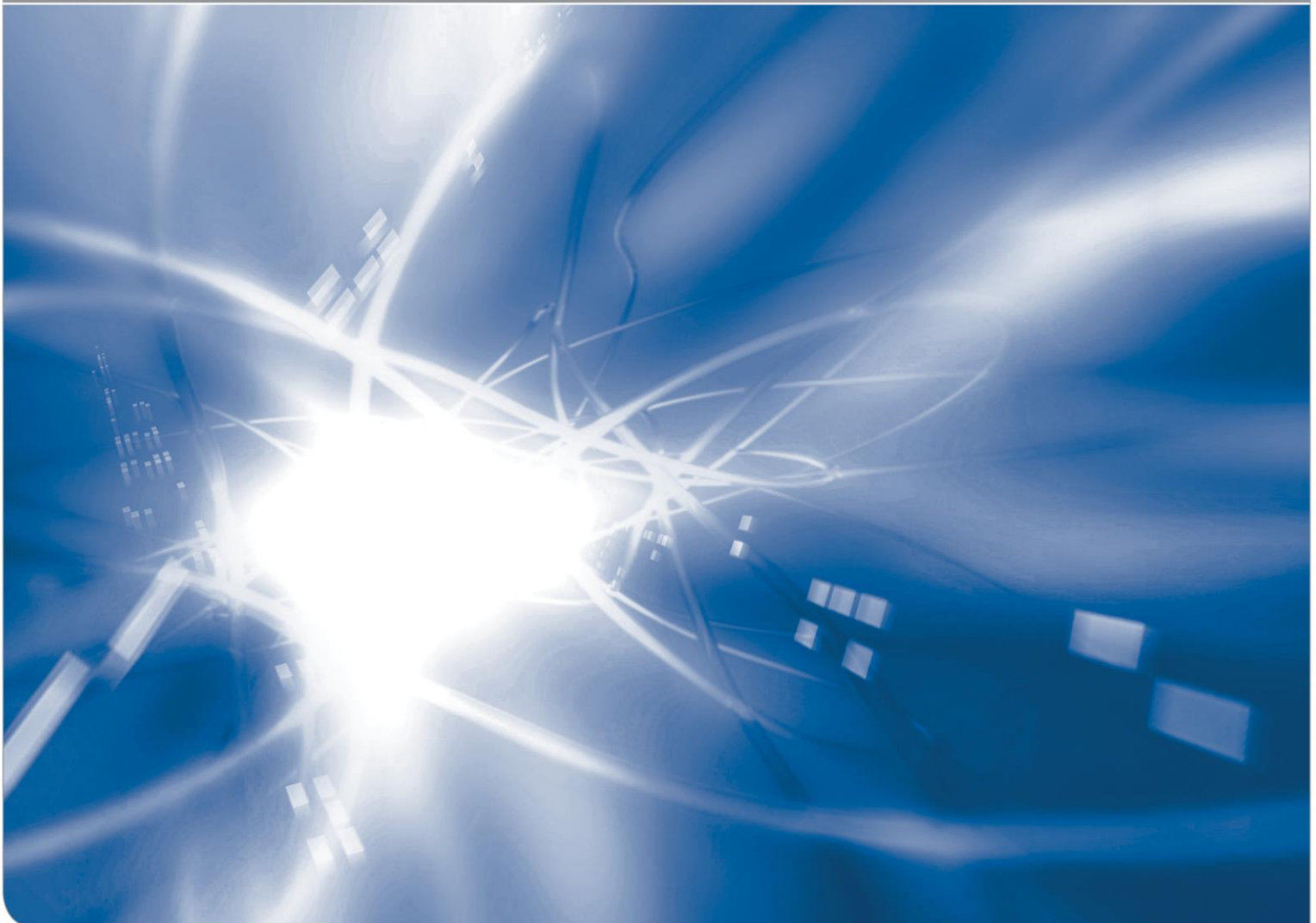


# Complete gas production data library for nuclides from Mg to Bi at neutron incident energies up to 200 MeV

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## **Abstract**

An evaluation of proton-, deuteron-, triton-,  $^3\text{He}$ -, and  $\alpha$ -particles- production cross-sections was performed for 262 stable nuclides with atomic number from 12 to 83 at the energies of primary neutrons up to 200 MeV. The data were compiled in ENDF formatted data files.





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## 1. Introduction

A study of primary radiation effects in material of fusion units and neutron spallation sources implies the use of a set of reliable data for a calculation of gas production rates for a wide range of primary neutron energies and target materials. An obtaining such data is one of important challenges of applied nuclear physics. The solution concerns the use of advanced theoretical models, experimental data, and data of systematics [1].

The goal of this work is to obtain gas production cross-sections for stable targets with the atomic number from 12 to 83 at incident neutron energies up to 200 MeV. The work involves

- the analysis of available experimental data
- the estimation of atomic mass dependence of cross-sections,  $\sigma(A)$  at primary neutron energy around hundred MeV to improve final evaluated curves, as described in Ref.[2]
- the analysis of evaluated data from ENDF/B-VII.1, JENDL-4, JEFF-3.2, and TENDL-2014, if available
- theoretical calculations
- the improvement of available evaluated data concerning an incorrect energy dependence, jumps, and other irregularities
- the cross-section evaluation involving measured data, values estimated using the  $\sigma(A)$ - dependence, systematics predictions, and results of model calculations.

In most cases, the evaluated data of JEFF-3.2 for (n,p), (n,t), (n,d), and (n, $\alpha$ ) reactions below 20 MeV were found to be correct and not requiring improvement. For a number of reactions data at neutron incident energies below 20 MeV were taken from other libraries or corrected.

Section 2 describes briefly experimental data used for the evaluation of gas production cross-sections, a selection and eventual corrections. The evaluation of atomic mass dependence of cross-sections to be used for the correction of components of evaluated gas production cross-sections, is discussed in Section 3. Section 4 explains the details of the use of available nuclear data files and results of model calculations for the evaluation. Section 5 describes results of the evaluation.

Obtained proton-, deuteron, triton, and  $\alpha$ -particle production cross-section are shown in Appendices A-D.

## **2. Experimental data**

The experimental data used for the evaluation of gas production cross-sections were taken from Refs.[3-26] and relating EXFOR files. Available measured data refer to individual target isotopes, as for example, Ref.[25], natural mixtures of isotopes, sums of proton-, deuteron-, and triton- production cross-sections,  $^3\text{He}$  and  $\alpha$ -particle production cross-sections. A number of cross-sections were measured for a limited energy range of emitted charged particles and require corrections to get total gas production cross-sections.

In the last case the data measured were corrected as described below. For some targets corrections performed by authors of measurements using the GNASH code [27] and TALYS code [28] were adopted for further use. In the present work, particle energy distributions were calculated with the TALYS code [28] using different models for the calculation of the nuclear level density for excited nuclei. In the most cases the calculated part of cross-section  $\sigma$  above the experimental low cut-off energy  $E_{\min}$  was normalized on the measured value; the obtained cross-section was added to the calculated part of  $\sigma$  below  $E_{\min}$  multiplied by the obtained coefficient to get the production cross-section at all emission energies. The final value of cross-section for each incident neutron energy was obtained by the averaging of results obtained using different models for nuclear level density.

The proton and  $\alpha$ -particle production cross-sections were extracted from the corresponding measured hydrogen and helium production cross-sections using available experimental information for neighbouring target nuclei and results of model calculations.

## **3. Evaluation of atomic mass dependence of gas production cross-sections**

The method of the correction of calculated gas-production cross-sections using the evaluated A-dependence is discussed in Refs.[2].

An idea is the evaluation of the atomic mass dependence of cross-sections using available experimental information and results of model calculations for a fixed incident particle energy. The approach gives a possibility to obtain experimentally based values of cross-sections for targets, if the measured data are absent. The method is different from the use of global A-systematics, where predictions are made basing on a global parameterization of existing data and approximate formulas.

In analogy with the common evaluation of the energy dependence of cross-section for a certain target, here the atomic mass dependence is estimated for different target nuclei for fixed incident particle energy. It is assumed that the energy of primary particles is high enough to attribute the possible difference of calculations and experimental data to deficiency of global parameter systematics used for calculations, for example for the simulation of non-equilibrium particle emission making the contribution to the gas production cross-section. Another criterion for selecting the primary particle energy for evaluation of  $\sigma(A)$  dependence is the number of available measurements.

The use of estimated A-dependence seems to be a natural way to apply available data for neighbouring target-nuclei for the evaluation of cross-sections [2].

After analysing the measured data, the neutron energy of 96 MeV was chosen for the evaluation of  $\sigma(A)$  dependence.

Improved and corrected experimental cross-sections  $\sigma^{\text{exp}}$  at 96 MeV used for the evaluation of A-dependence of components of gas production cross-sections are shown in Tables 1-5. In some cases errors of particle production cross-sections  $\Delta\sigma$  shown in Tables reflect performed corrections and improvements and are not original errors reported in corresponding experimental works.

The calculation of gas production cross-section components were performed for 278 stable nuclei from  ${}^7\text{Li}$  to  ${}^{209}\text{Bi}$  using nuclear models implemented in the ALICE/ASH [29] code and the TALYS [28] code. Different models describing the nuclear level density were applied for calculations. The details are discussed in Ref.[2].

Figures 1-5 shows examples of calculations using ALICE/ASH and TALYS codes.

Table 1. Cross-sections  $\sigma^{\text{exp}}$  adopted for the evaluation of proton production cross-section in neutron induced reactions (n,x)p at the incident neutron energy 96 MeV. Corrections of original data are discussed in the text.

Nucleus	Cross-section (mb)	Reference
<sup>nat</sup> C	$170 \pm 17$	[8]
<sup>nat</sup> O	$257.5 \pm 14.4$	[10]
<sup>nat</sup> Si	$494.8 \pm 22.7$	[18]
<sup>nat</sup> Cr	$639.6 \pm 127.9$	[21]
<sup>nat</sup> Fe	$697.9 \pm 30.7$	[19]
<sup>nat</sup> Fe	$588.4 \pm 117.7$	[21]
<sup>181</sup> Ta	$237.6 \pm 47.5$	[21]
<sup>nat</sup> Pb	$485 \pm 24.3$	[19]

Table 2. Cross-sections  $\sigma^{\text{exp}}$  adopted for the evaluation of deuteron production cross-section in neutron induced reactions (n,x)d at the incident neutron energy 96 MeV. Corrections of original data are discussed in the text.

Nucleus	Cross-section (mb)	Reference
<sup>nat</sup> C	$70 \pm 4$	[8]
<sup>nat</sup> O	$80.1 \pm 4.1$	[10]
<sup>nat</sup> Si	$84.3 \pm 4.0$	[18]
<sup>nat</sup> Cr	$146.3 \pm 29.3$	[21]
<sup>nat</sup> Fe	$133.1 \pm 6.5$	[19]
<sup>nat</sup> Fe	$112.2 \pm 22.5$	[21]
<sup>181</sup> Ta	$68.5 \pm 13.7$	[21]
<sup>nat</sup> Pb	$137.0 \pm 6.9$	[19]

Table 3. Cross-sections  $\sigma^{\text{exp}}$  adopted for the evaluation of triton production cross-section in neutron induced reactions (n,x)t at the incident neutron energy 96 MeV. Derivation of data and corrections are discussed in the text.

Nucleus	Cross-section (mb)	Reference
<sup>nat</sup> C	$32.0 \pm 2.0$	[8]
<sup>nat</sup> O	$24.20 \pm 1.15$	[10]
<sup>nat</sup> Si	$16.00 \pm 0.82$	[18]
<sup>nat</sup> Cr	$23.2 \pm 5.1$	[21]
<sup>nat</sup> Fe	$21.2 \pm 1.1$	[19]
<sup>nat</sup> Fe	$17.9 \pm 3.6$	[21]
<sup>181</sup> Ta	$24.9 \pm 5.0$	[21]
<sup>nat</sup> Pb	$53.0 \pm 2.7$	[19]

Table 4. Cross-sections  $\sigma^{\text{exp}}$  adopted for the evaluation of <sup>3</sup>He production cross-section in neutron induced reactions (n,x)<sup>3</sup>He at the incident neutron energy 96 MeV. Derivation of data and corrections are discussed in the text.

Nucleus	Cross-section (mb)	Reference
<sup>nat</sup> C	$16.0 \pm 2.0$	[8]
<sup>nat</sup> O	$11.2 \pm 1.5$	[10]
<sup>nat</sup> Si	$10.8 \pm 1.0$	[18]
<sup>nat</sup> Cr	$12.4 \pm 2.5$	[21]
<sup>nat</sup> Fe	$10.70 \pm 0.52$	[19]
<sup>nat</sup> Fe	$8.96 \pm 1.79$	[21]
<sup>181</sup> Ta	$6.47 \pm 5.35$	[21]
<sup>nat</sup> Pb	$5.12 \pm 1.02$	[19]

Table 5. Cross-sections  $\sigma^{\text{exp}}$  adopted for the evaluation of  $\alpha$ -particle production cross-section in neutron induced reactions  $(n,x)\alpha$  at the incident neutron energy 96 MeV. Corrections of original data are discussed in the text.

Nucleus	Cross-section (mb)	Reference
$^{\text{nat}}\text{C}$	$207 \pm 12$	[8]
$^{\text{nat}}\text{O}$	$168.7 \pm 7.4$	[10]
$^{\text{nat}}\text{Si}$	$155.1 \pm 7.1$	[18]
$^{\text{nat}}\text{Cr}$	$202.6 \pm 40.5$	[21]
$^{\text{nat}}\text{Fe}$	$182.7 \pm 8.4$	[19]
$^{\text{nat}}\text{Fe}$	$153.2 \pm 30.6$	[21]
$^{181}\text{Ta}$	$38.3 \pm 7.6$	[21]
$^{\text{nat}}\text{Pb}$	$45.0 \pm 2.2$	[19]

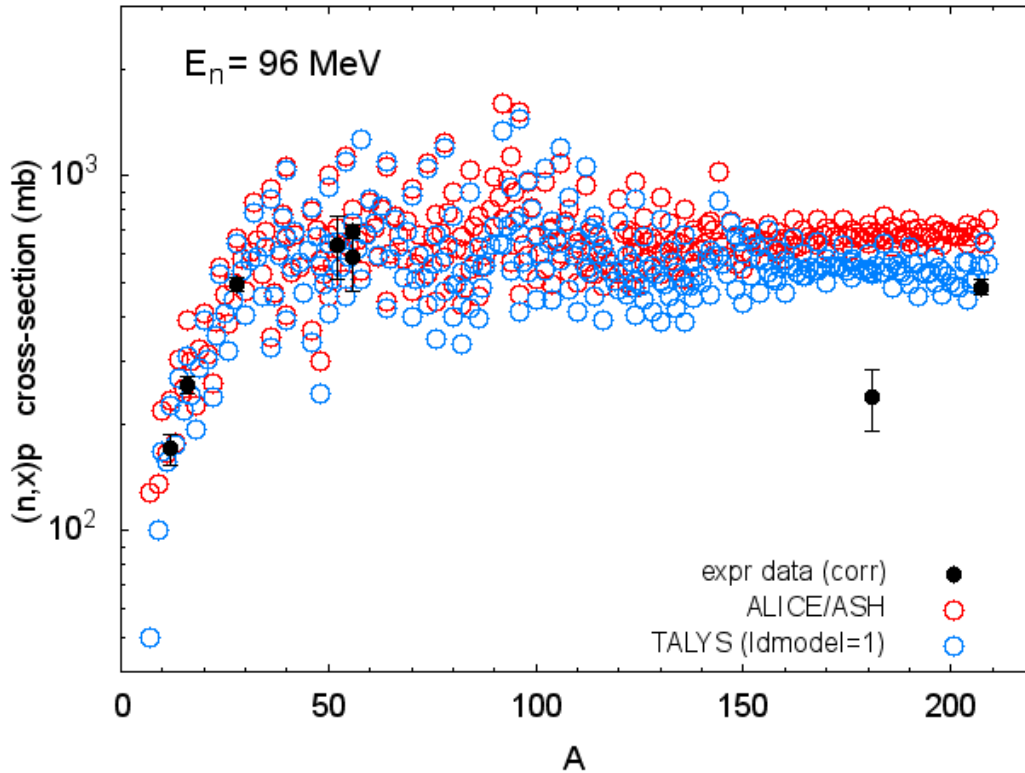


Fig.1 Proton production cross-sections for 278 stable target nuclei from  $^7\text{Li}$  to  $^{209}\text{Bi}$  at the incident neutron energy 96 MeV calculated using the ALICE/ASH code and the TALYS code applying the nuclear level density model corresponding to the input variable *ldmodel* equal to one. See explanations in the text.



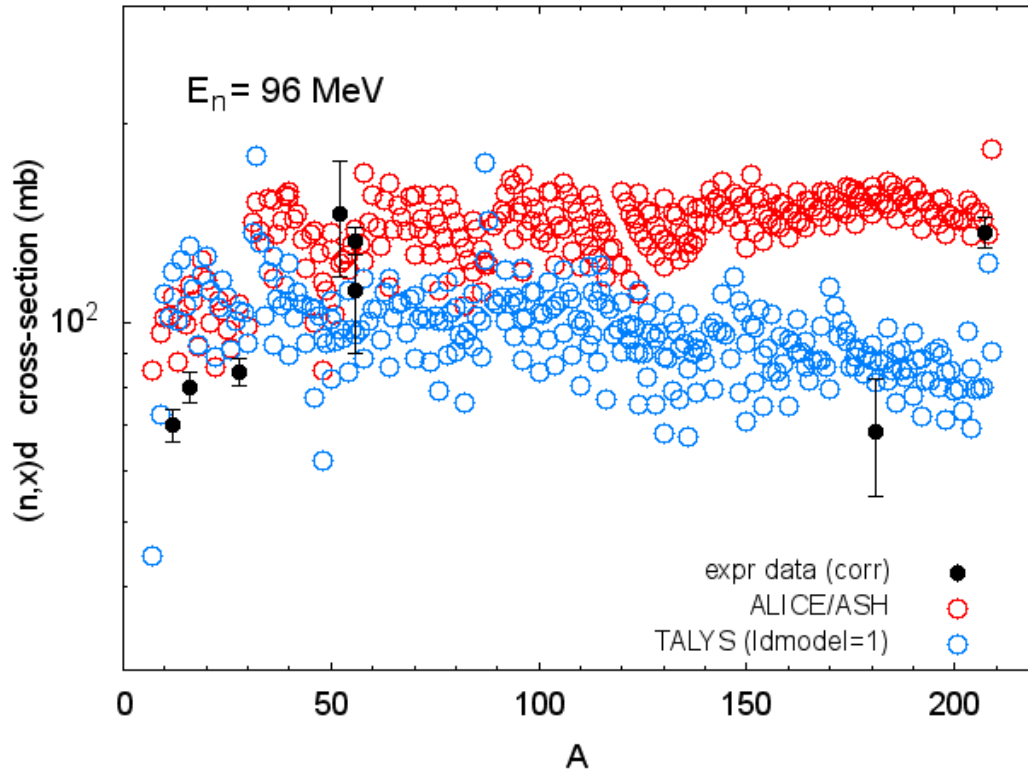


Fig.2 Deuteron production cross-sections for 278 stable target nuclei from  ${}^7\text{Li}$  to  ${}^{209}\text{Bi}$  at the incident neutron energy 96 MeV calculated using the ALICE/ASH code and the TALYS code with the input variable  $ldmodel=1$ . See explanations in the text.

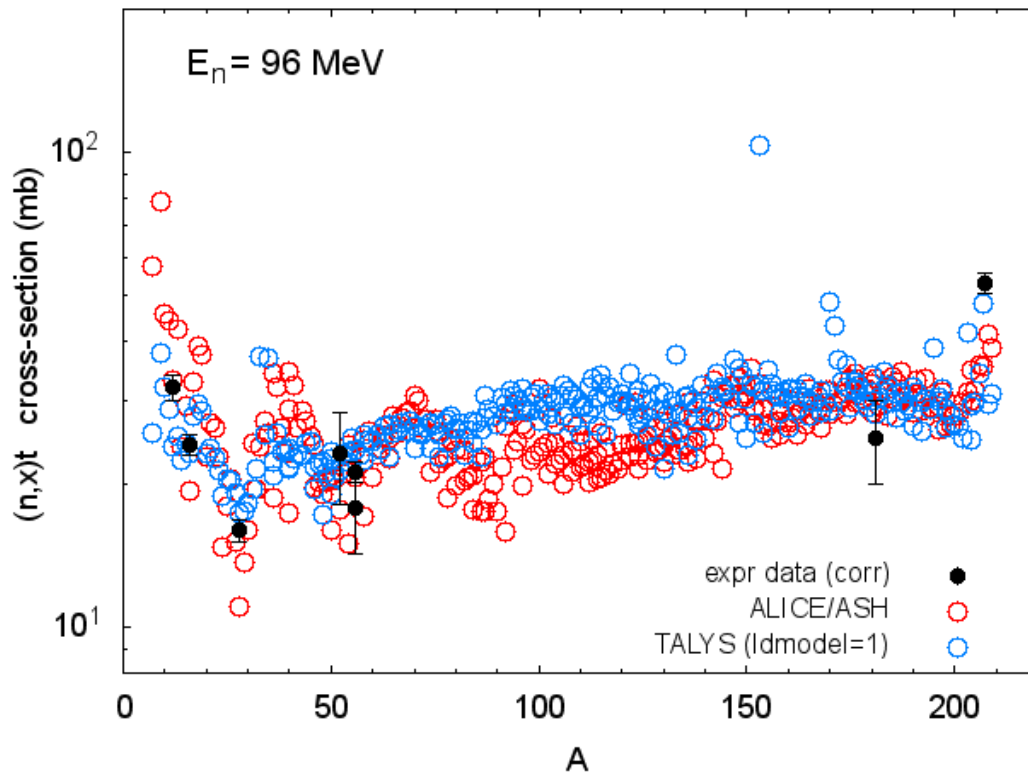


Fig.3 Triton production cross-sections for 278 stable target nuclei from  ${}^7\text{Li}$  to  ${}^{209}\text{Bi}$  at the incident neutron energy 96 MeV calculated using the ALICE/ASH code and the TALYS code with the input variable  $ldmodel=1$ . See explanations in the text.

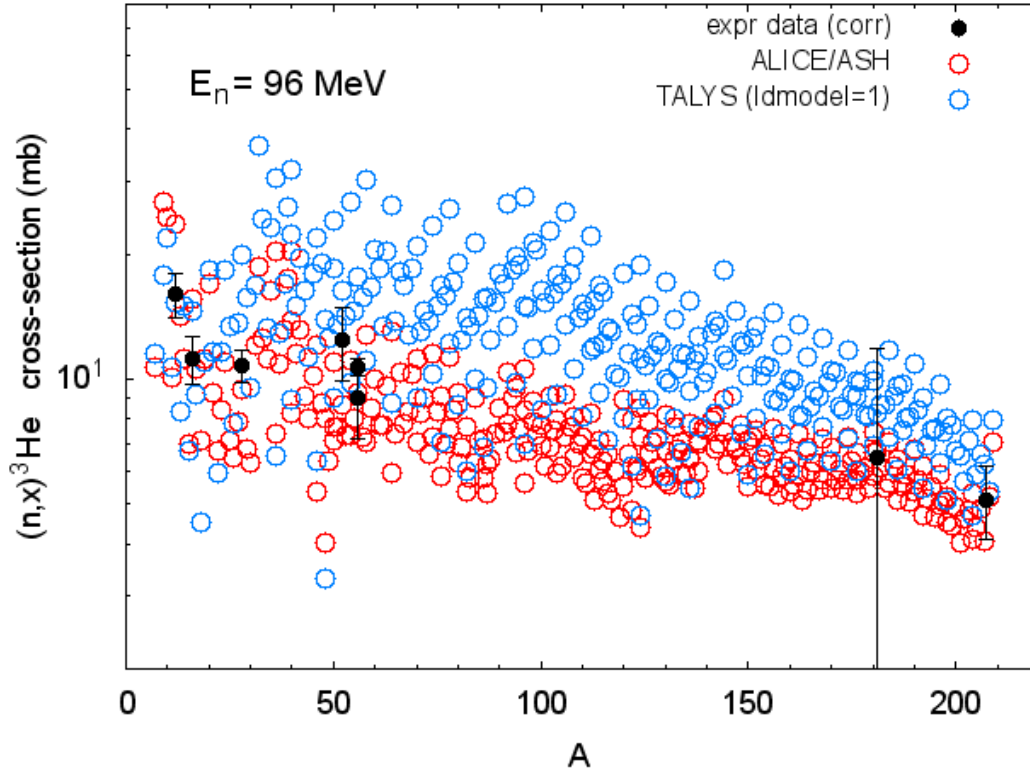


Fig.4  $^3\text{He}$  production cross-sections for 278 stable target nuclei from  $^7\text{Li}$  to  $^{209}\text{Bi}$  at the incident neutron energy 96 MeV calculated using the ALICE/ASH code and the TALYS code with the input variable  $ldmodel=1$ . See explanations in the text.

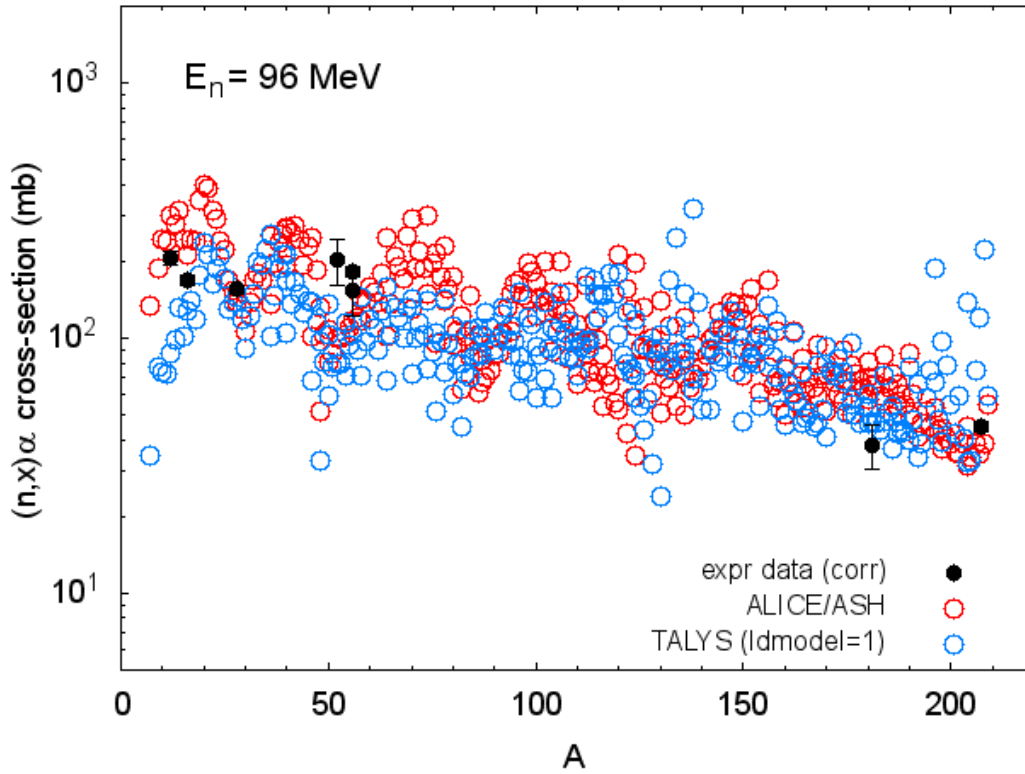


Fig.5  $\alpha$ -particle production cross-sections for 278 stable target nuclei from  $^7\text{Li}$  to  $^{209}\text{Bi}$  at the incident neutron energy 96 MeV calculated using the ALICE/ASH code and the TALYS code with the input variable  $ldmodel=1$ . See explanations in the text.

The evaluation of atomic mass dependence for proton-, deuteron-, triton-,  $^3\text{He}$ -, and  $\alpha$ -particle production cross-section was performed using results of model calculations and measured data, Table 1-5. The BEKED package [30] was applied for computations.

The deviation of calculated cross-sections from measured data was attributed to the global deficiency of models applied, particularly, to the sets of parameters of non-equilibrium models, which utilization can be improved by the redefinition of their general  $A$ -dependence. Estimated errors of evaluated production cross-sections result from the application of different nuclear models implemented in the ALICE/ASH code and in the TALYS code corresponding to input variable *ldmodel* from 1 to 3 and the procedure of the data improvement [2].

Evaluated proton-, deuteron-, triton-,  $^3\text{He}$ -, and  $\alpha$ -particle- production cross-sections were obtained for 278 stable target nuclei from  $^7\text{Li}$  to  $^{209}\text{Bi}$  at the incident neutron energy 96 MeV. The cross-sections are shown in Figs.6-10.

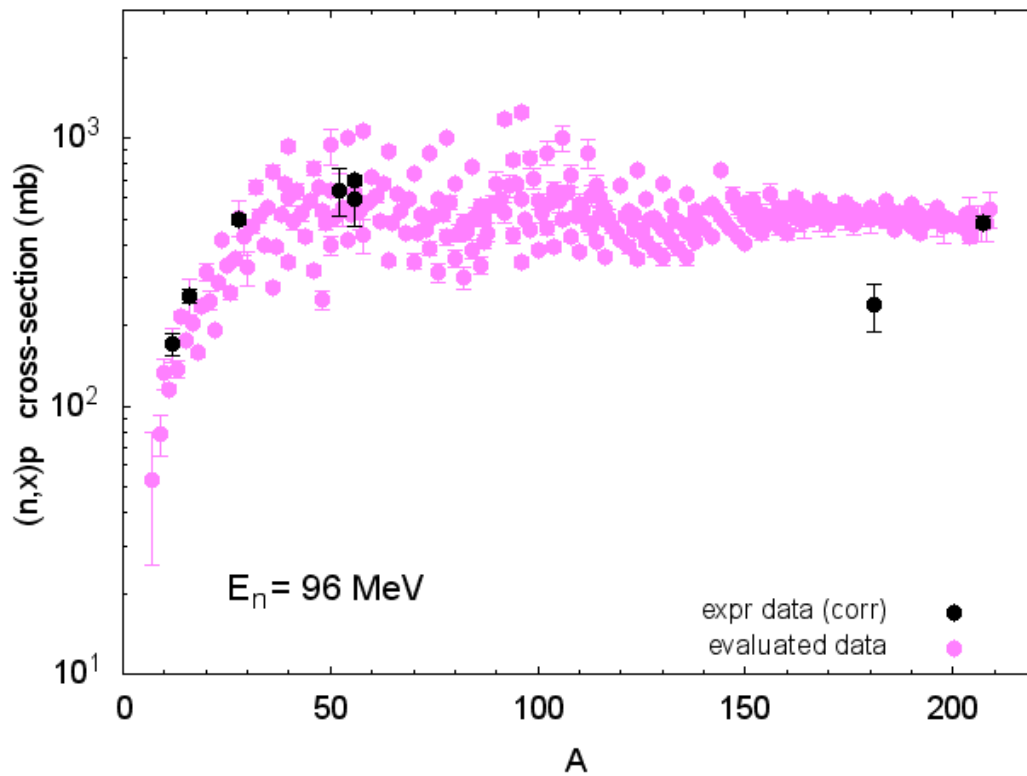


Fig.6 Evaluated proton production cross-sections for stable target nuclei from  $^7\text{Li}$  to  $^{209}\text{Bi}$  at the incident neutron energy 96 MeV

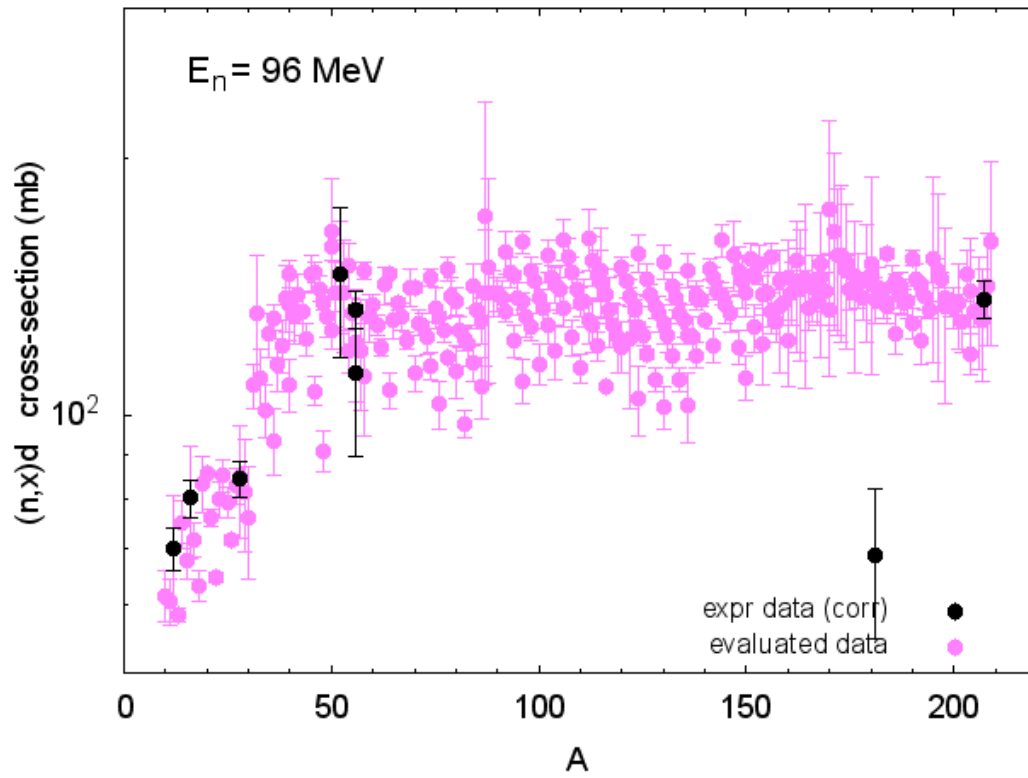


Fig.7 Evaluated deuteron production cross-sections for stable target nuclei from  ${}^7\text{Li}$  to  ${}^{209}\text{Bi}$  at the incident neutron energy 96 MeV

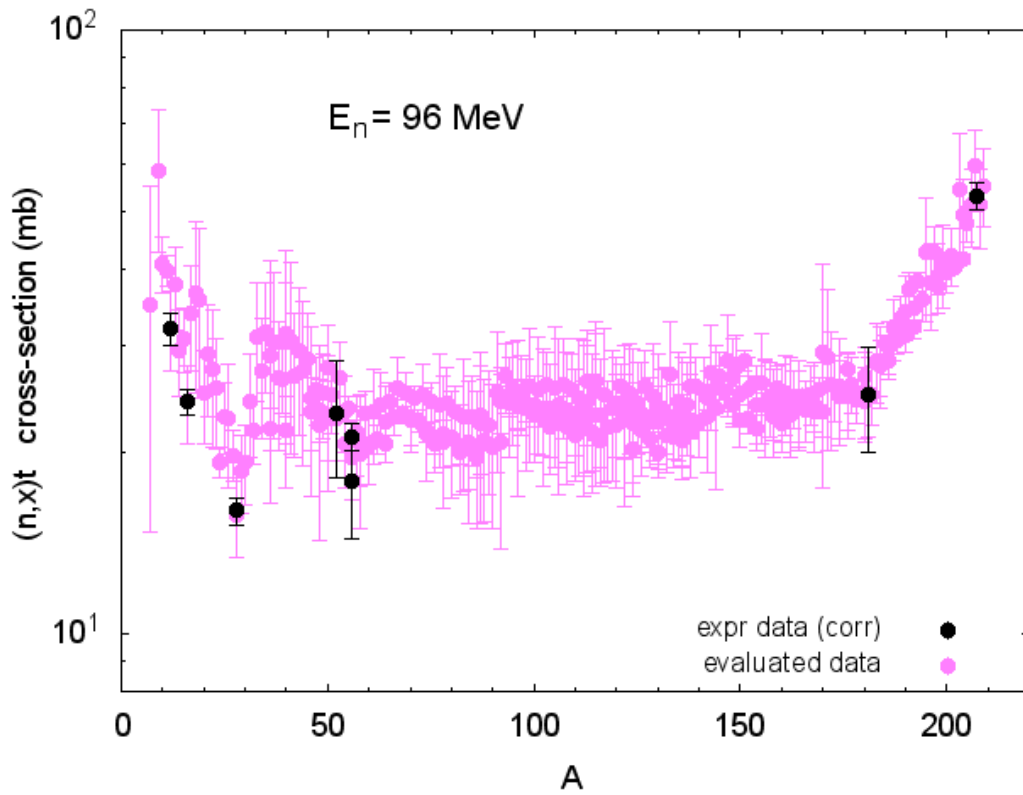


Fig.8 Evaluated triton production cross-sections for stable target nuclei from  ${}^7\text{Li}$  to  ${}^{209}\text{Bi}$  at the incident neutron energy 96 MeV

