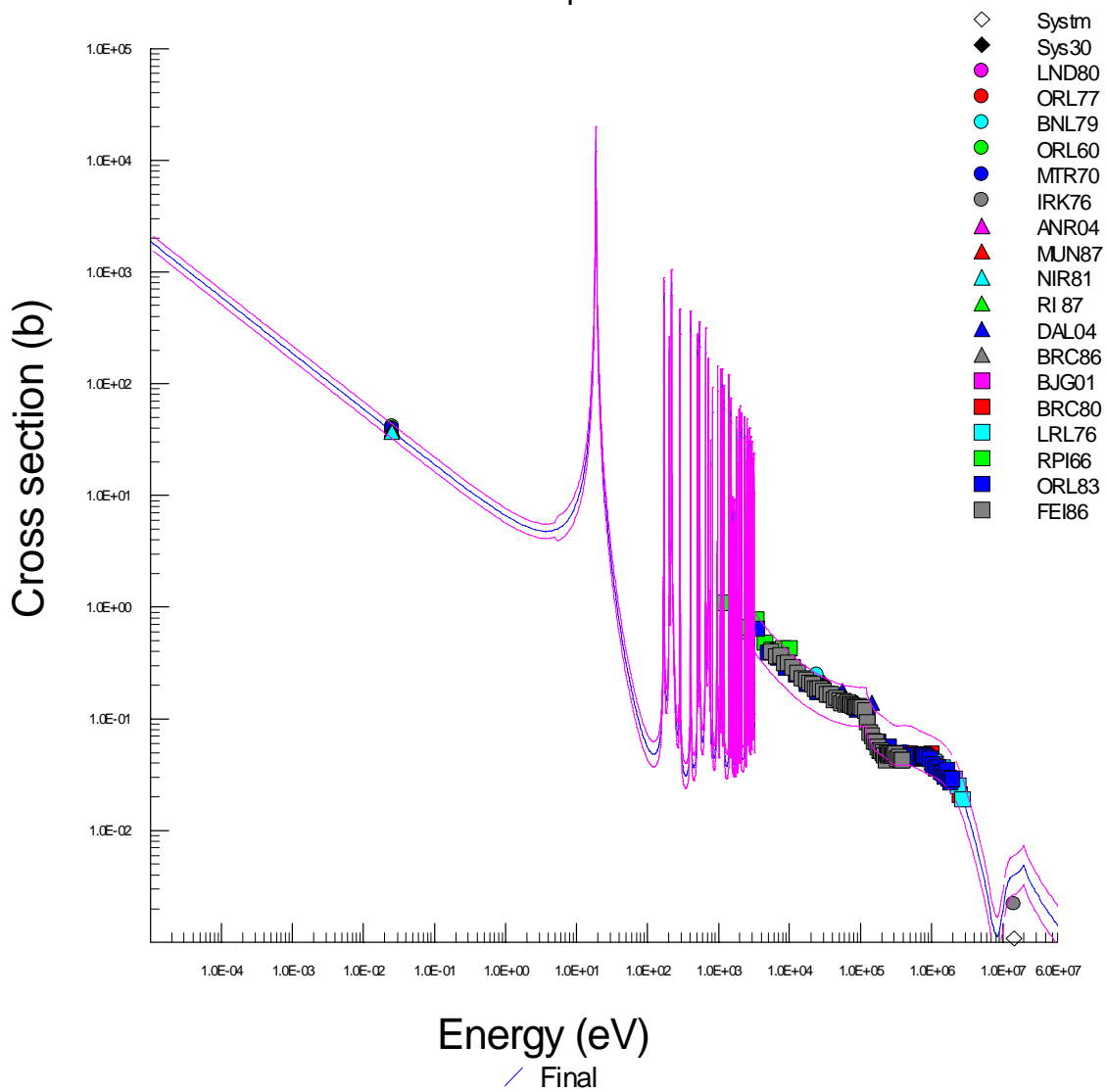
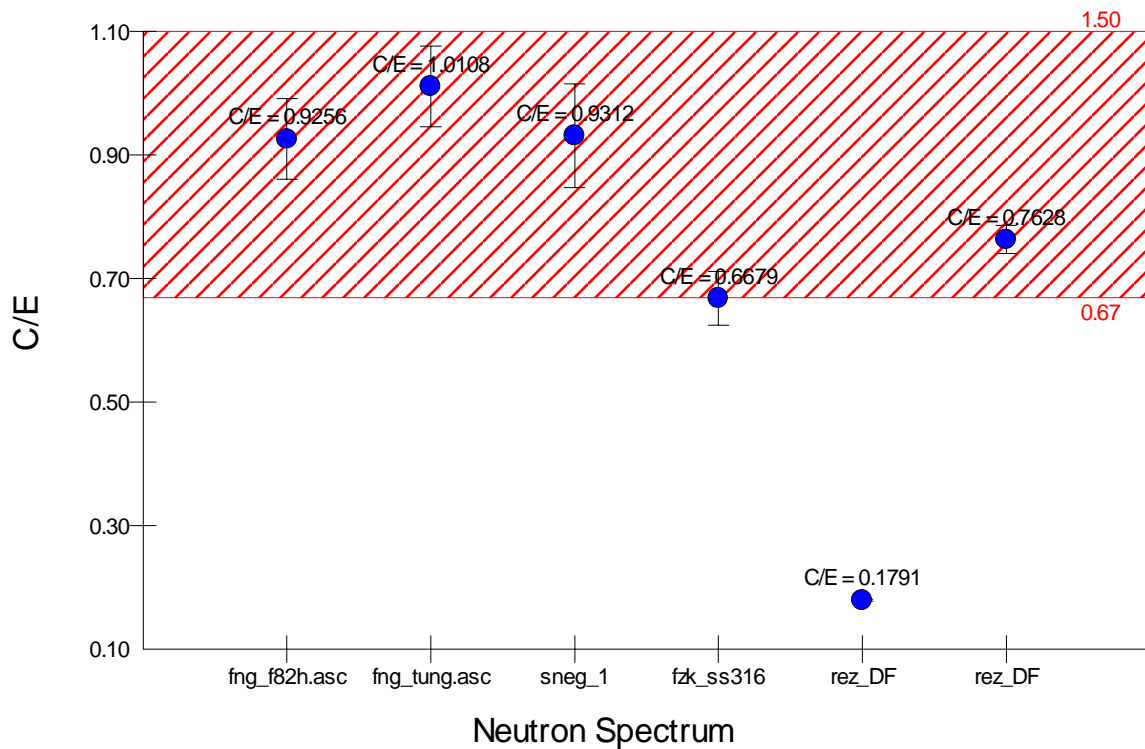


$^{186}\text{W}(n,n'p+d)^{185}\text{Ta}$

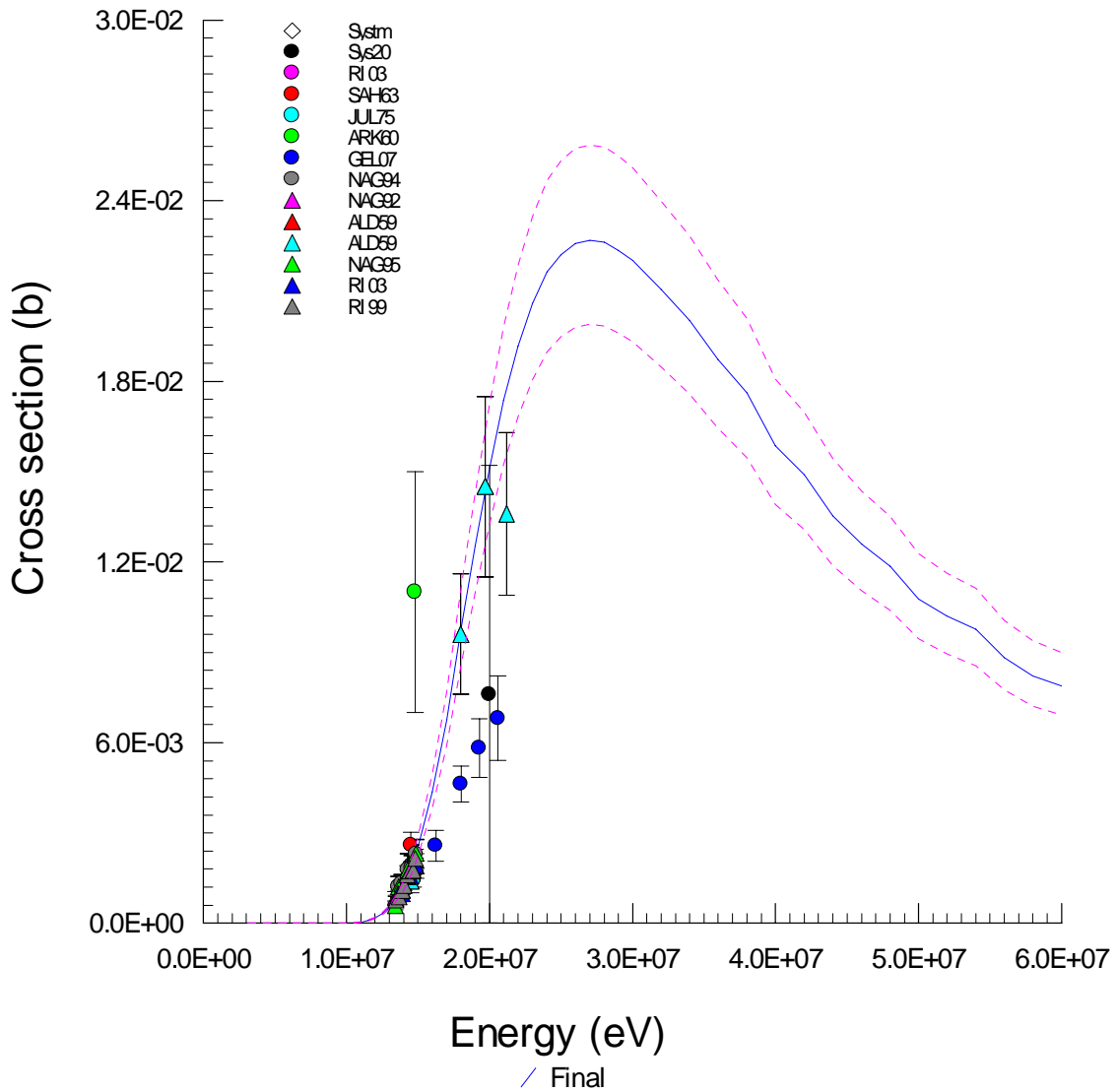
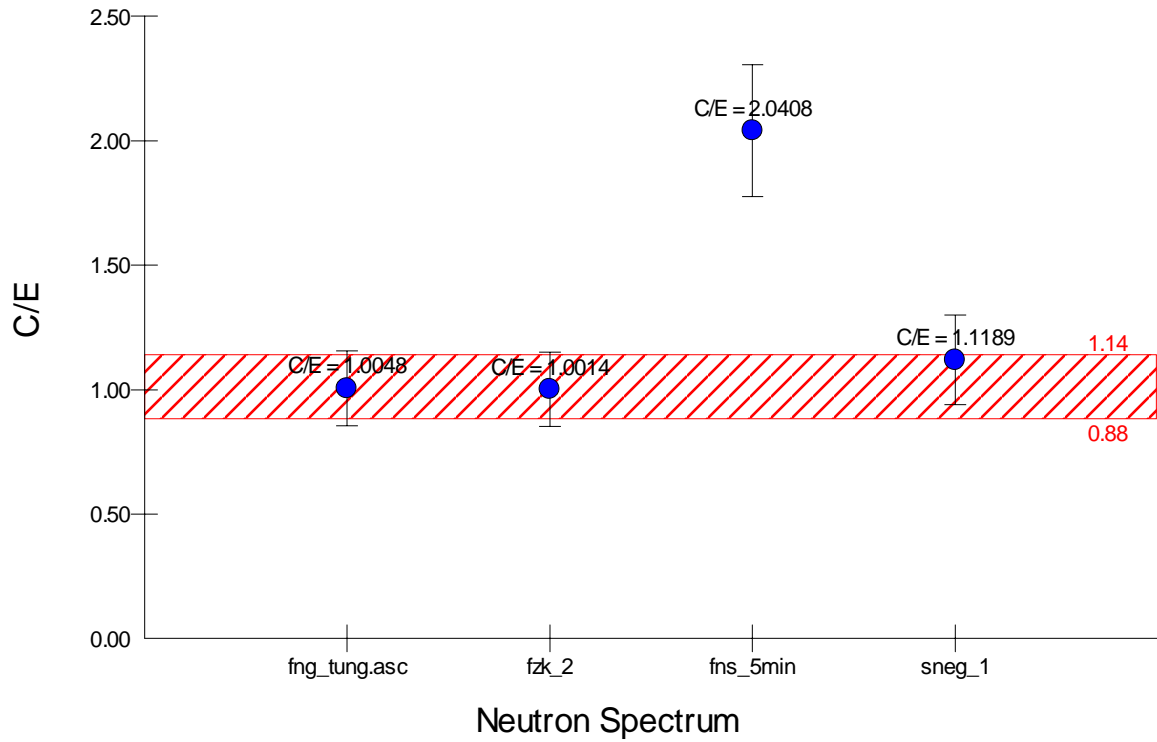




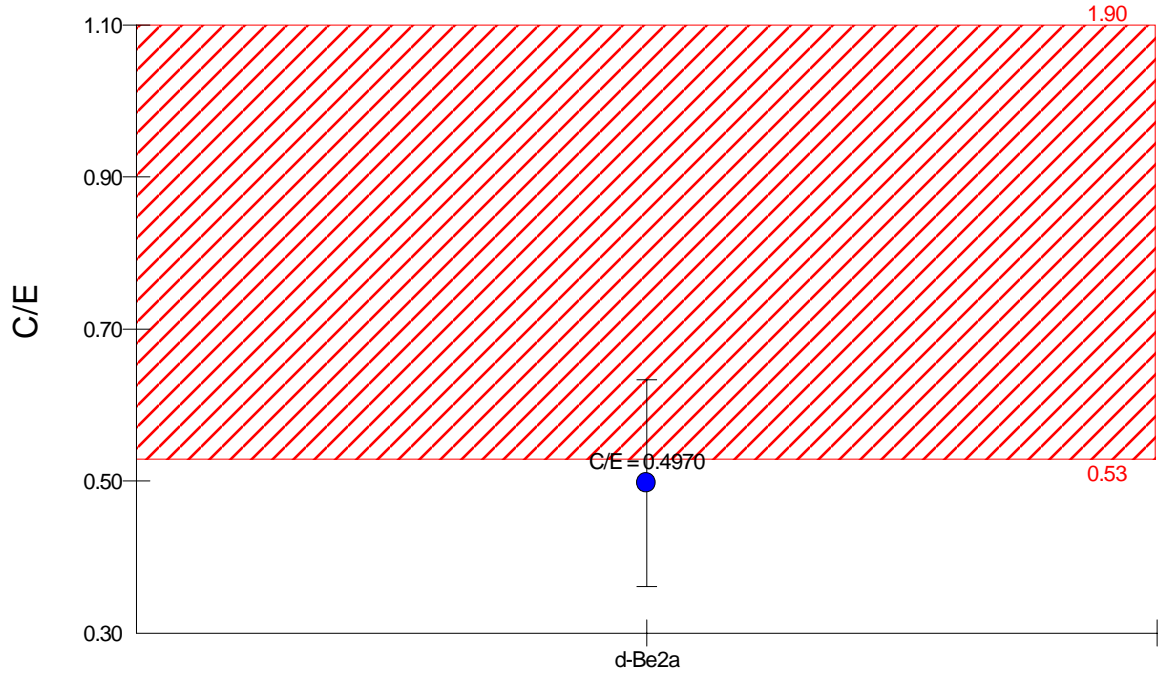
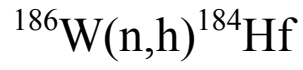
$^{186}\text{W}(n,\gamma)^{187}\text{W}$



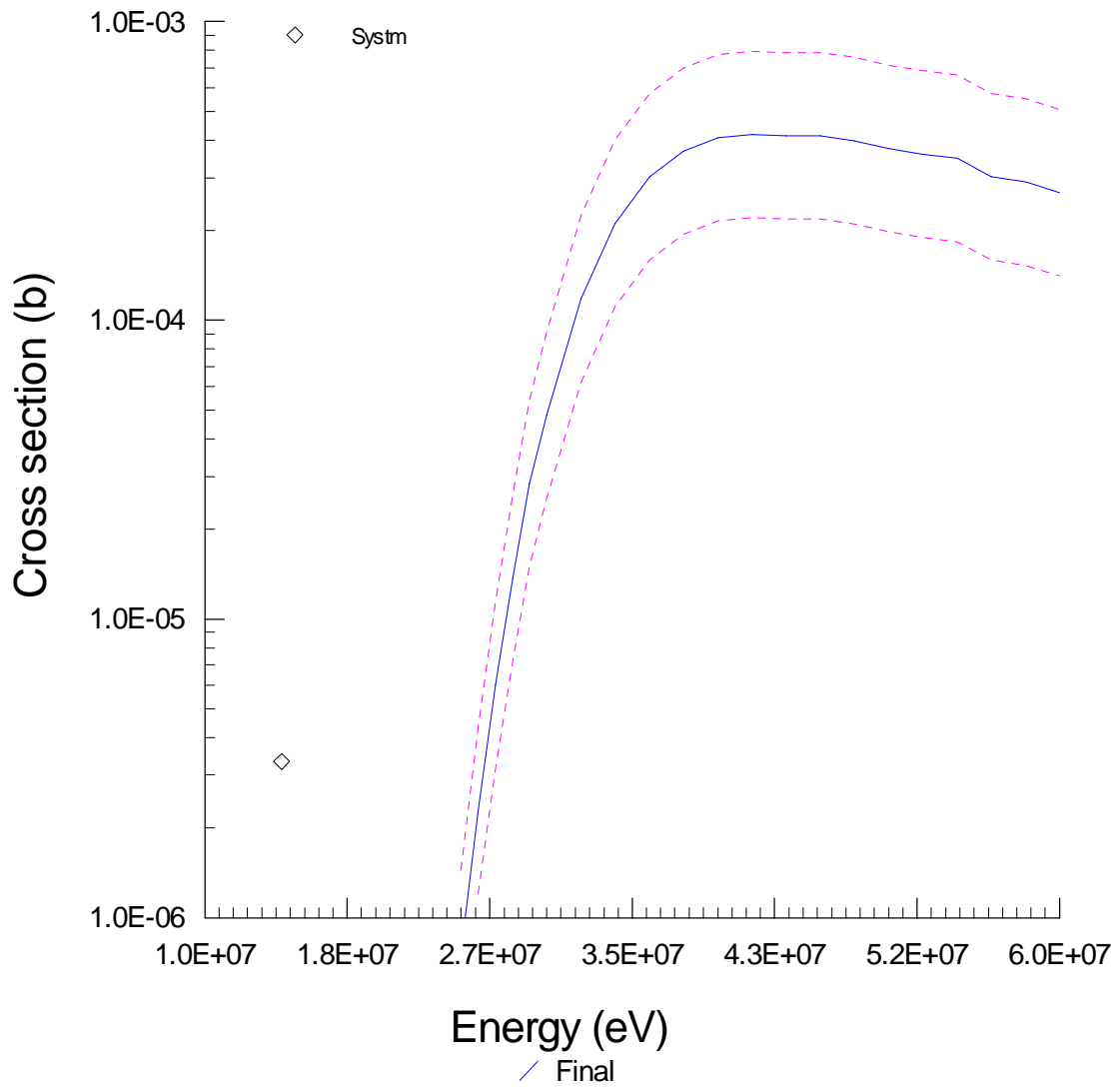
# $^{186}\text{W}(n,p)^{186}\text{Ta}$

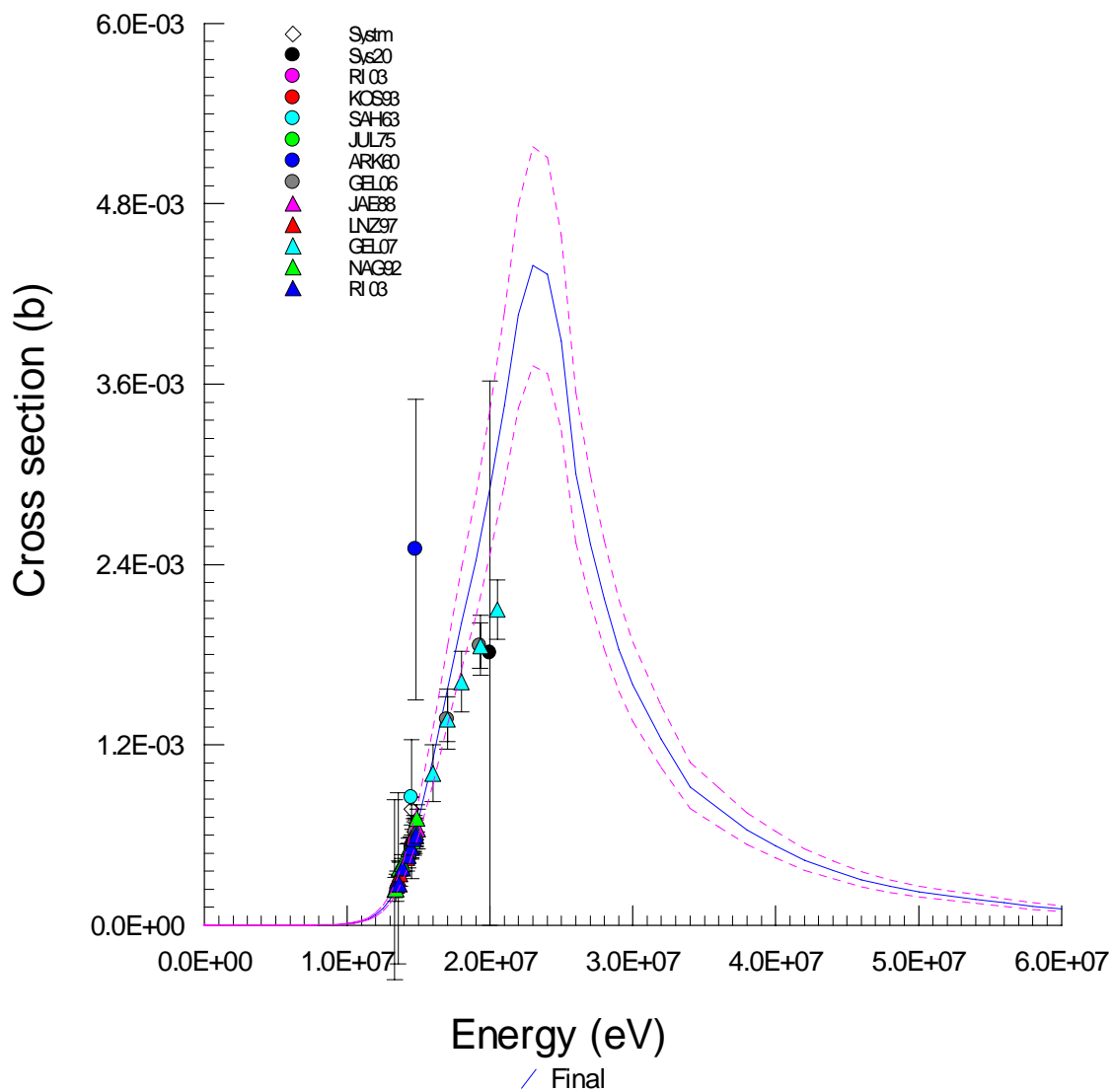
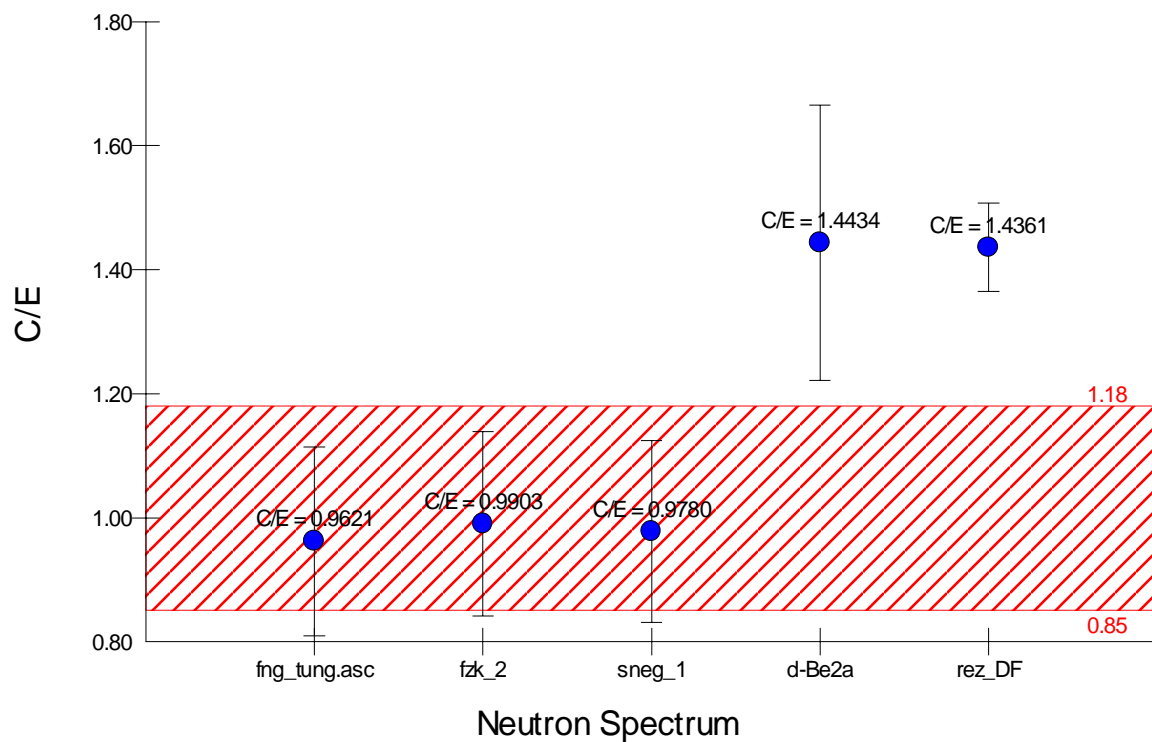
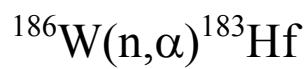


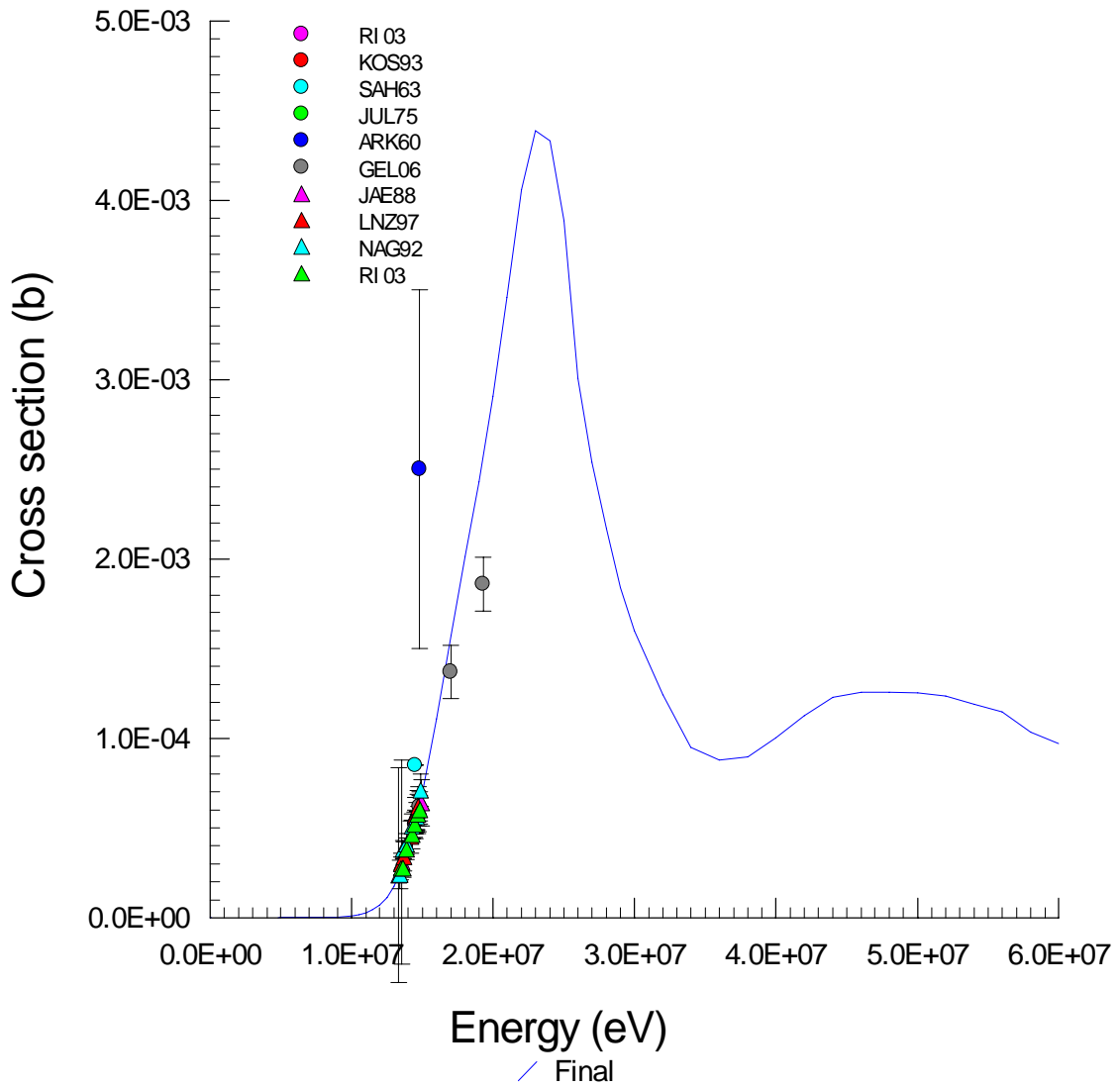
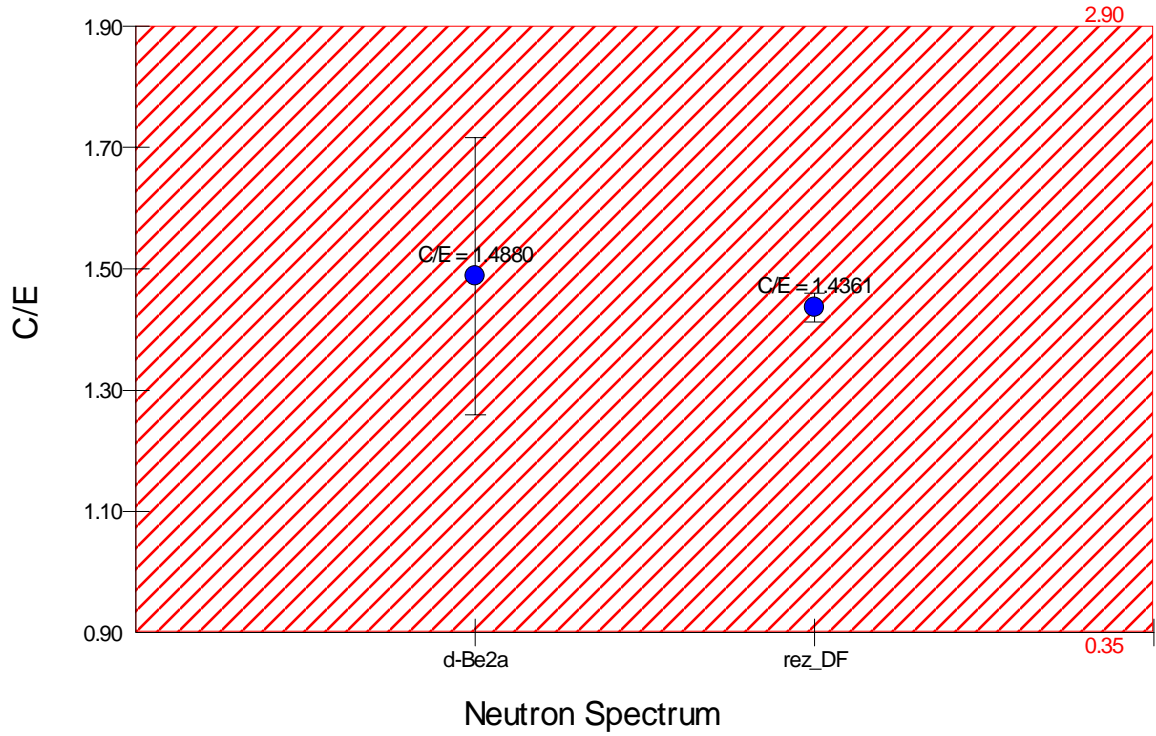
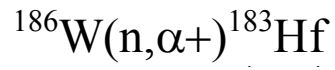




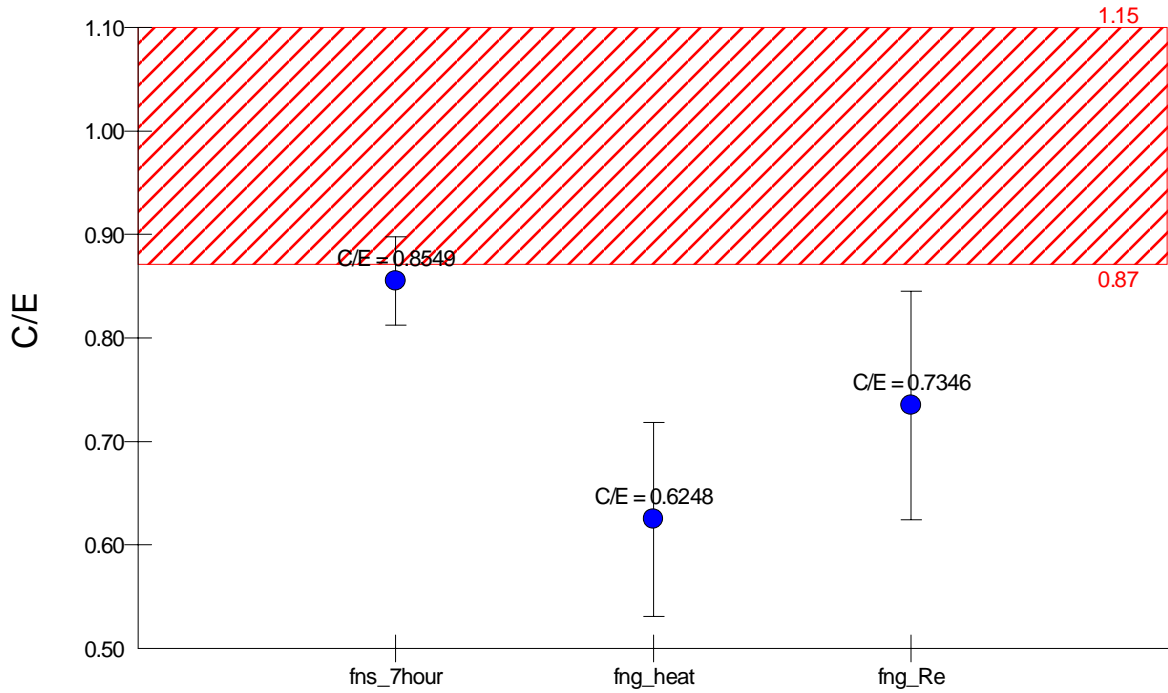
Neutron Spectrum



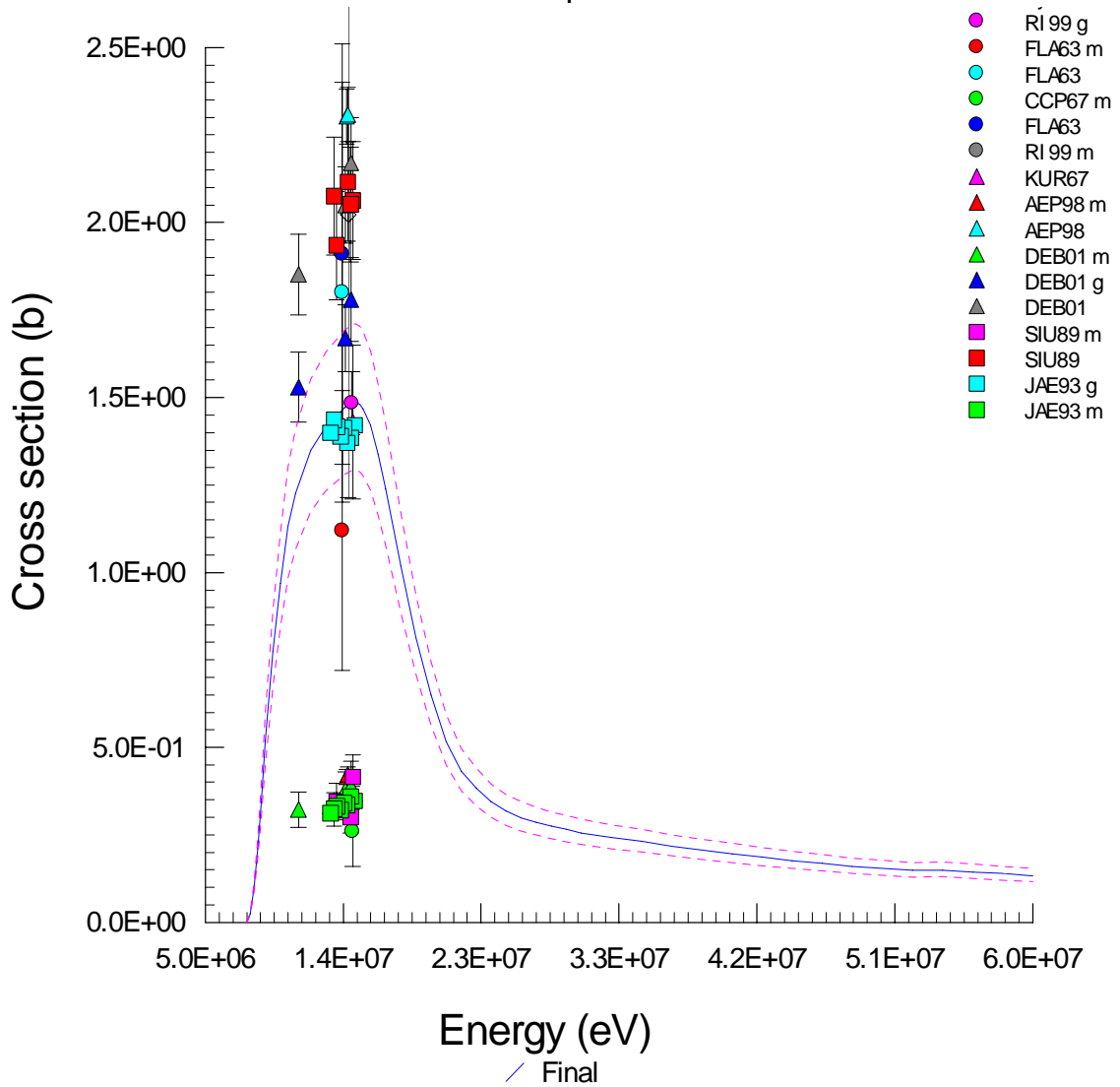




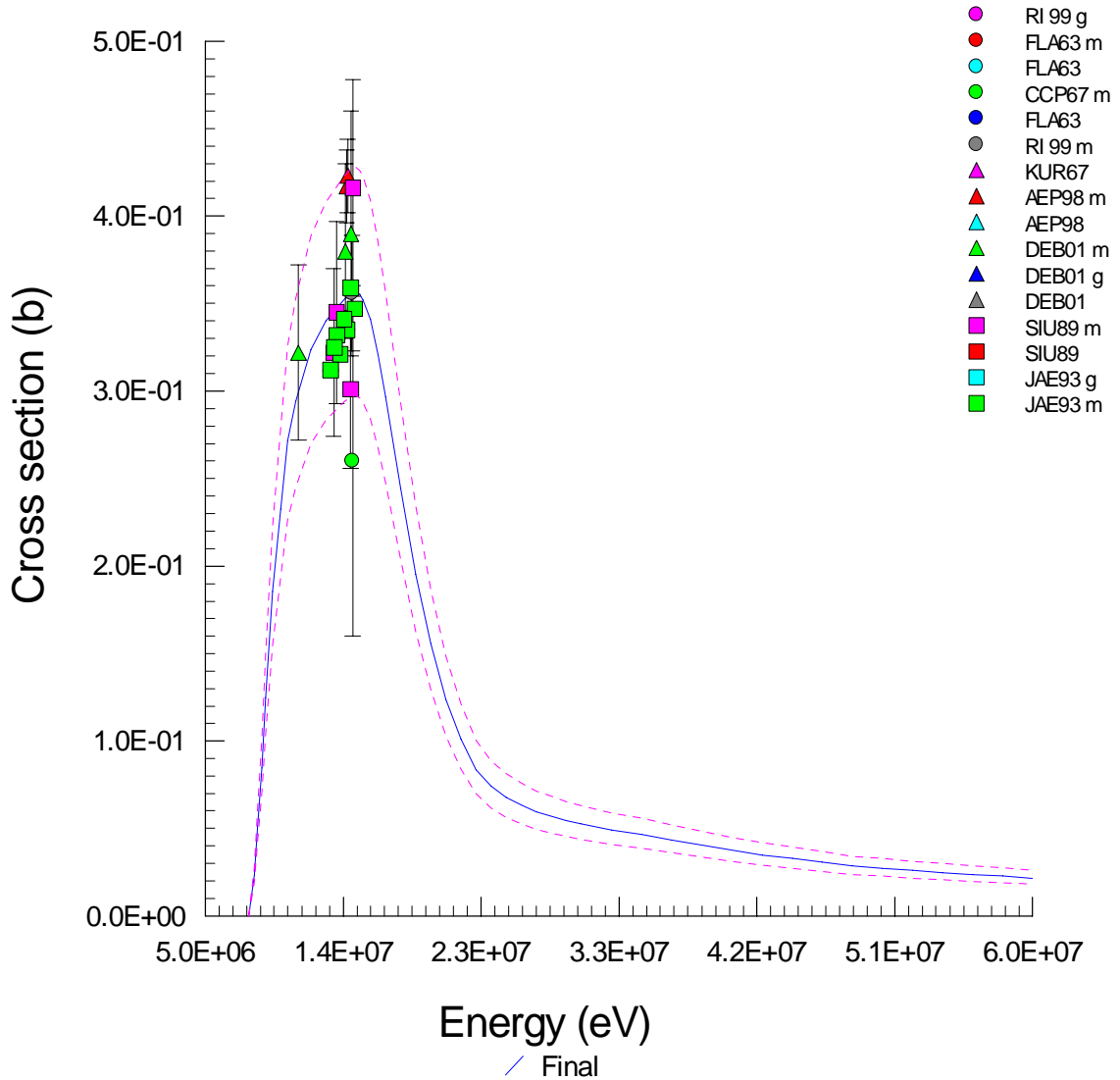
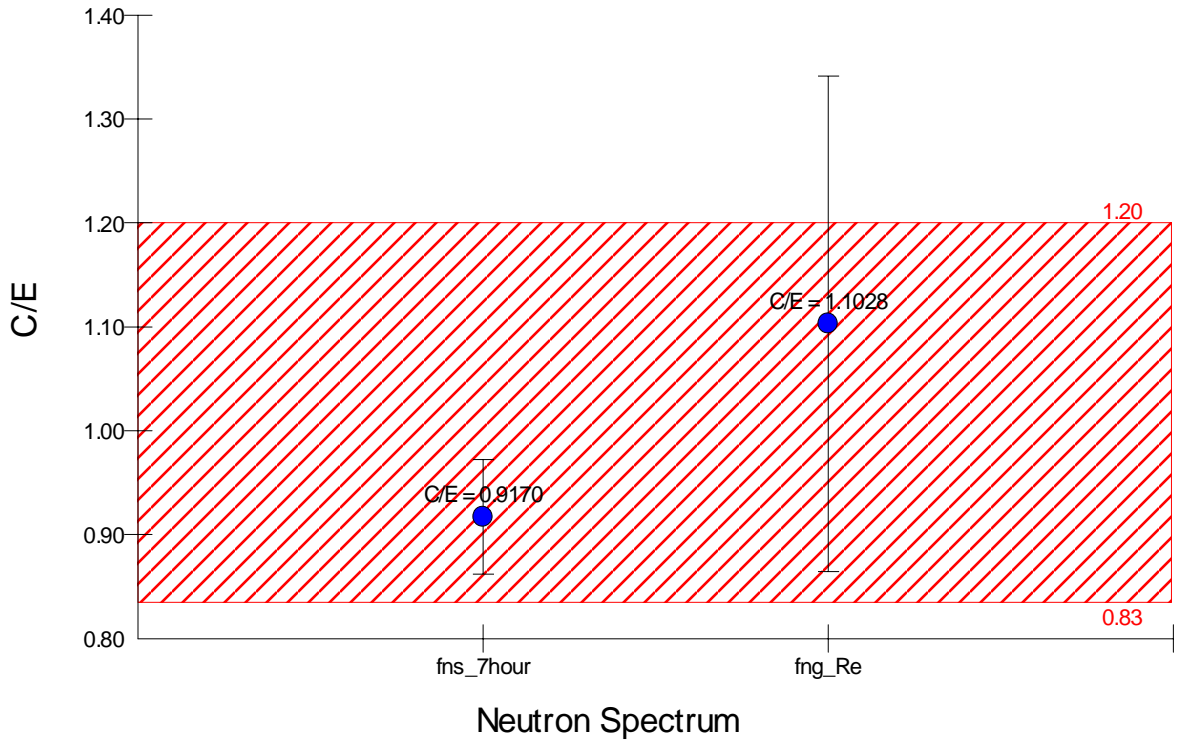
$^{185}\text{Re}(n,2n)^{184g}\text{Re}$

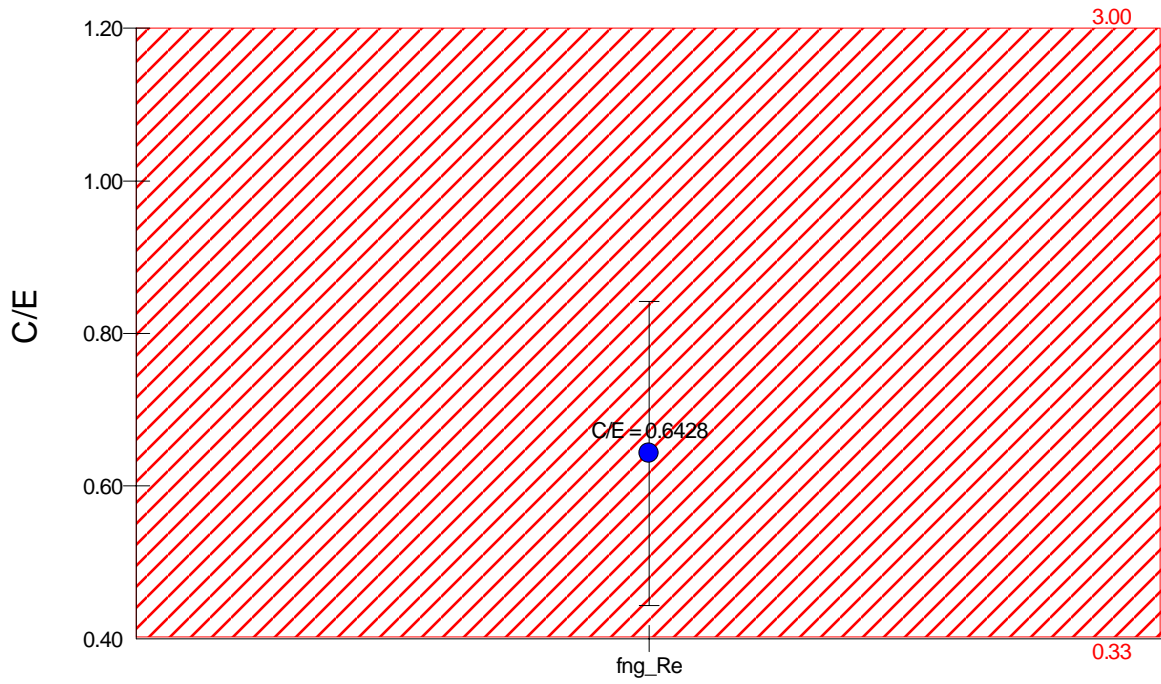
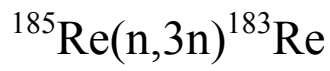


Neutron Spectrum

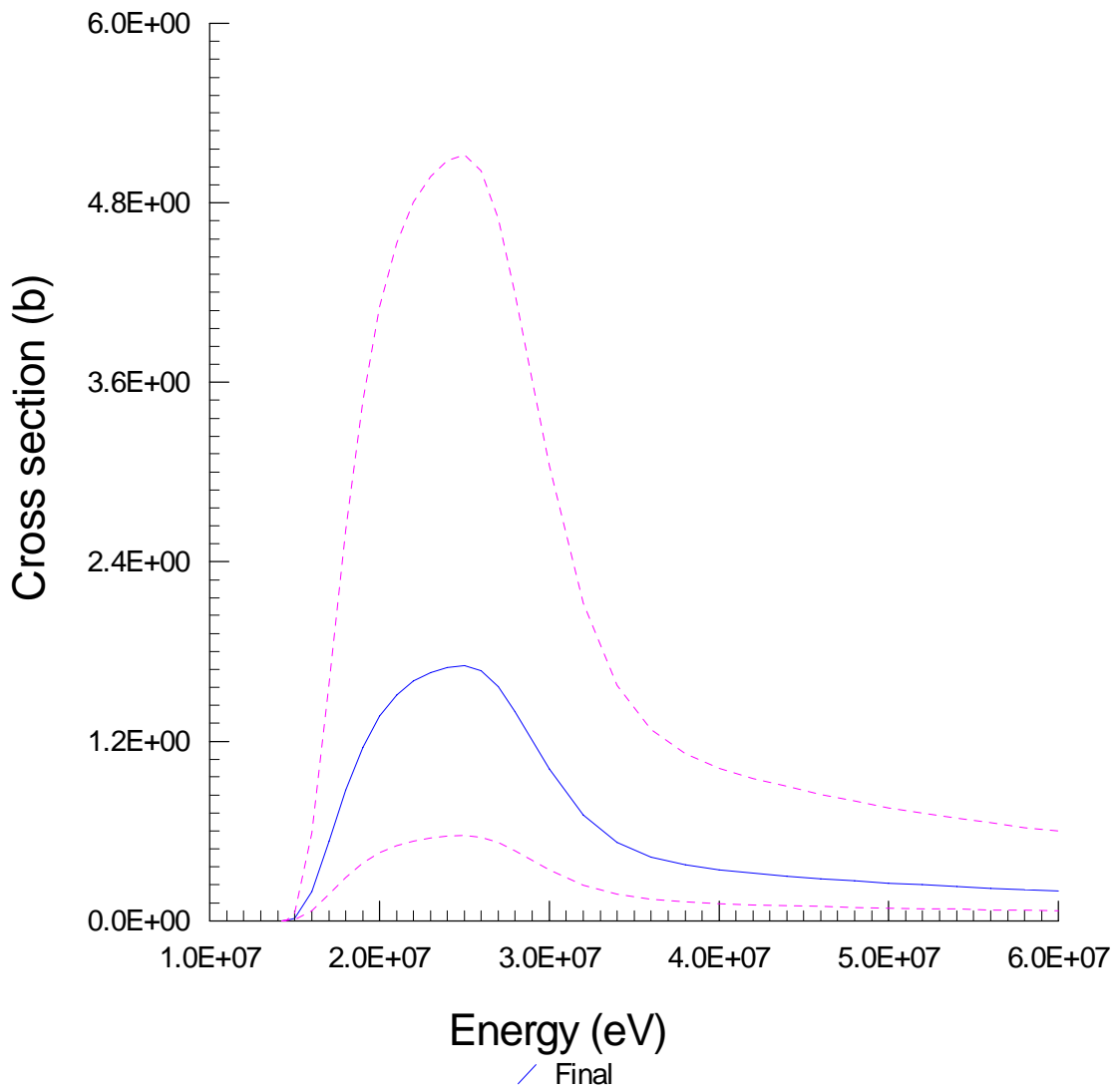


$^{185}\text{Re}(n,2n)^{184\text{m}}\text{Re}$

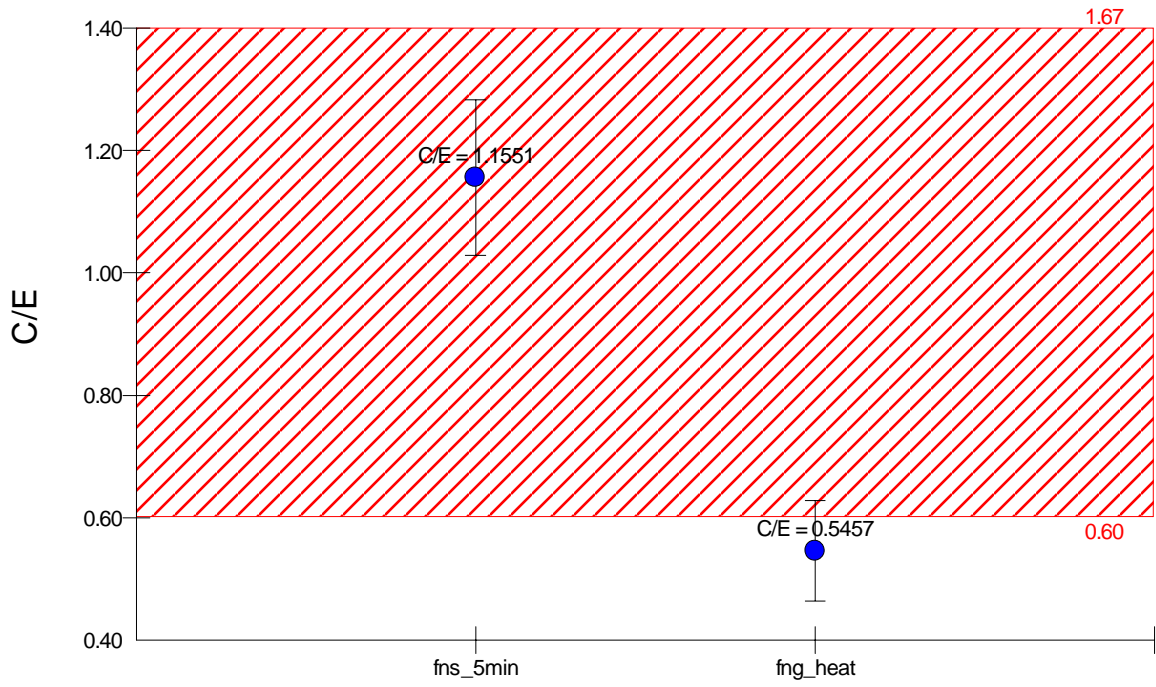




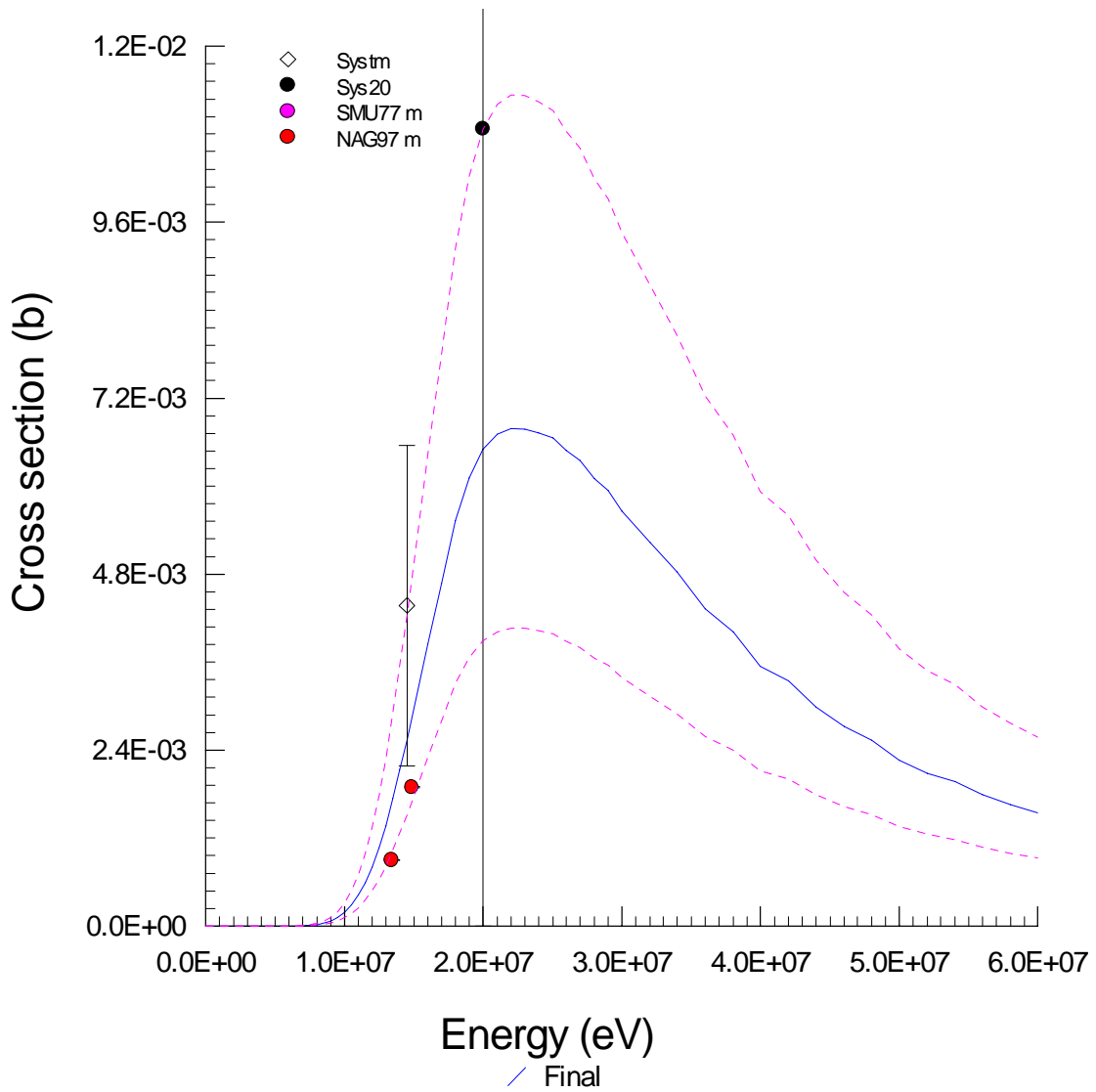
Neutron Spectrum



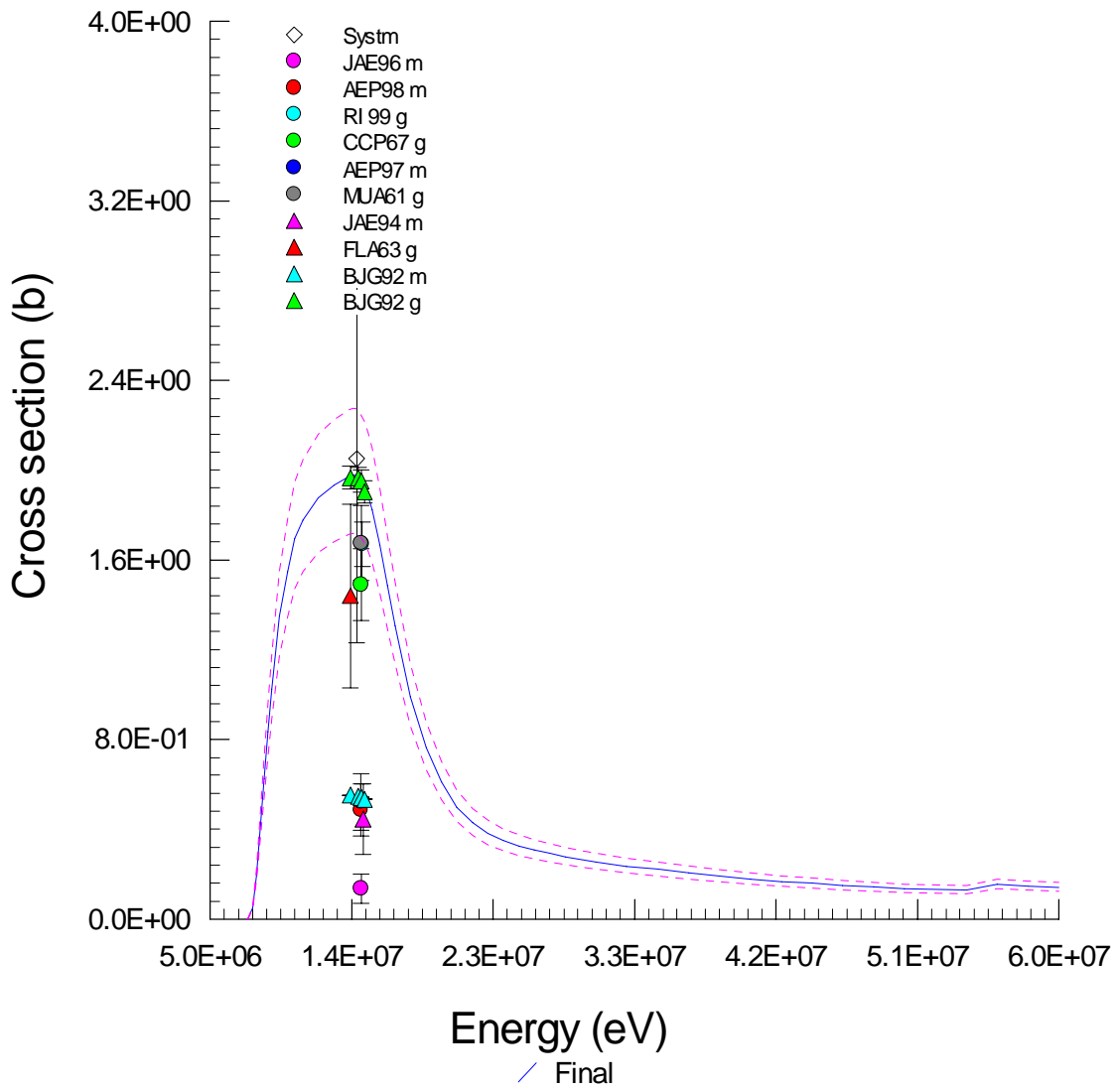
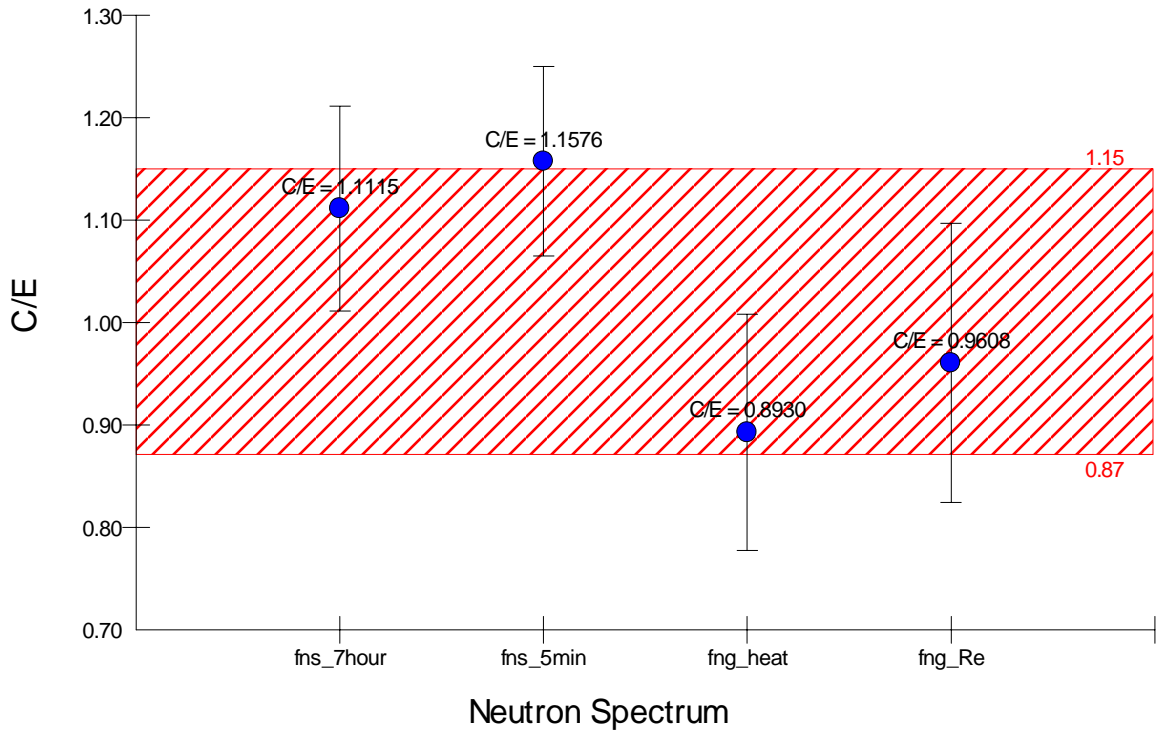
$^{185}\text{Re}(n,p)^{185\text{m}}\text{W}$



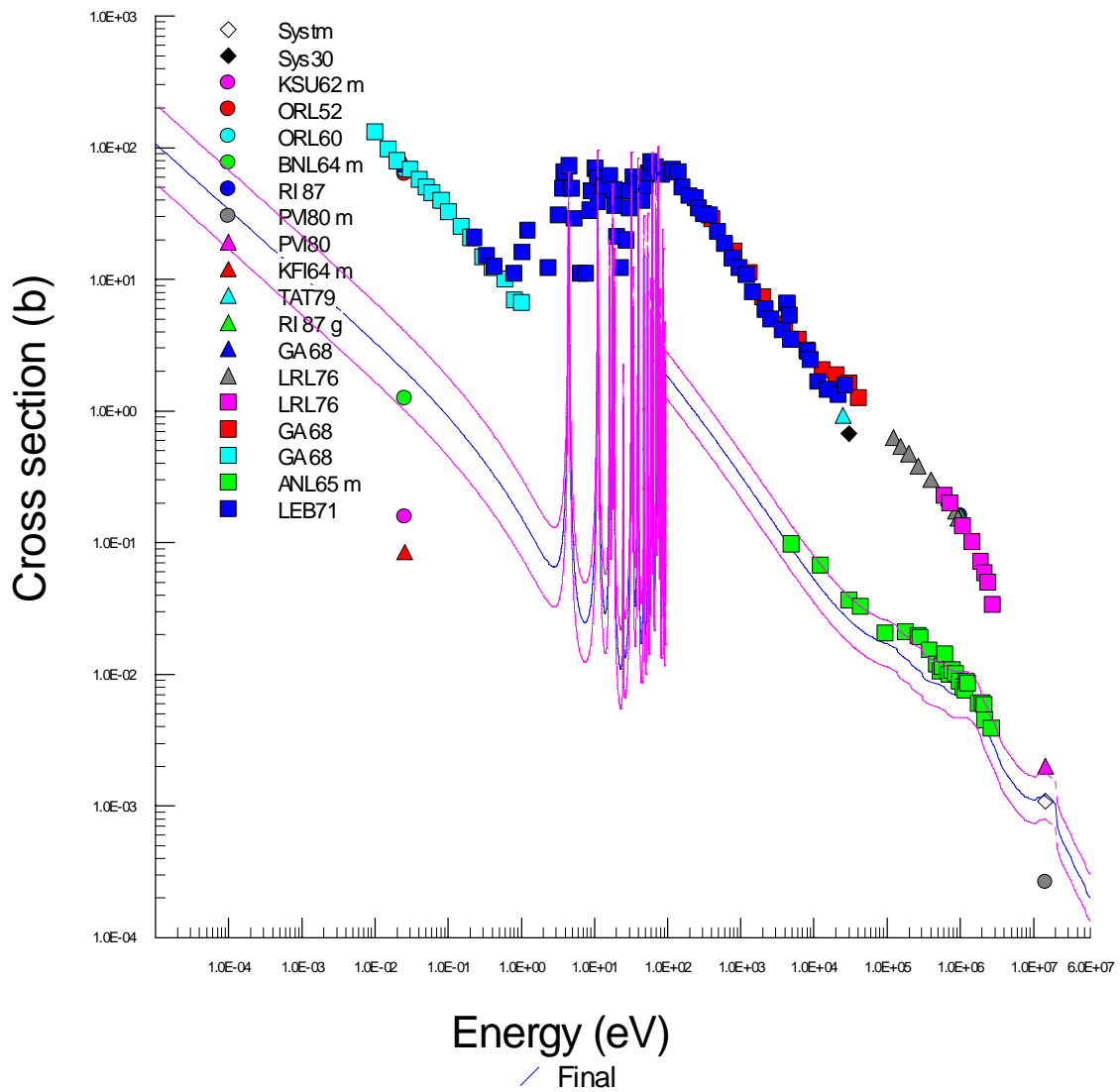
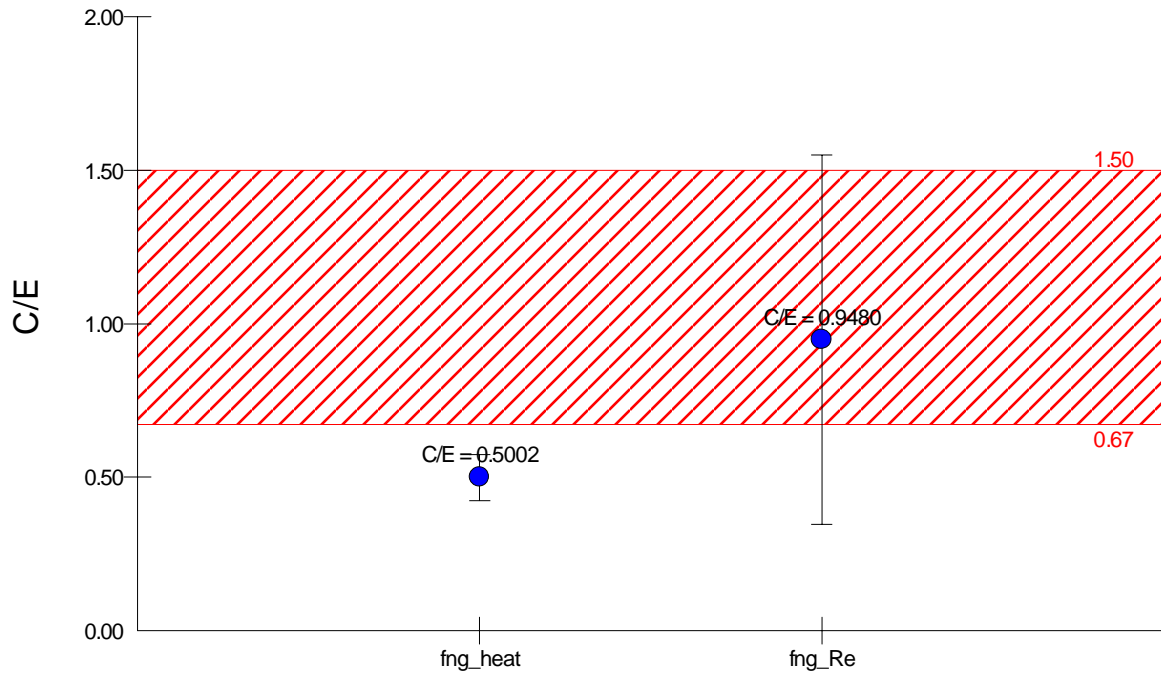
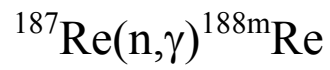
Neutron Spectrum