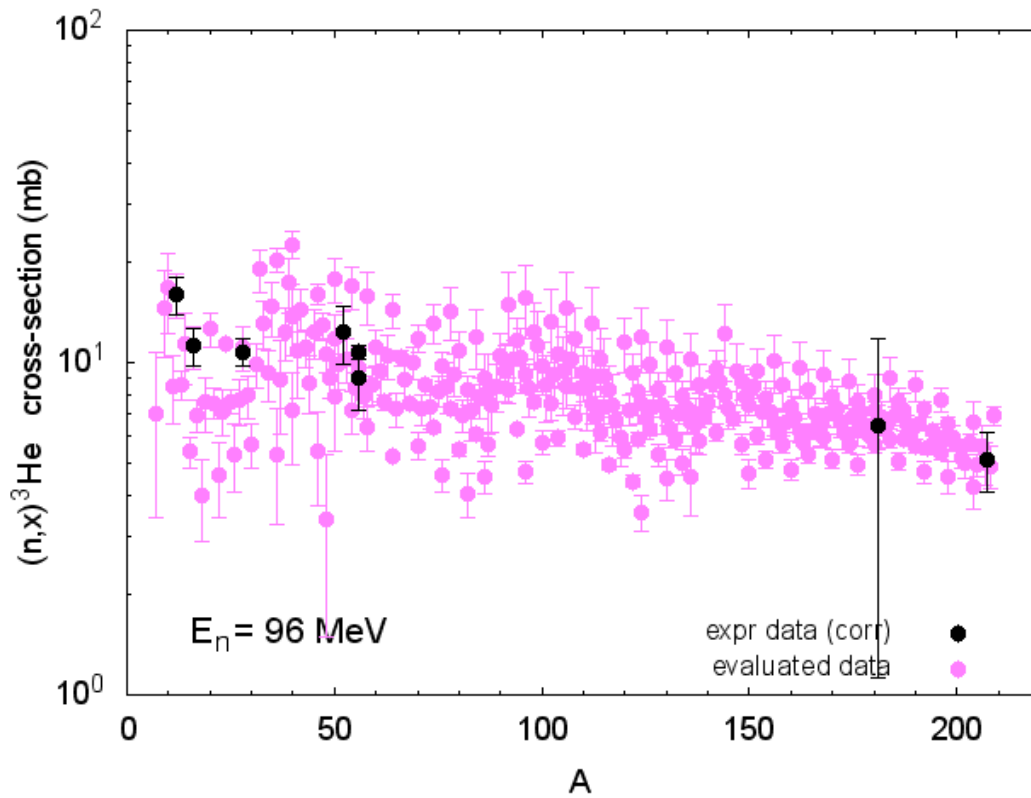


Fig.9 Evaluated  ${}^3\text{He}$  production cross-sections for stable target nuclei from  ${}^7\text{Li}$  to  ${}^{209}\text{Bi}$  at the incident neutron energy 96 MeV

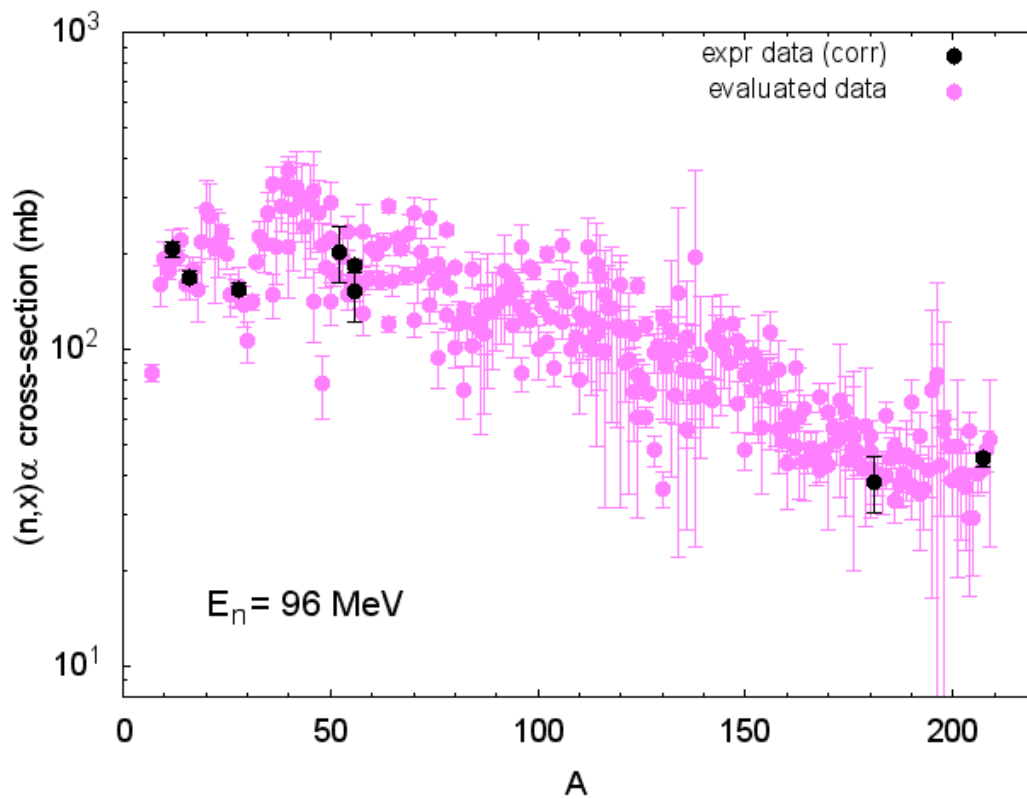


Fig.10 Evaluated  $\alpha$ -particle production cross-sections for stable target nuclei from  ${}^7\text{Li}$  to  ${}^{209}\text{Bi}$  at the incident neutron energy 96 MeV

Obtained cross-sections were applied as the reference data for the evaluation of gas production cross-sections including the correction of theoretical curves at neutron energies up to 200 MeV.

Examples of the use of obtained cross-sections for improvement of the data are shown in Fig.11.

#### **4. Use of nuclear data files and results of model calculations**

##### *4.1 Neutron energies above 20 MeV*

Data from ENDF/B-VII.1, JEFF-3.2, and TENDL-2014 were applied for subsequent corrections using the estimated cross-sections described in Section 3. In the case of large differences between the shapes of energy dependence of cross-sections from different libraries, reference calculations were carried out using ALICE/ASH and TALYS codes. Calculations were also used to extrapolate the available data up to 200 MeV.

Similarly, data from libraries and results of calculations were used for evaluation of gas production cross sections together with the experimental data [3-26]. Examples are shown in the next Section.

##### *4.2 Neutron energies below 20 MeV*

In most cases, the JEFF-3.2 data for (n,p), (n,t), (n,d), and (n, $\alpha$ ) reactions below 20 MeV were found to be correct and not requiring improvement. Some cross-sections were calculated, corrected or taken from other libraries. In the last case, the comparative analysis was performed for cross-sections from ENDF/B-VII.1, JENDL-4, JEFF-3.2, TENDL-2014, and EAF-2010 using available measured data [31].

#### **5. Evaluated data**

The improvement and correction of available evaluated data and new evaluations were performed using the BEKED package [30]. The details were discussed above.

Examples of evaluated components of gas production cross-sections are shown in Figs.12-42. Experimental values shown in Figures were corrected, if it was

necessary for specific reactions. For example, data of Ref.[25] have been reduced by the estimated contribution of  $^3\text{He}$ .

Obtained proton-, deuteron-, triton-,  $^3\text{He}$ -, and  $\alpha$ -particle- production cross-section are shown together with the data at 96 MeV (Section 3) and data from ENDF/B-VII.1, JEFF-3.2, and TENDL-2014 in Appendices A-D. The difference between evaluated data and estimated values at 96 MeV, observed in some cases, is due to the use of experimental data from the evaluation, as for example for the reaction  $\text{Fe}(n,x)\text{He}$ , Fig.27 and for  $^{56}\text{Fe}(n,x)\alpha$ , Fig.28.

Obtained data are written in the ENDF format. Conventional MT-numbers 203, 204, 205, 206, and 207 were applied for the files with proton-, deuteron-, triton-,  $^3\text{He}$ -, and  $\alpha$ -particle production cross-sections, respectively.

## 6. Conclusion

Proton-, deuteron-, triton-,  $^3\text{He}$ -, and  $\alpha$ -particles- production cross-sections were obtained for 262 stable nuclides with atomic number from 12 to 83 at the energies of primary neutrons up to 200 MeV.

The data evaluation involved the analysis of available experimental data, the estimation of atomic mass dependence of cross-sections to improve final evaluated curves, the analysis of evaluated data from ENDF/B-VII.1, JENDL-4, JEFF-3.2, and TENDL-2014, nuclear model calculations, the improvement of existing evaluated data concerning the incorrect energy dependence, and statistical combination of experimental and theoretical data.

Final evaluated data were written in the ENDF format.

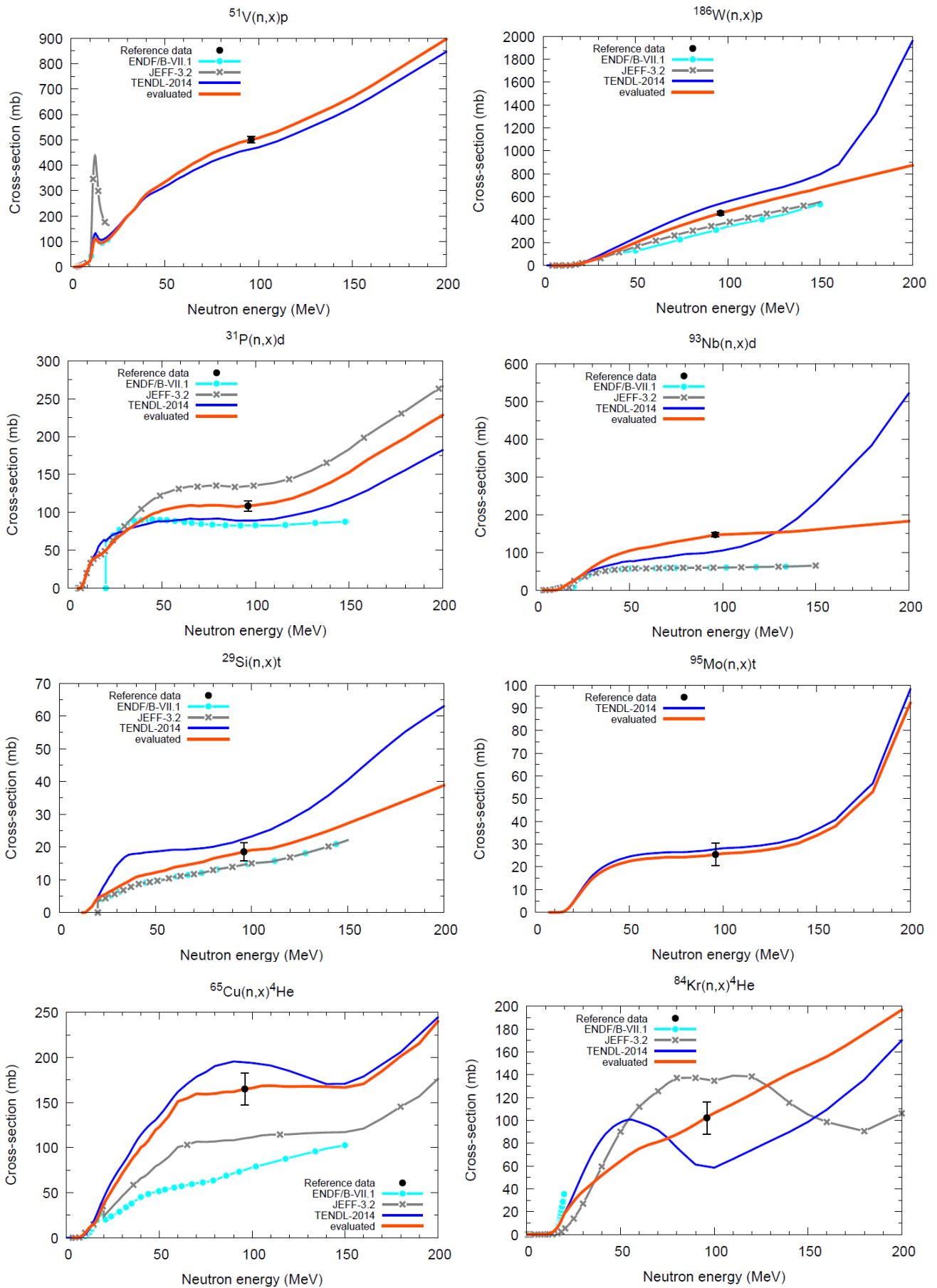


Fig.11 Examples of the use of evaluated data at 96 MeV (black circle) for the correction of components of gas production cross-sections.



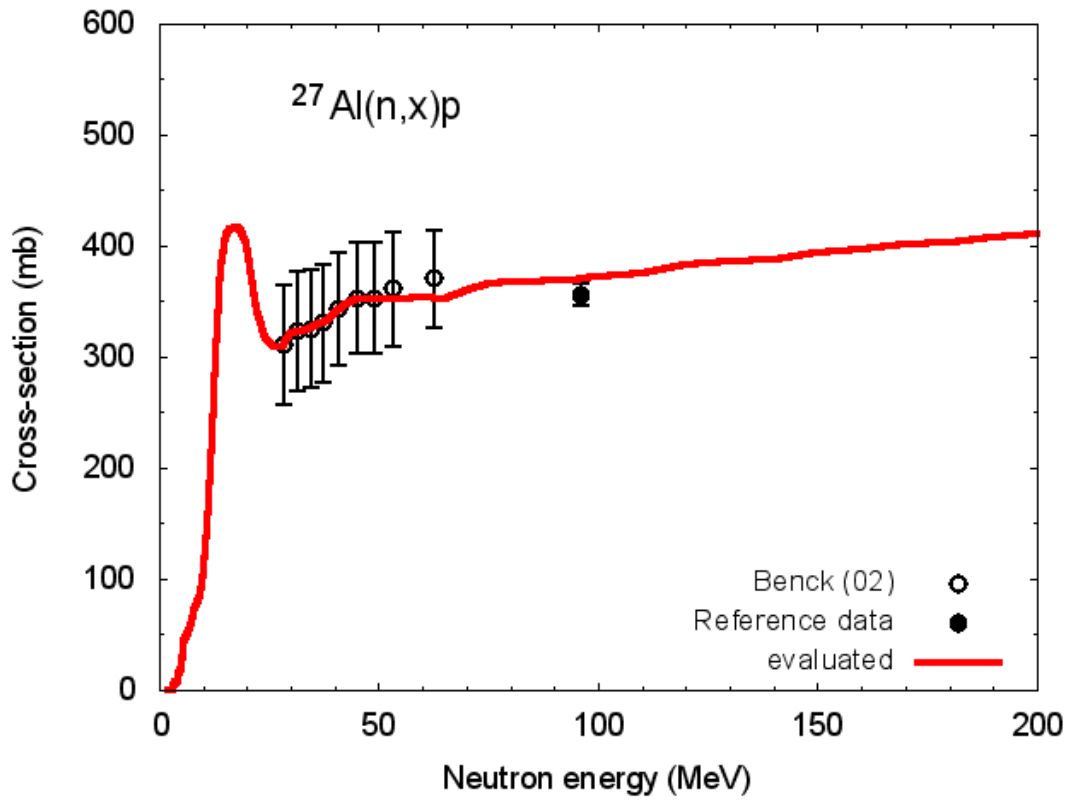


Fig.12 Evaluated proton production cross-section for  $^{27}\text{Al}$ . Reference data are discussed in Section 3.

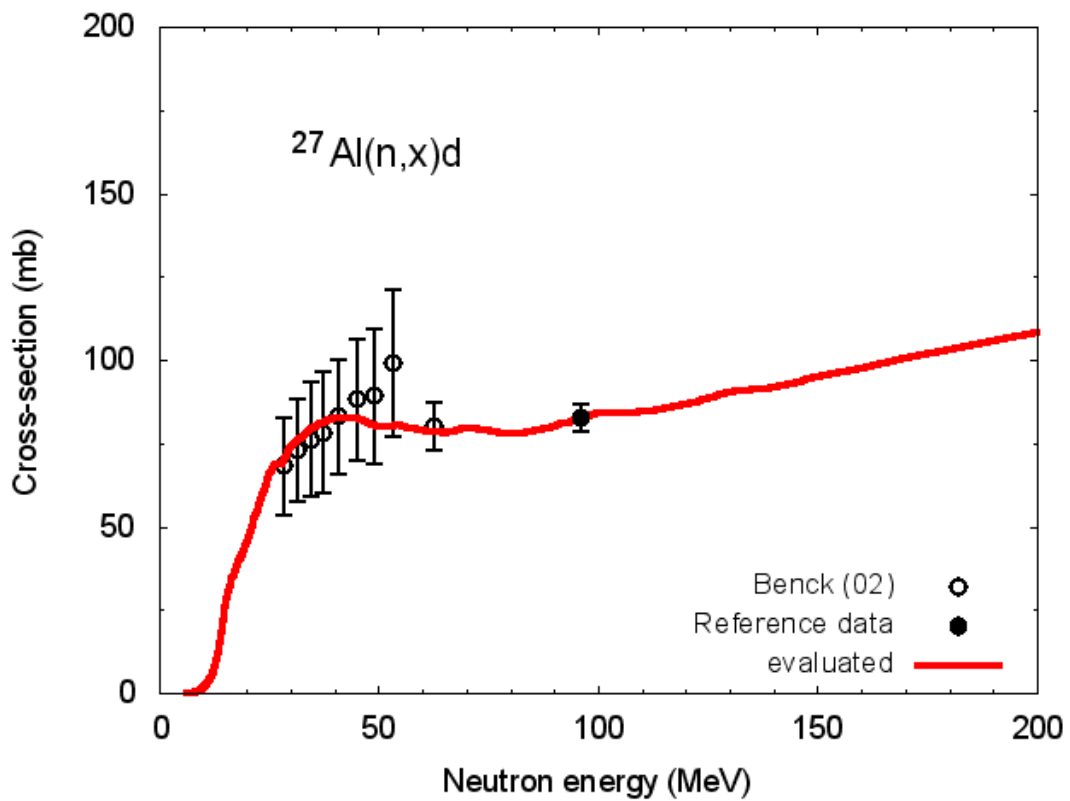


Fig.13 Evaluated deuteron production cross-section for  $^{27}\text{Al}$ .

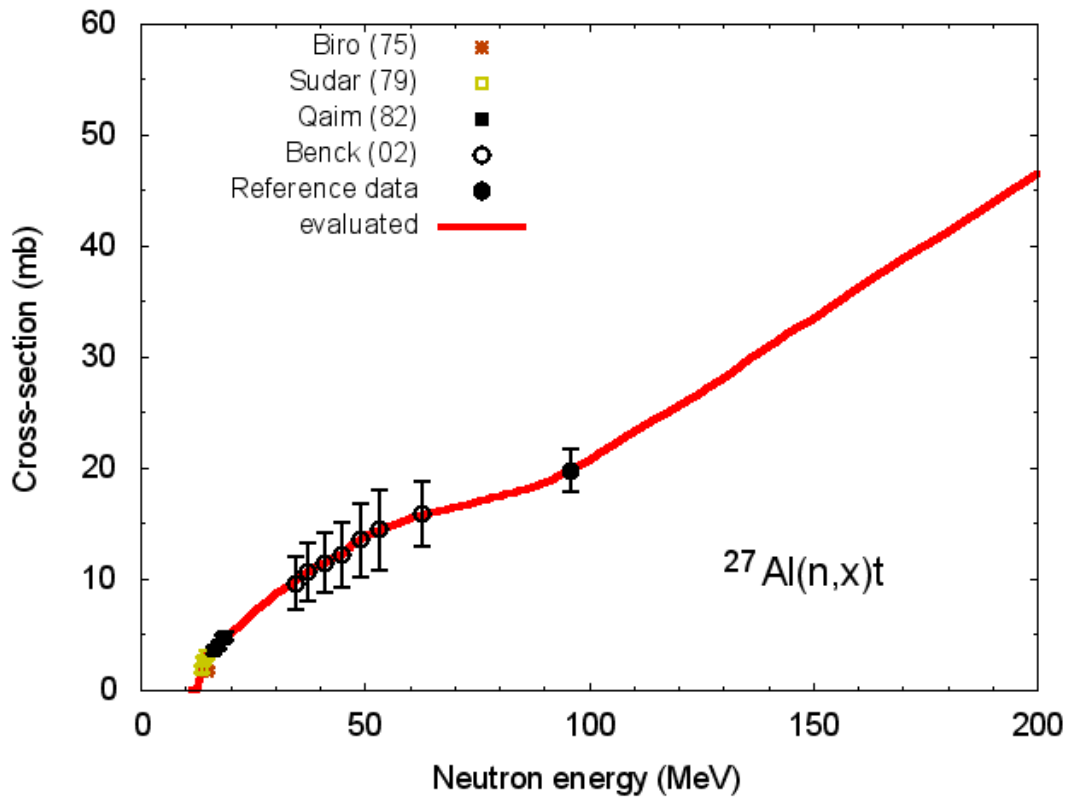


Fig.14 Evaluated triton production cross-section for  $^{27}\text{Al}$ .

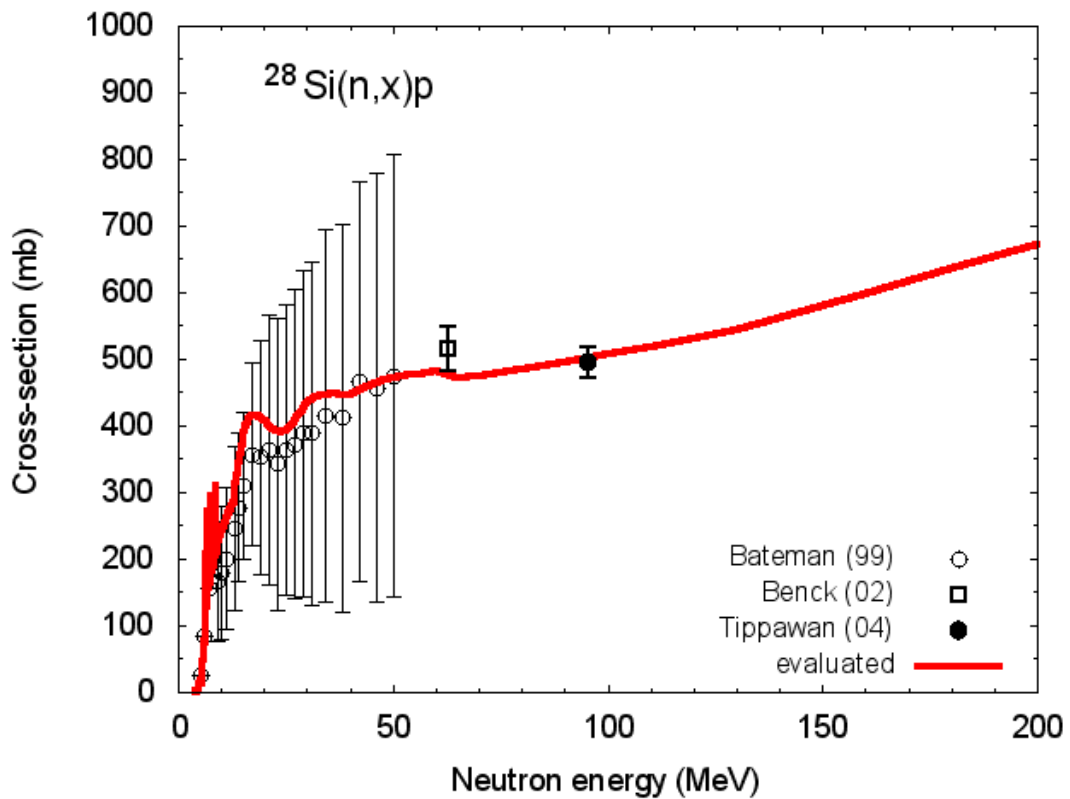


Fig.15 Evaluated proton production cross-section for  $^{28}\text{Si}$ .

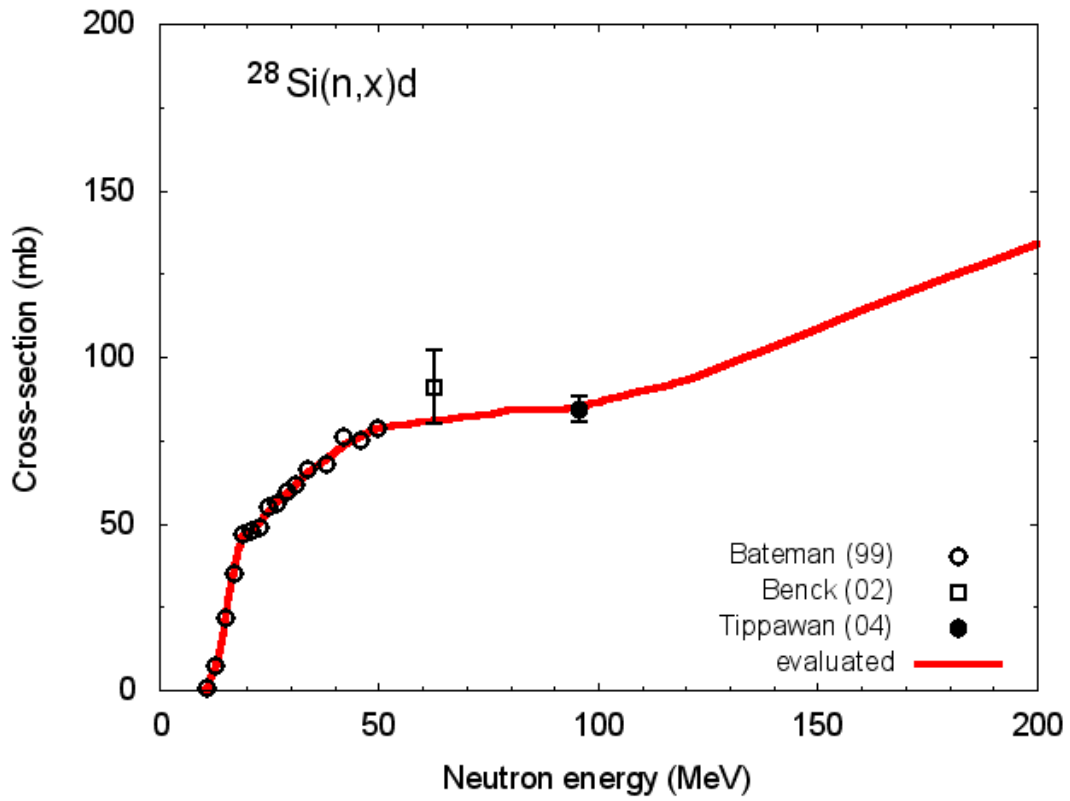


Fig.16 Evaluated deuteron production cross-section for  $^{28}\text{Si}$ .

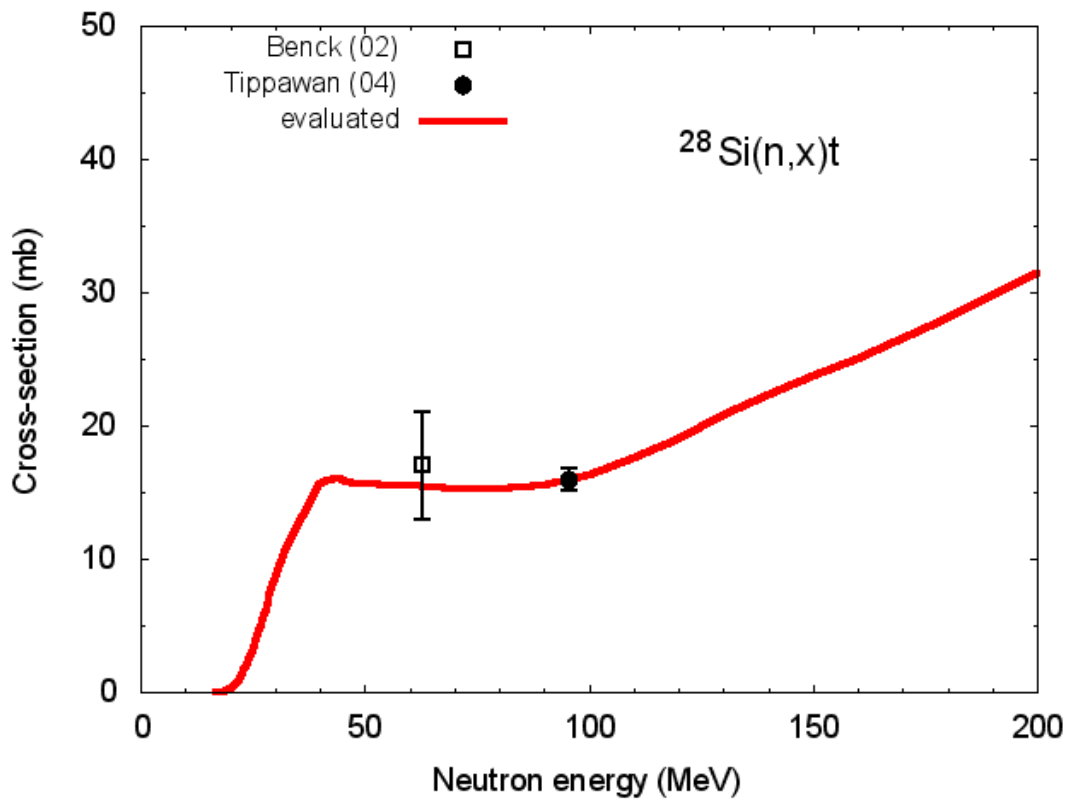


Fig.17 Evaluated triton production cross-section for  $^{28}\text{Si}$ .

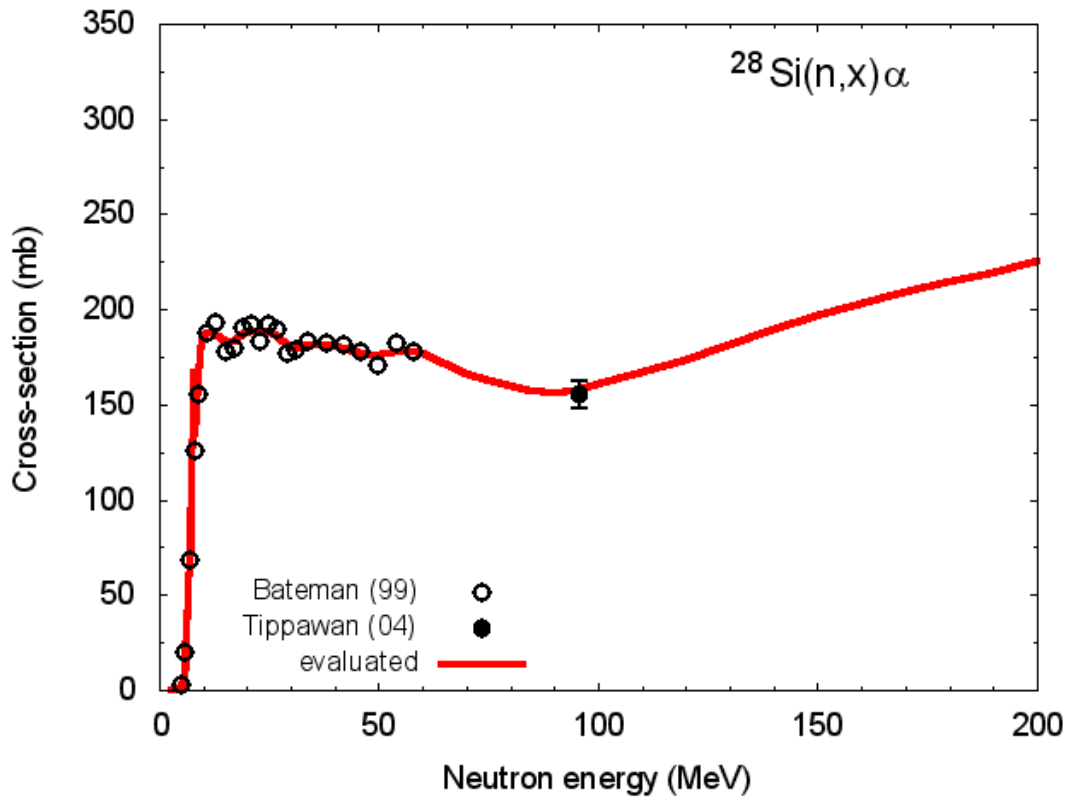


Fig.18 Evaluated  $\alpha$ -particle production cross-section for  $^{28}\text{Si}$ .

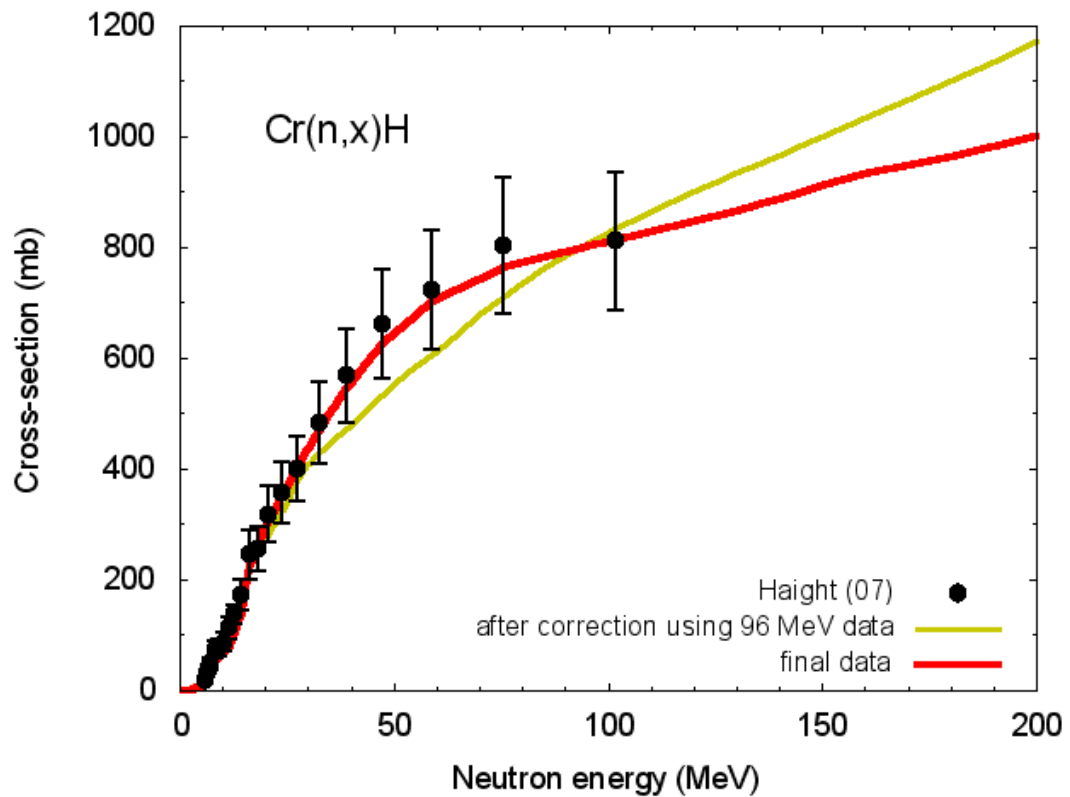


Fig.19 Evaluated hydrogen production cross-section (sum of proton-, deuteron-, and triton-production cross-sections) for chromium.

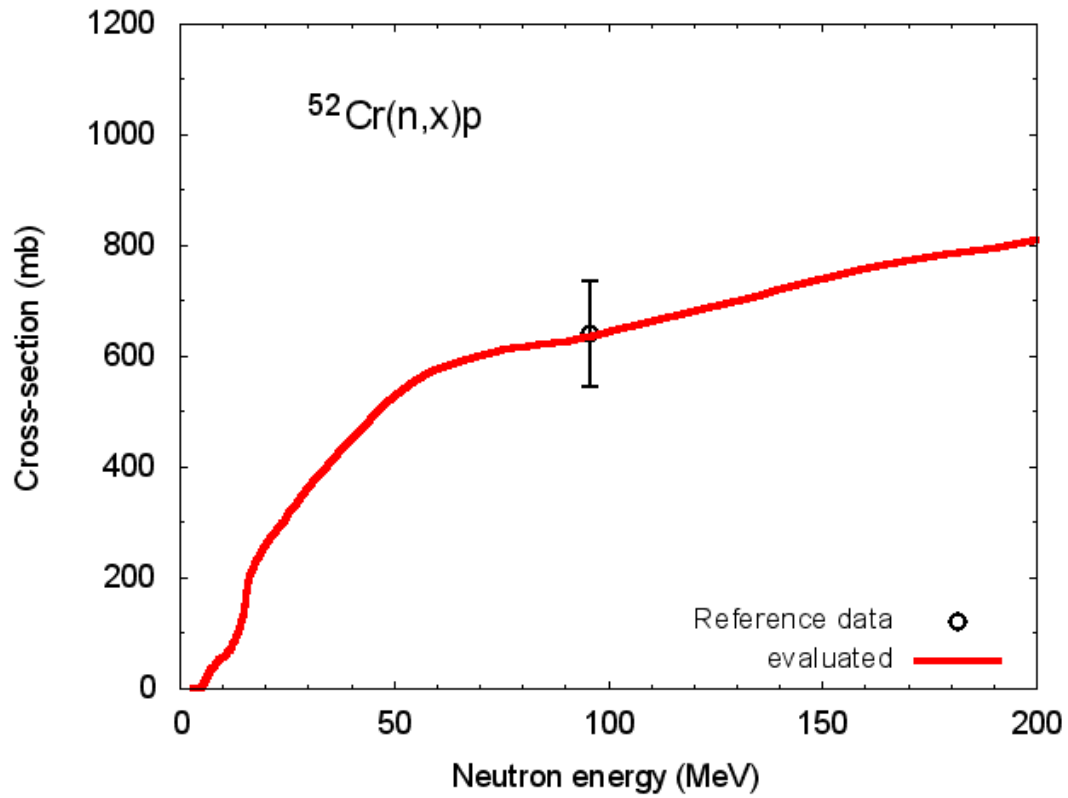


Fig.20 Evaluated proton production cross-section for  $^{52}\text{Cr}$ .

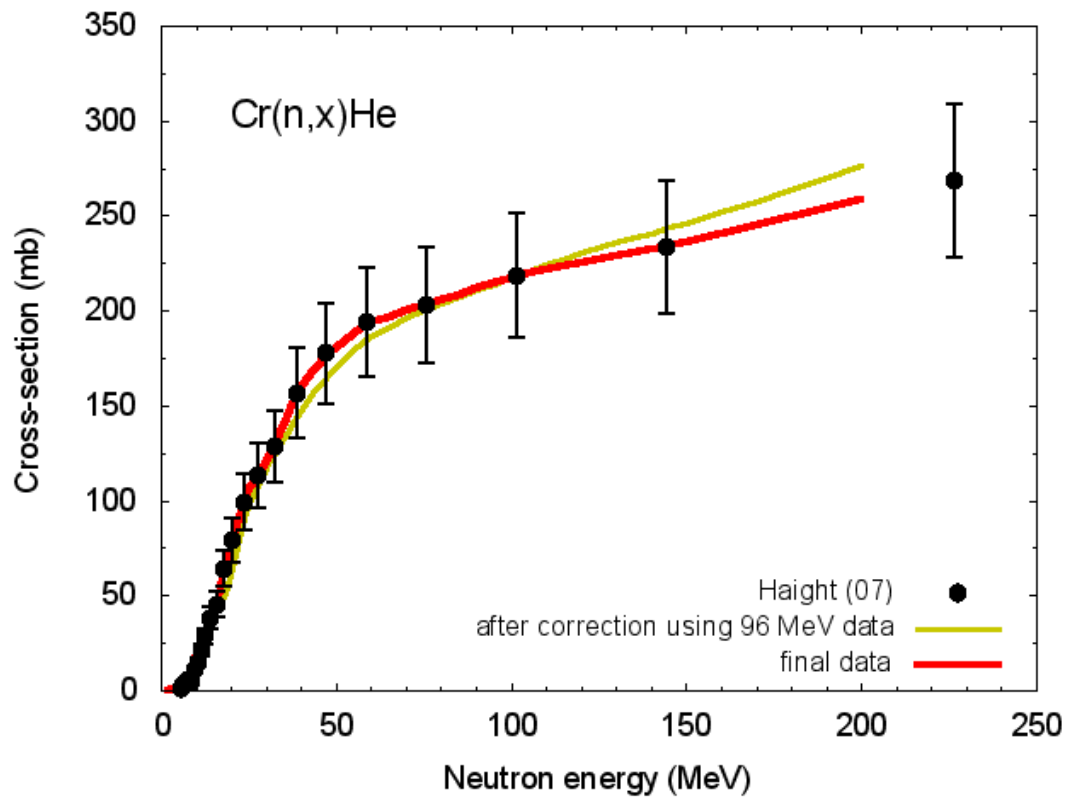


Fig.21 Evaluated helium production cross-section (sum of  $^3\text{He}$ - and  $\alpha$ -particle- production cross-sections) for chromium.

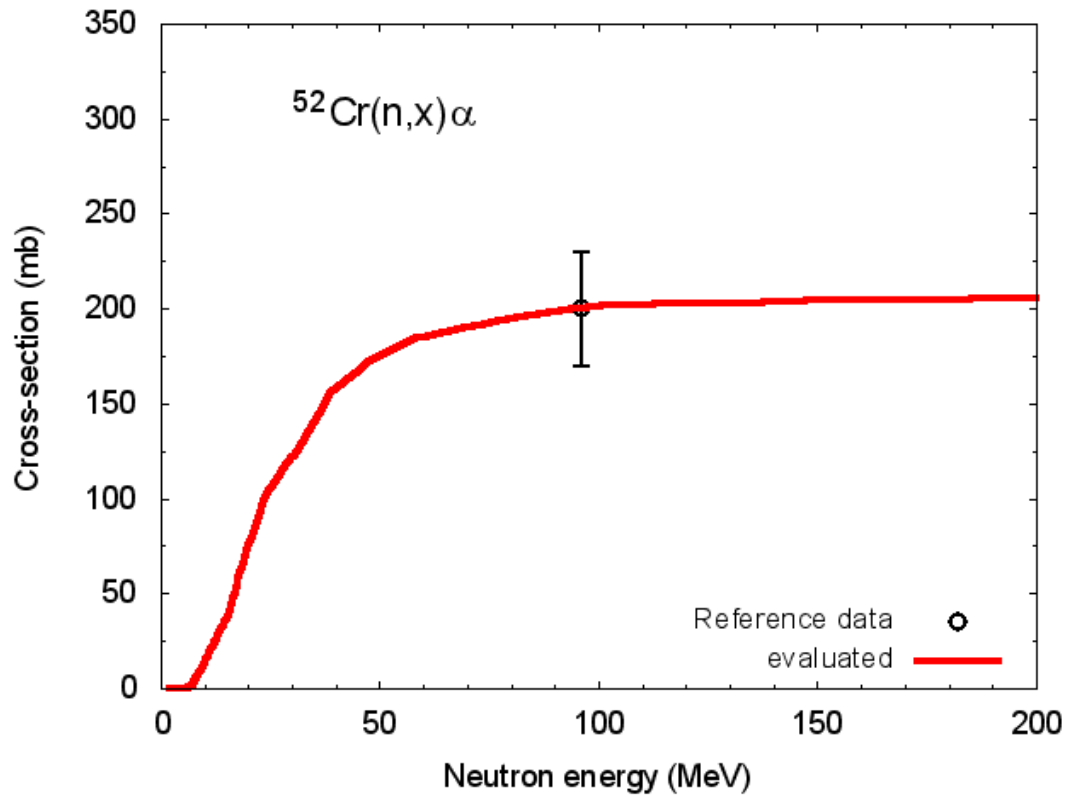


Fig.22 Evaluated  $\alpha$ -particle production cross-section for  $^{52}\text{Cr}$ .

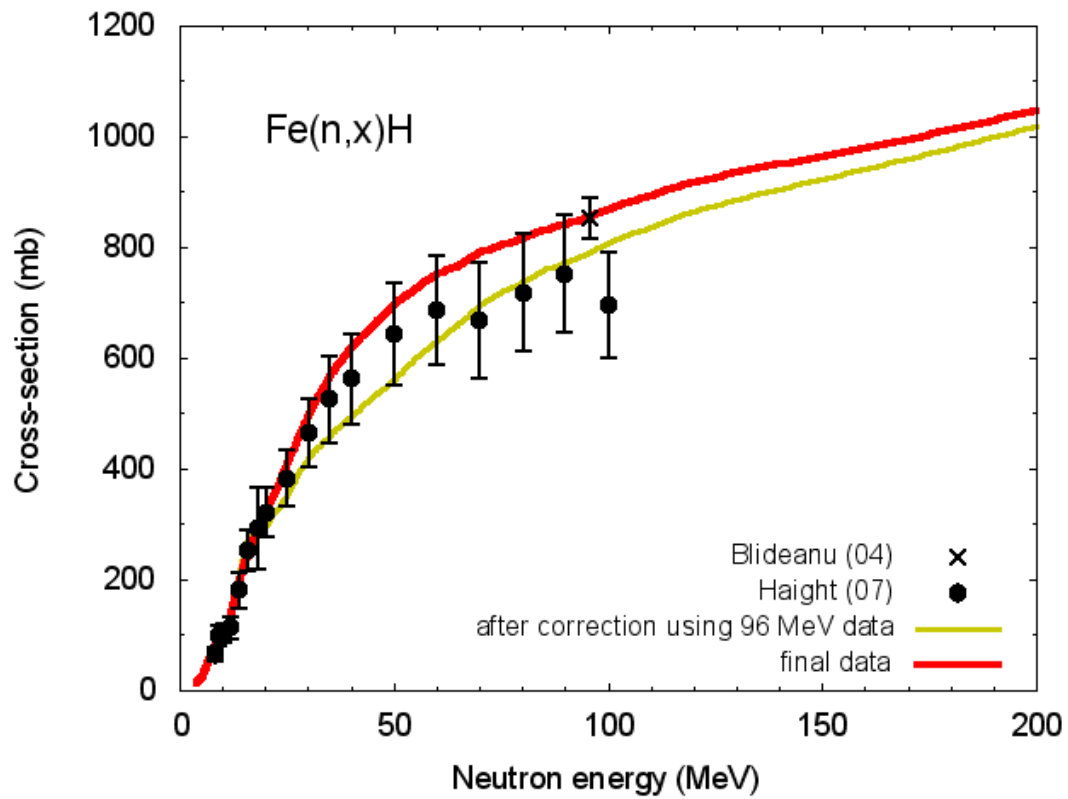


Fig.23 Evaluated hydrogen production cross-section (sum of proton-, deuteron-, and triton-production cross-sections) for iron.

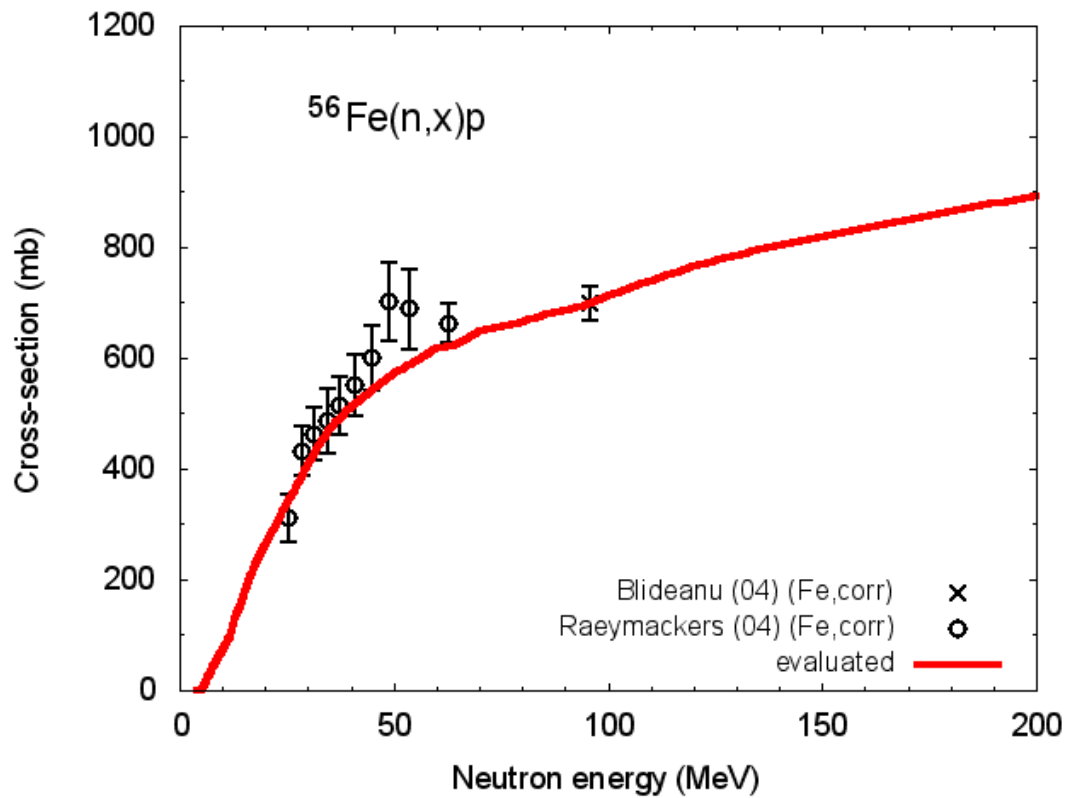


Fig.24 Evaluated proton production cross-section for  $^{56}\text{Fe}$ .

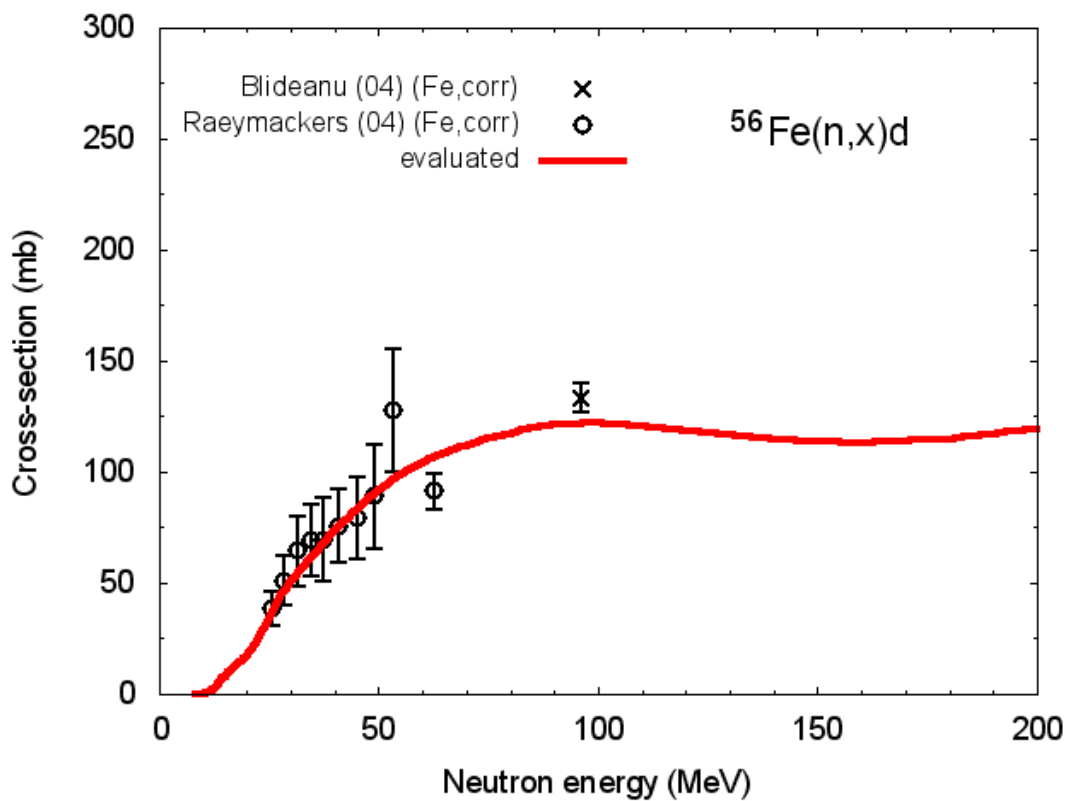


Fig.25 Evaluated deuteron production cross-section for  $^{56}\text{Fe}$ .

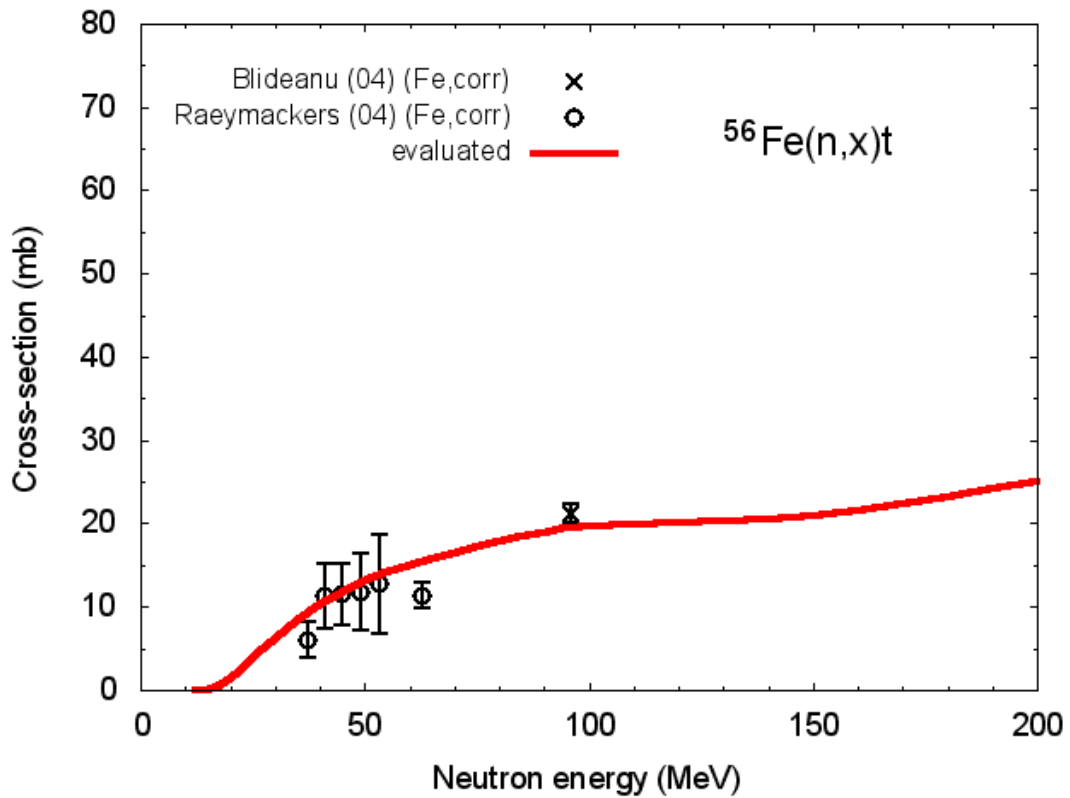


Fig.26 Evaluated triton production cross-section for  $^{56}\text{Fe}$ .

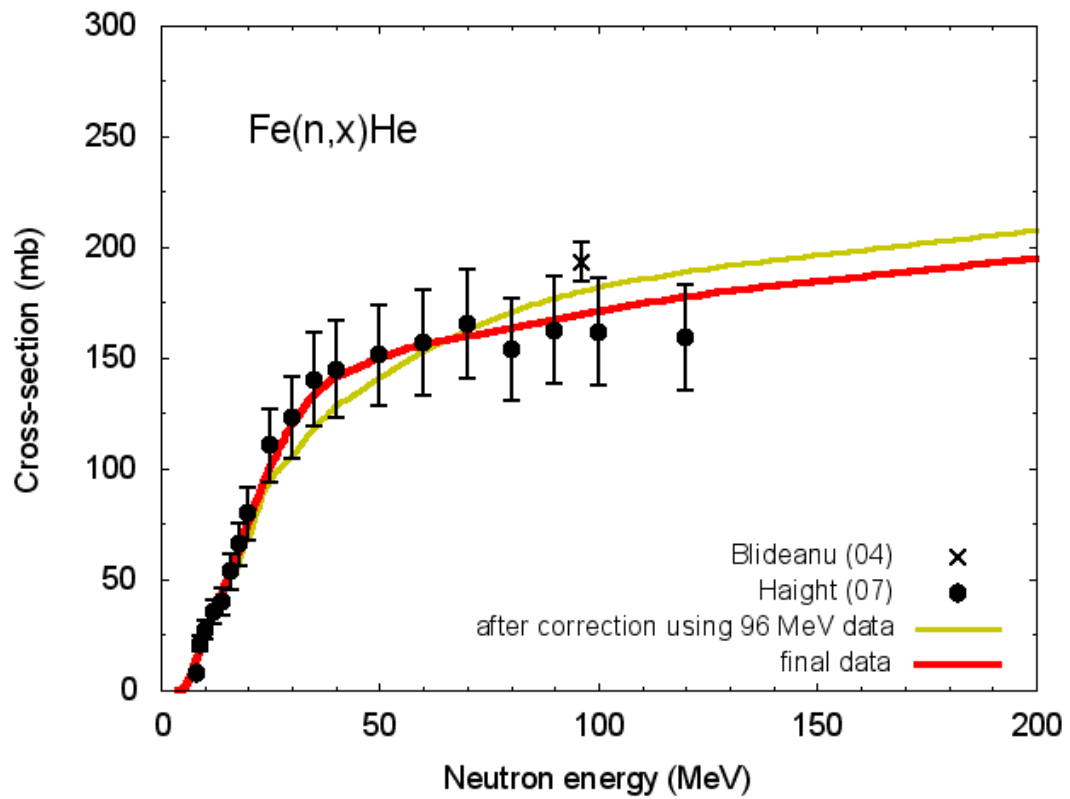


Fig.27 Evaluated helium production cross-section (sum of  $^3\text{He}$ - and  $\alpha$ -particle- production cross-sections) for iron.



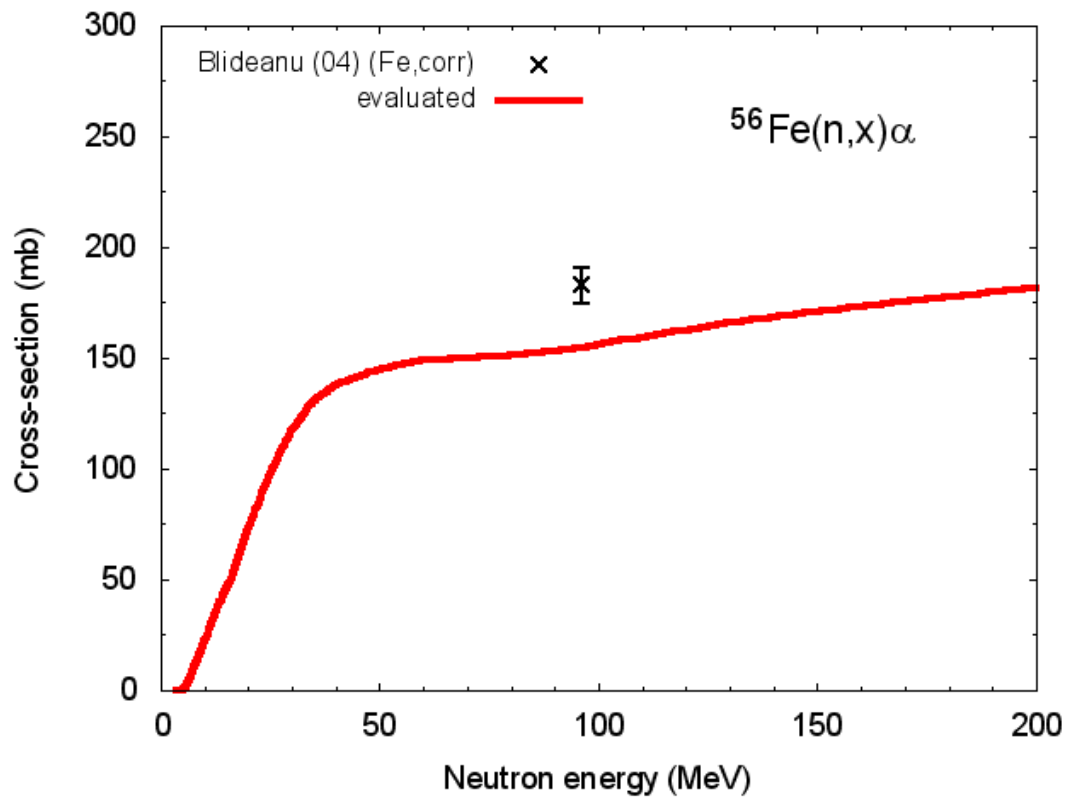


Fig.28 Evaluated  $\alpha$ -particle production cross-section for  $^{56}\text{Fe}$ .

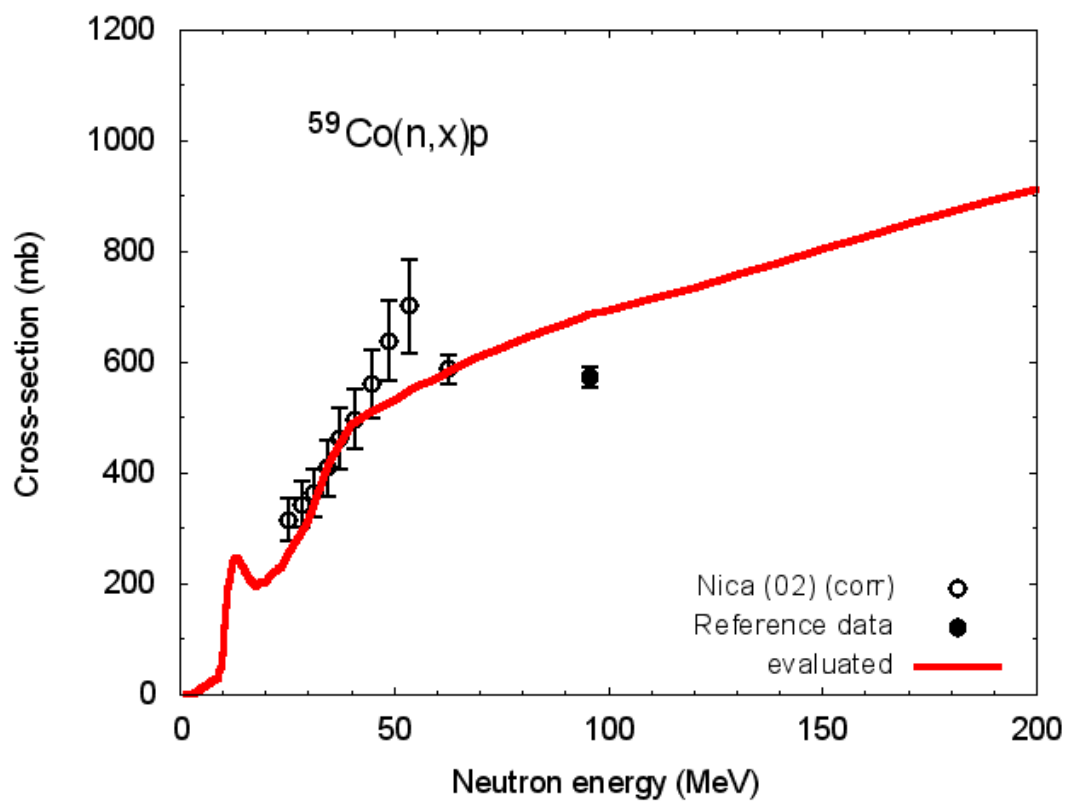


Fig.29 Evaluated proton production cross-section for  $^{59}\text{Co}$ .

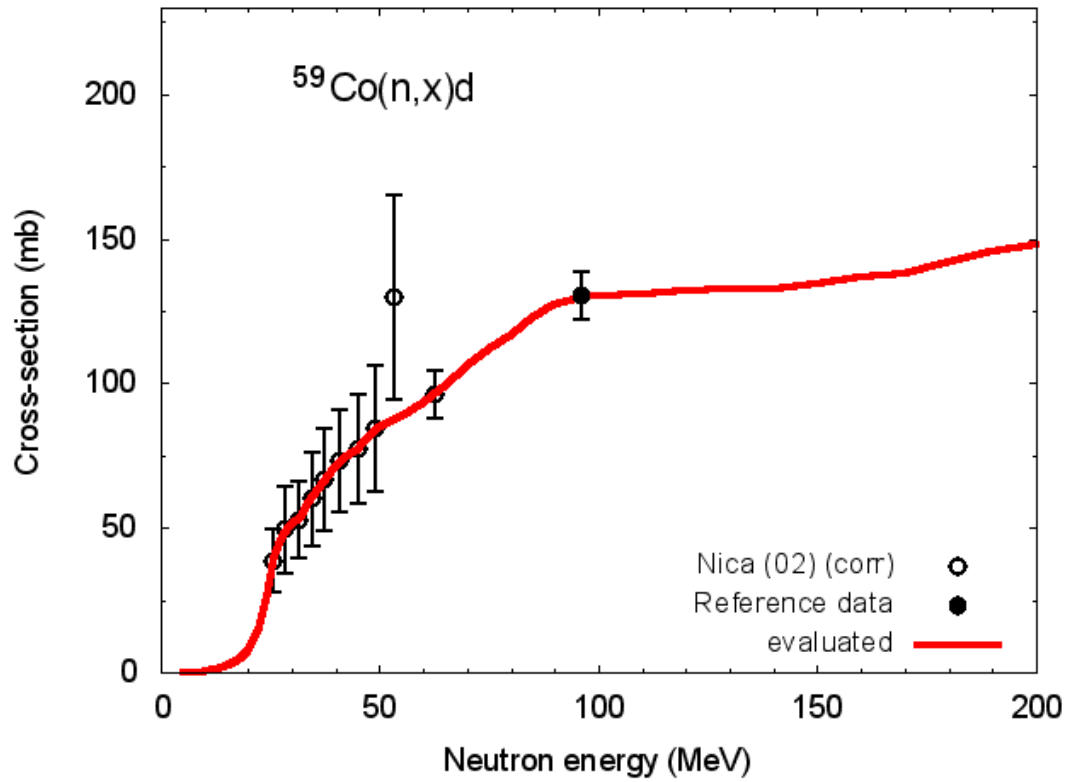


Fig.30 Evaluated deuteron production cross-section for  $^{59}\text{Co}$ .

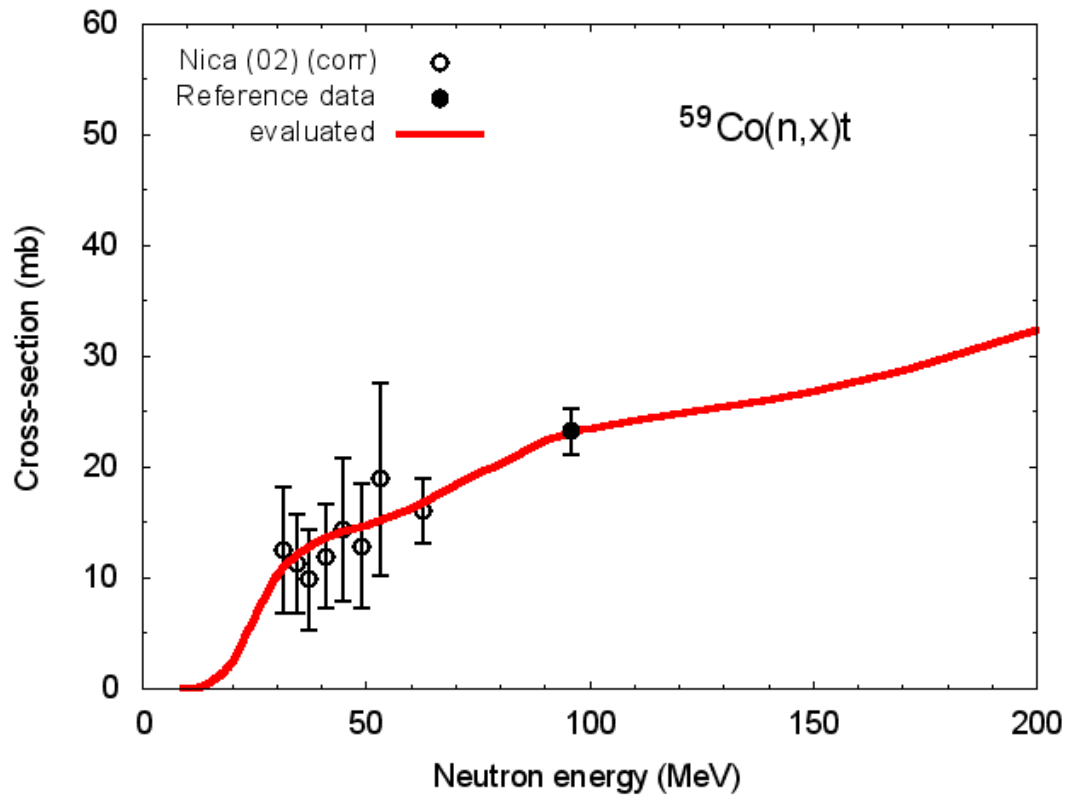


Fig.31 Evaluated triton production cross-section for  $^{59}\text{Co}$ .

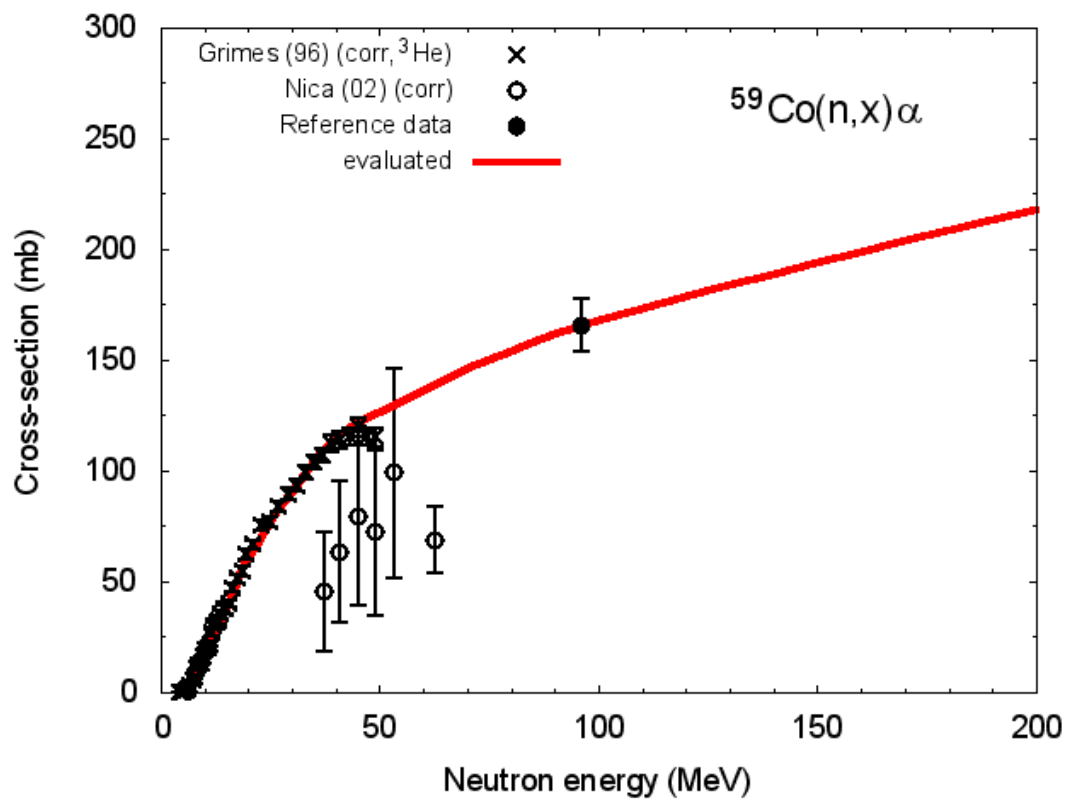


Fig.32 Evaluated  $\alpha$ -particle production cross-section for  $^{59}\text{Co}$ .