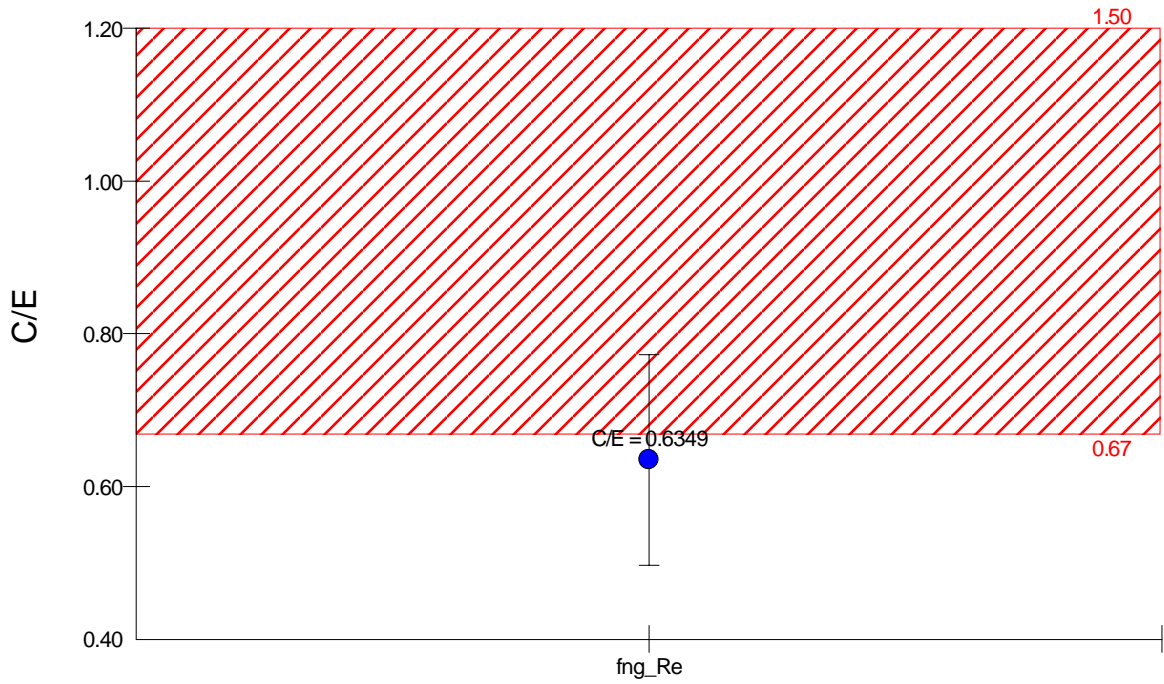
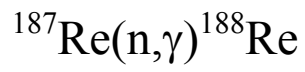


$^{187}\text{Re}(n,2n)^{186g}\text{Re}$

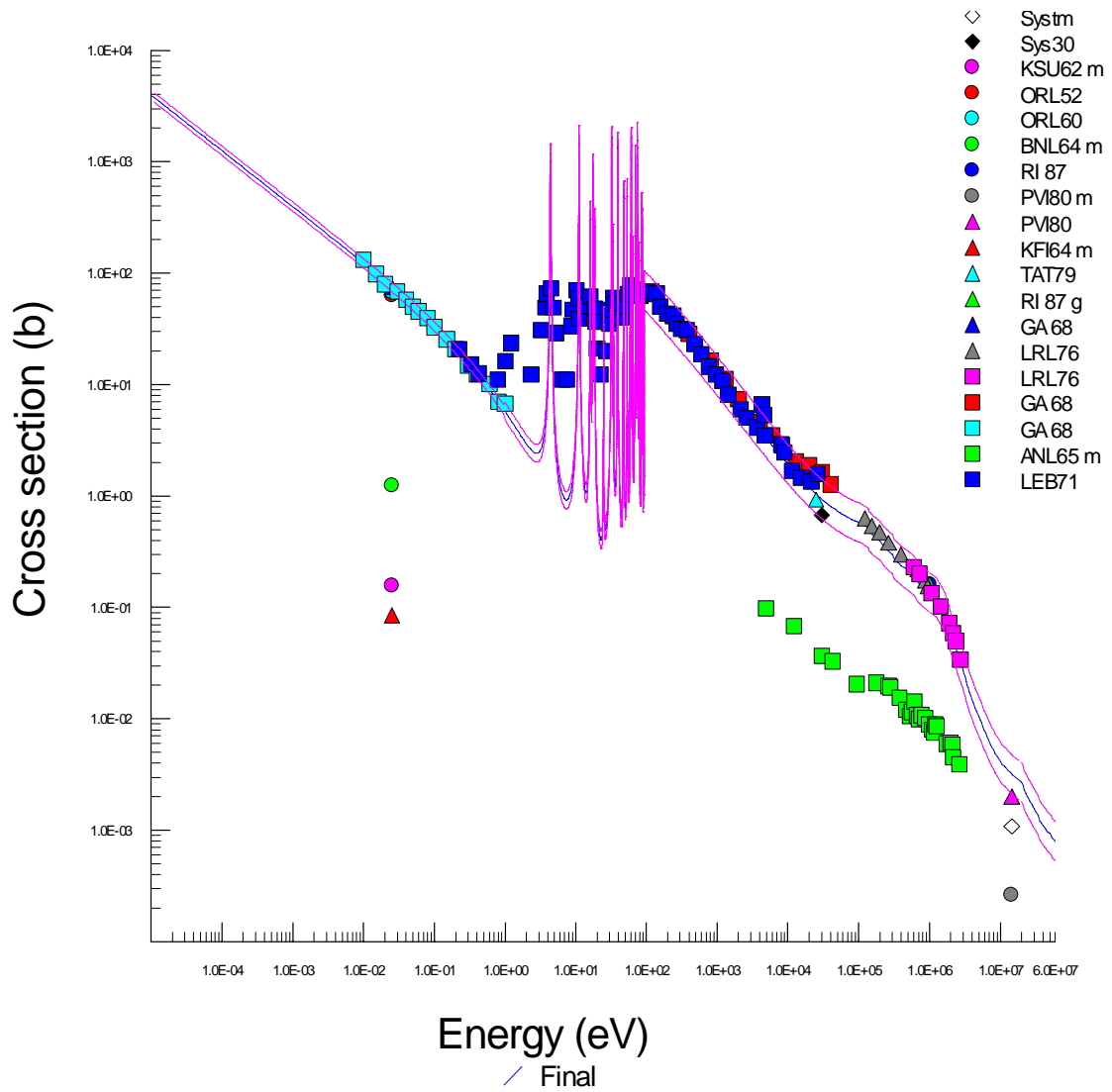




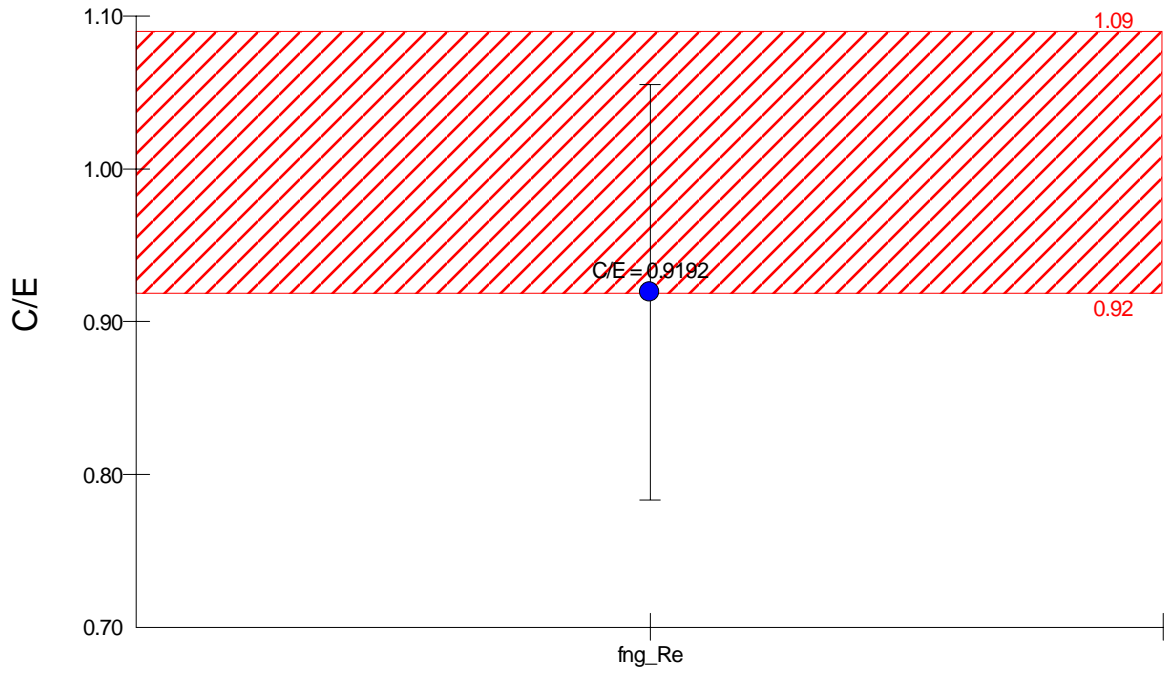




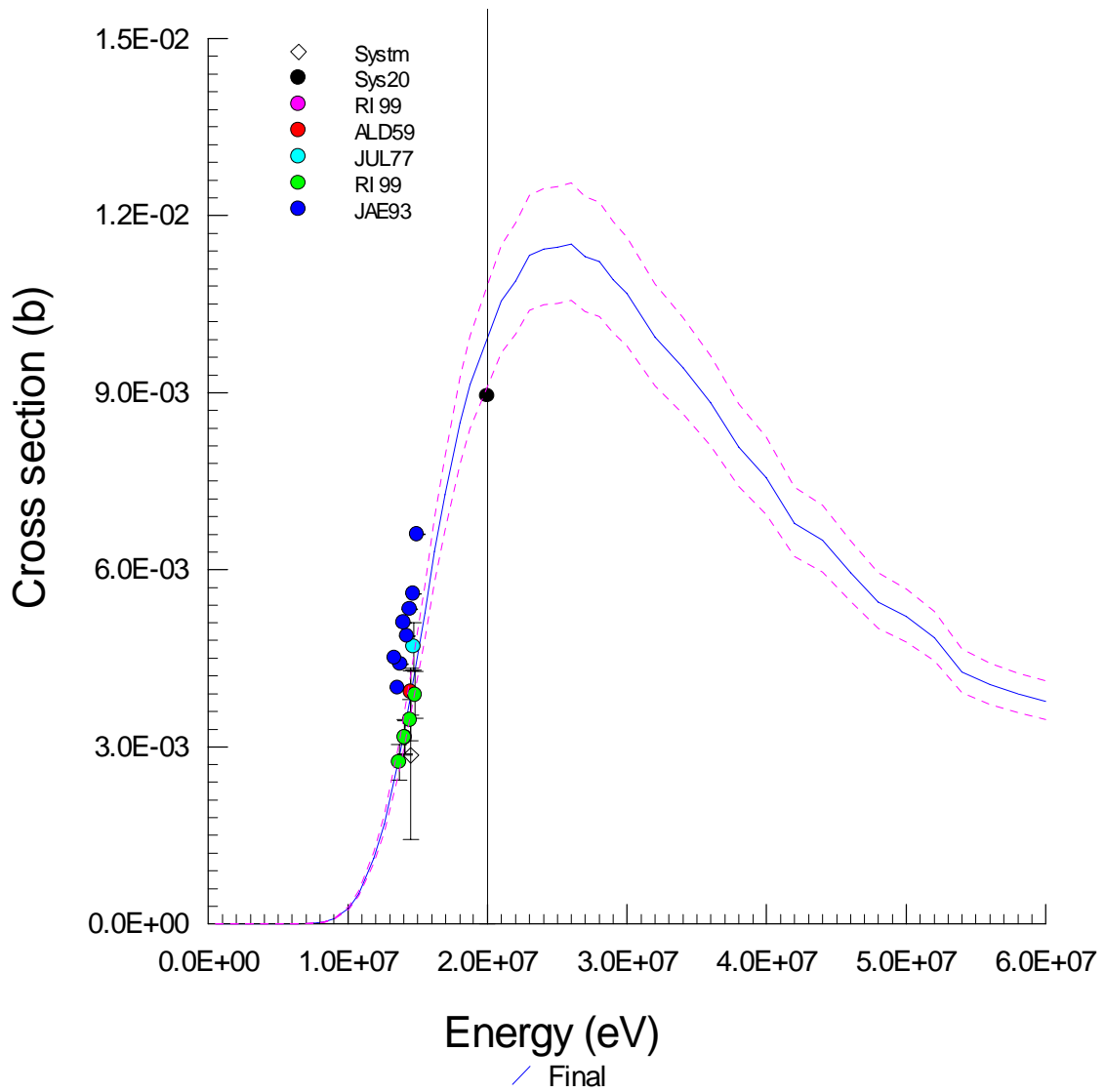
Neutron Spectrum



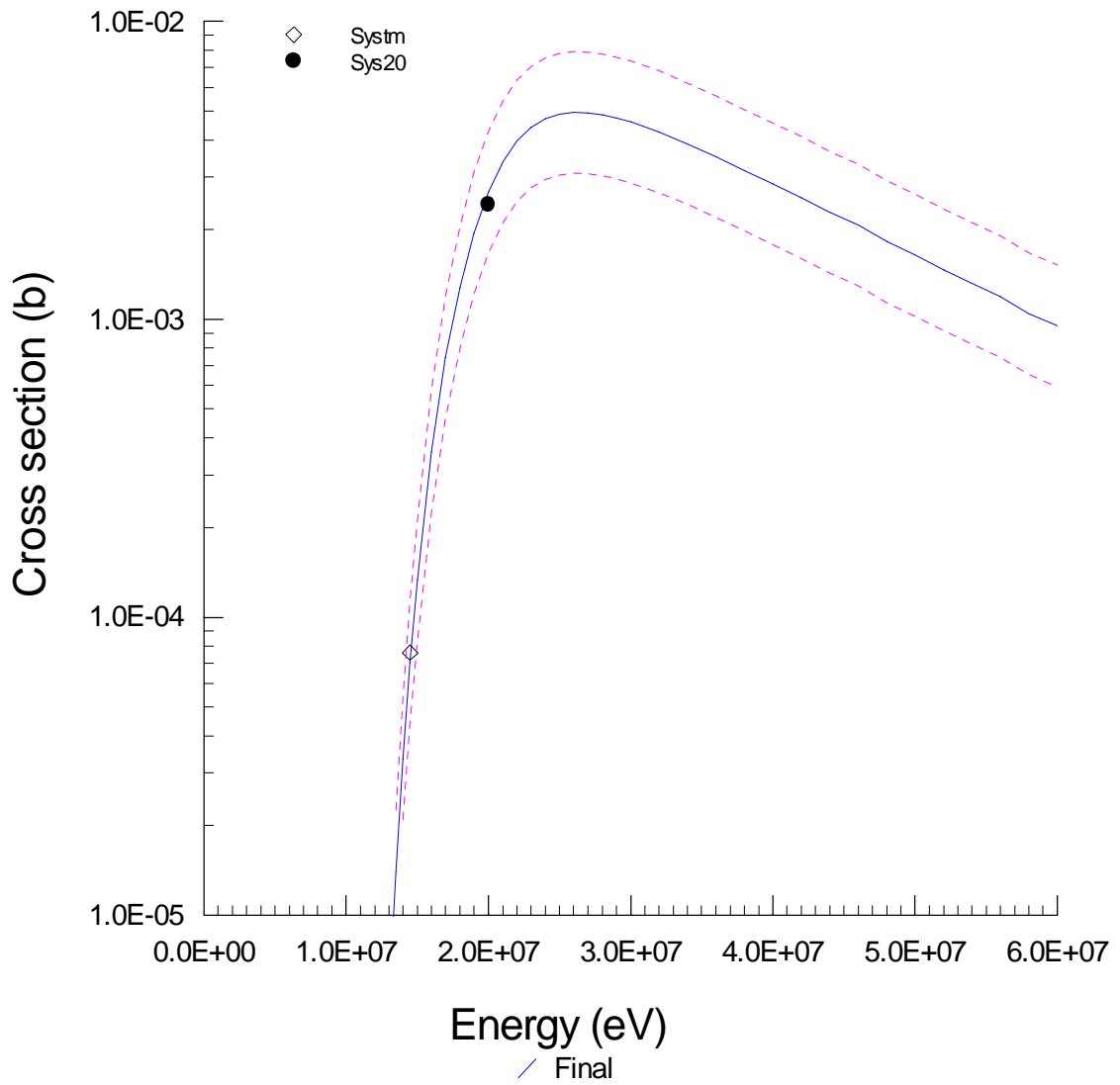
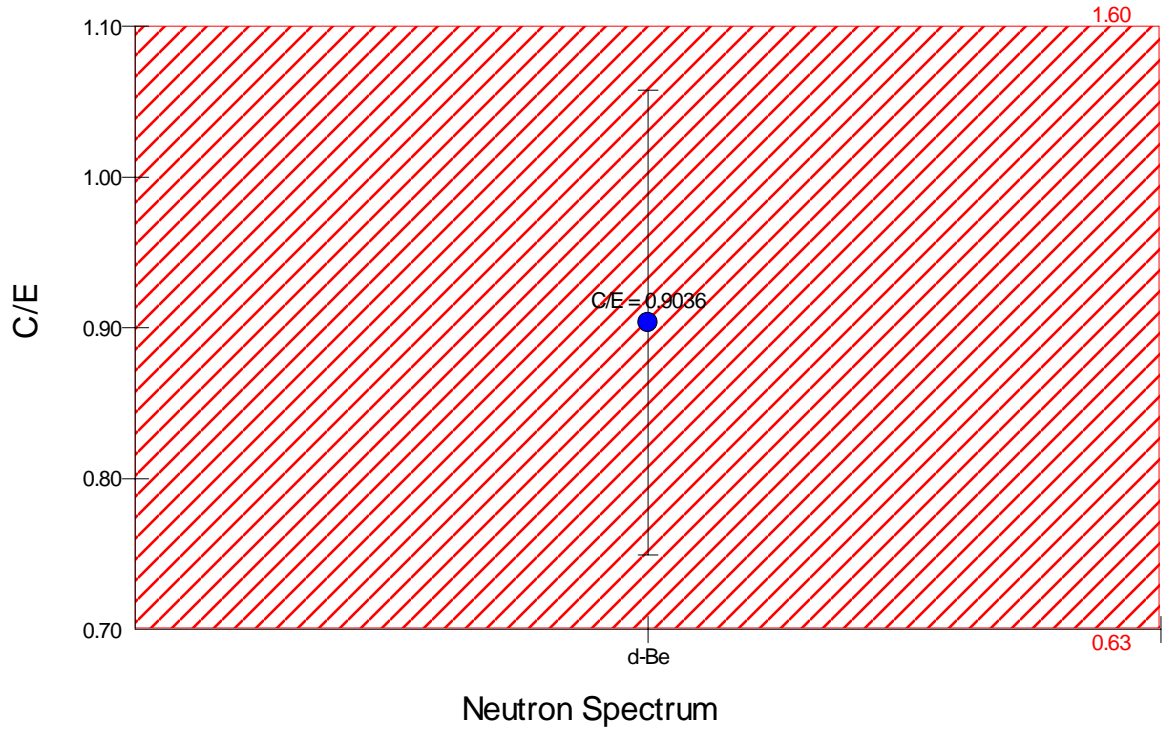
$^{187}\text{Re}(n,p)^{187}\text{W}$

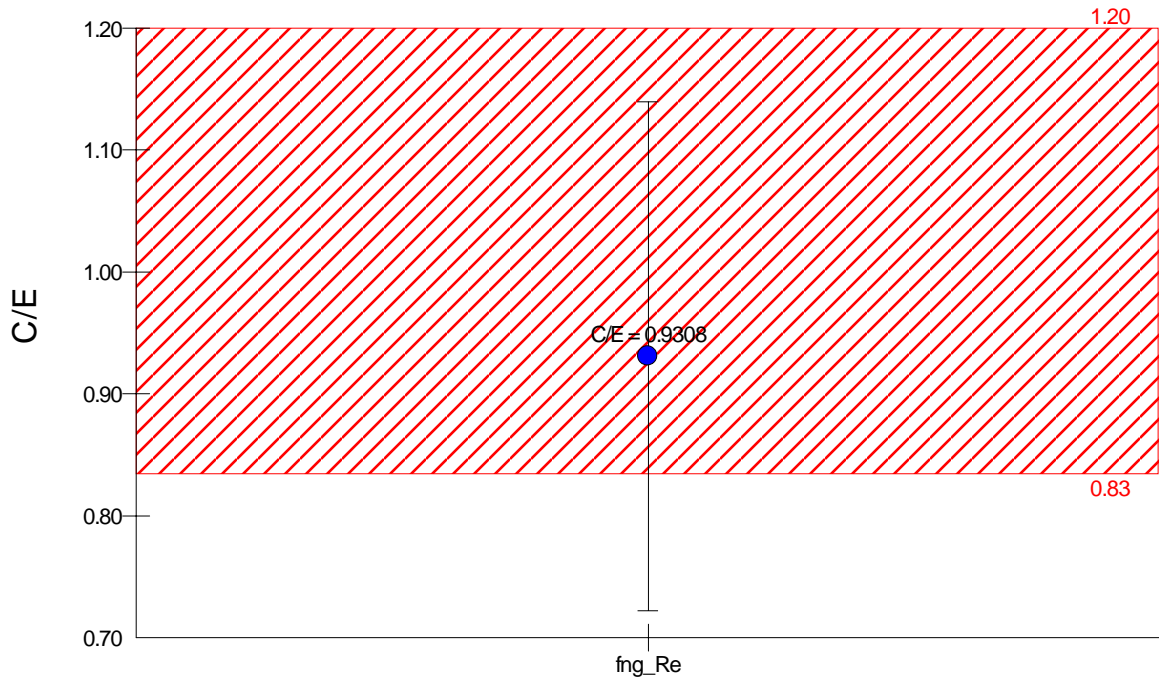
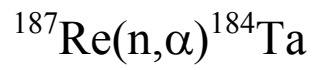


Neutron Spectrum

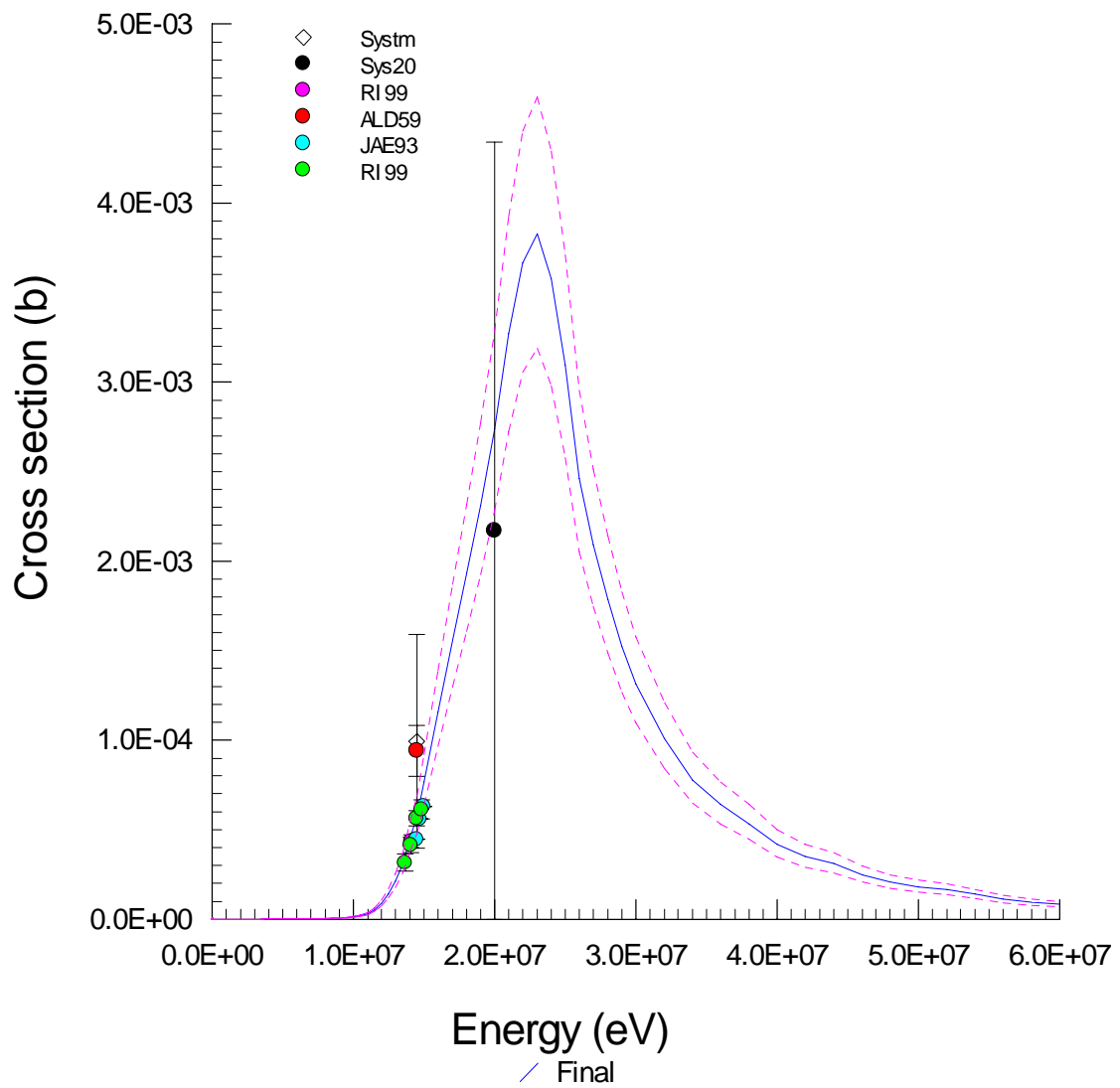


$^{187}\text{Re}(n,t)^{185}\text{W}$

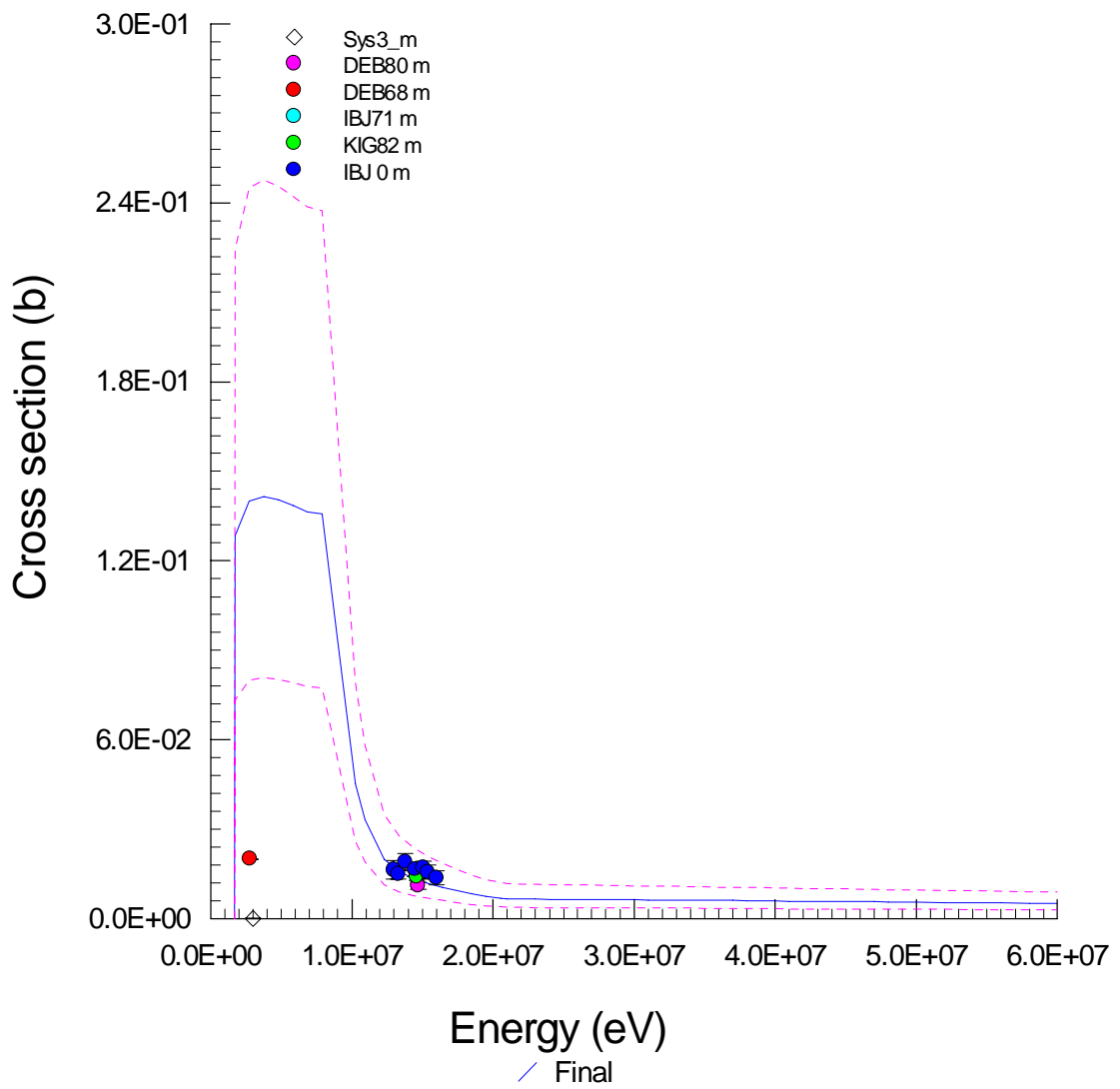
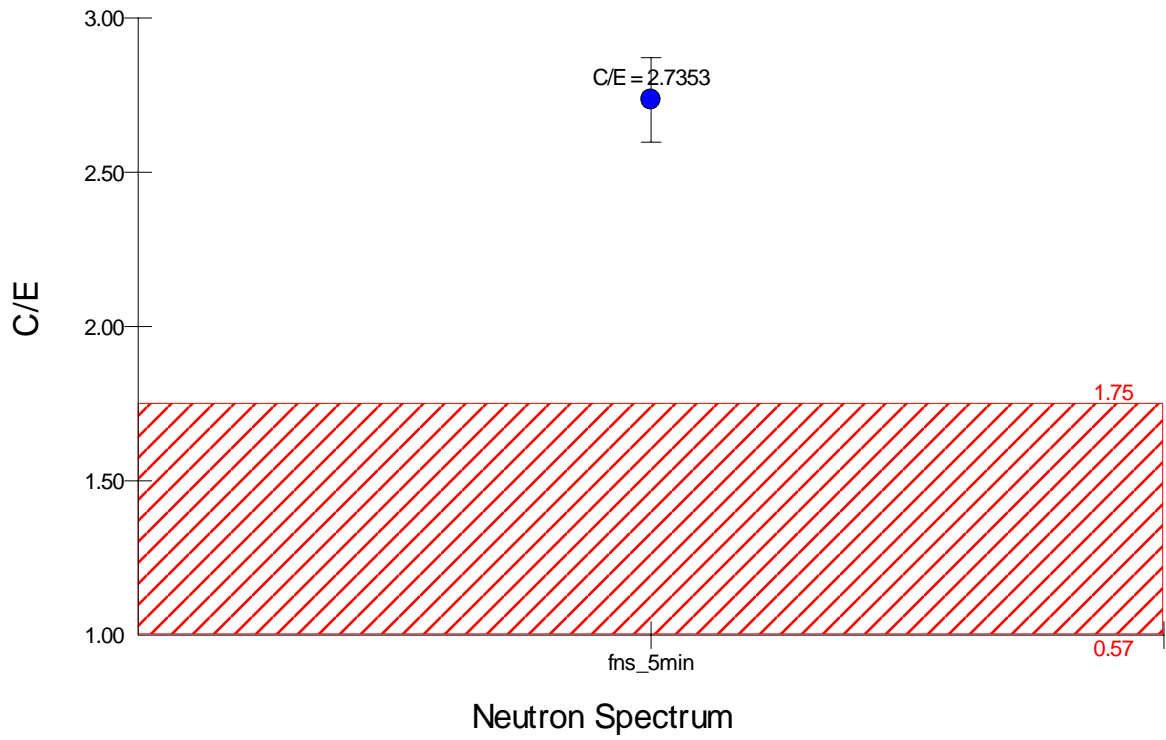


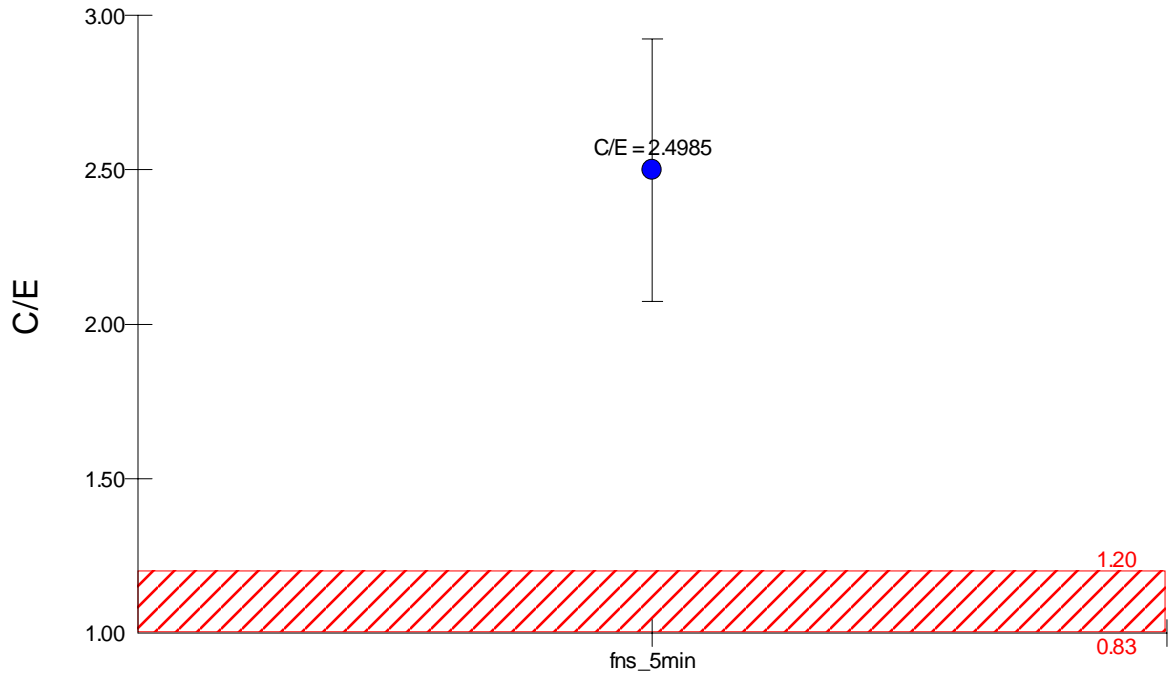
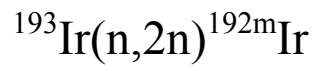


Neutron Spectrum

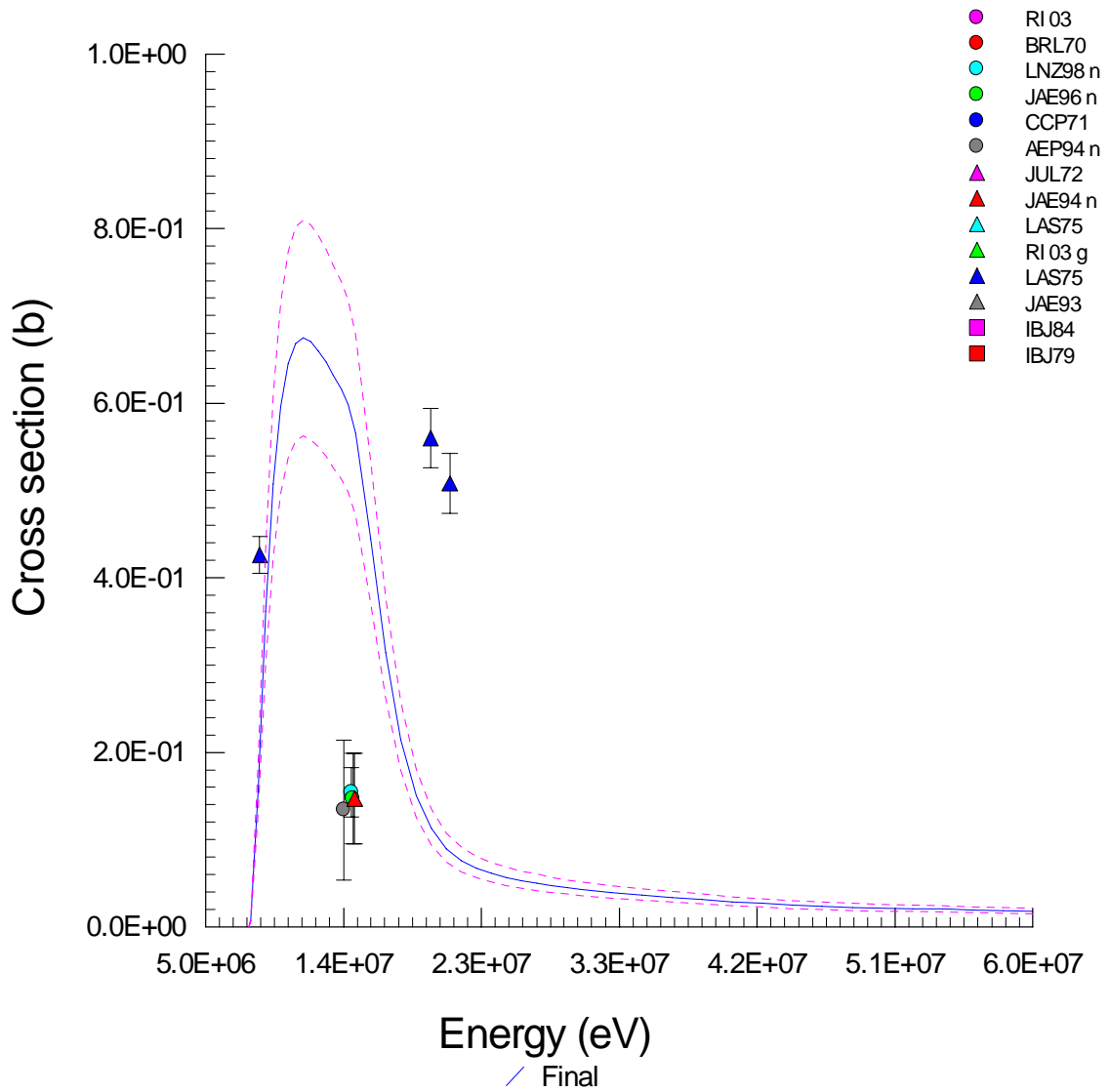


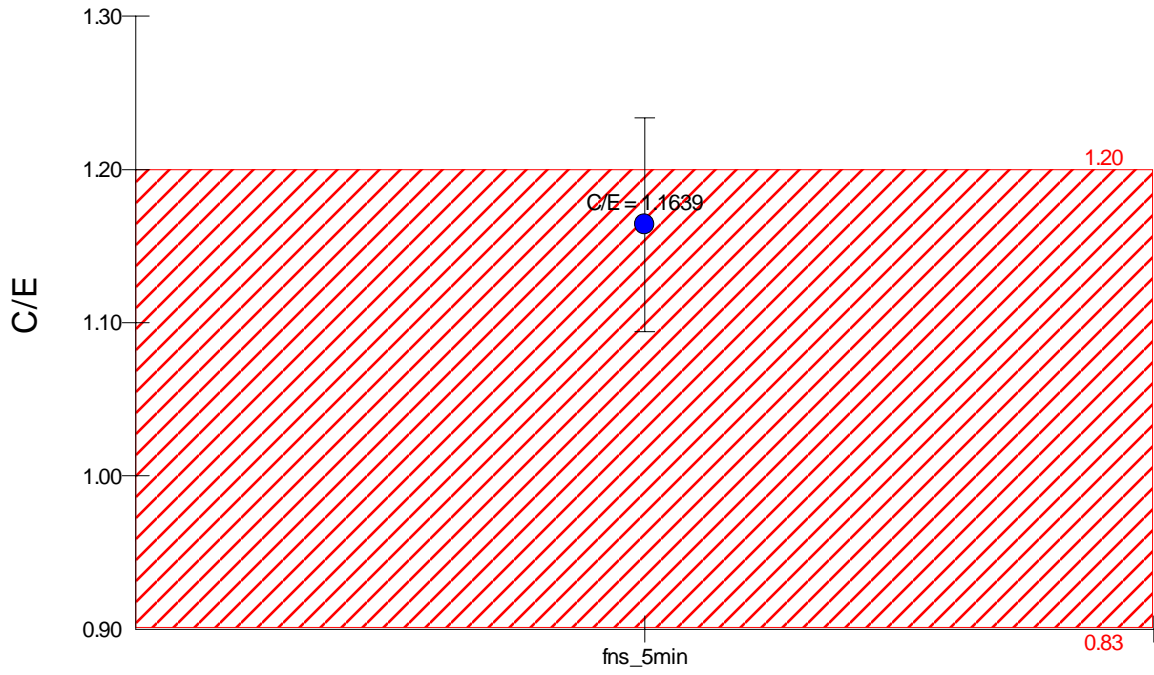
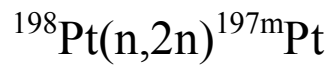
$^{190}\text{Os}(n,n')^{190\text{m}}\text{Os}$



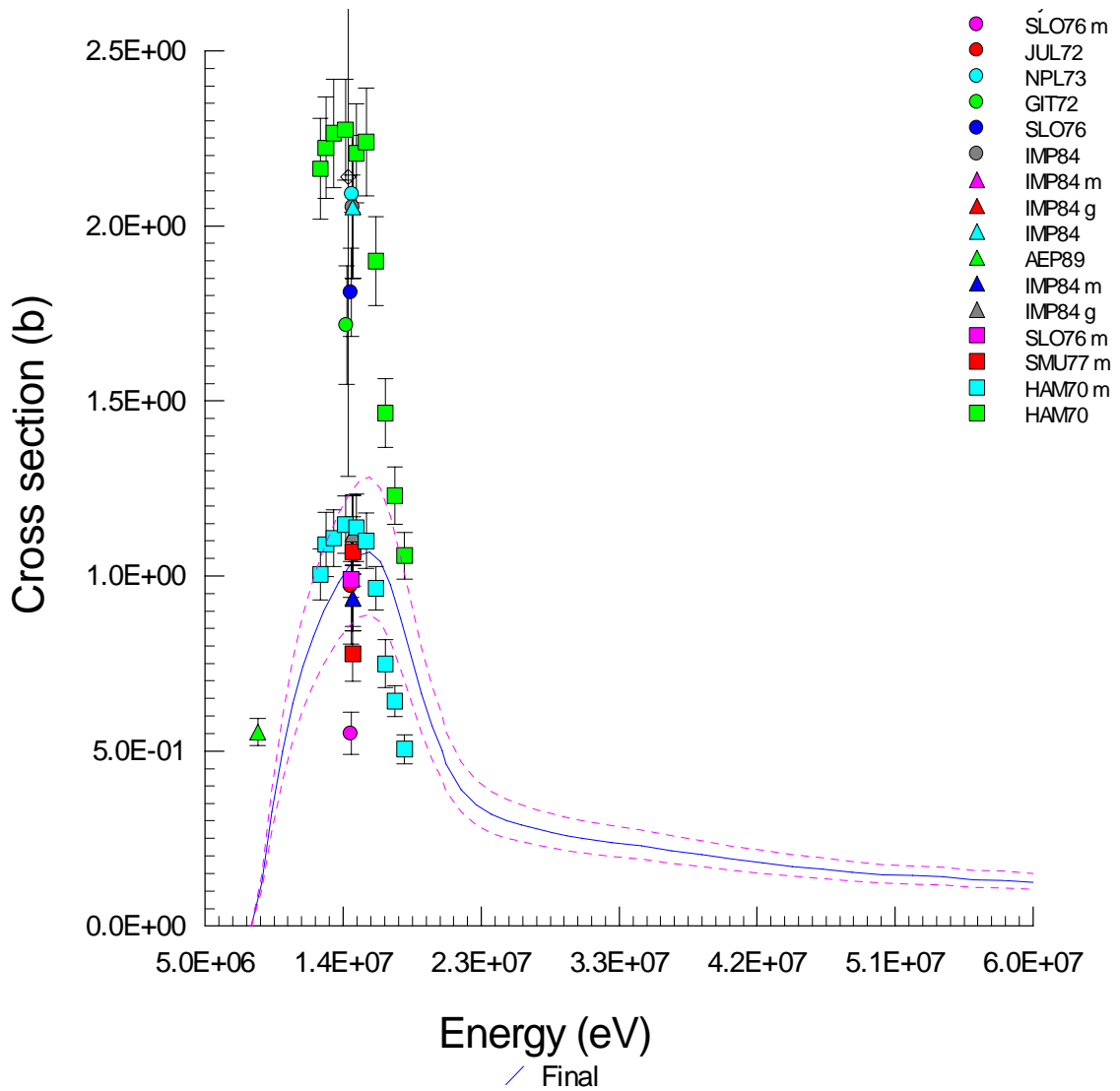


Neutron Spectrum



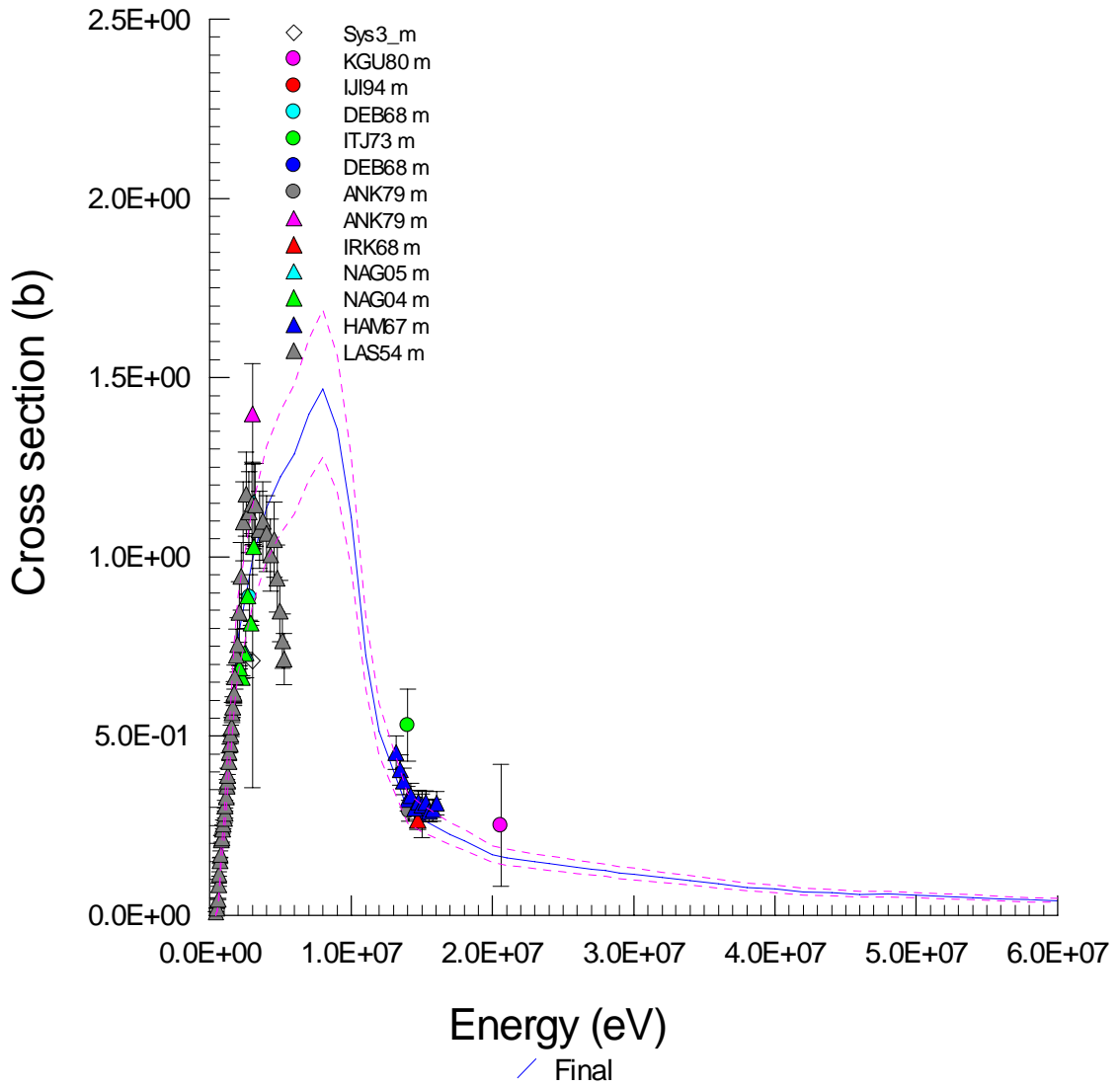
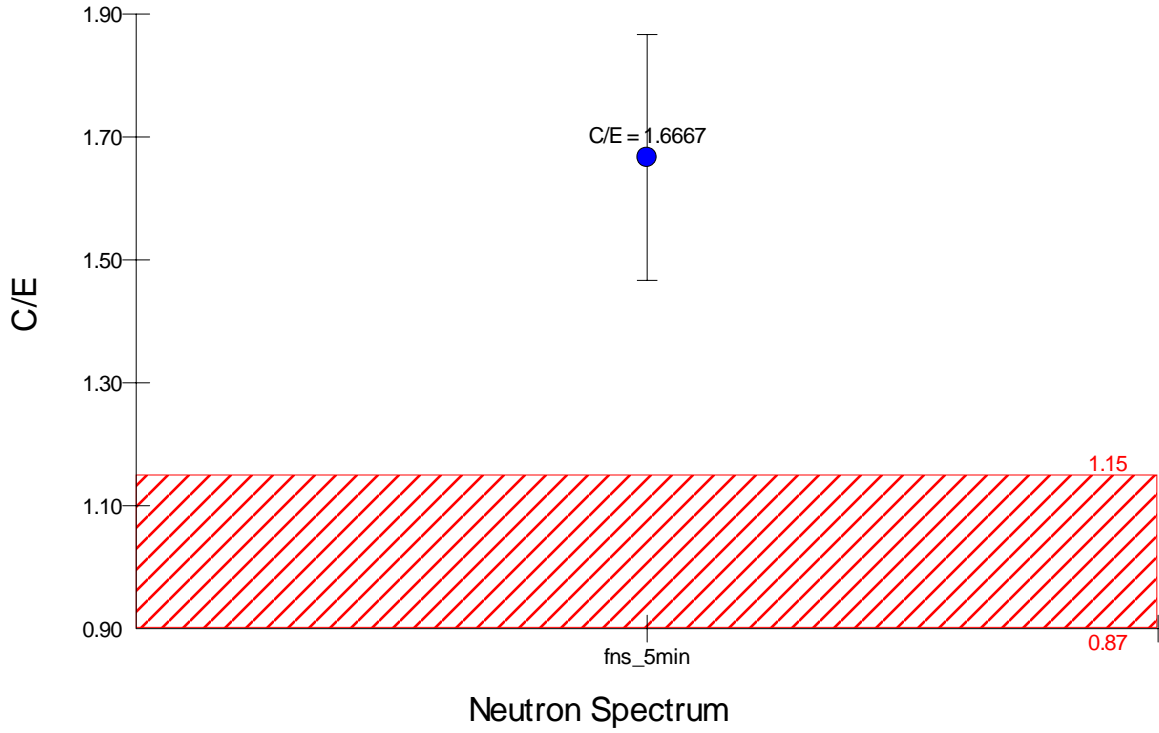


Neutron Spectrum

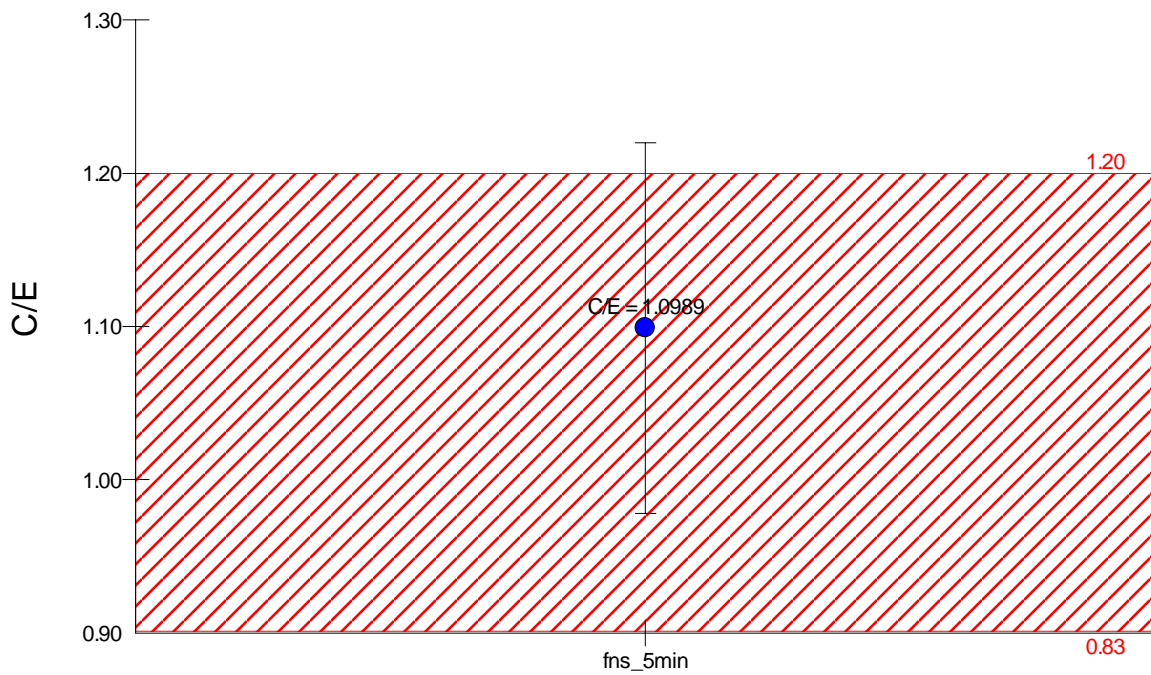




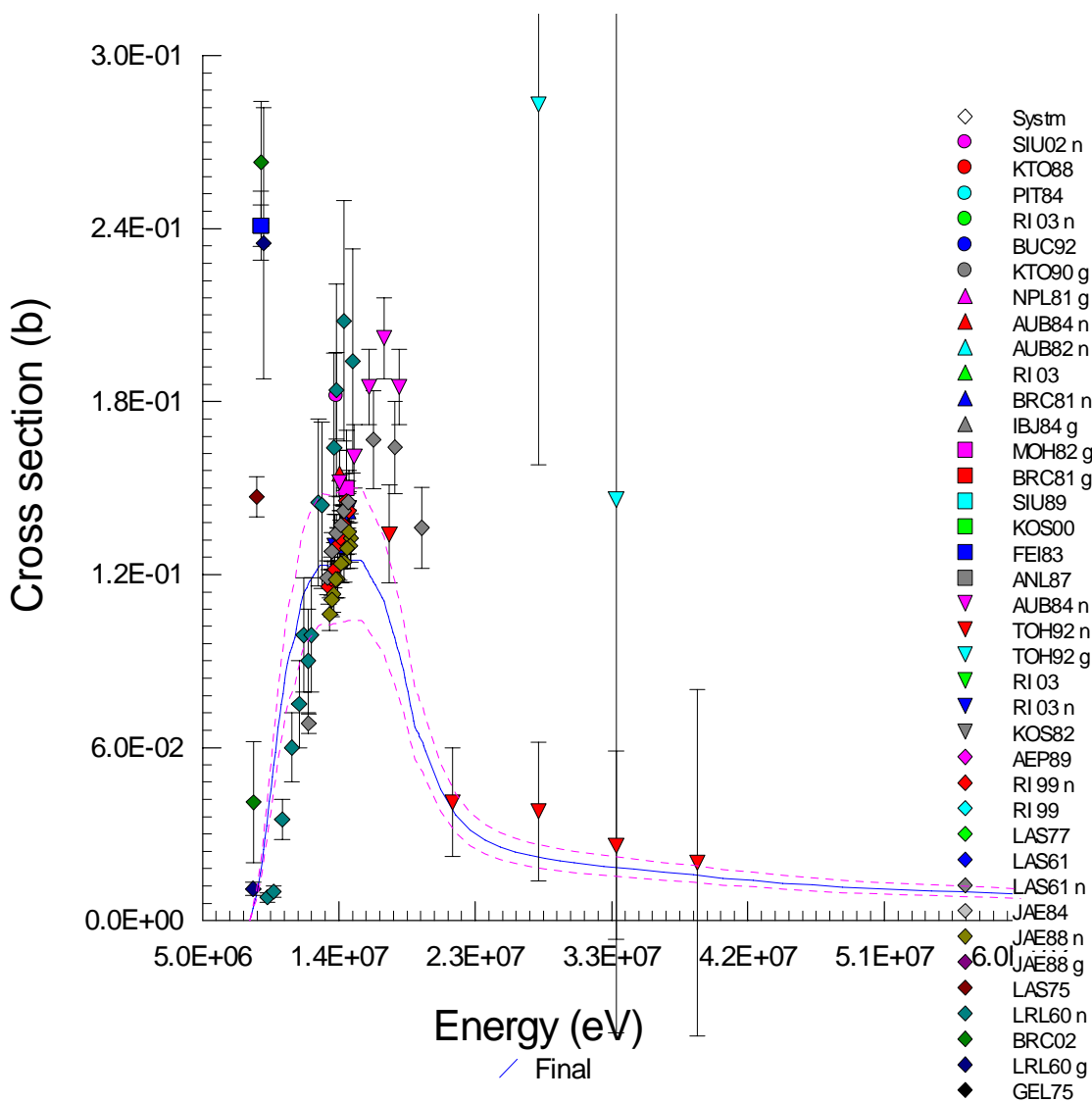
$^{197}\text{Au}(n,n')^{197\text{m}}\text{Au}$



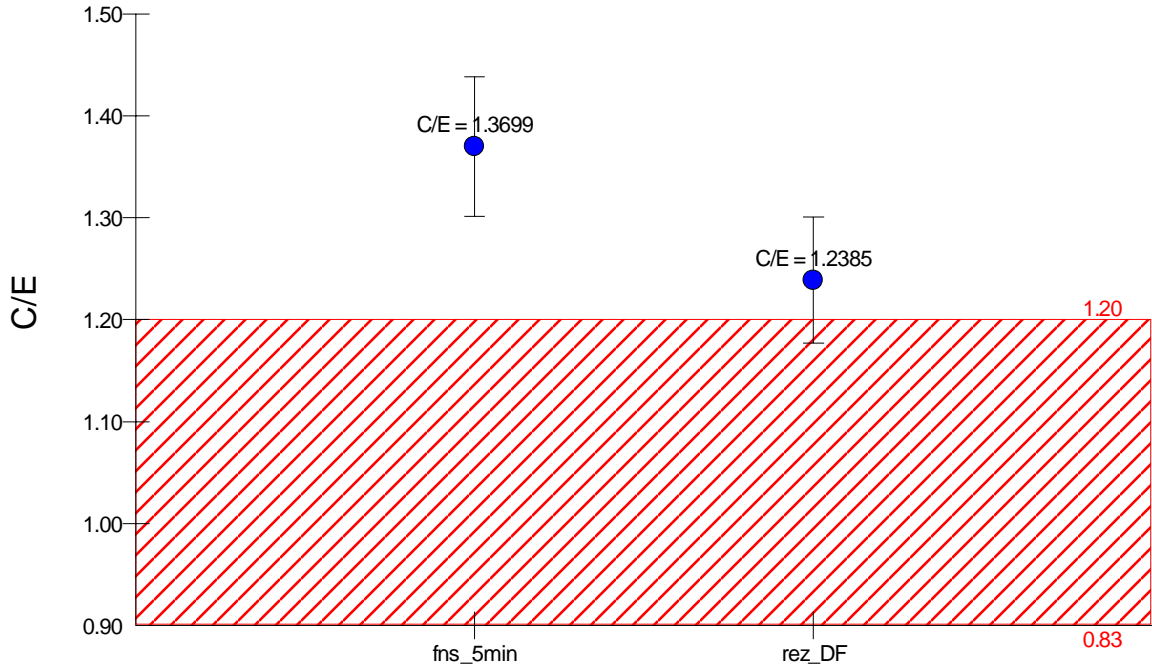
$^{197}\text{Au}(n,2n)^{196\text{m}}\text{Au}$



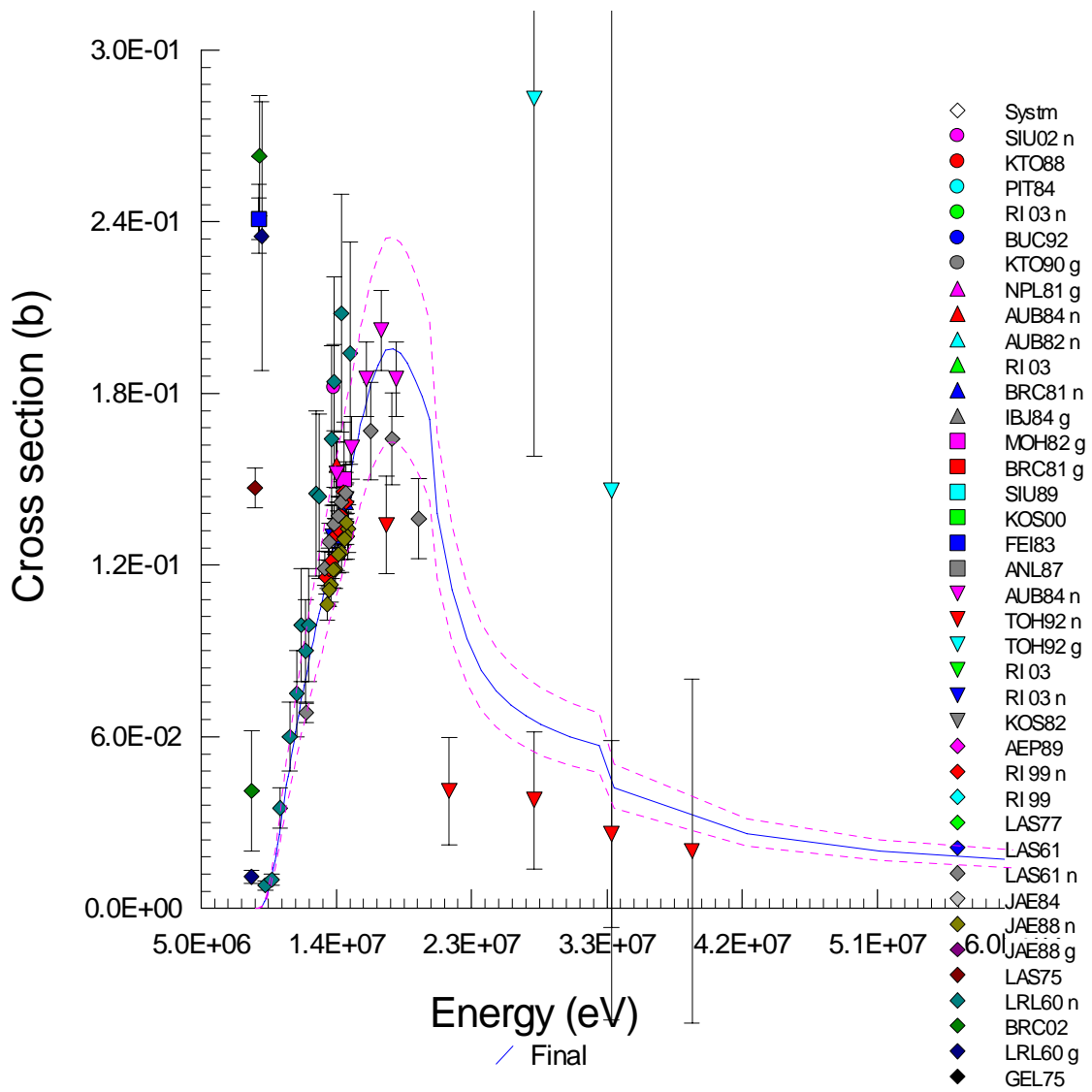
Neutron Spectrum



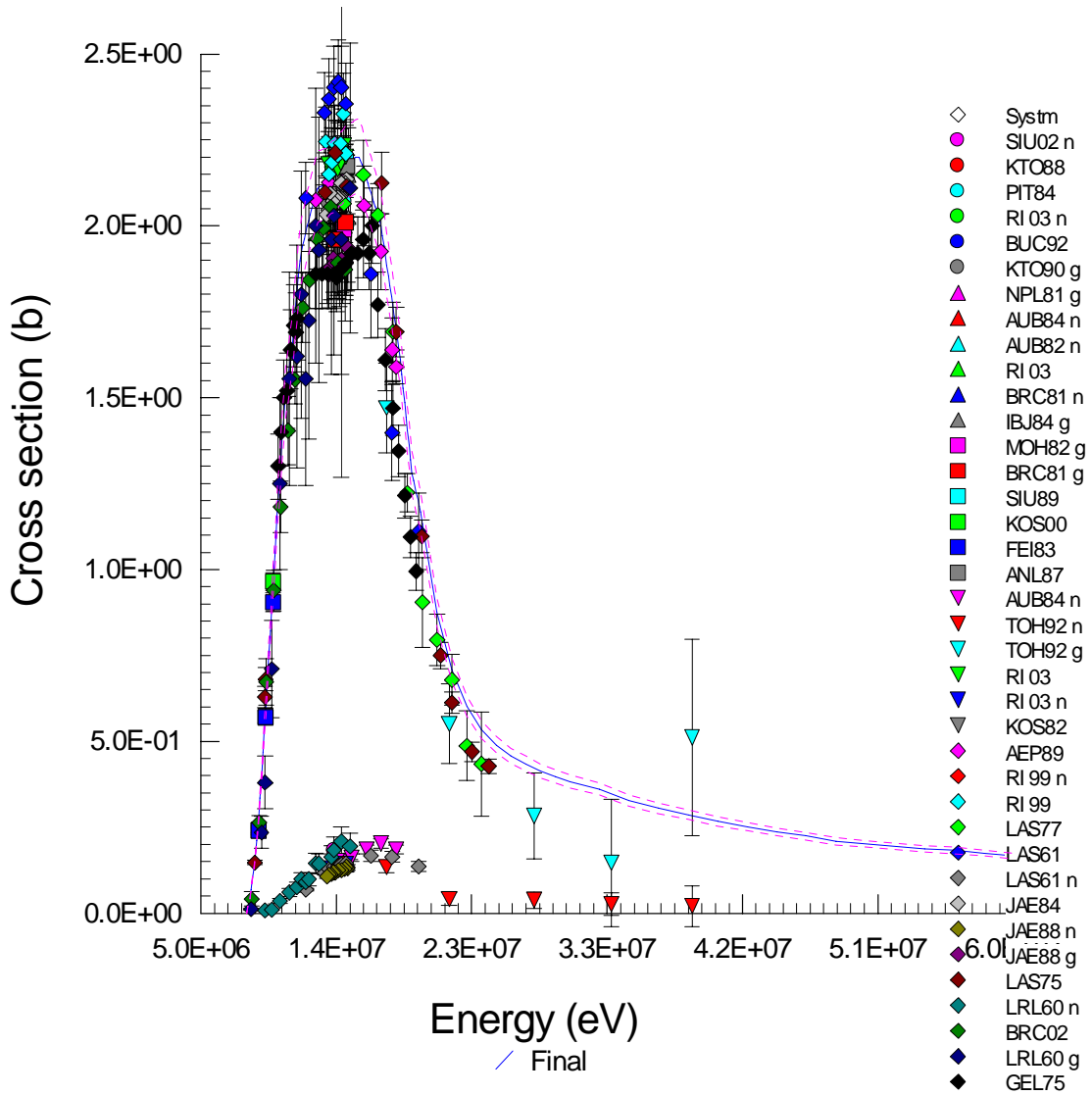
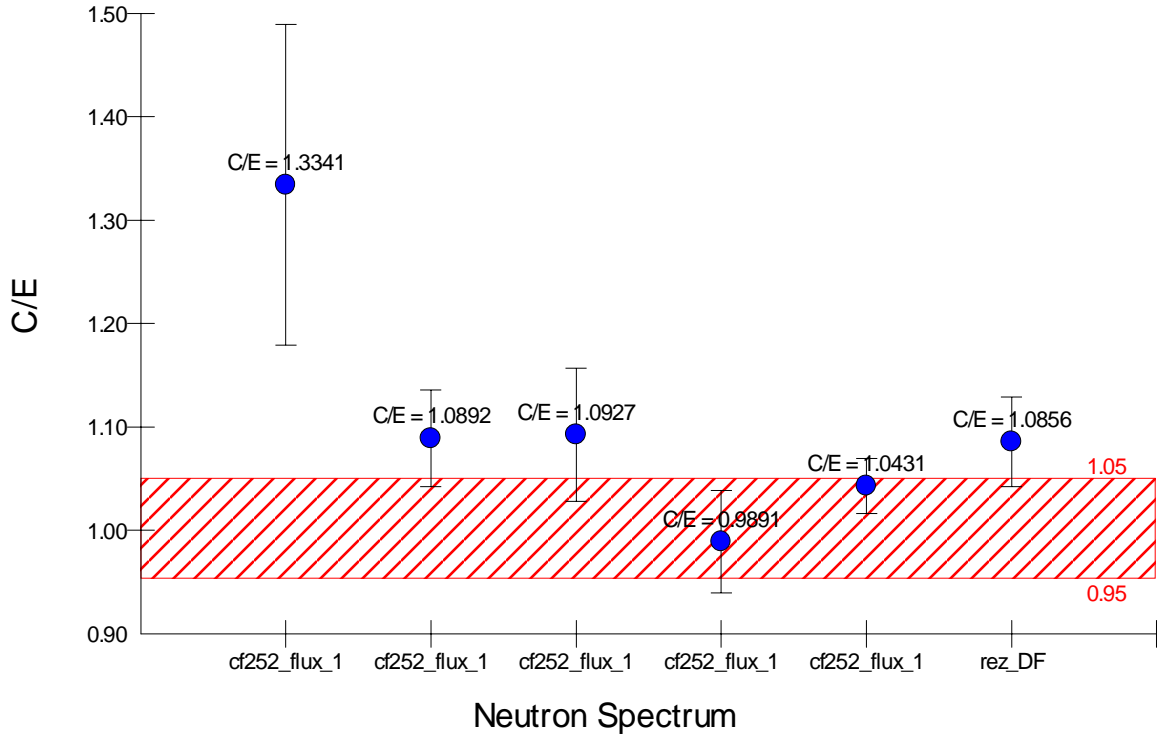
$^{197}\text{Au}(n,2n)^{196\text{n}}\text{Au}$