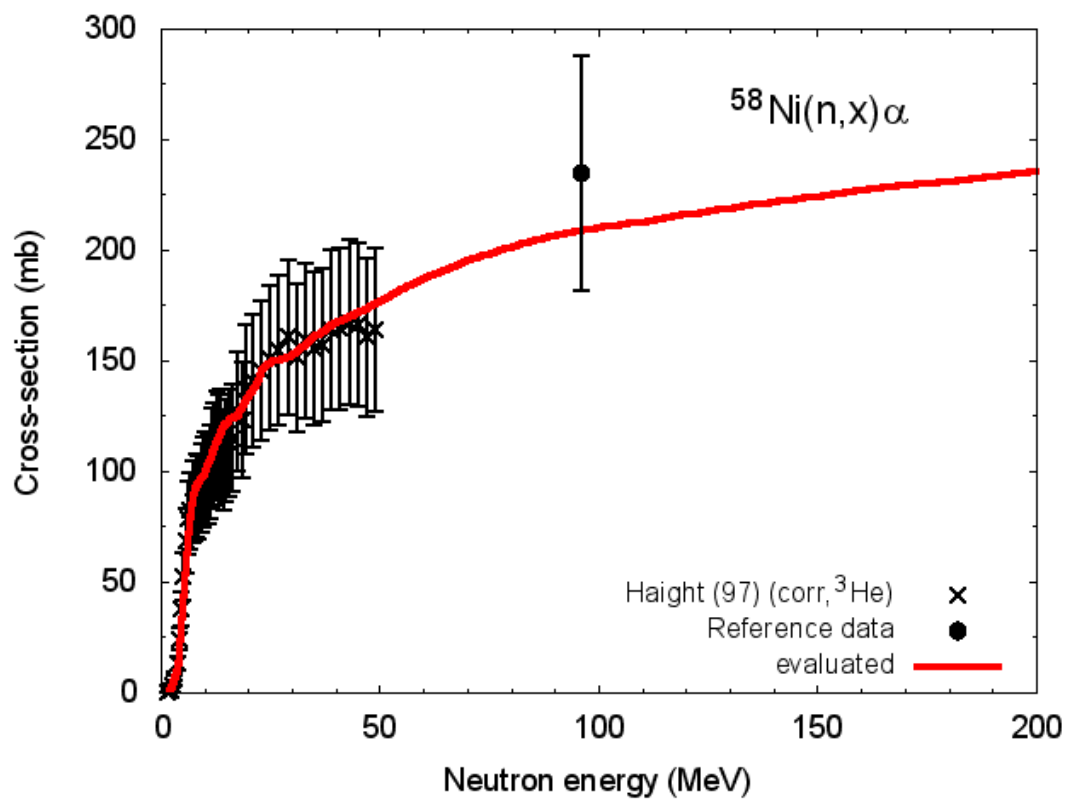


Fig.33 Evaluated  $\alpha$ -particle production cross-section for  $^{58}\text{Ni}$ .

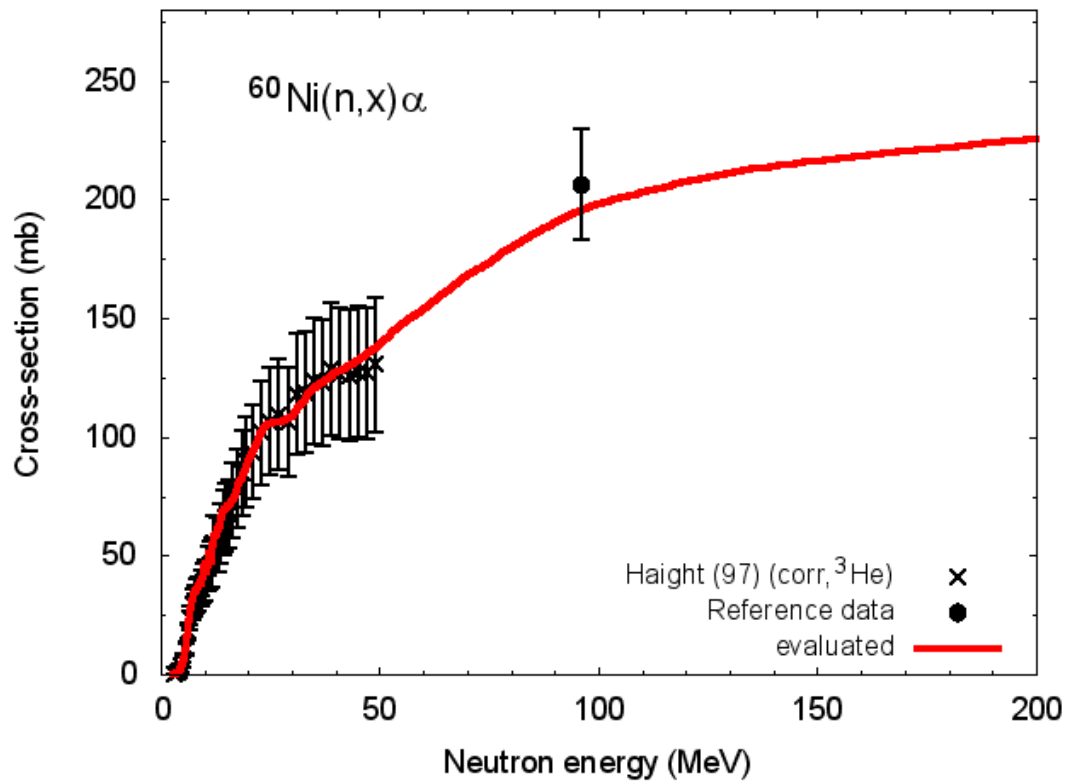


Fig.34 Evaluated  $\alpha$ -particle production cross-section for  $^{60}\text{Ni}$ .

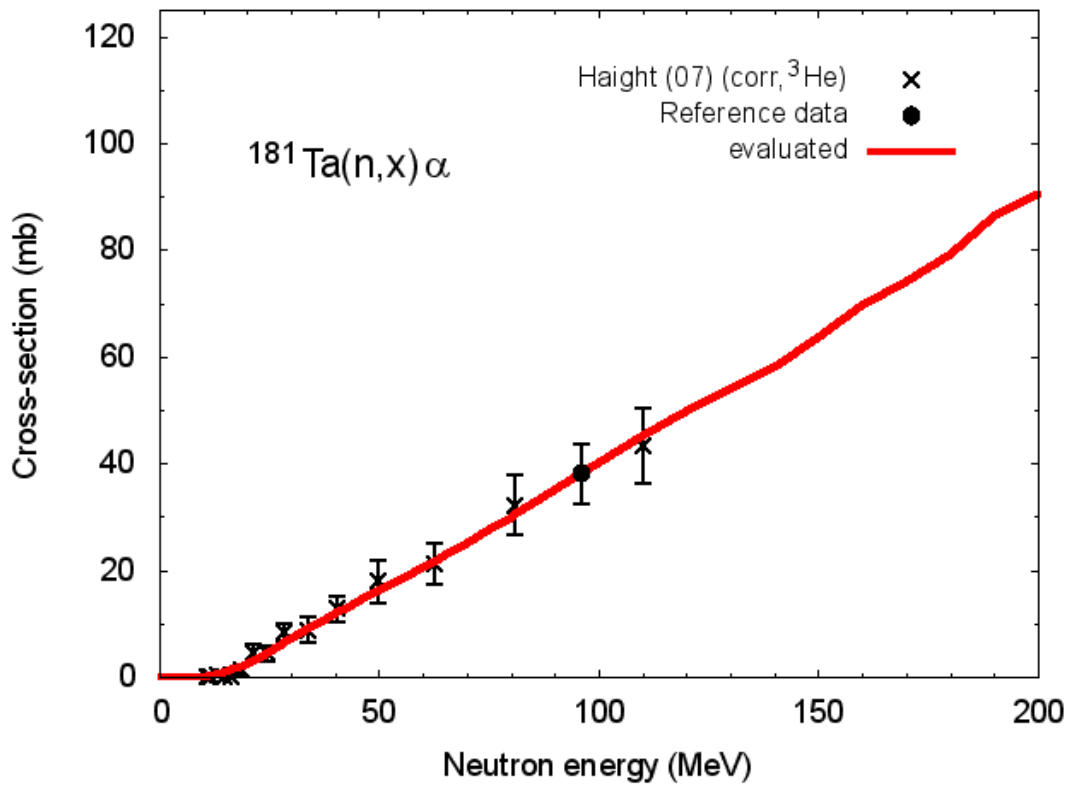


Fig.35 Evaluated  $\alpha$ -particle production cross-section for  $^{181}\text{Ta}$ .

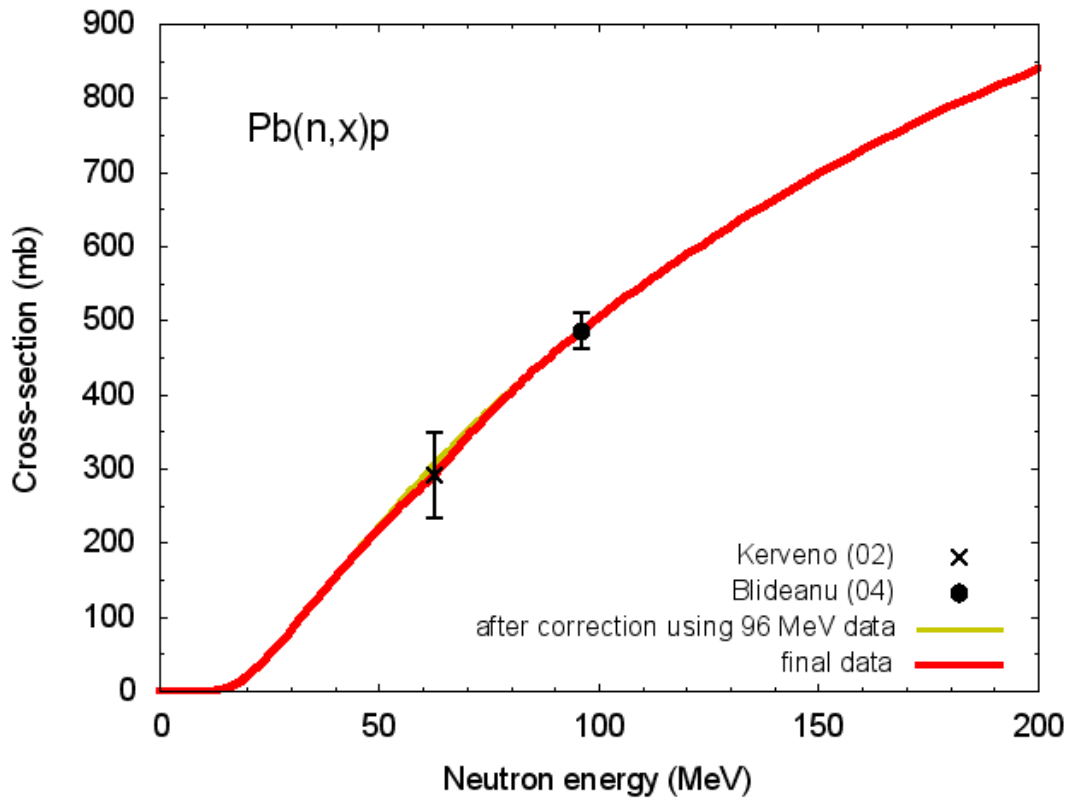


Fig.36 Evaluated proton production cross-section for lead.

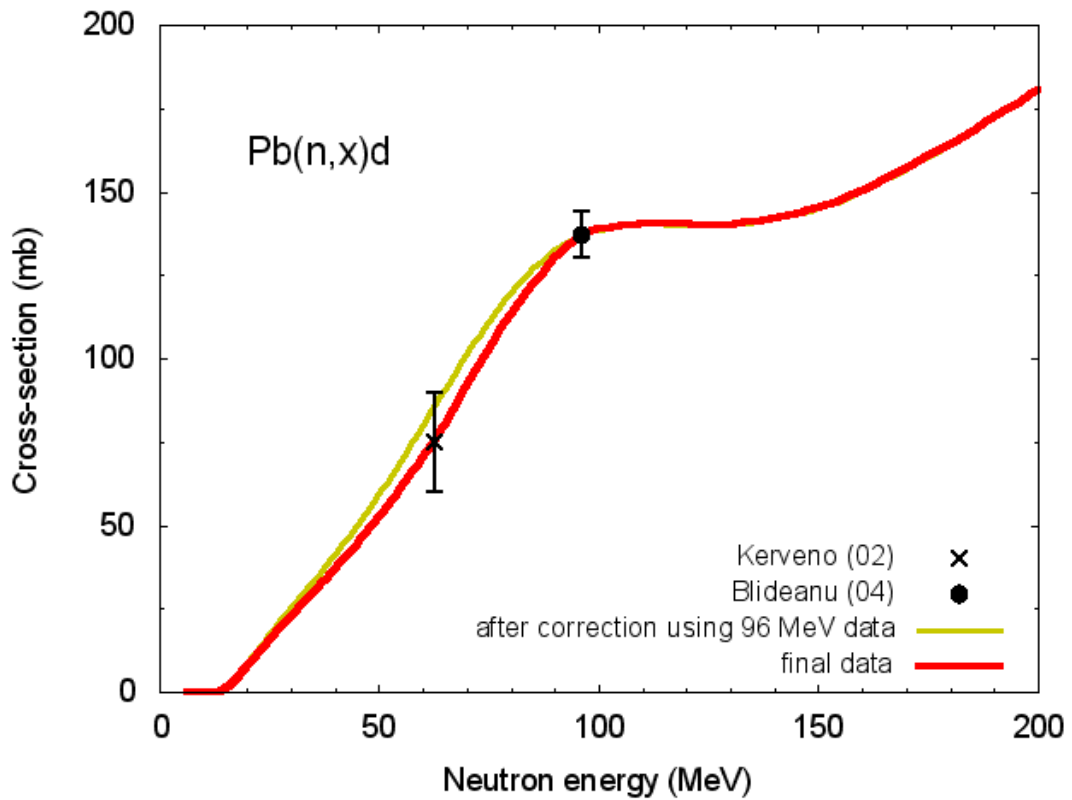


Fig.37 Evaluated deuteron production cross-section for lead.

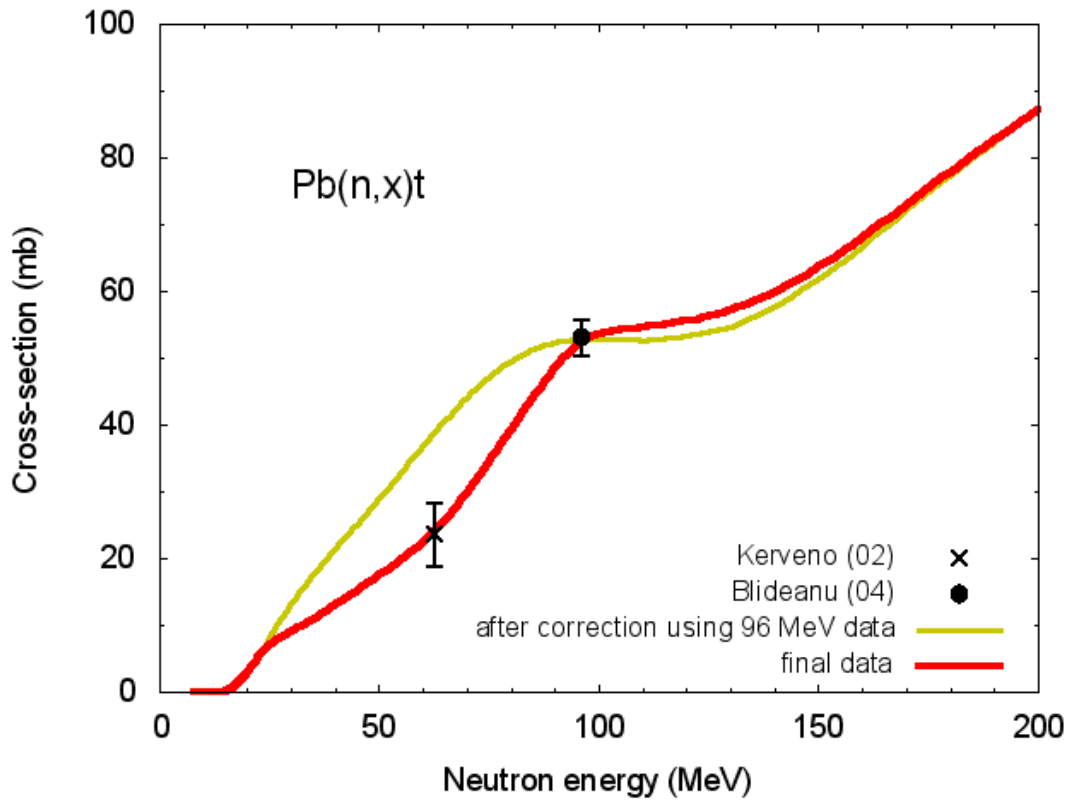


Fig.38 Evaluated triton production cross-section for lead.

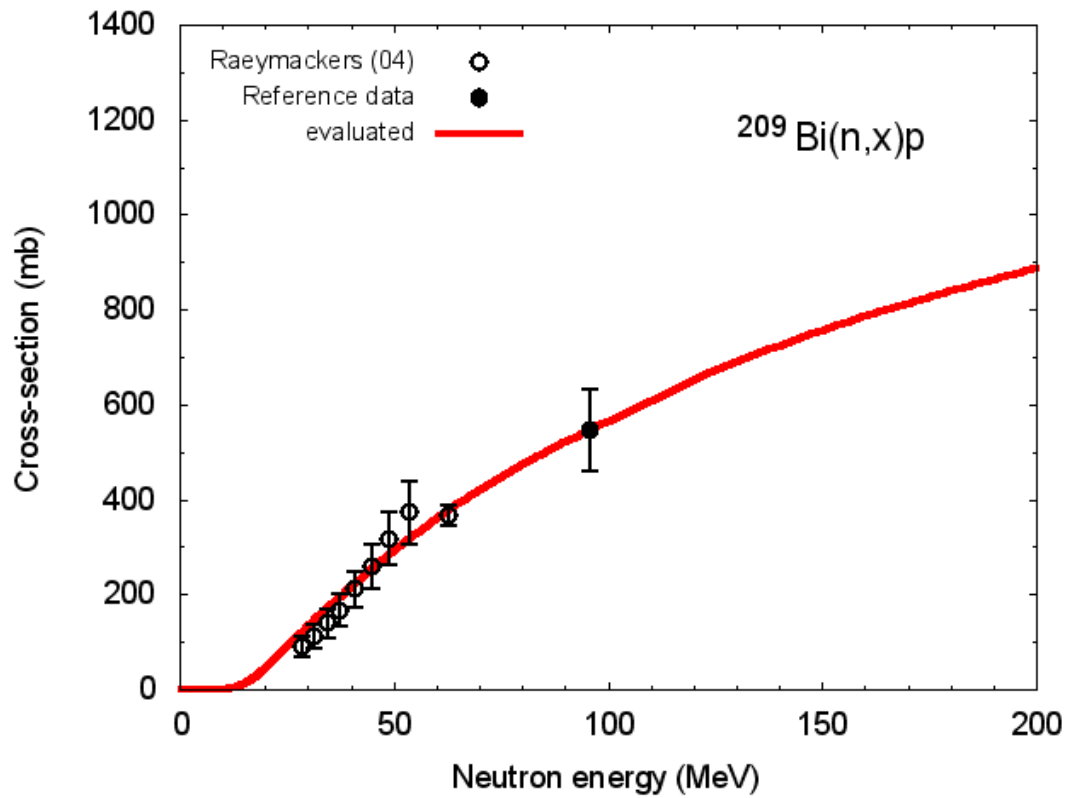


Fig.39 Evaluated proton production cross-section for  $^{209}\text{Bi}$ .

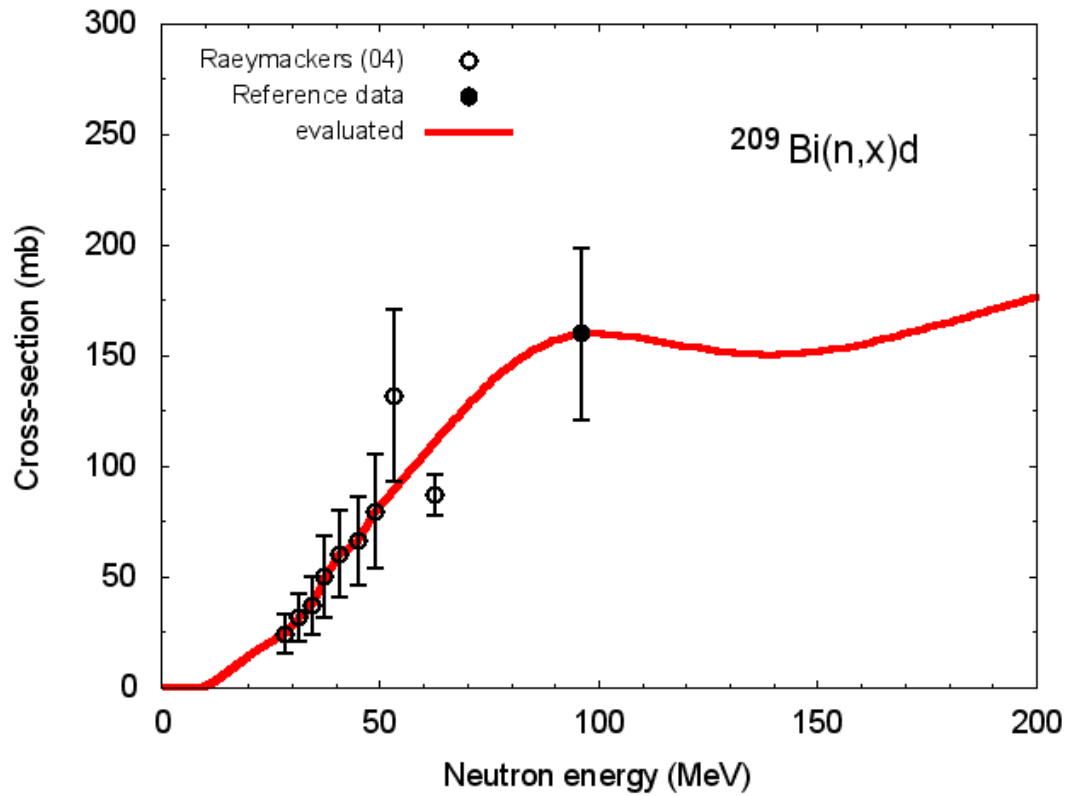


Fig.40 Evaluated deuteron production cross-section for  $^{209}\text{Bi}$ .

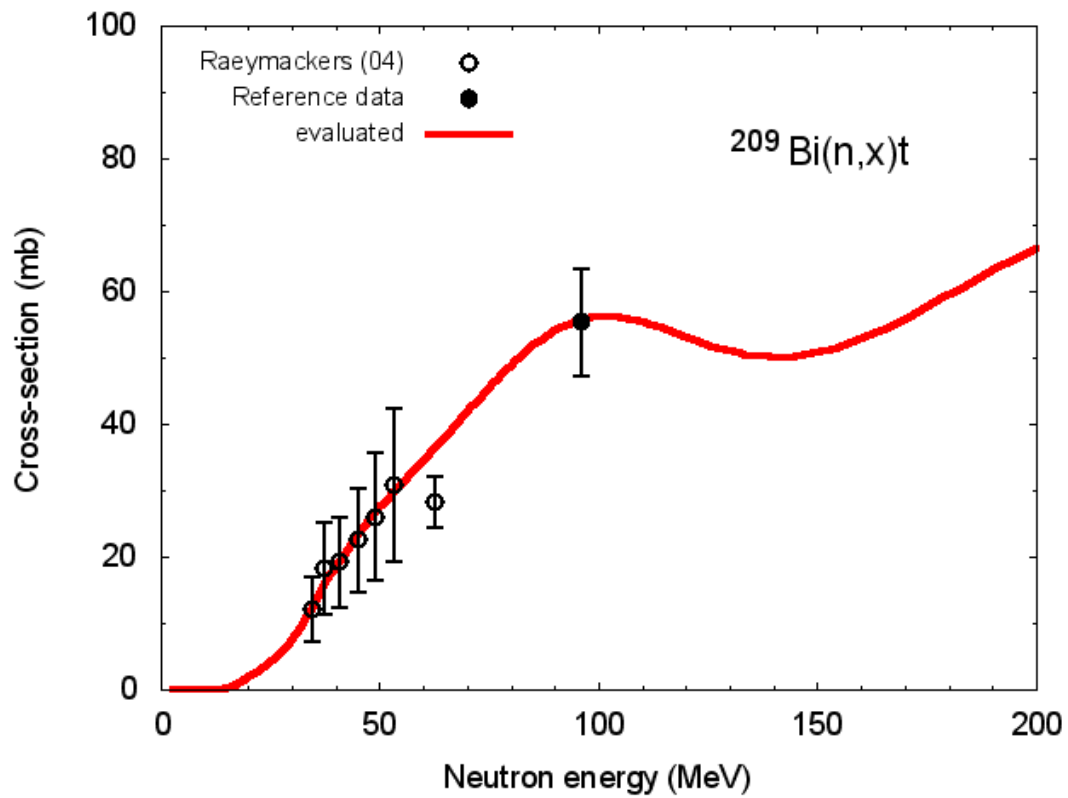


Fig.41 Evaluated triton production cross-section for  $^{209}\text{Bi}$ .

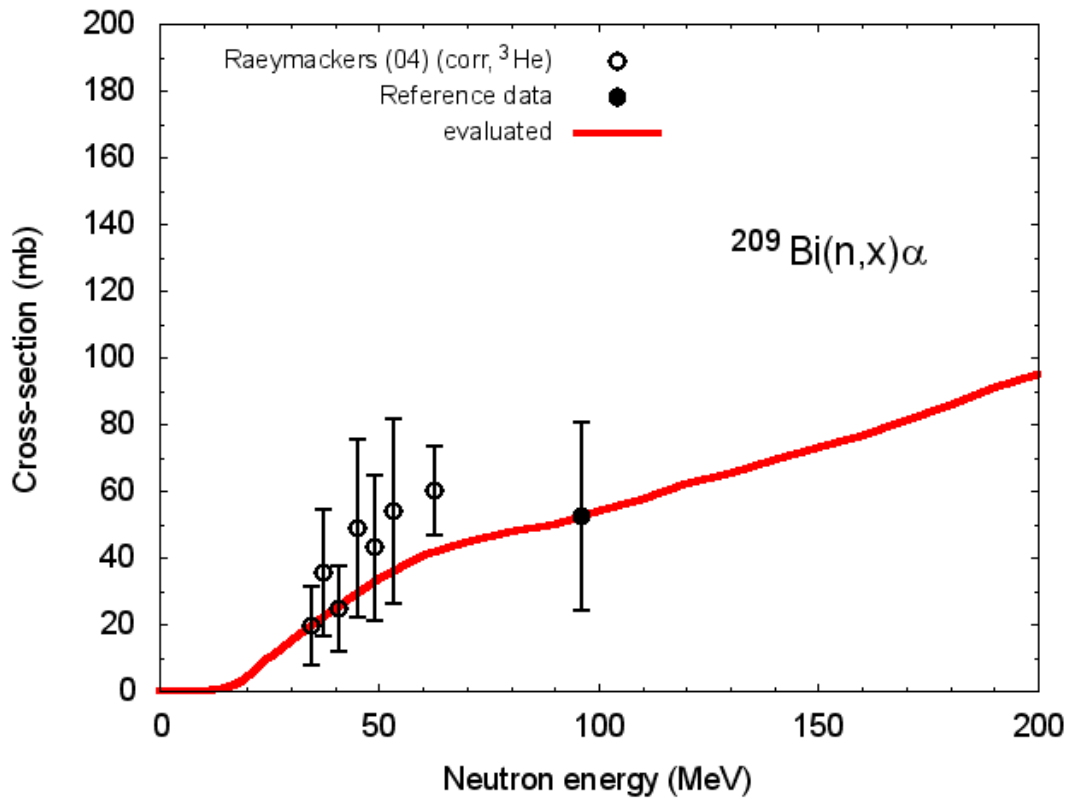


Fig.42 Evaluated  $\alpha$ -particle production cross-section for  $^{209}\text{Bi}$ .



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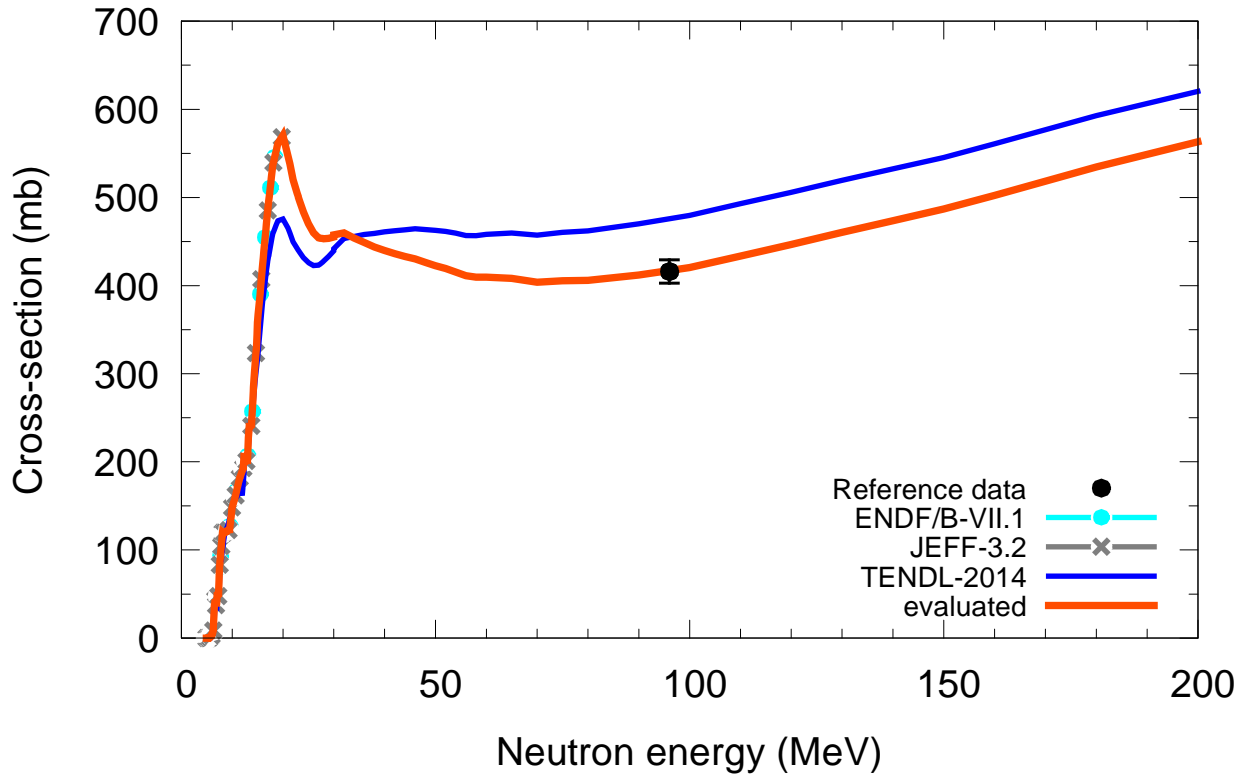
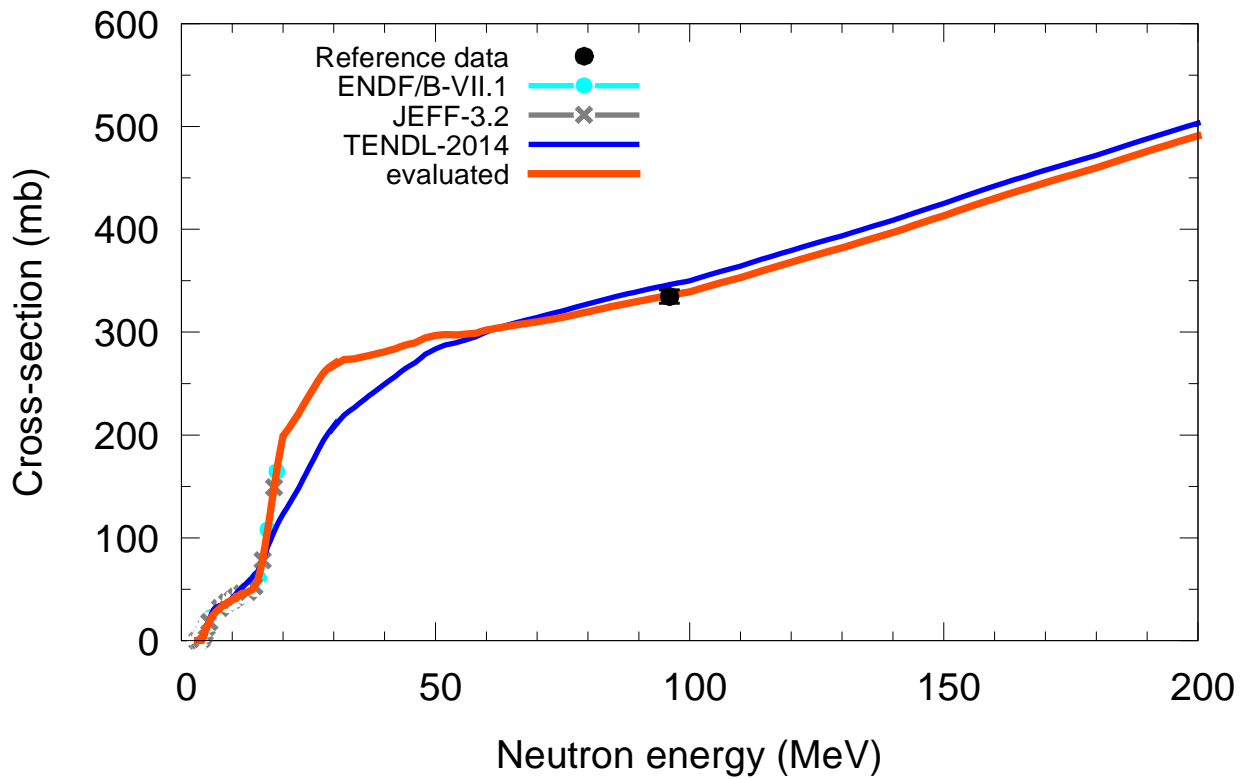
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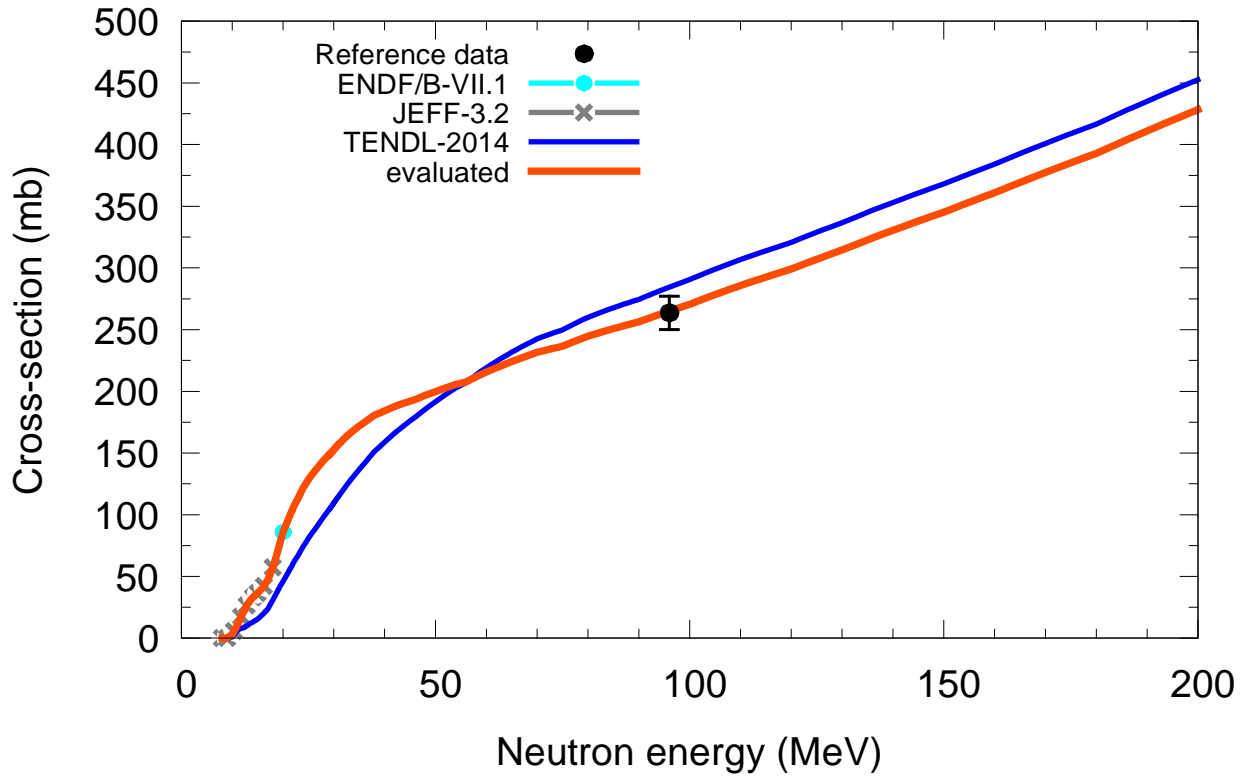
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## Appendix A