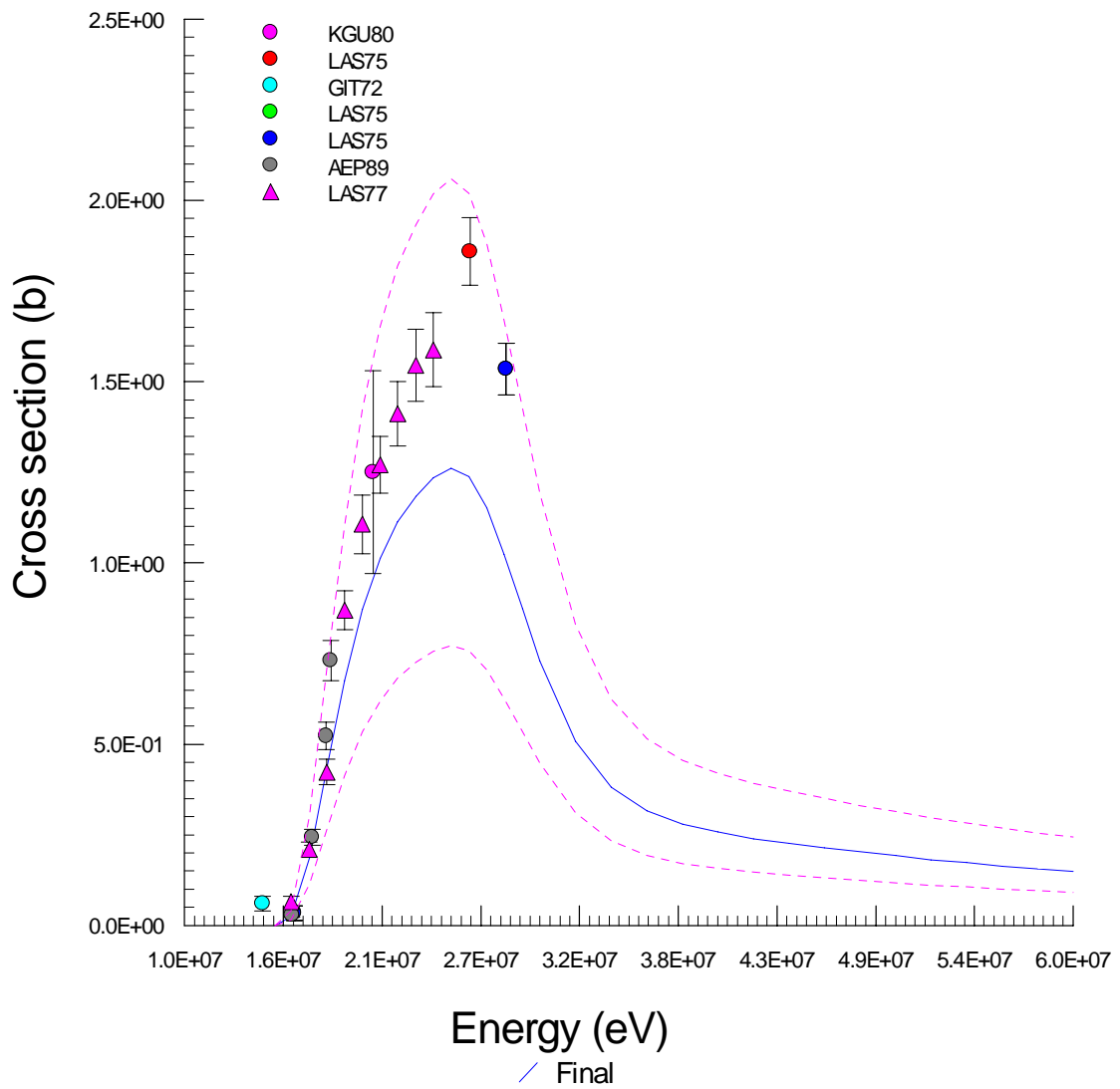
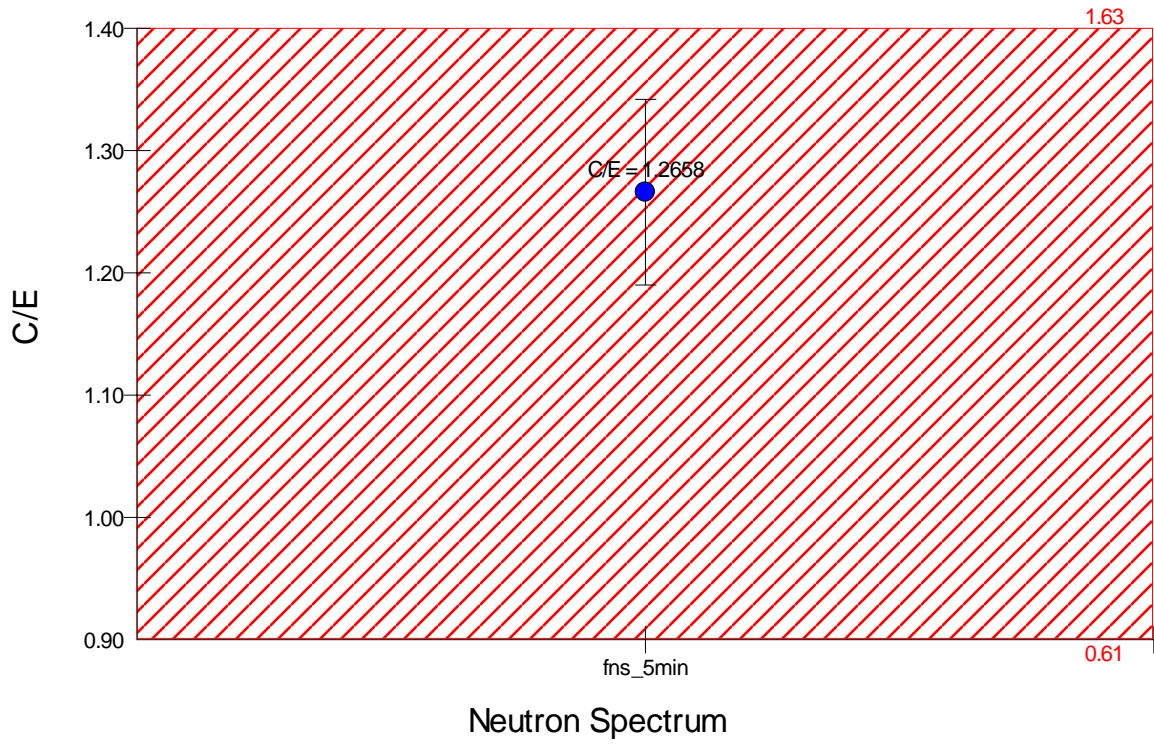
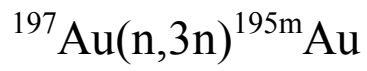


Neutron Spectrum

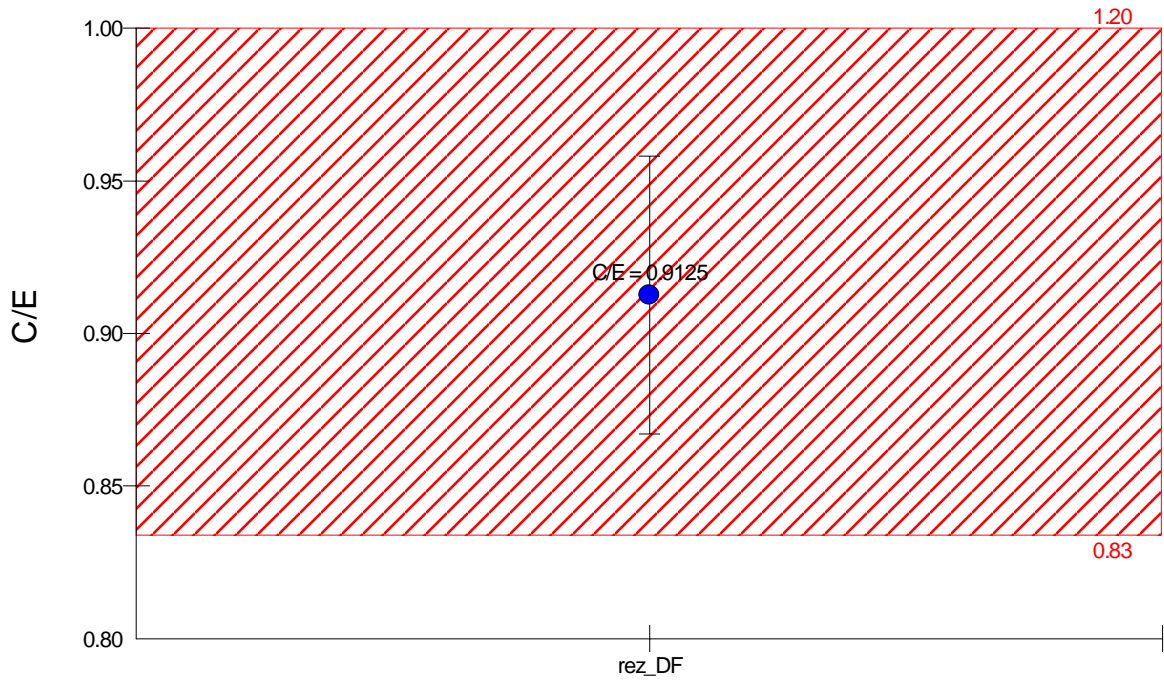


$^{197}\text{Au}(n,2n)^{196}\text{Au}$

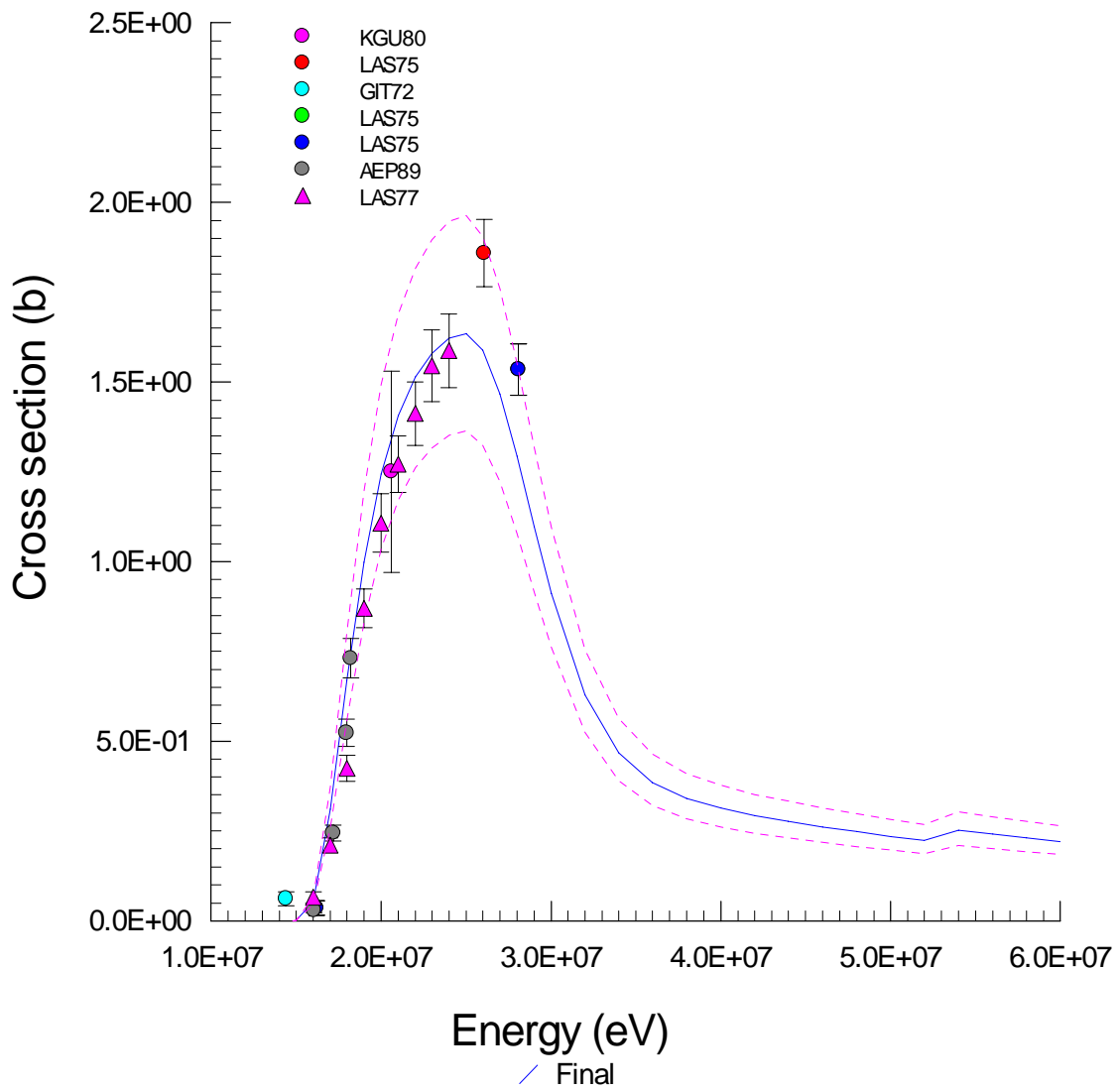


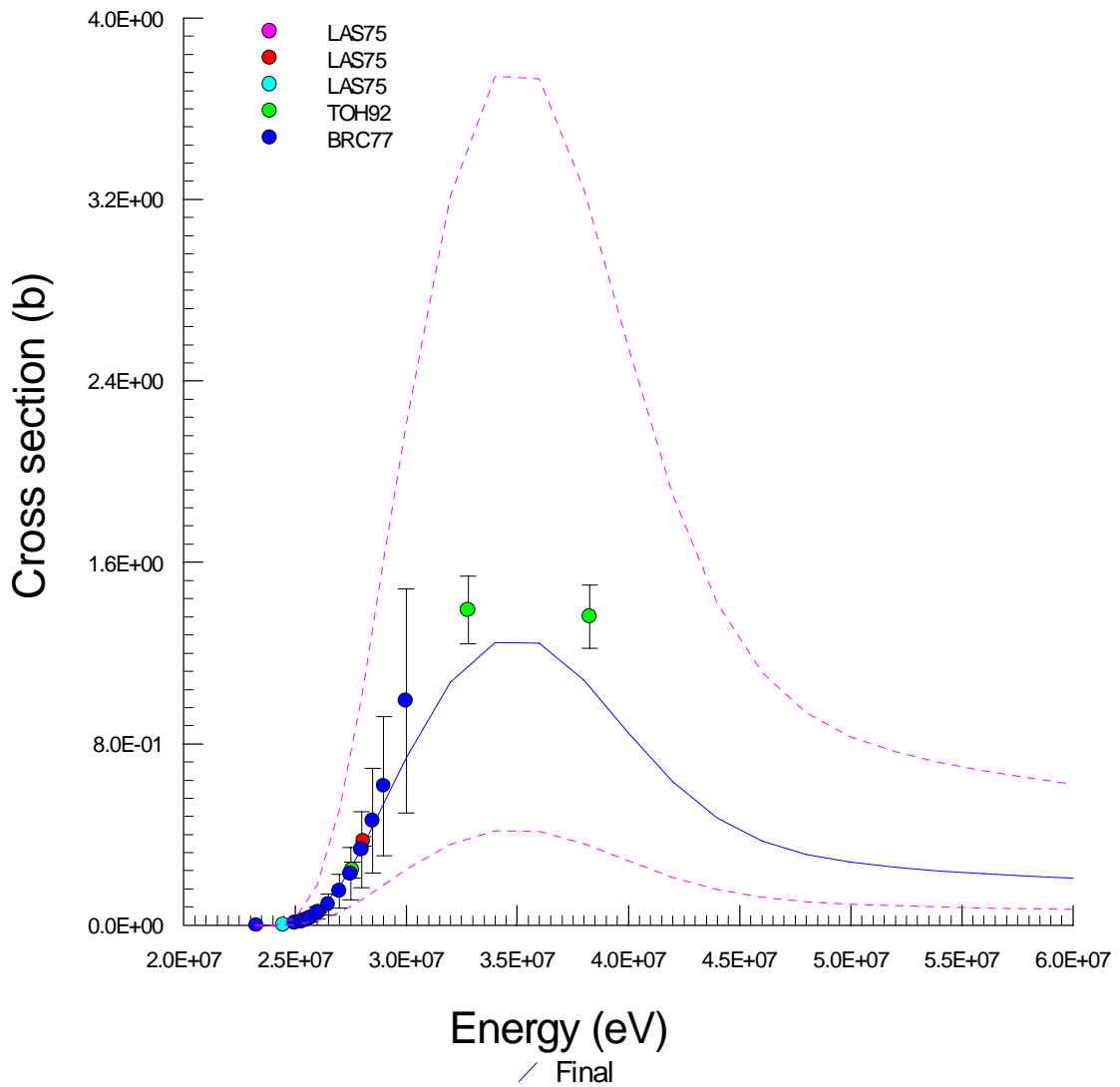
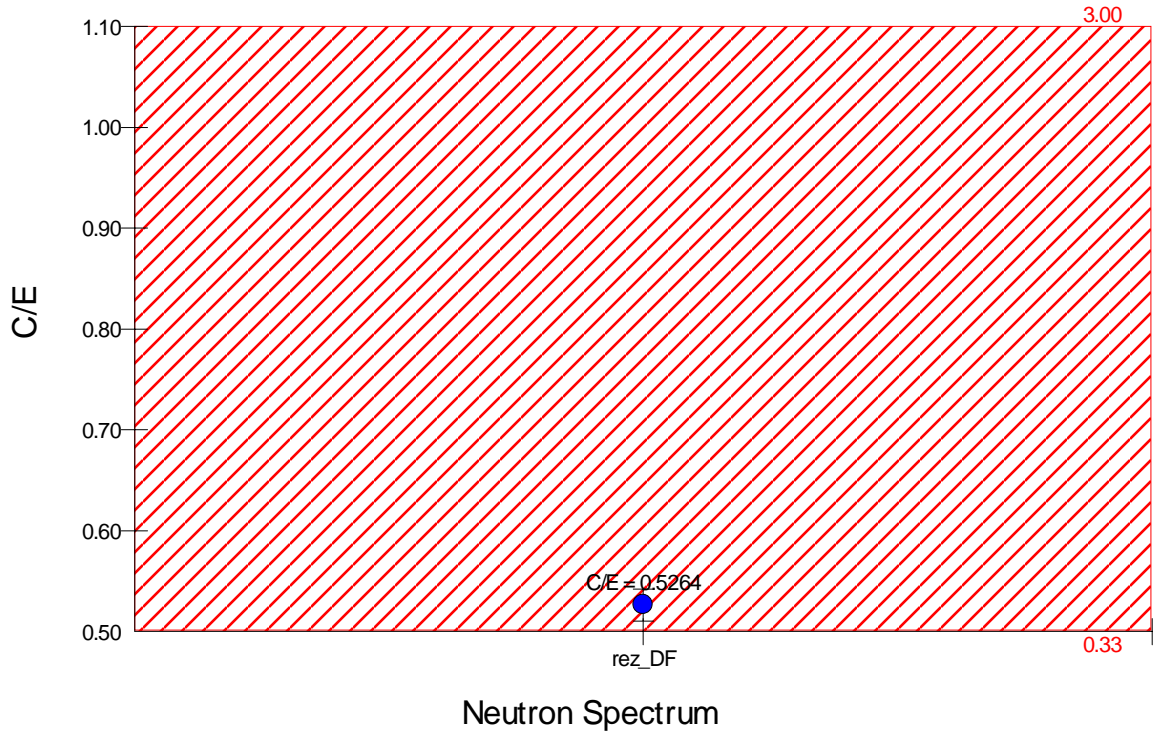
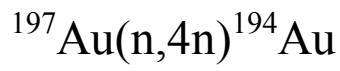


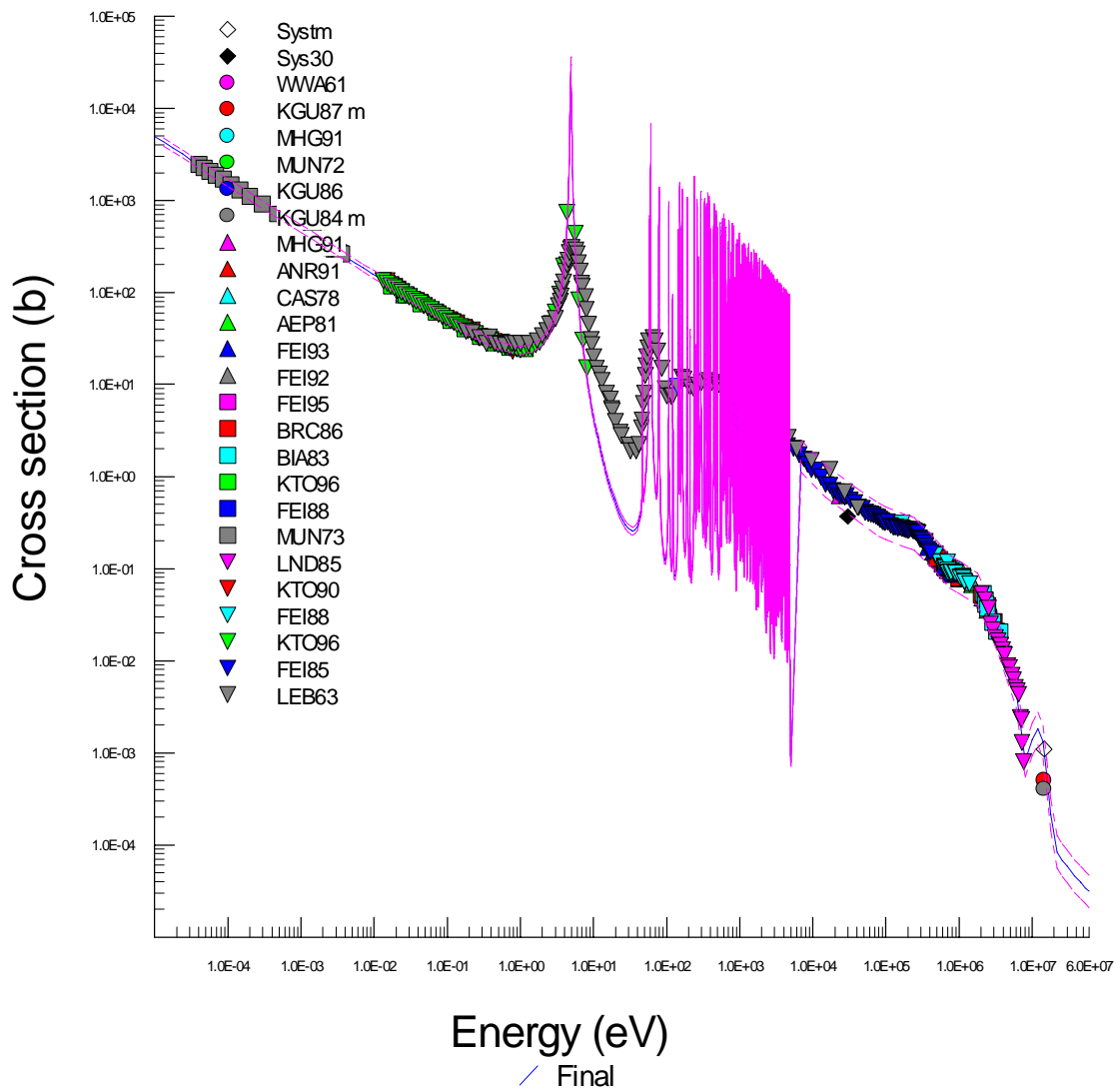
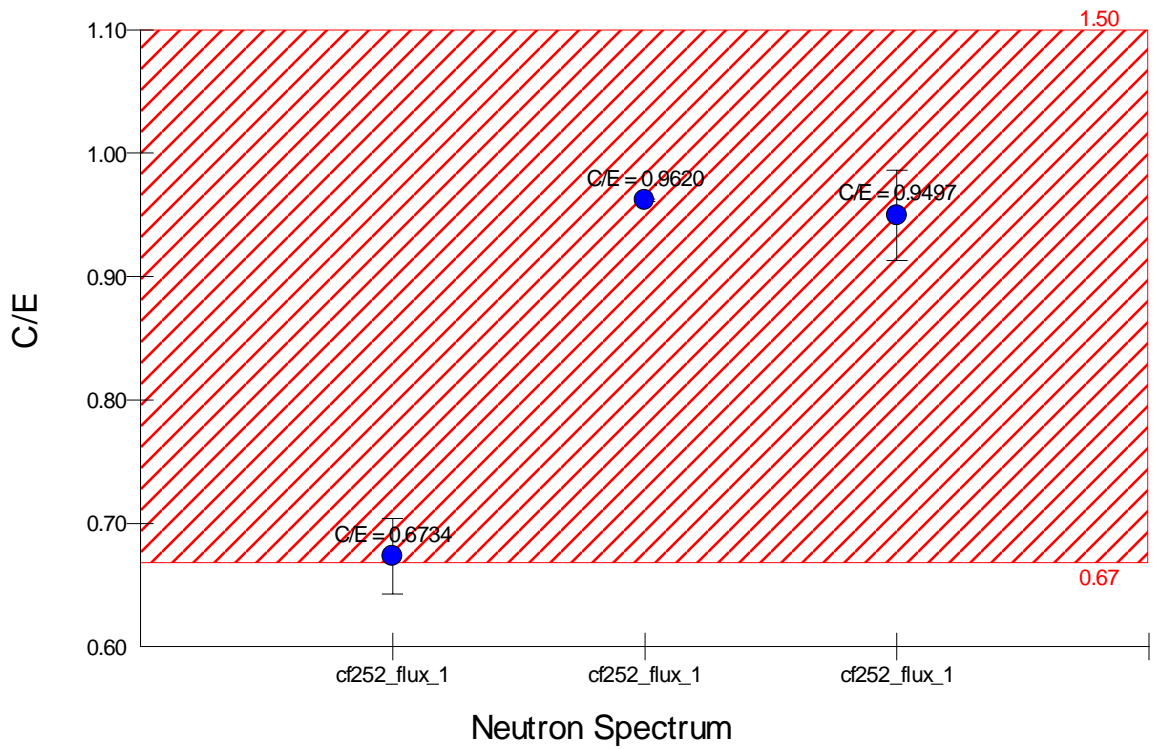
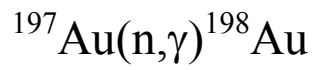
$^{197}\text{Au}(n,3n)^{195}\text{Au}$



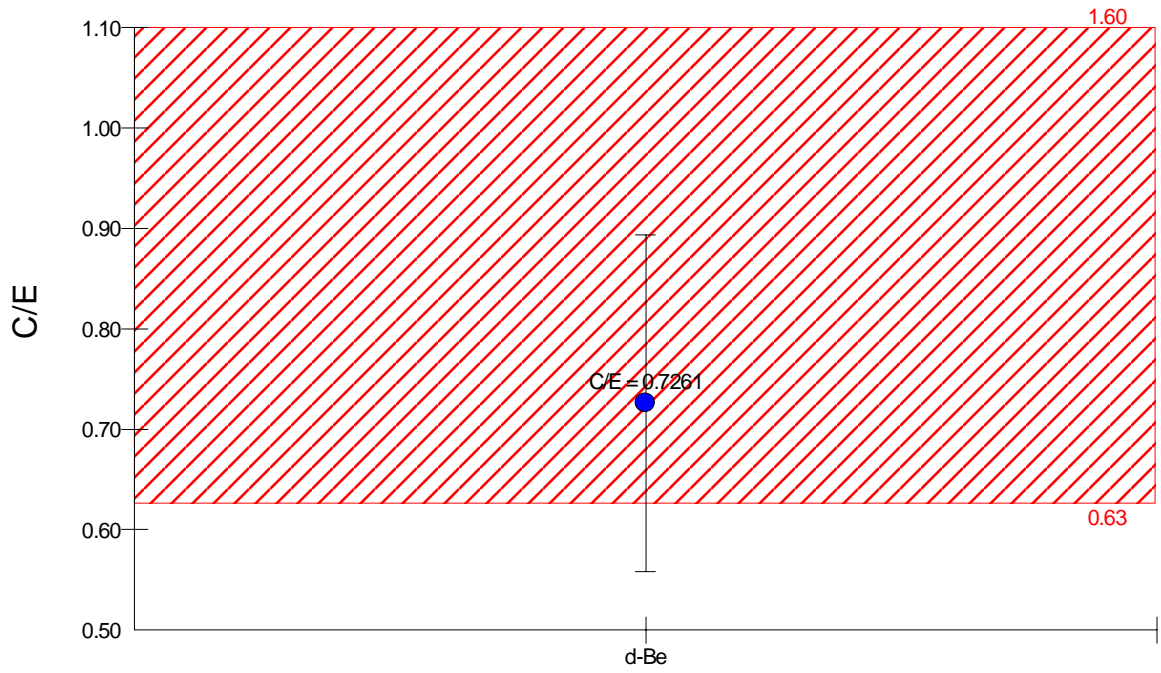
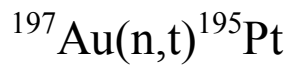
Neutron Spectrum



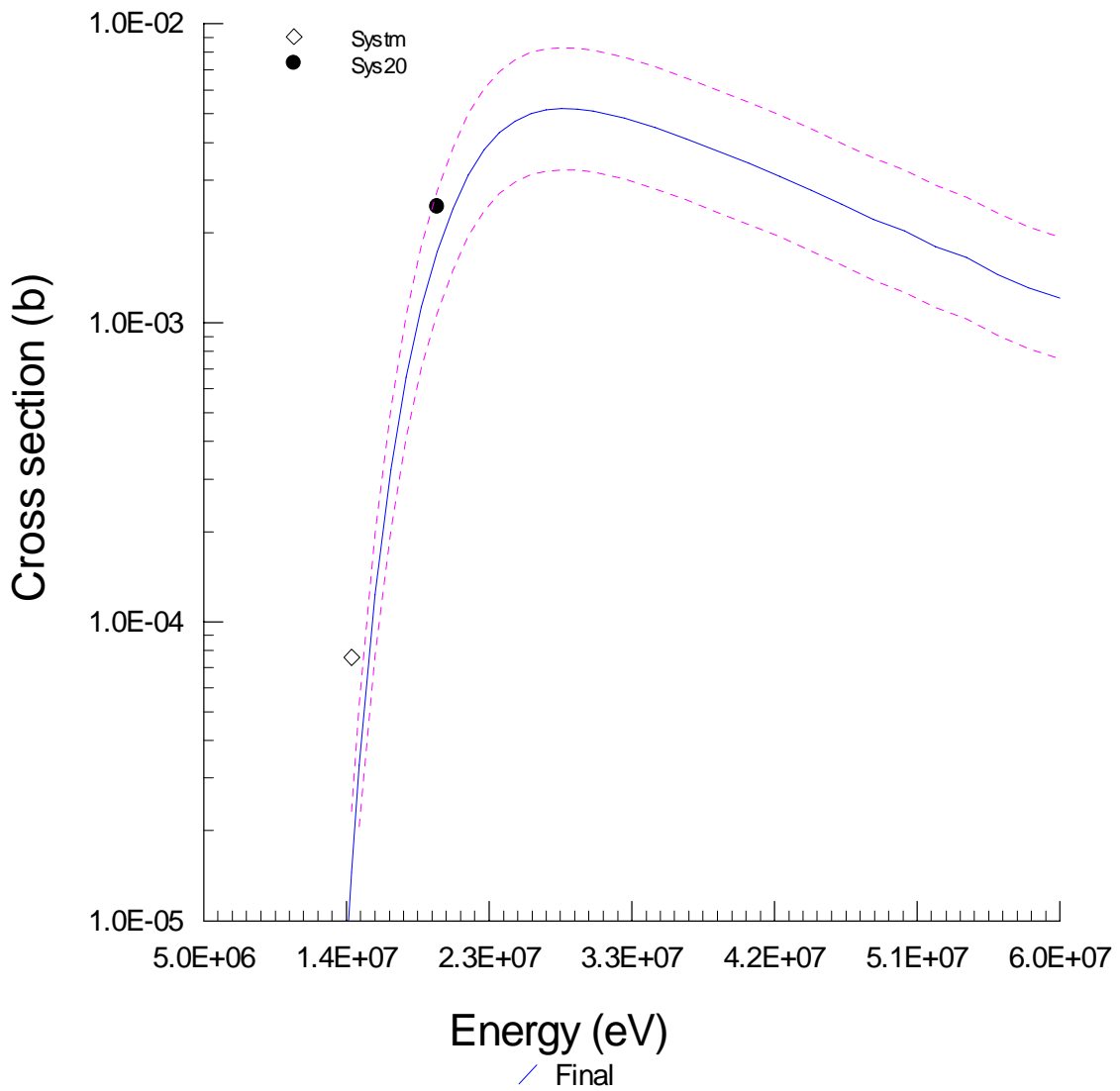


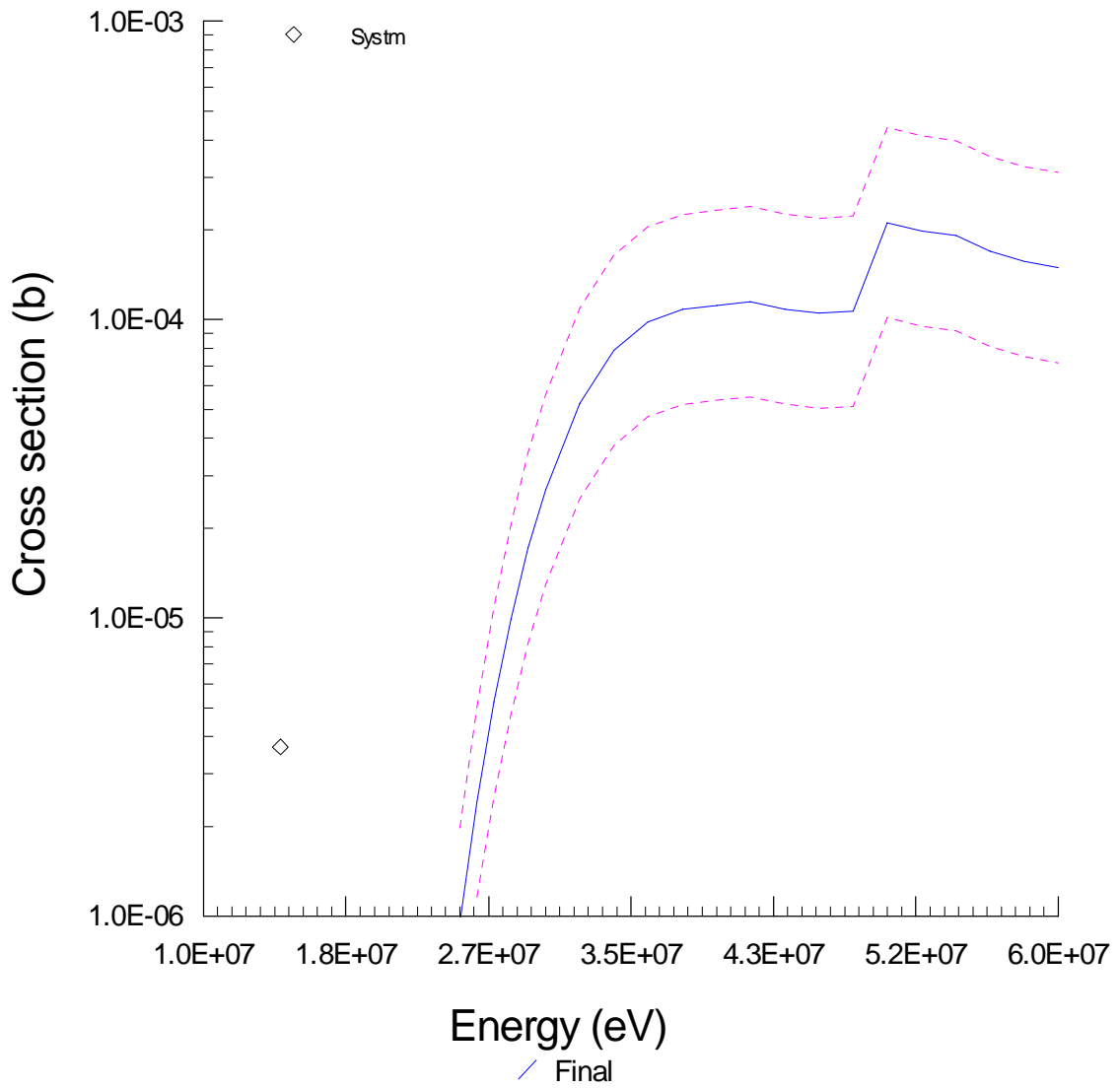
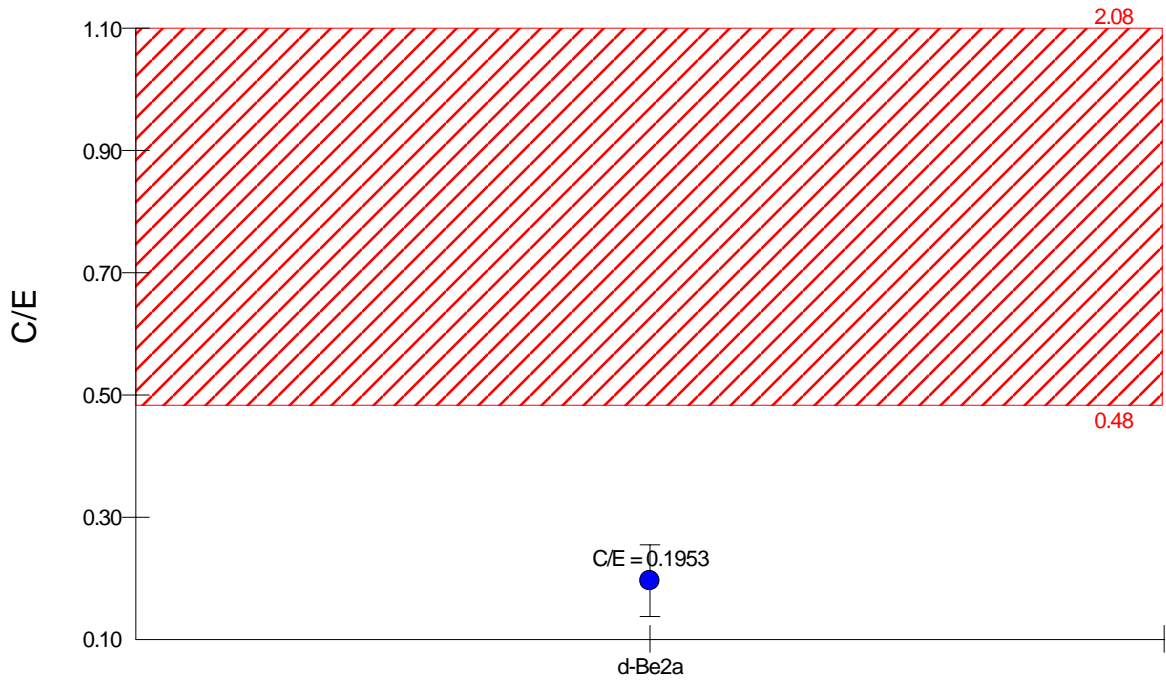
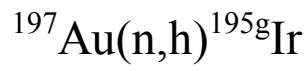


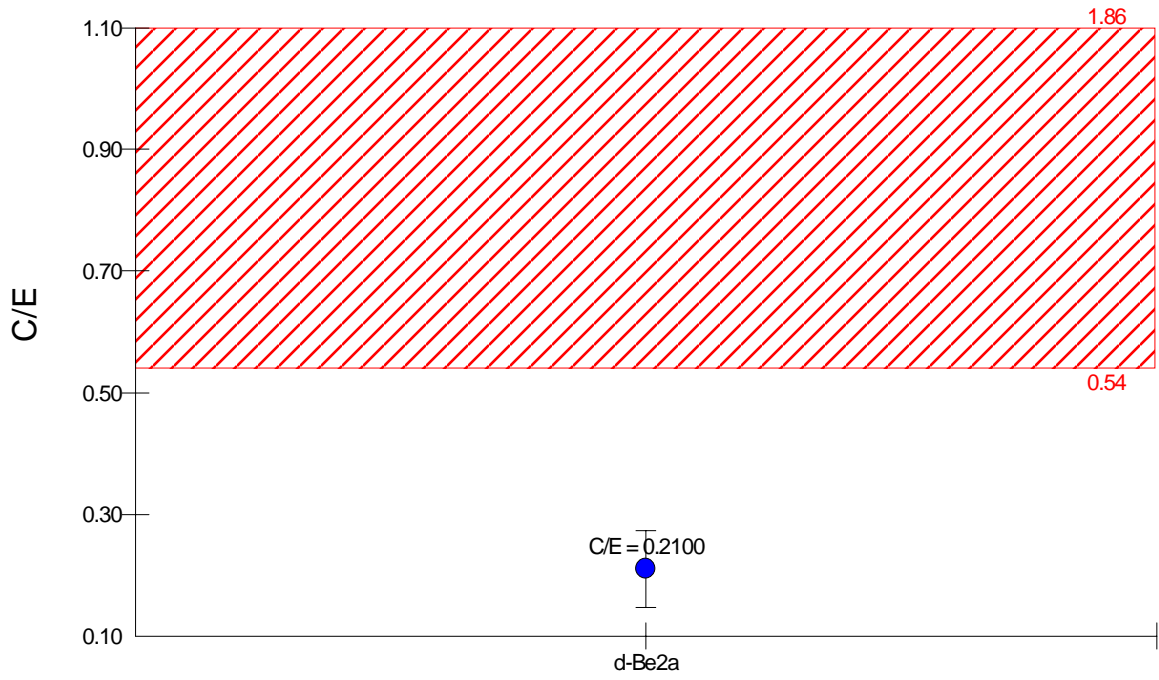
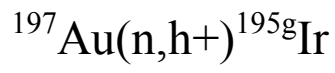




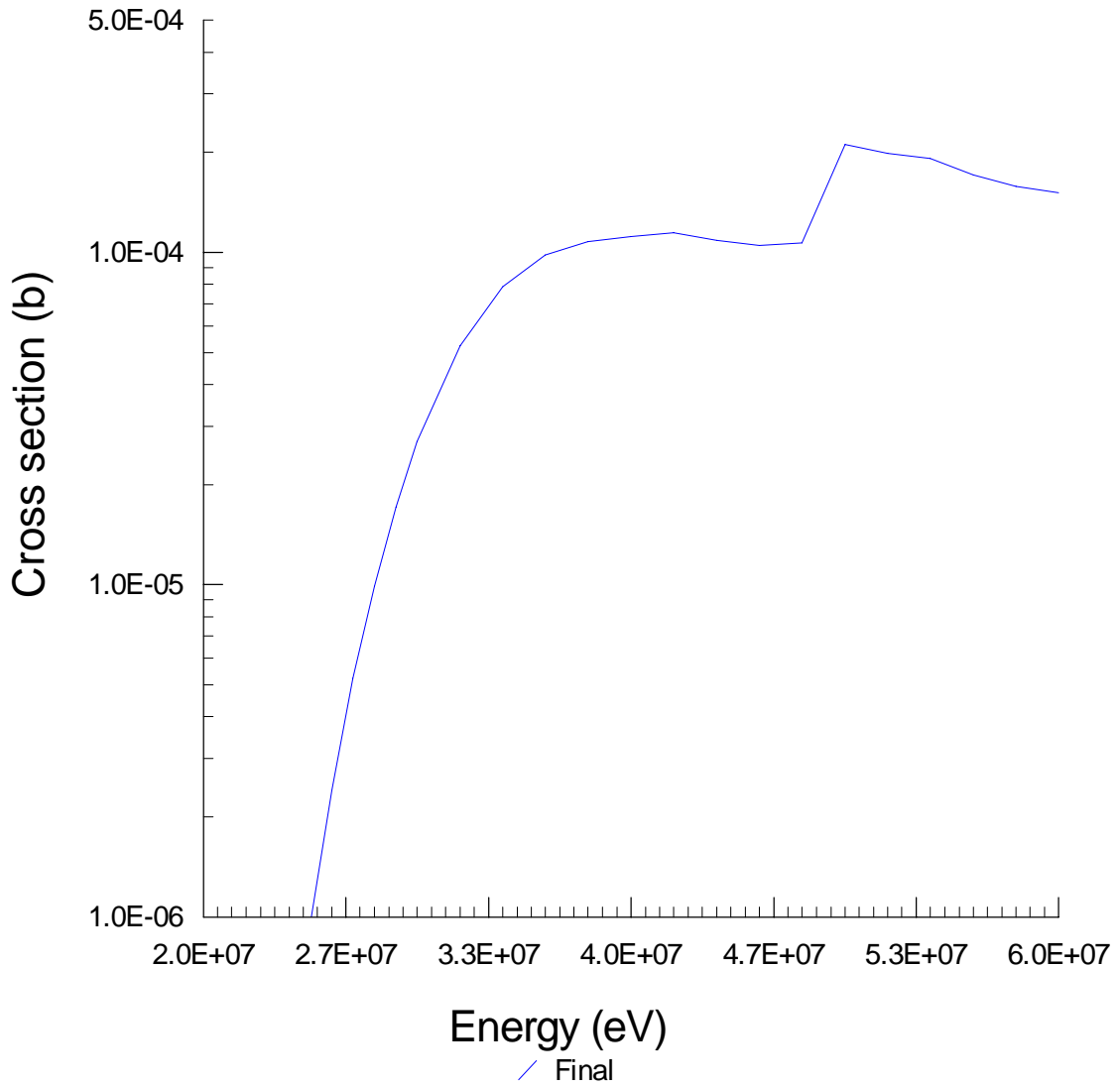
Neutron Spectrum



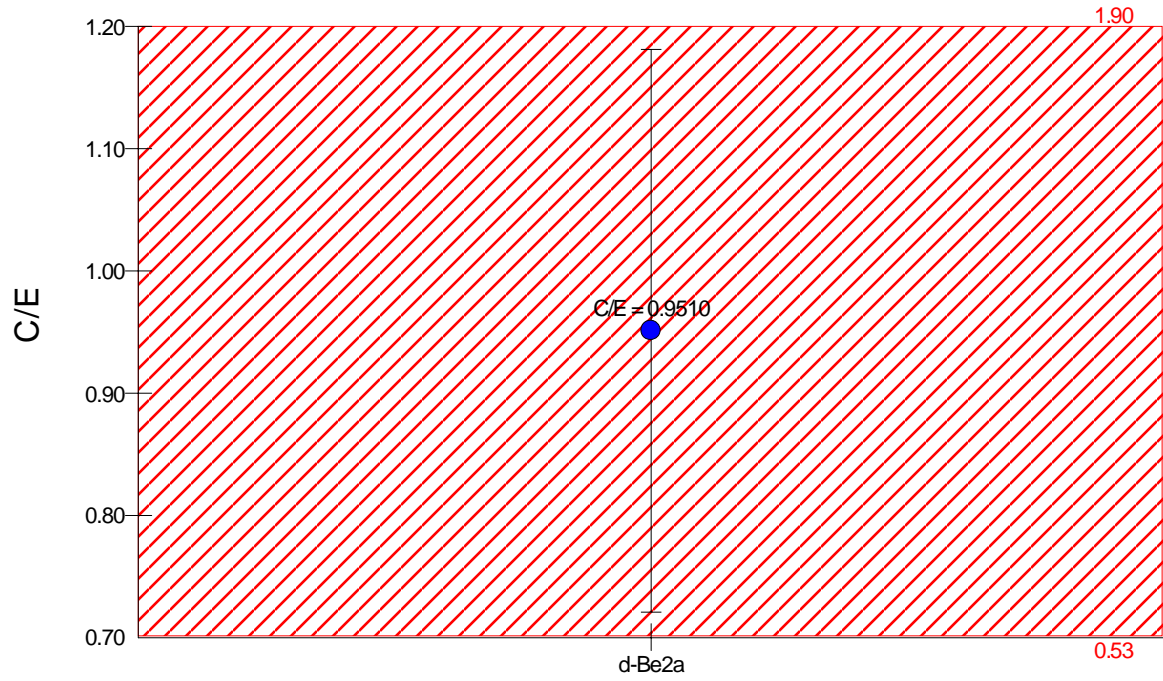




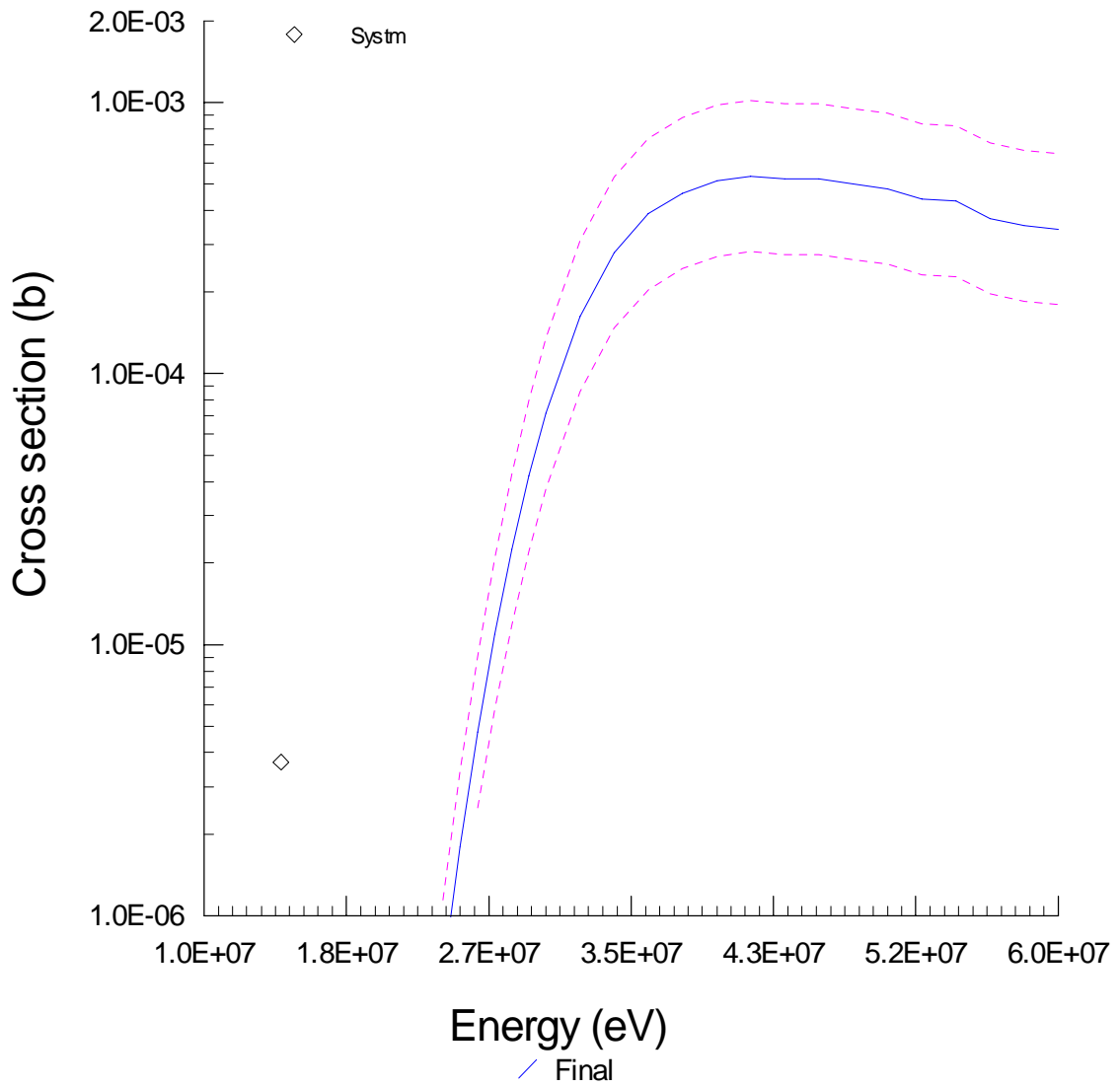
Neutron Spectrum

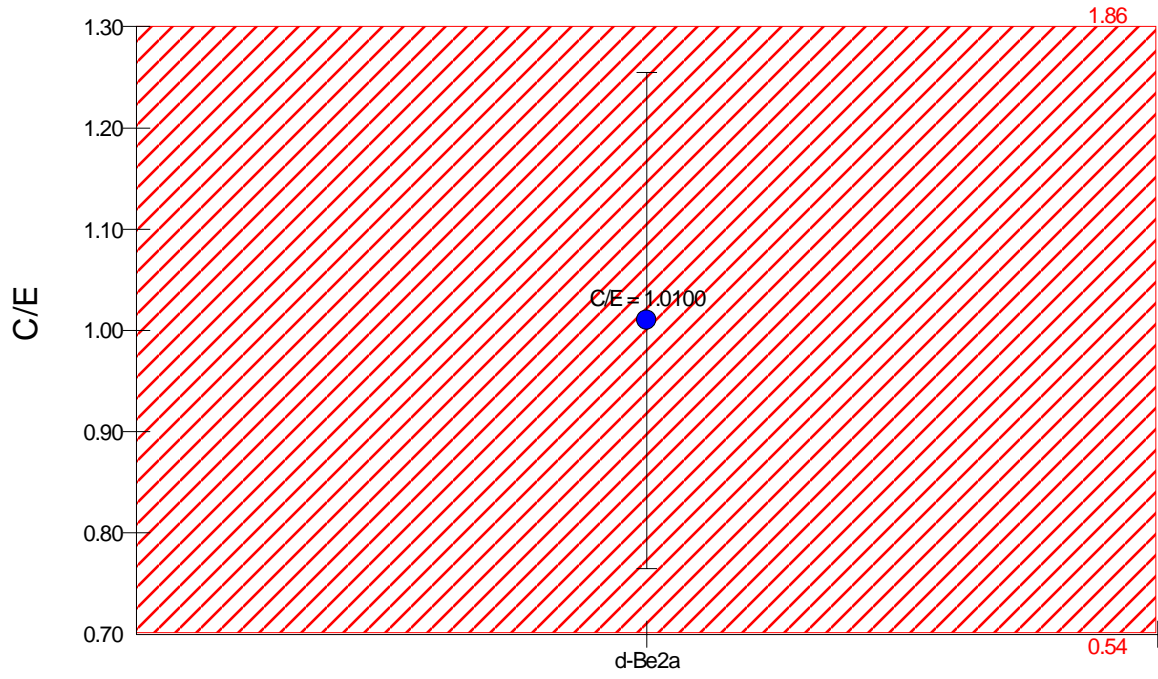
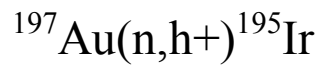


$^{197}\text{Au}(n,h)^{195}\text{Ir}$

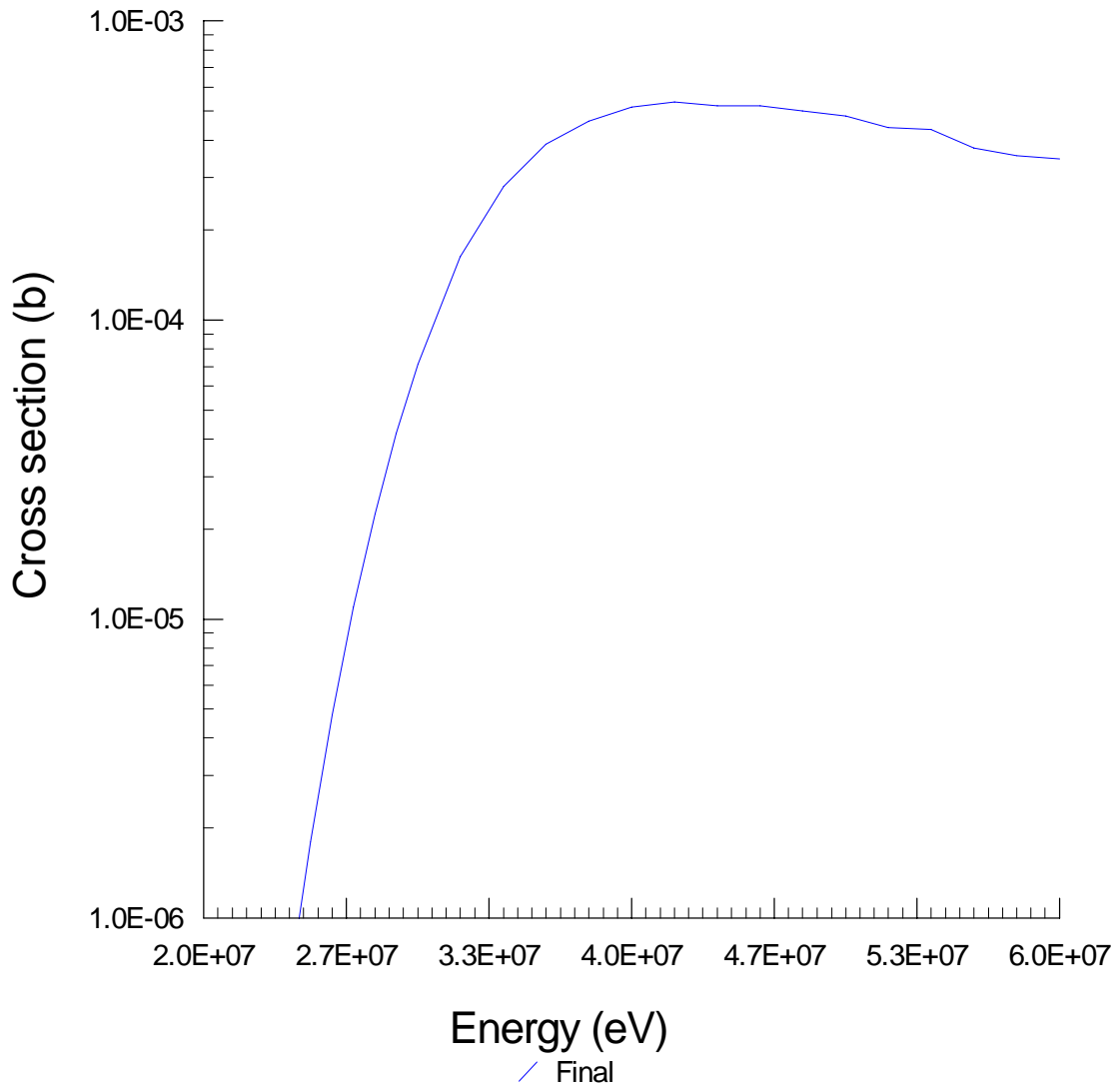


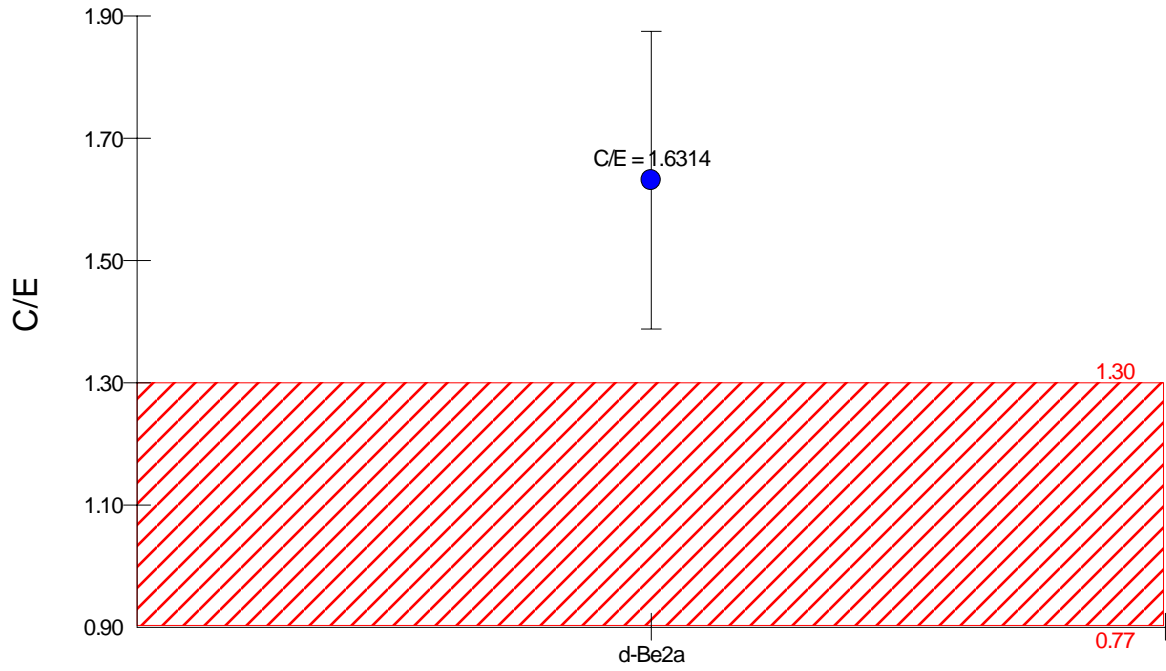
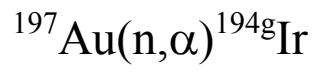
Neutron Spectrum



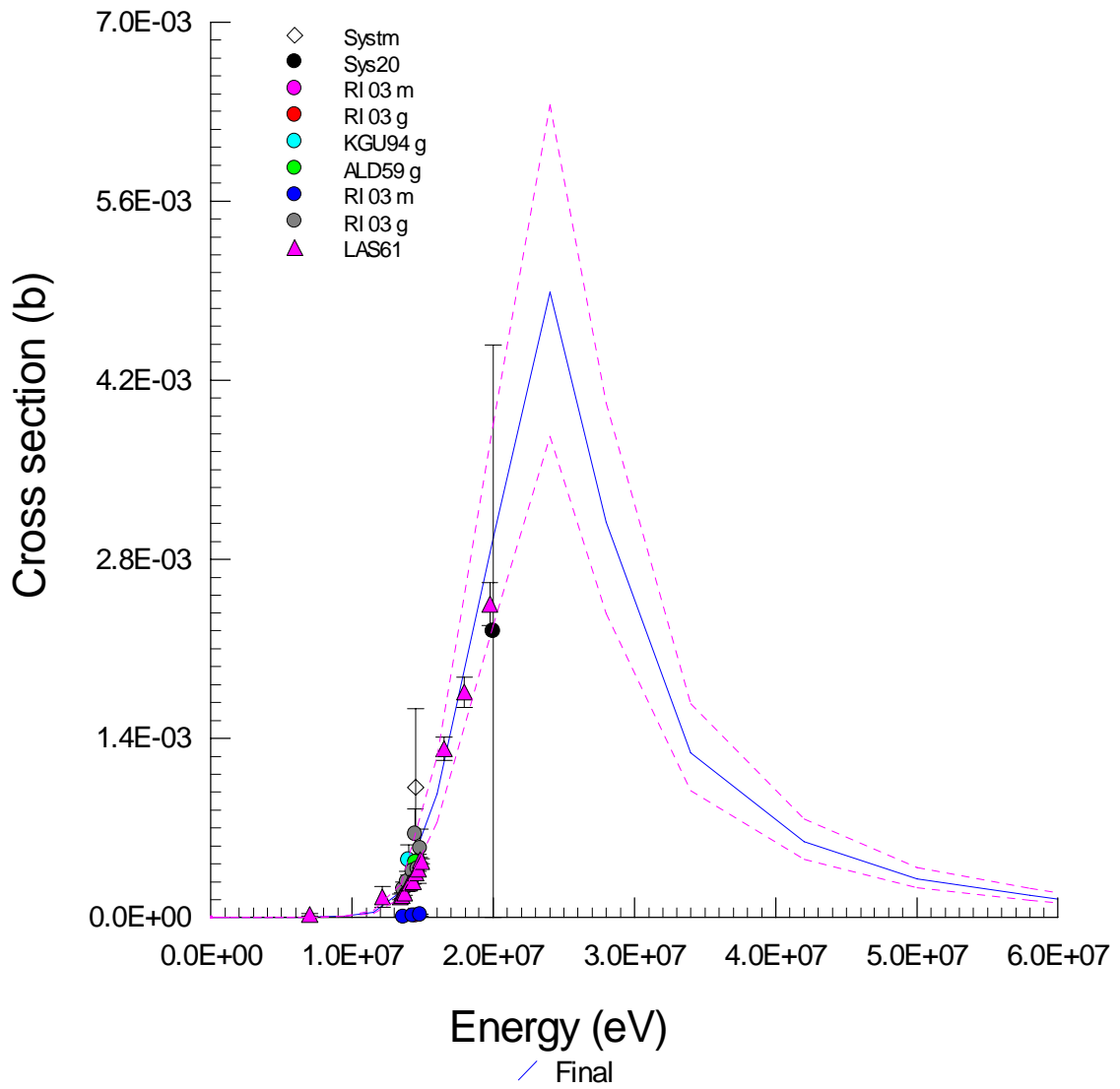


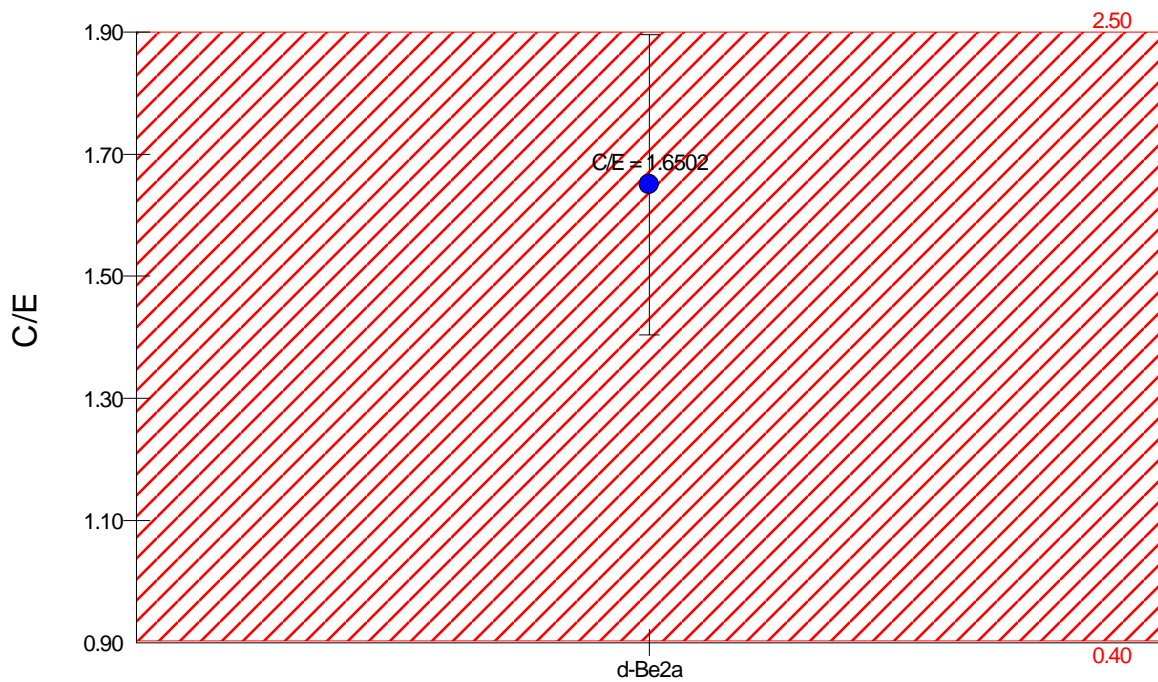
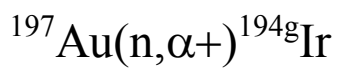
Neutron Spectrum



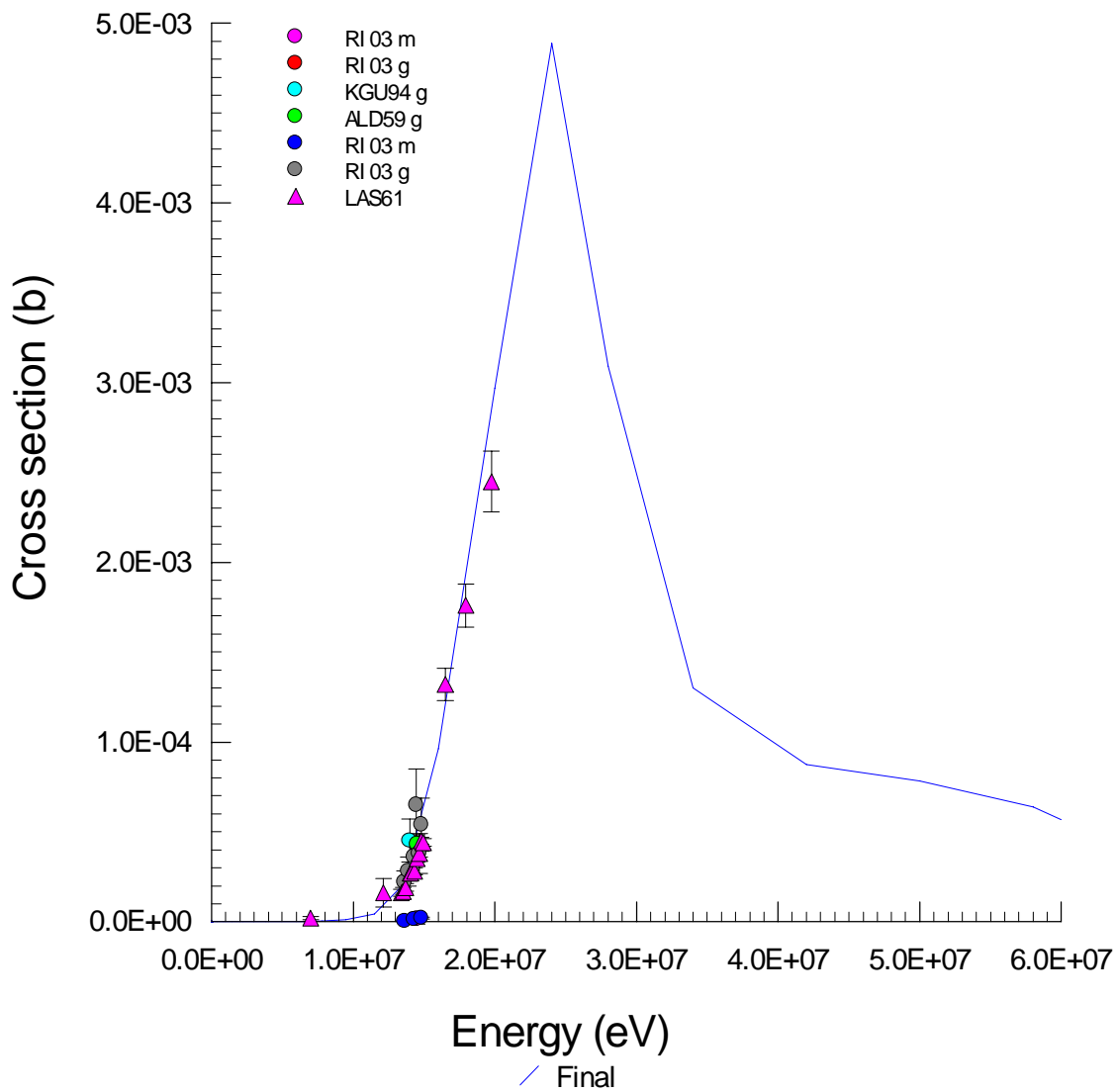


Neutron Spectrum

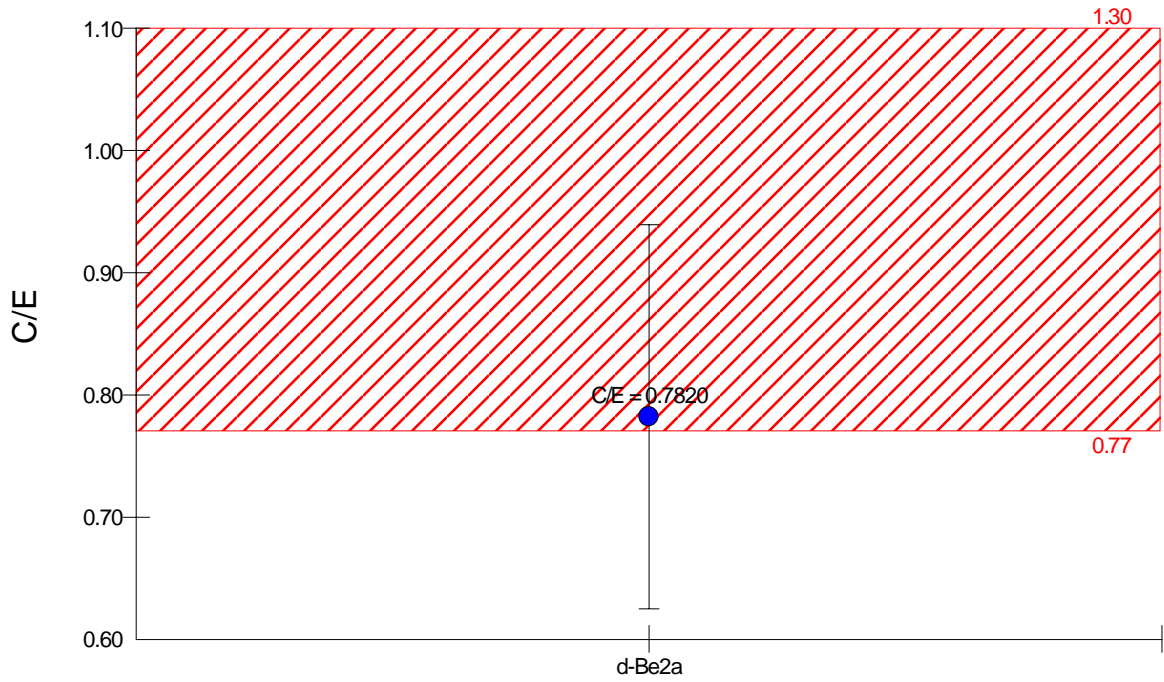




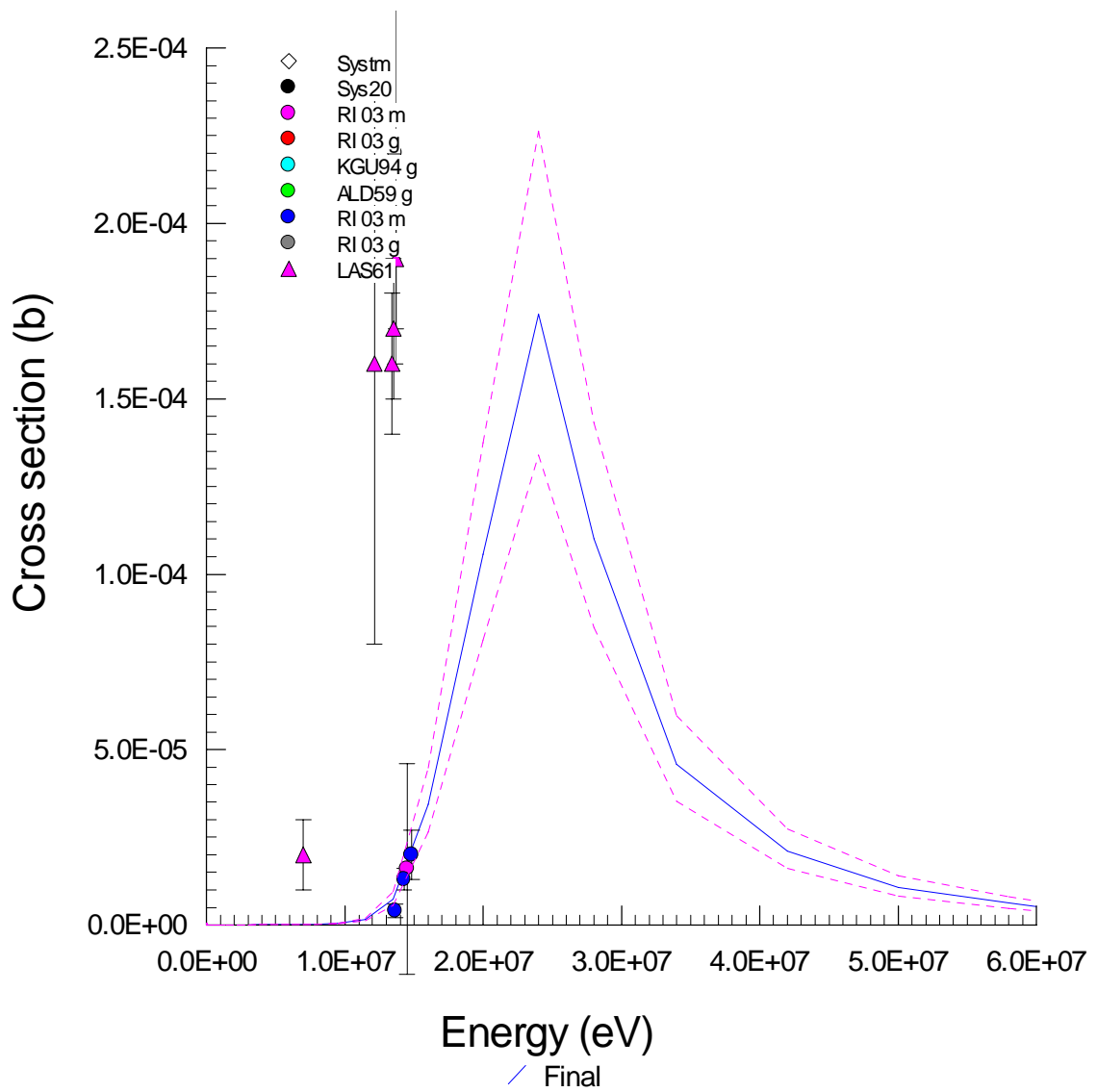
Neutron Spectrum



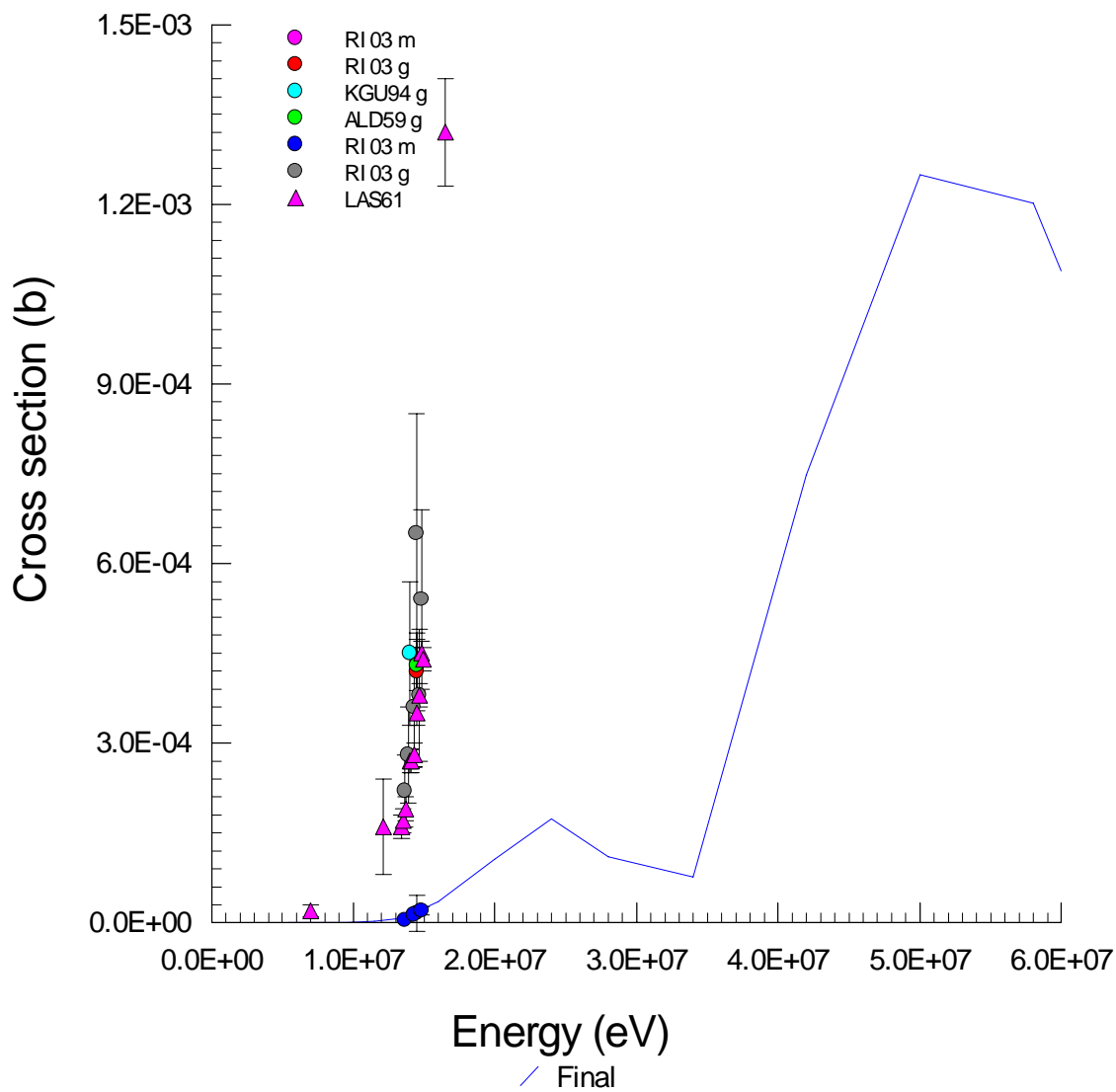
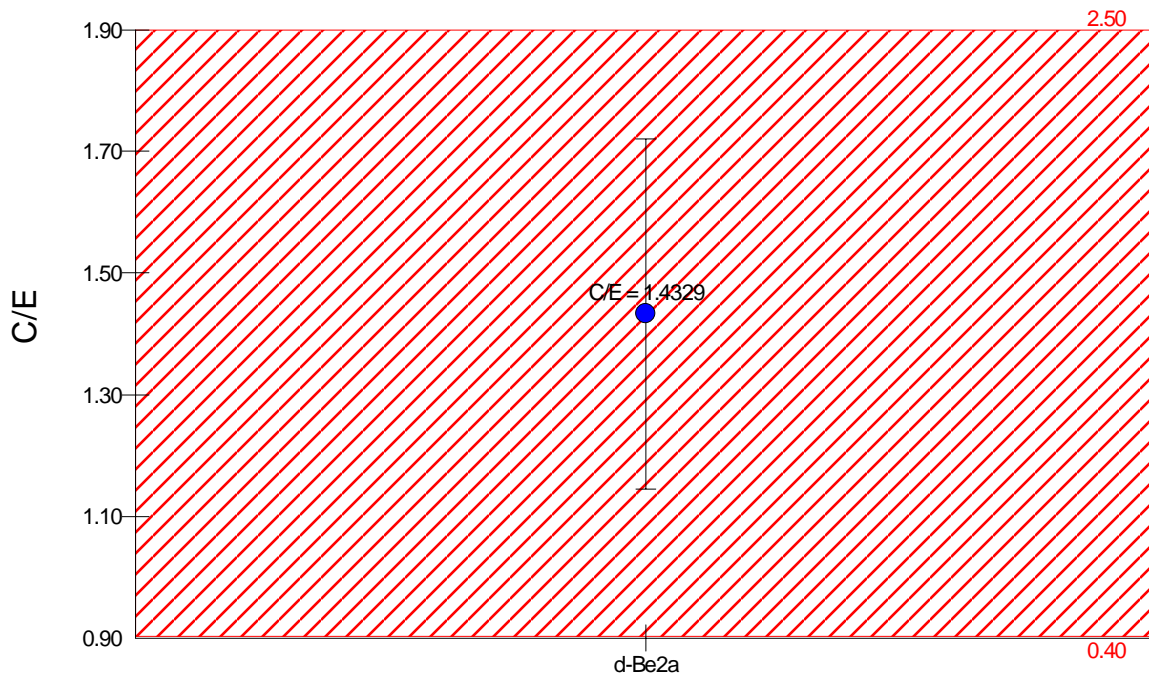
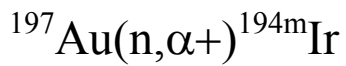
$^{197}\text{Au}(n,\alpha)^{194\text{m}}\text{Ir}$

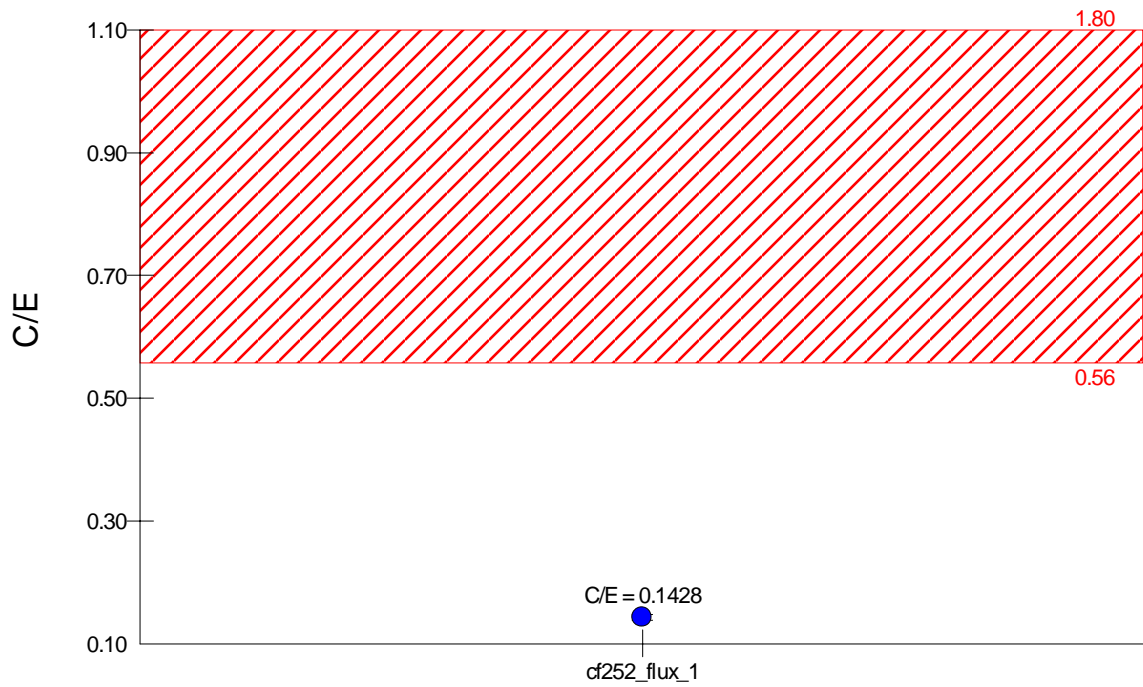
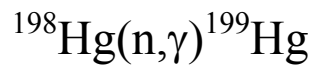


Neutron Spectrum

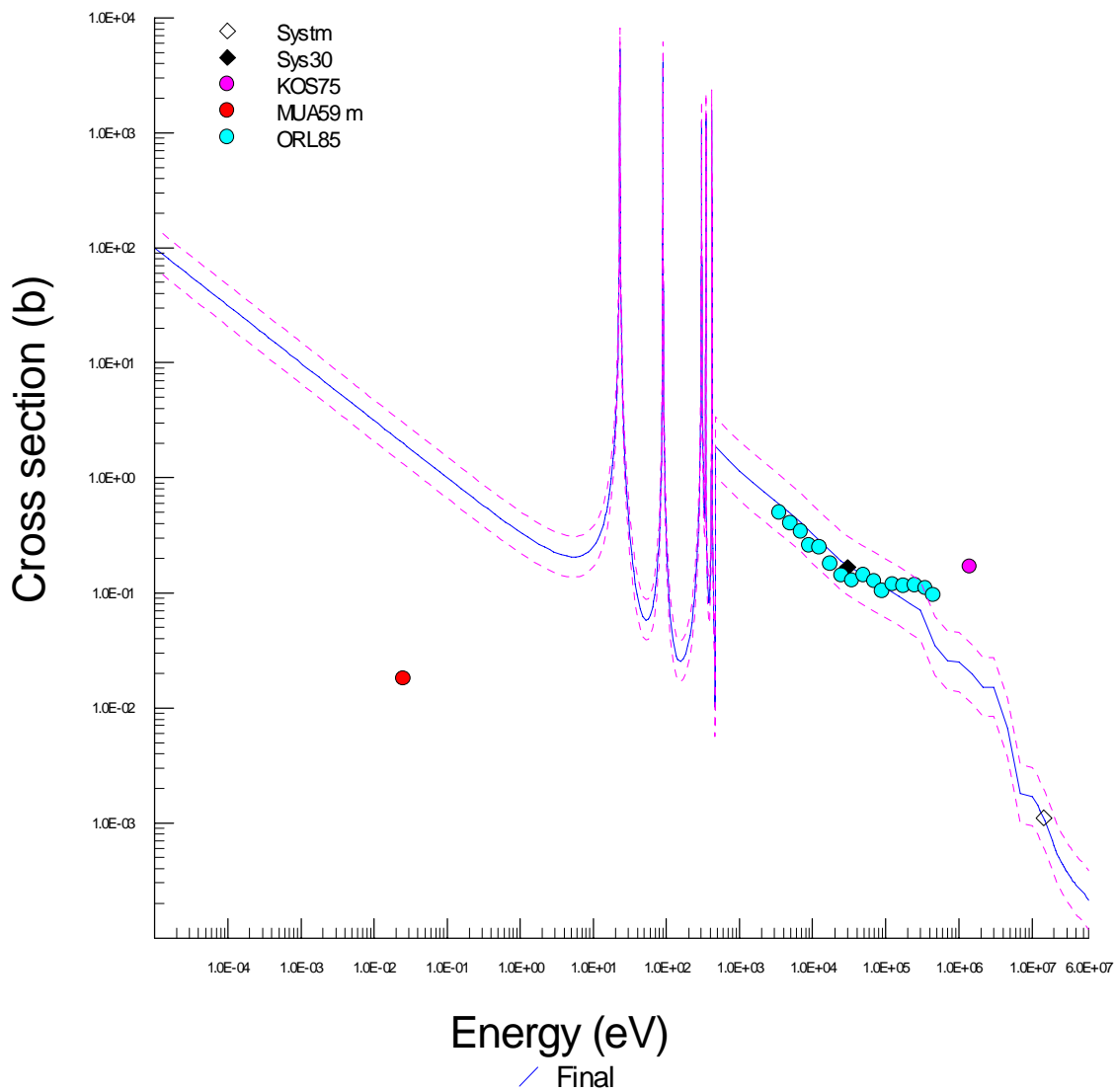


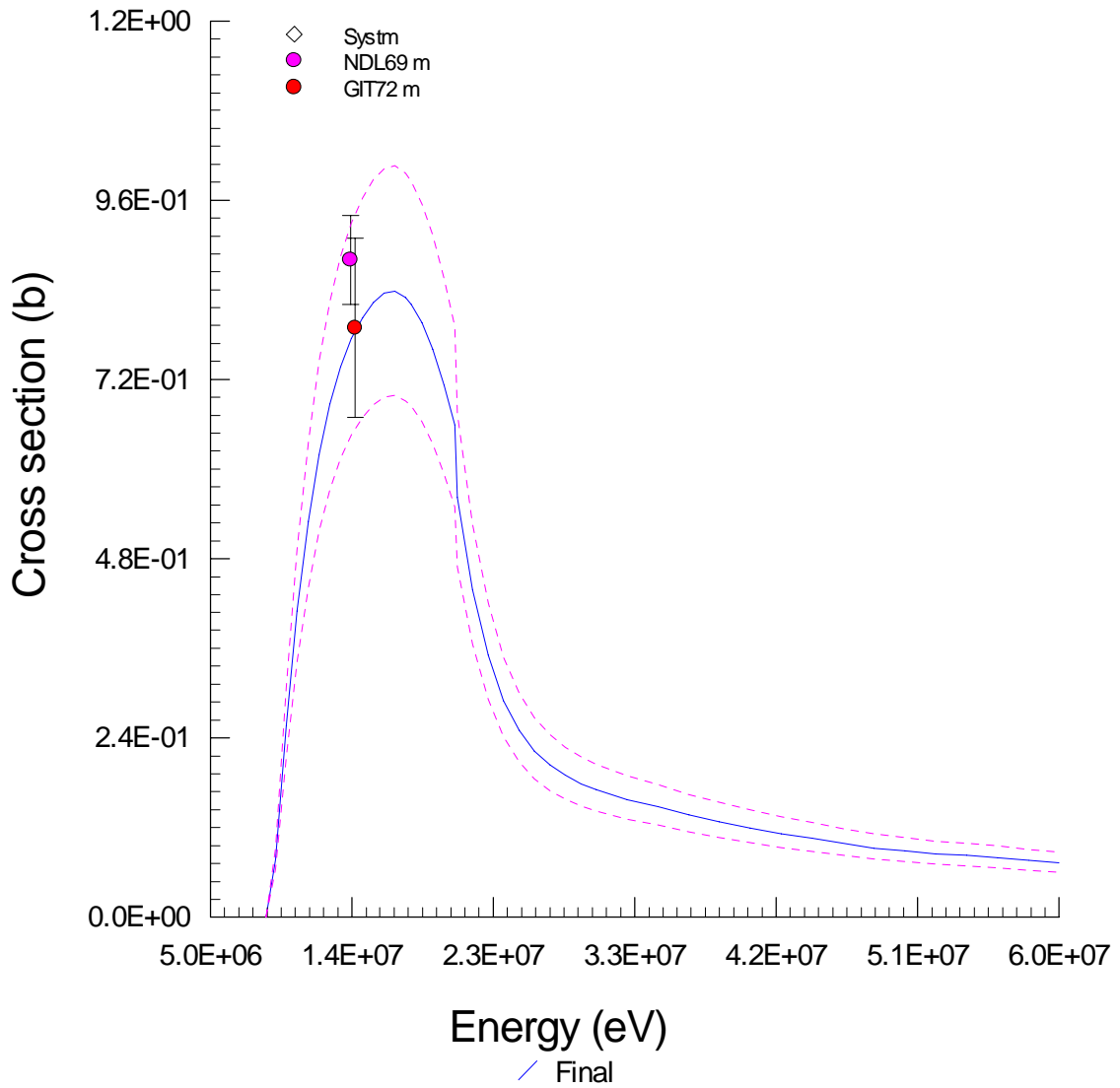
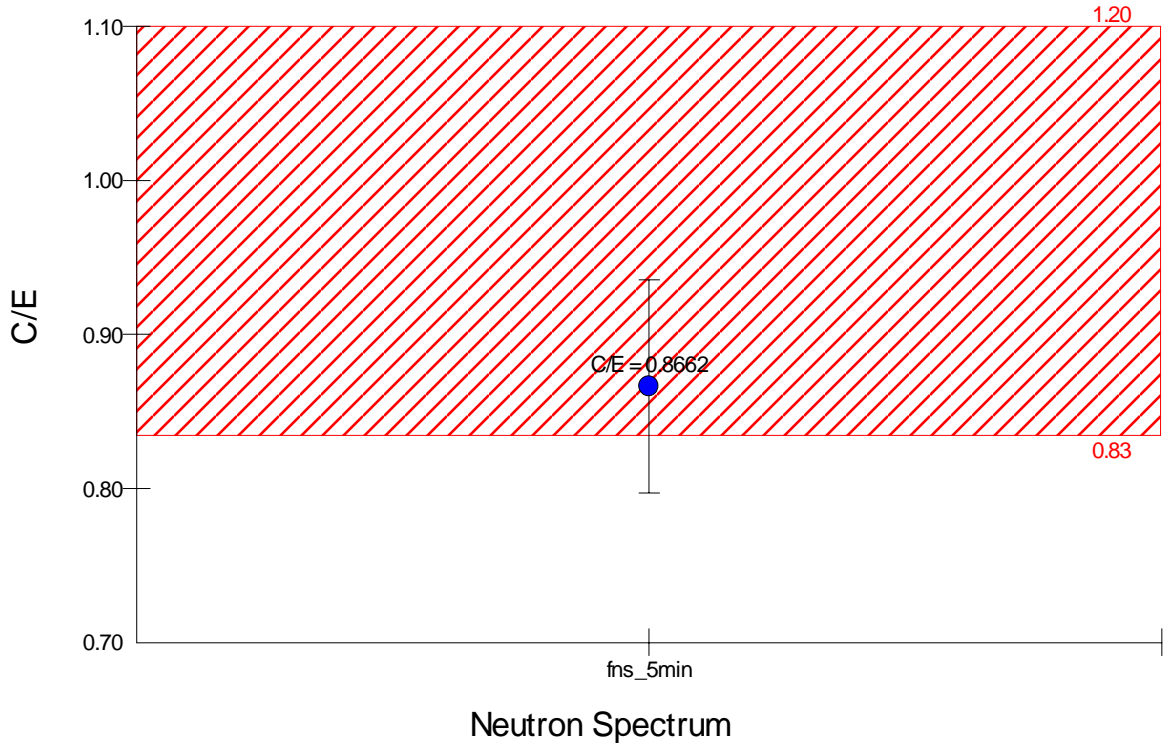
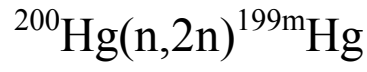


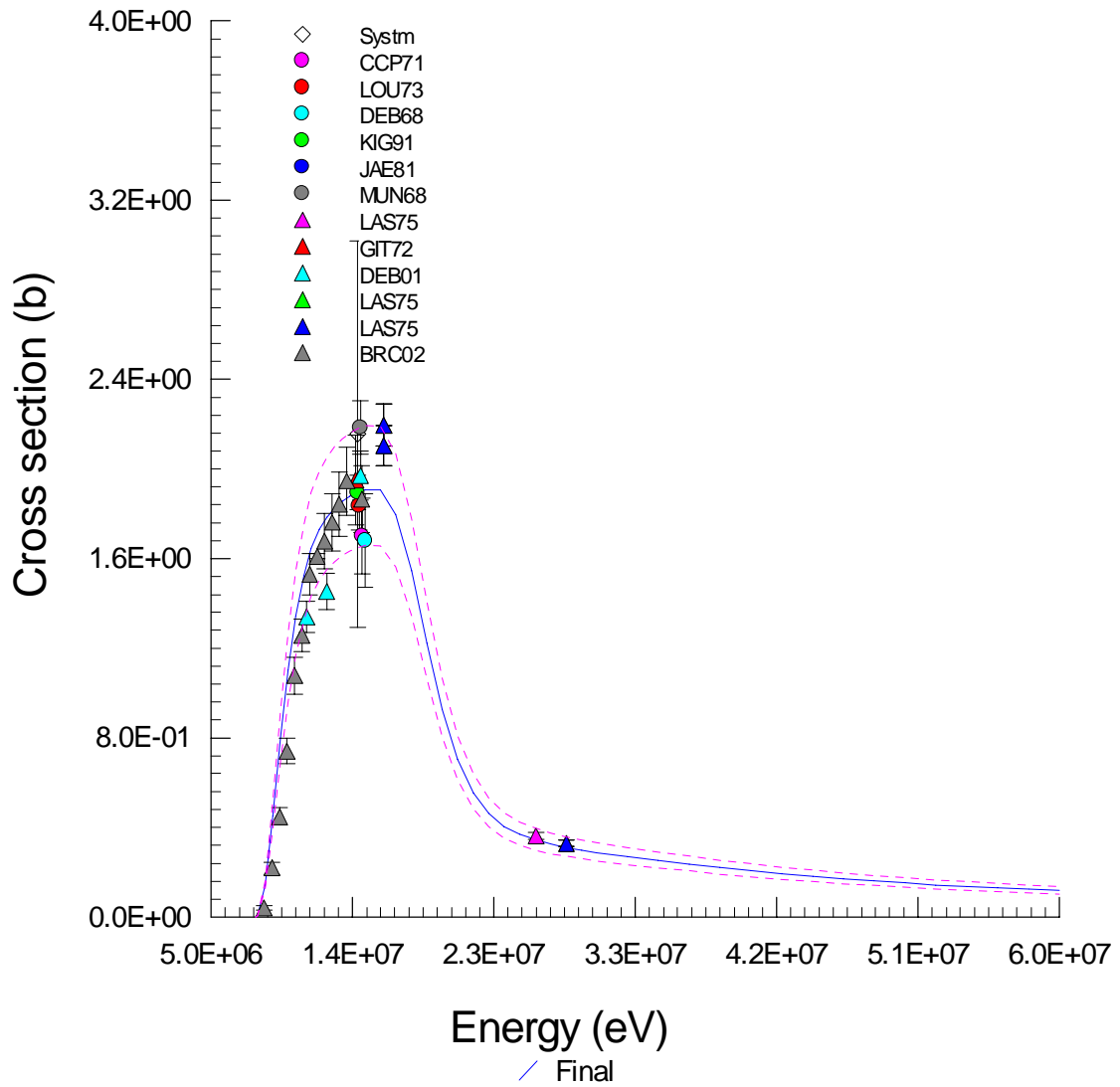
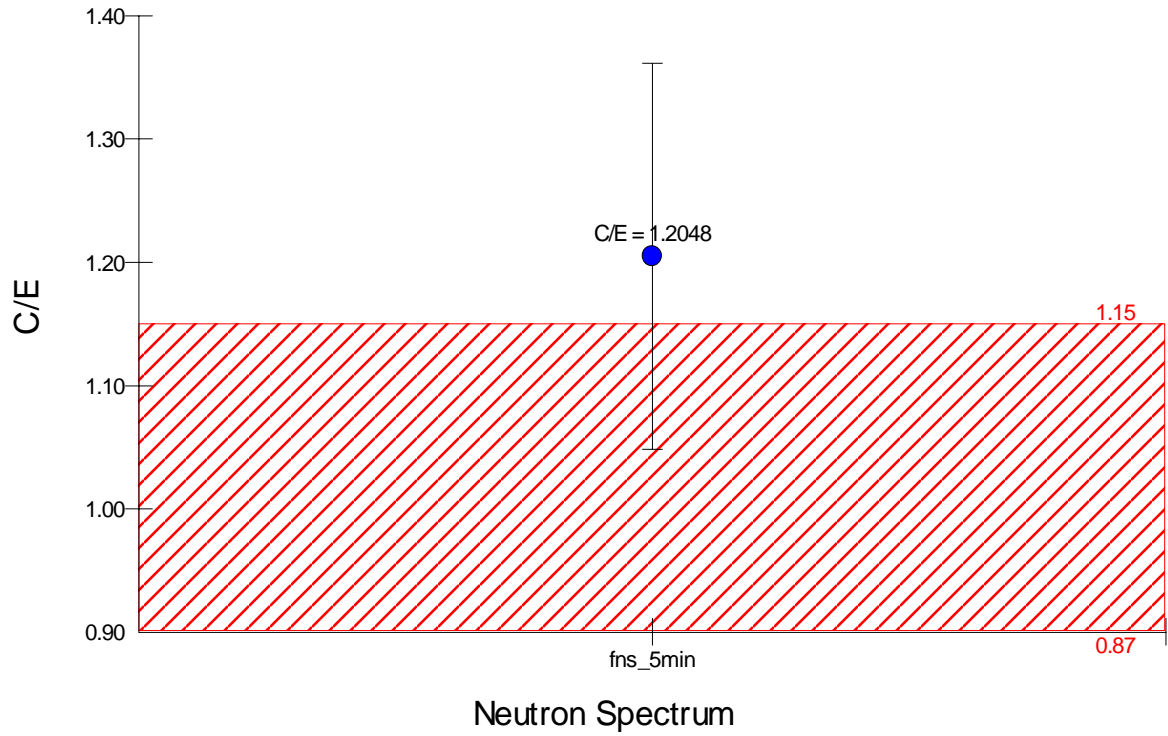
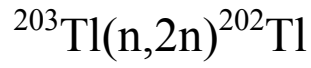




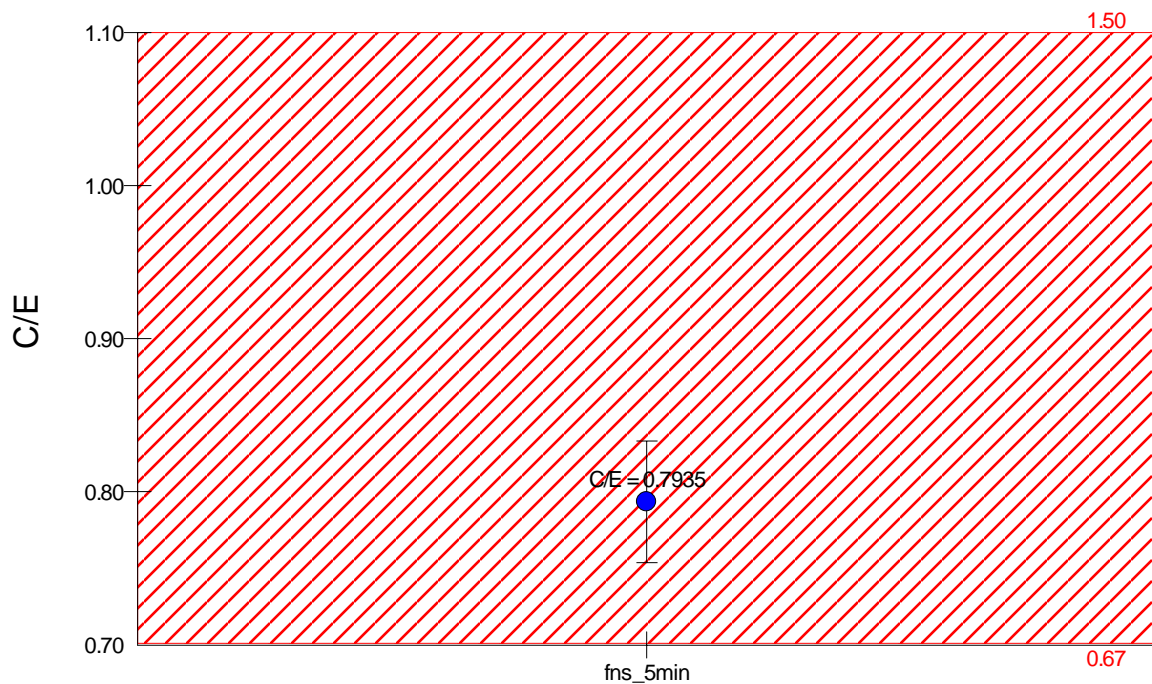
Neutron Spectrum



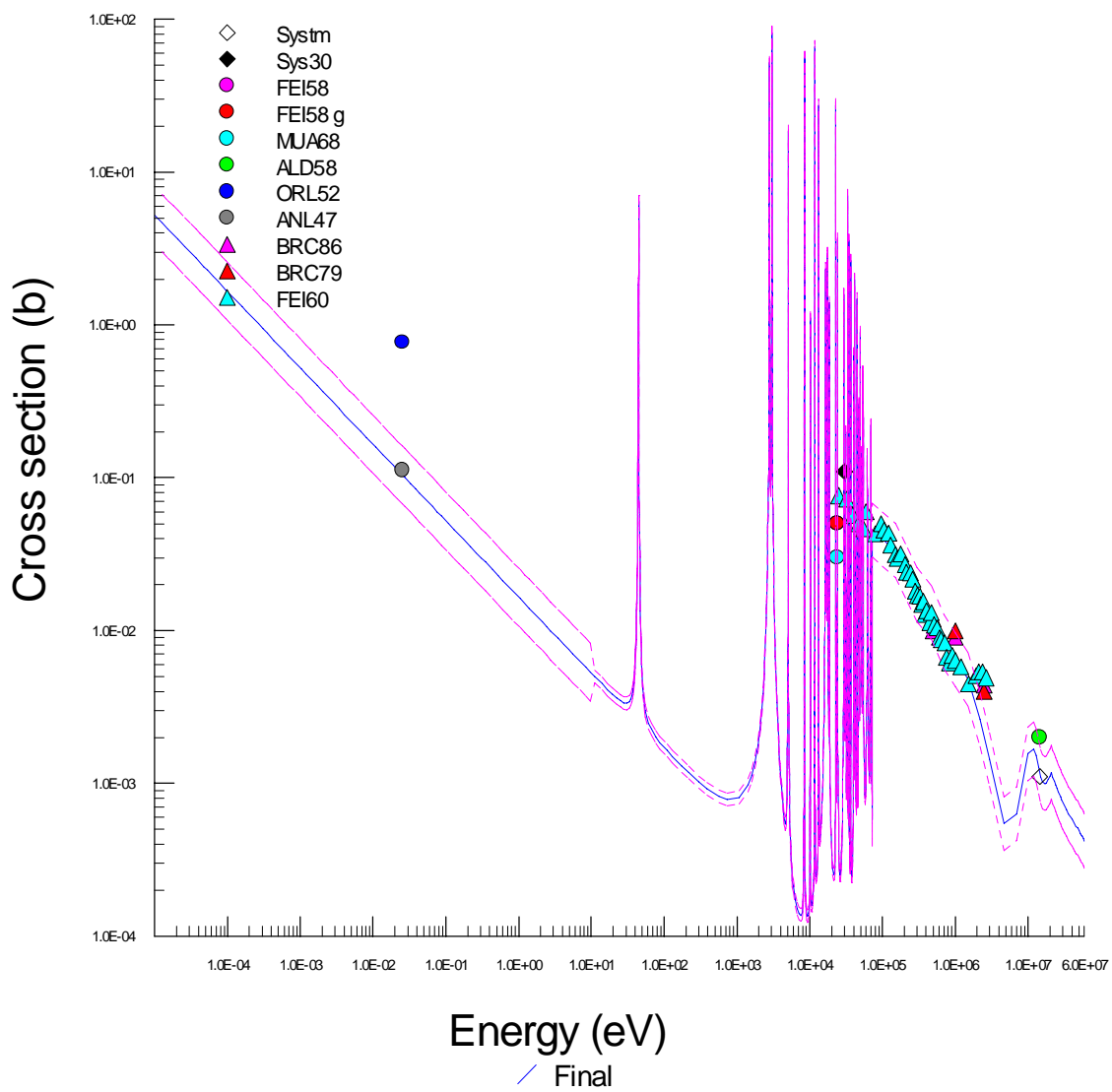


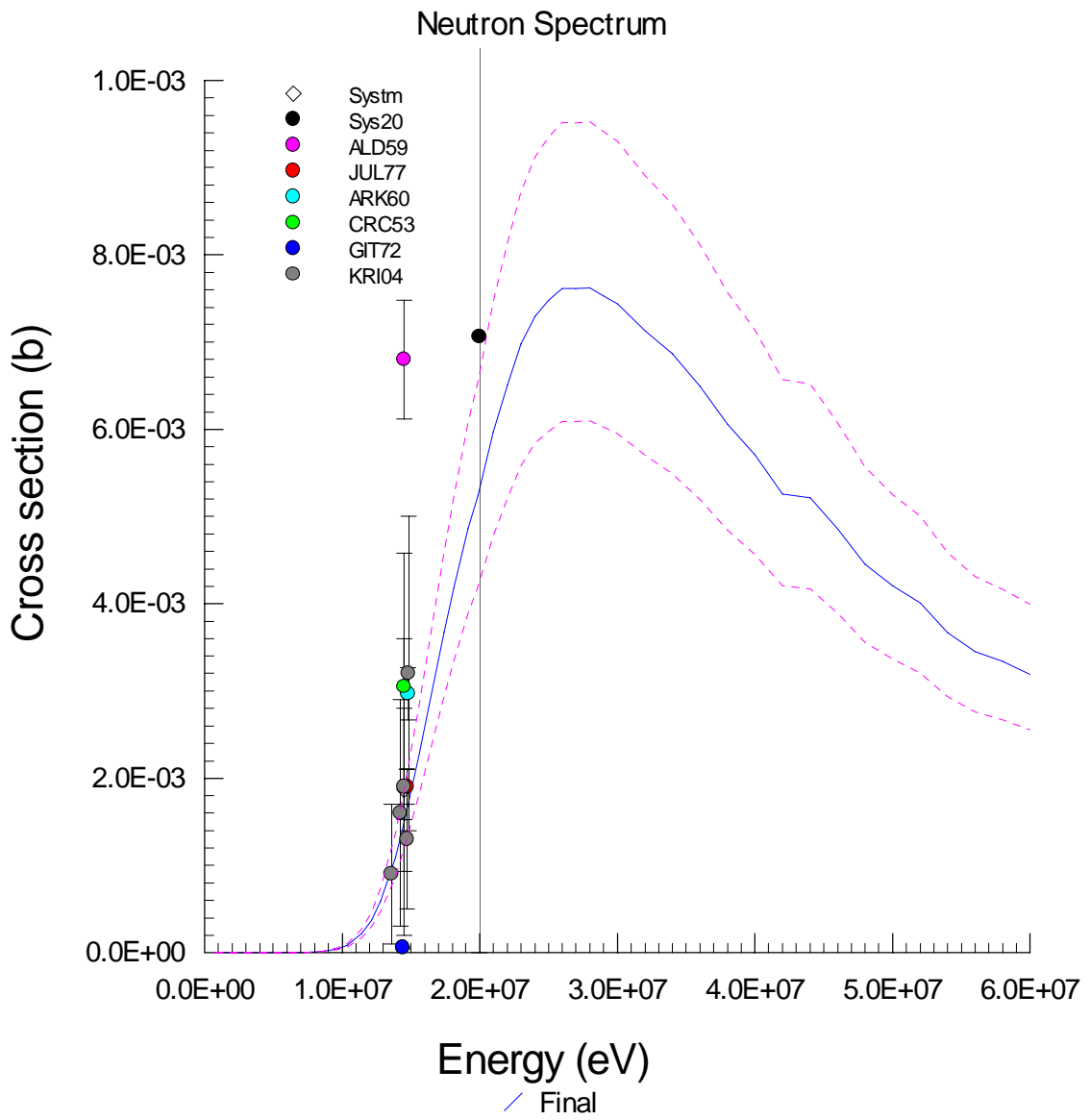
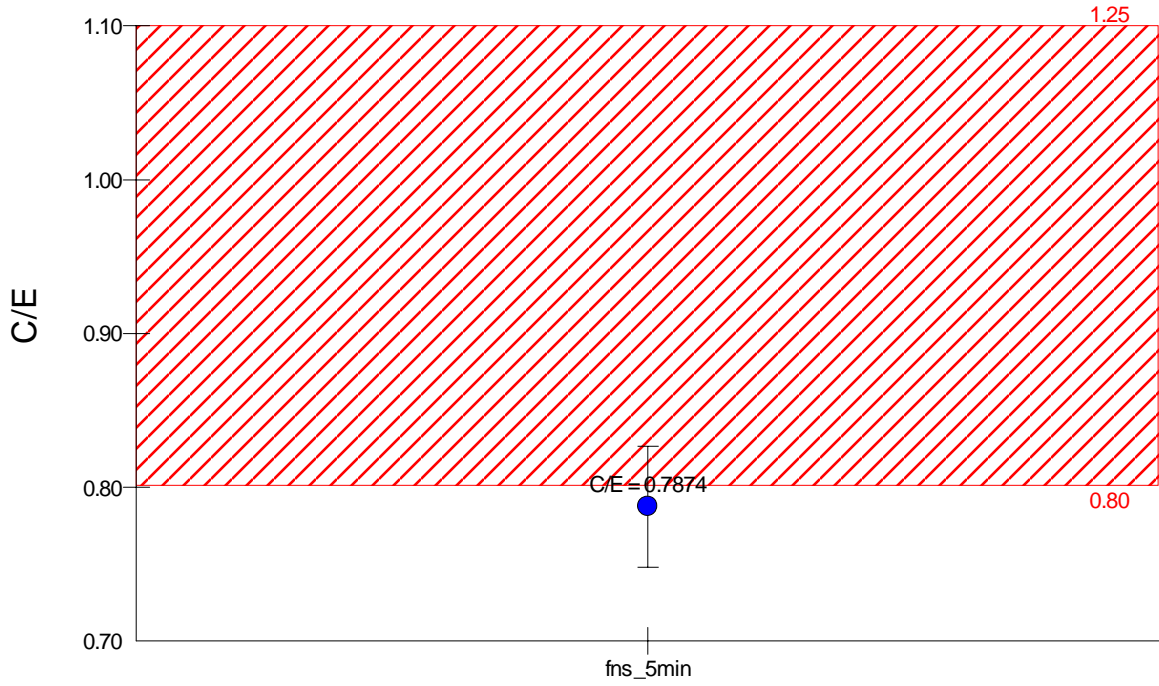
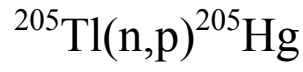


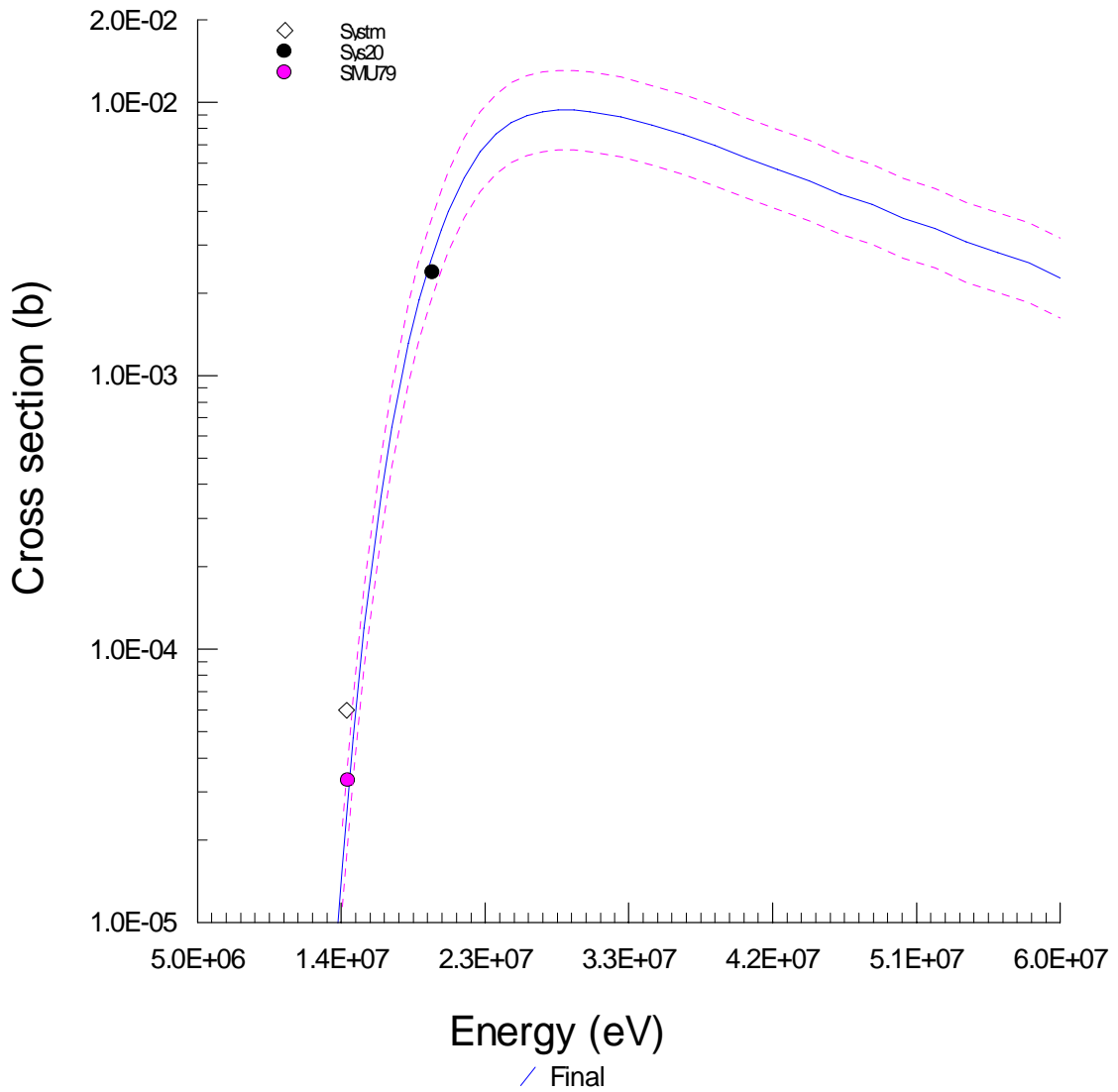
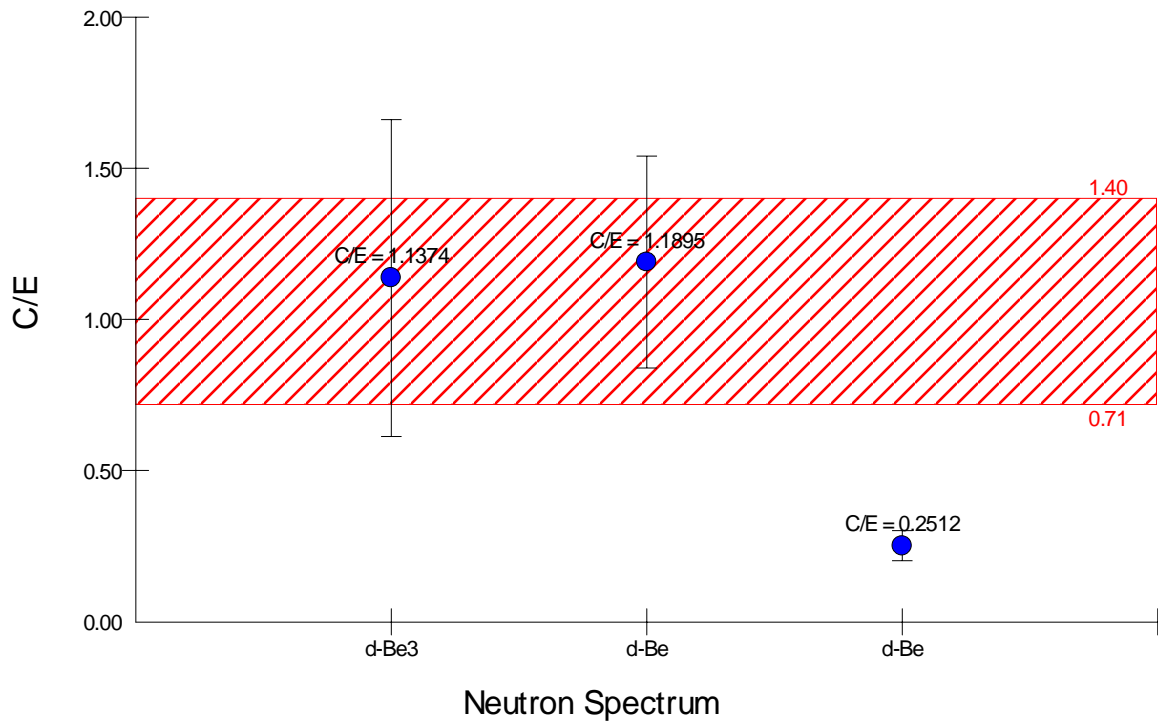
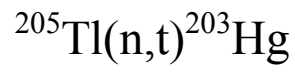
$^{205}\text{Tl}(n,\gamma)^{206}\text{Tl}$

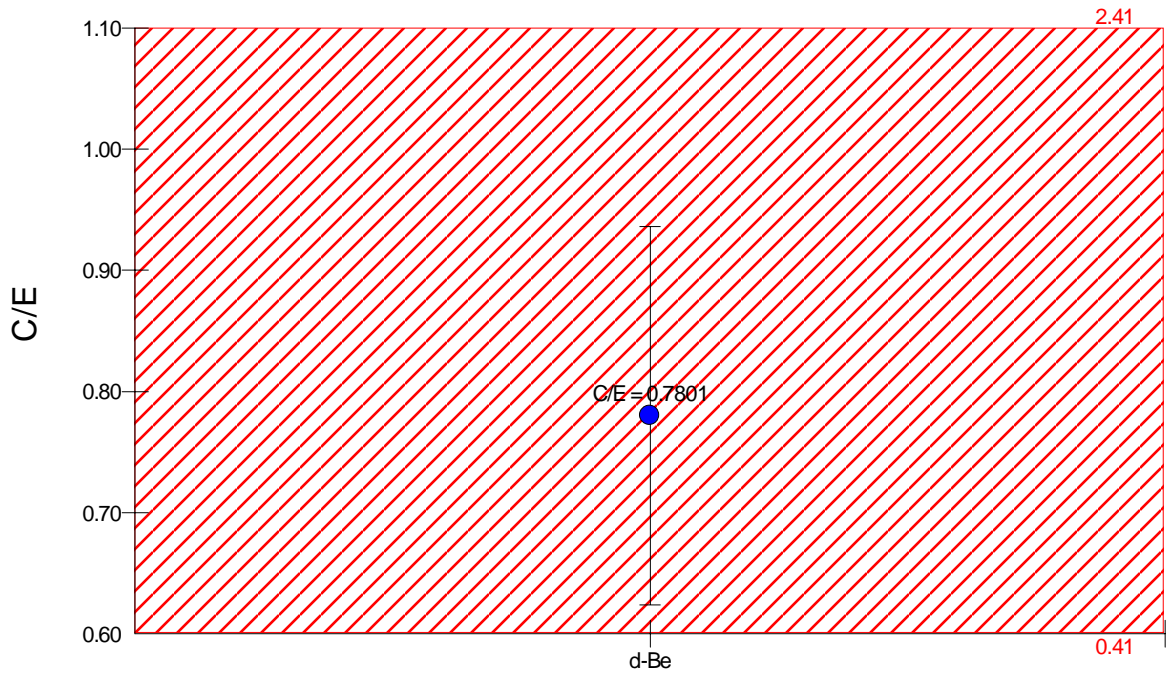
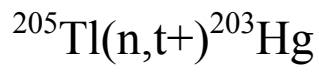


Neutron Spectrum

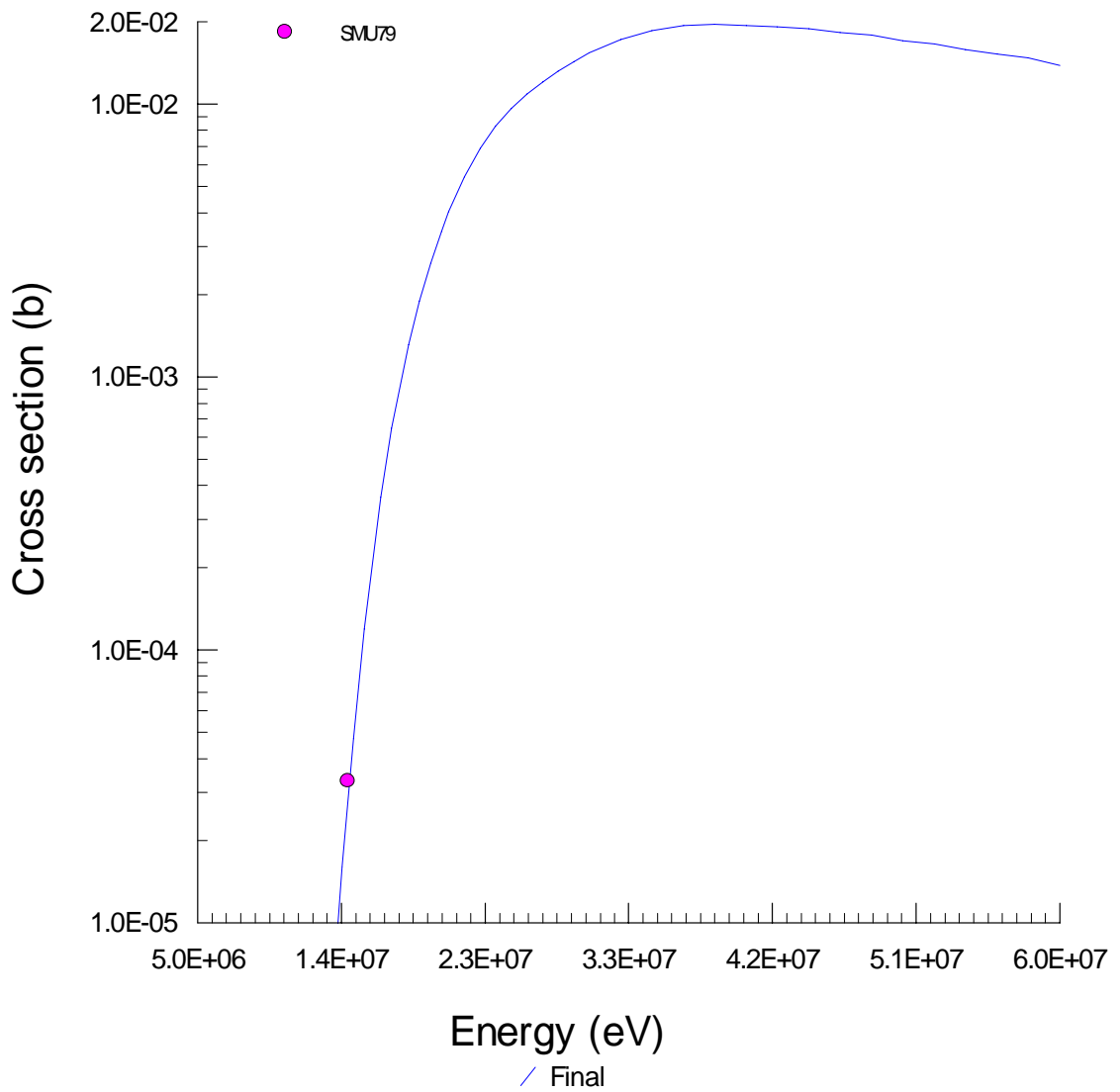




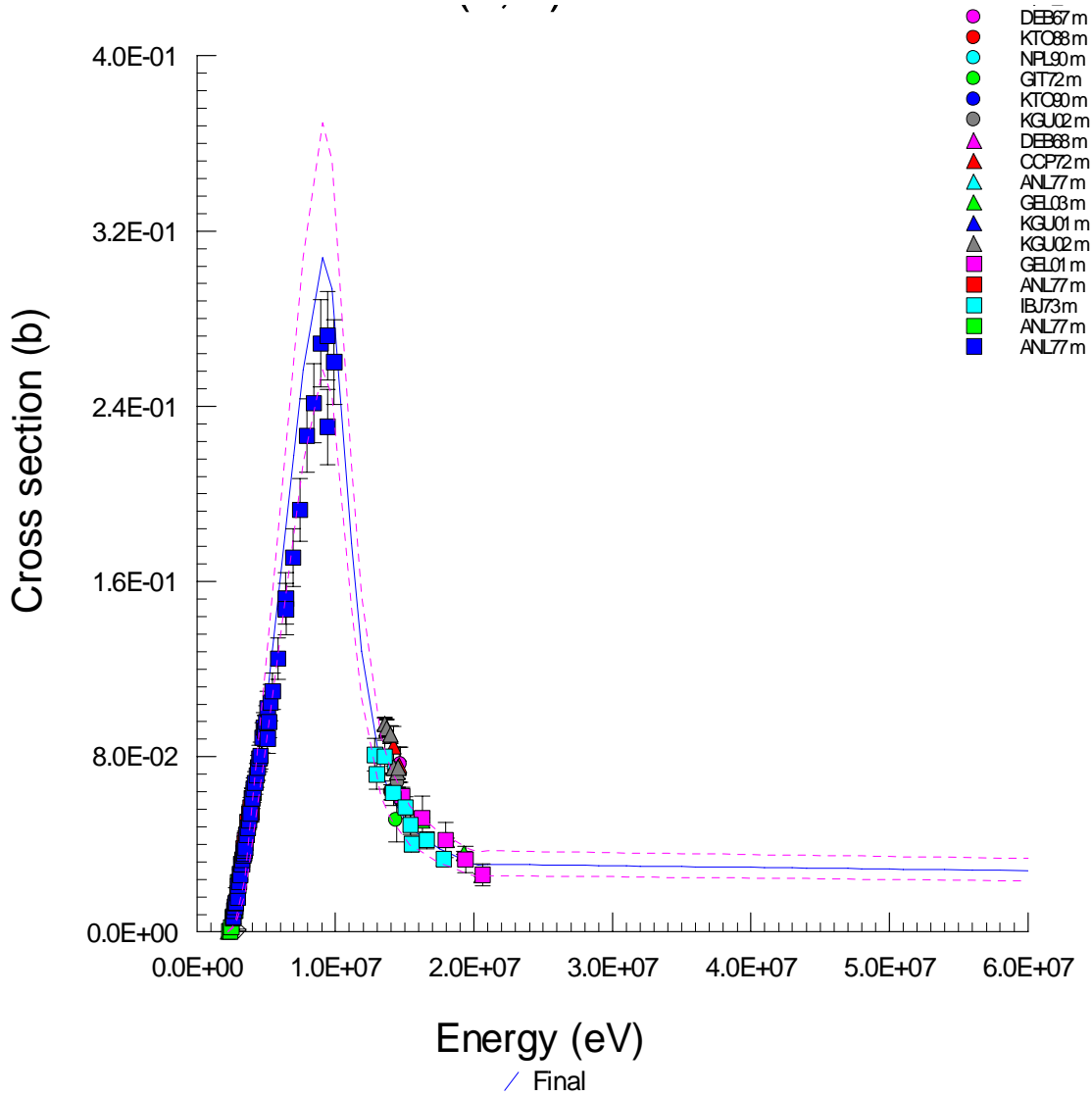
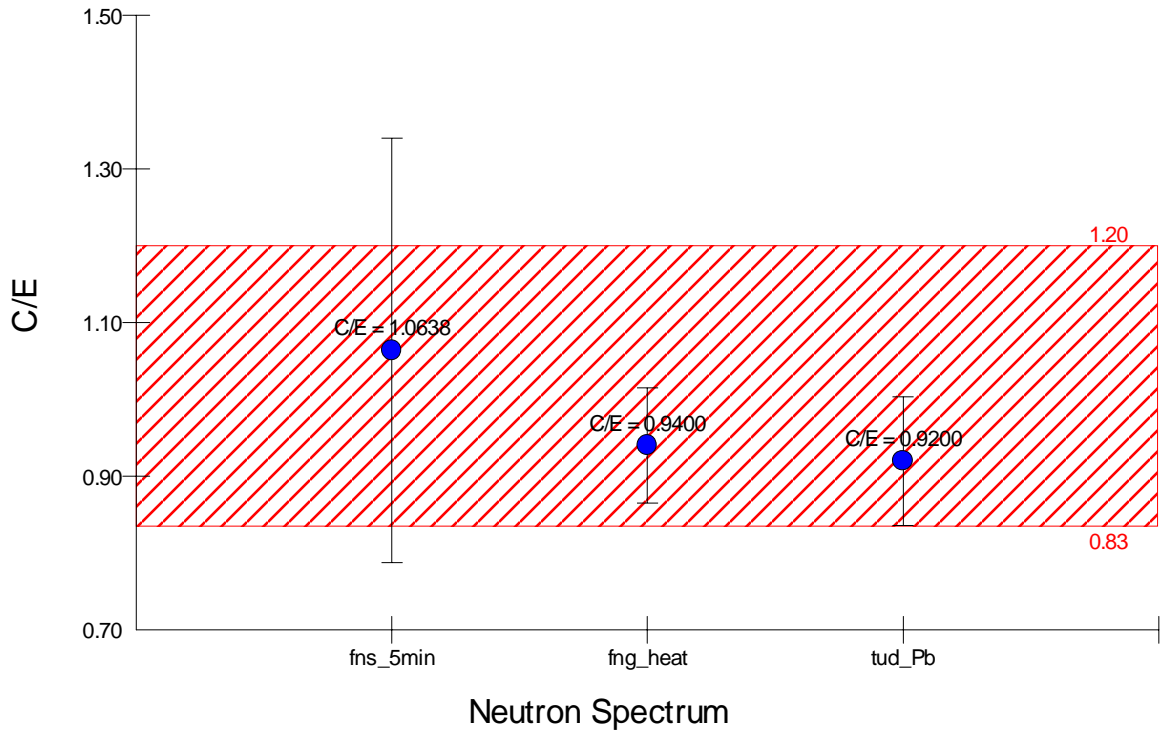
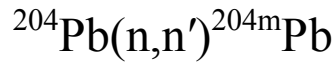