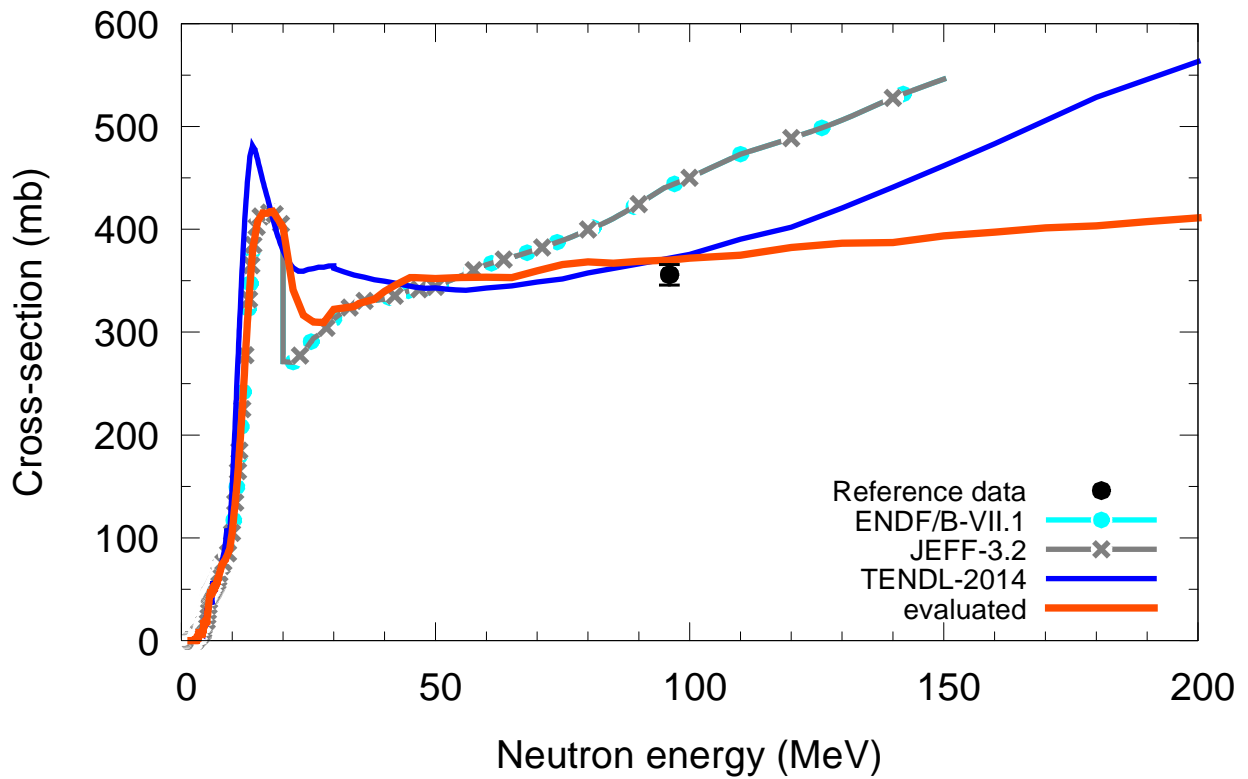
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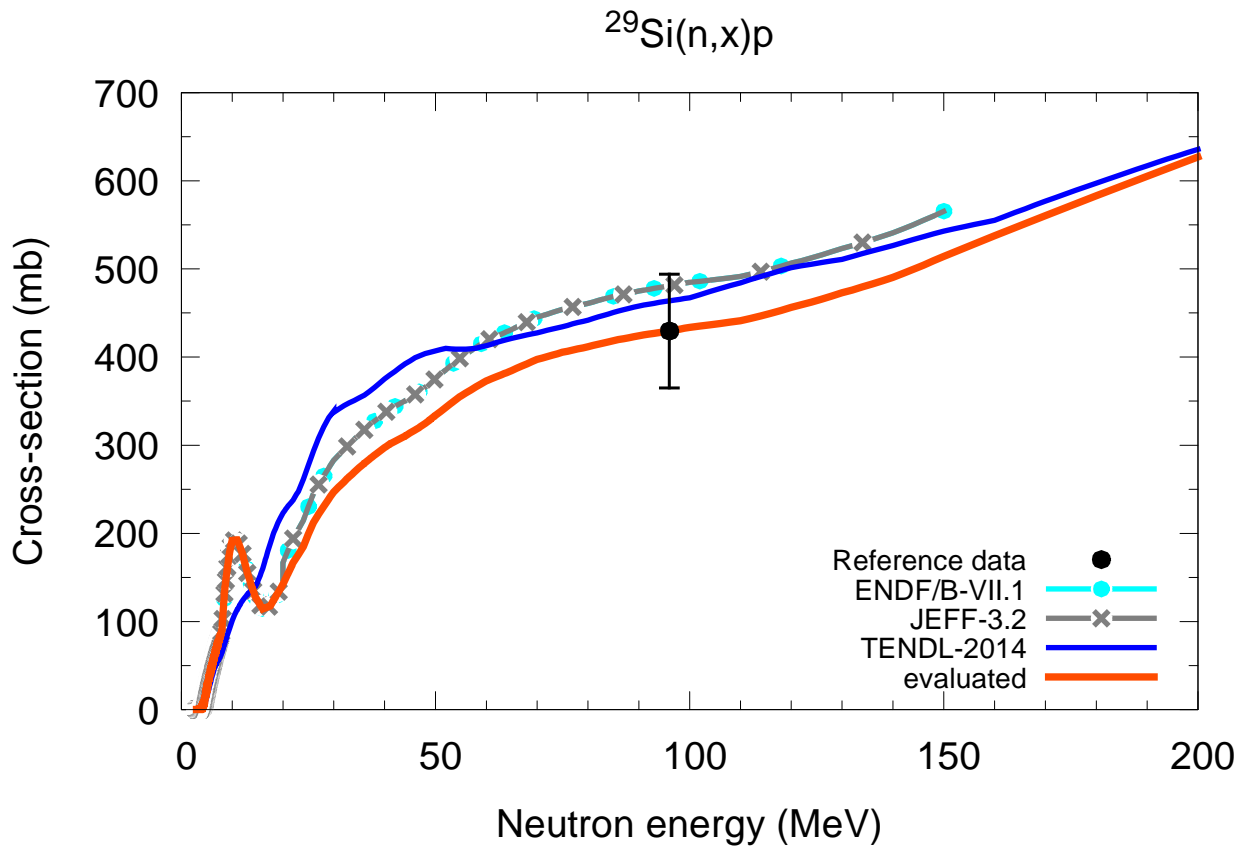
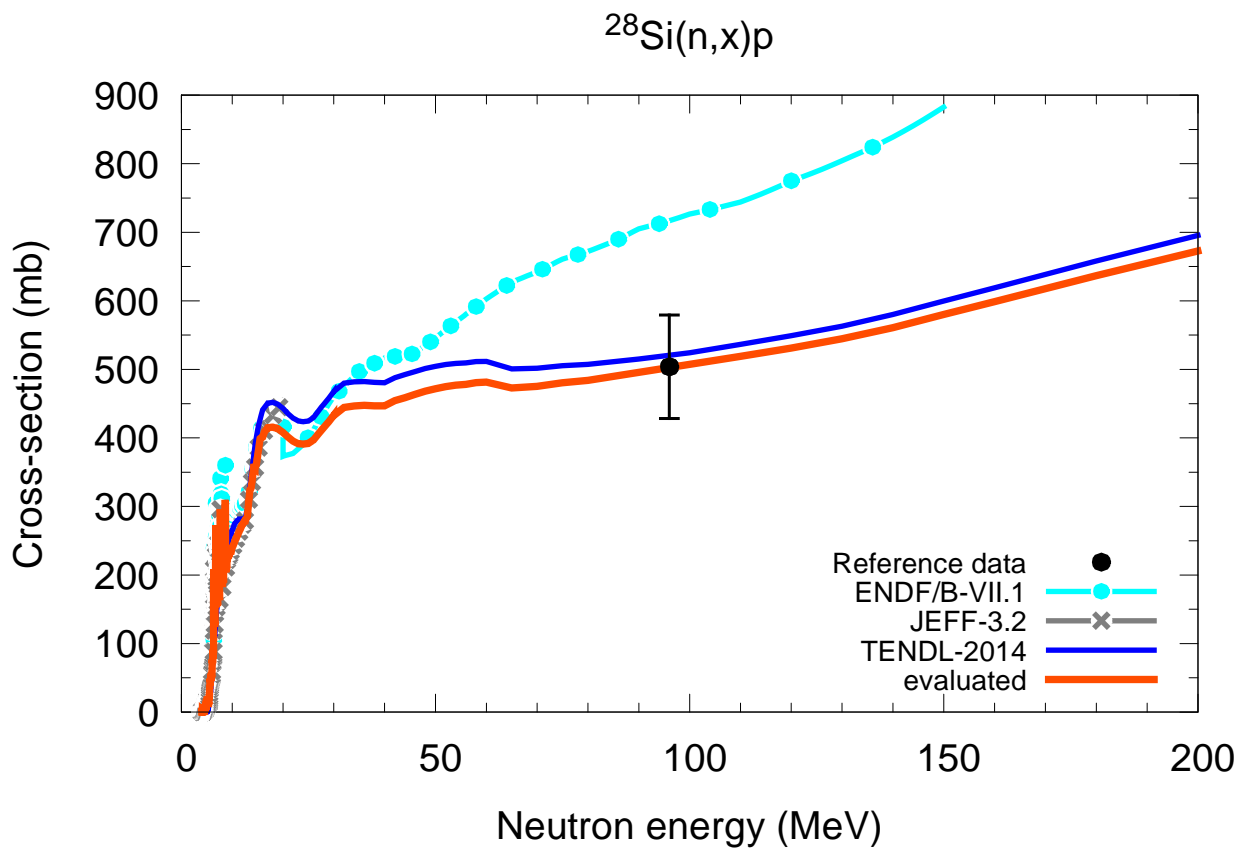
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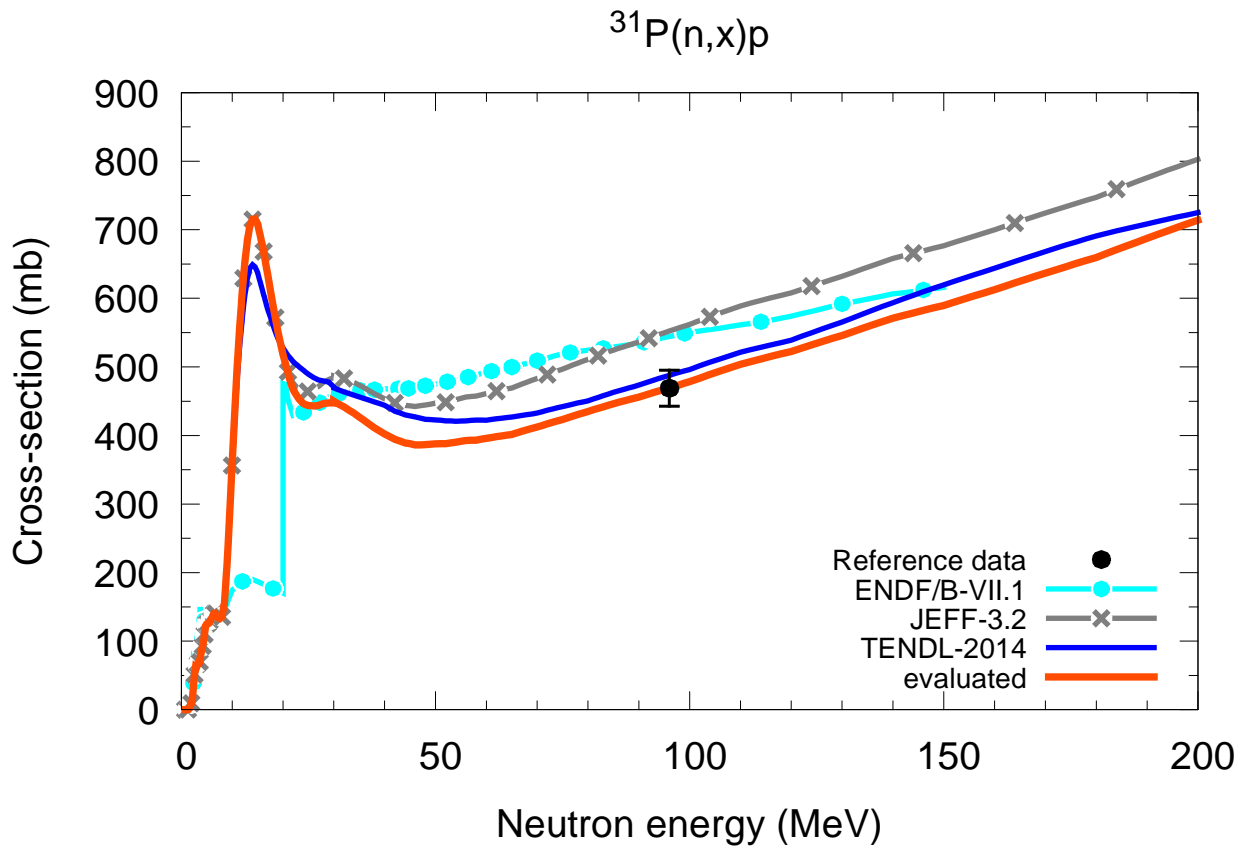
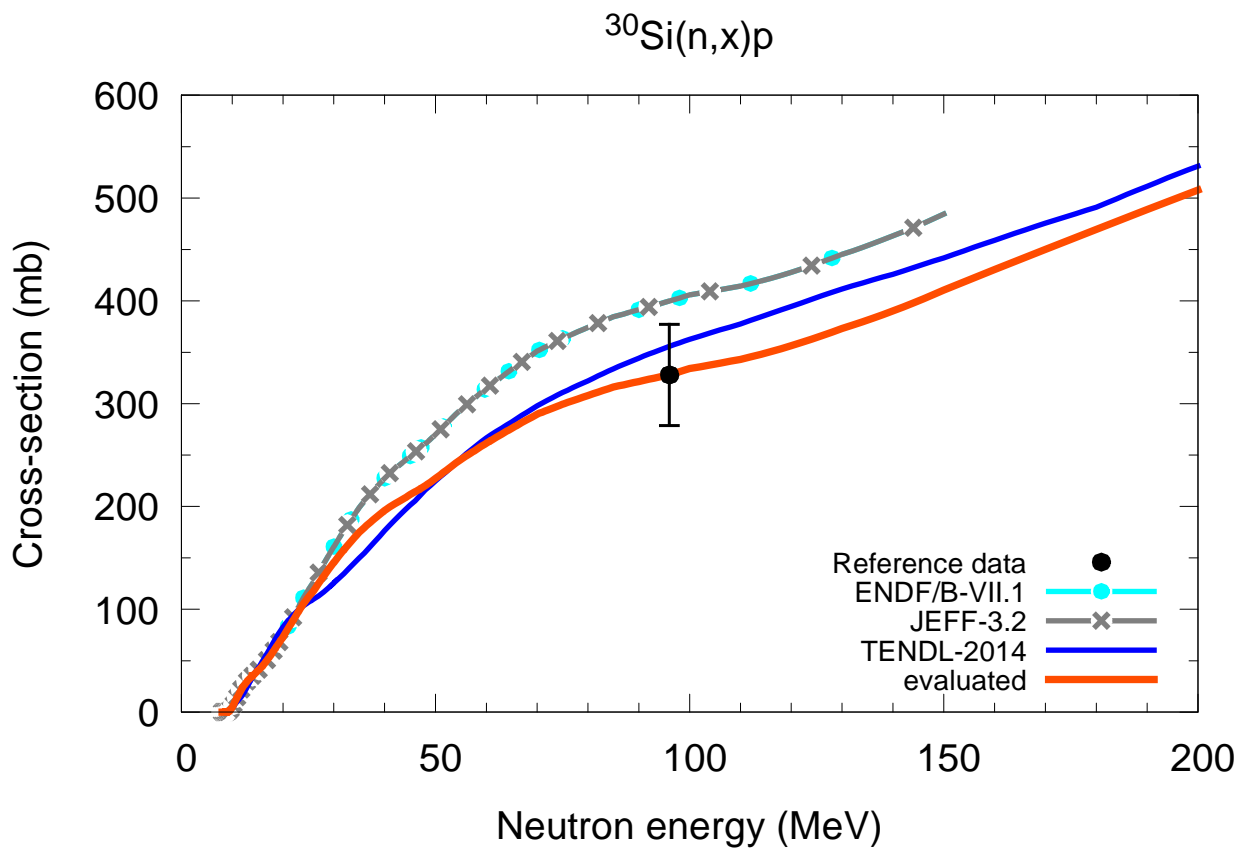


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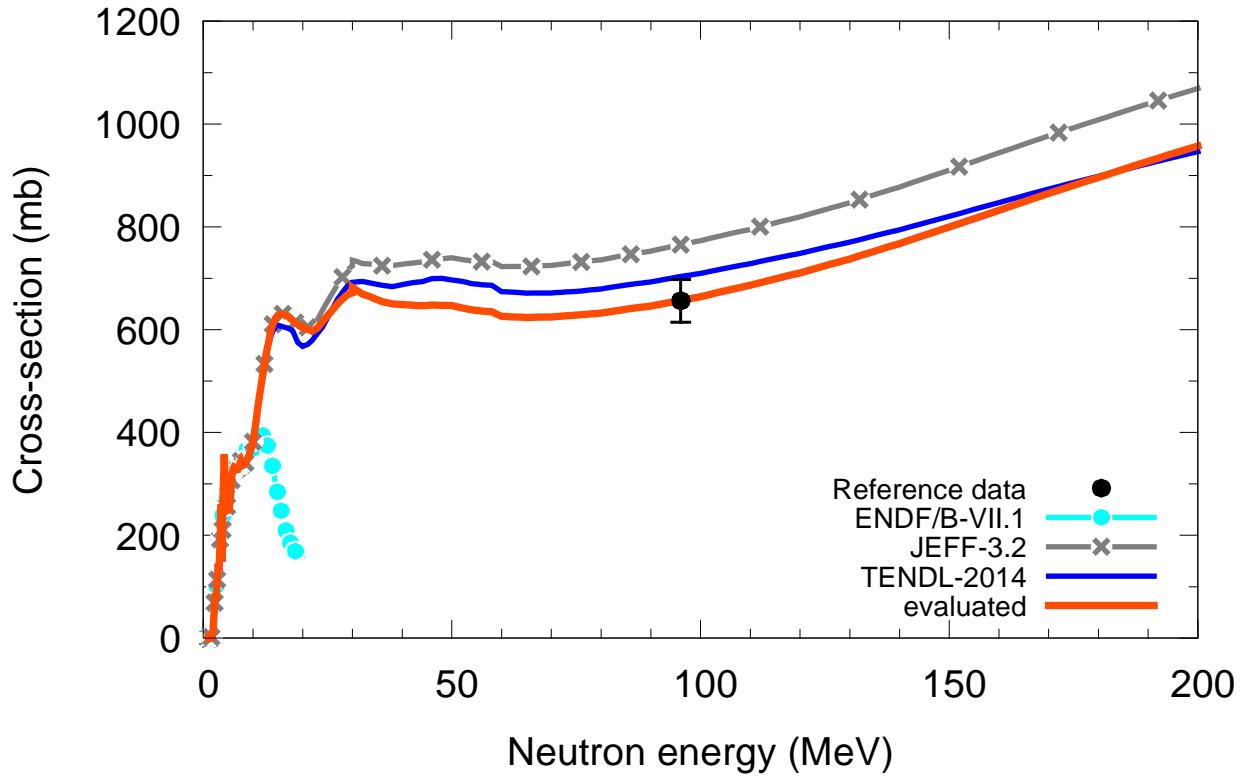




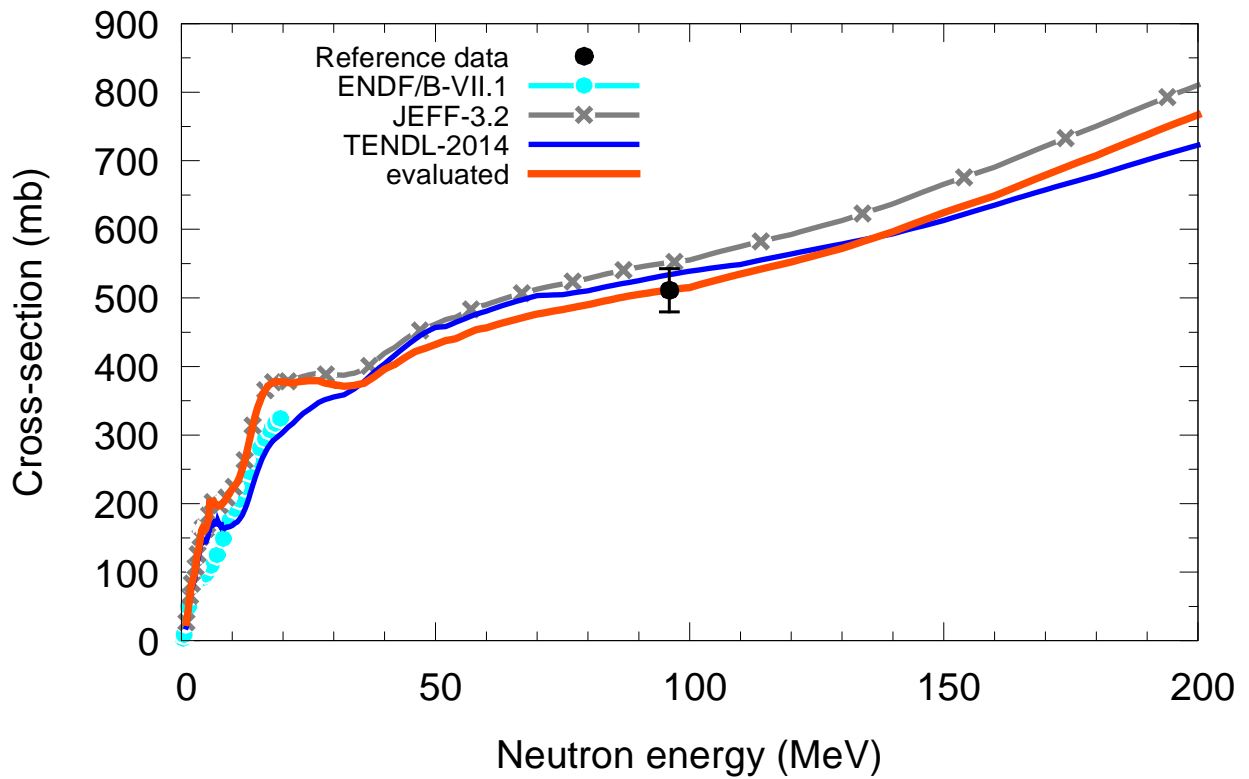




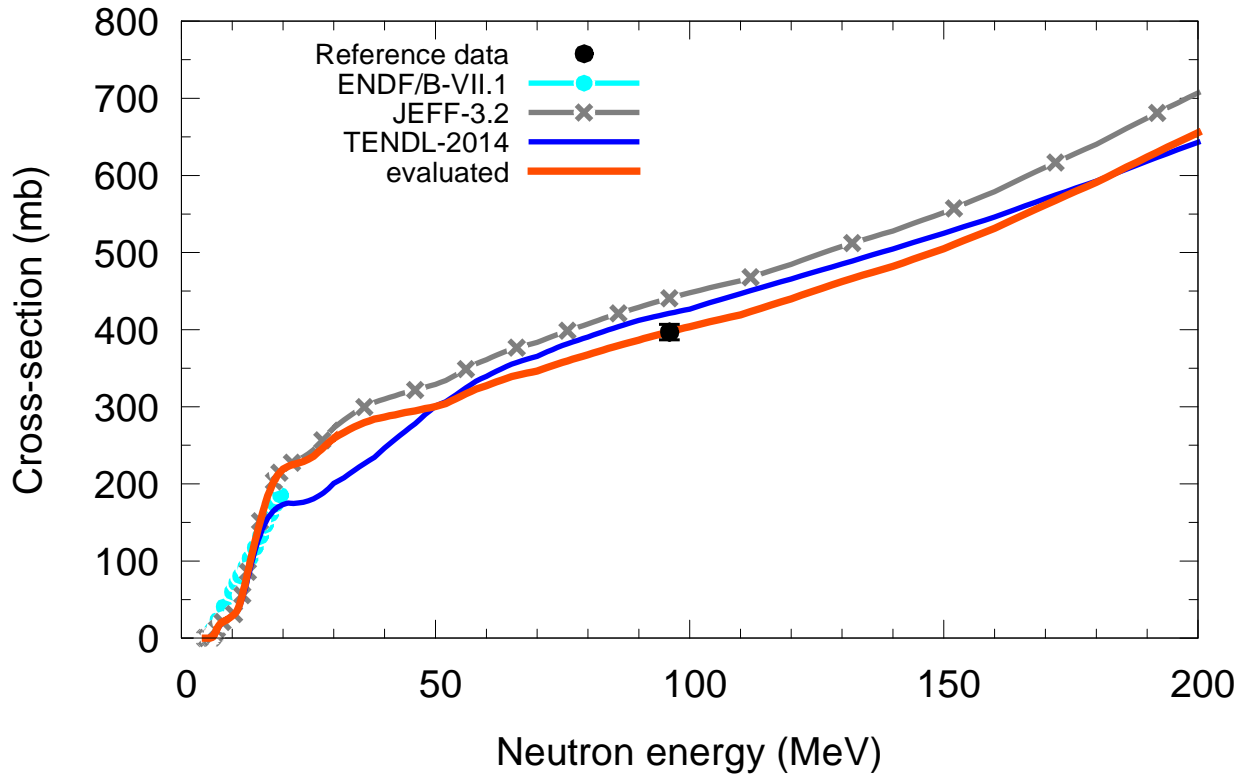
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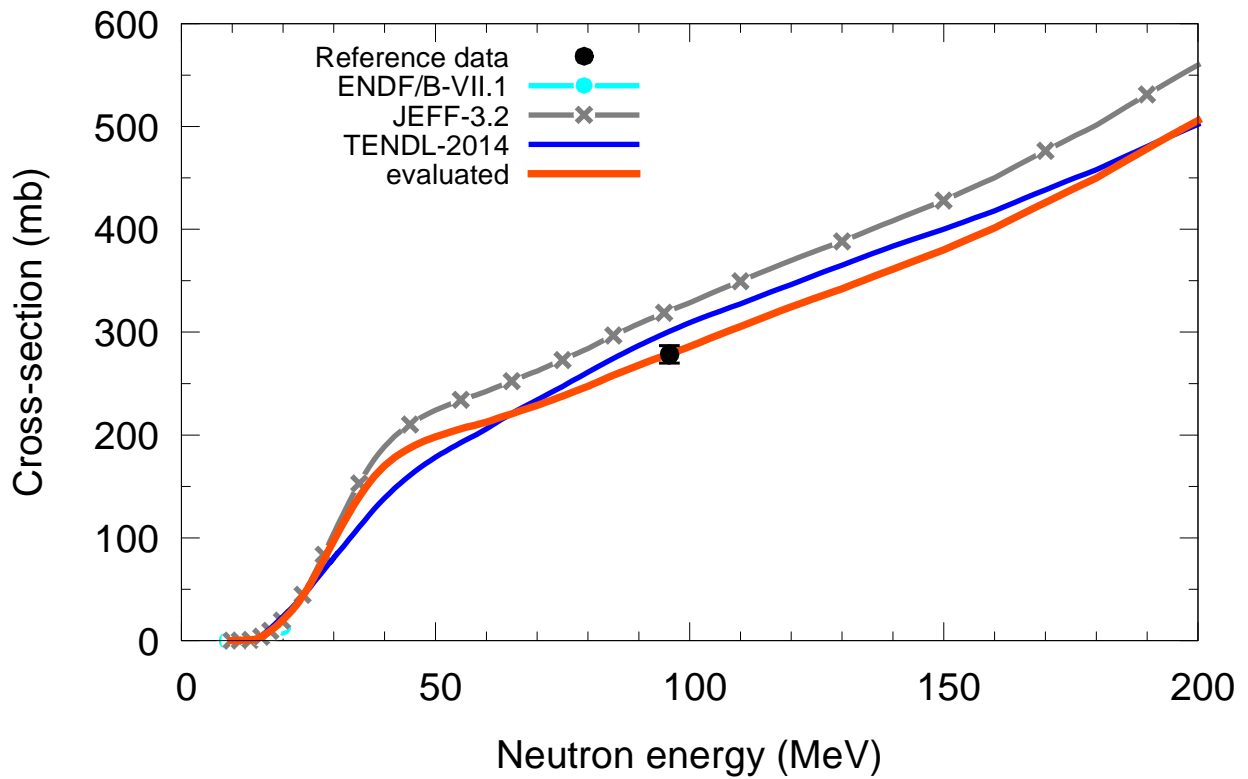
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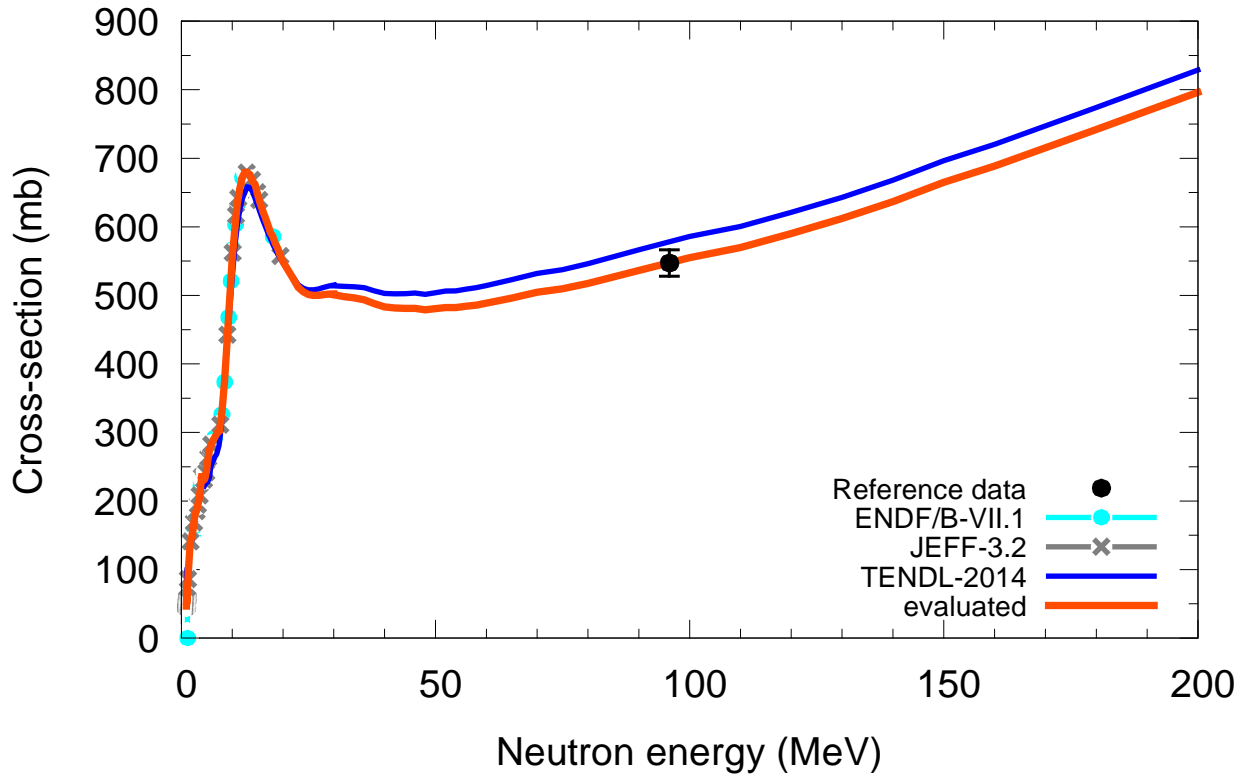
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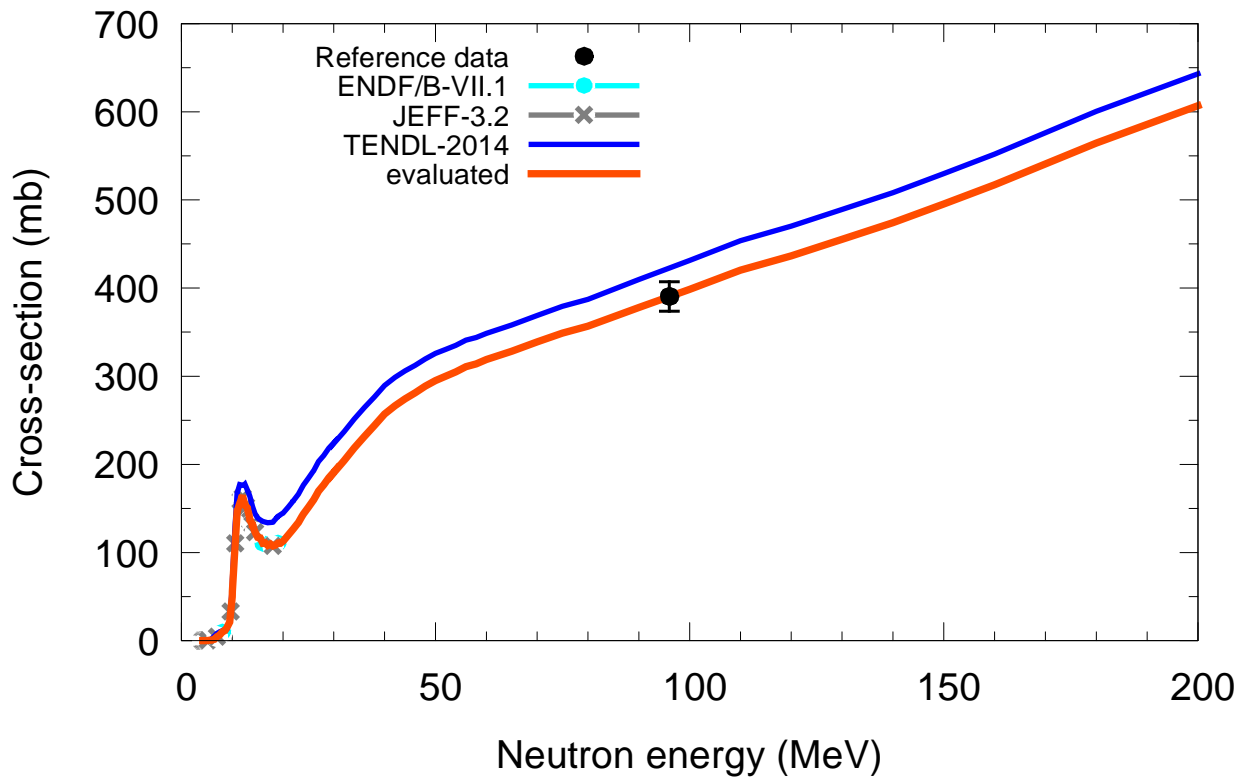
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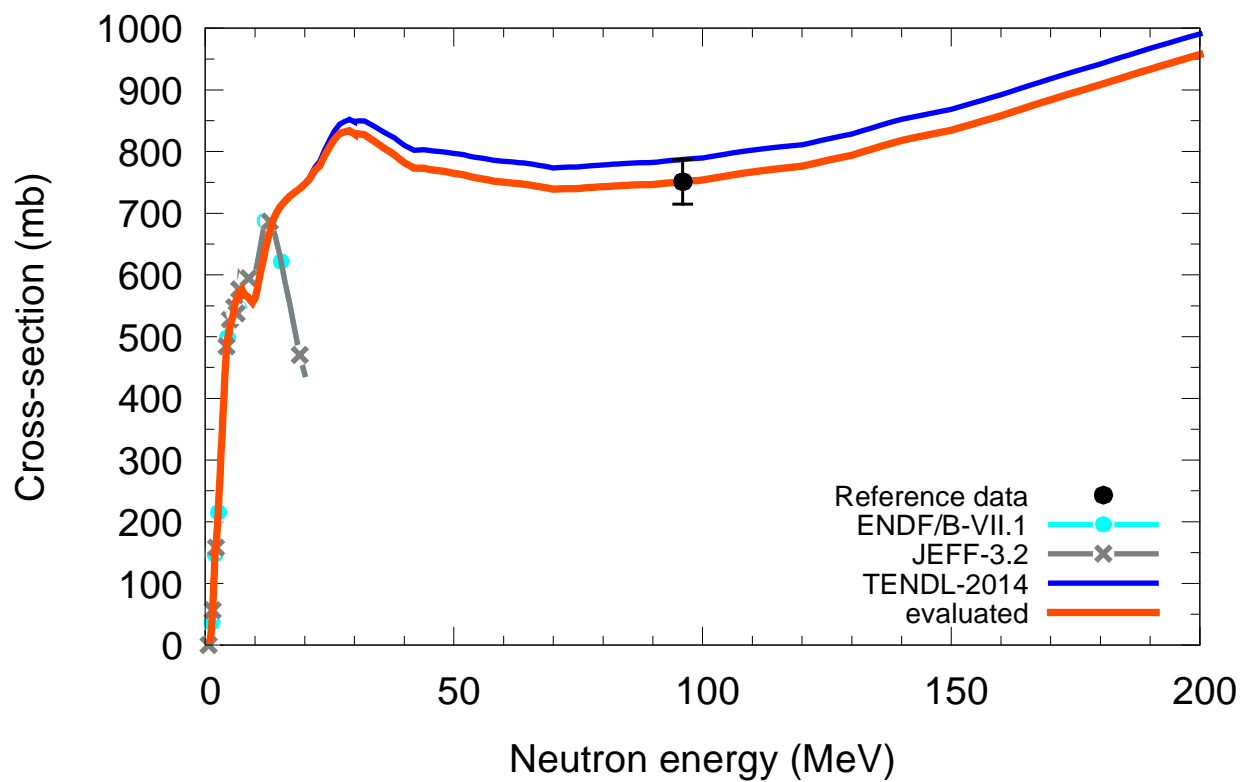
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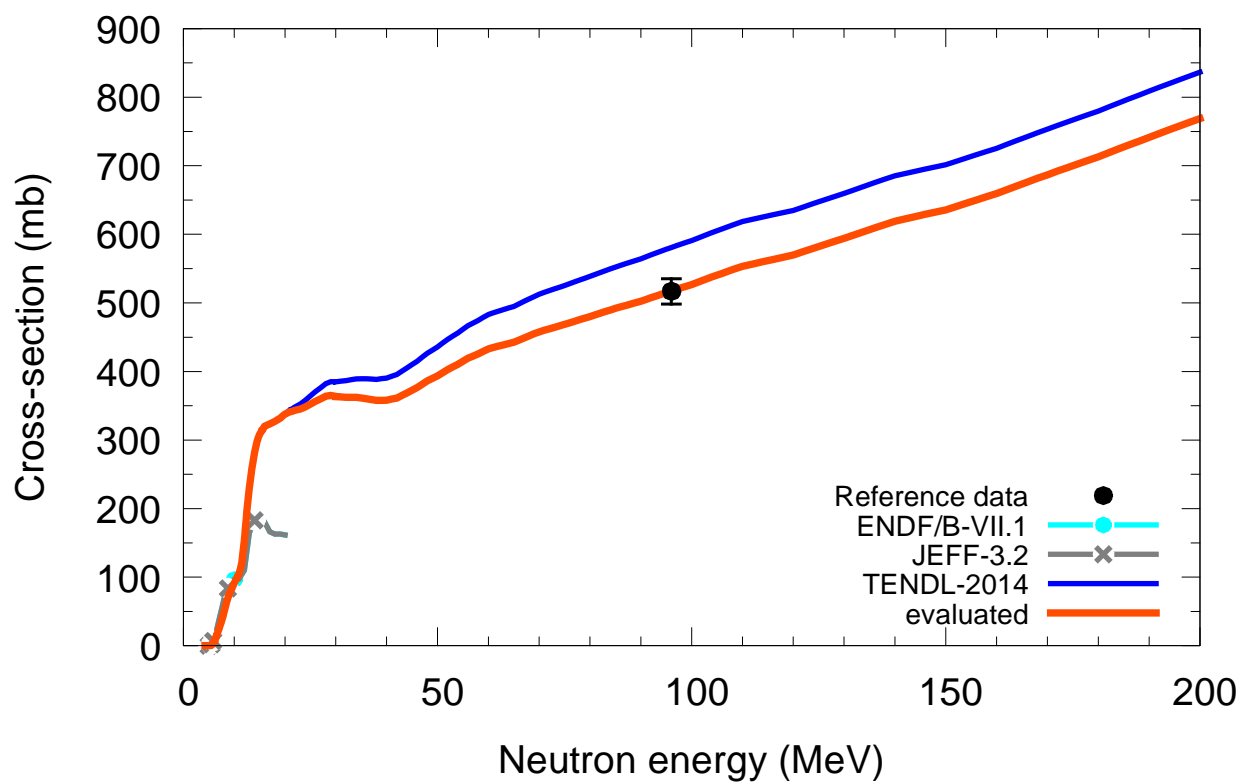
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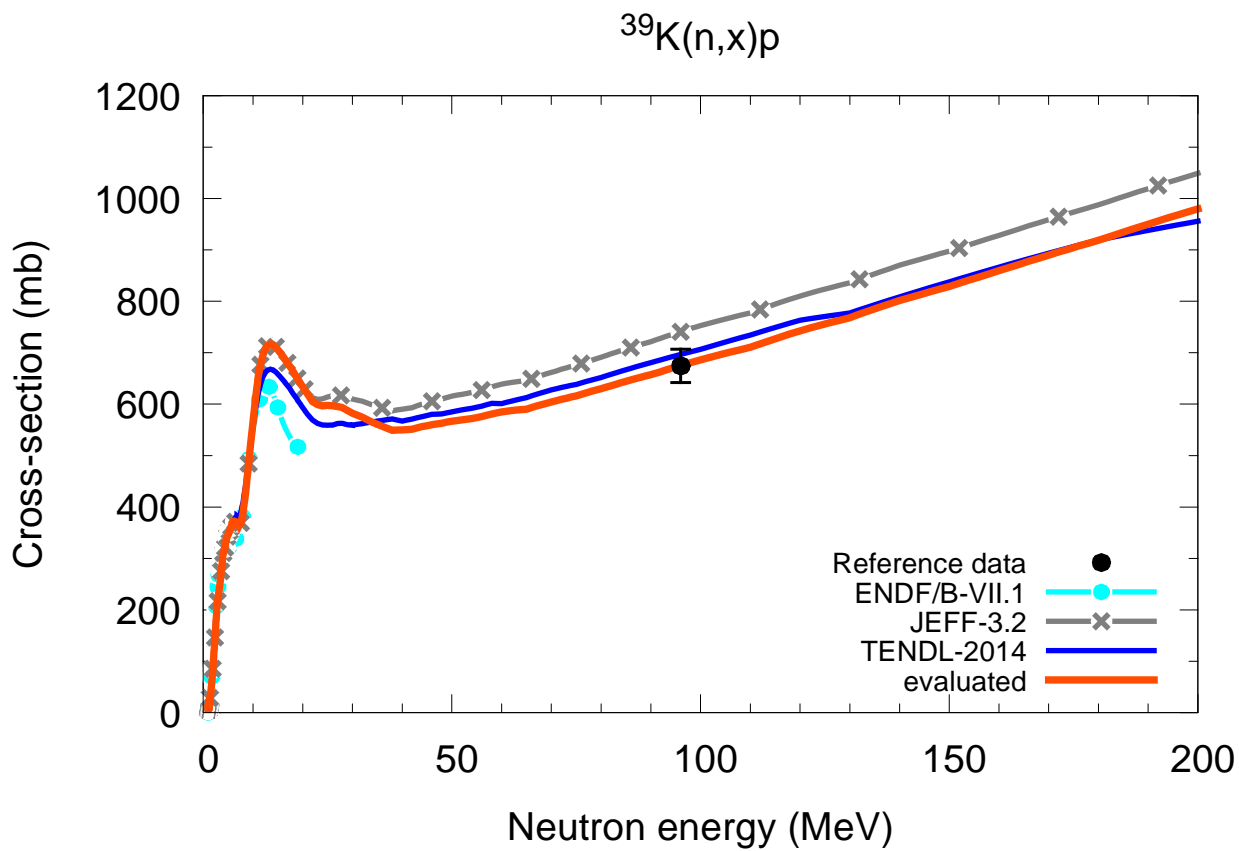
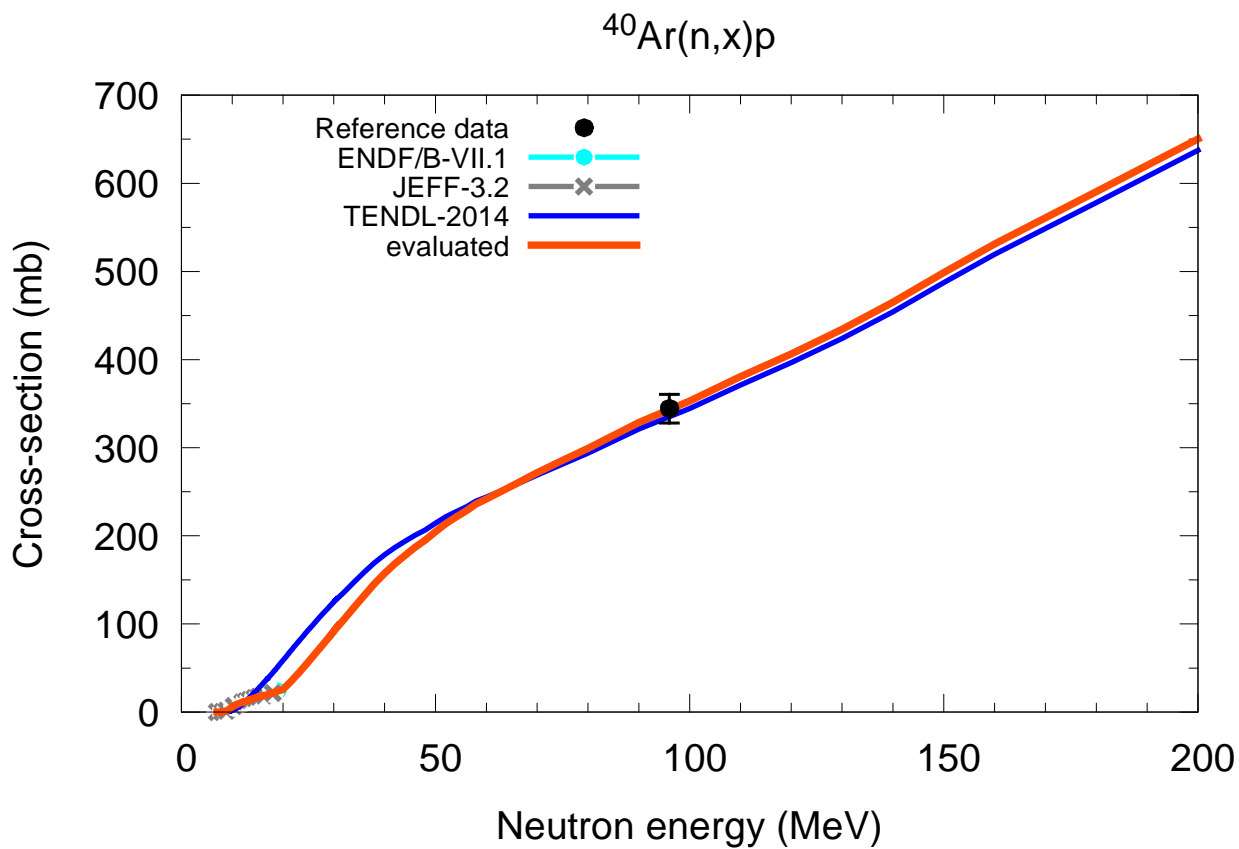


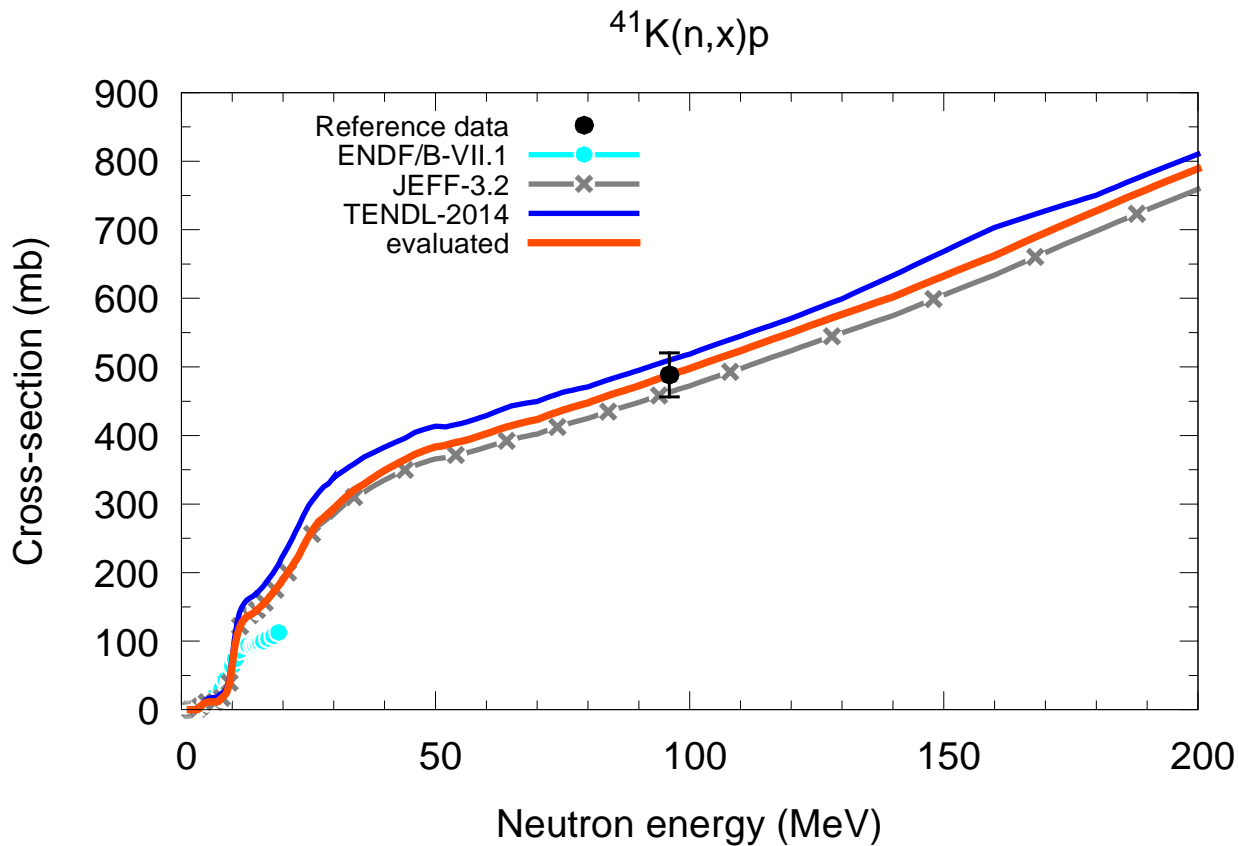
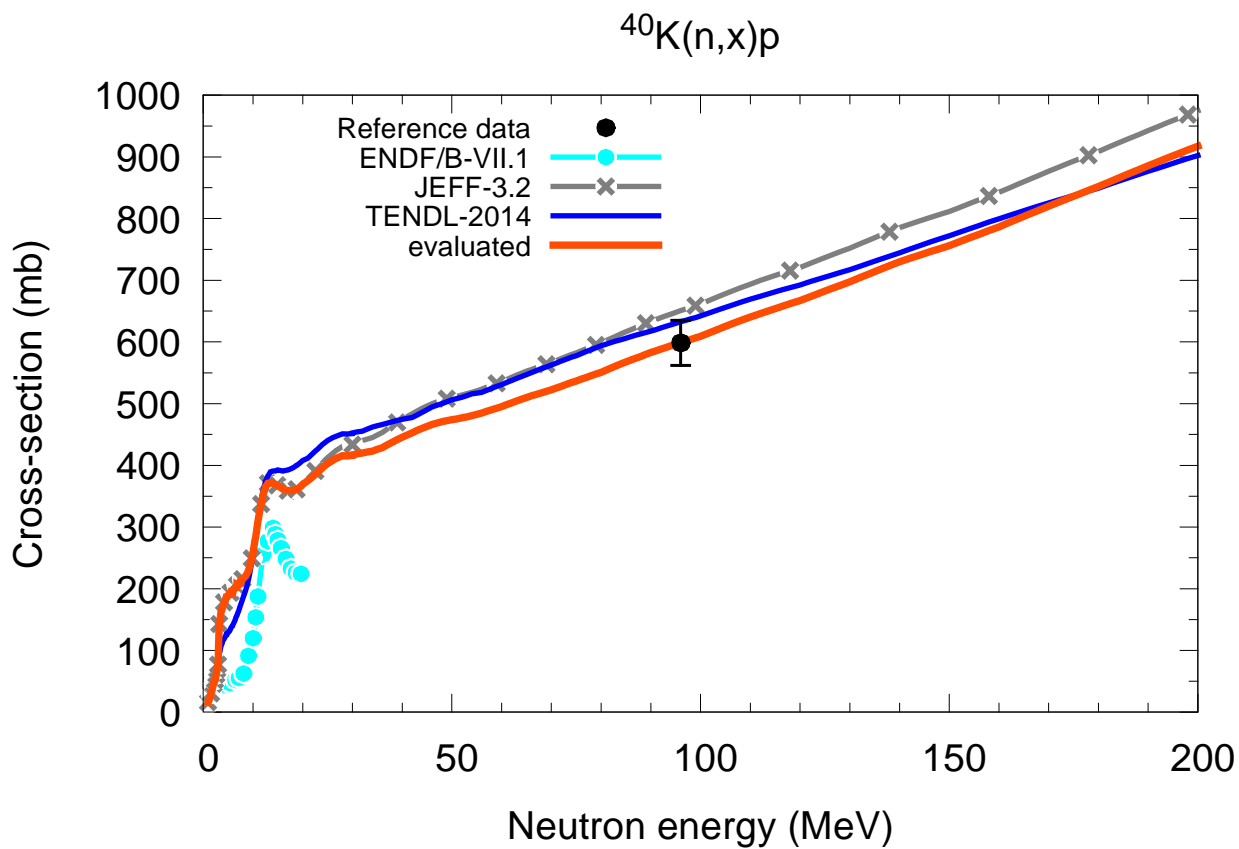
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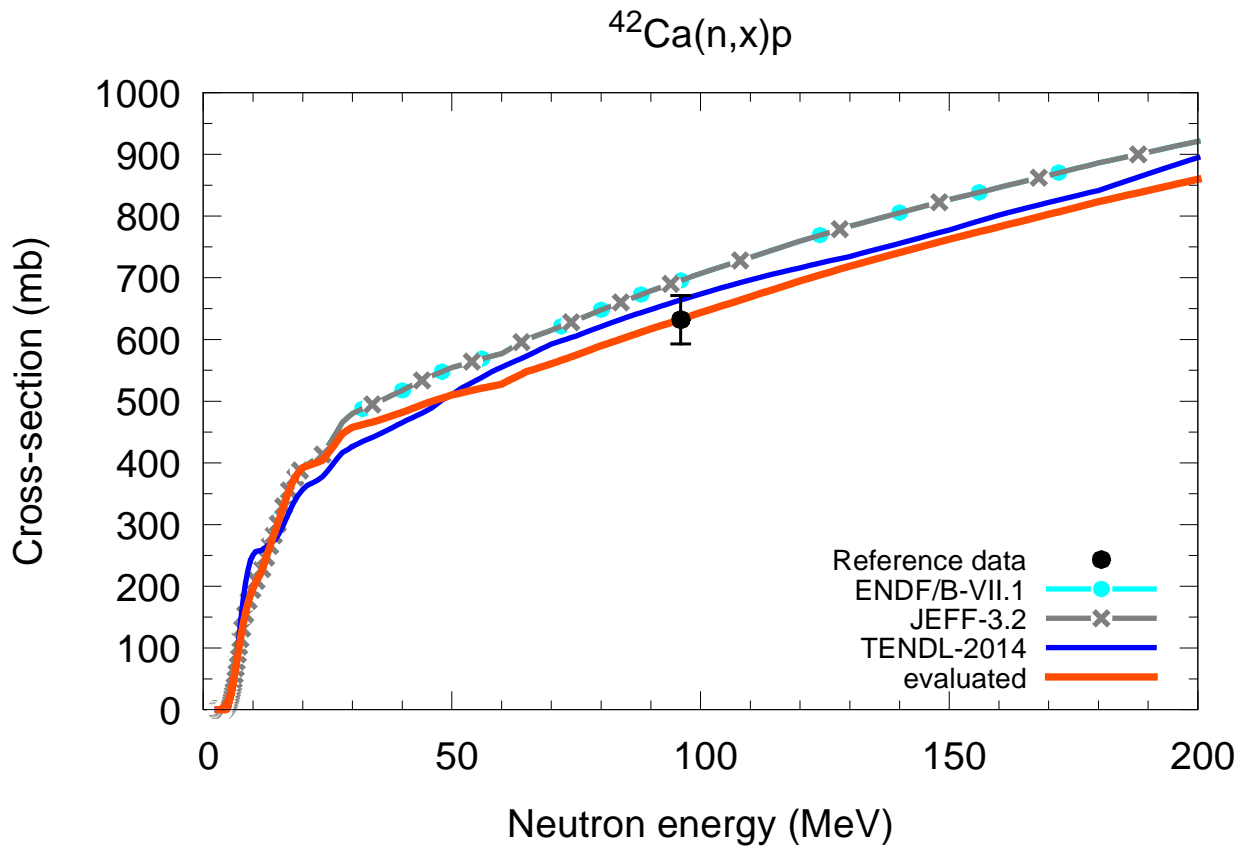
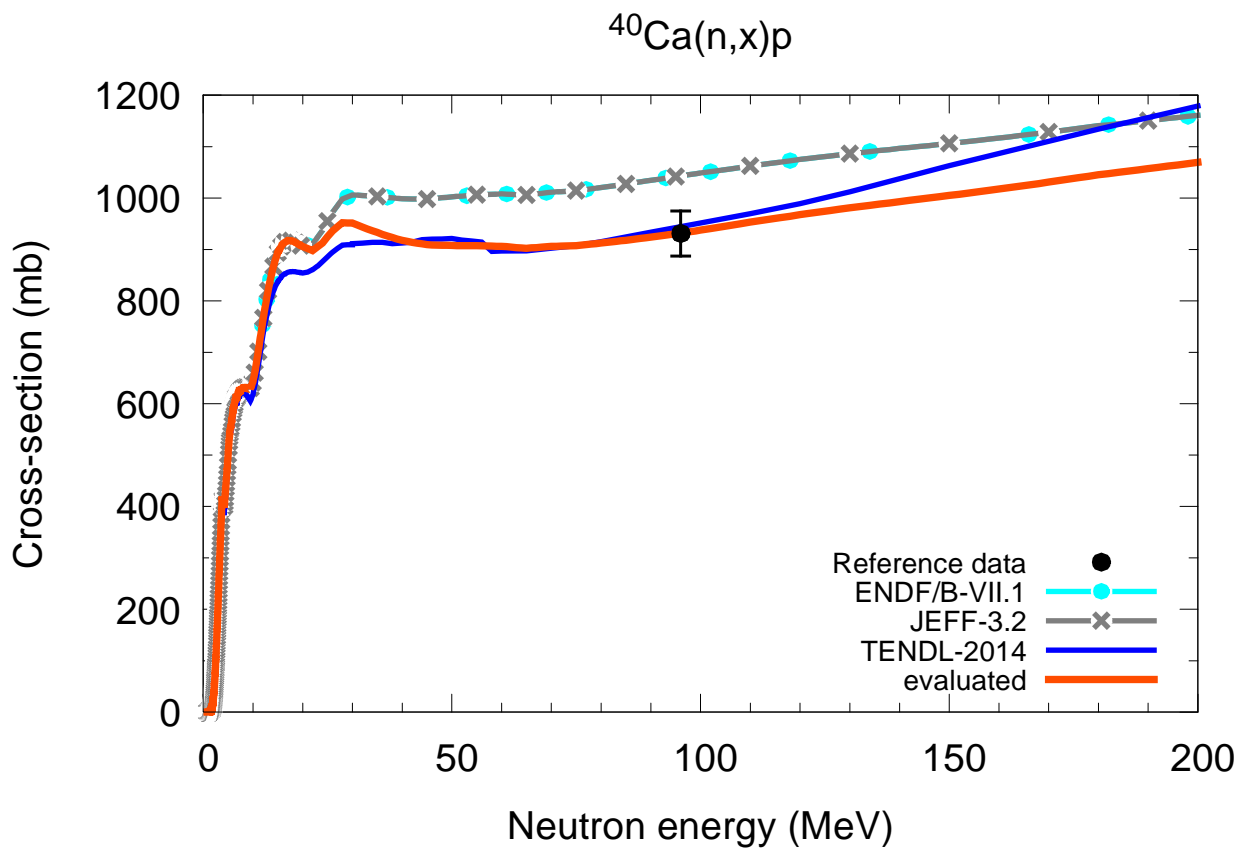


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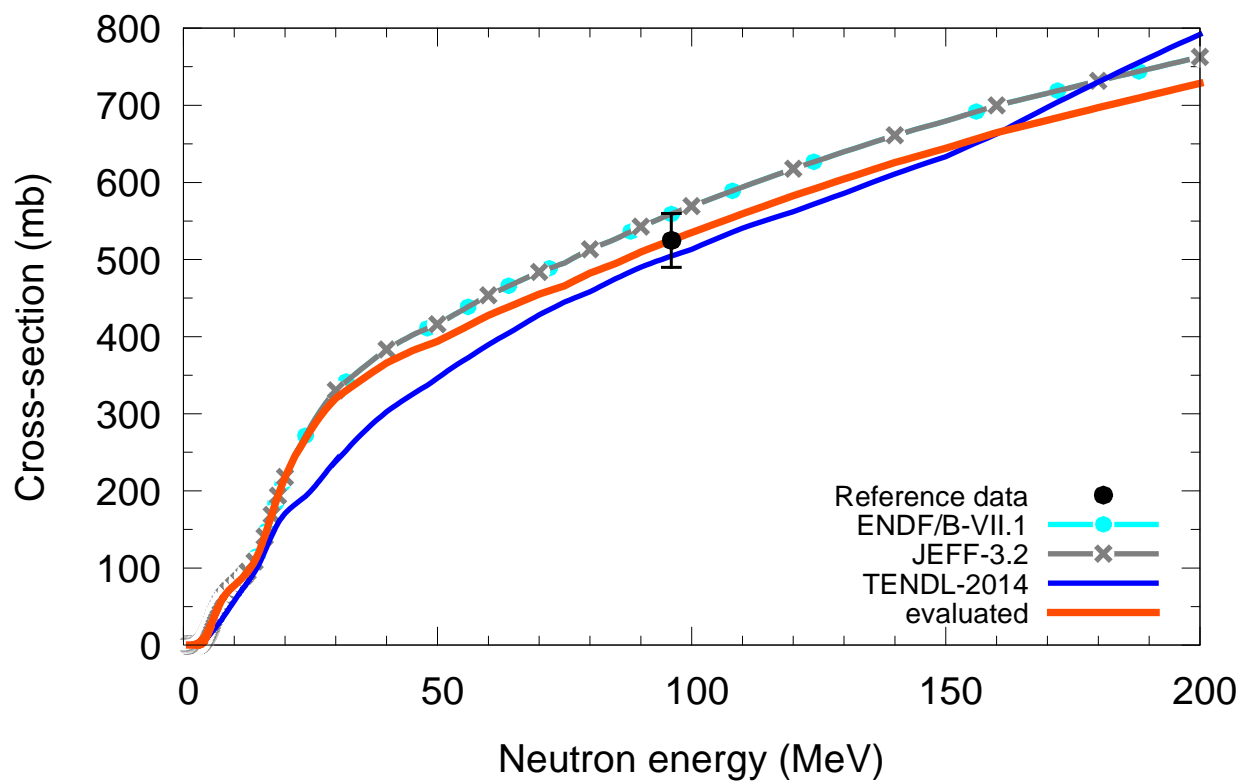
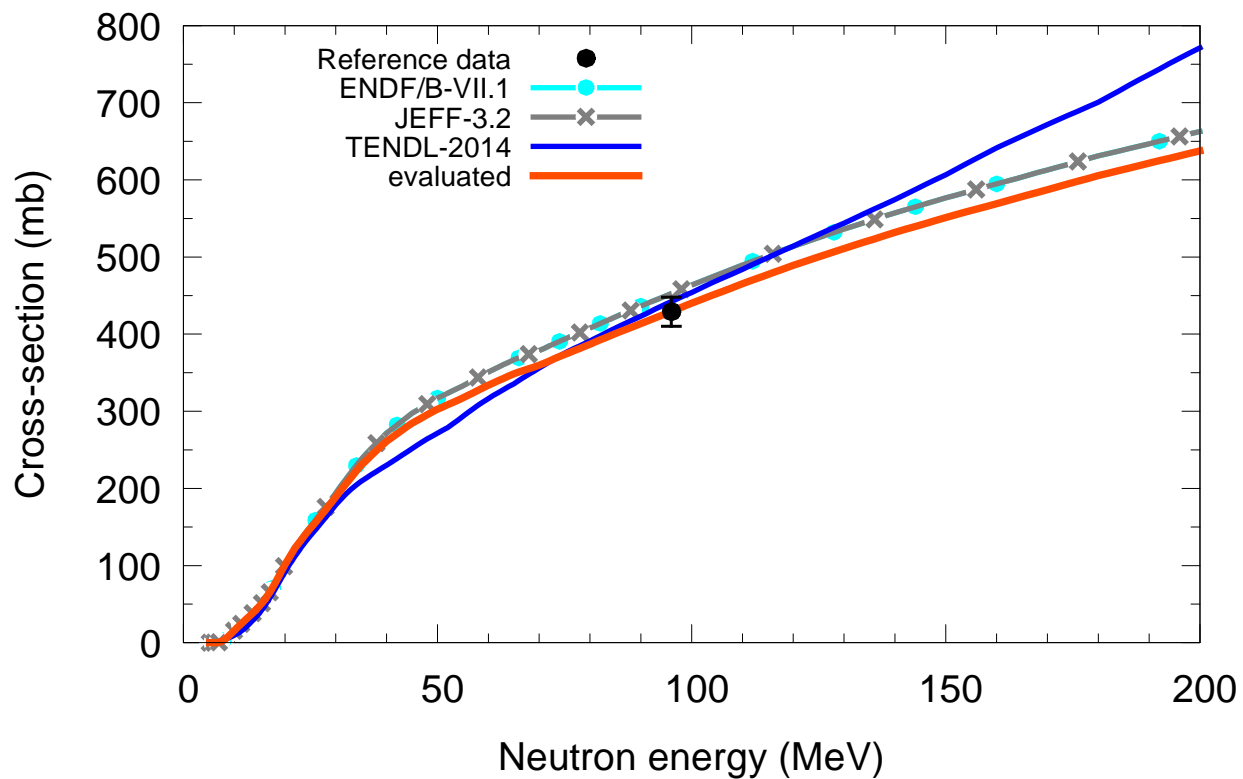