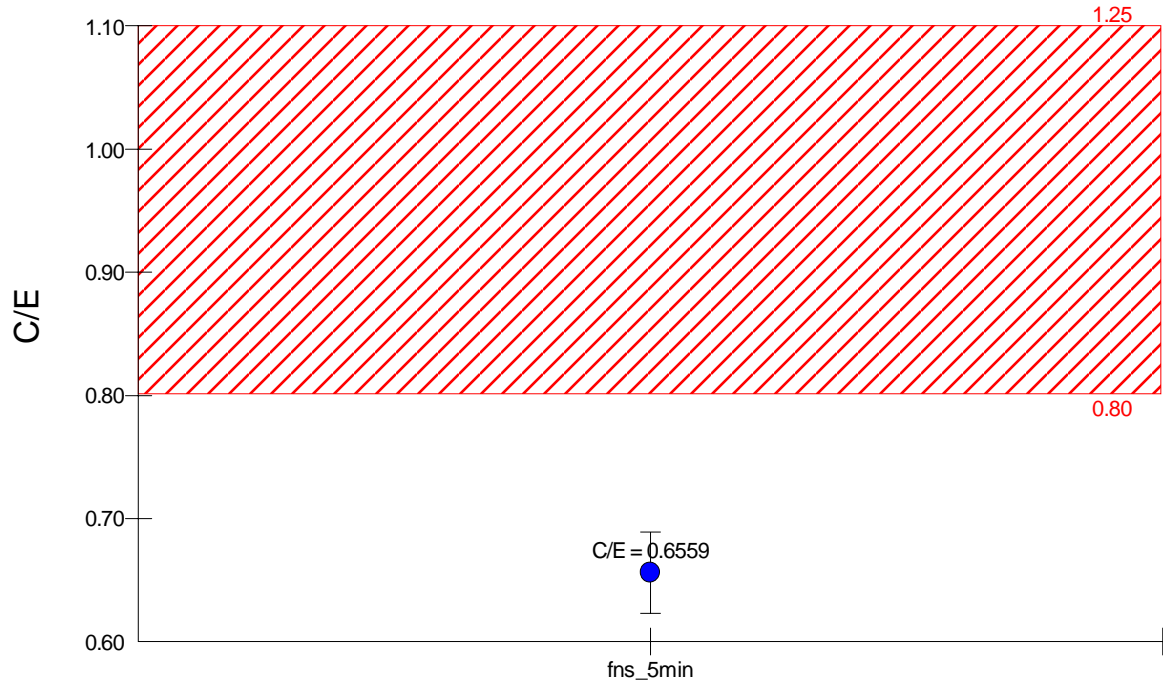
Neutron Spectrum



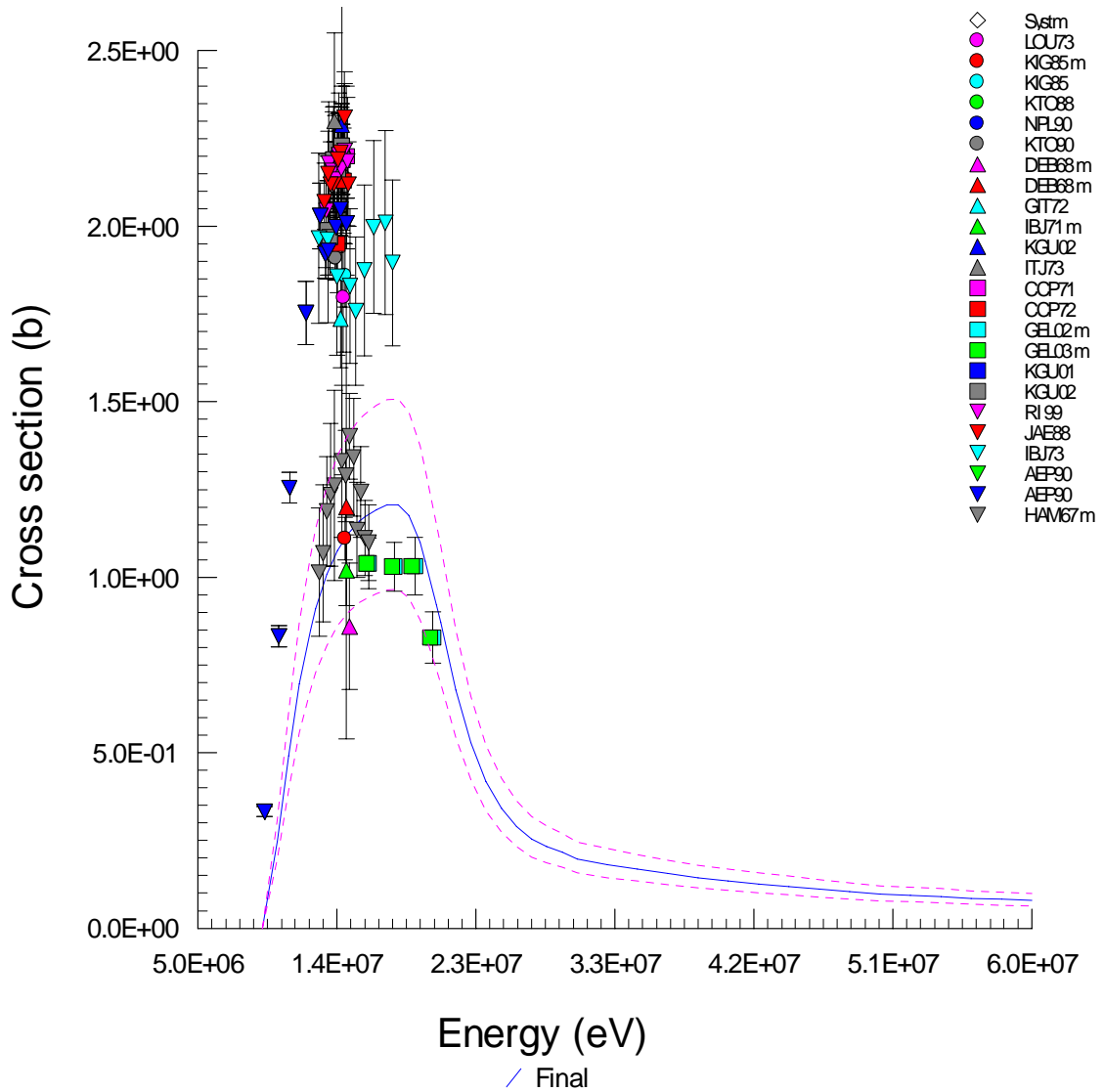




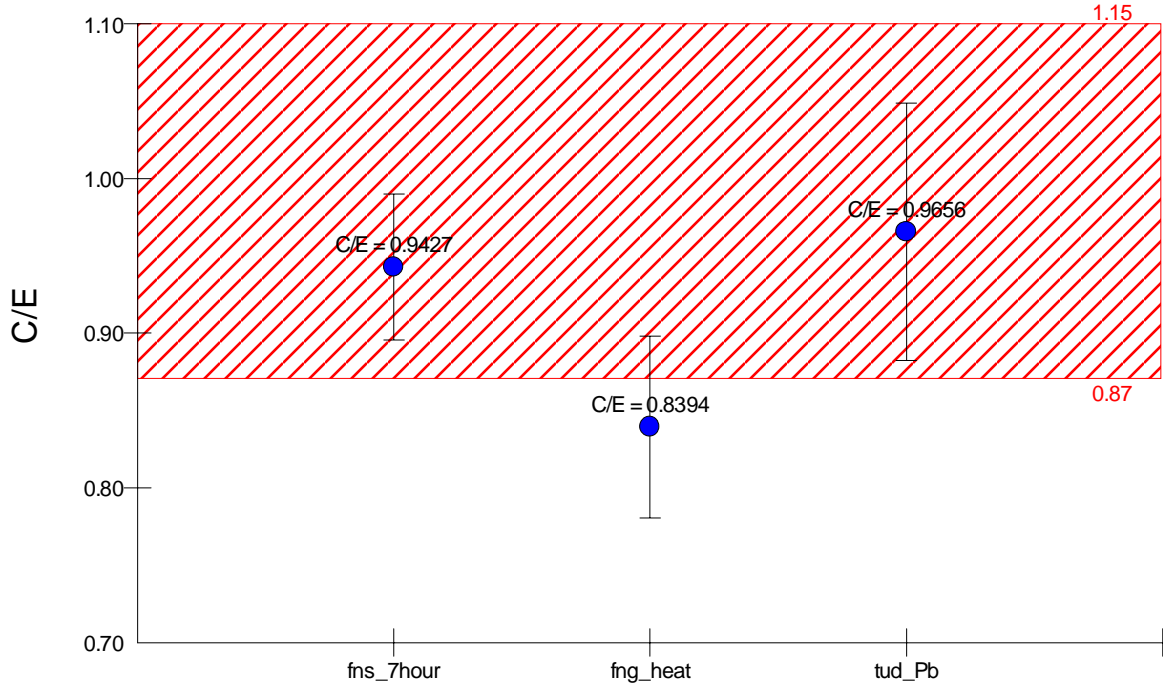
$^{204}\text{Pb}(n,2n)^{203\text{m}}\text{Pb}$



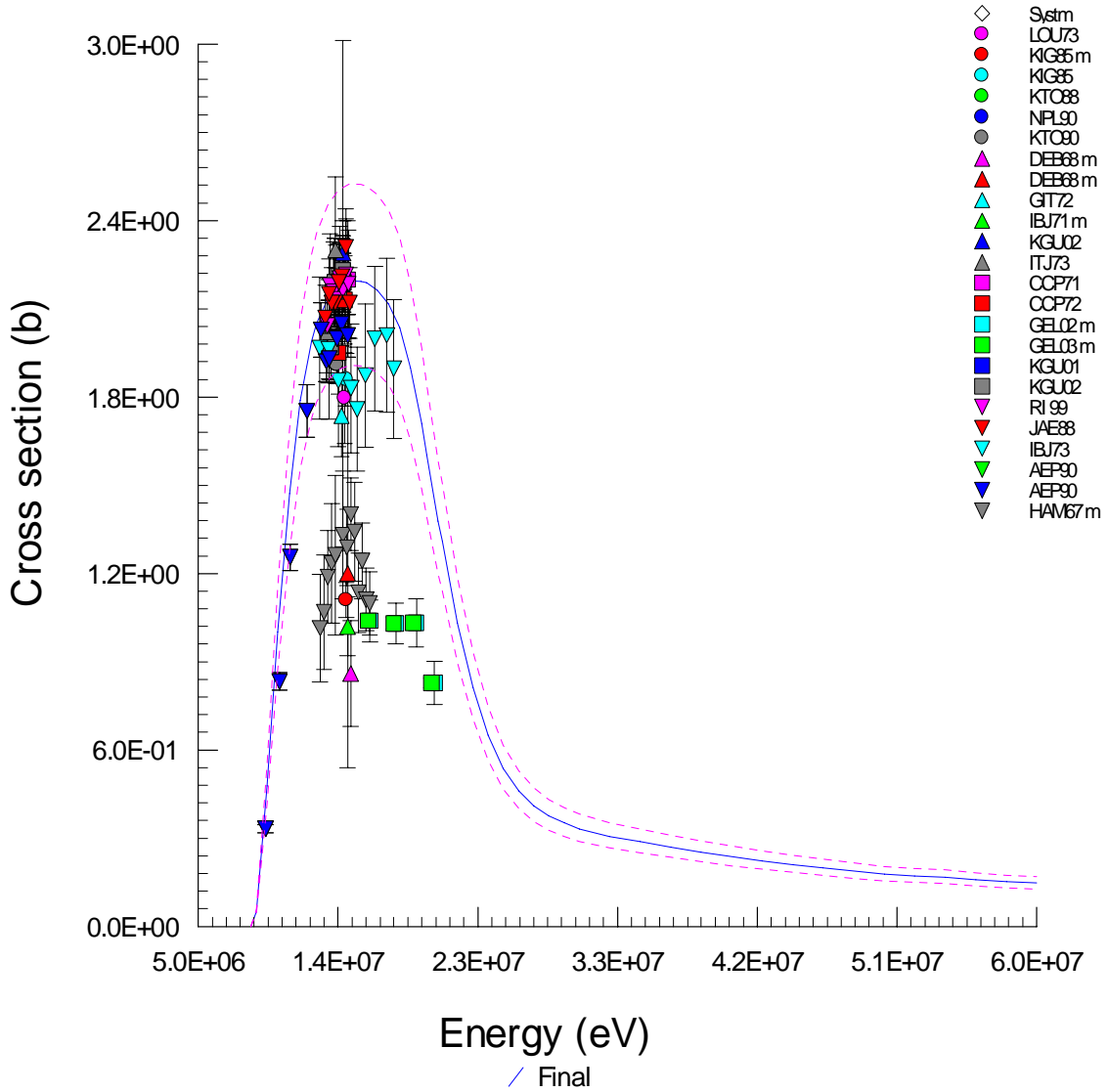
Neutron Spectrum

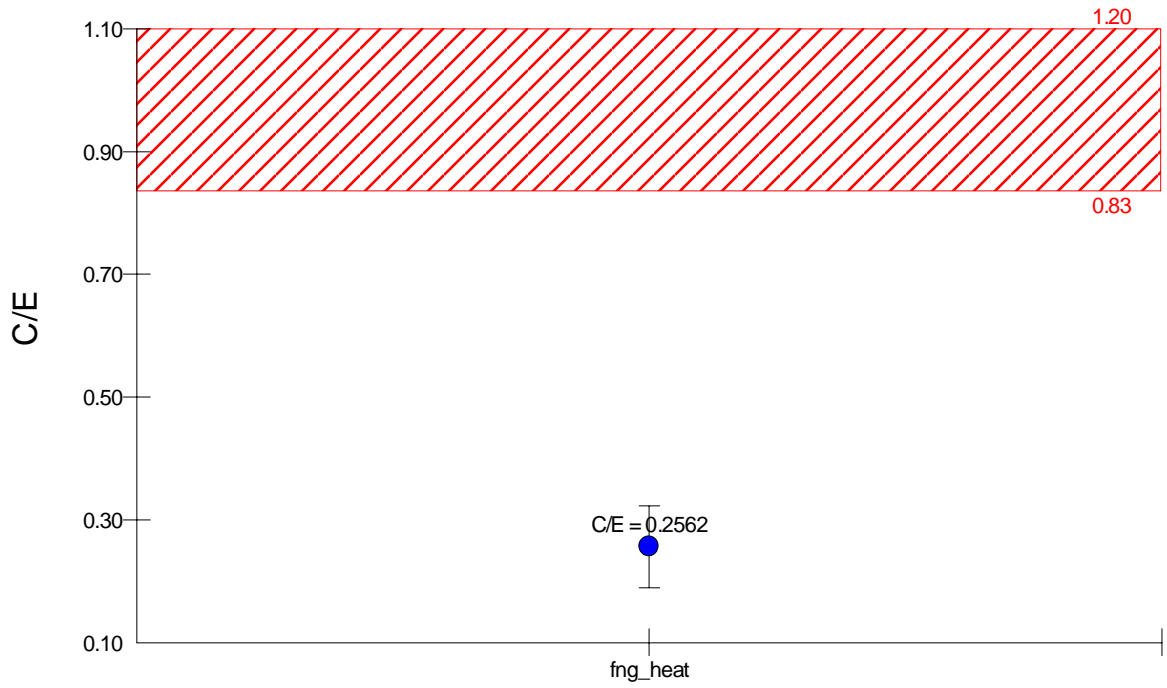
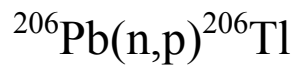


$^{204}\text{Pb}(n,2n)^{203}\text{Pb}$

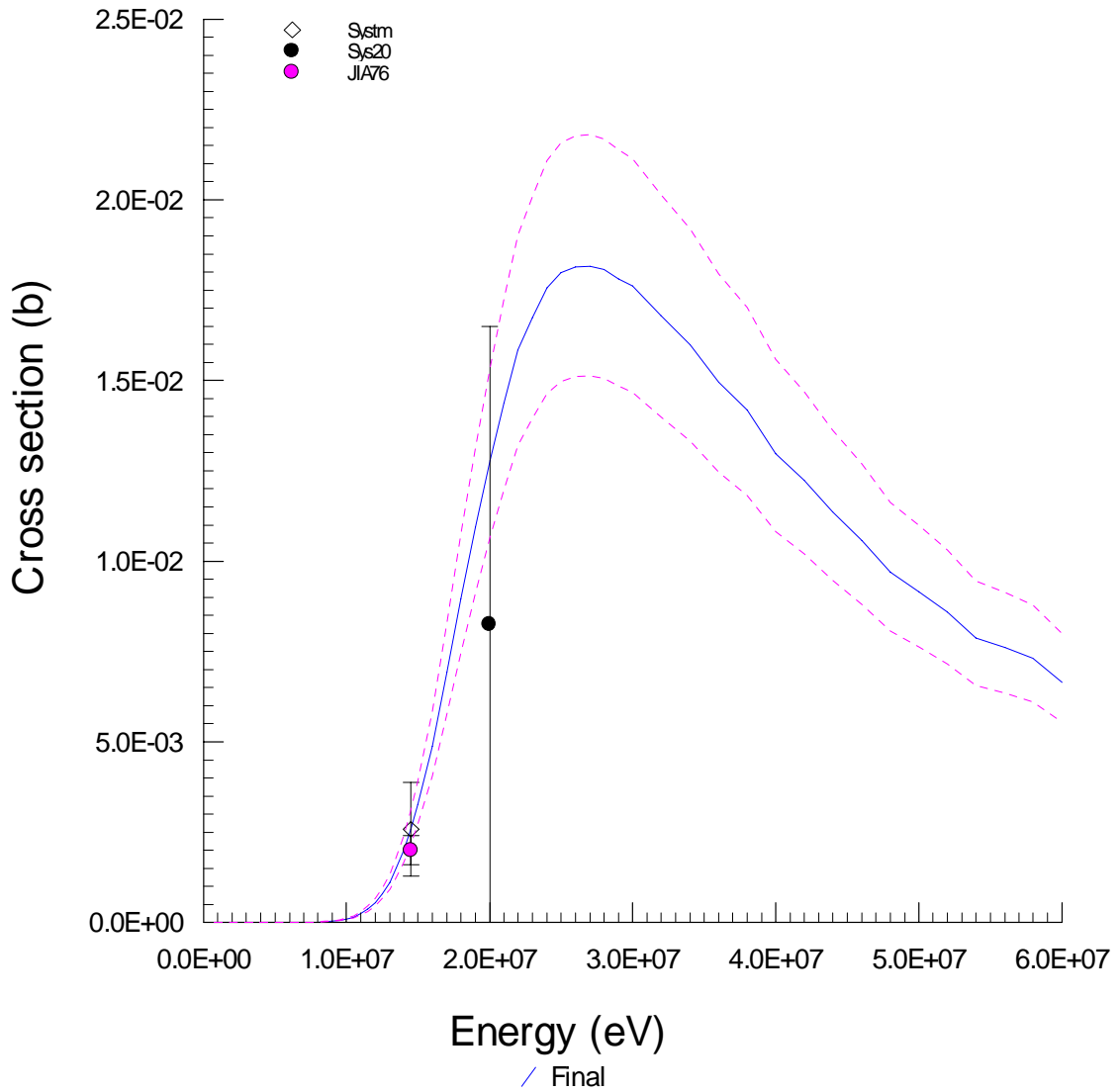


Neutron Spectrum

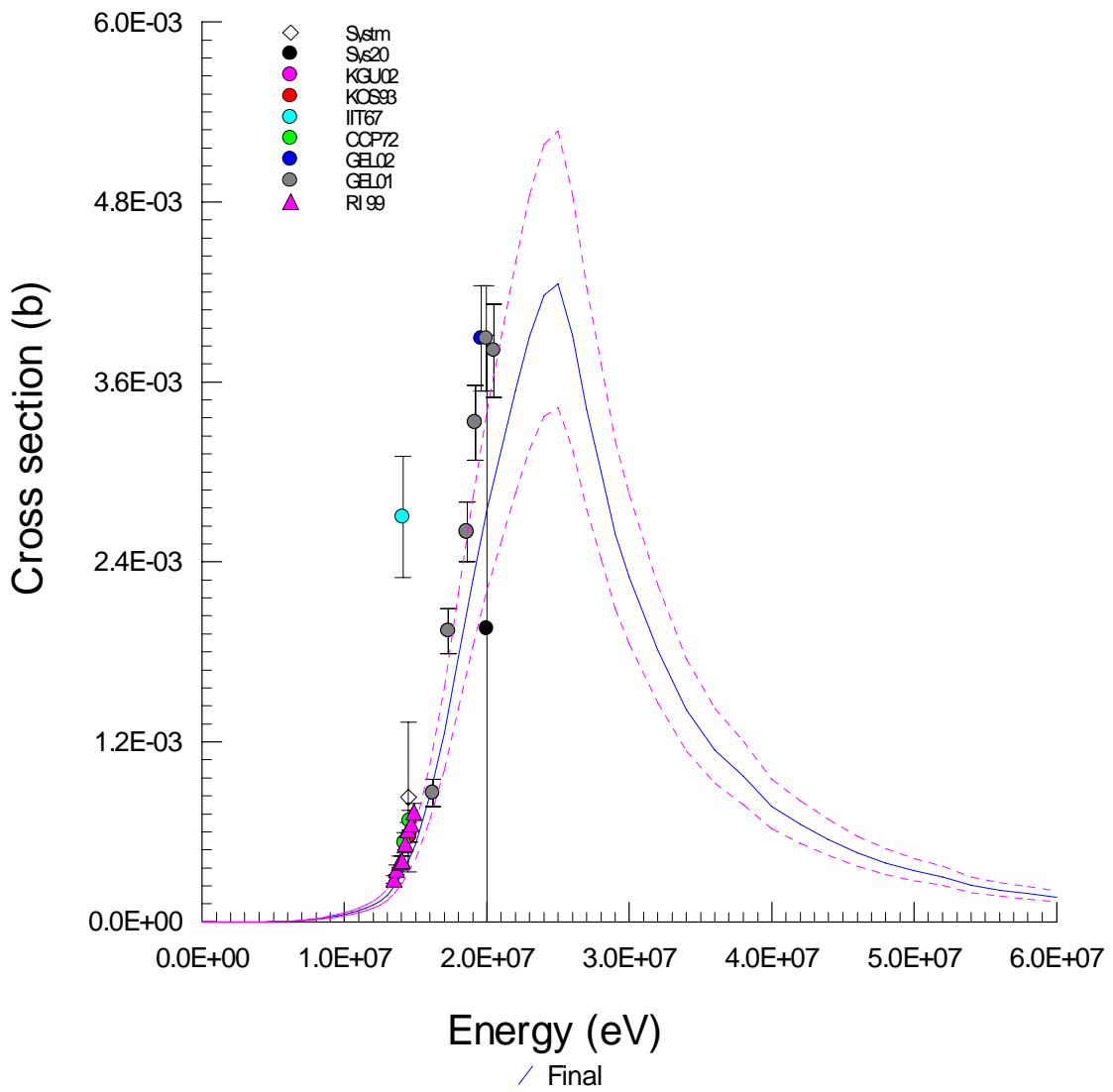
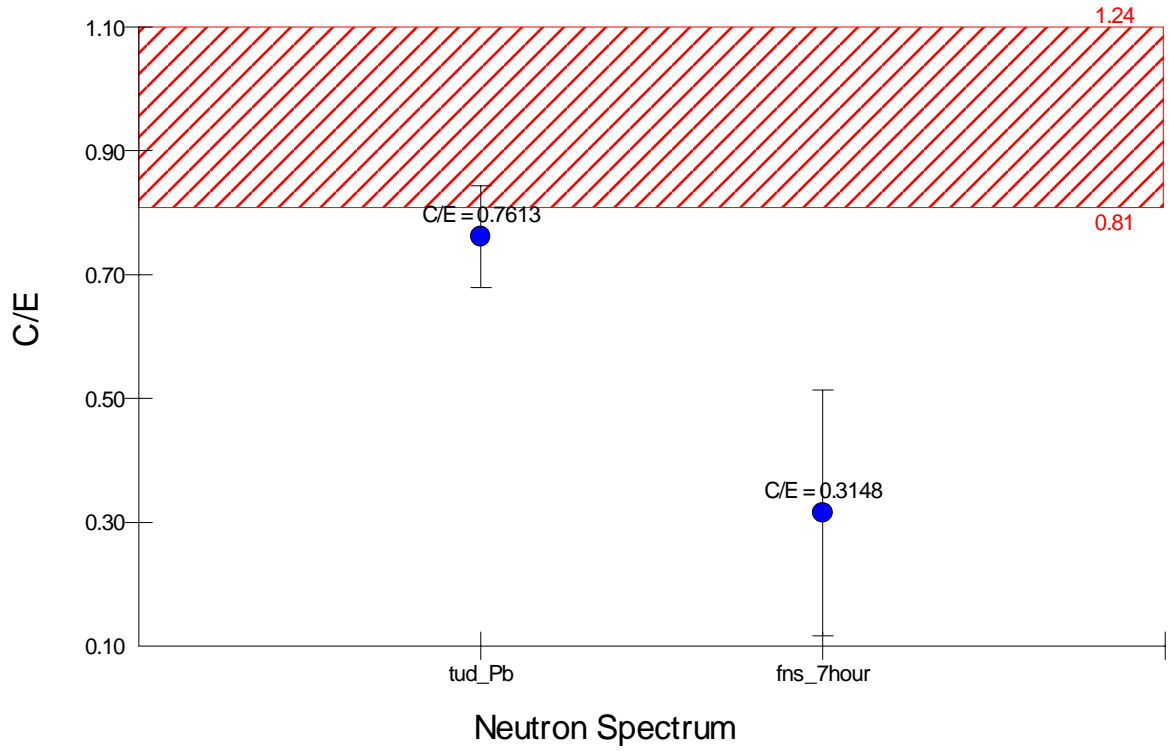




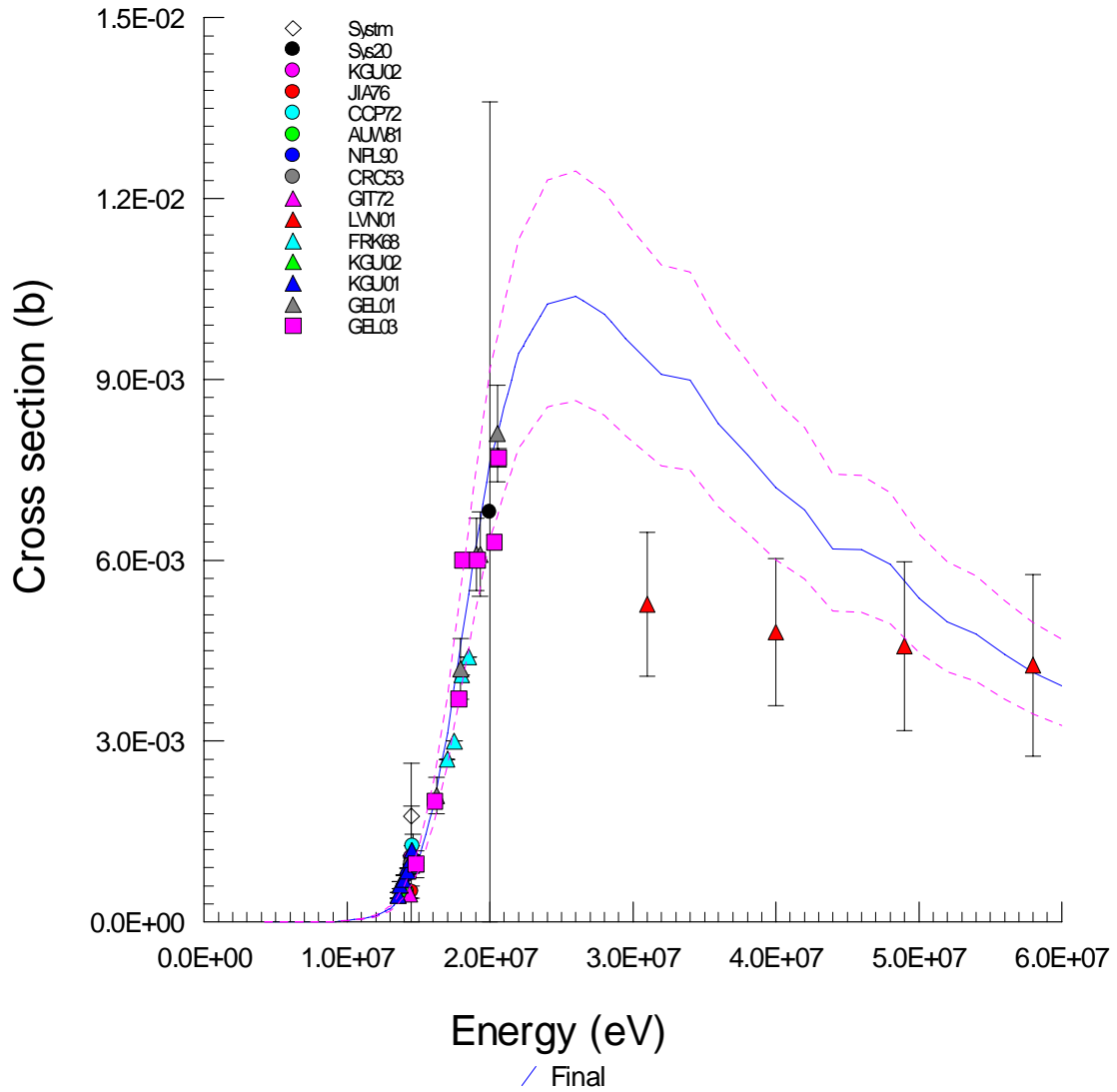
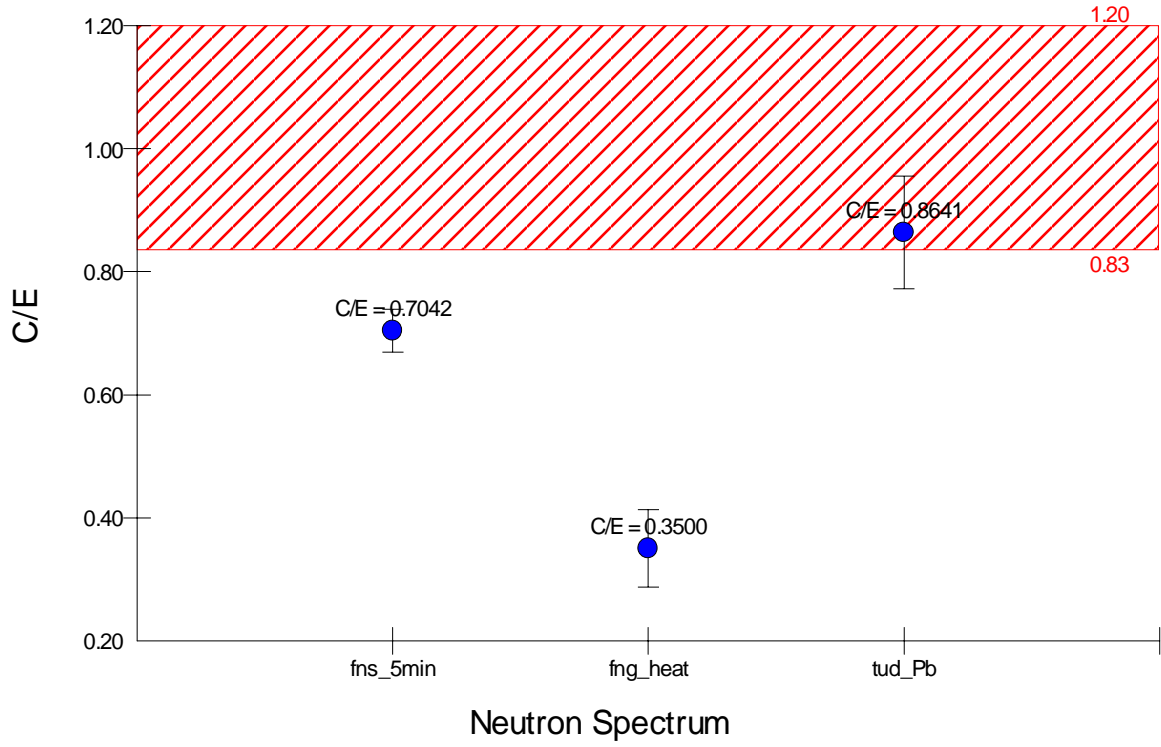
Neutron Spectrum

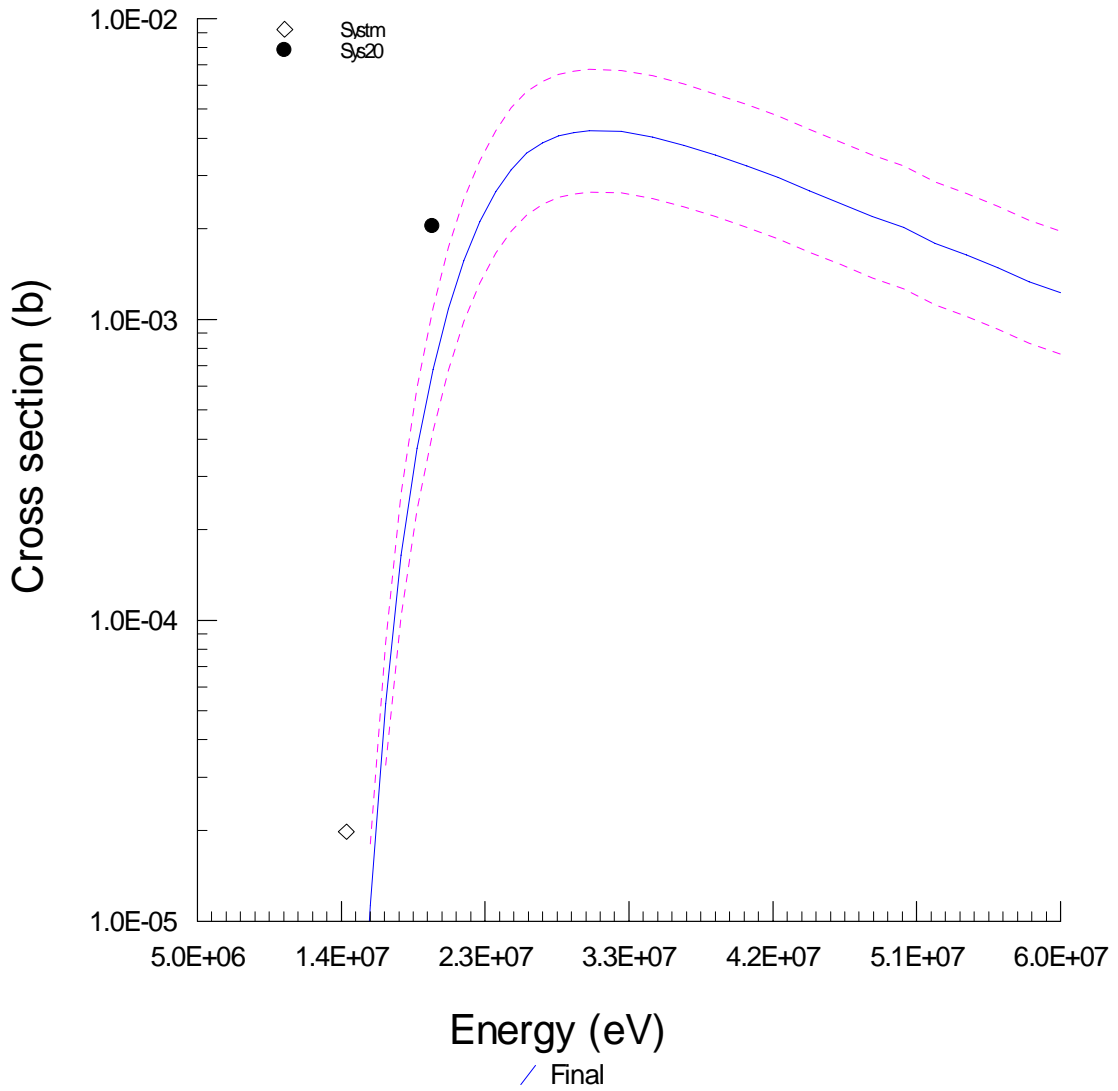
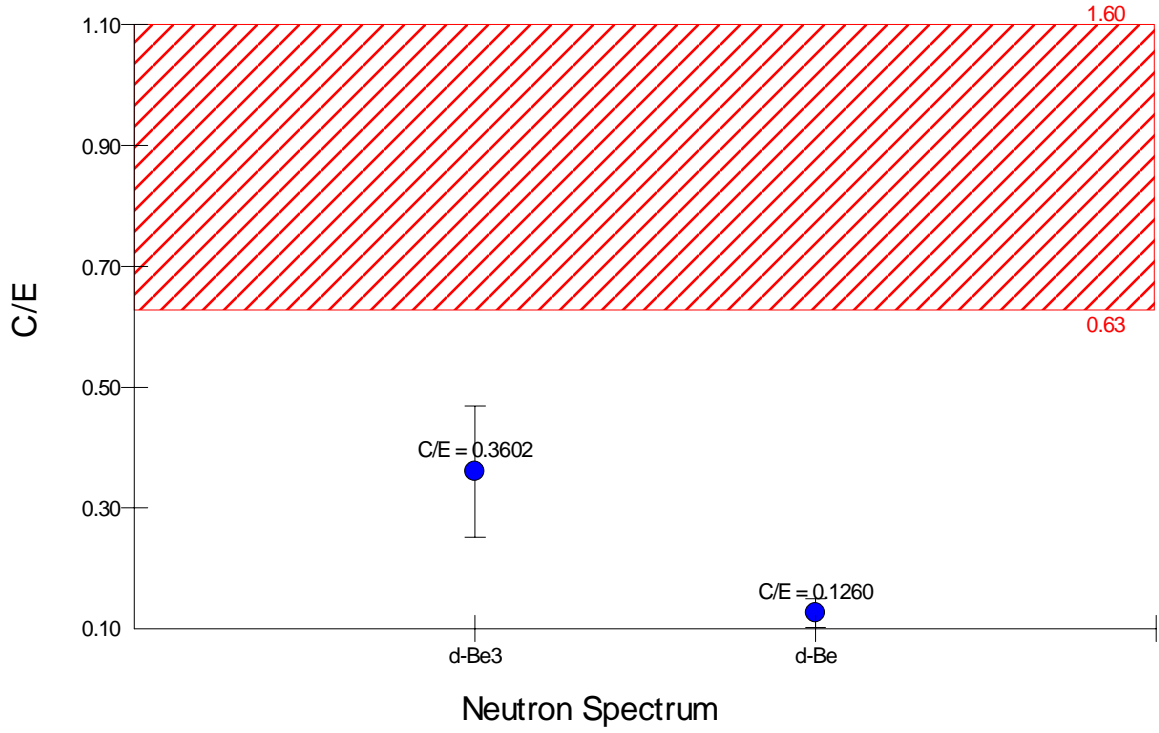
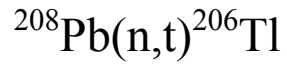


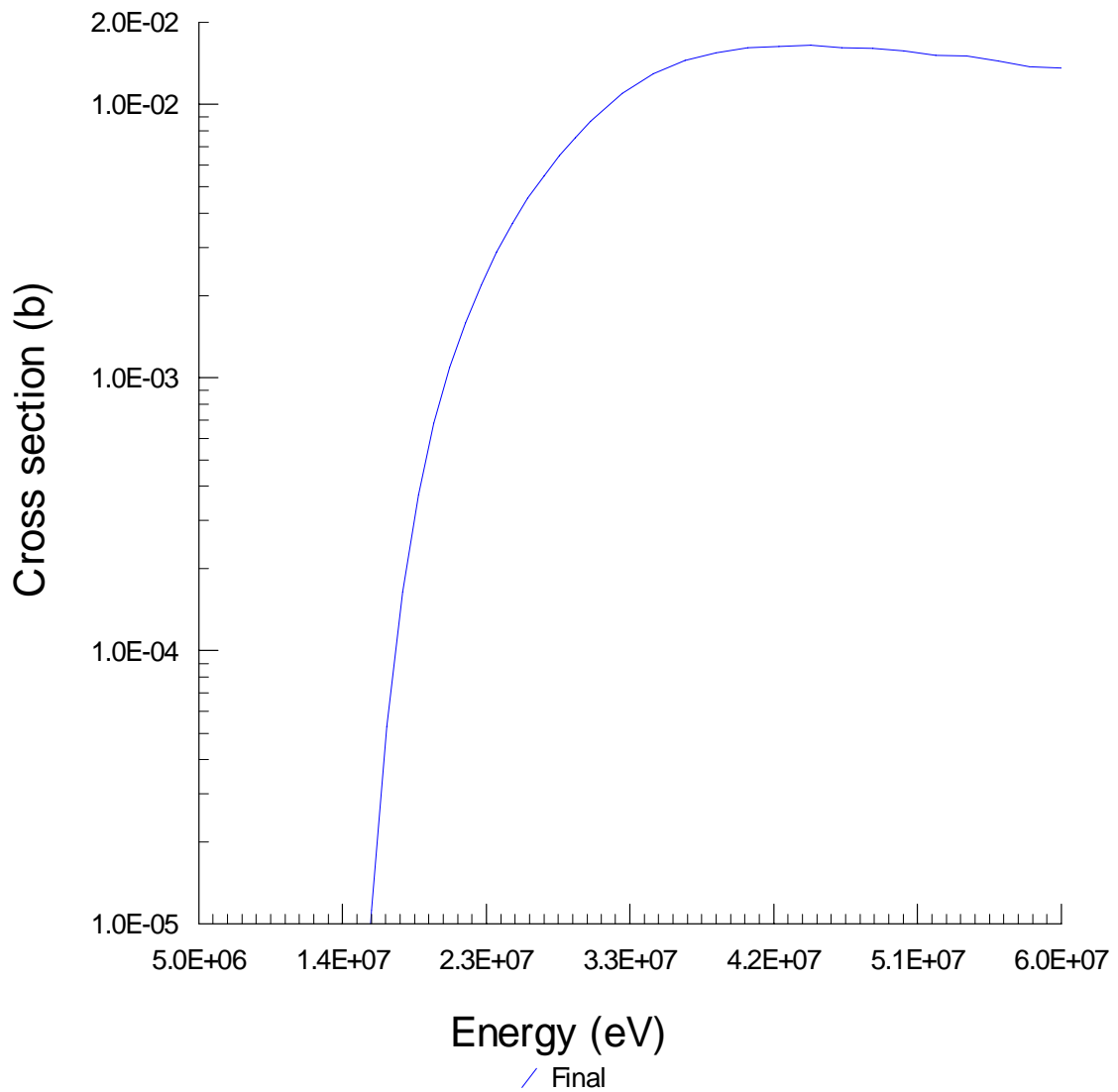
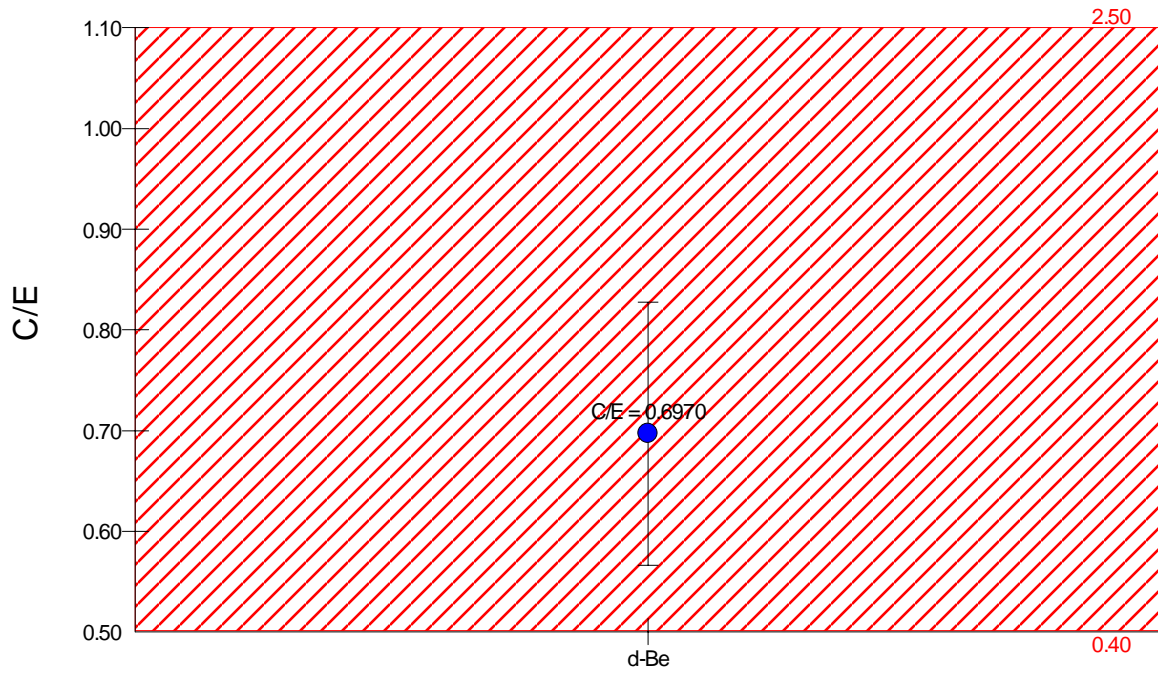
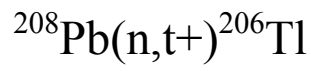
# $^{206}\text{Pb}(n,\alpha)^{203}\text{Hg}$



# $^{208}\text{Pb}(n,p)^{208}\text{Tl}$

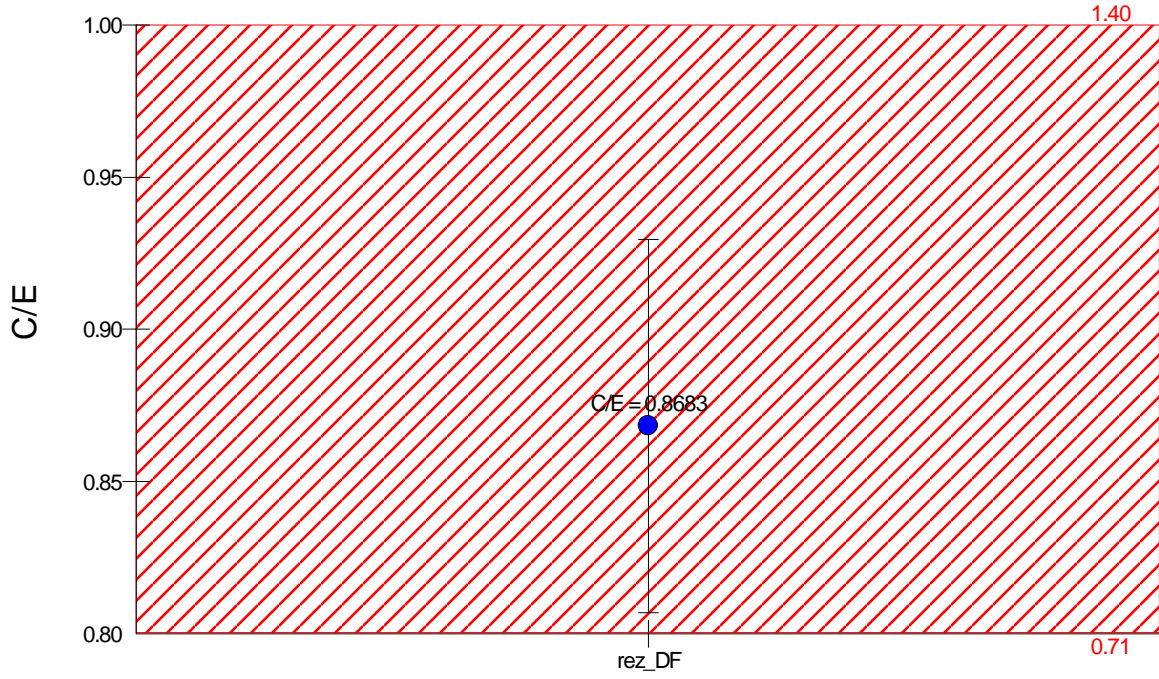




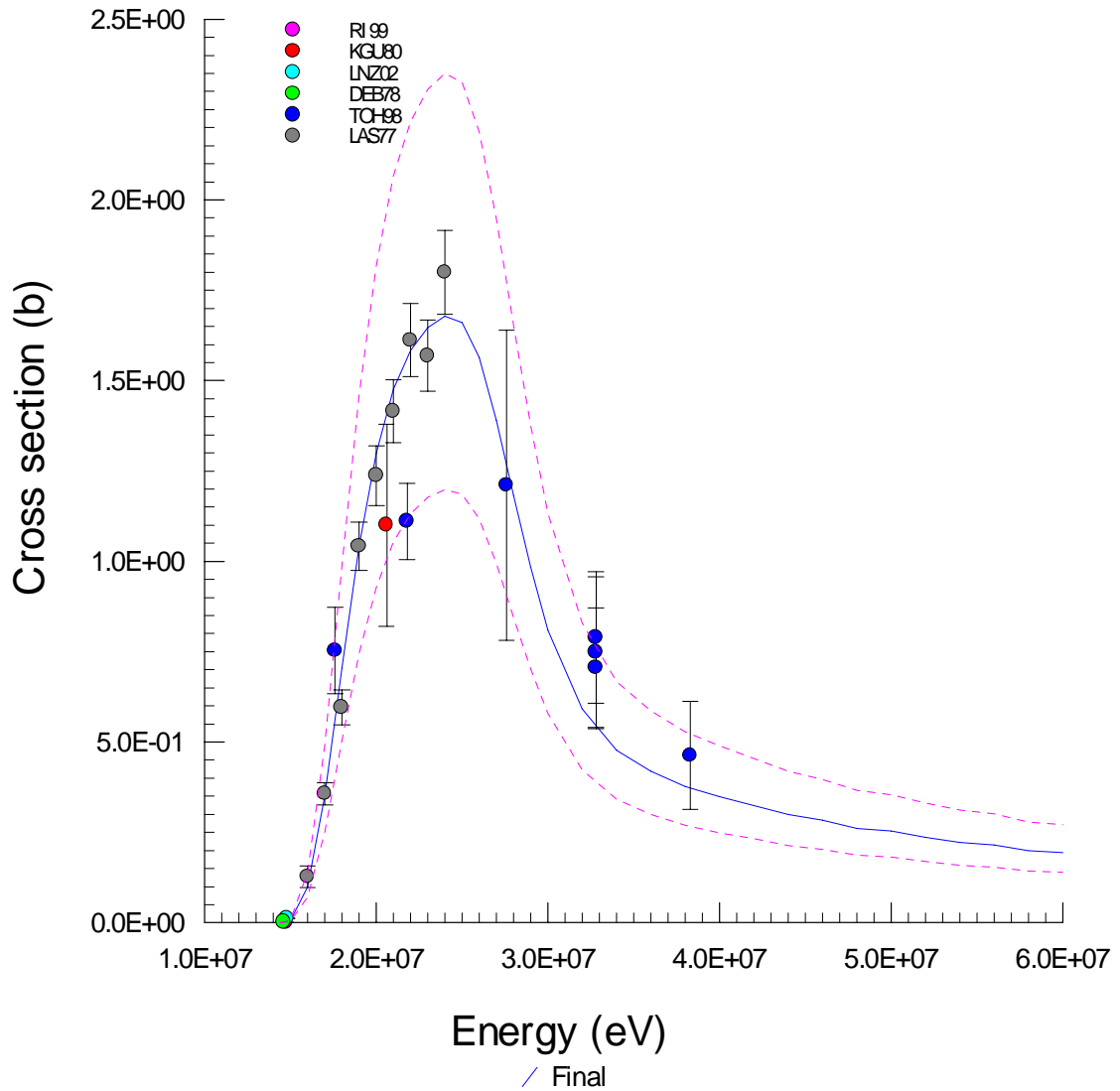


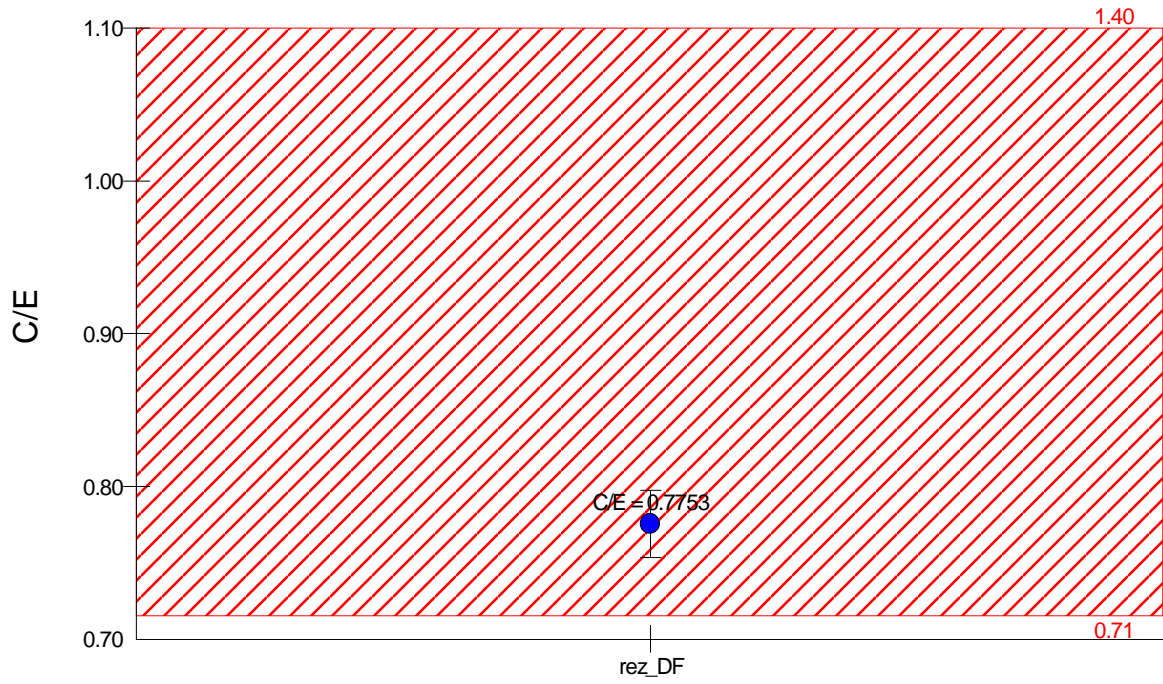
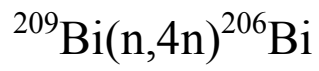


$^{209}\text{Bi}(n,3n)^{207}\text{Bi}$

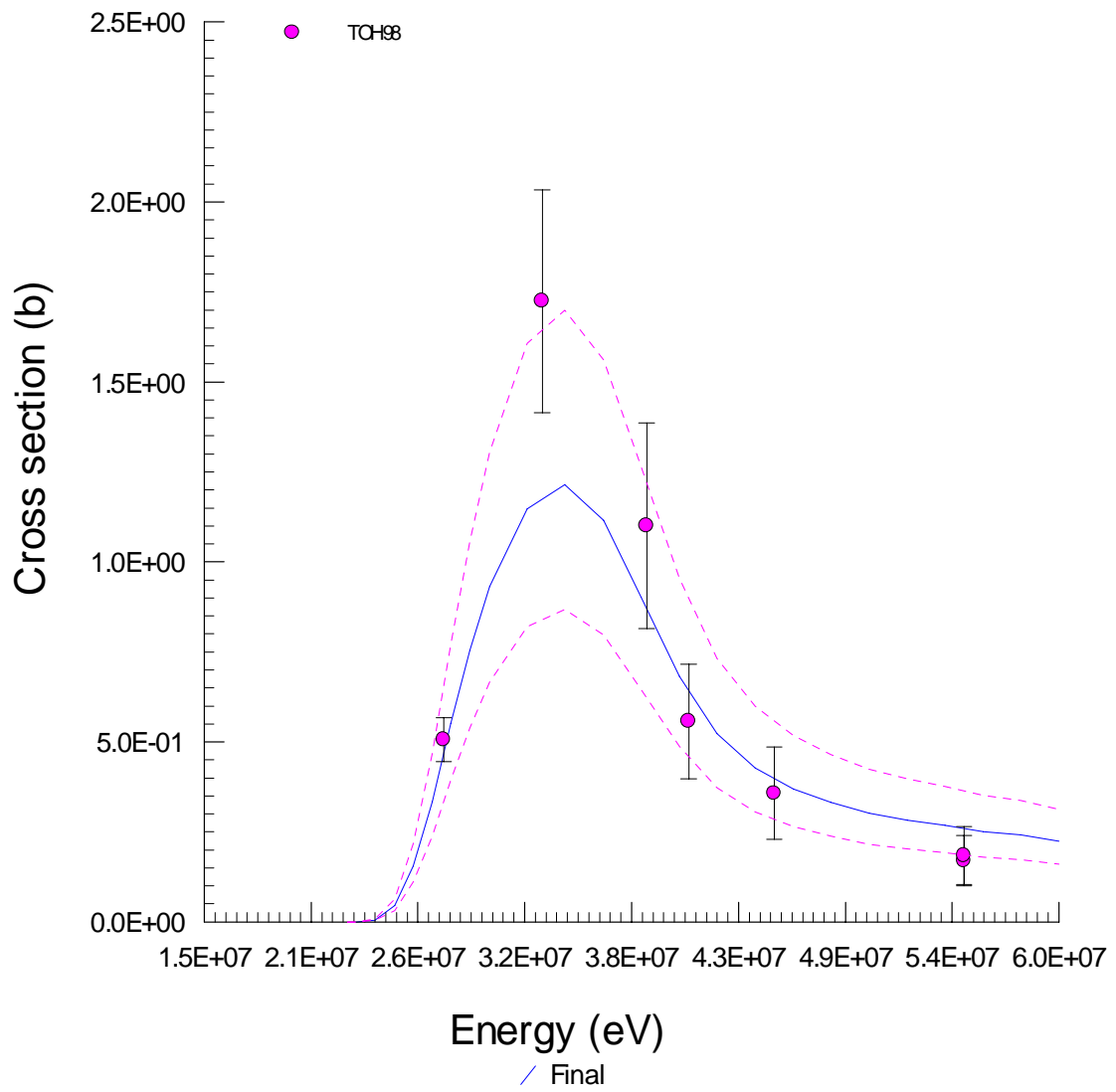


Neutron Spectrum

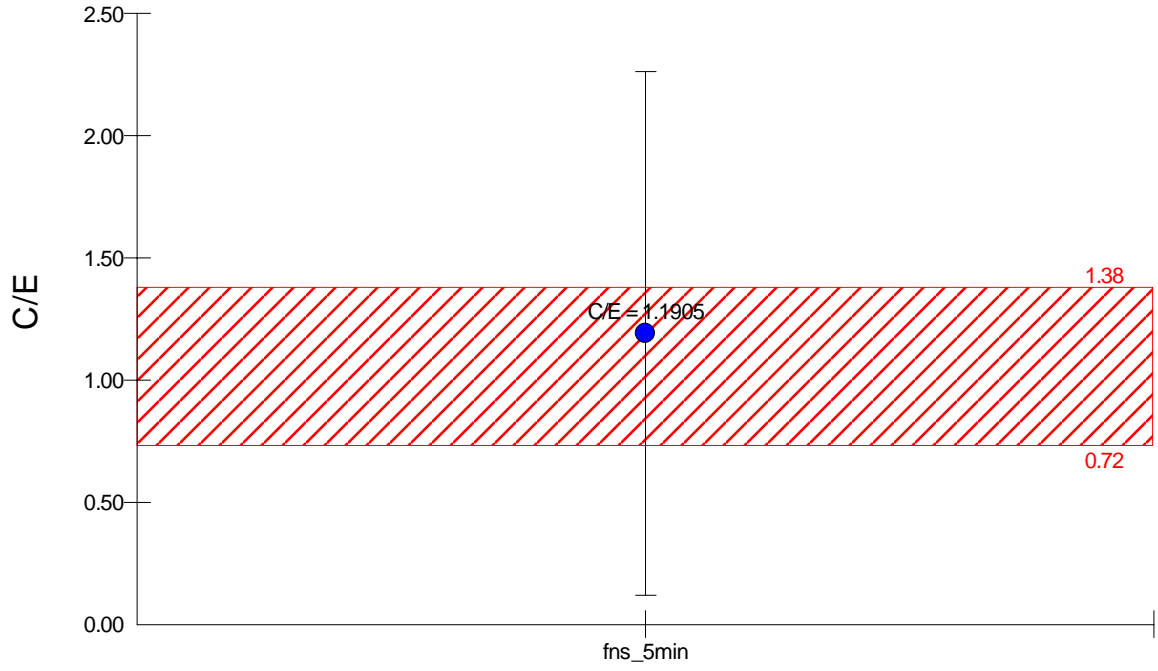




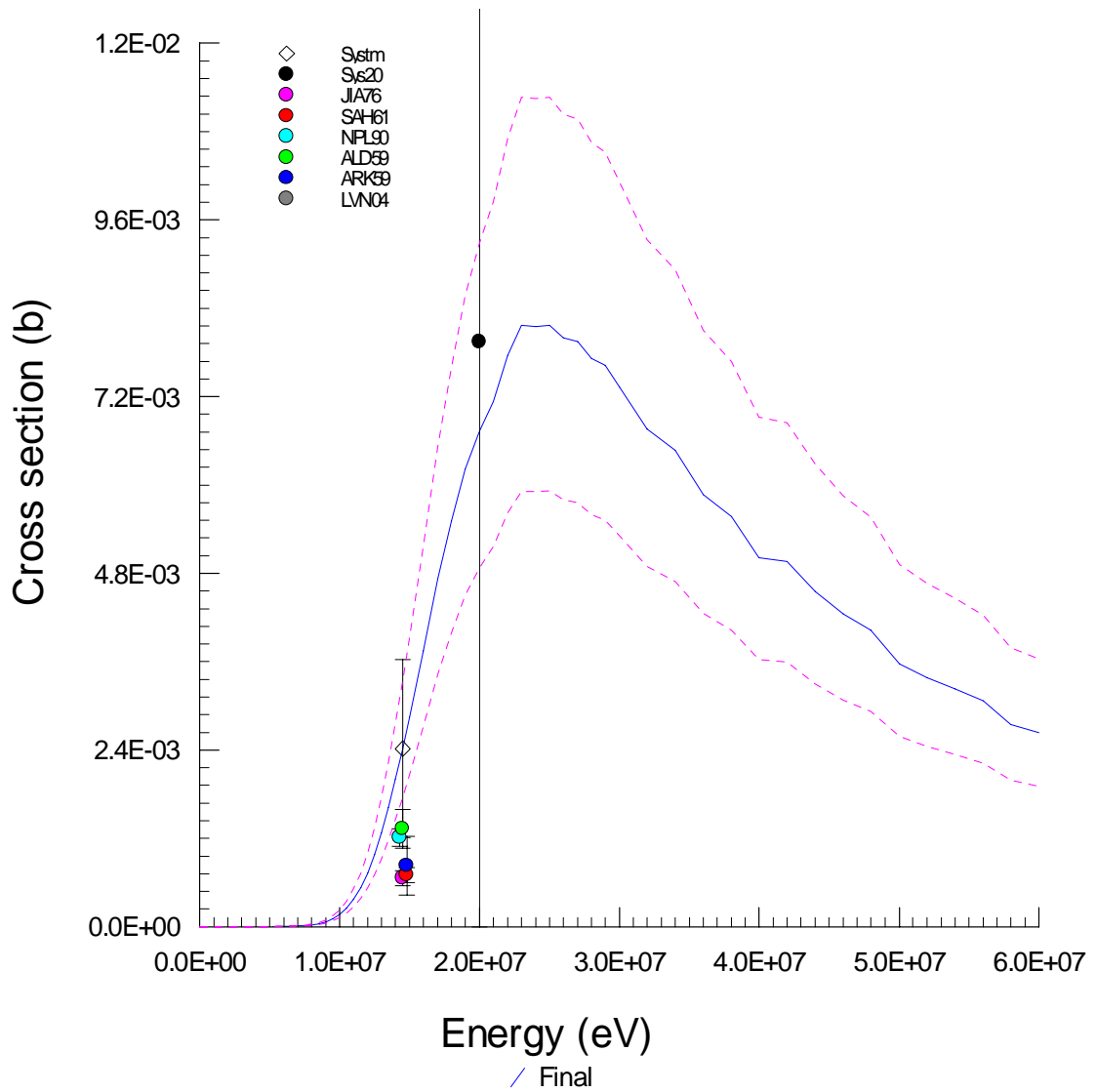
Neutron Spectrum

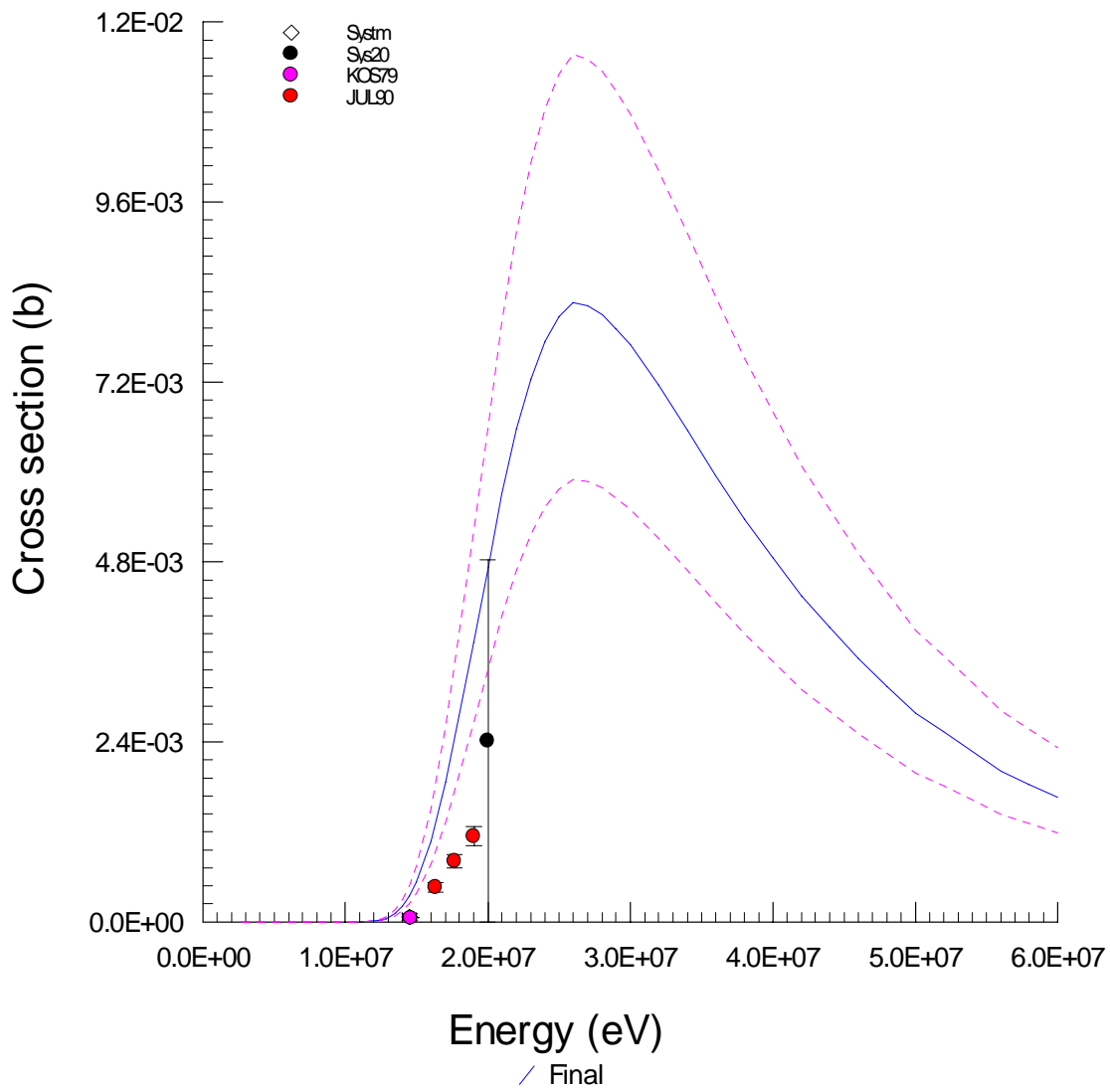
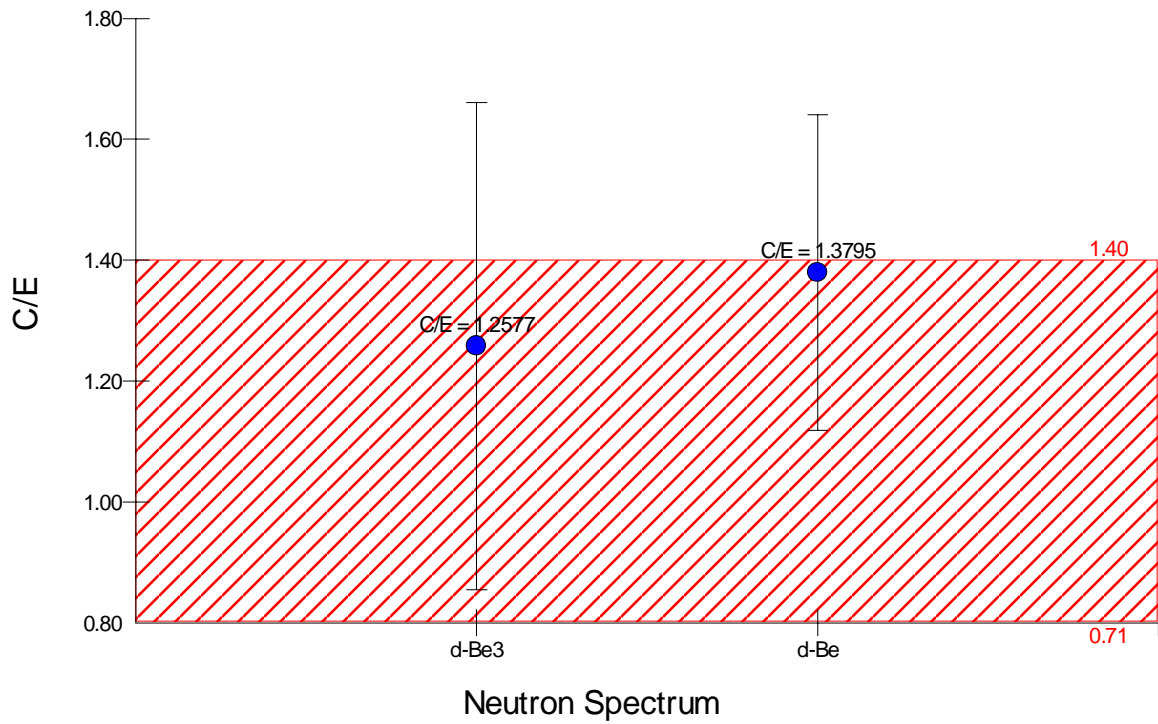
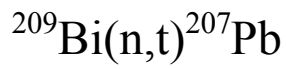


$^{209}\text{Bi}(n,p)^{209}\text{Bi}$

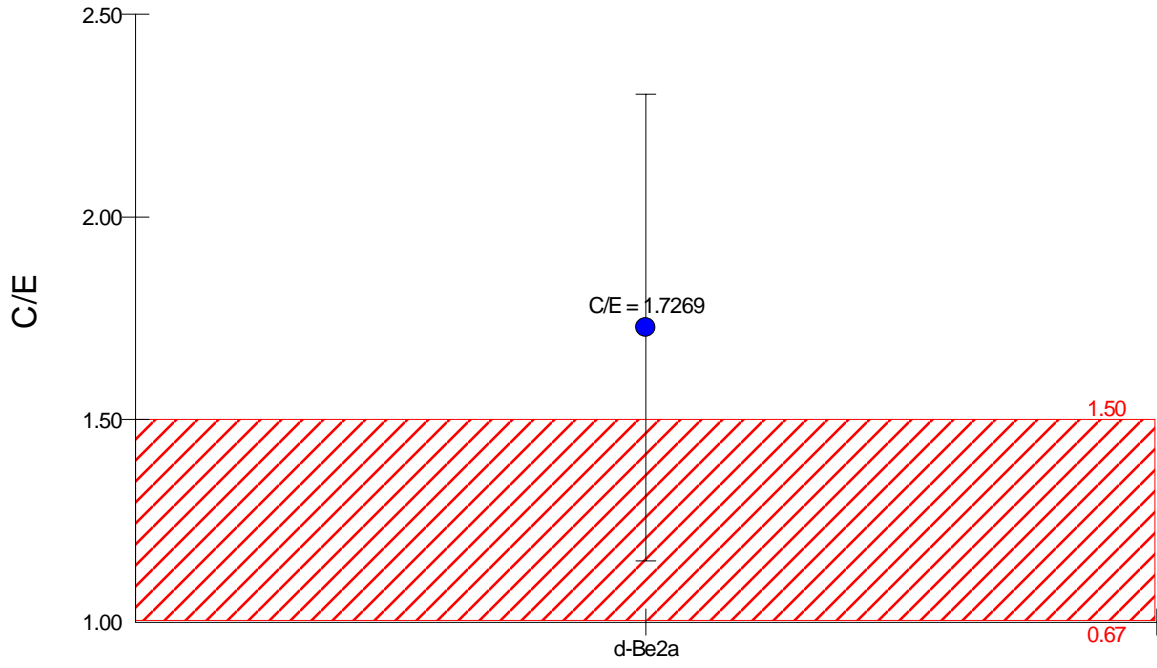


Neutron Spectrum

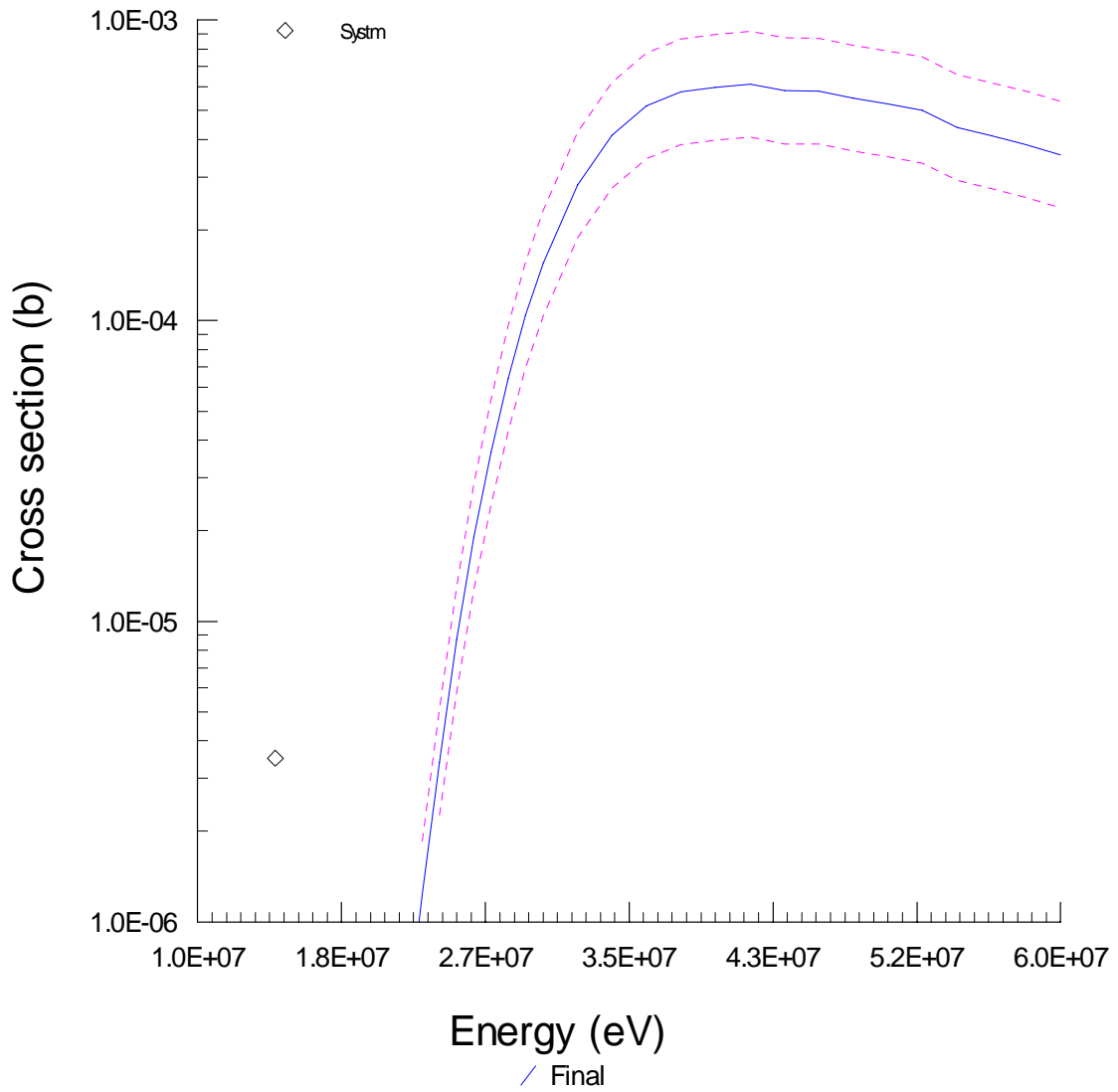


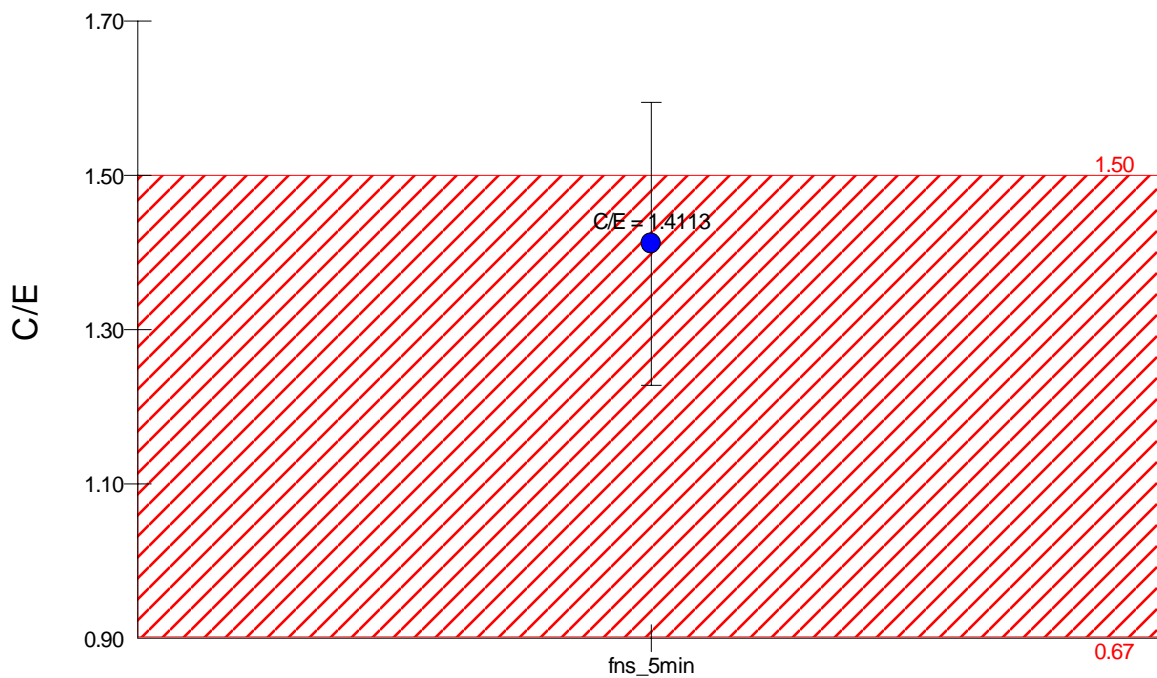
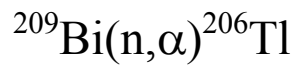


$^{209}\text{Bi}(n,h)^{207}\text{Tl}$

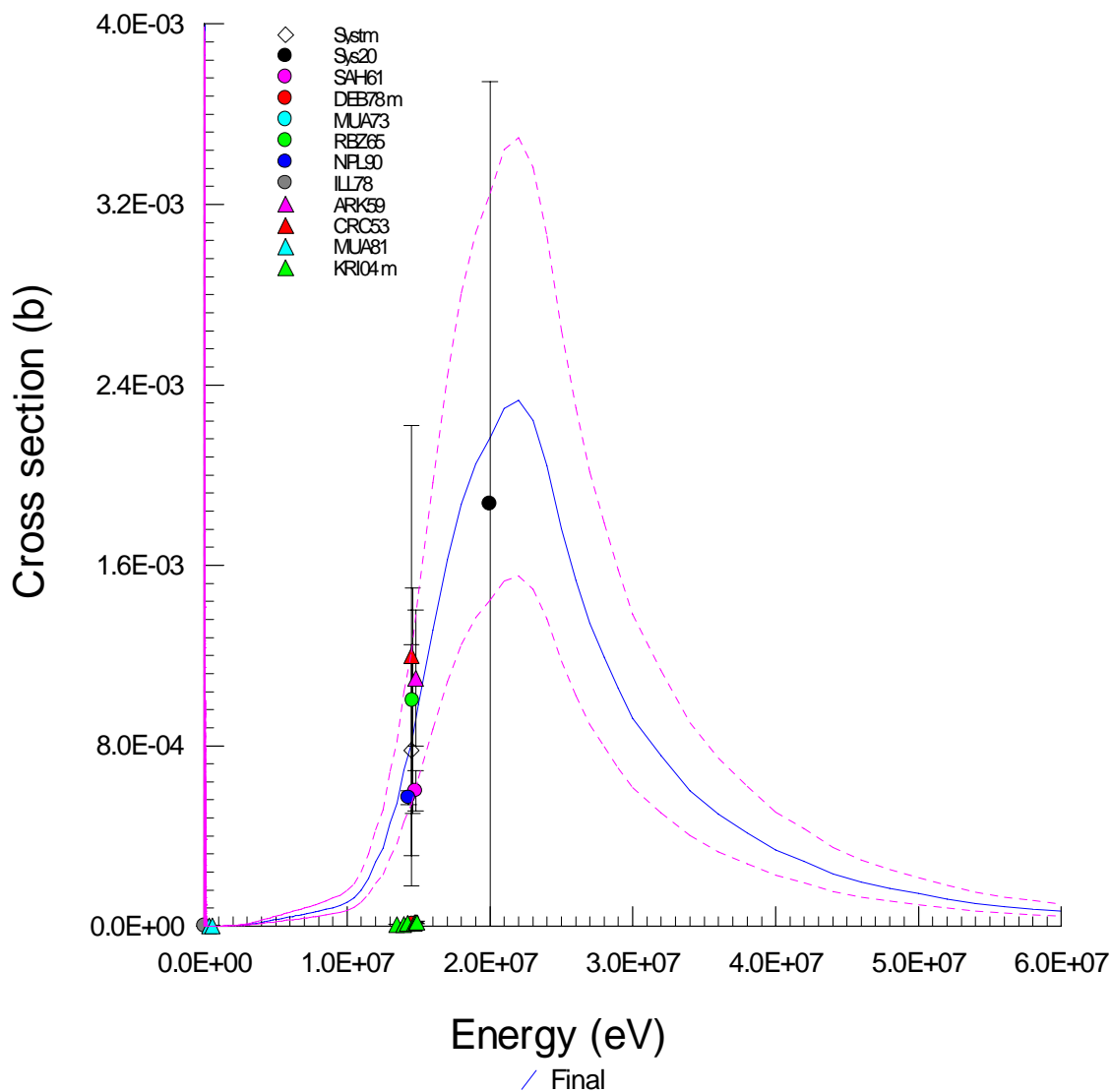


Neutron Spectrum

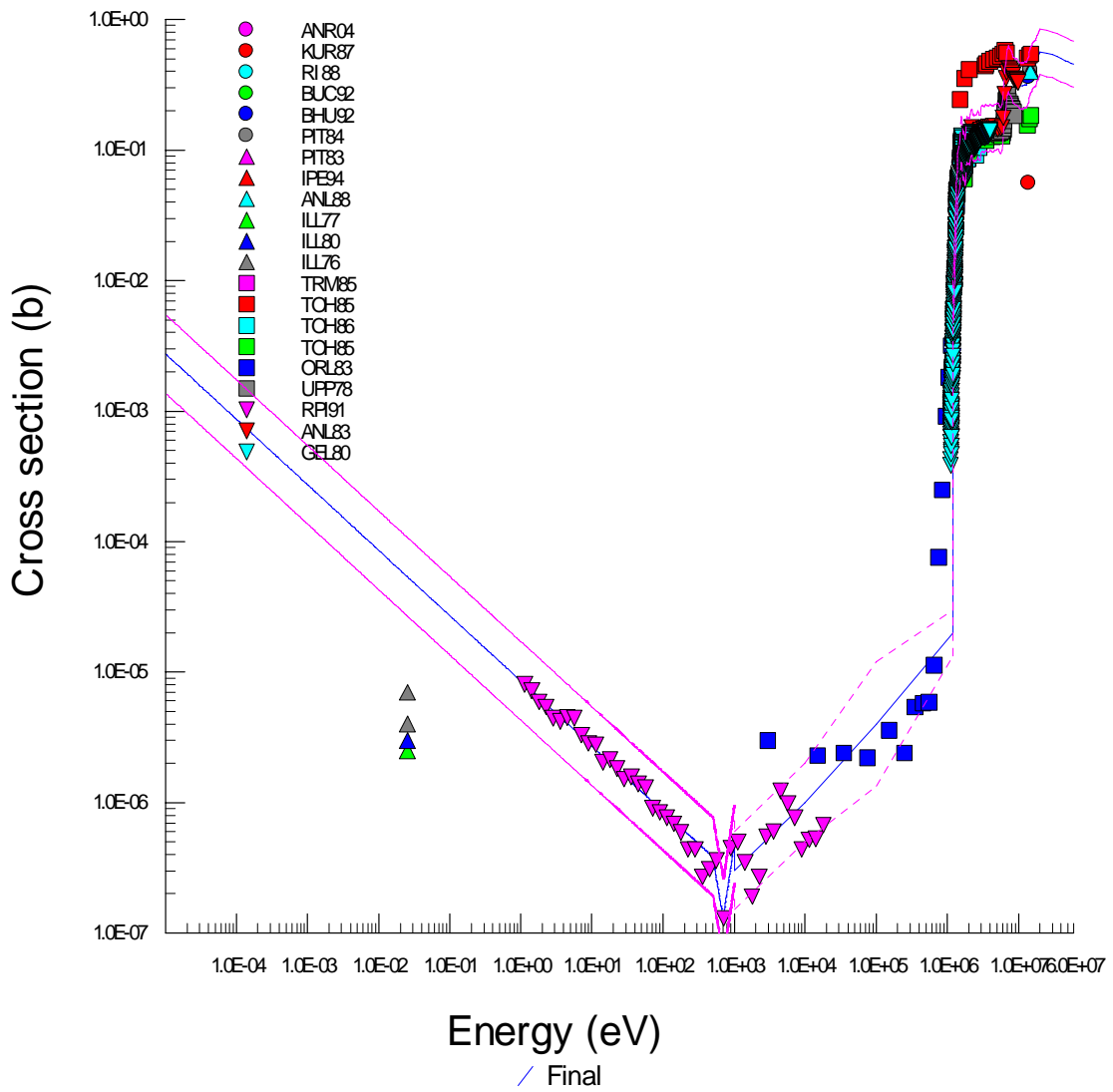
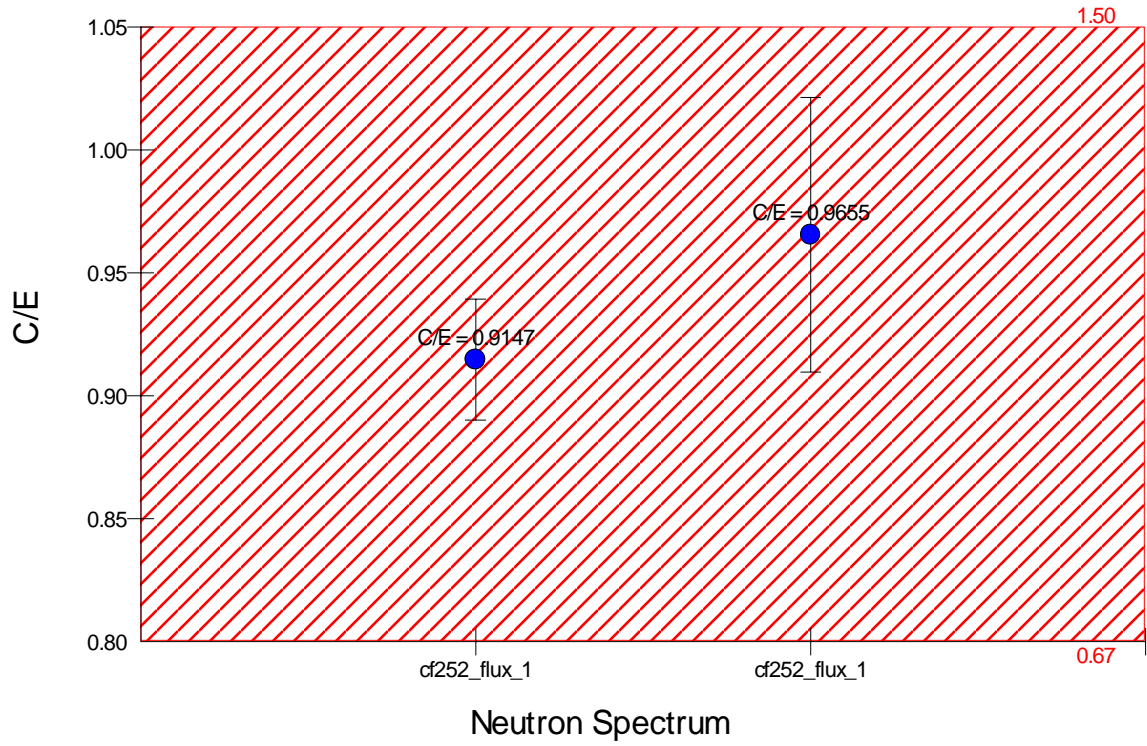




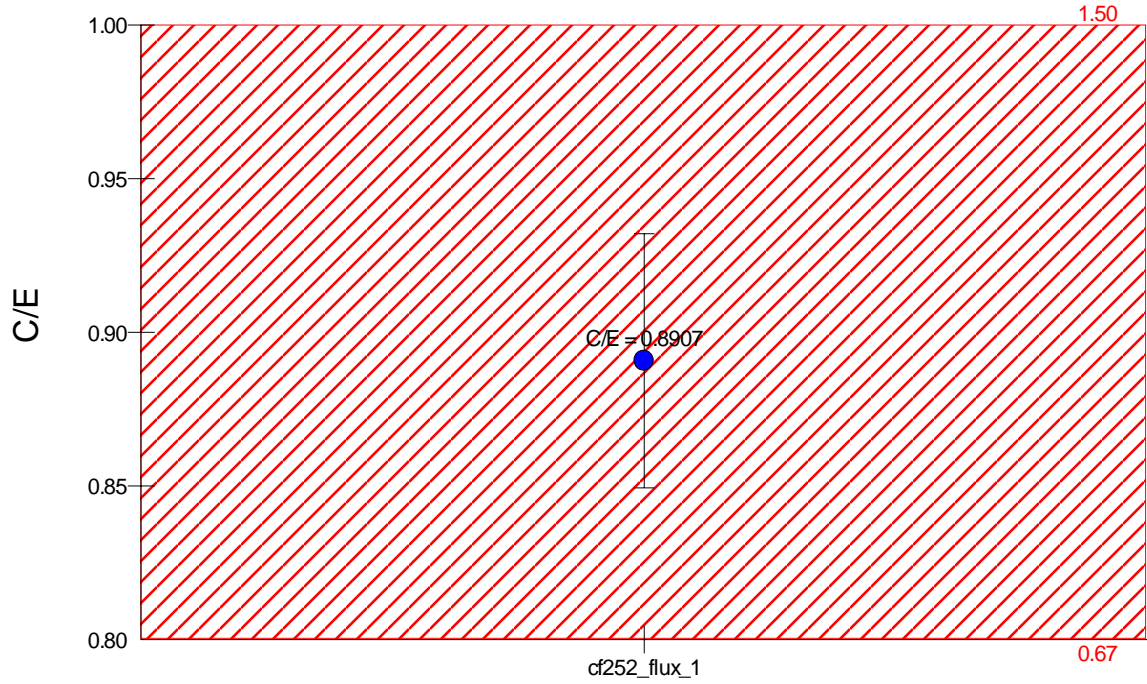
Neutron Spectrum



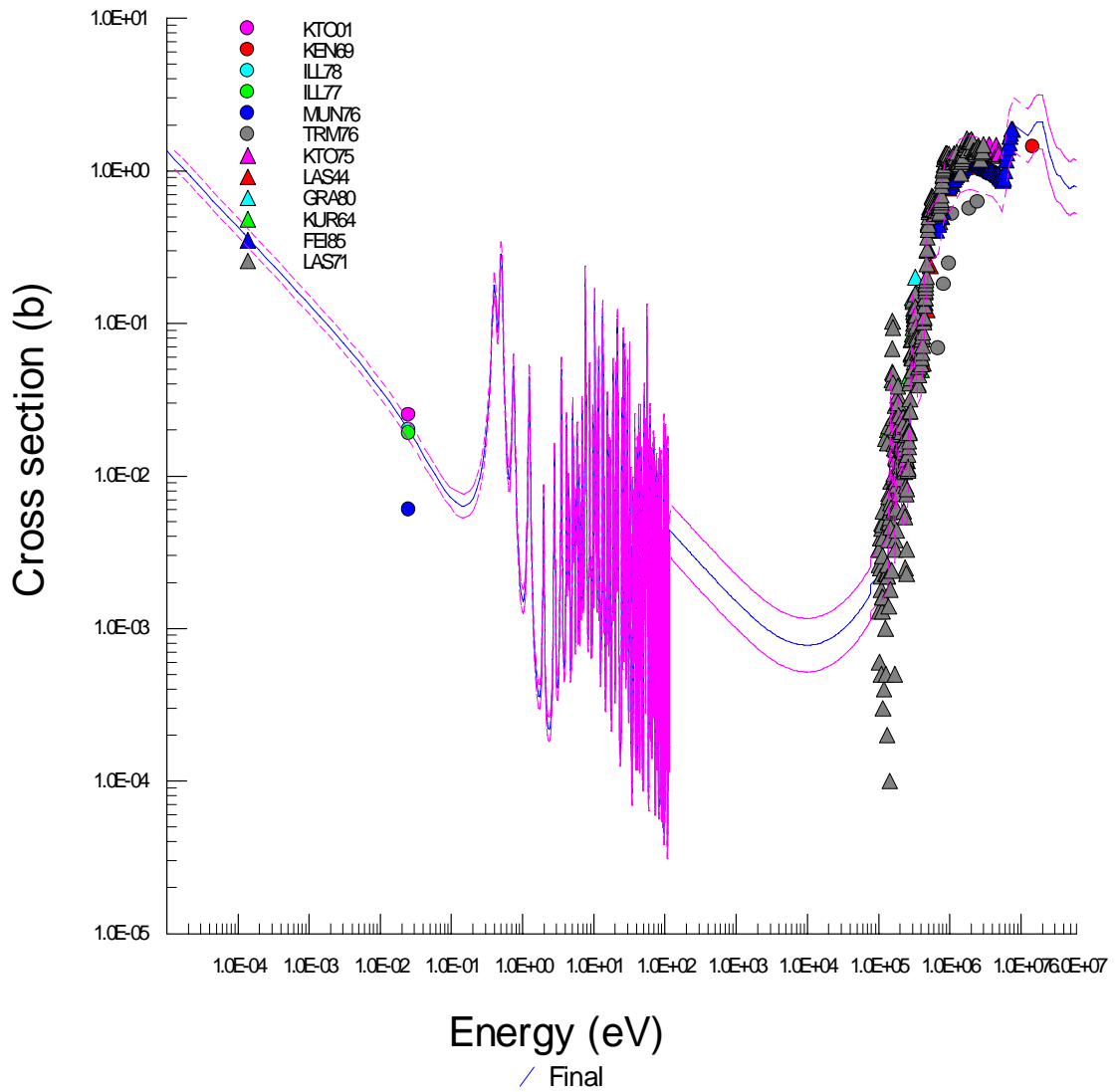
# $^{232}\text{Th}(n,f)$



# $^{231}\text{Pa}(n,f)$

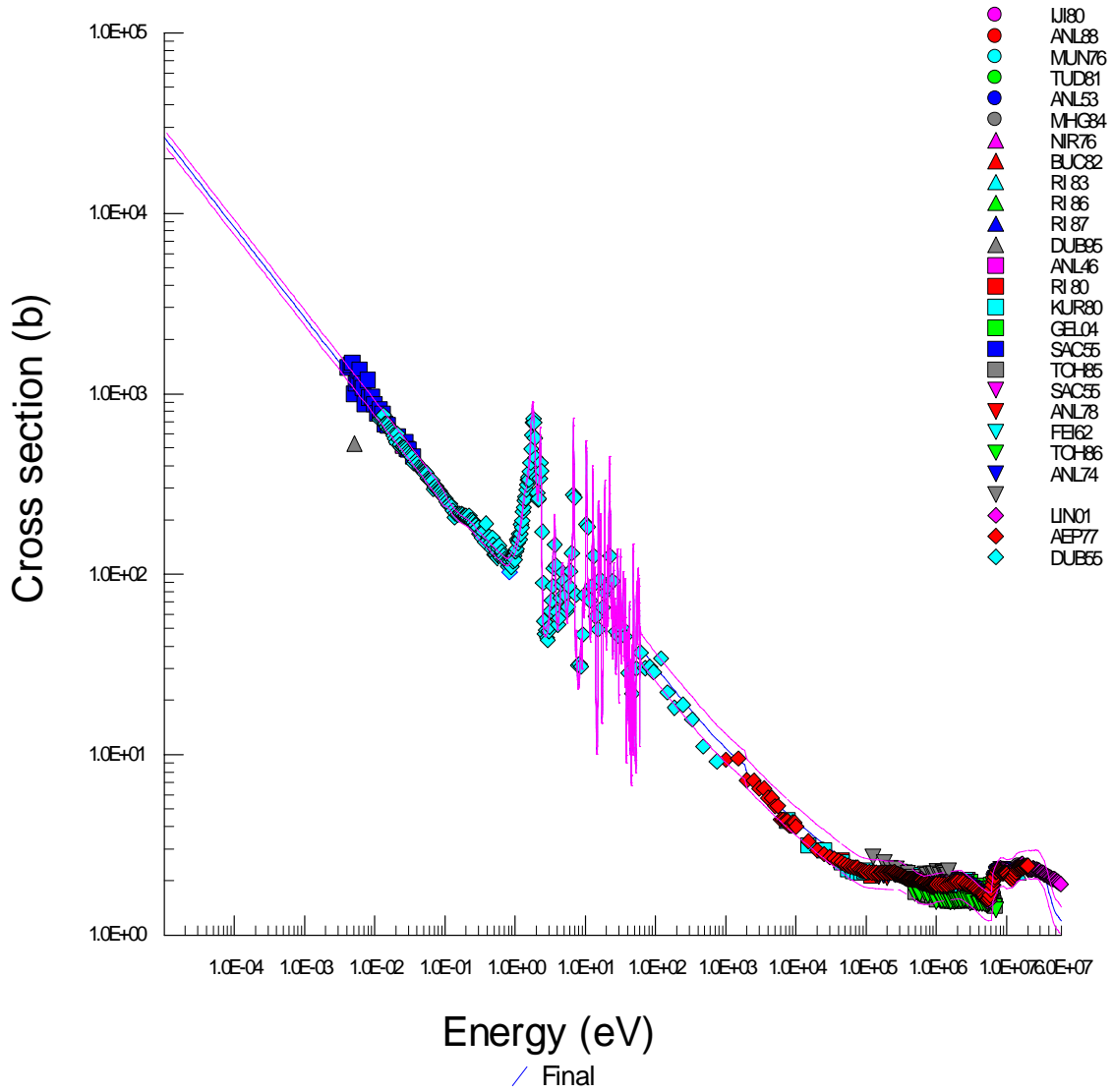
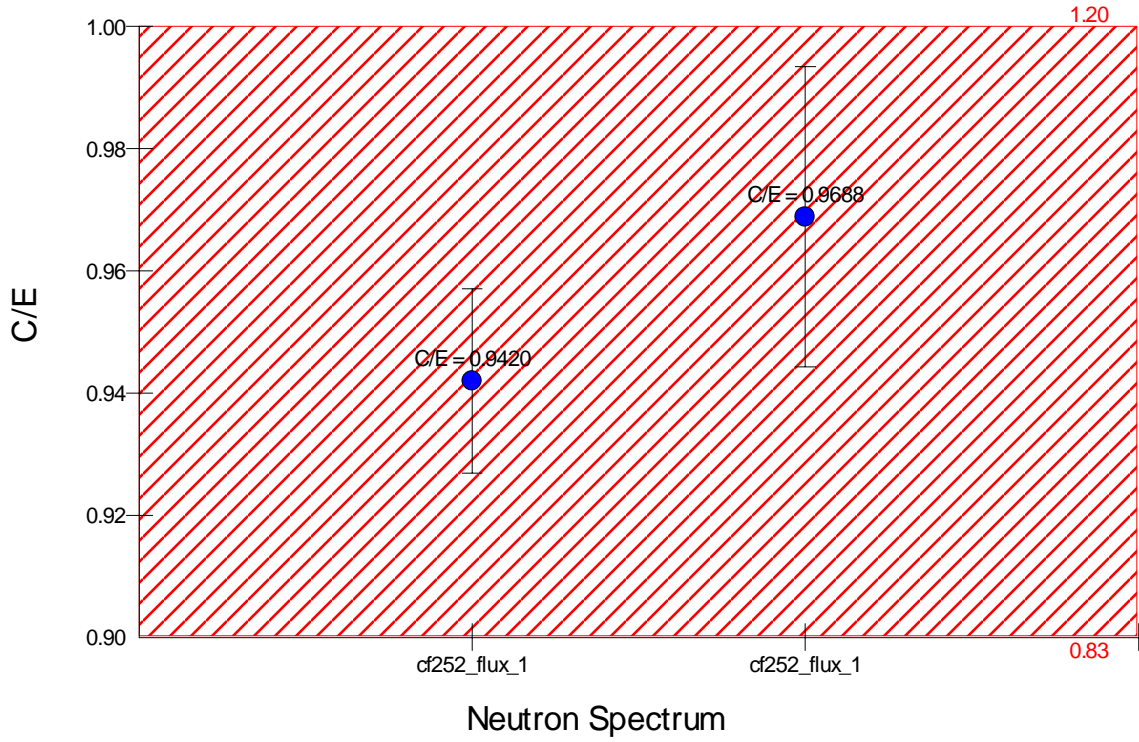


## Neutron Spectrum

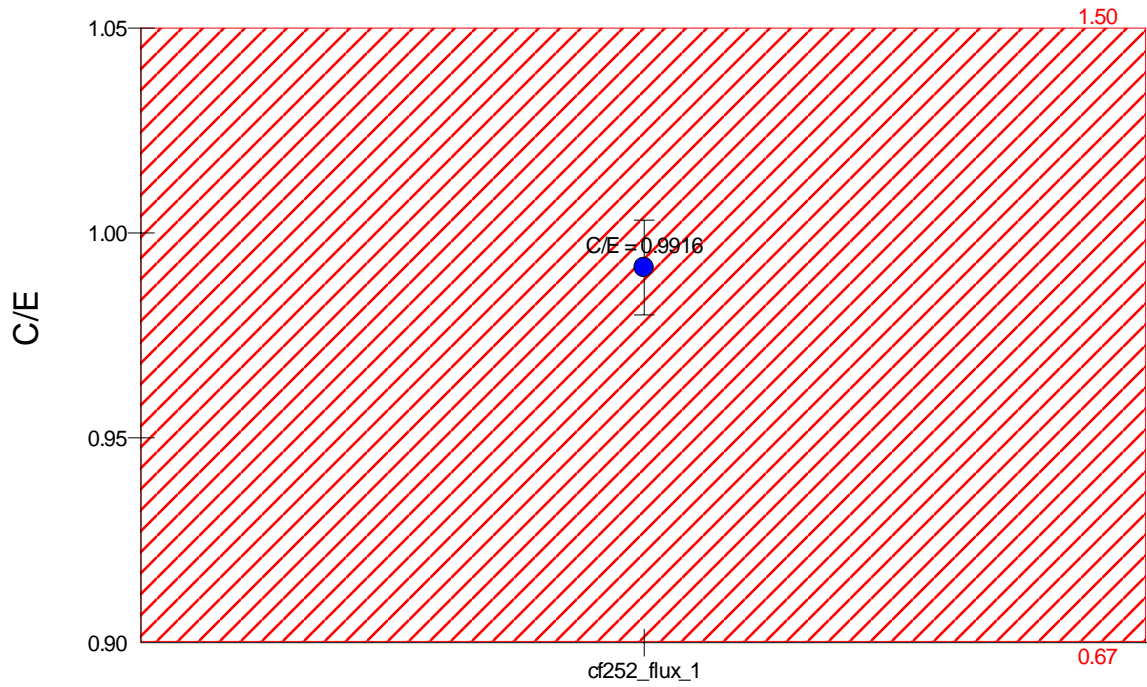




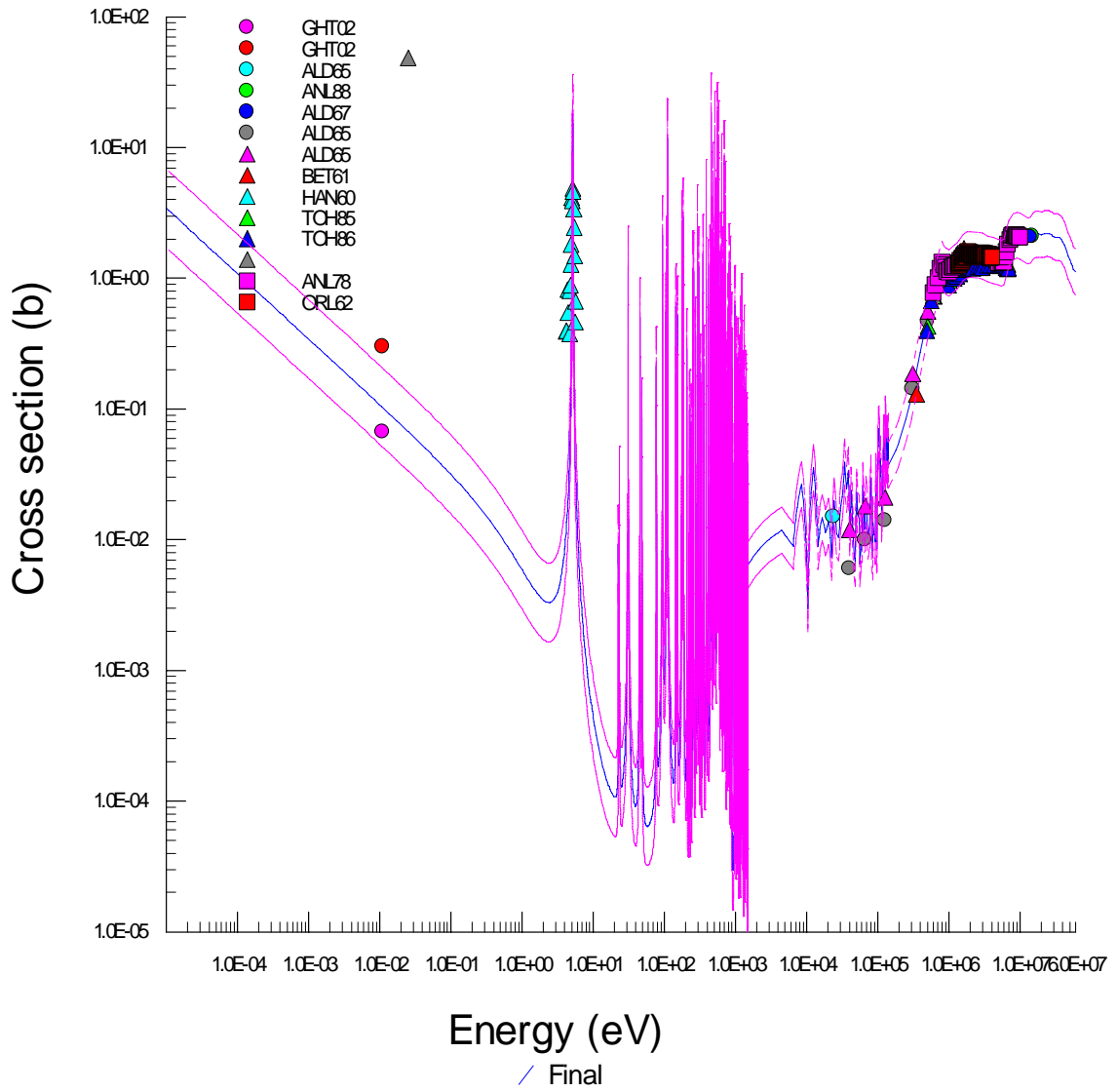
# $^{233}\text{U}(n,f)$



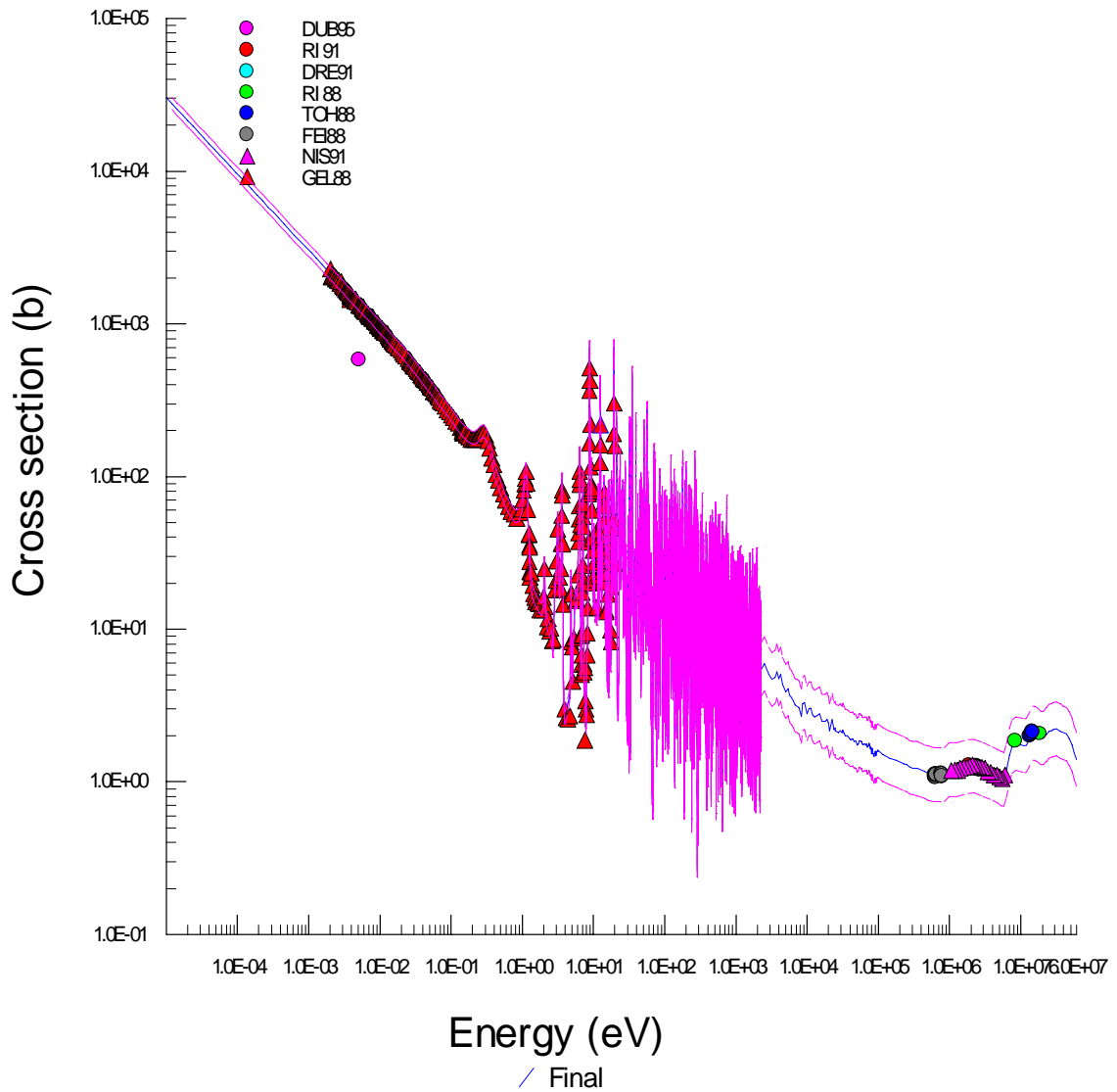
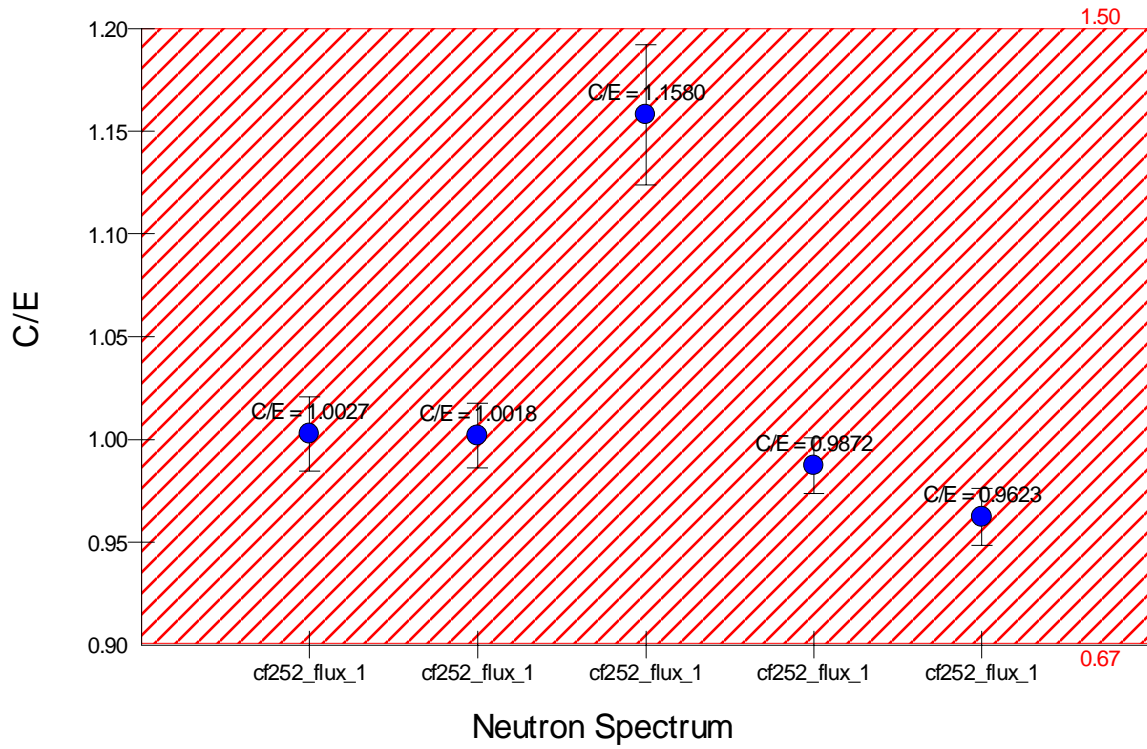
# $^{234}\text{U}(n,f)$



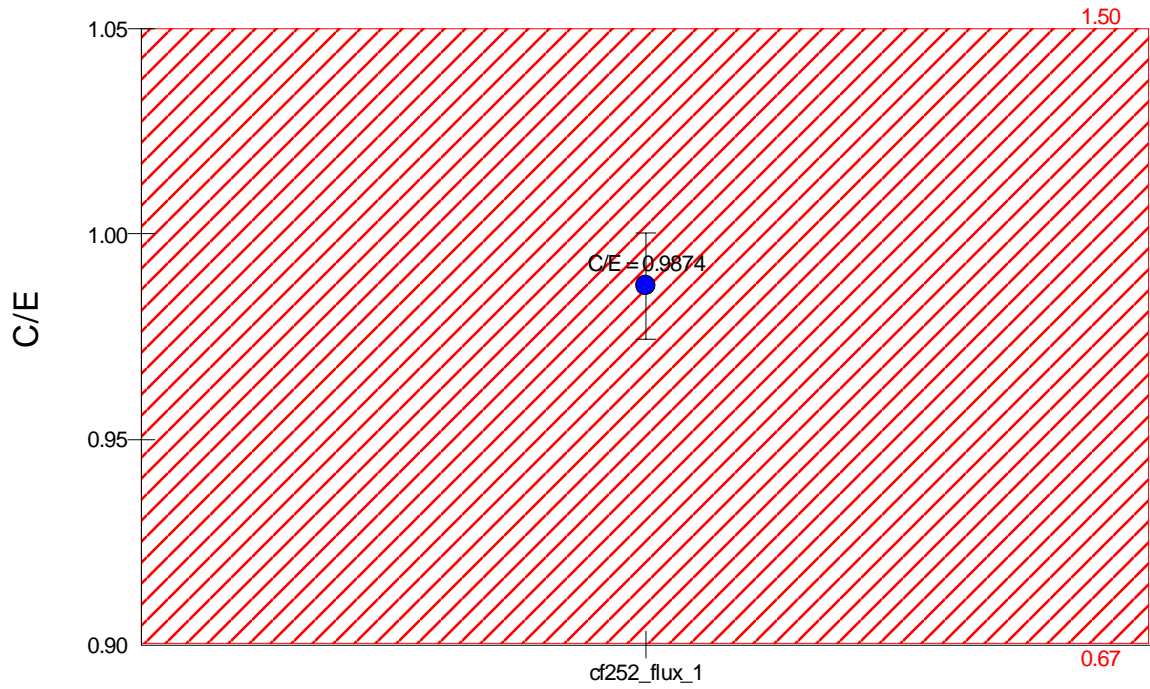
## Neutron Spectrum



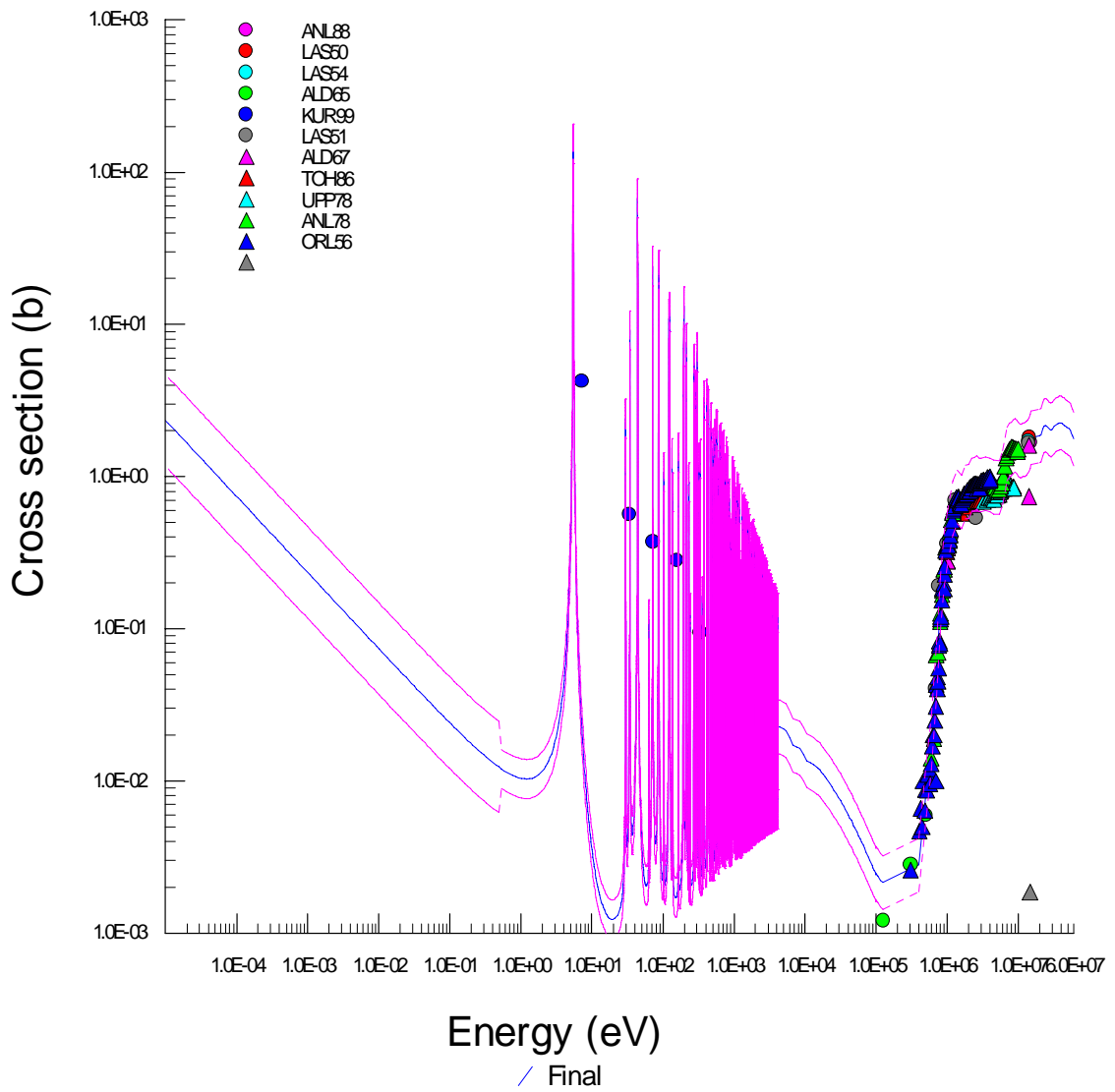
# $^{235}\text{U}(n,f)$

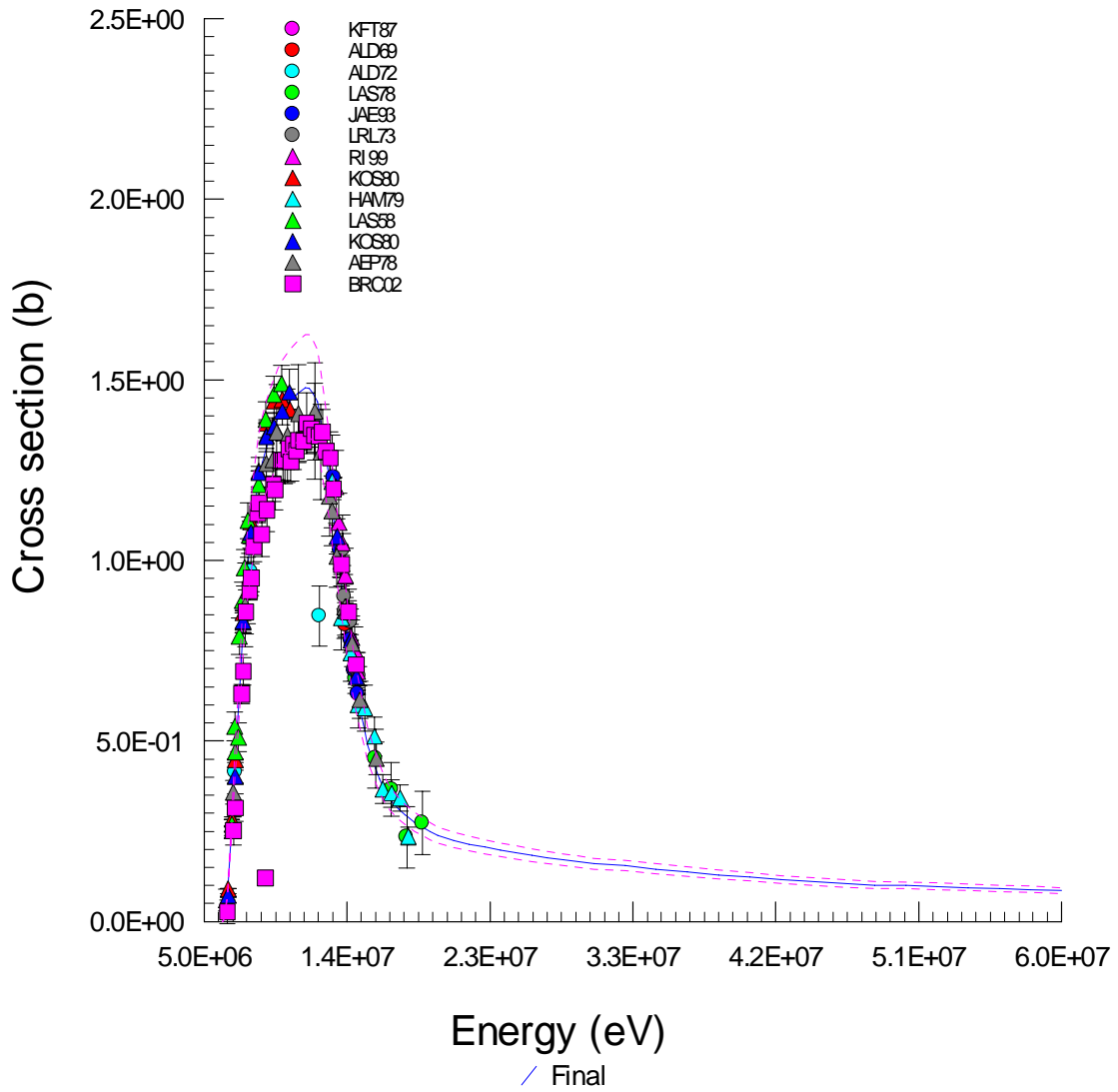
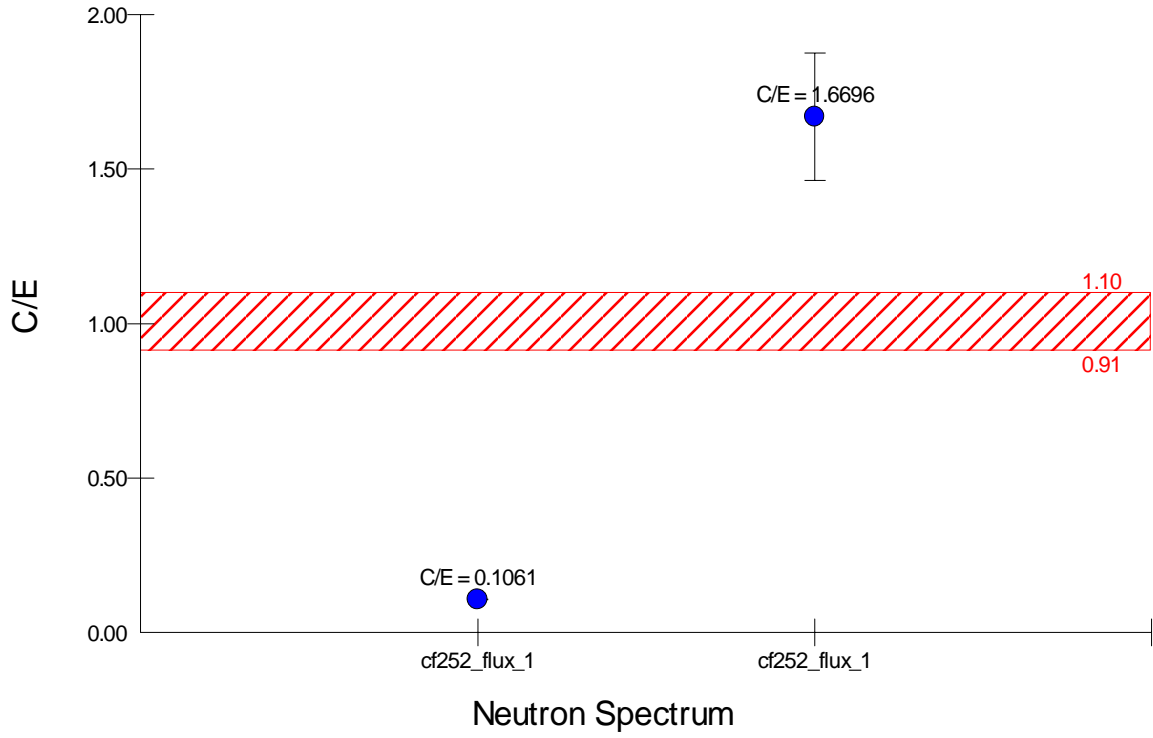
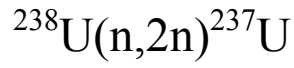


# $^{236}\text{U}(n,f)$

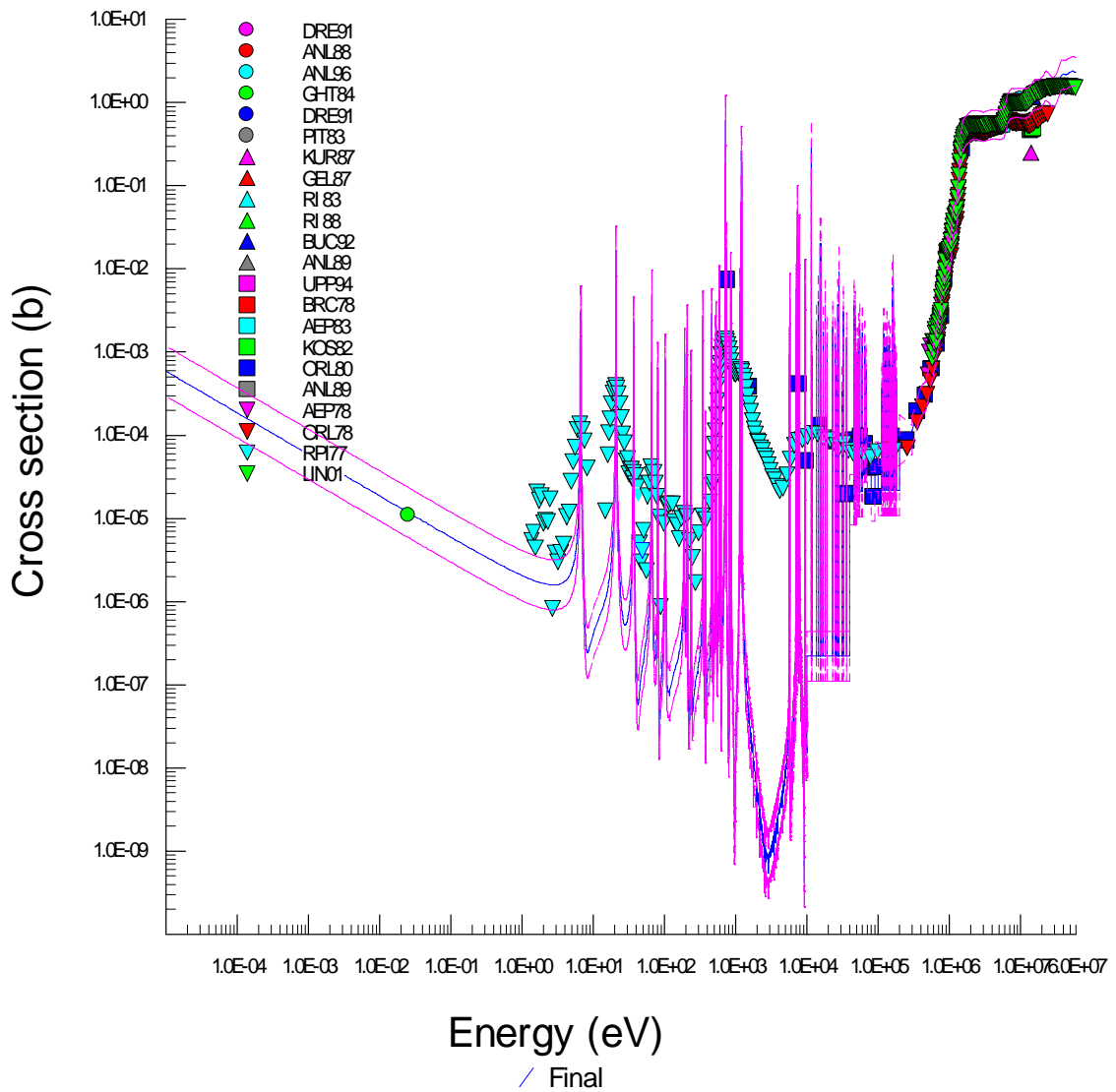
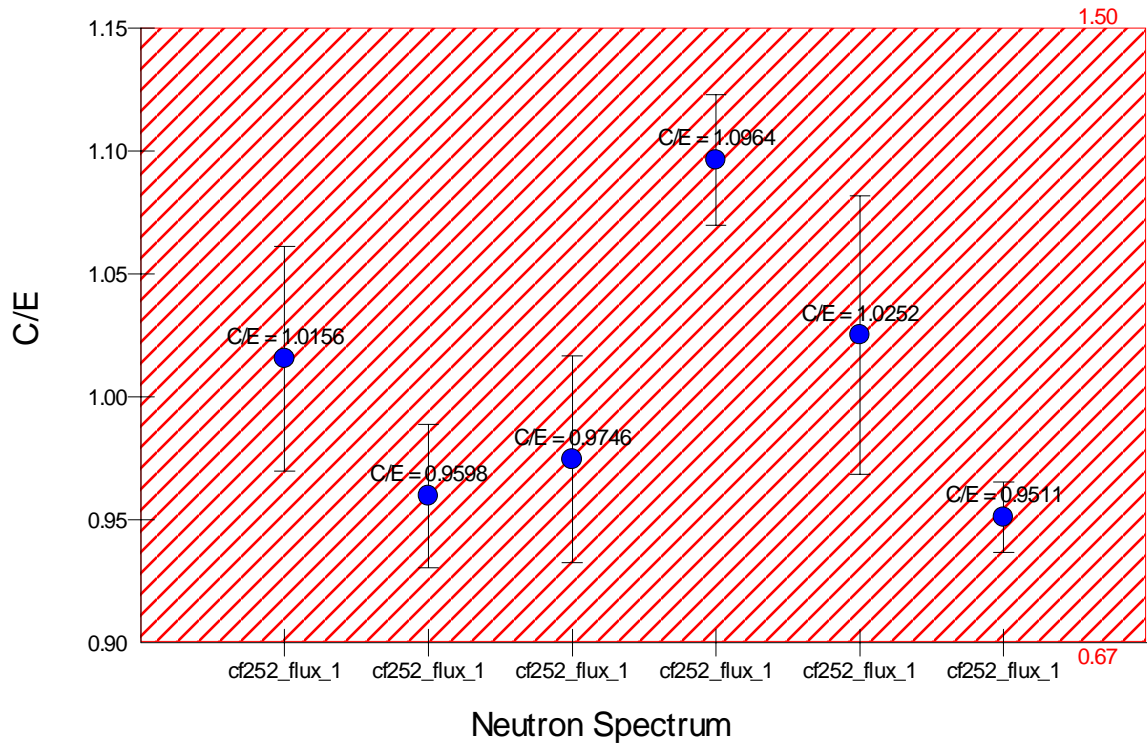


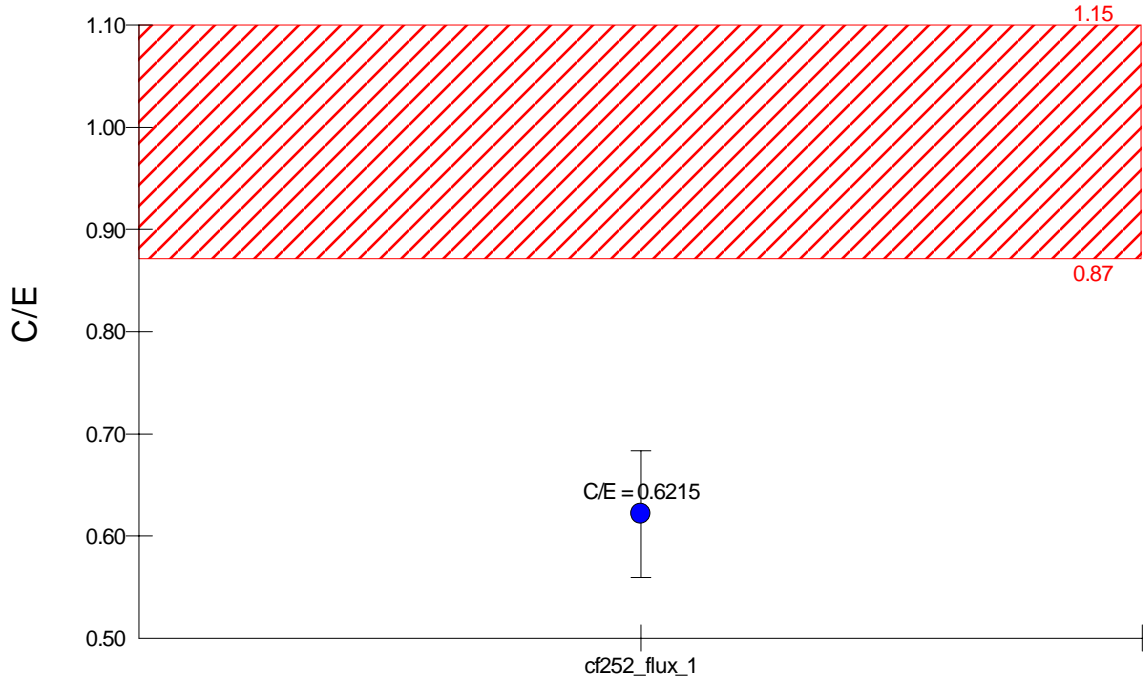
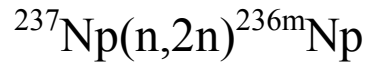
## Neutron Spectrum