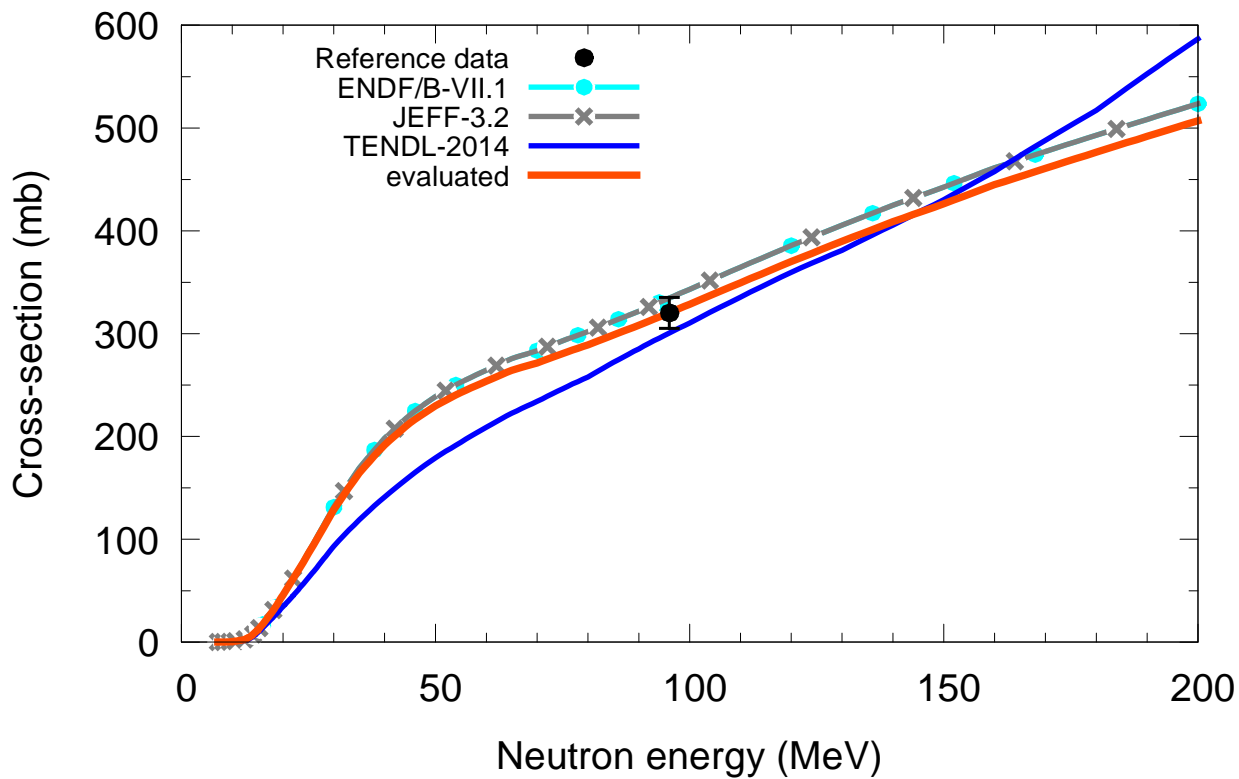




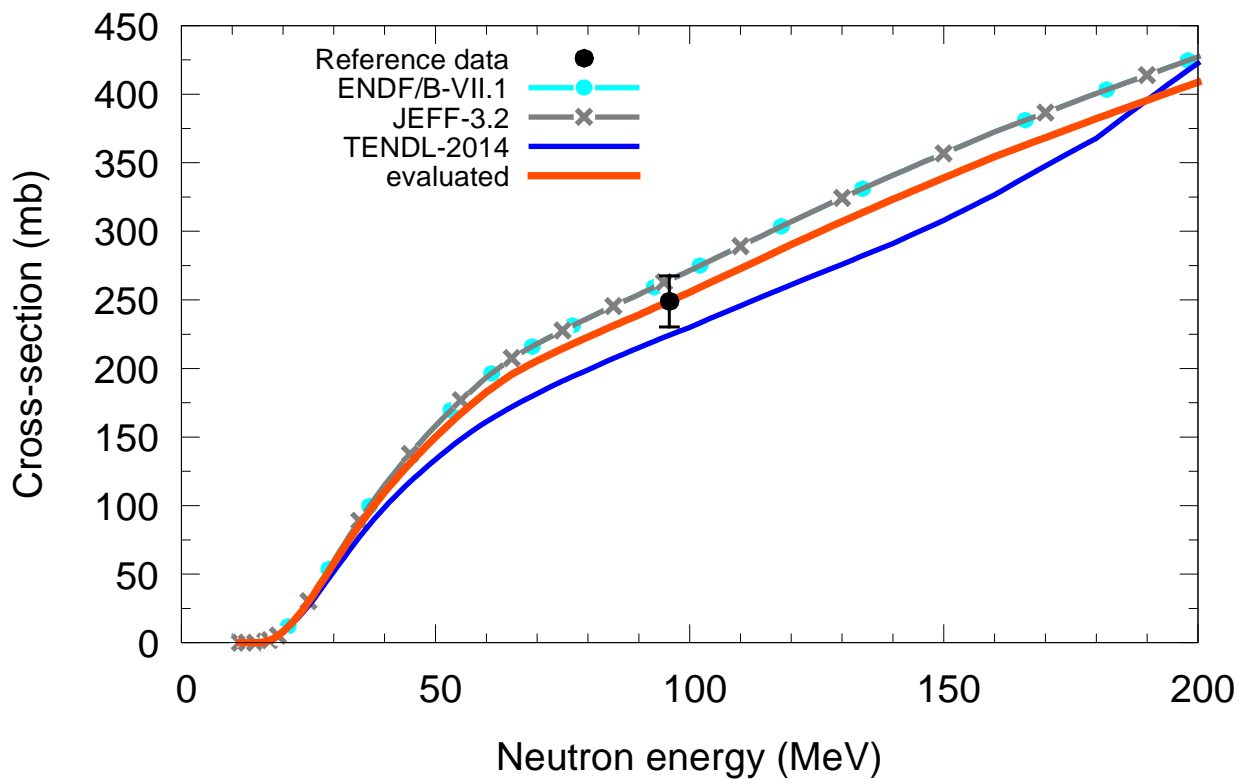


$^{43}\text{Ca}(n,x)p$  $^{44}\text{Ca}(n,x)p$ 

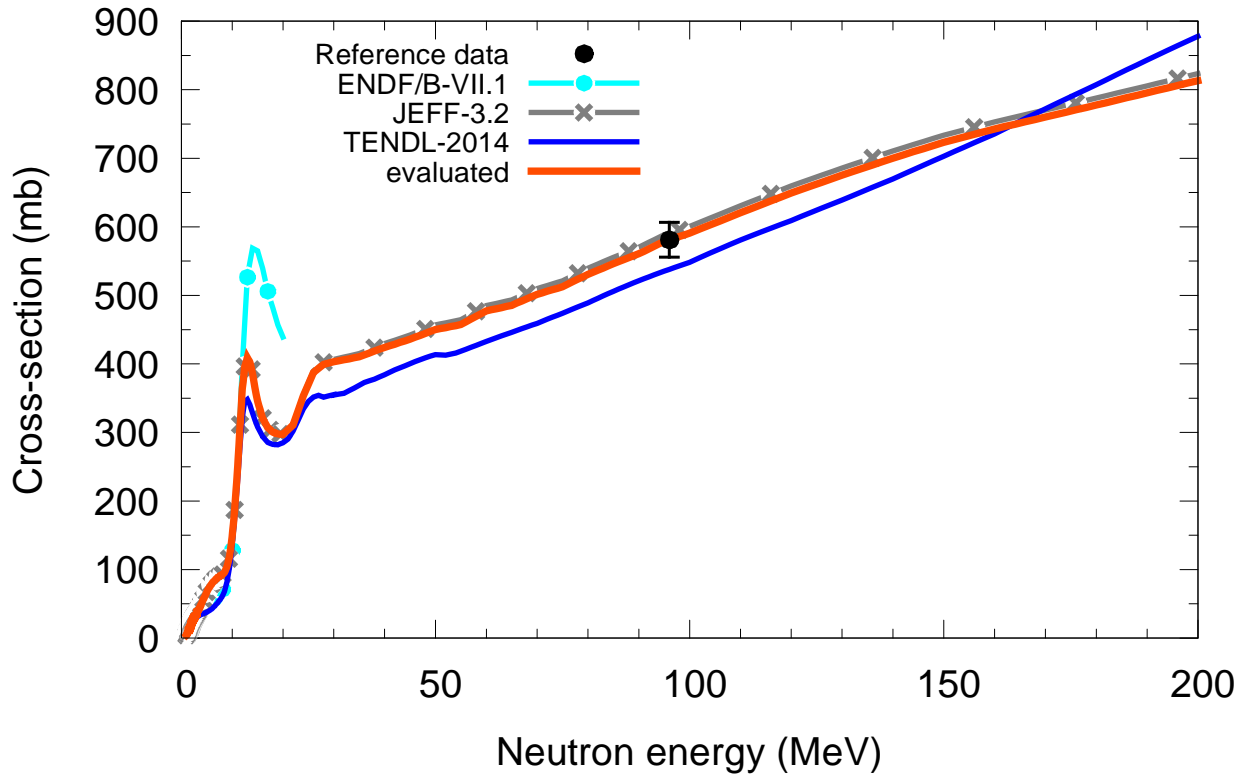
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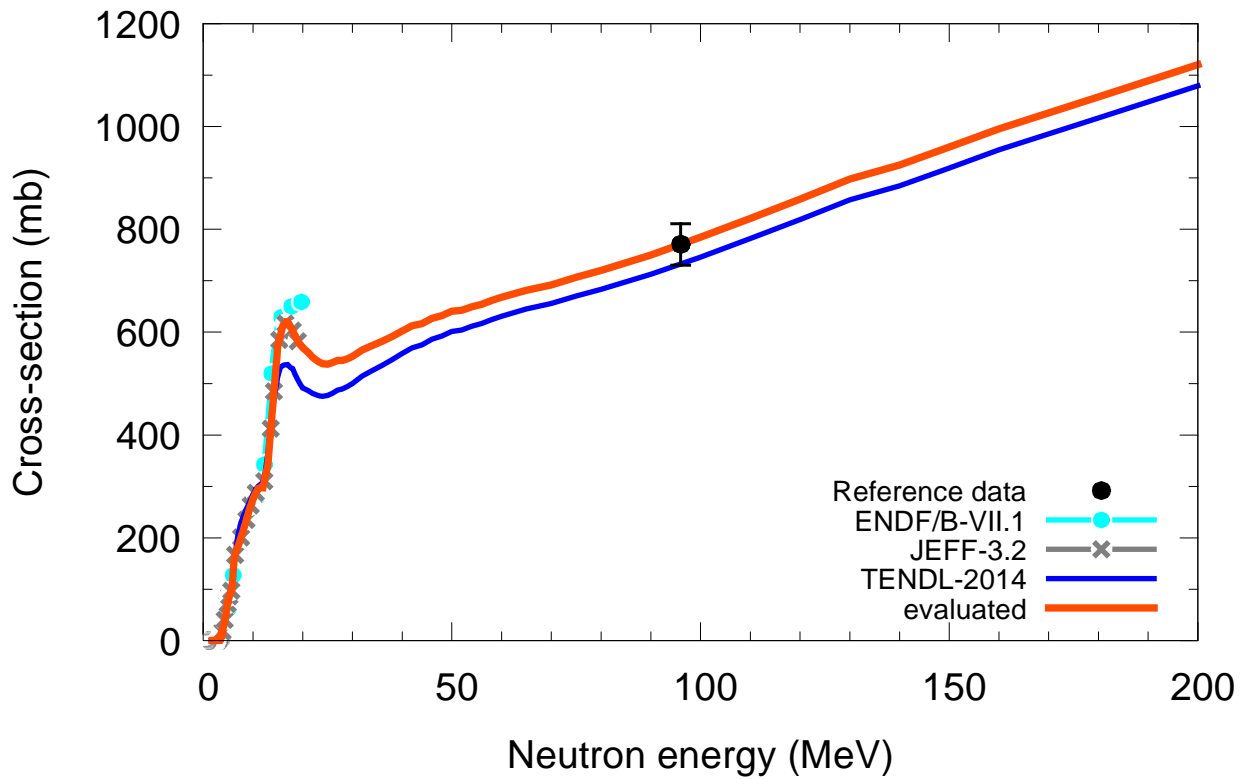
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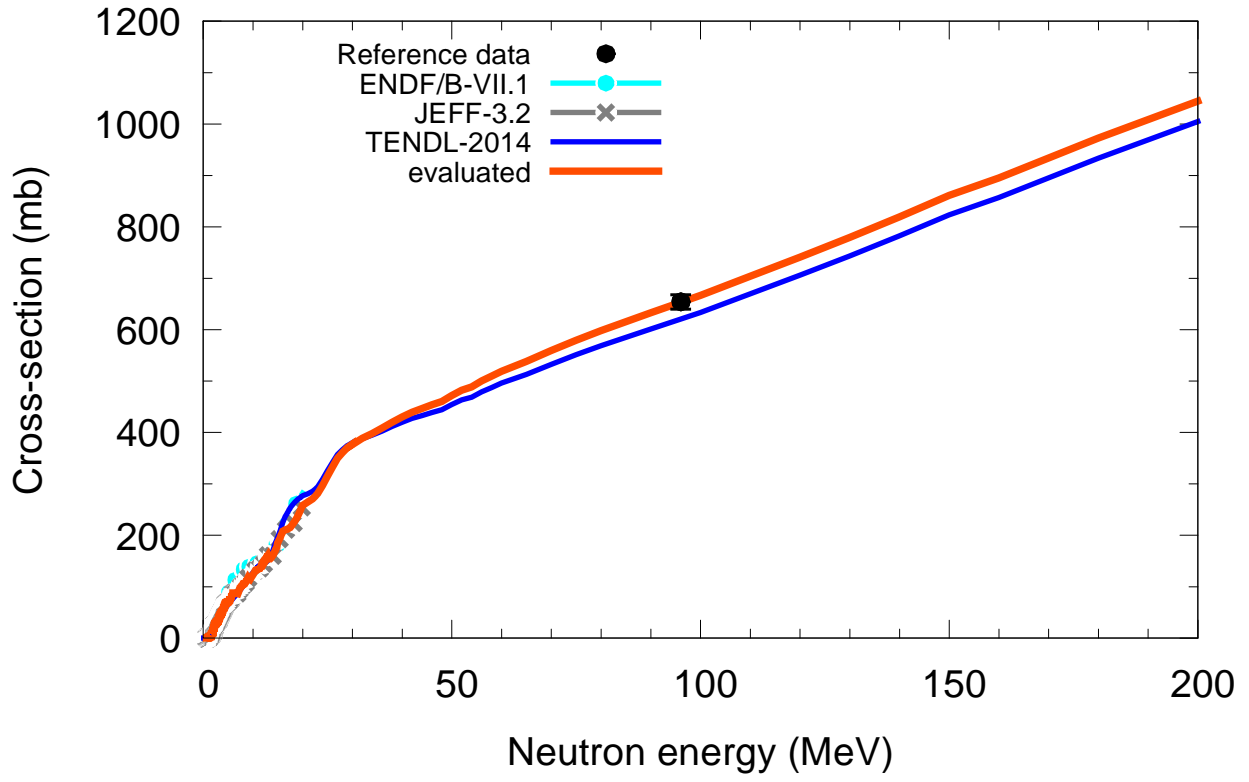
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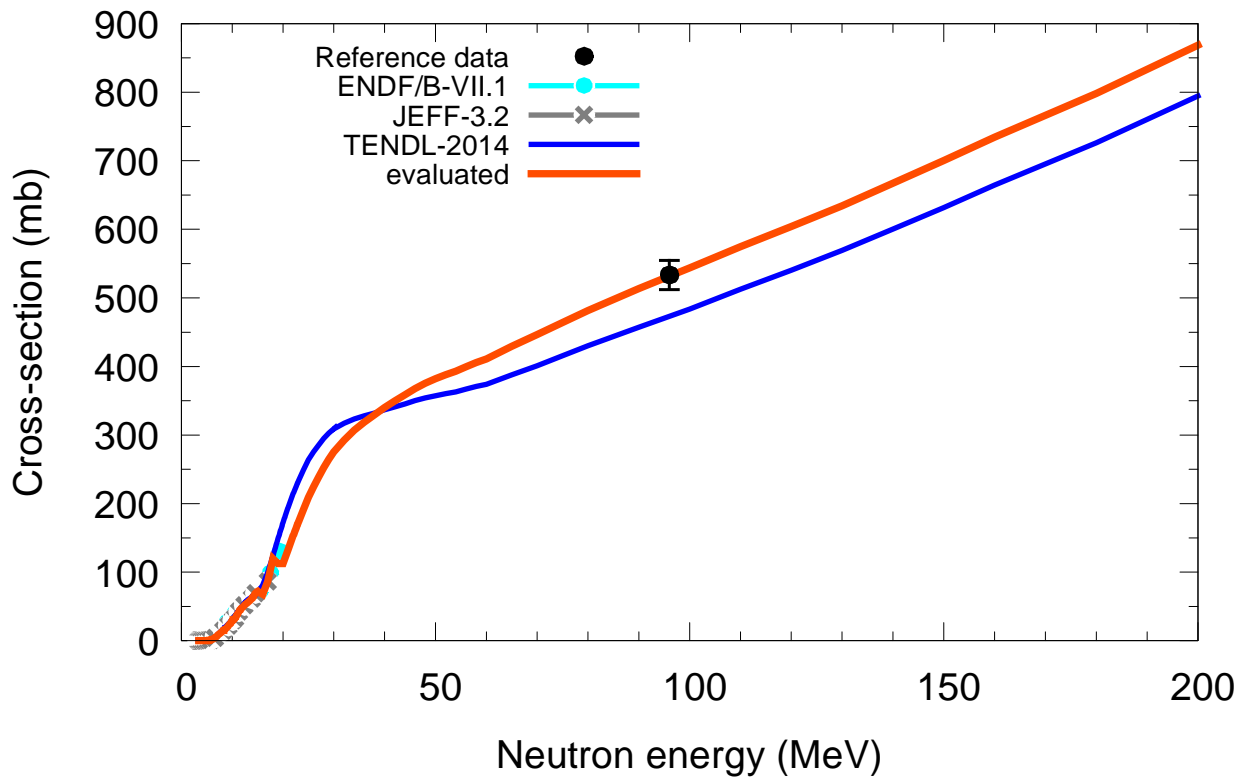
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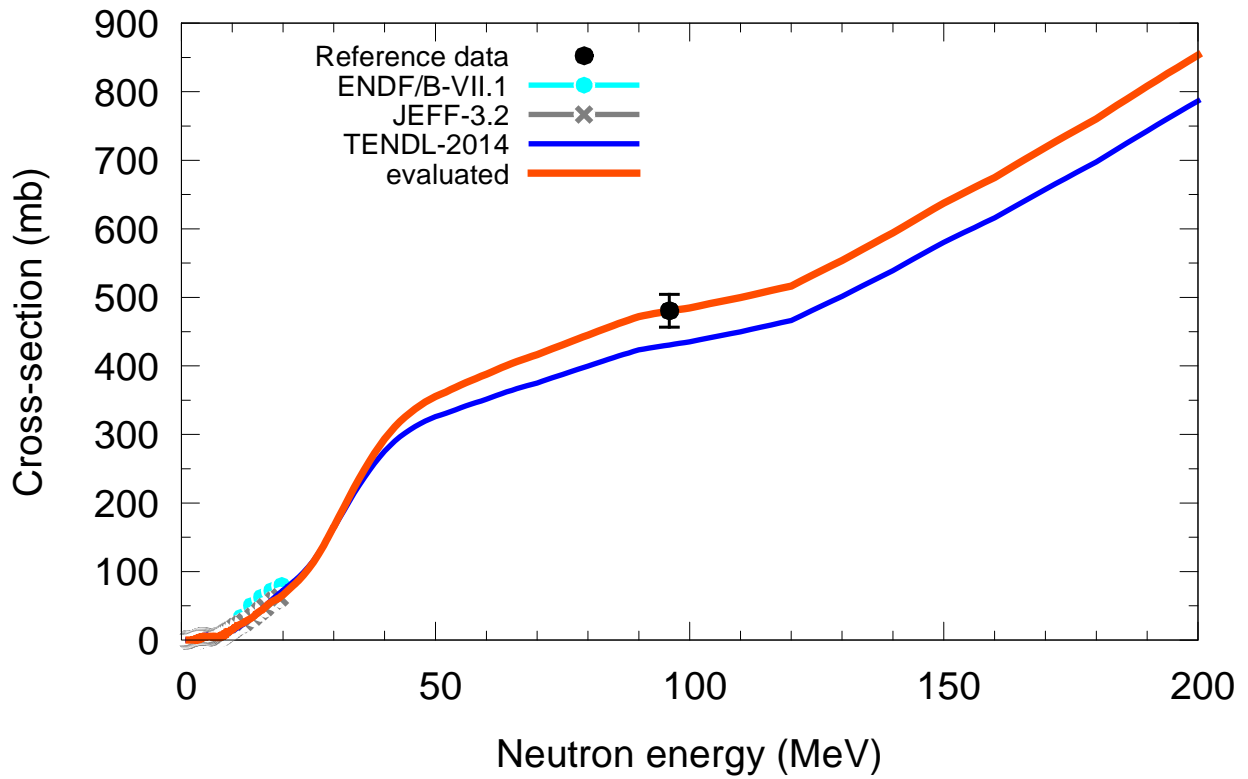
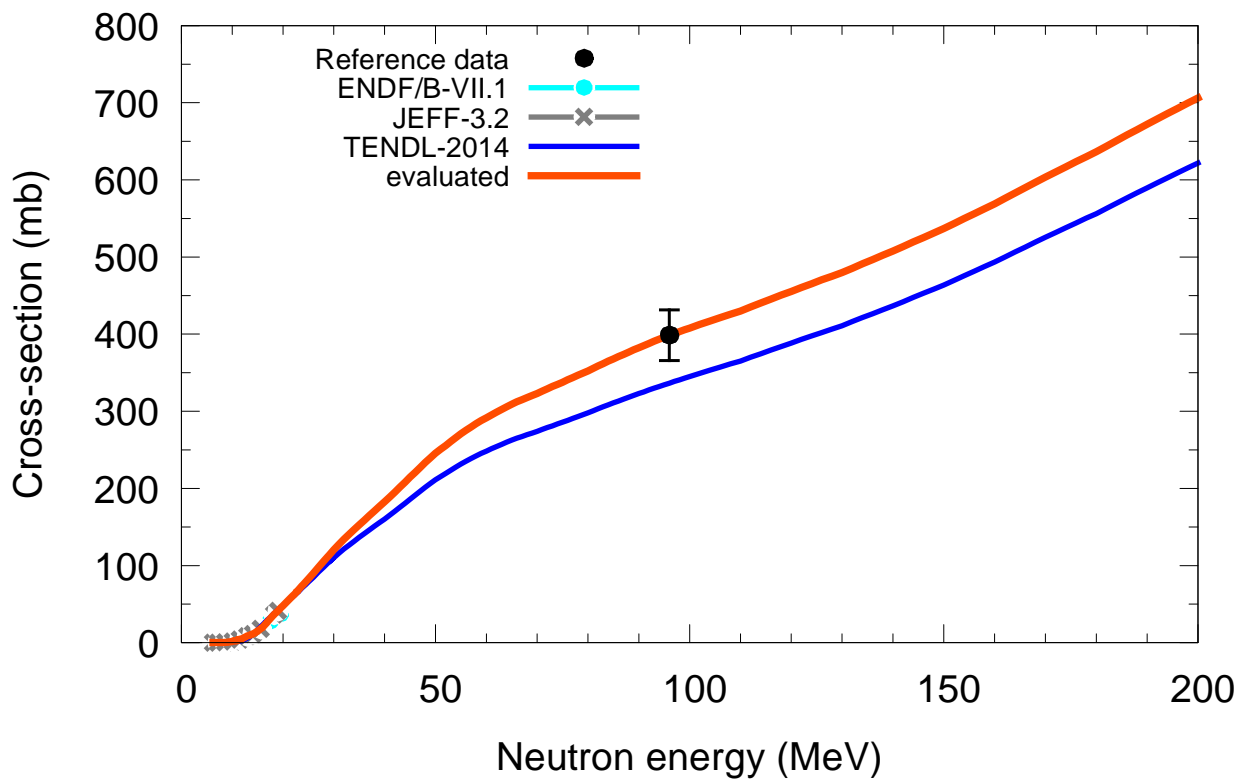


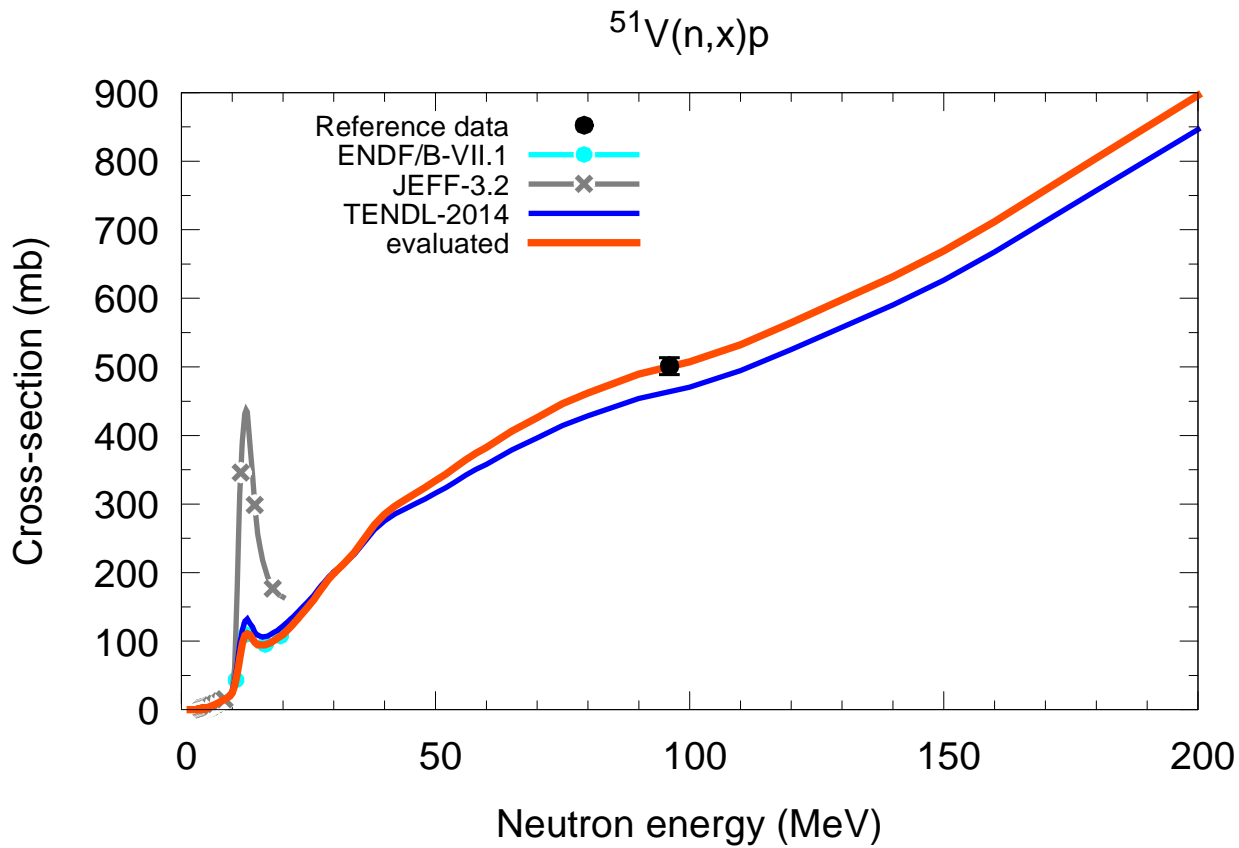
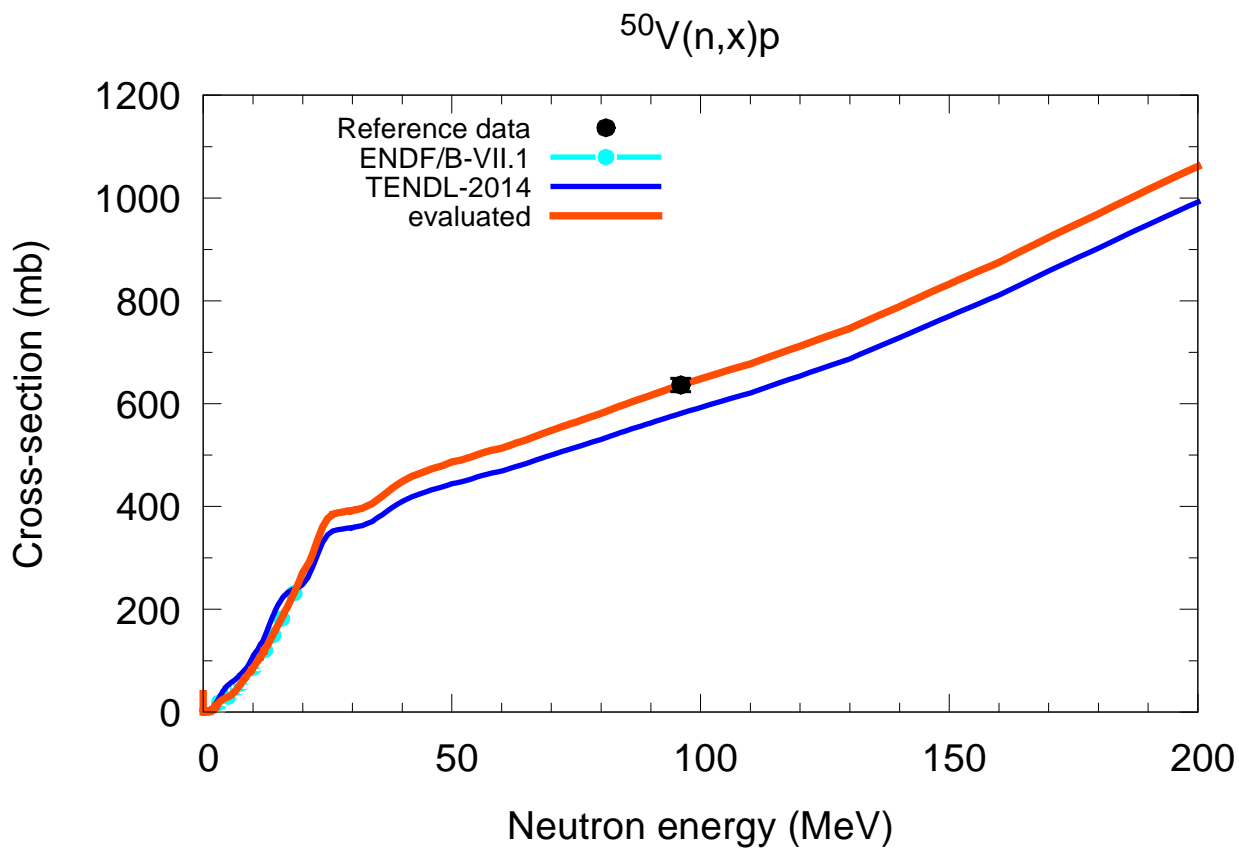
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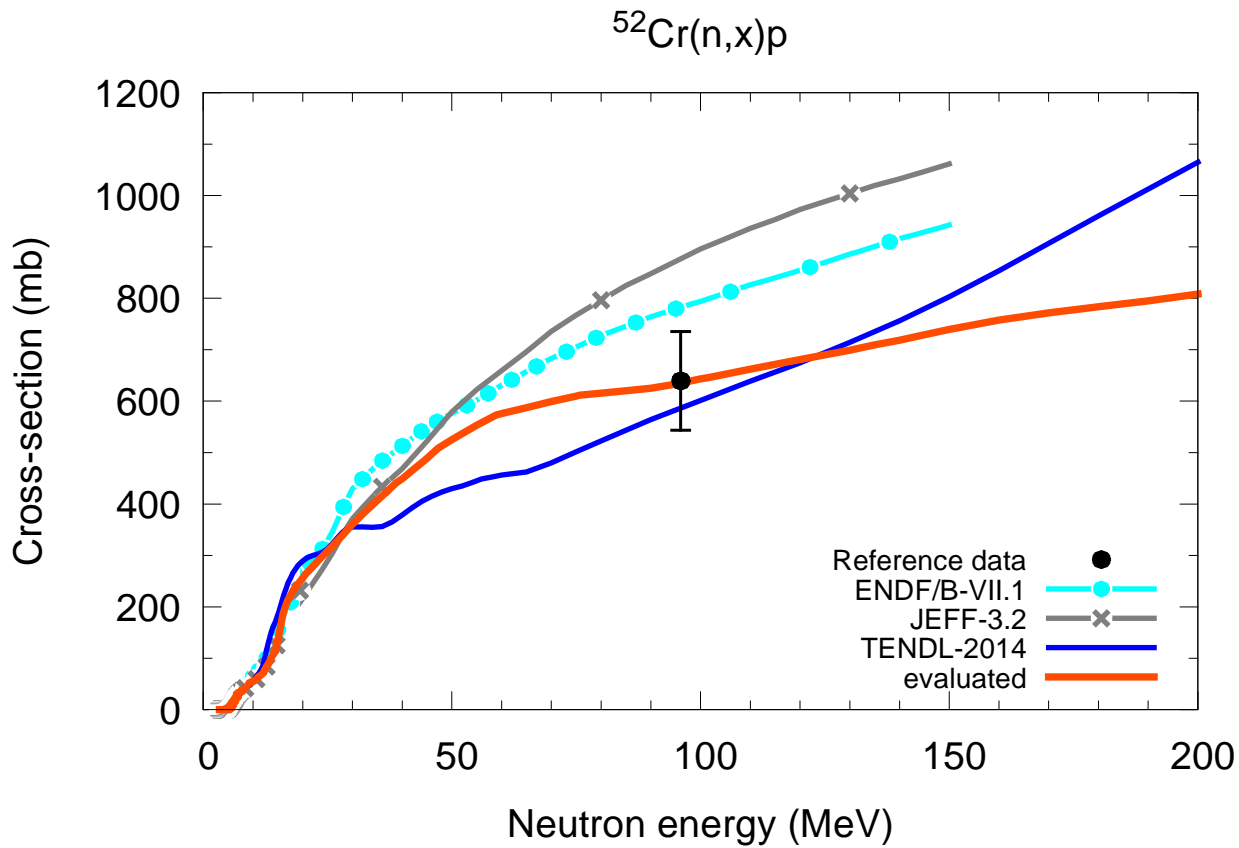
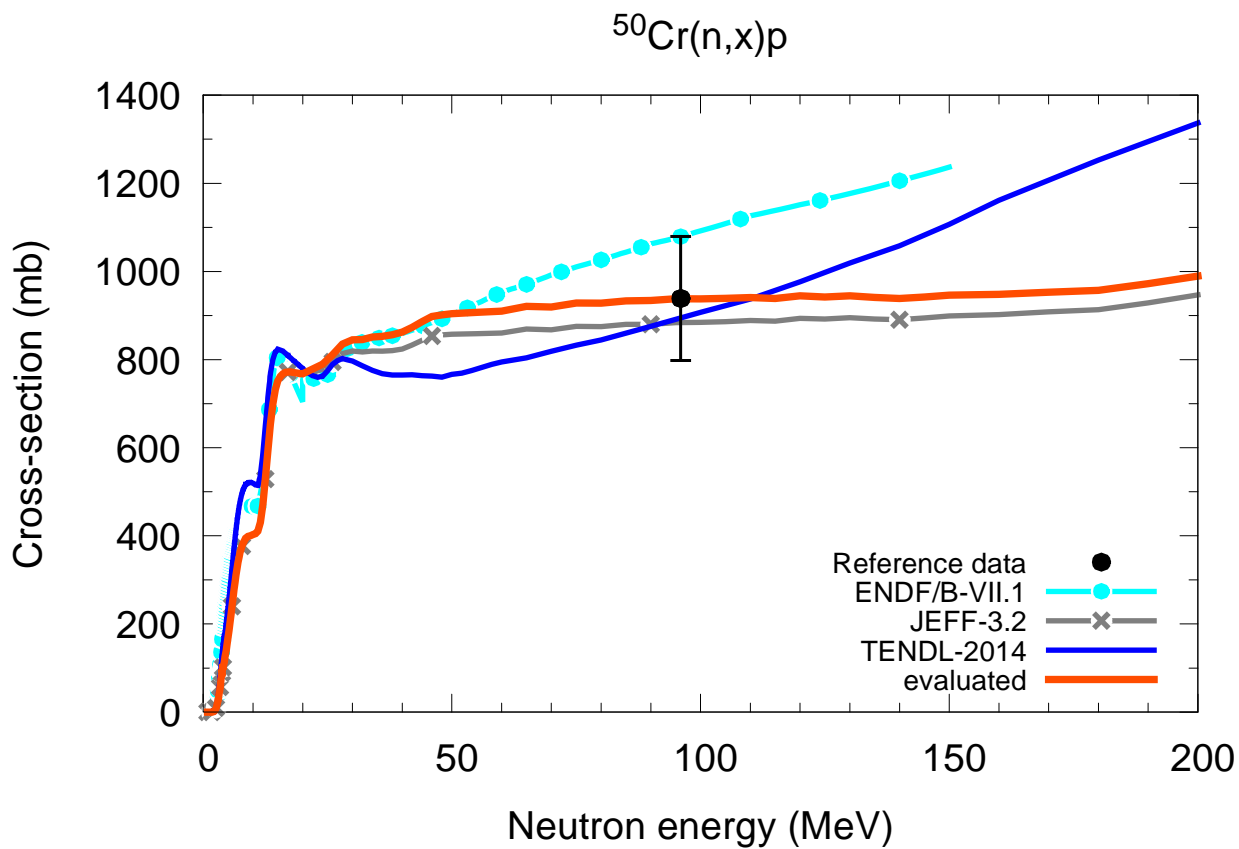