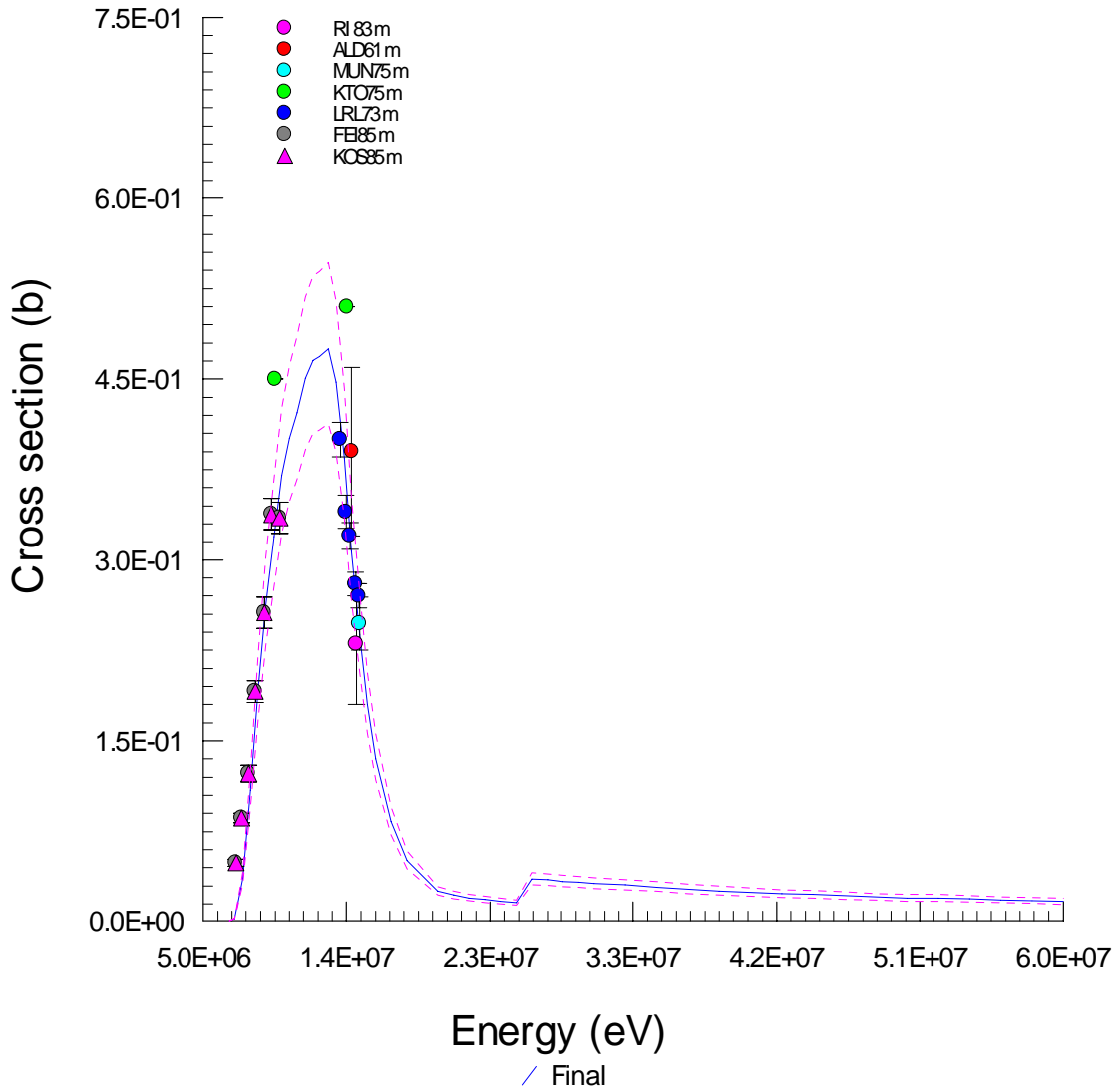


# $^{238}\text{U}(n,f)$

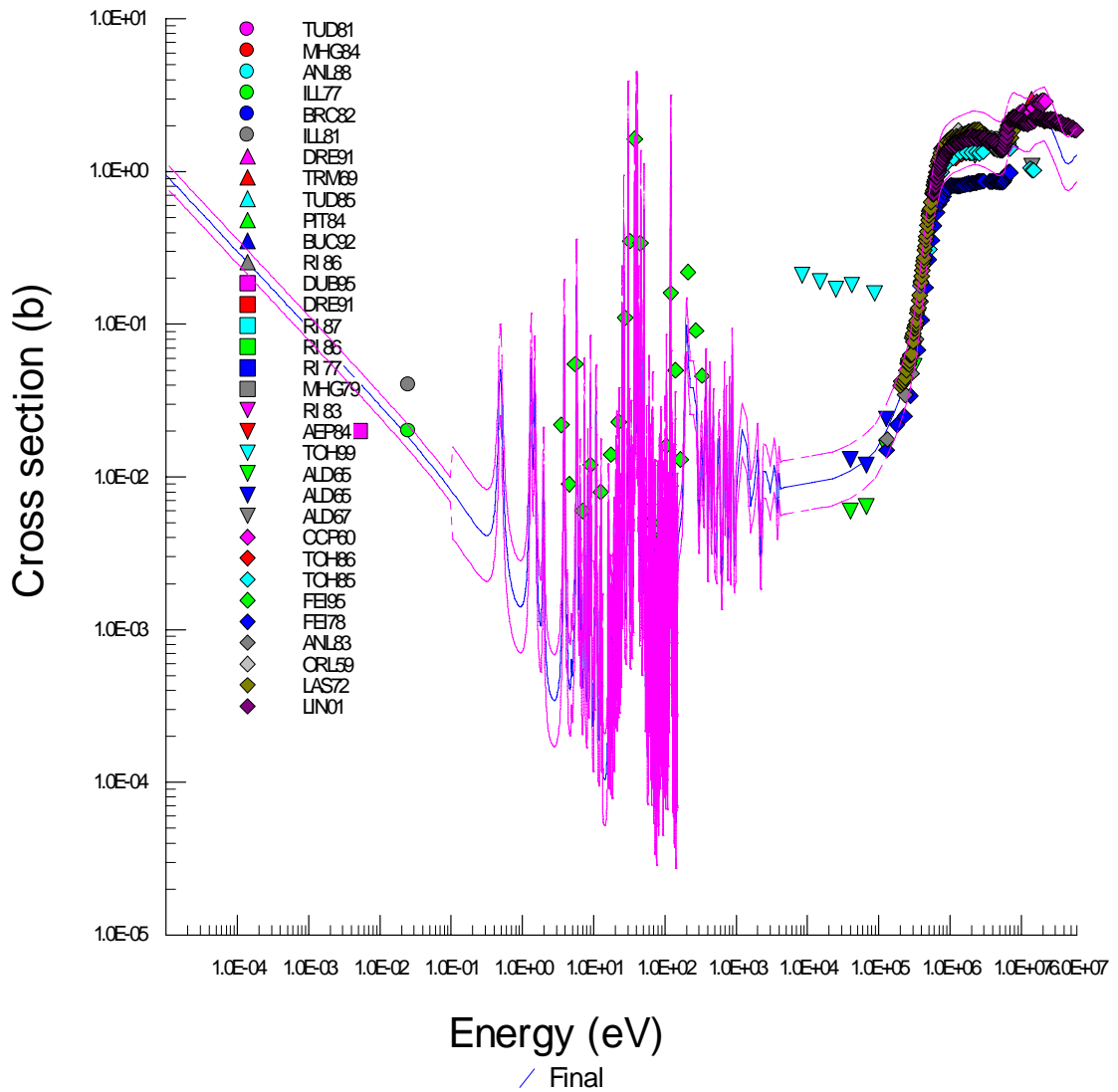
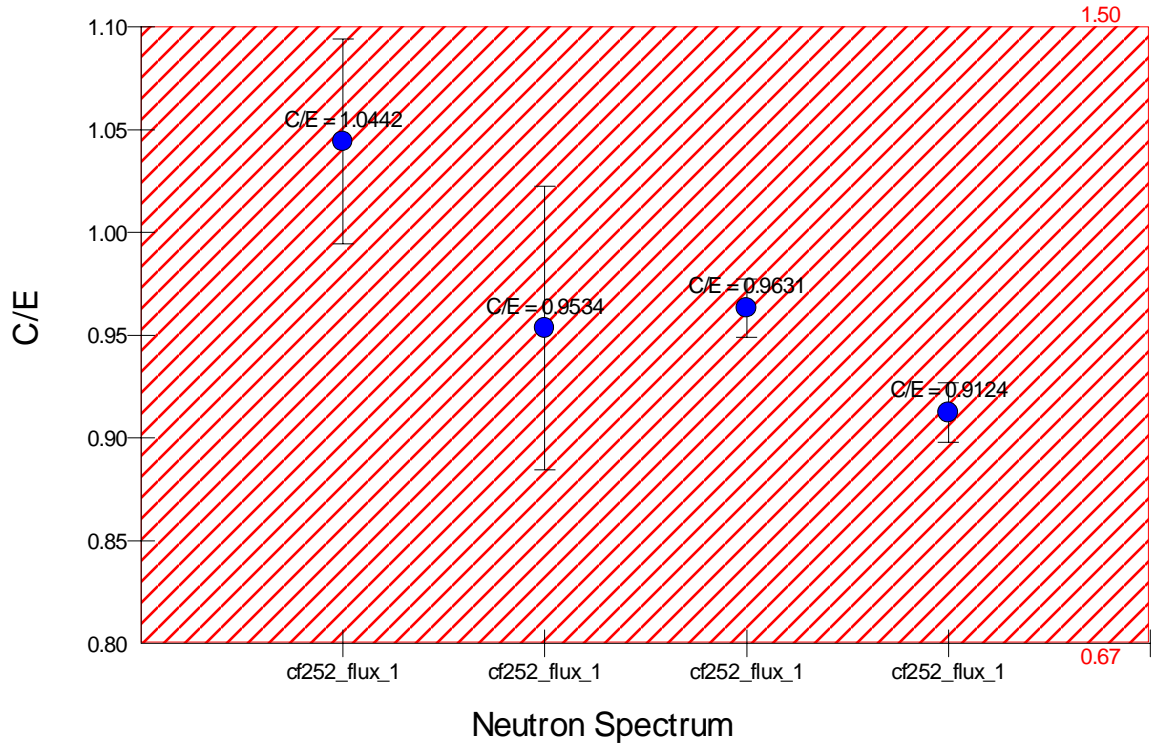




Neutron Spectrum

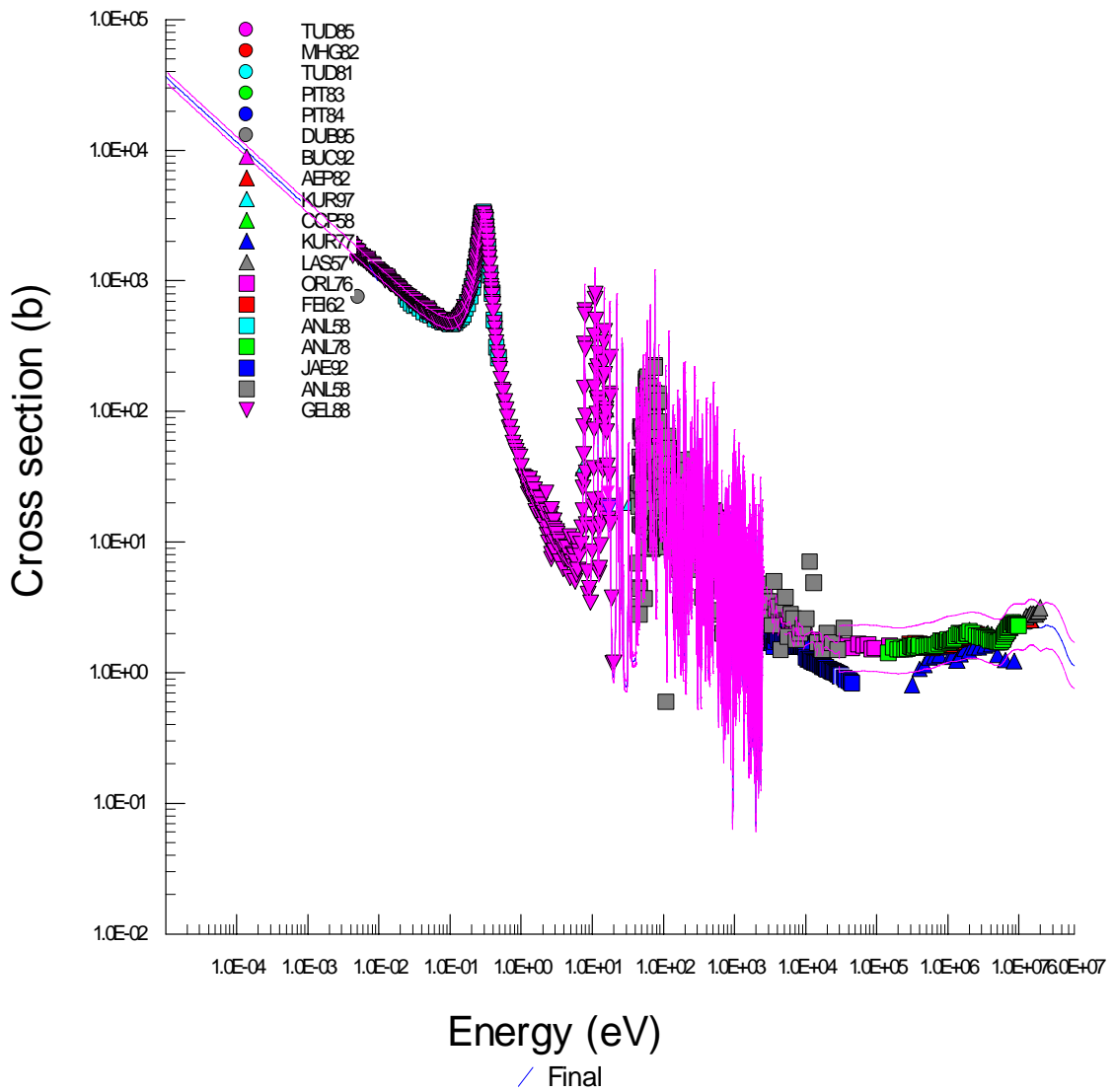
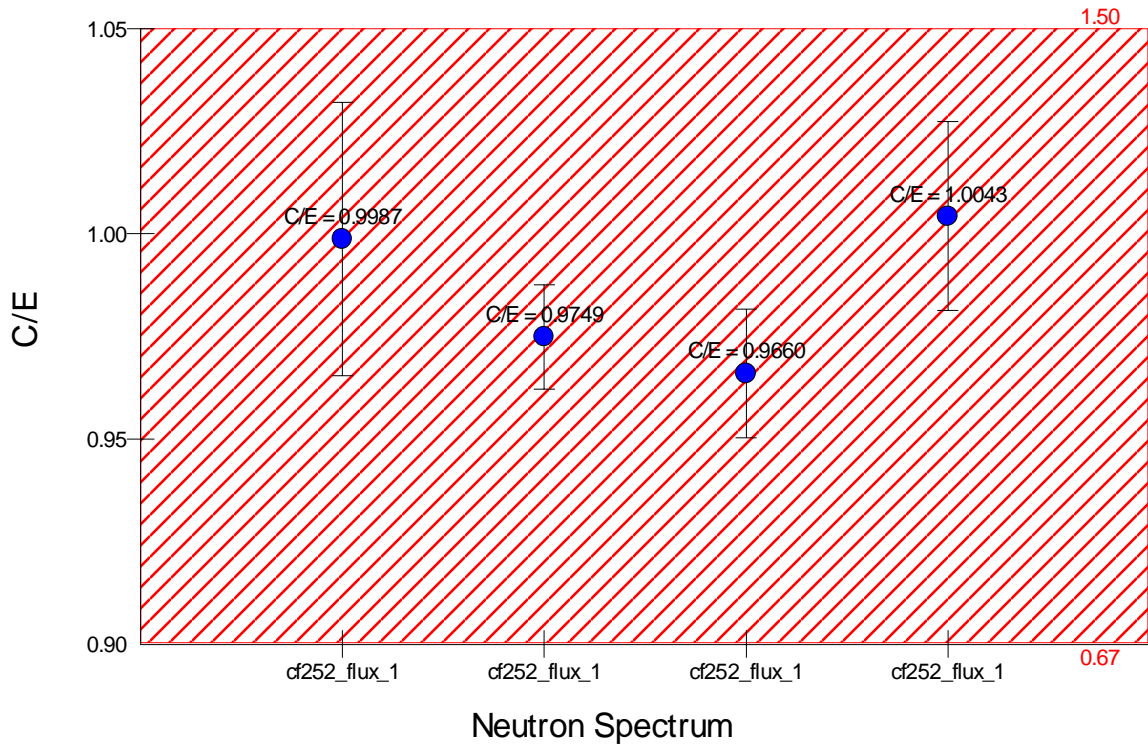


# $^{237}\text{Np}(n,f)$

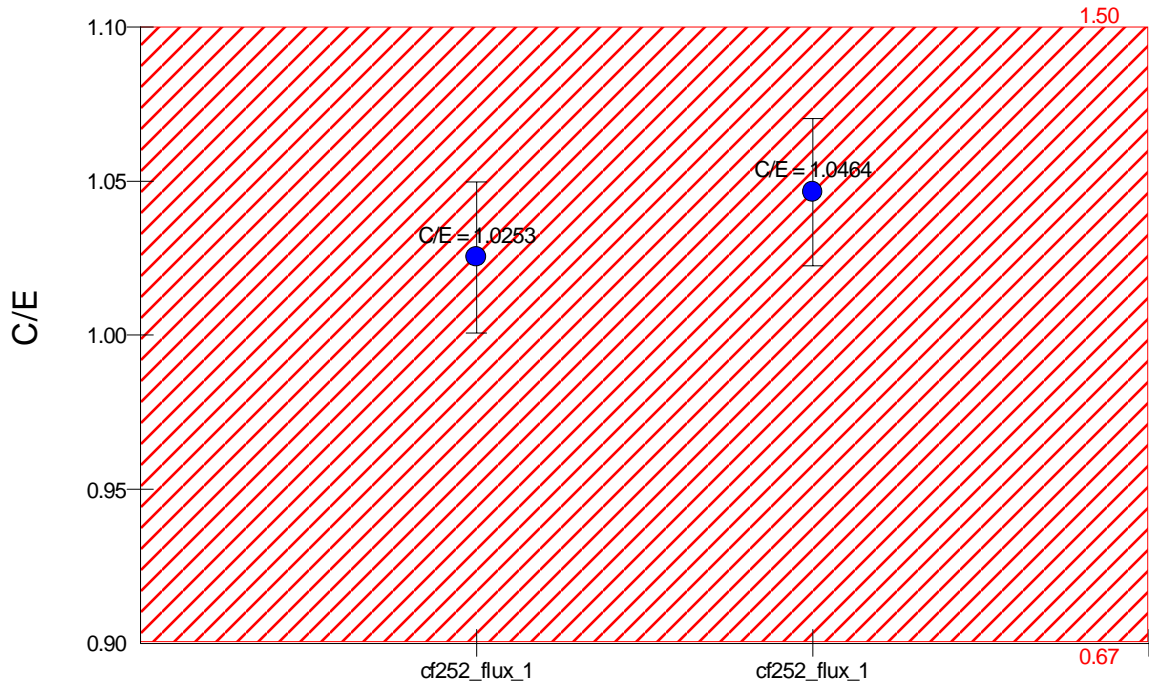




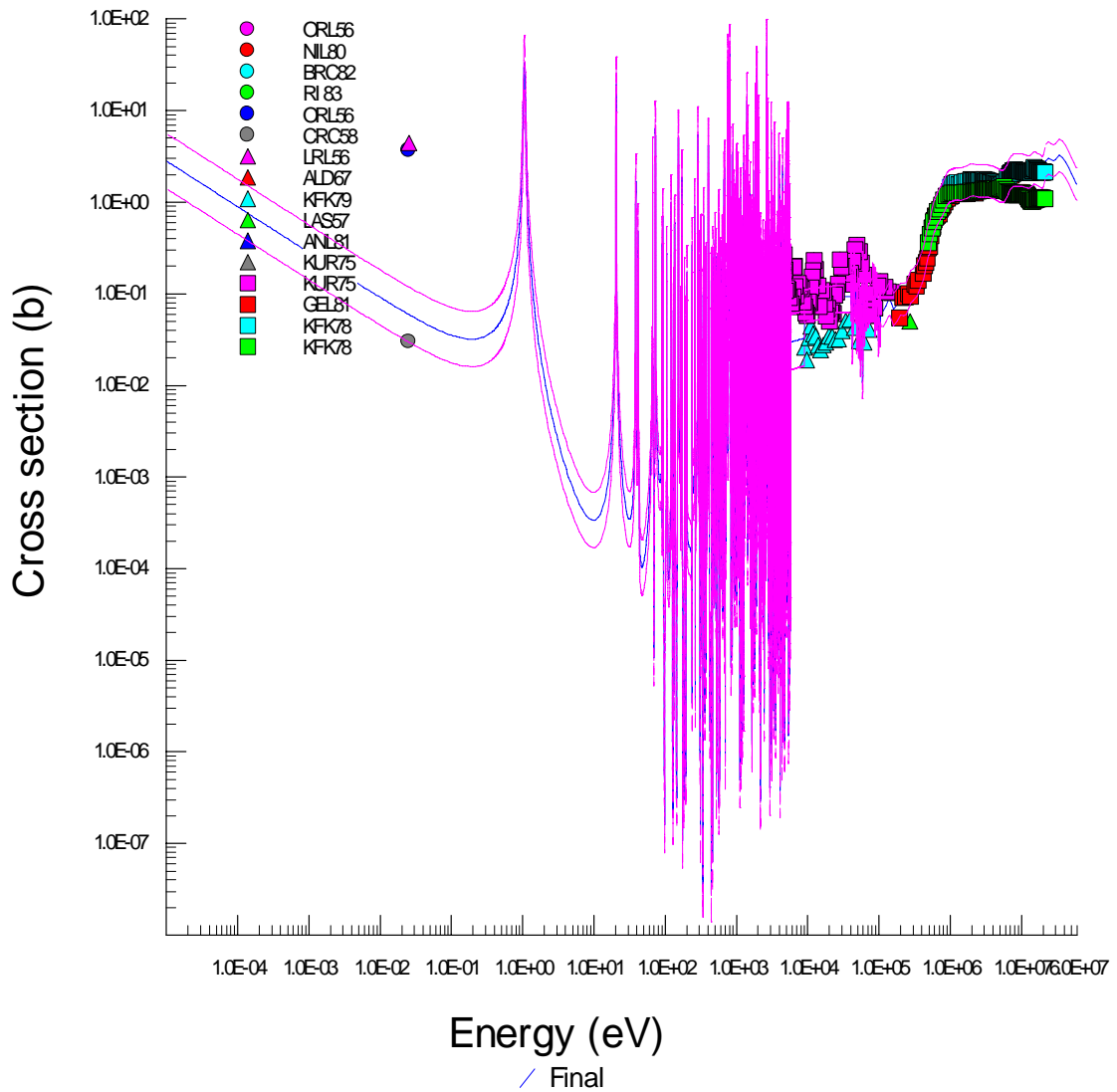
# $^{239}\text{Pu}(n,f)$



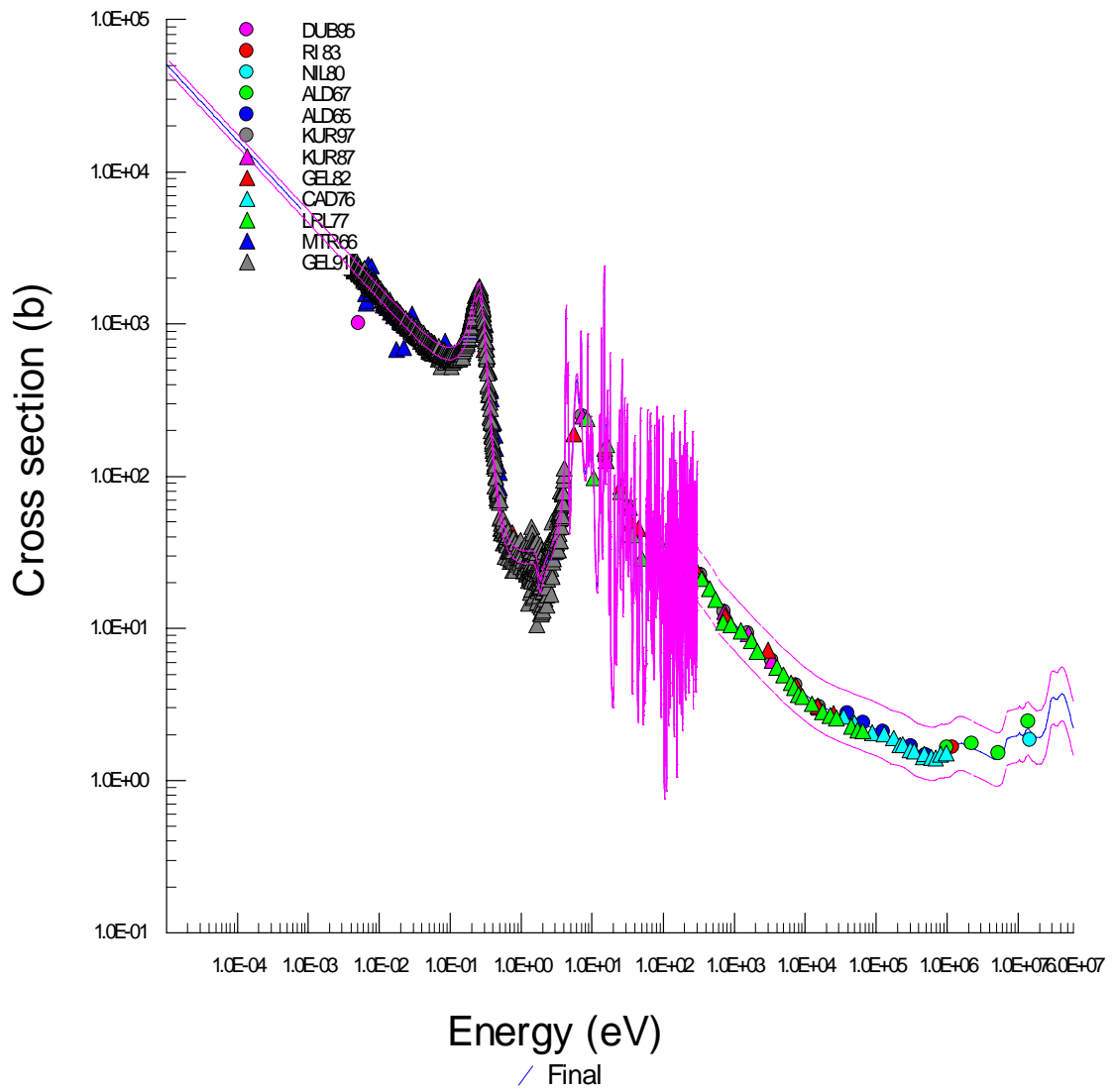
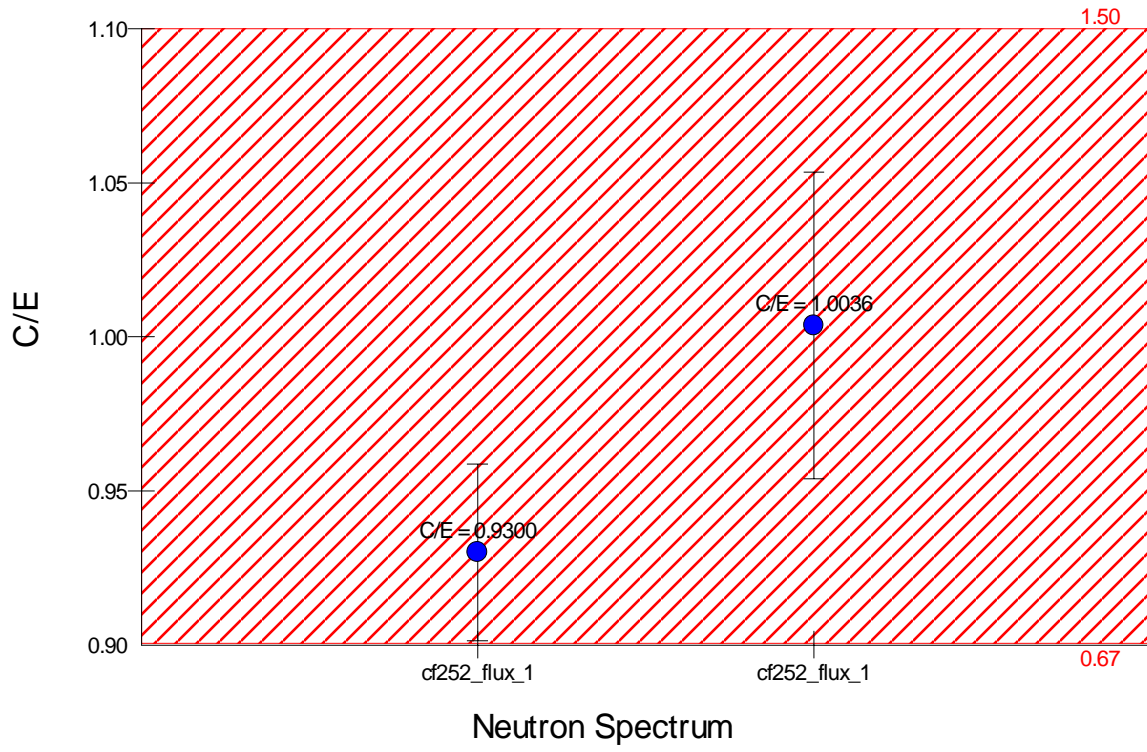
# $^{240}\text{Pu}(n,f)$



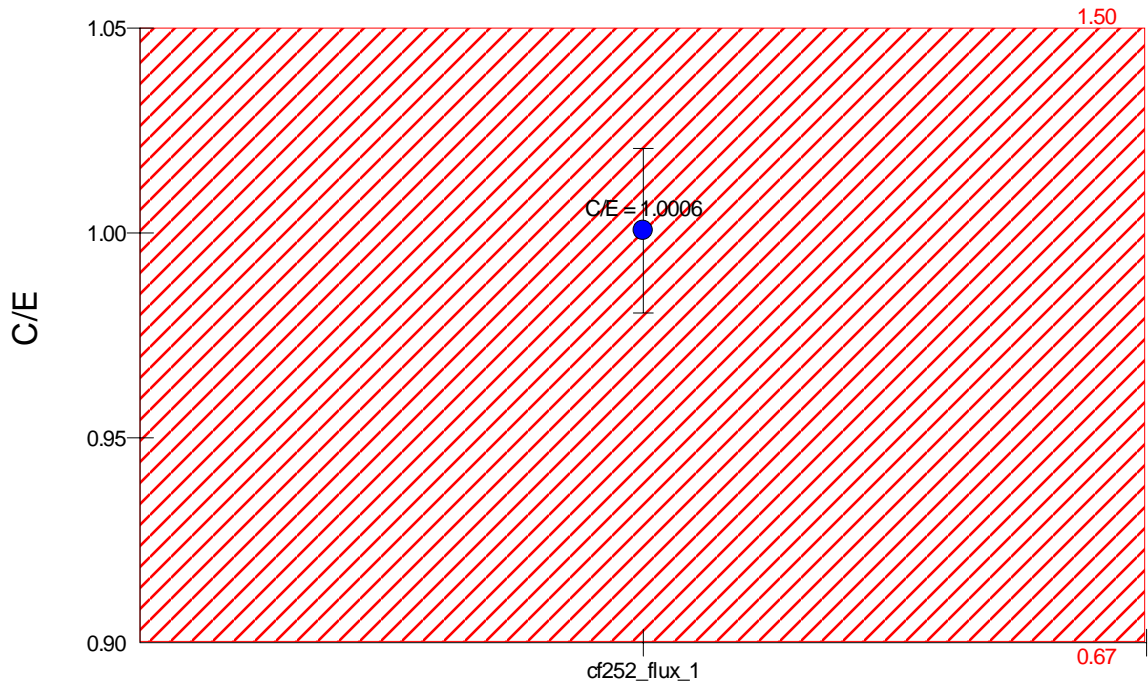
## Neutron Spectrum



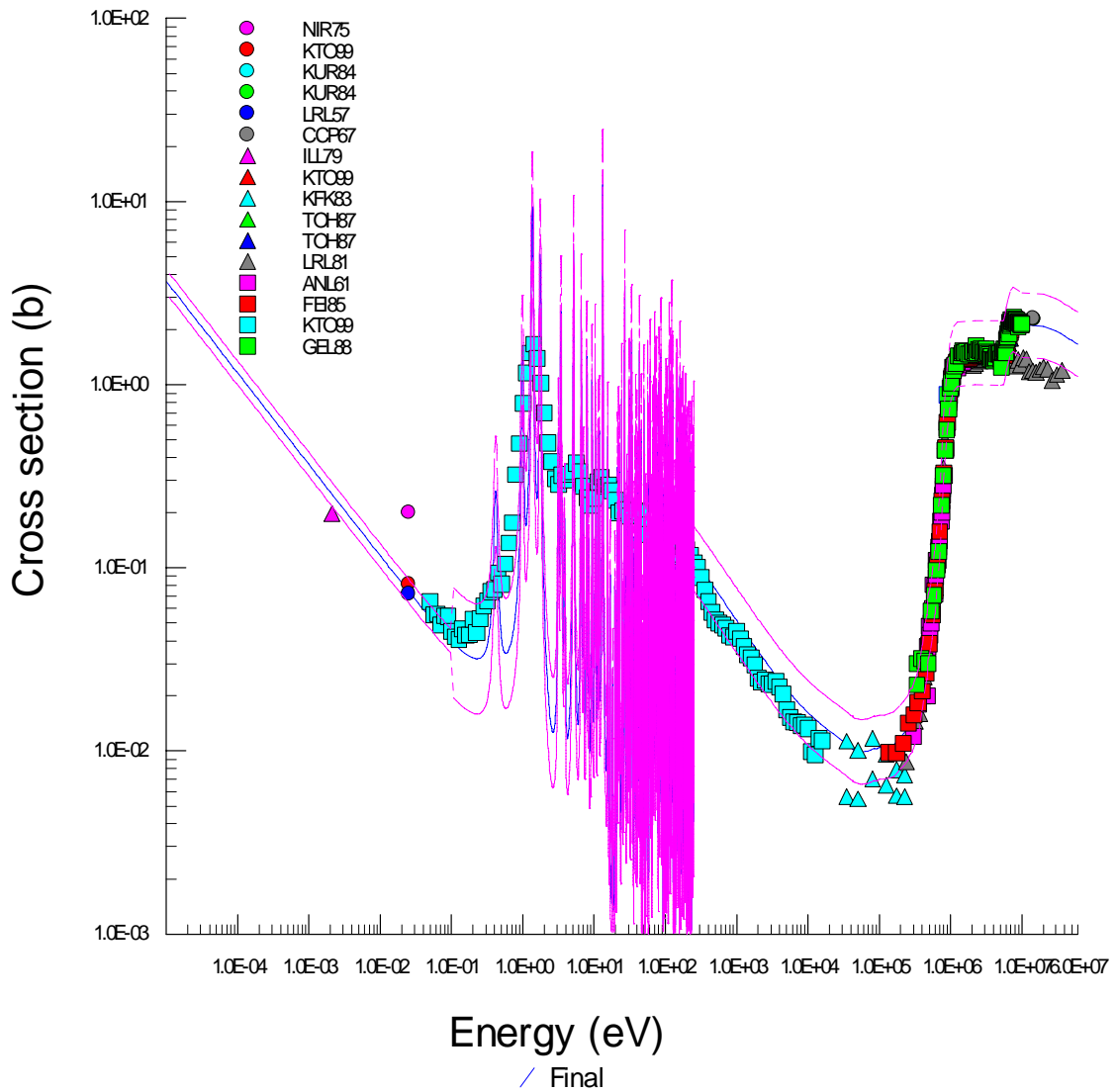
# $^{241}\text{Pu}(n,f)$

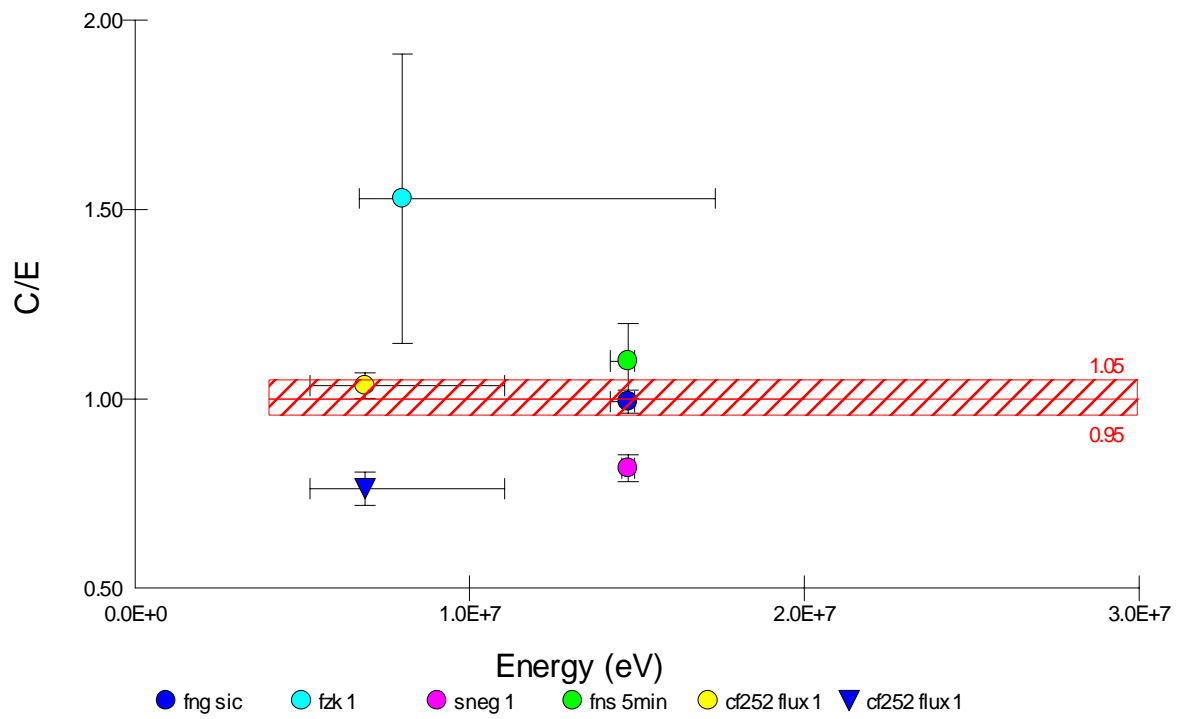
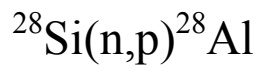
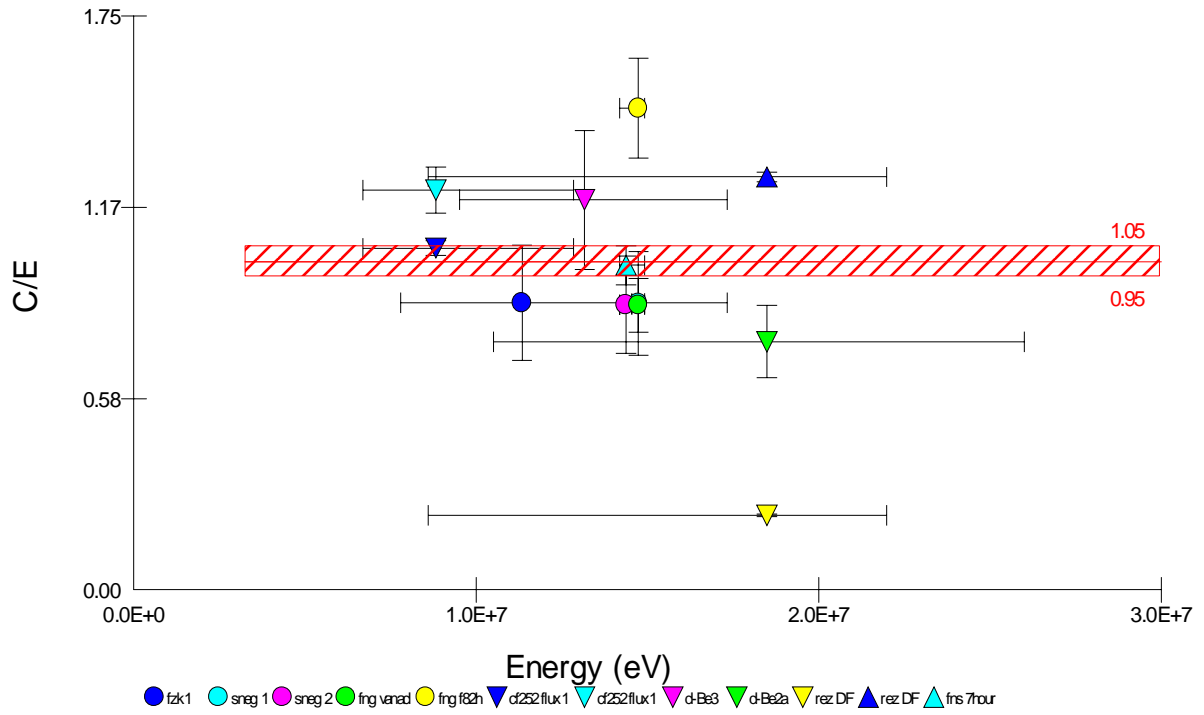
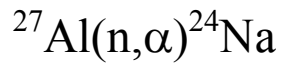


$^{243}\text{Am}(n,f)$

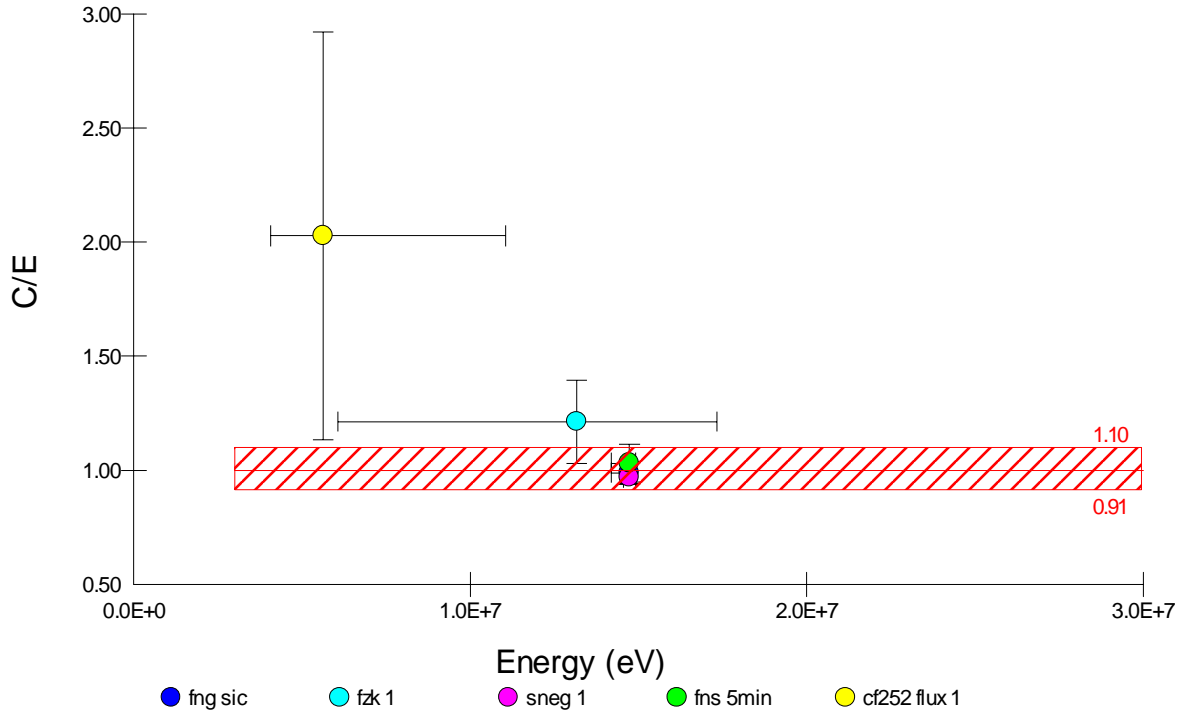


Neutron Spectrum

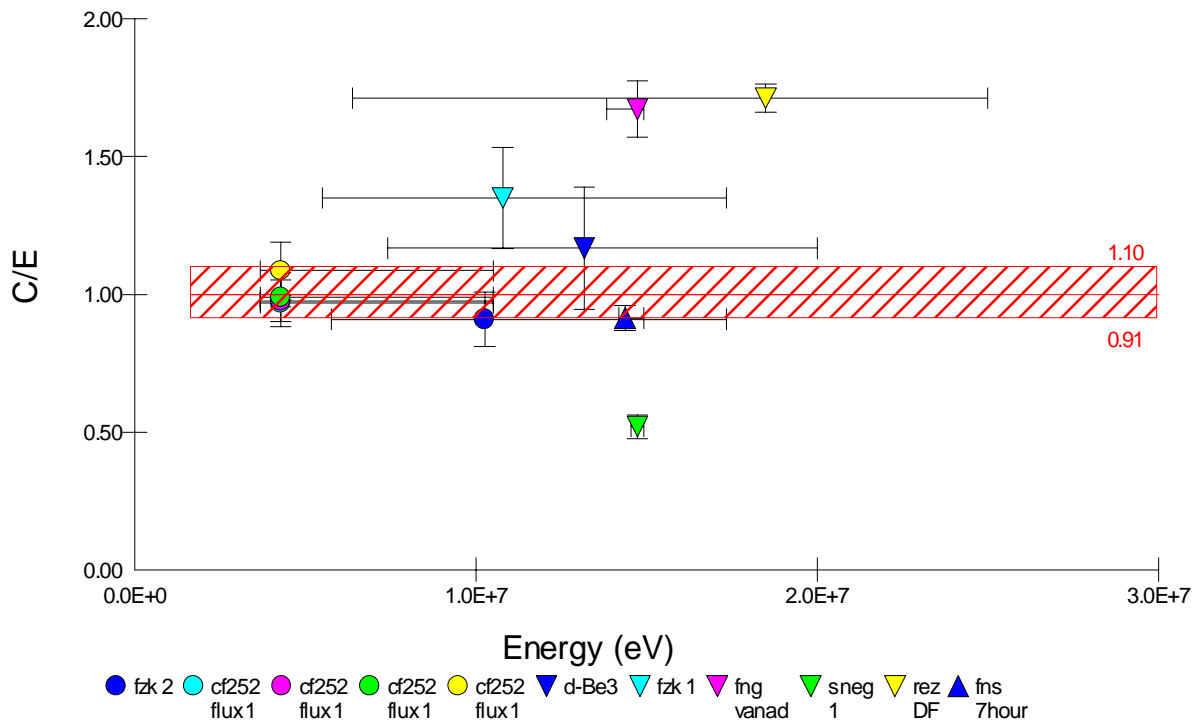




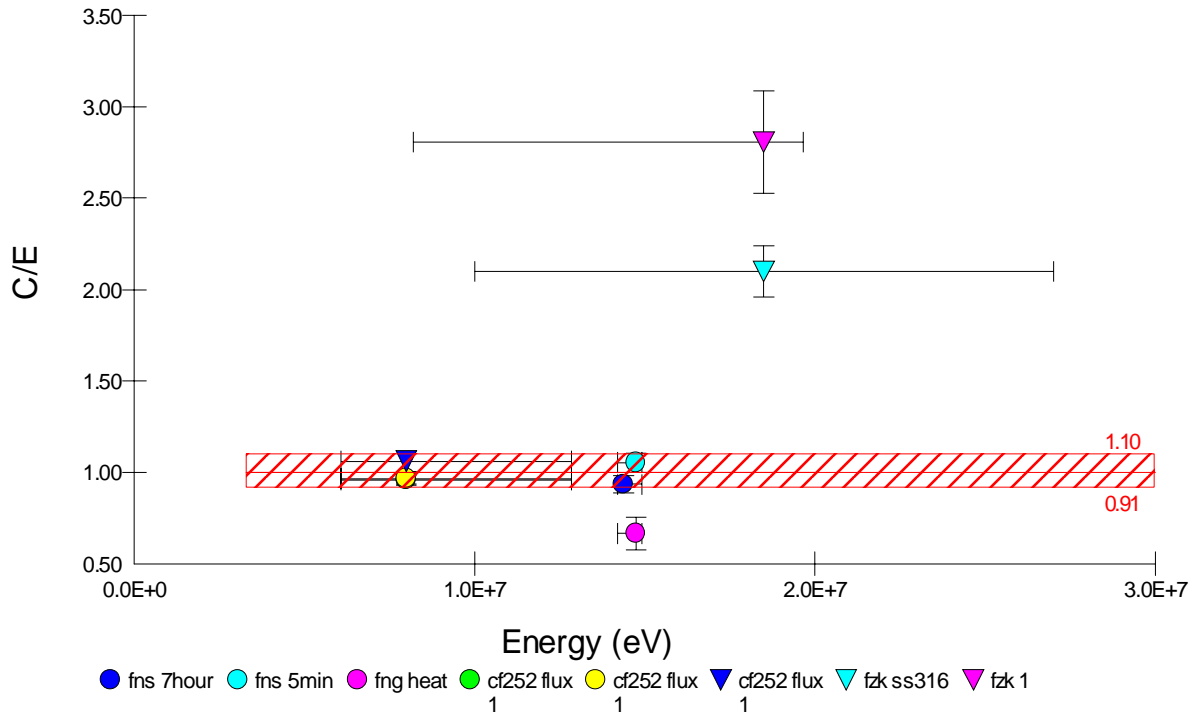
$^{29}\text{Si}(n,p)^{29}\text{Al}$



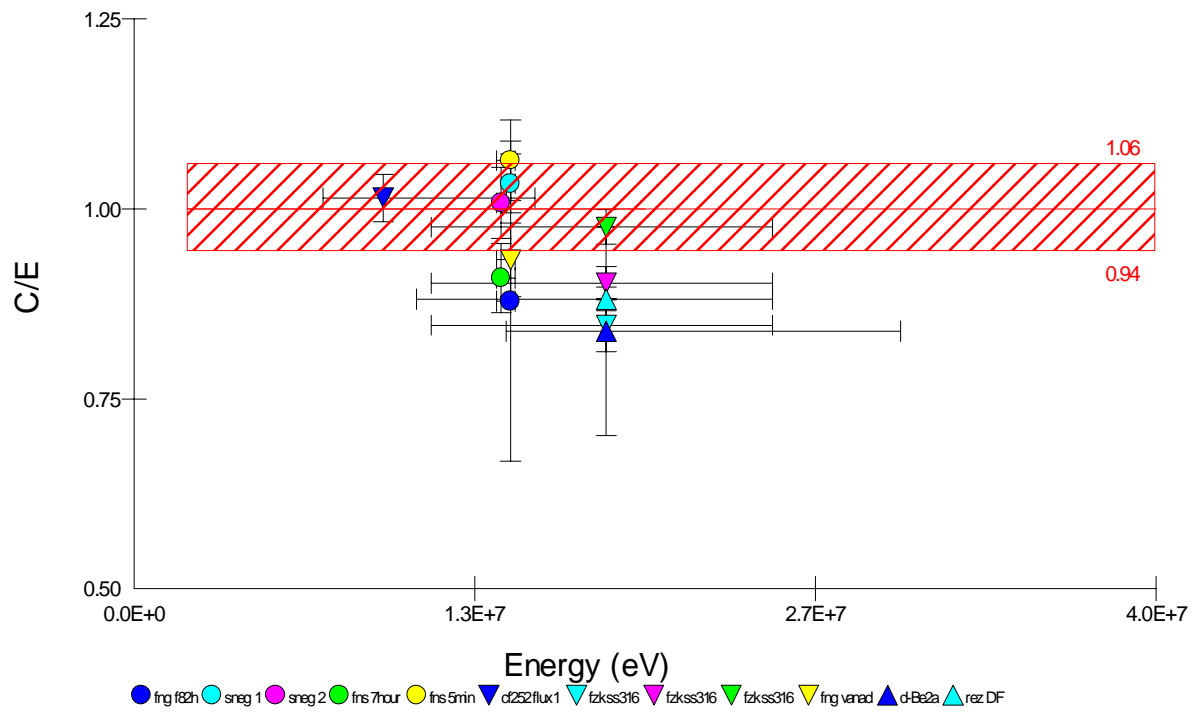
$^{46}\text{Ti}(n,p)^{46}\text{Sc}$



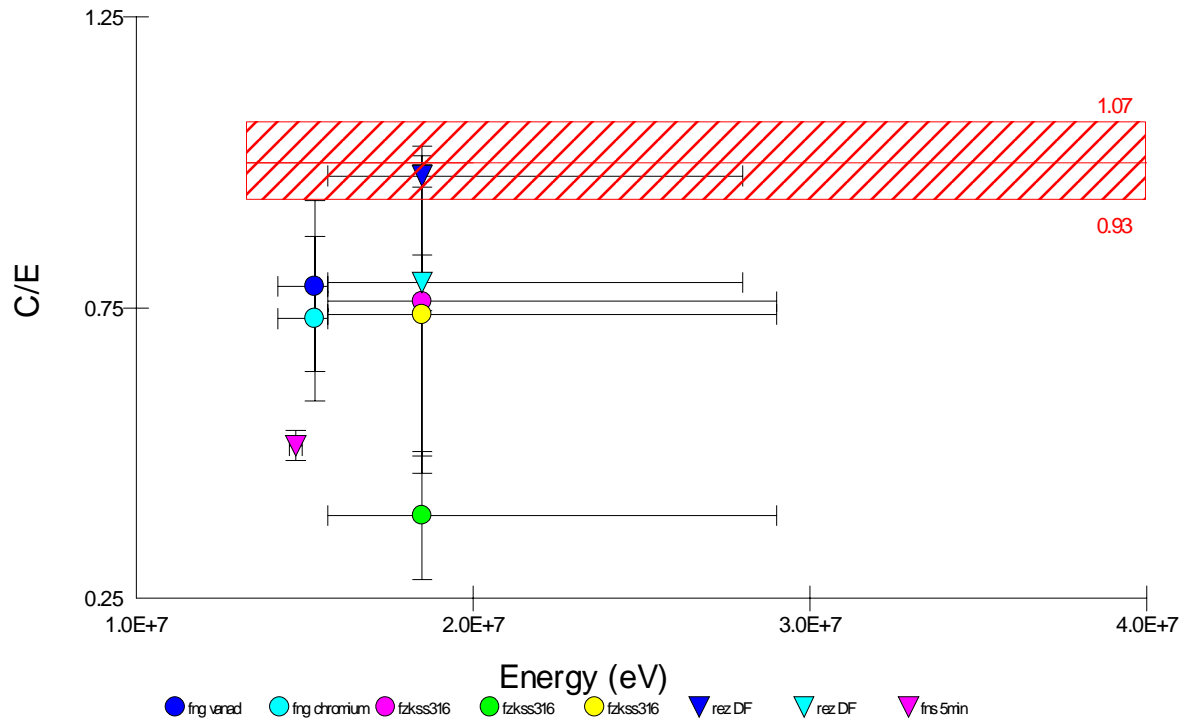
$^{48}\text{Ti}(n,p)^{48}\text{Sc}$



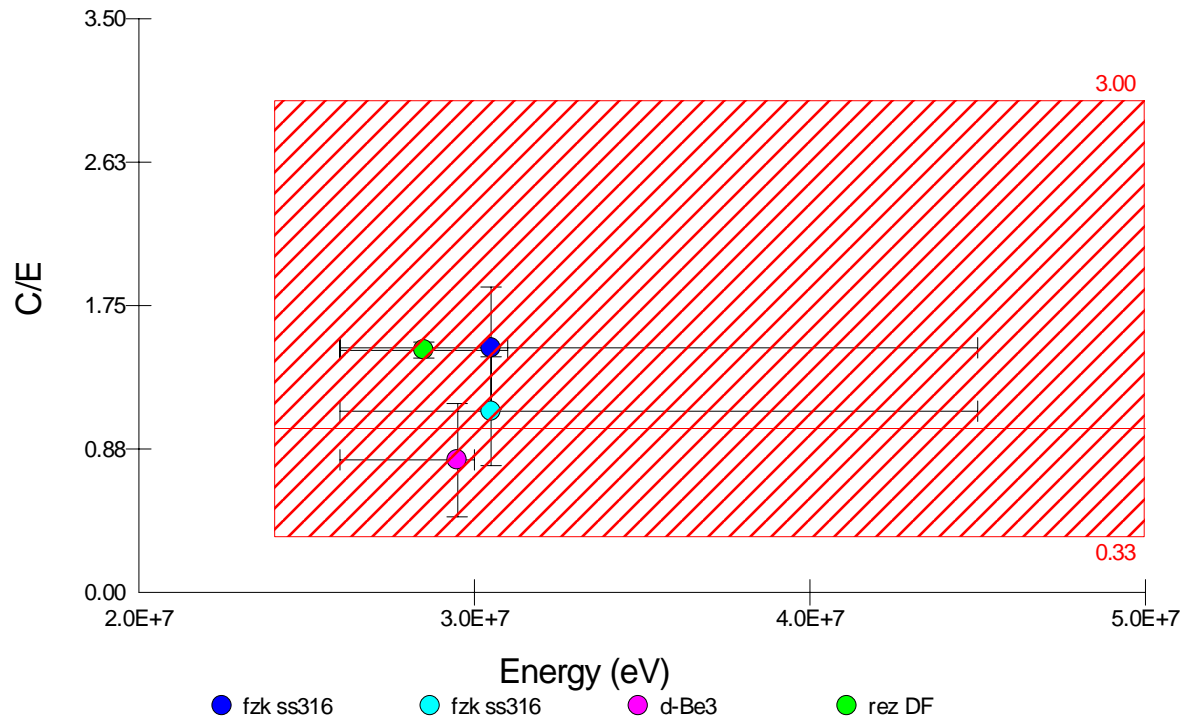
$^{51}\text{V}(n,\alpha)^{48}\text{Sc}$



$^{50}\text{Cr}(n,2n)^{49}\text{Cr}$

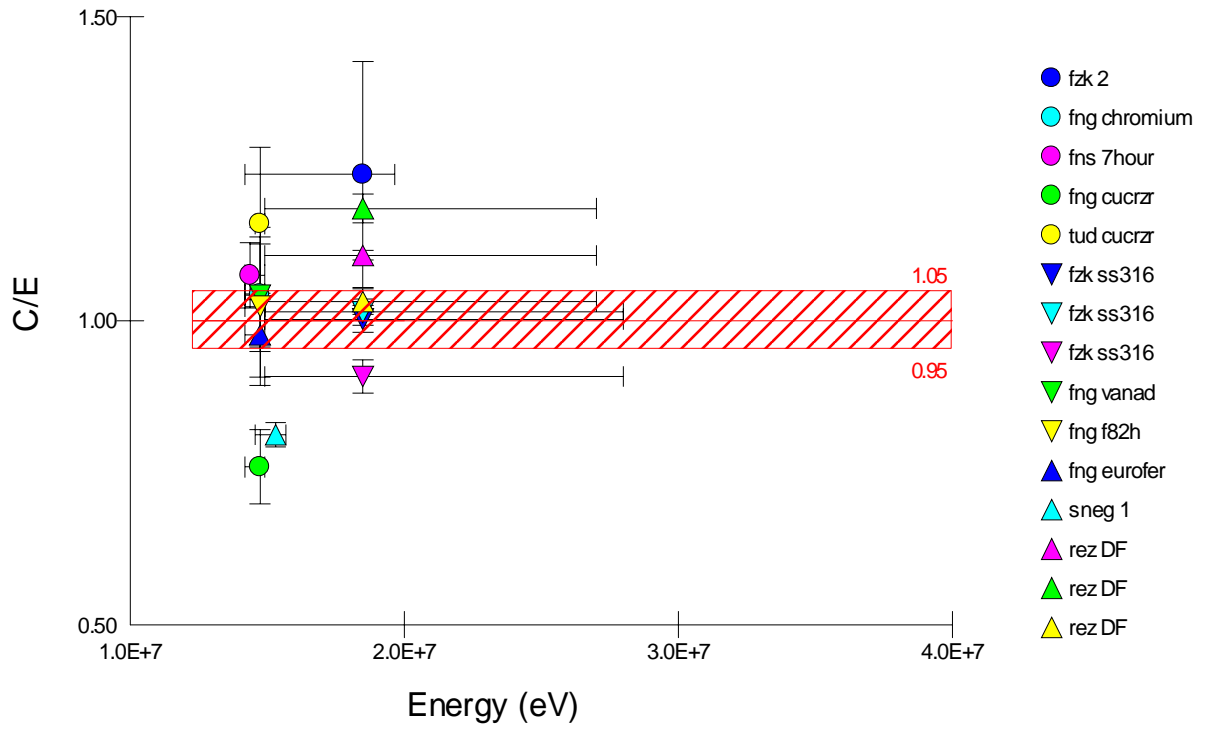


$^{50}\text{Cr}(n,3n)^{48}\text{Cr}$

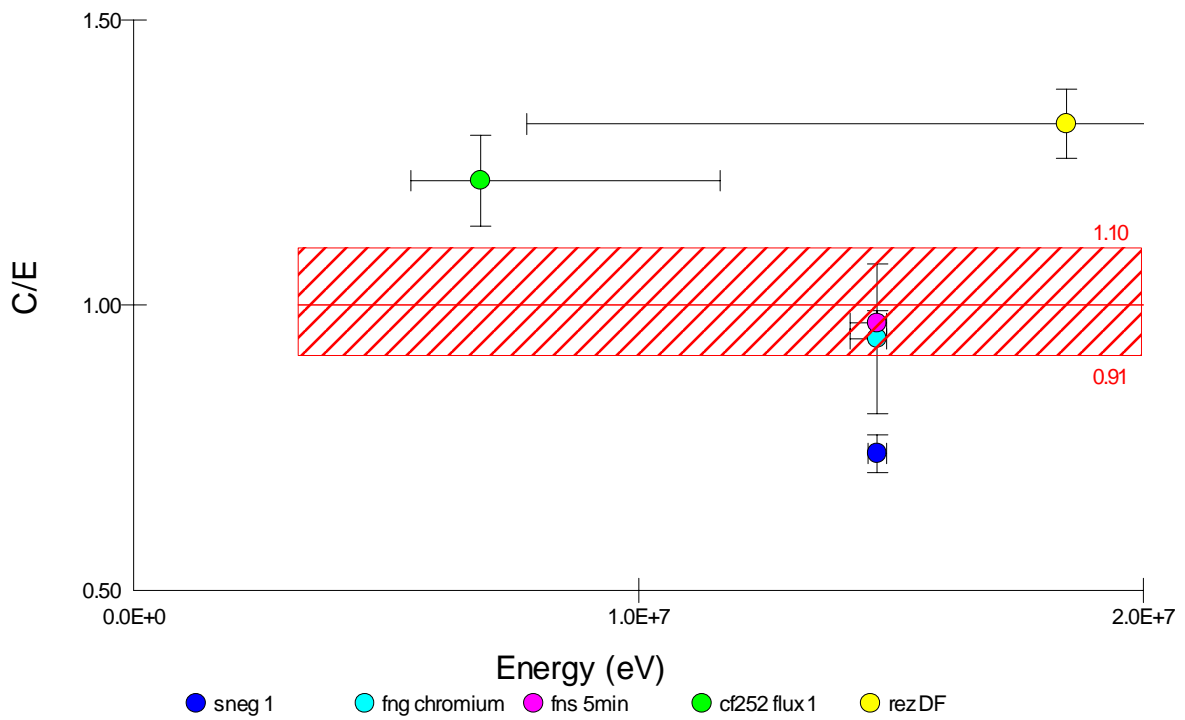




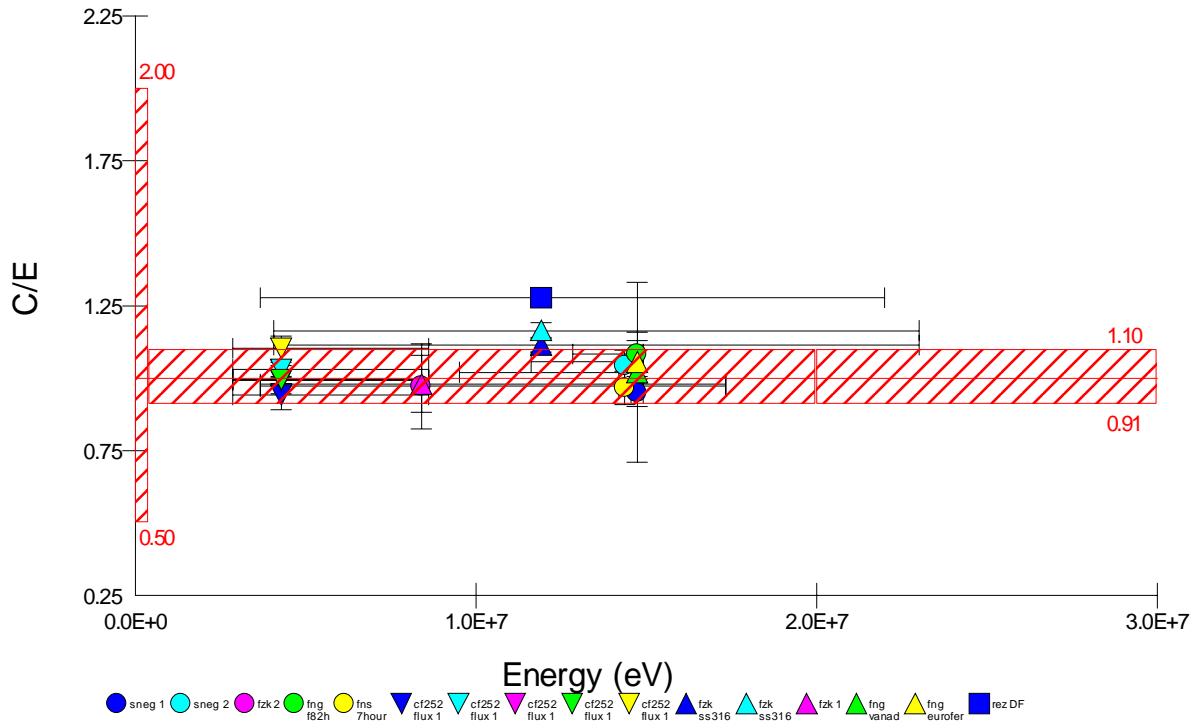
$^{52}\text{Cr}(n,2n)^{51}\text{Cr}$



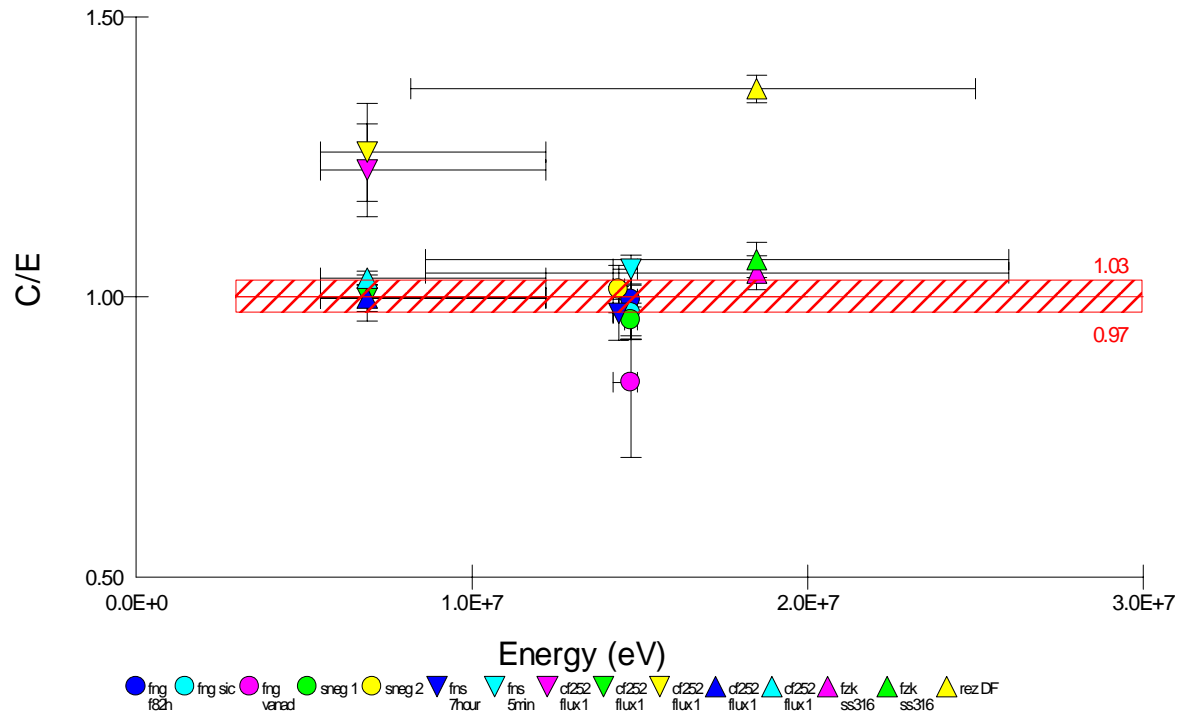
$^{52}\text{Cr}(n,p)^{52}\text{V}$



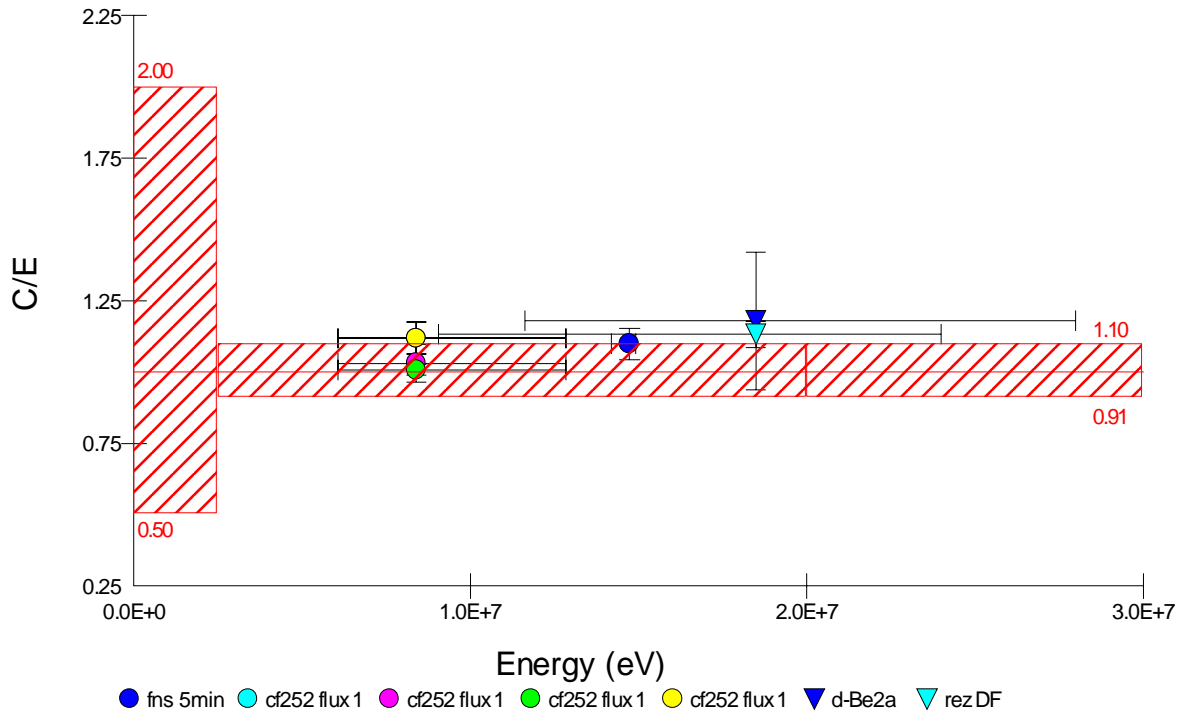
# $^{54}\text{Fe}(n,p)^{54}\text{Mn}$



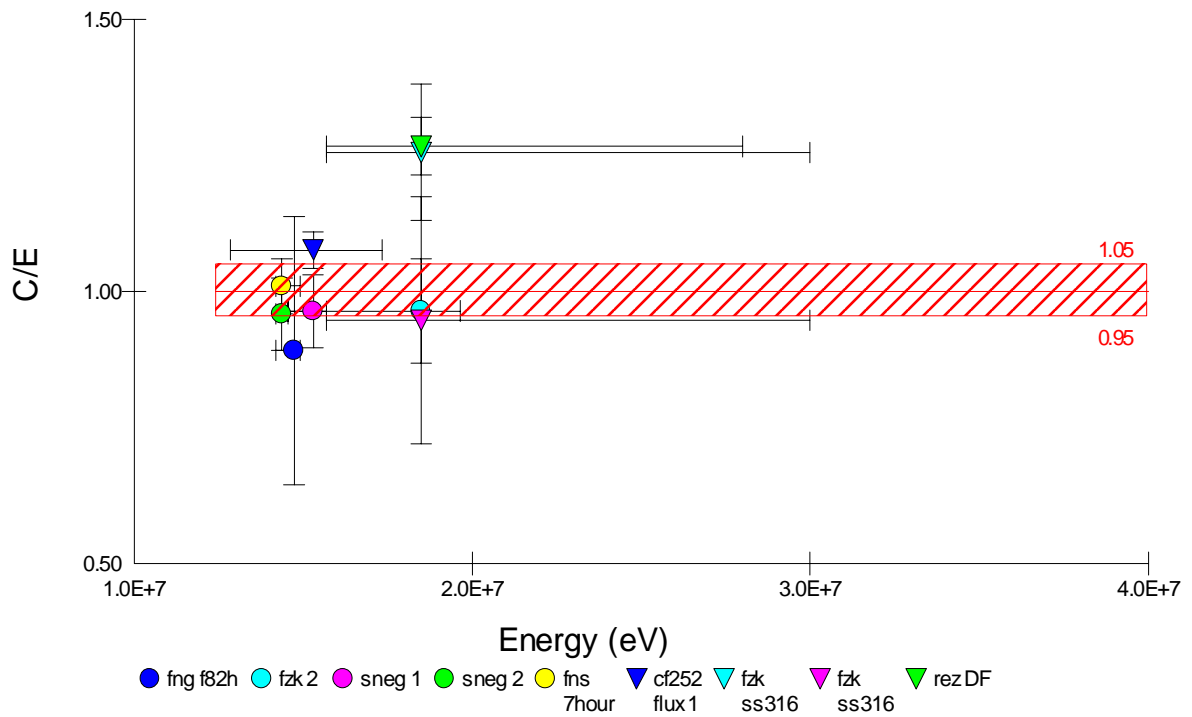
# $^{56}\text{Fe}(n,p)^{56}\text{Mn}$



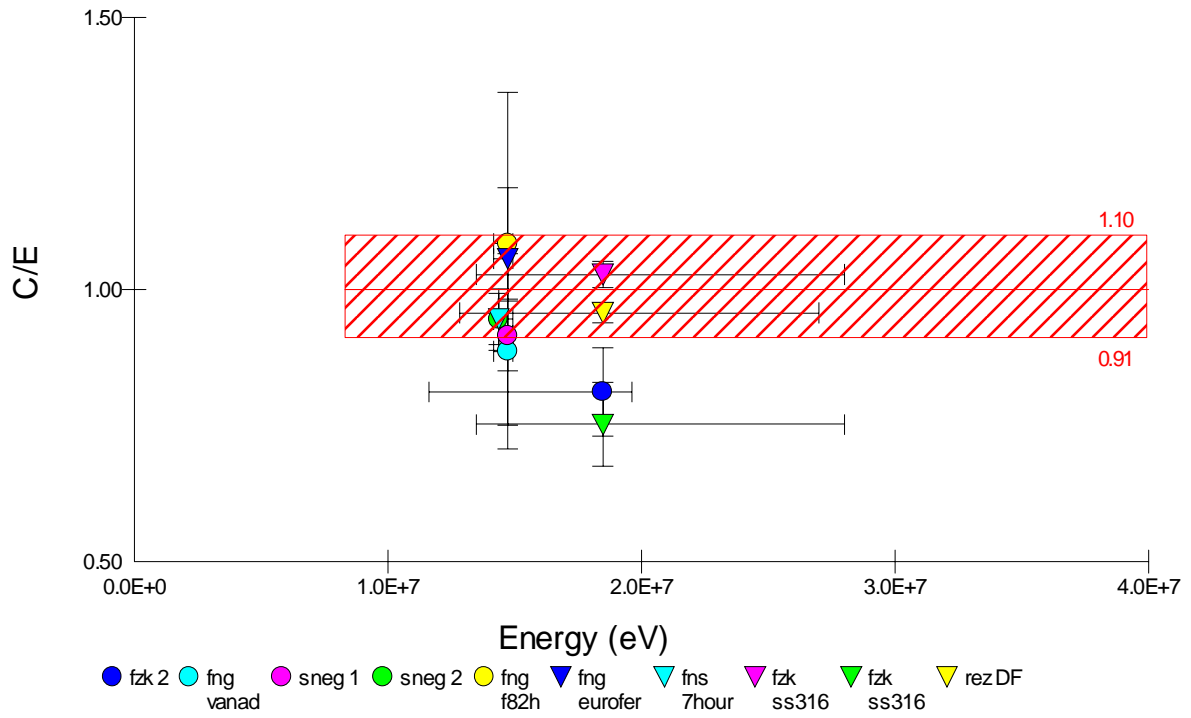
$^{59}\text{Co}(n,\alpha)^{56}\text{Mn}$



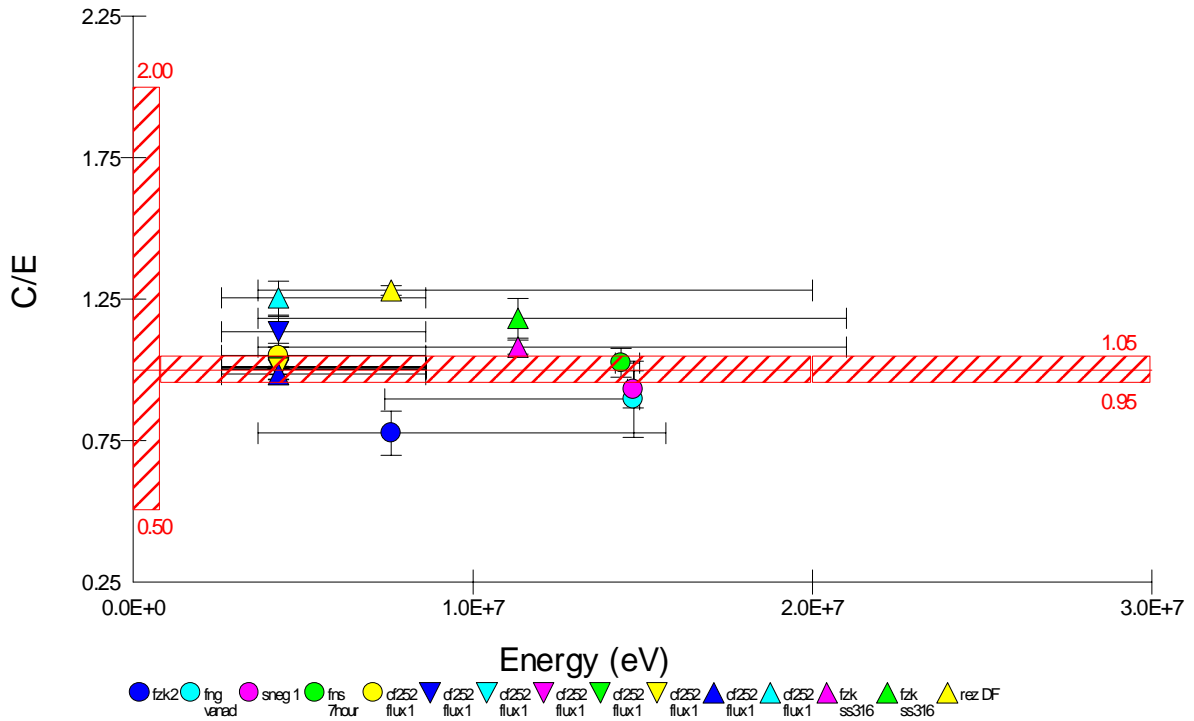
$^{58}\text{Ni}(n,2n)^{57}\text{Ni}$



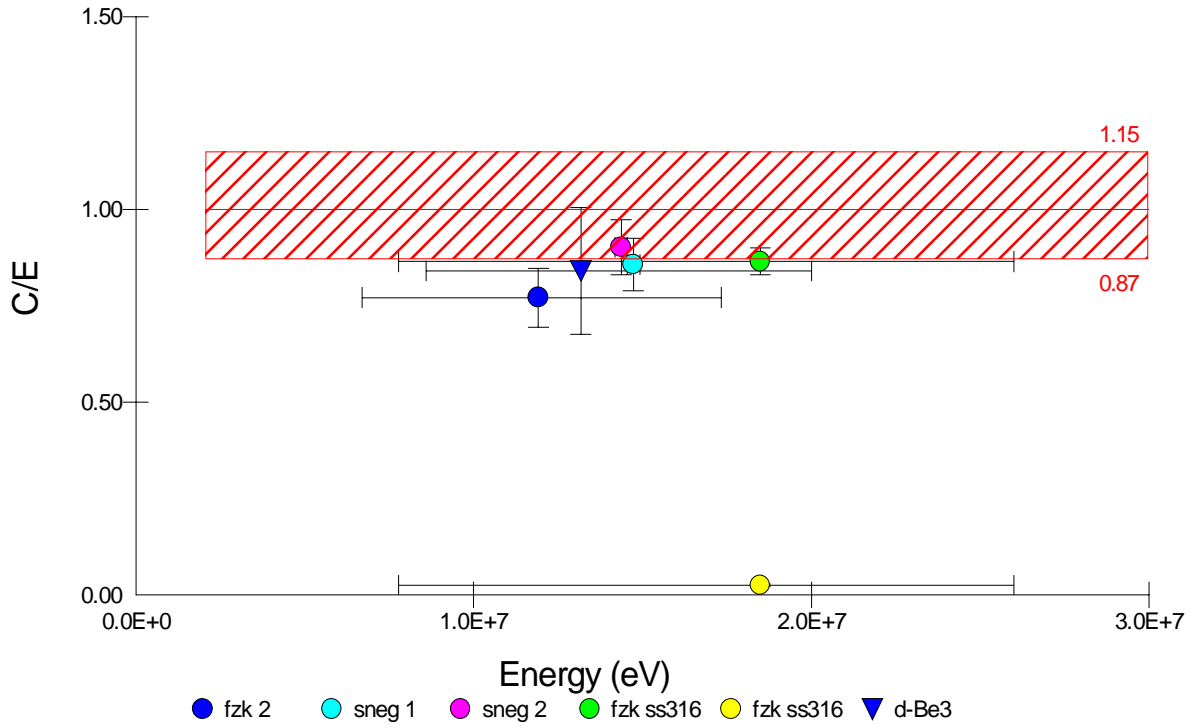
$^{58}\text{Ni}(n,n'p)^{57}\text{Co}$



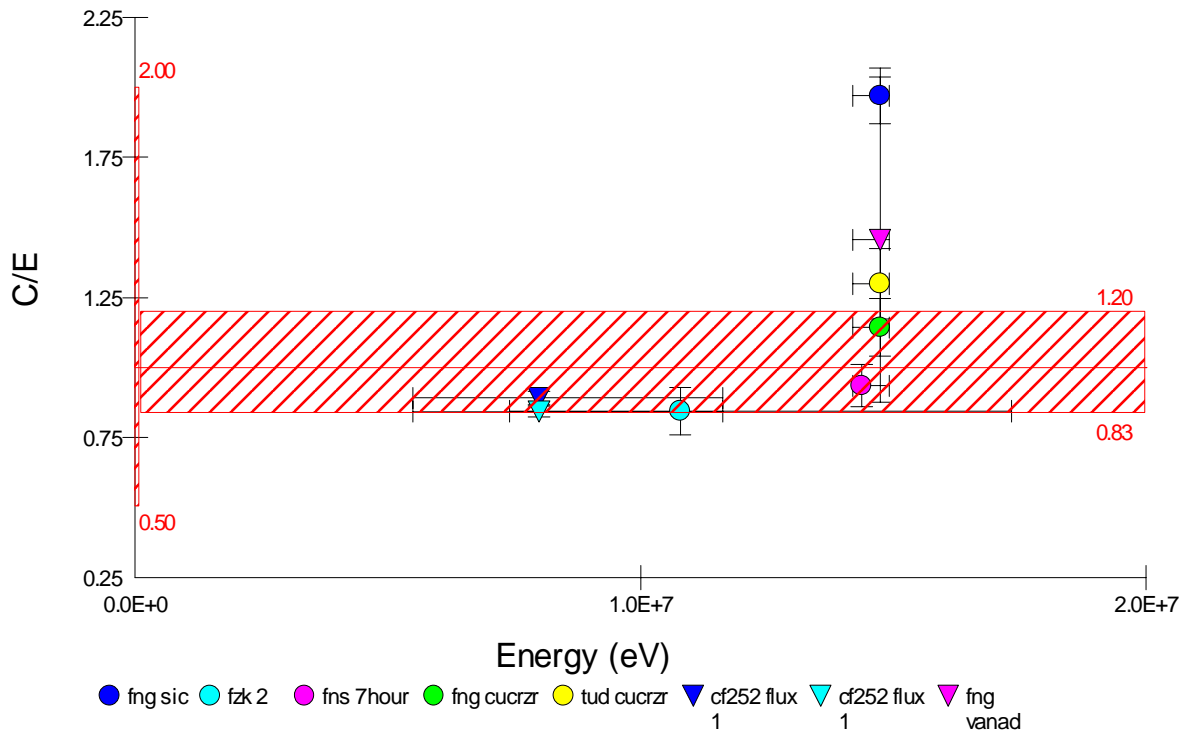
$^{58}\text{Ni}(n,p)^{58}\text{Co}$



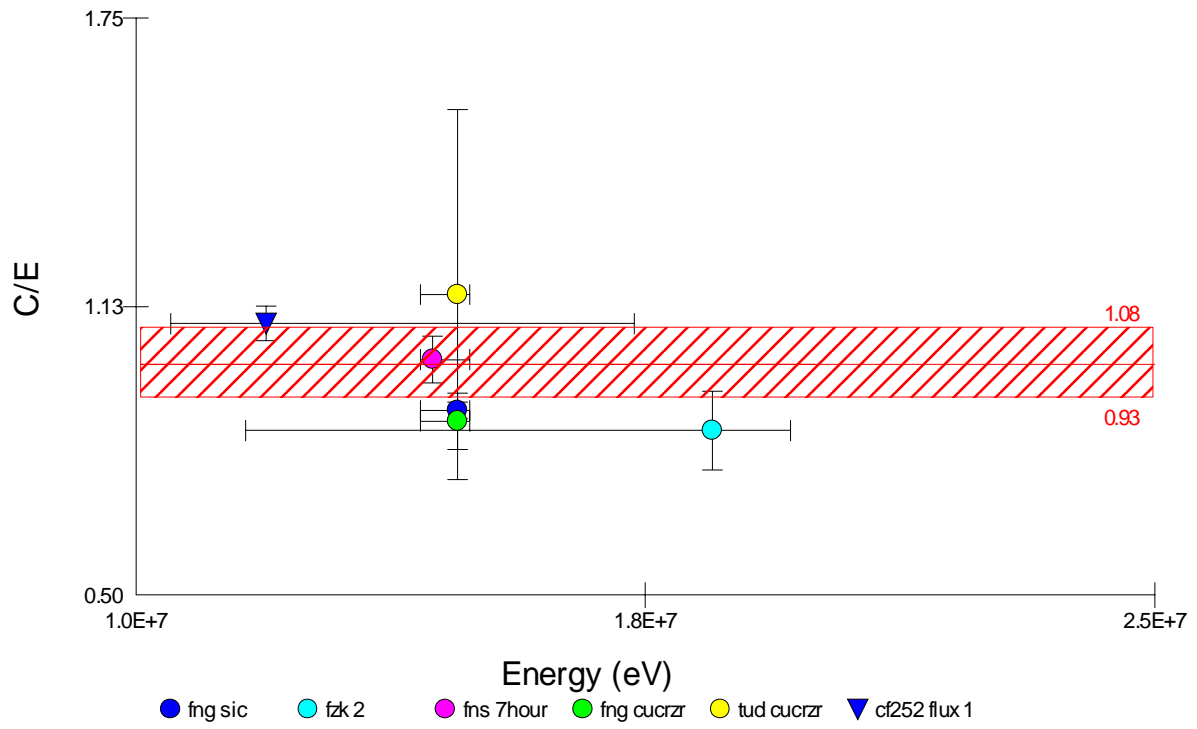
$^{60}\text{Ni}(n,p)^{60}\text{Co}$



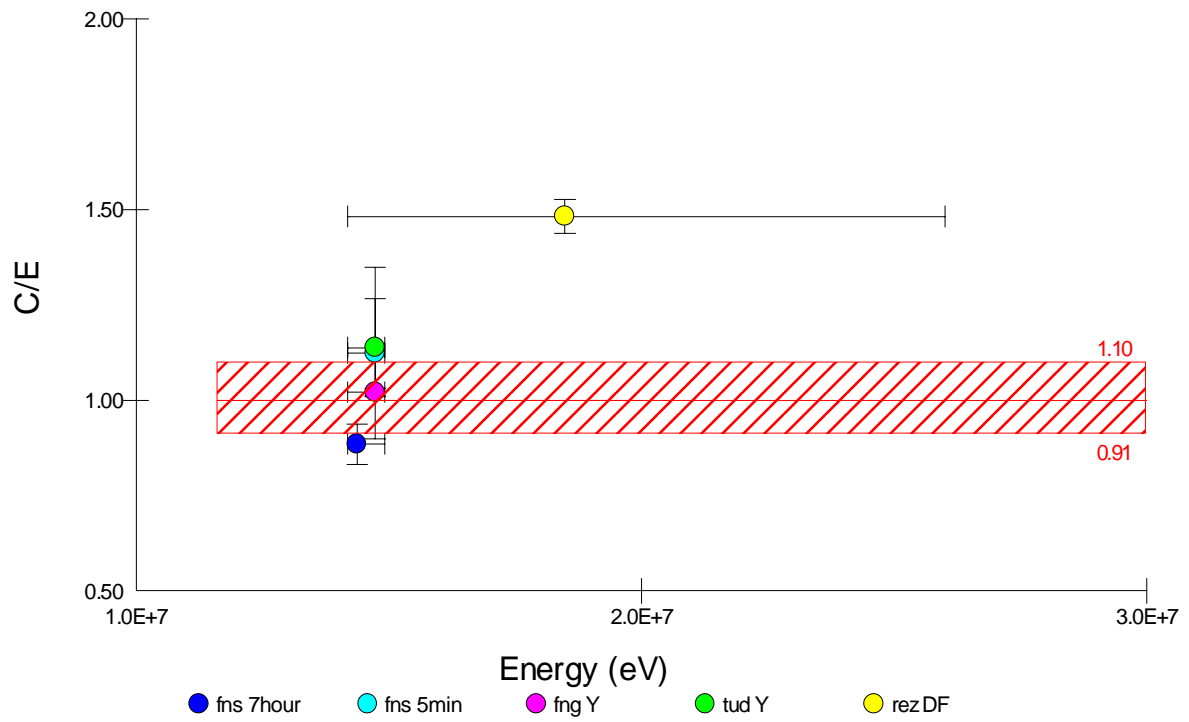
$^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$

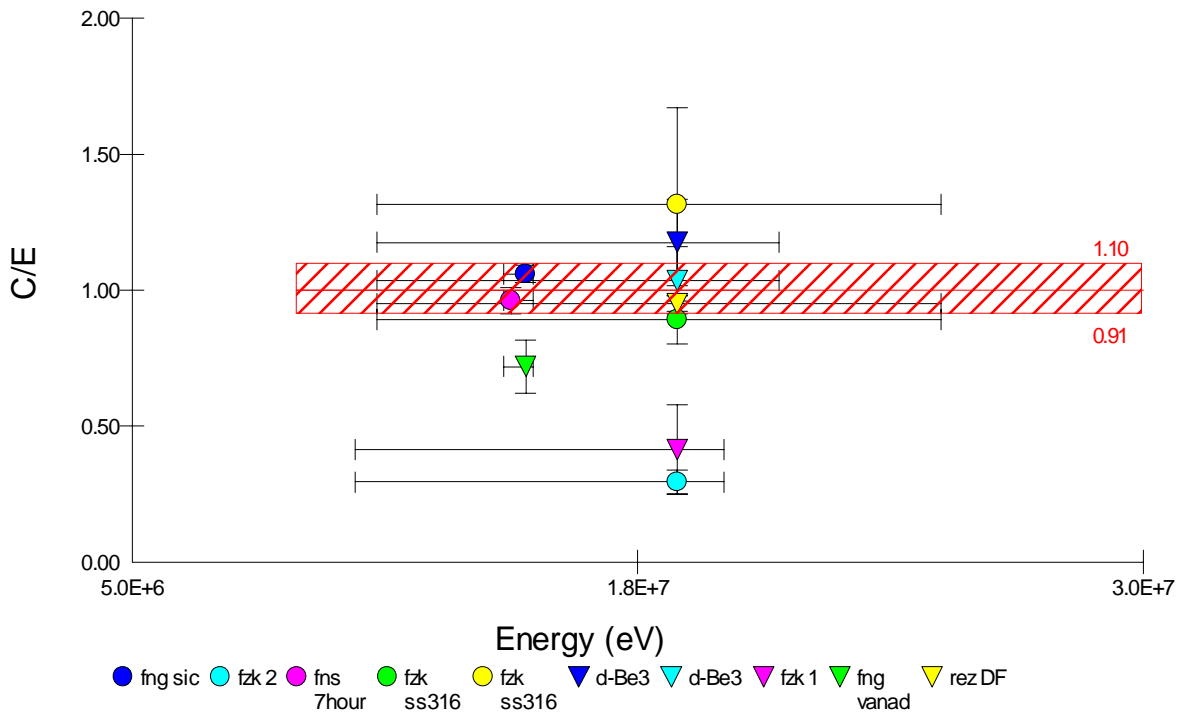
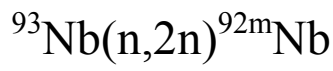
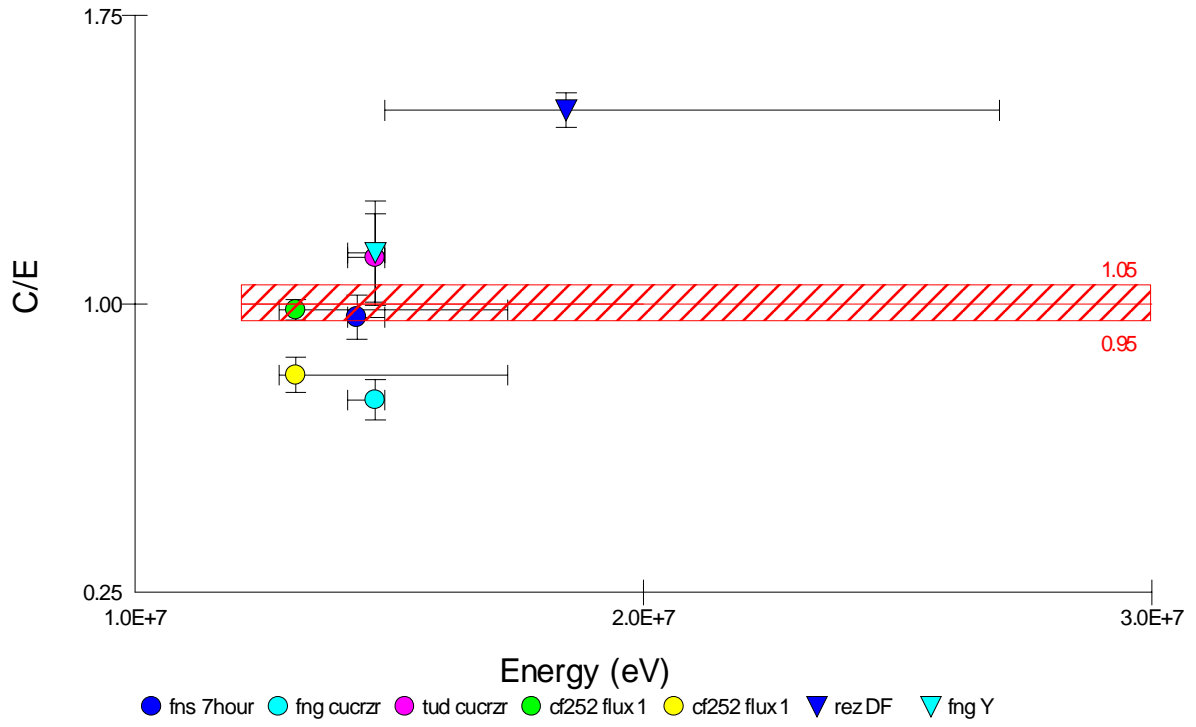
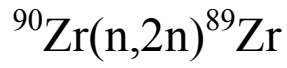


# $^{65}\text{Cu}(n,2n)^{64}\text{Cu}$

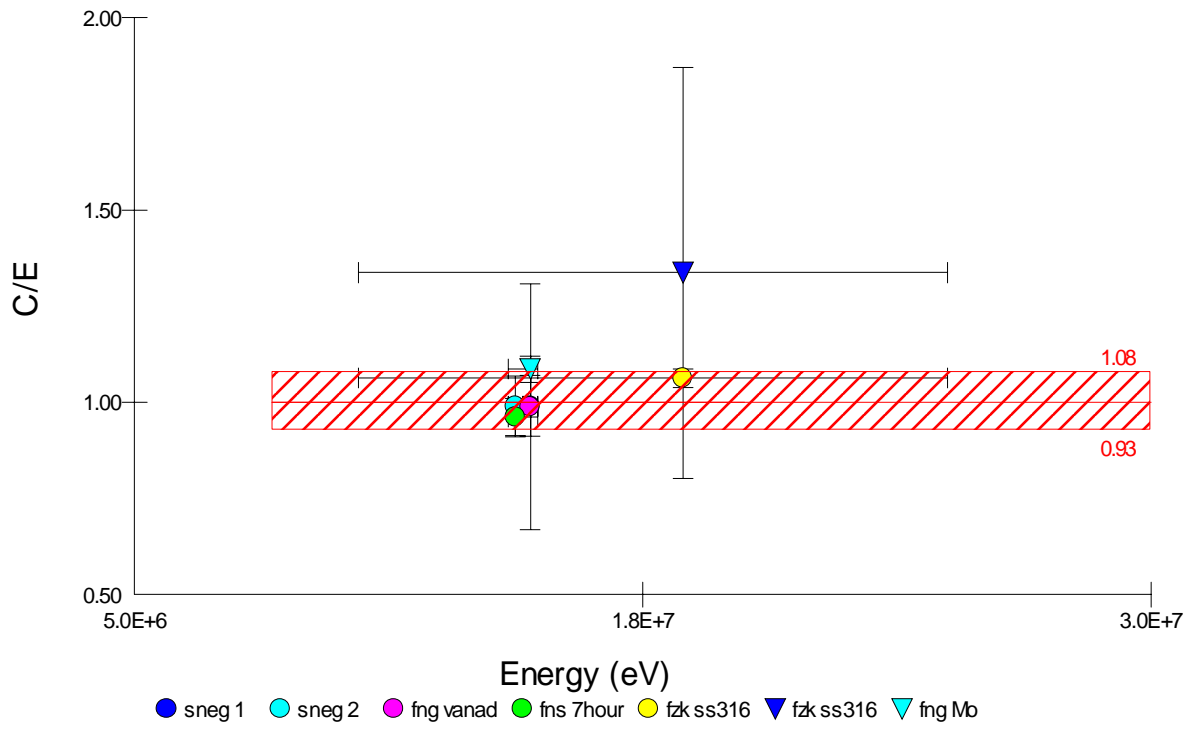


# $^{89}\text{Y}(n,2n)^{88}\text{Y}$

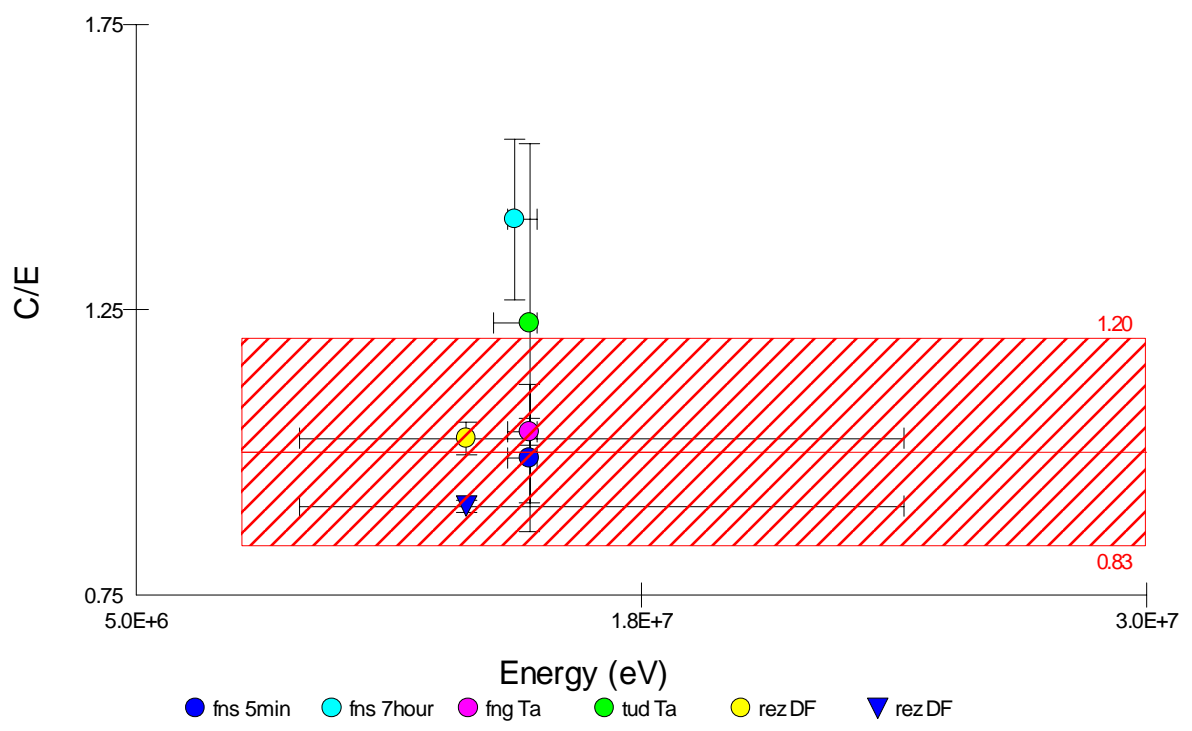




$^{100}\text{Mo}(n,2n)^{99}\text{Mo}$

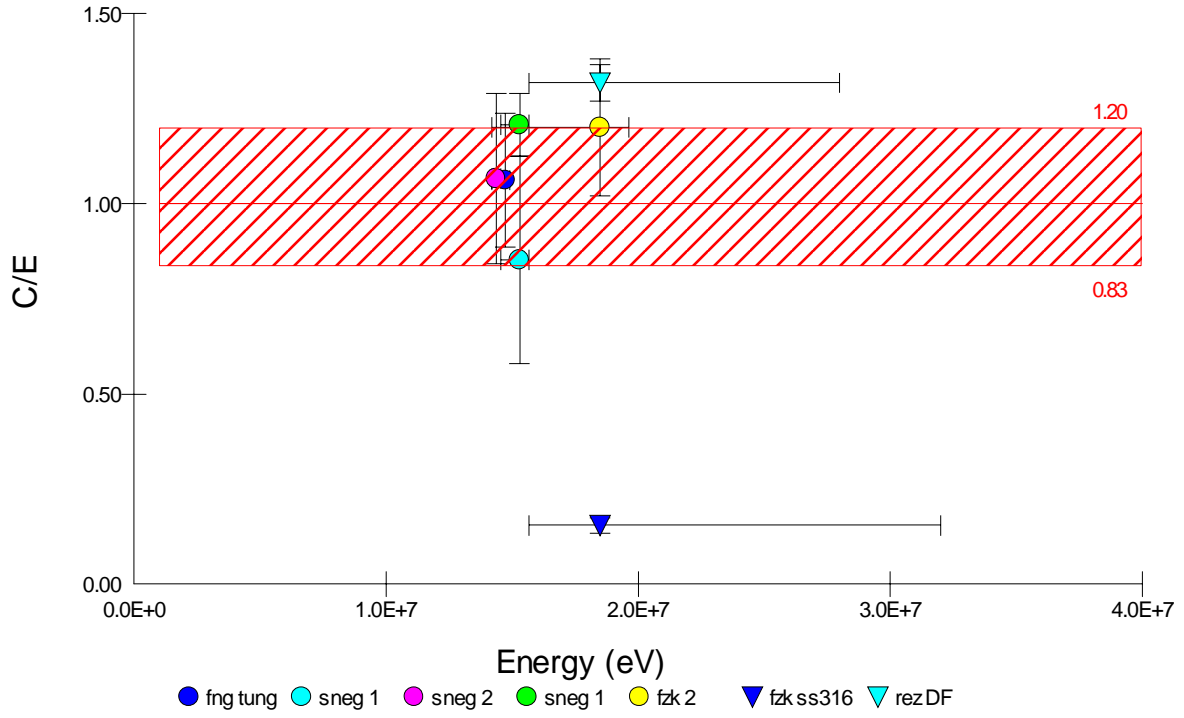


$^{181}\text{Ta}(n,2n)^{180g}\text{Ta}$

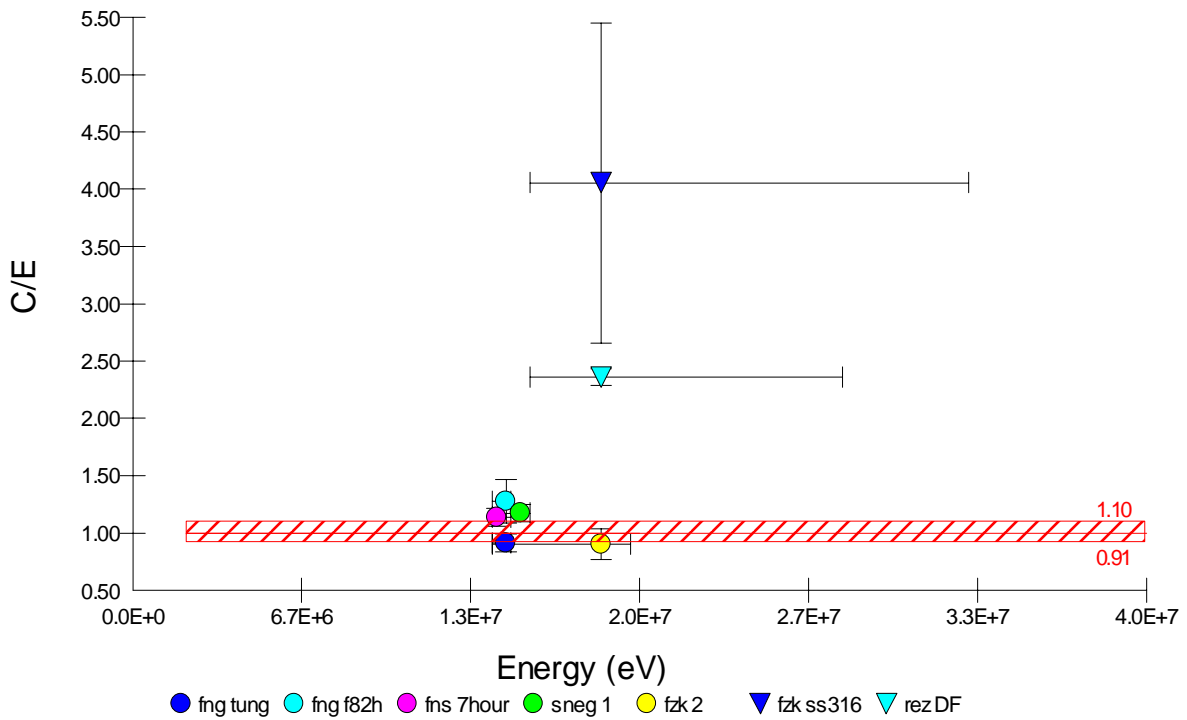




$^{182}\text{W}(n,p)^{182}\text{Ta}$



$^{184}\text{W}(n,p)^{184}\text{Ta}$



## 6. Summary of validated reactions

Reactions that either produce a good C/E value for radionuclide production or where the effective cross section C/E value is close to 1 are considered to be validated by the integral experiments. The reactions in Table 12 that have a Quality score of 6 [including \*, but excluding ()] are validated. There are 217 such reactions. In addition 43 reactions have a score of (6) but these are for cases where the total cross section has been validated and only the split reactions are present in EAF-2007.

The reactions in Table 12 that have a Quality score of 5 [including \*, but excluding ()] are reactions that either have discrepant C/E values or no differential data. In some cases changes can be made in future EAF libraries to improve the C/E fit. A summary of these 156 reactions plus the 54 summed reactions [shown as () in Table 12] is given in Table 13, summed reactions in **bold**. This table can be used as a list of reactions that should be considered for new measurements by experimentalists.

Note that eighteen reactions which were considered in the EASY-2005 validation report [3] do not appear in the current report. This is because the analysis of the experiments with EASY-2007 no longer shows these reactions as significantly contributing to the measured activity. Table 14 lists these reactions, the neutron spectrum in the previous analysis and how the Quality score will change in a future EAF library.

The meaning of the entries in the Comments columns of Table 13 are:

“First diff. measurements” – no differential data exist and a measurement is needed.

“Add. diff. measurements” – additional differential data needed to resolve conflicts.

“Diff. data agreement” – agreement between differential data and data in EAF-2007.

“Add. integral measurements” – existing integral data very different from unity (especially when there is differential data agreement) or the data are discrepant. However, for reactions such as (n,t) and (n,h) where the excitation curve shape is not well known, effort is required on a better theoretical description of the excitation curves rather than further integral measurements.

If “no comment” given in both columns, both experimental data are close to reasonable agreement but should be improved if possible.

**Table 13.** Summary of reactions with Quality scores of 5

Reaction	Comment on differential data	Comment on integral data
${}^7\text{Li}(n,n'\alpha){}^3\text{H}$	First diff. measurements	
${}^9\text{Be}(n,t){}^7\text{Li}$	Diff. data agreement	
${}^{11}\text{B}(n,t){}^9\text{Be}$	Diff. data agreement	
${}^{12}\text{C}(n,t){}^{10}\text{B}$	First diff. measurements	
${}^{14}\text{N}(n,\gamma){}^{15}\text{N}$	Diff. data agreement	Add. integral measurements
${}^{14}\text{N}(n,t){}^{12}\text{C}$	Diff. data agreement	
${}^{16}\text{O}(n,t){}^{14}\text{N}$	Diff. data agreement	
${}^{19}\text{F}(n,t){}^{17}\text{O}$	First diff. measurements	
${}^{20}\text{Ne}(n,t){}^{18}\text{F}$	First diff. measurements	
${}^{23}\text{Na}(n,t){}^{21}\text{Ne}$		
<b><math>{}^{24}\text{Mg}(n,p){}^{24}\text{Na}</math></b>	Diff. data agreement	Add. integral measurements
${}^{24}\text{Mg}(n,t){}^{22}\text{Na}$	First diff. measurements	
${}^{27}\text{Al}(n,h){}^{25}\text{Na}$		
${}^{27}\text{Al}(n,2n\alpha){}^{22}\text{Na}$	First diff. measurements	
<b><math>{}^{28}\text{Si}(n,t){}^{26}\text{Al}</math></b>	First diff. measurements	
${}^{29}\text{Si}(n,2p){}^{28}\text{Mg}$	Add. diff. measurements	
${}^{31}\text{P}(n,t){}^{29}\text{Si}$	First diff. measurements	

Reaction	Comment on differential data	Comment on integral data
$^{31}\text{P}(\text{n},\text{h})^{29}\text{Al}$		
<b><math>^{31}\text{P}(\text{n},2\alpha)^{24}\text{Na}</math></b>	First diff. measurements	
$^{32}\text{S}(\text{n},\text{t})^{30}\text{P}$	Diff. data agreement	Add. integral measurements
$^{35}\text{Cl}(\text{n},2\text{n})^{34\text{m}}\text{Cl}$	Diff. data agreement	Add. integral measurements
$^{35}\text{Cl}(\text{n},\text{t})^{33}\text{S}$	First diff. measurements	
<b><math>^{40}\text{Ar}(\text{n},\text{t})^{38}\text{Cl}</math></b>	First diff. measurements	
$^{39}\text{K}(\text{n},2\alpha)^{32}\text{P}$		
$^{41}\text{K}(\text{n},\text{h})^{39}\text{Cl}$		
<b><math>^{41}\text{K}(\text{n},\alpha)^{38}\text{Cl}</math></b>	Diff. data agreement	Add. integral measurements
<b><math>^{40}\text{Ca}(\text{n},\text{t})^{38}\text{K}</math></b>		
$^{40}\text{Ca}(\text{n},\text{h})^{38}\text{Ar}$	First diff. measurements	
$^{42}\text{Ca}(\text{n},\text{p})^{42}\text{K}$	Diff. data agreement	Add. integral measurements
$^{44}\text{Ca}(\text{n},\text{t})^{42}\text{K}$	First diff. measurements	
$^{45}\text{Sc}(\text{n},2\text{n})^{44\text{g}}\text{Sc}$	Diff. data agreement	Add. integral measurements
$^{45}\text{Sc}(\text{n},\text{h})^{43}\text{K}$		
$^{46}\text{Ti}(\text{n},\text{n}'\text{t})^{43}\text{Sc}$	First diff. measurements	
$^{46}\text{Ti}(\text{n},\text{t})^{44\text{g}}\text{Sc}$		
$^{46}\text{Ti}(\text{n},\text{t})^{44\text{m}}\text{Sc}$		
$^{47}\text{Ti}(\text{n},3\text{n})^{45}\text{Ti}$	First diff. measurements	
$^{48}\text{Ti}(\text{n},\text{n}'\text{p})^{47}\text{Sc}$		
$^{48}\text{Ti}(\text{n},\text{t})^{46\text{g}}\text{Sc}$	First diff. measurements	
$^{48}\text{Ti}(\text{n},\text{t})^{46\text{m}}\text{Sc}$	First diff. measurements	
<b><math>^{48}\text{Ti}(\text{n},\text{t})^{46}\text{Sc}</math></b>	First diff. measurements	
$^{50}\text{Ti}(\text{n},\alpha)^{47}\text{Ca}$	Diff. data agreement	Add. integral measurements
$^{51}\text{V}(\text{n},4\text{n})^{48}\text{V}$	First diff. measurements	
$^{51}\text{V}(\text{n},\text{h})^{49}\text{Sc}$	First diff. measurements	
$^{51}\text{V}(\text{n},\text{p}\alpha)^{47}\text{Ca}$	First diff. measurements	
<b><math>^{51}\text{V}(\text{n},2\text{n}\alpha)^{46}\text{Sc}</math></b>	First diff. measurements	
$^{50}\text{Cr}(\text{n},2\text{n})^{49}\text{Cr}$		
$^{50}\text{Cr}(\text{n},3\text{n})^{48}\text{Cr}$		
$^{50}\text{Cr}(\text{n},\text{t})^{48}\text{V}$	Diff. data agreement	
<b><math>^{50}\text{Cr}(\text{n},\text{p}\alpha)^{46}\text{Sc}</math></b>	First diff. measurements	
$^{52}\text{Cr}(\text{n},\text{t})^{50}\text{V}$	First diff. measurements	
$^{52}\text{Cr}(\text{n},\text{p}\alpha)^{48}\text{Sc}$	First diff. measurements	
$^{52}\text{Cr}(\text{n},\text{d}\alpha)^{47}\text{Sc}$	First diff. measurements	
$^{53}\text{Cr}(\text{n},3\text{n})^{51}\text{Cr}$	First diff. measurements	
$^{53}\text{Cr}(\text{n},\text{h})^{51}\text{Ti}$	First diff. measurements	
$^{54}\text{Cr}(\text{n},\alpha)^{51}\text{Ti}$	Diff. data agreement	Add. integral measurements
$^{55}\text{Mn}(\text{n},\text{h})^{53}\text{V}$		
$^{55}\text{Mn}(\text{n},2\alpha)^{48}\text{Sc}$	First diff. measurements	
<b><math>^{54}\text{Fe}(\text{n},2\text{n})^{53}\text{Fe}</math></b>	Diff. data agreement	
$^{54}\text{Fe}(\text{n},3\text{n})^{52\text{g}}\text{Fe}$	Diff. data agreement	
$^{54}\text{Fe}(\text{n},\text{t})^{52\text{g}}\text{Mn}$		Add. integral measurements
$^{54}\text{Fe}(\text{n},\text{t})^{52\text{m}}\text{Mn}$	Add. diff. measurements	
$^{56}\text{Fe}(\text{n},\text{h})^{54}\text{Cr}$	First diff. measurements	
<b><math>^{59}\text{Co}(\text{n},2\text{n})^{58}\text{Co}</math></b>	Diff. data agreement	Add. integral measurements
$^{59}\text{Co}(\text{n},\text{h})^{57}\text{Mn}$		
$^{59}\text{Co}(\text{n},2\alpha)^{52}\text{V}$	First diff. measurements	
$^{58}\text{Ni}(\text{n},3\text{n})^{56}\text{Ni}$	First diff. measurements	
$^{60}\text{Ni}(\text{n},2\text{p})^{59}\text{Fe}$	First diff. measurements	

Reaction	Comment on differential data	Comment on integral data
$^{61}\text{Ni}(n,p)^{61}\text{Co}$	Diff. data agreement	
$^{62}\text{Ni}(n,n')^{61}\text{Co}$	Diff. data agreement	Add. integral measurements
$^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$	Diff. data agreement	Add. integral measurements
$^{63}\text{Cu}(n,t)^{61}\text{Ni}$	First diff. measurements	
$^{63}\text{Cu}(n,h)^{61}\text{Co}$		
$^{64}\text{Zn}(n,h)^{62}\text{Ni}$	First diff. measurements	
$^{66}\text{Zn}(n,2\alpha)^{59}\text{Fe}$	First diff. measurements	
$^{67}\text{Zn}(n,h)^{65}\text{Ni}$	First diff. measurements	
$^{68}\text{Zn}(n,\gamma)^{69\text{m}}\text{Cu}$	Diff. data agreement	Add. integral measurements
$^{68}\text{Zn}(n,h)^{66}\text{Ni}$	First diff. measurements	
$^{69}\text{Ga}(n,t)^{67}\text{Zn}$	First diff. measurements	
$^{74}\text{Ge}(n,p)^{74}\text{Ga}$	Diff. data agreement	Add. integral measurements
$^{74}\text{Ge}(n,t)^{72}\text{Ga}$	First diff. measurements	
$^{75}\text{As}(n,t)^{73}\text{Ge}$	First diff. measurements	
$^{75}\text{As}(n,h)^{73}\text{Ga}$		
$^{80}\text{Se}(n,t)^{78}\text{As}$	First diff. measurements	
$^{82}\text{Se}(n,2n)^{81}\text{Se}$	Add. diff. measurements	Add. integral measurements
$^{86}\text{Sr}(n,\gamma)^{87\text{m}}\text{Sr}$	Diff. data agreement	Add. integral measurements
$^{89}\text{Y}(n,3n)^{87}\text{Y}$	Diff. data agreement	Add. integral measurements
$^{89}\text{Y}(n,\alpha)^{86}\text{Rb}$	Diff. data agreement	Add. integral measurements
$^{96}\text{Zr}(n,\gamma)^{97}\text{Zr}$	Diff. data agreement	Add. integral measurements
$^{93}\text{Nb}(n,3n)^{91\text{m}}\text{Nb}$		
$^{93}\text{Nb}(n,4n)^{90}\text{Nb}$	First diff. measurements	
$^{93}\text{Nb}(n,h)^{91\text{m}}\text{Y}$		
$^{93}\text{Nb}(n,h)^{91}\text{Y}$		
$^{93}\text{Nb}(n,\alpha)^{90\text{g}}\text{Y}$	Diff. data agreement	Add. integral measurements
$^{93}\text{Nb}(n,2\alpha)^{86}\text{Rb}$	First diff. measurements	
$^{92}\text{Mo}(n,2n)^{91\text{m}}\text{Mo}$	Diff. data agreement	Add. integral measurements
$^{92}\text{Mo}(n,2n)^{91}\text{Mo}$	Diff. data agreement	
$^{92}\text{Mo}(n,3n)^{90}\text{Mo}$	First diff. measurements	
$^{92}\text{Mo}(n,p)^{92}\text{Nb}$	First diff. measurements	
$^{92}\text{Mo}(n,t)^{90}\text{Nb}$		Add. integral measurements
$^{92}\text{Mo}(n,2\alpha)^{85\text{m}}\text{Sr}$	First diff. measurements	
$^{92}\text{Mo}(n,p\alpha)^{88}\text{Y}$	First diff. measurements	
$^{92}\text{Mo}(n,d\alpha)^{87\text{m}}\text{Y}$	First diff. measurements	
$^{92}\text{Mo}(n,2n\alpha)^{87}\text{Zr}$	First diff. measurements	
$^{92}\text{Mo}(n,3n\alpha)^{86}\text{Zr}$	First diff. measurements	
$^{95}\text{Mo}(n,3n)^{93\text{m}}\text{Mo}$	First diff. measurements	
$^{95}\text{Mo}(n,p)^{95}\text{Nb}$	Diff. data agreement	Add. integral measurements
$^{98}\text{Mo}(n,p)^{98\text{m}}\text{Nb}$	Diff. data agreement	
$^{98}\text{Mo}(n,t)^{96}\text{Nb}$	First diff. measurements	
$^{98}\text{Mo}(n,\alpha)^{95}\text{Zr}$	Diff. data agreement	Add. integral measurements
$^{100}\text{Mo}(n,\alpha)^{97}\text{Zr}$	Diff. data agreement	Add. integral measurements
$^{103}\text{Rh}(n,n')^{103\text{m}}\text{Rh}$	Diff. data agreement	Add. integral measurements
$^{103}\text{Rh}(n,2n)^{102\text{g}}\text{Rh}$	Diff. data agreement	Add. integral measurements
$^{103}\text{Rh}(n,3n)^{101\text{m}}\text{Rh}$	First diff. measurements	
$^{103}\text{Rh}(n,4n)^{100}\text{Rh}$	First diff. measurements	
$^{103}\text{Rh}(n,\gamma)^{104}\text{Rh}$	Diff. data agreement	Add. integral measurements
$^{103}\text{Rh}(n,p)^{103}\text{Ru}$	Diff. data agreement	Add. integral measurements
$^{106}\text{Pd}(n,t)^{104}\text{Rh}$	First diff. measurements	

Reaction	Comment on differential data	Comment on integral data
$^{108}\text{Pd}(n,2n)^{107\text{m}}\text{Pd}$	Diff. data agreement	Add. integral measurements
$^{107}\text{Ag}(n,t)^{105}\text{Pd}$	First diff. measurements	Add. integral measurements
$^{107}\text{Ag}(n,h)^{105}\text{Rh}$	First diff. measurements	
$^{110}\text{Cd}(n,\gamma)^{111}\text{Cd}$	Diff. data agreement	Add. integral measurements
$^{116}\text{Cd}(n,\gamma)^{117}\text{Cd}$	Diff. data agreement	Add. integral measurements
$^{113}\text{In}(n,2n)^{112\text{m}}\text{In}$	Diff. data agreement	Add. integral measurements
$^{113}\text{In}(n,2n)^{112}\text{In}$	Diff. data agreement	Add. integral measurements
$^{115}\text{In}(n,2n)^{114\text{g}}\text{In}$	Diff. data agreement	Add. integral measurements
$^{115}\text{In}(n,n'\alpha)^{111}\text{Ag}$	Diff. data agreement	Add. integral measurements
$^{115}\text{In}(n,\gamma)^{116\text{m}}\text{In}$		Add. integral measurements
$^{115}\text{In}(n,\gamma)^{116}\text{In}$	Diff. data agreement	Add. integral measurements
$^{115}\text{In}(n,h)^{113\text{g}}\text{Ag}$		
$^{115}\text{In}(n,h)^{113}\text{Ag}$	Add. diff. measurements	
$^{115}\text{In}(n,\alpha)^{112}\text{Ag}$	Diff. data agreement	Add. integral measurements
$^{114}\text{Sn}(n,2n)^{113}\text{Sn}$	Diff. data agreement	Add. integral measurements
$^{114}\text{Sn}(n,n'p)^{113\text{m}}\text{In}$	First diff. measurements	
$^{116}\text{Sn}(n,p)^{116}\text{In}$	First diff. measurements	
$^{116}\text{Sn}(n,n'p)^{115\text{m}}\text{In}$	First diff. measurements	
$^{117}\text{Sn}(n,p)^{117\text{m}}\text{In}$	Diff. data agreement	Add. integral measurements
$^{117}\text{Sn}(n,p)^{117}\text{In}$		Add. integral measurements
$^{118}\text{Sn}(n,2n)^{117\text{m}}\text{Sn}$	Diff. data agreement	Add. integral measurements
$^{118}\text{Sn}(n,\alpha)^{115\text{g}}\text{Cd}$	Diff. data agreement	Add. integral measurements
$^{120}\text{Sn}(n,p)^{120\text{m}}\text{In}$	Diff. data agreement	Add. integral measurements
$^{120}\text{Sn}(n,\alpha)^{117\text{g}}\text{Cd}$		Add. integral measurements
$^{120}\text{Sn}(n,\alpha)^{117\text{m}}\text{Cd}$	Diff. data agreement	Add. integral measurements
$^{121}\text{Sb}(n,t)^{119}\text{Sn}$	First diff. measurements	
$^{128}\text{Te}(n,t)^{126}\text{Sb}$	First diff. measurements	
$^{127}\text{I}(n,\gamma)^{128}\text{I}$	Diff. data agreement	Add. integral measurements
$^{127}\text{I}(n,h)^{125}\text{Sb}$	First diff. measurements	
$^{127}\text{I}(n,\alpha)^{124}\text{Sb}$	First diff. measurements	
$^{133}\text{Cs}(n,h)^{131}\text{I}$		
$^{134}\text{Ba}(n,\gamma)^{135}\text{Ba}$	Diff. data agreement	Add. integral measurements
$^{134}\text{Ba}(n,t)^{132}\text{Cs}$	First diff. measurements	
$^{136}\text{Ba}(n,\gamma)^{137}\text{Ba}$	Diff. data agreement	Add. integral measurements
$^{139}\text{La}(n,h)^{137}\text{Cs}$	First diff. measurements	
$^{141}\text{Pr}(n,2n)^{140}\text{Pr}$	Diff. data agreement	Add. integral measurements
$^{146}\text{Nd}(n,h)^{144}\text{Ce}$	First diff. measurements	
$^{150}\text{Nd}(n,2n)^{149}\text{Nd}$	Diff. data agreement	Add. integral measurements
$^{151}\text{Eu}(n,\gamma)^{152\text{m}}\text{Eu}$	Diff. data agreement	Add. integral measurements
$^{158}\text{Gd}(n,\alpha)^{155}\text{Sm}$	Diff. data agreement	Add. integral measurements
$^{160}\text{Gd}(n,2n)^{159}\text{Gd}$	Diff. data agreement	Add. integral measurements
$^{160}\text{Gd}(n,p)^{160}\text{Eu}$	First diff. measurements	
$^{159}\text{Tb}(n,2n)^{158\text{m}}\text{Tb}$		Add. integral measurements
$^{159}\text{Tb}(n,t)^{157}\text{Gd}$	First diff. measurements	
$^{162}\text{Dy}(n,t)^{160}\text{Tb}$		
$^{164}\text{Dy}(n,\gamma)^{165\text{g}}\text{Dy}$	Diff. data agreement	
$^{164}\text{Dy}(n,\gamma)^{165}\text{Dy}$		Add. integral measurements
$^{164}\text{Dy}(n,p)^{164}\text{Tb}$	Diff. data agreement	Add. integral measurements
$^{165}\text{Ho}(n,t)^{163}\text{Dy}$	First diff. measurements	
$^{165}\text{Ho}(n,h)^{163}\text{Tb}$		

Reaction	Comment on differential data	Comment on integral data
$^{164}\text{Er}(n,2n)^{163}\text{Er}$	Diff. data agreement	Add. integral measurements
$^{166}\text{Er}(n,2n)^{165}\text{Er}$	Diff. data agreement	Add. integral measurements
$^{170}\text{Er}(n,p)^{170\text{g}}\text{Ho}$		
$^{174}\text{Yb}(n,h)^{172}\text{Er}$	First diff. measurements	
$^{175}\text{Lu}(n,2n)^{174\text{g}}\text{Lu}$		
$^{175}\text{Lu}(n,3n)^{173}\text{Lu}$	Diff. data agreement	Add. integral measurements
<b><math>^{175}\text{Lu}(n,4n)^{172}\text{Lu}</math></b>	First diff. measurements	
$^{177}\text{Hf}(n,n')^{177\text{m}}\text{Hf}$	First diff. measurements	
$^{179}\text{Hf}(n,p)^{179}\text{Lu}$	Diff. data agreement	Add. integral measurements
$^{180}\text{Hf}(n,\gamma)^{181}\text{Hf}$	Diff. data agreement	Add. integral measurements
$^{181}\text{Ta}(n,n'\alpha)^{177\text{m}}\text{Lu}$	First diff. measurements	
<b><math>^{181}\text{Ta}(n,n'\alpha)^{177}\text{Lu}</math></b>	First diff. measurements	
$^{181}\text{Ta}(n,4n)^{178\text{m}}\text{Ta}$	First diff. measurements	
$^{181}\text{Ta}(n,t)^{179\text{n}}\text{Hf}$	First diff. measurements	
$^{181}\text{Ta}(n,h)^{179}\text{Lu}$		
$^{181}\text{Ta}(n,\alpha)^{178\text{g}}\text{Lu}$		
$^{180}\text{W}(n,3n)^{178}\text{W}$	First diff. measurements	
$^{183}\text{W}(n,p)^{183}\text{Ta}$		Add. integral measurements
$^{184}\text{W}(n,n'p)^{183}\text{Ta}$		
<b><math>^{184}\text{W}(n,t)^{182}\text{Ta}</math></b>	First diff. measurements	
$^{186}\text{W}(n,n'p)^{185}\text{Ta}$	First diff. measurements	
$^{186}\text{W}(n,n'\alpha)^{182\text{m}}\text{Hf}$		
$^{186}\text{W}(n,h)^{184}\text{Hf}$		
$^{185}\text{Re}(n,2n)^{184\text{g}}\text{Re}$	Add. diff. measurements	Add. integral measurements
$^{185}\text{Re}(n,3n)^{183}\text{Re}$		
<b><math>^{187}\text{Re}(n,t)^{185}\text{W}</math></b>	First diff. measurements	
$^{190}\text{Os}(n,n')^{190\text{m}}\text{Os}$	Add. diff. measurements	Add. integral measurements
$^{193}\text{Ir}(n,2n)^{192\text{m}}\text{Ir}$	First diff. measurements	
$^{197}\text{Au}(n,n')^{197\text{m}}\text{Au}$	Add. diff. measurements	Add. integral measurements
$^{197}\text{Au}(n,2n)^{196\text{m}}\text{Au}$	Add. diff. measurements	Add. integral measurements
$^{197}\text{Au}(n,3n)^{195\text{m}}\text{Au}$	First diff. measurements	Add. integral measurements
<b><math>^{197}\text{Au}(n,t)^{195}\text{Pt}</math></b>	First diff. measurements	
$^{197}\text{Au}(n,h)^{195\text{g}}\text{Ir}$	First diff. measurements	
<b><math>^{197}\text{Au}(n,h)^{195}\text{Ir}</math></b>	First diff. measurements	
<b><math>^{198}\text{Hg}(n,\gamma)^{199}\text{Hg}</math></b>	Diff. data agreement	Add. integral measurements
$^{205}\text{Tl}(n,\alpha)^{202}\text{Au}$		
$^{204}\text{Pb}(n,2n)^{203\text{m}}\text{Pb}$	Diff. data agreement	Add. integral measurements
<b><math>^{206}\text{Pb}(n,p)^{206}\text{Tl}</math></b>	Add. diff. measurements	Add. integral measurements
$^{208}\text{Pb}(n,p)^{208}\text{Tl}$	Diff. data agreement	Add. integral measurements
<b><math>^{208}\text{Pb}(n,t)^{206}\text{Tl}</math></b>	First diff. measurements	
$^{209}\text{Bi}(n,p)^{209}\text{Bi}$	Add. diff. measurements	
<b><math>^{209}\text{Bi}(n,t)^{207}\text{Pb}</math></b>		
<b><math>^{209}\text{Bi}(n,h)^{207}\text{Tl}</math></b>	First diff. measurements	
$^{238}\text{U}(n,2n)^{237}\text{U}$	Diff. data agreement	Add. integral measurements
$^{237}\text{Np}(n,2n)^{236\text{m}}\text{U}$	Diff. data agreement	Add. integral measurements

**Table 14.** Reactions removed from the present analysis

Reaction	Spectrum	QS
$^{59}\text{Co}(n,\gamma)^{60\text{m}}\text{Co}$	fns_5min	5→4
$^{66}\text{Zn}(n,p)^{66}\text{Cu}$	fns_5min	6→4
$^{80}\text{Se}(n,2n)^{79\text{m}}\text{Se}$	fns_5min	6→4
$^{80}\text{Se}(n,p)^{80}\text{As}$	fns_5min	6→4
$^{82}\text{Se}(n,2n)^{81\text{g}}\text{Se}$	fns_5min	5→4
$^{85}\text{Rb}(n,2n)^{84\text{m}}\text{Rb}$	fns_5min	6→4
$^{90}\text{Zr}(n,n'p)^{89\text{m}}\text{Y}$	fns_5min	5→0
$^{92}\text{Mo}(n,\alpha)^{89\text{g}}\text{Zr}$	fng_Mo	6→4
$^{103}\text{Rh}(n,\gamma)^{104\text{g}}\text{Rh}$	fns_5min	5→4
$^{103}\text{Rh}(n,\gamma)^{104\text{m}}\text{Rh}$	fns_5min	5→4
$^{106}\text{Pd}(n,p)^{106\text{m}}\text{Rh}$	fns_5min	6→4
$^{108}\text{Pd}(n,p)^{108\text{g}}\text{Rh}$	fns_5min	5→4
$^{191}\text{Ir}(n,2n)^{190\text{n}}\text{Ir}$	fns_5min	6→4
$^{193}\text{Ir}(n,\alpha)^{190}\text{Re}$	fns_5min	(5)→1
$^{196}\text{Pt}(n,p)^{196\text{g}}\text{Ir}$	fns_5min	6→4
$^{205}\text{Tl}(n,\alpha)^{202}\text{Au}$	fns_5min	5→4
$^{209}\text{Bi}(n,\alpha)^{206\text{g}}\text{Tl}$	fns_5min	6→0
$^{209}\text{Bi}(n,\alpha)^{206\text{m}}\text{Tl}$	fns_5min	5→3

## 7. Conclusions

As part of the EFDA Materials Research Programme, continuing effort to develop tools for the prediction of neutron activation has been undertaken. This has led to the release of various versions of the European Activation System (EASY), the latest of which is EASY-2007. The present report gives detailed information on 470 reactions. The total number of reactions in EAF-2007 is 65,565, but it should be noted that the materials for validation have been selected in close contact with the EFDA Materials Programme so that the fraction of reactions having great practical importance for fusion technology is high.

For each of the experimental irradiations the C/E values of the measured radionuclides, the dominant pathways and uncertainty information are summarised in a table, either in the present report or in references 1, 2 and 3. Much of the experimental information is too detailed for the present summary report, but is available in the publications from the various laboratories. In cases where either a single reaction pathway or one of the parallel pathways dominates the formation of a particular nuclide it is possible to extract a measured effective cross section for the reaction. This effective cross section can be directly compared with the EAF cross section averaged in the appropriate neutron spectrum. Values of the C/E ratios for the effective cross sections can be studied in SAFEP AQ-II and graphs are presented of these ratios plotted with the EAF and experimental uncertainties. From these graphs and plots of the cross section excitation function shown with the available differential experimental data, judgements can be made on whether a reaction has been validated by the experimental data or whether it is possible to improve the data for a future version of EAF.

The energy dependent C/E plots emphasise that even when several integral measurements have been made, that the energy range covered is limited and only in a few cases includes energies > 20 MeV. Thus even for reactions that are classified as 'validated' additional measurements are desirable so that cross sections at all energies in the library can be tested. The statement that a reaction has been validated by the integral and differential measurements only refers to the energy range over which experimental data are available. Note that if activation of a material is considered in a neutron spectrum very different from those studied

here, then there is no guarantee that the predictions would be as accurate as indicated by the present results.

A total of 217 reactions have been validated and several reactions are recommended to be improved for EAF-2009. A summary of the numbers of reactions covered by the report is given in Figure 21. The growing database of integral measurements is a valuable resource for validating and improving each version of the EAF library and so maintaining the claim that EASY is the most thoroughly tested and validated activation code/data system world-wide.

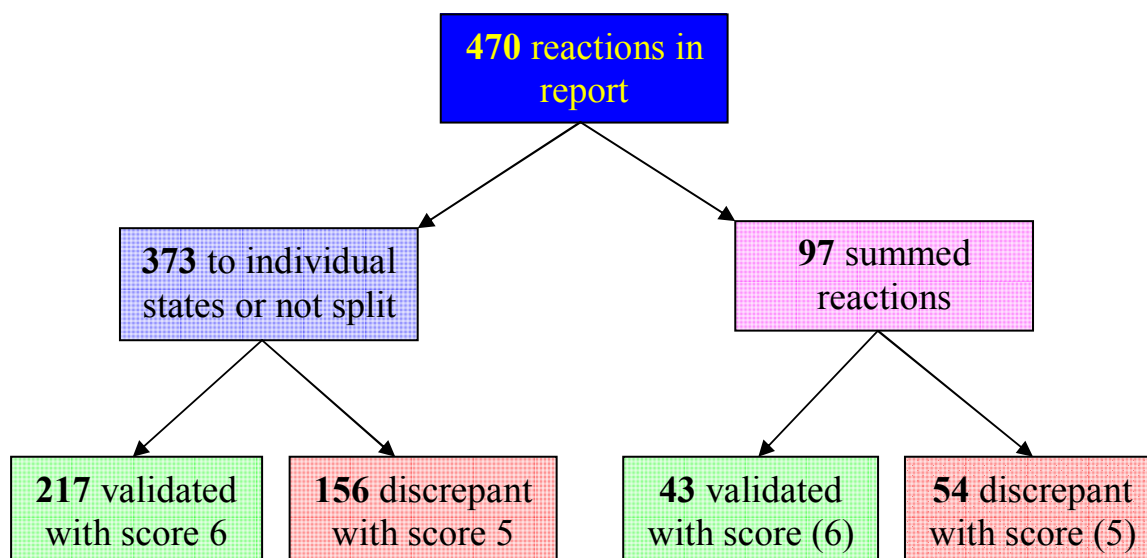


Figure 21. Summary of reactions.

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Many of the references for experimental results used already in the EASY-2001 [1], EASY-2003 [2] and EASY-2005 [3] validation are not repeated here. In the following references some refer to the EFF-Doc series. JEFF members with the necessary password can download these documents from the NEA Data Bank web site ([http://www.nea.fr/html/dbdata/nds\\_eval\\_effdoc.htm](http://www.nea.fr/html/dbdata/nds_eval_effdoc.htm)). Other people who require these documents should contact one of the authors ([robin.forrest@ukaea.org](mailto:robin.forrest@ukaea.org)).

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