### $^{48}\text{Ti}(n,x)p$

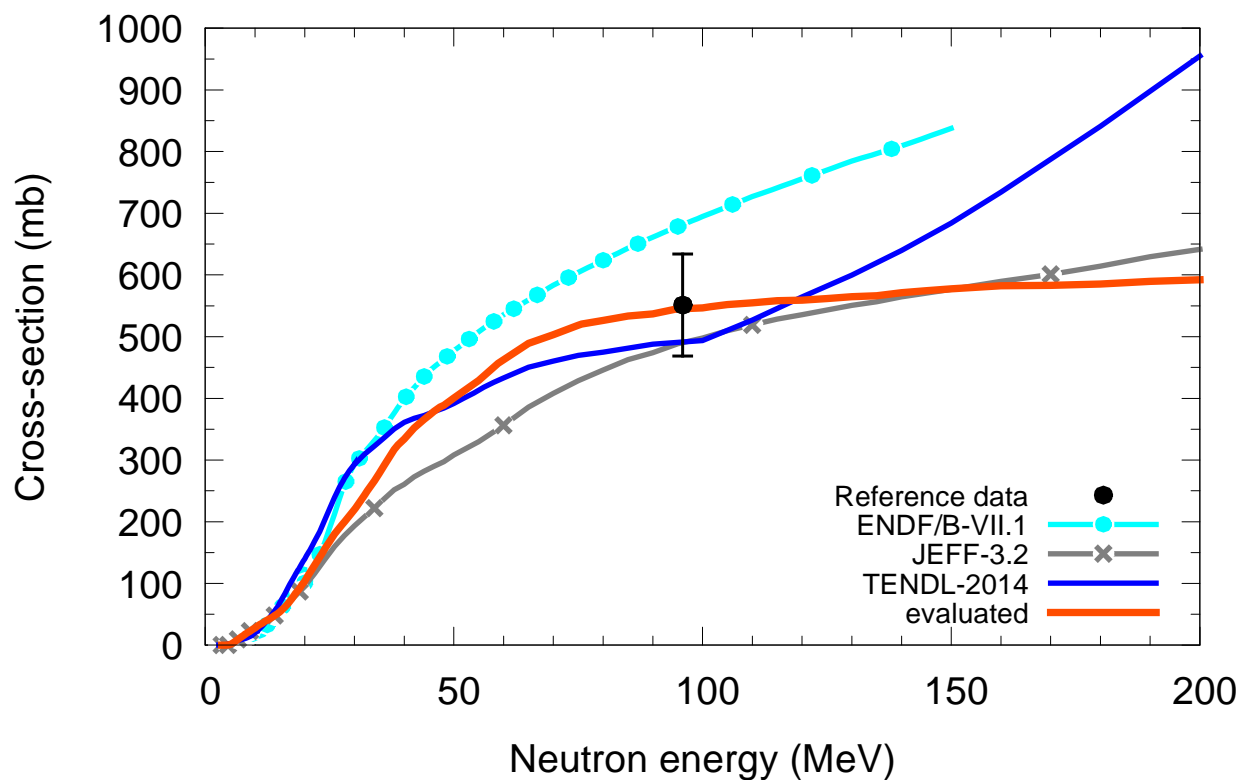


$^{49}\text{Ti}(n,x)p$  $^{50}\text{Ti}(n,x)p$ 

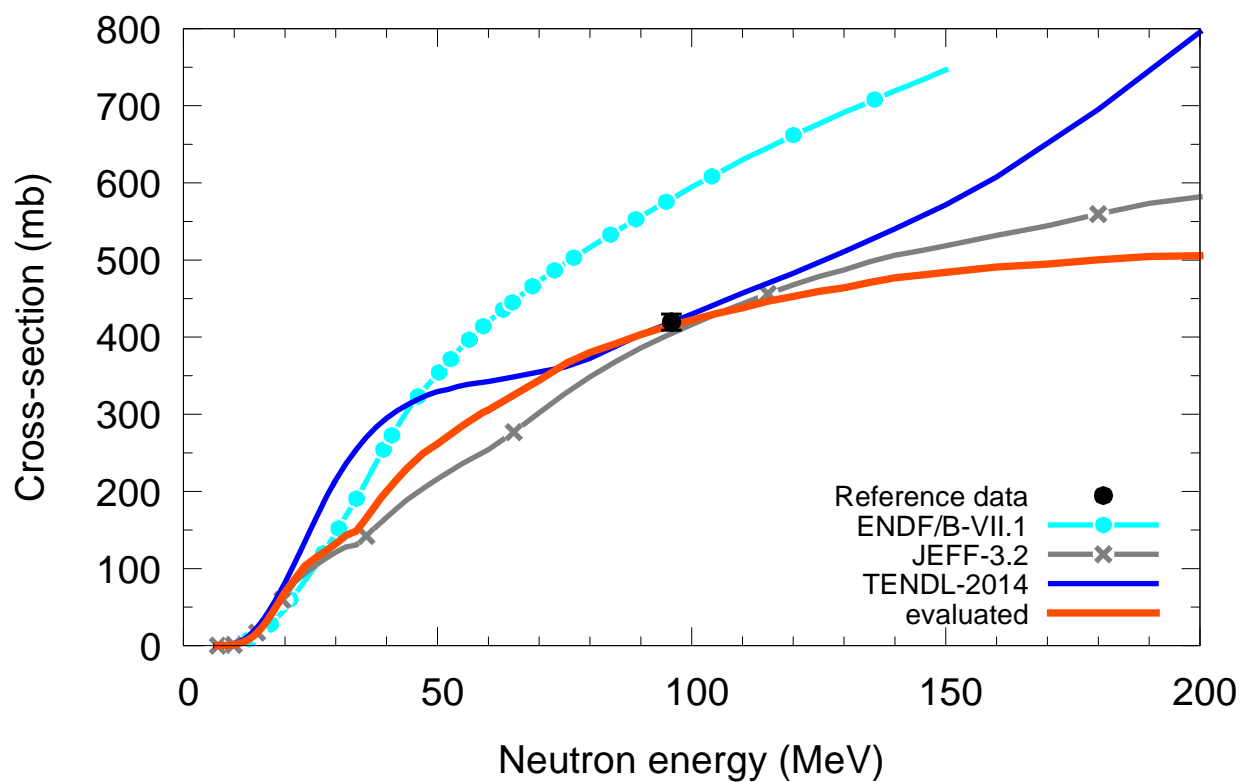




### $^{53}\text{Cr}(n,x)p$

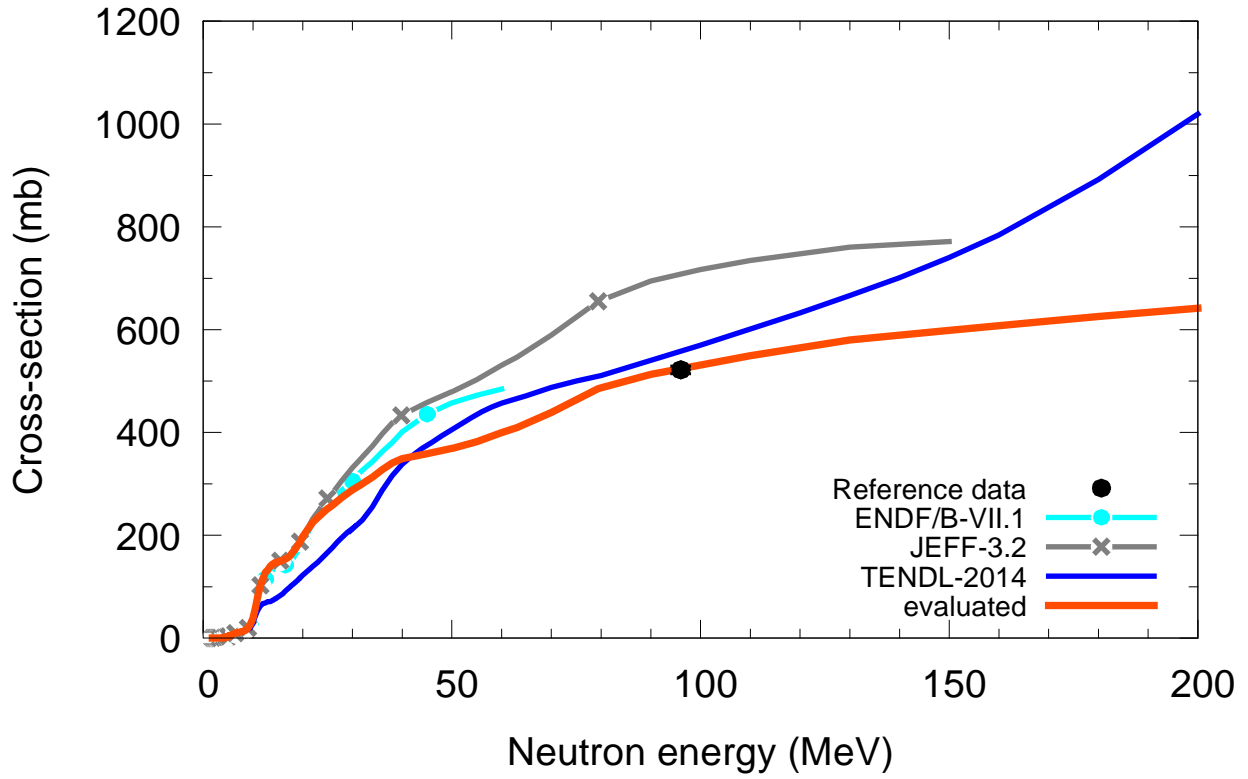


### $^{54}\text{Cr}(n,x)p$

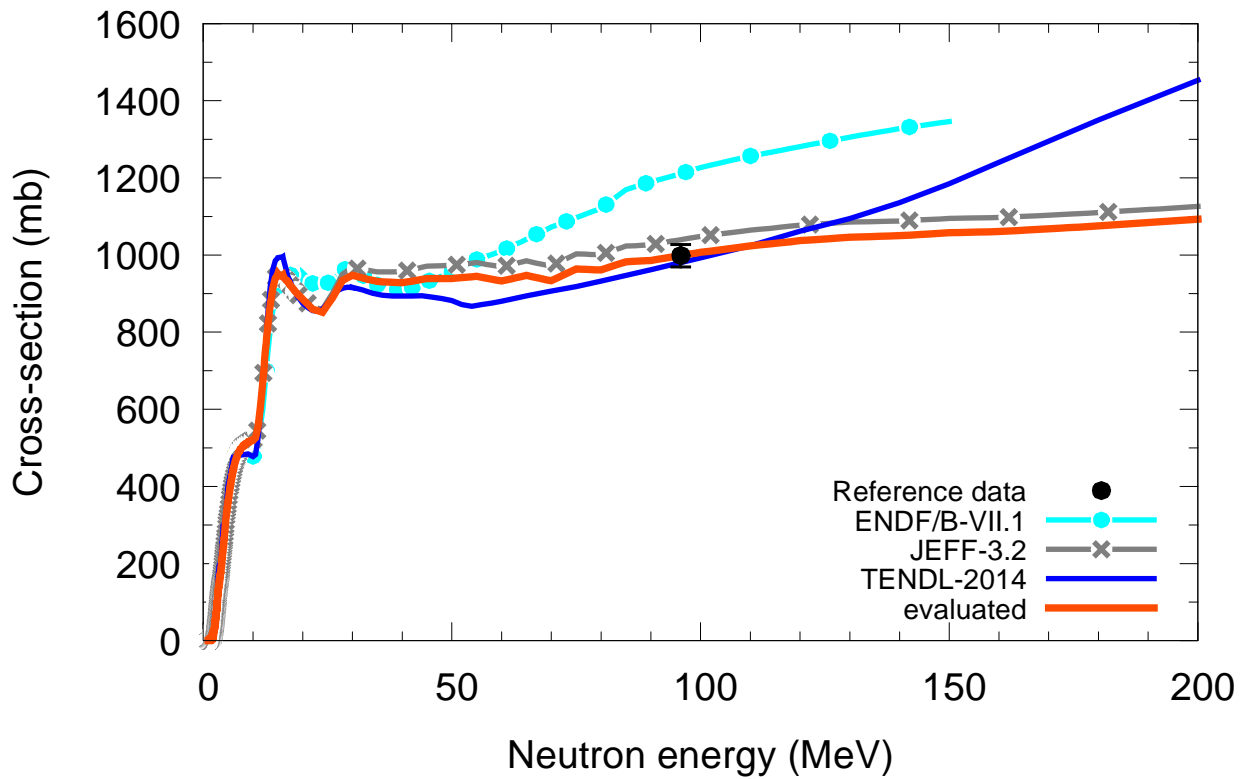


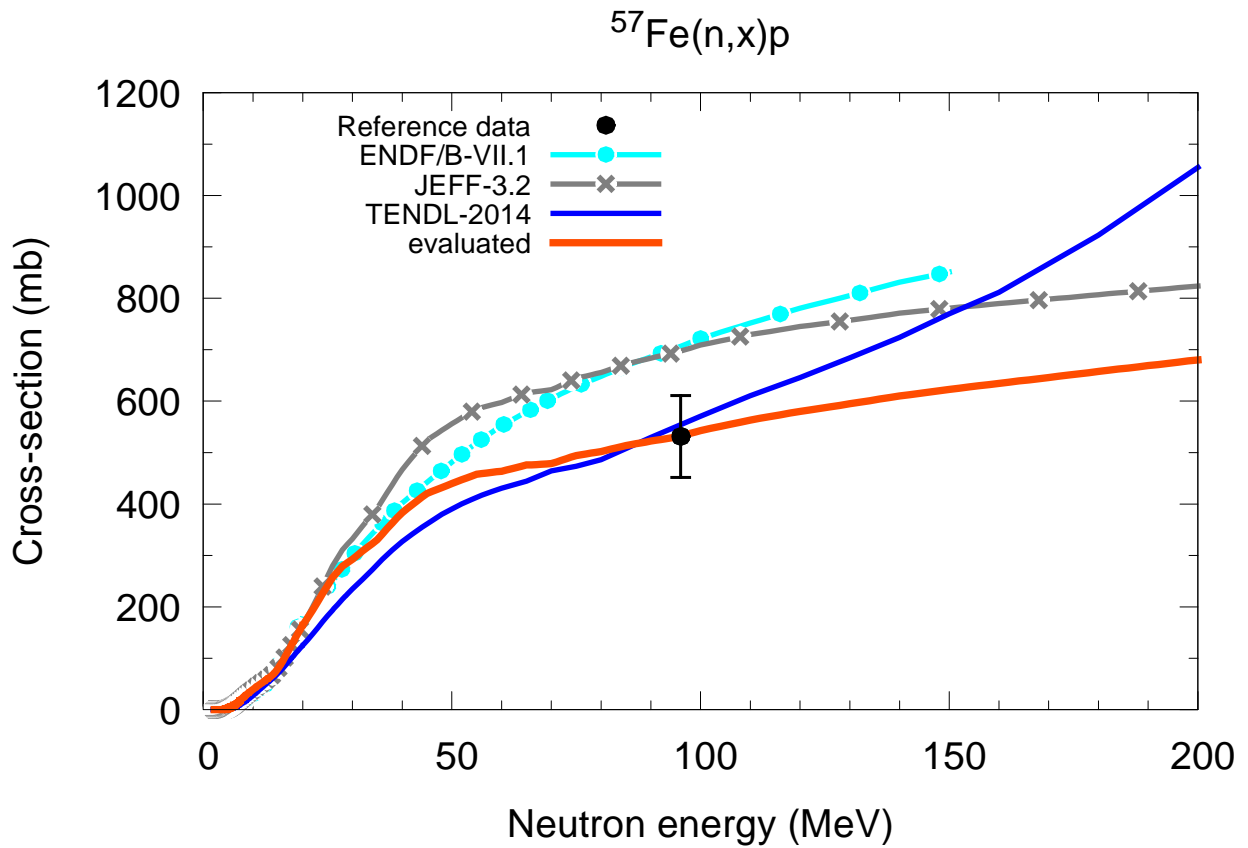
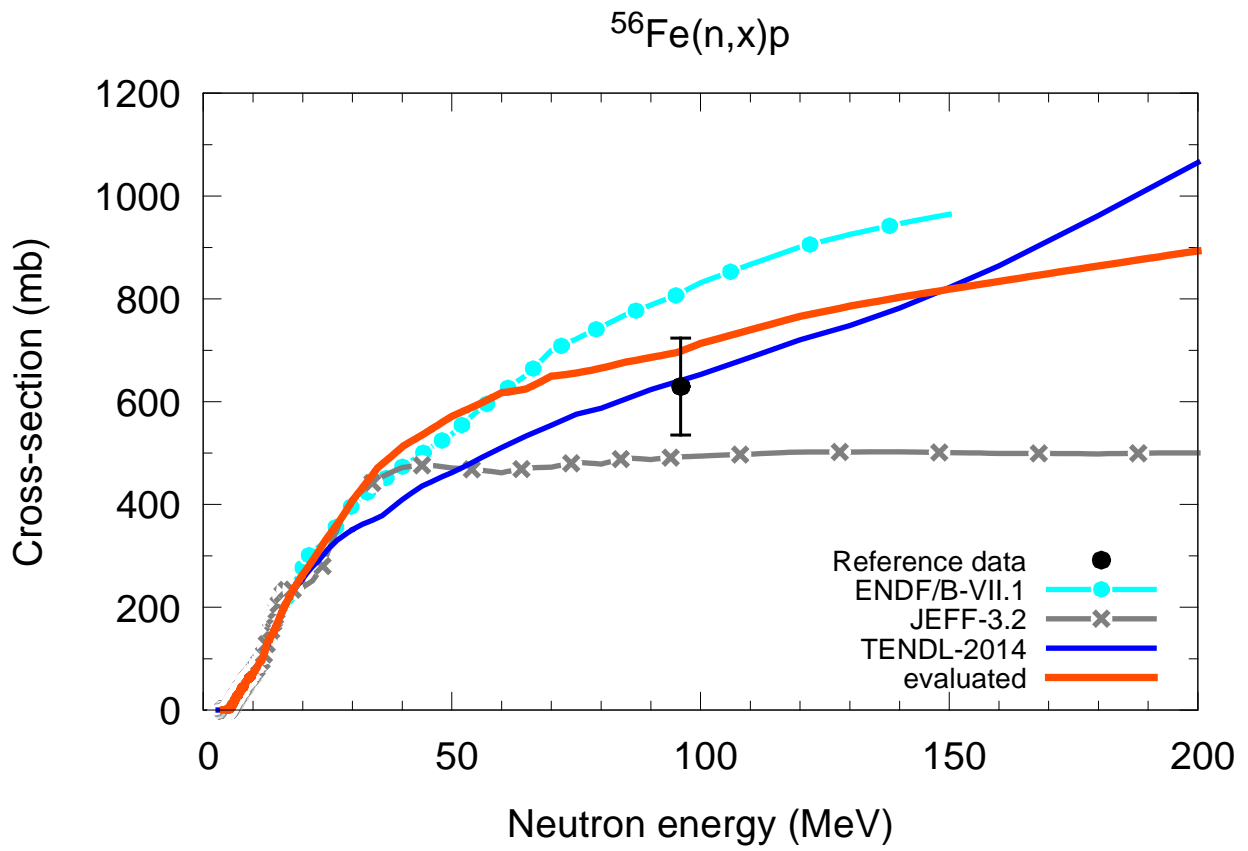


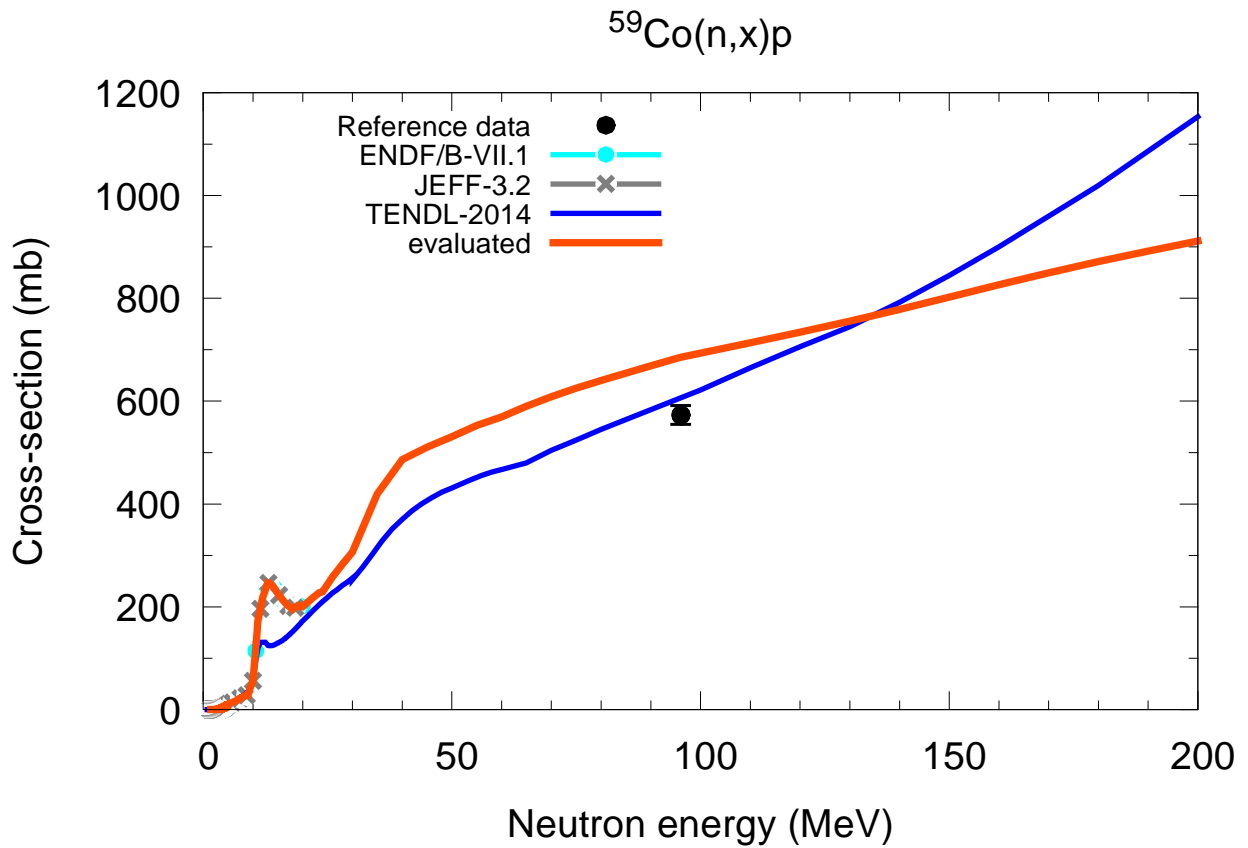
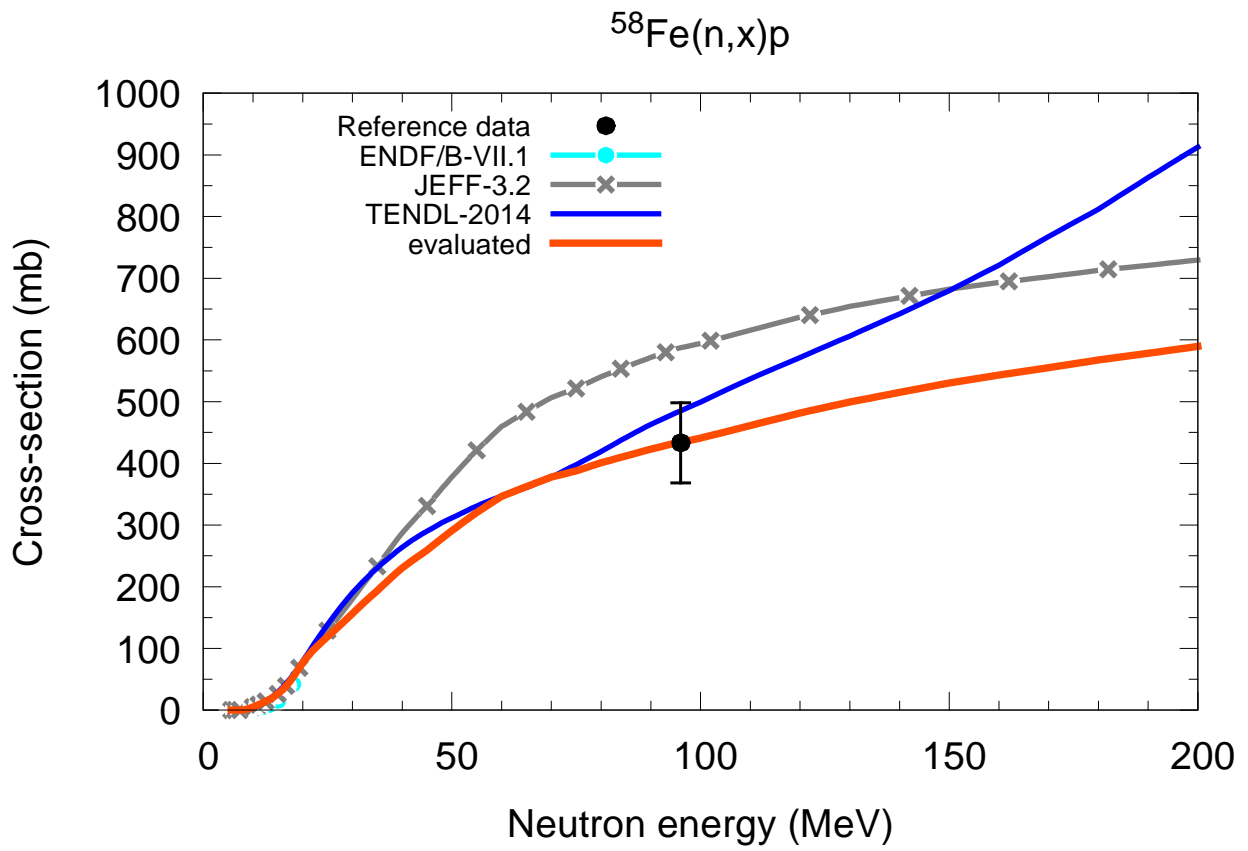
### $^{55}\text{Mn}(n,x)p$

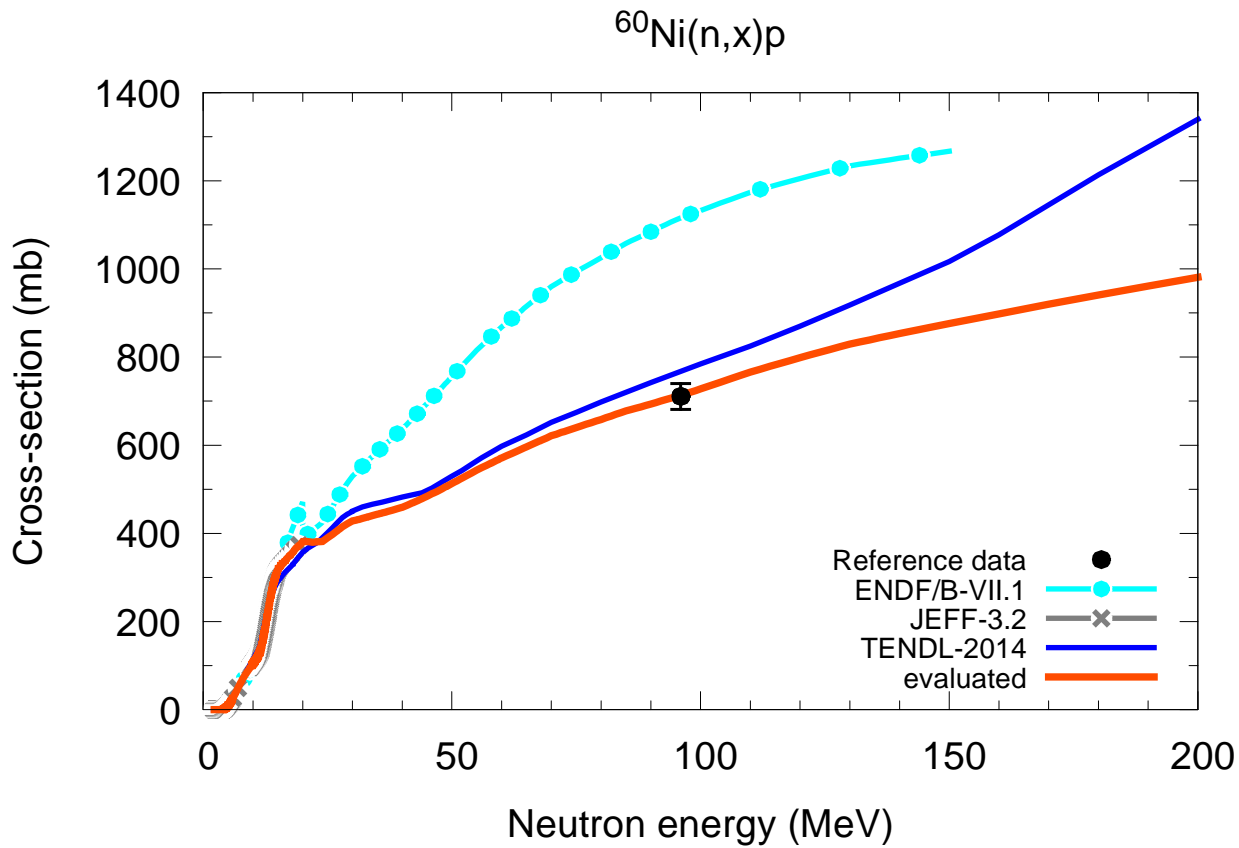
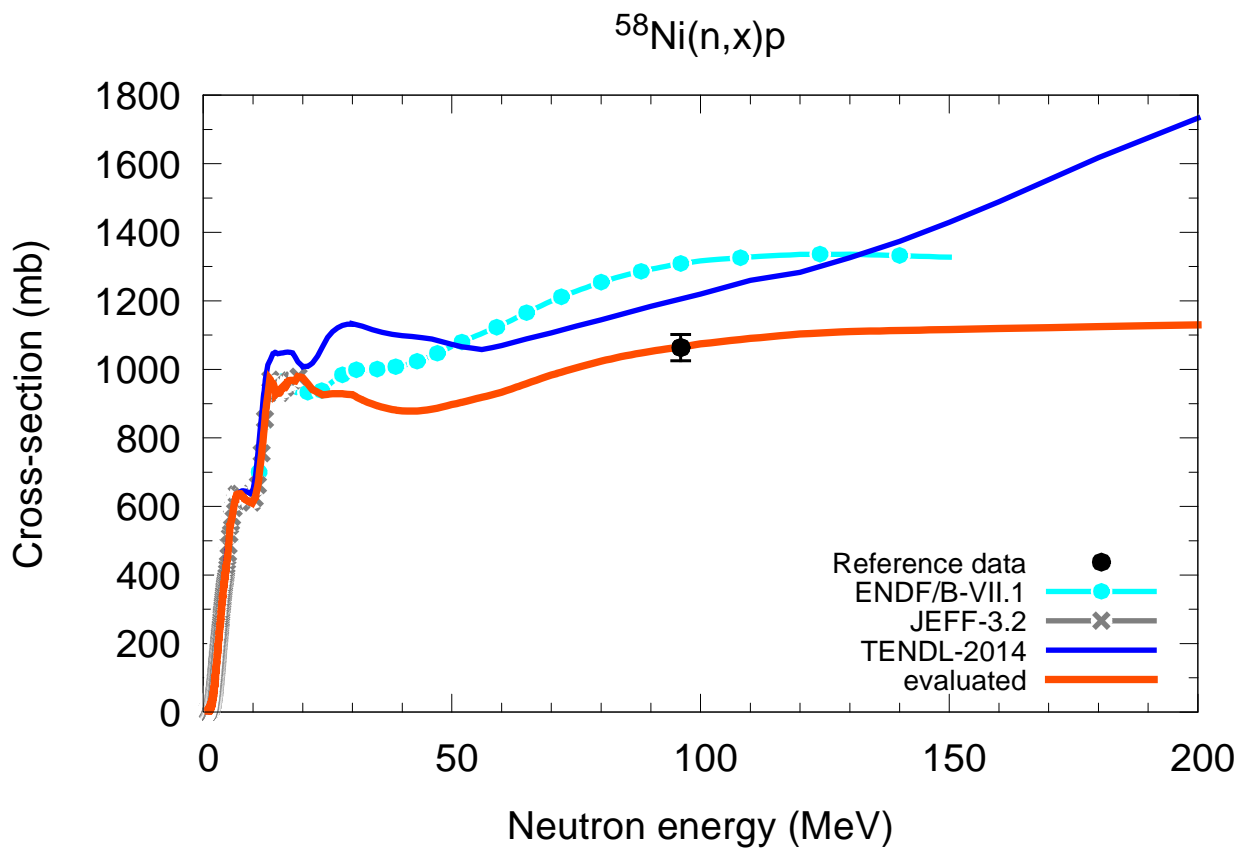


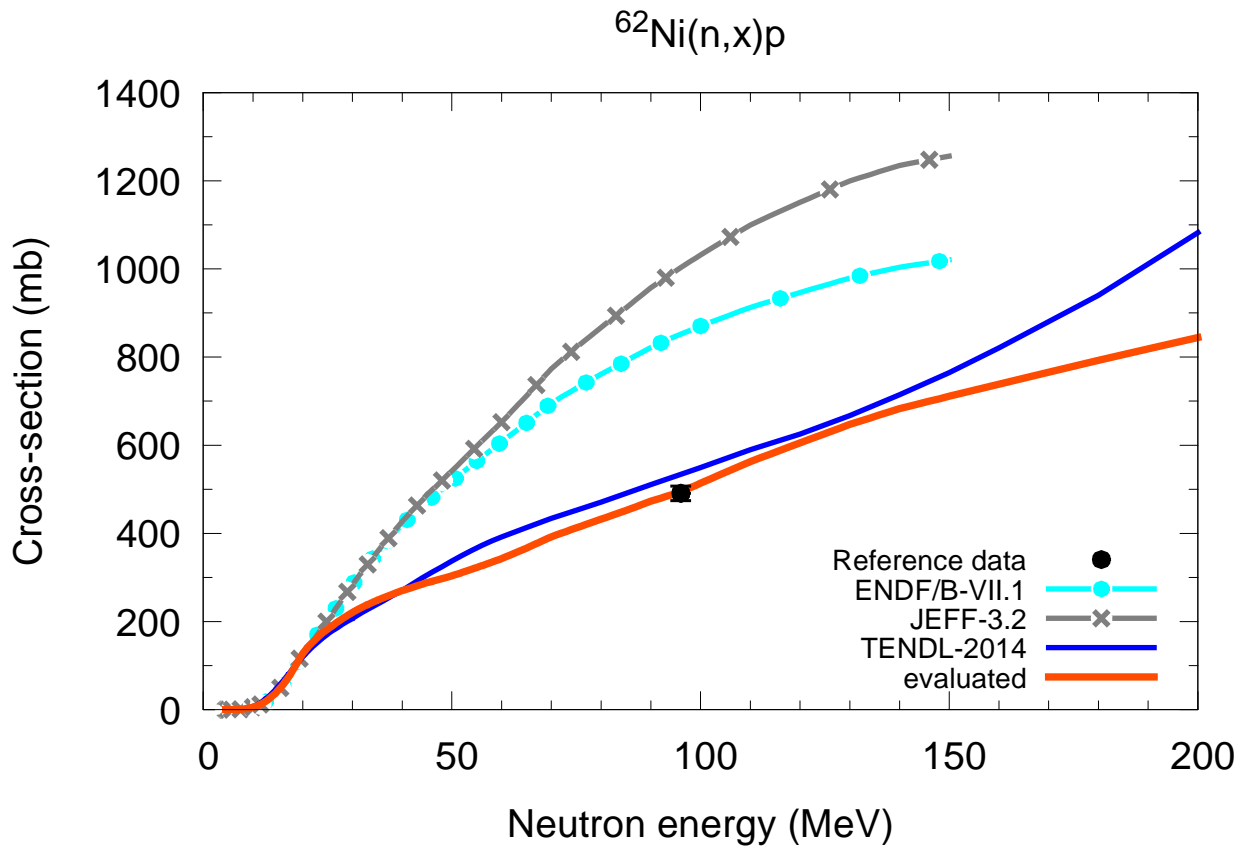
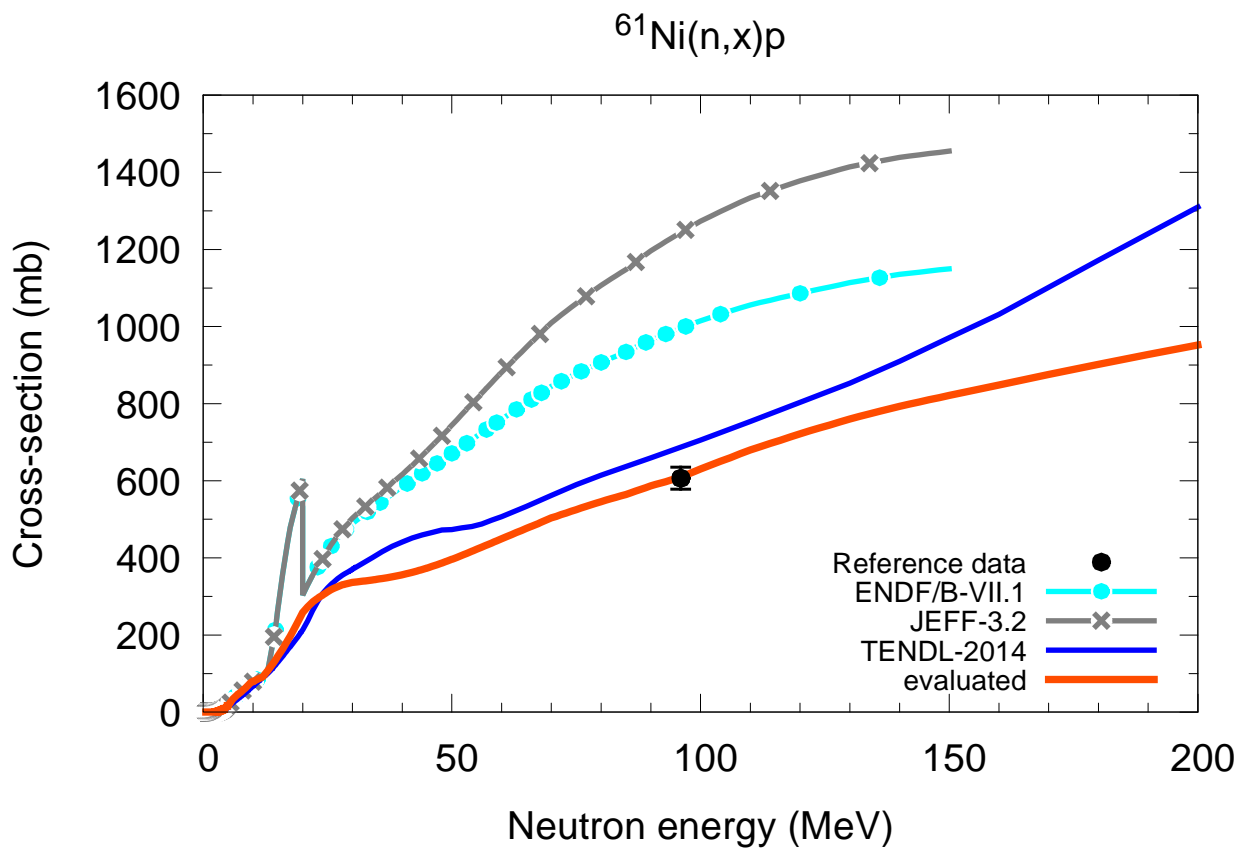
### $^{54}\text{Fe}(n,x)p$

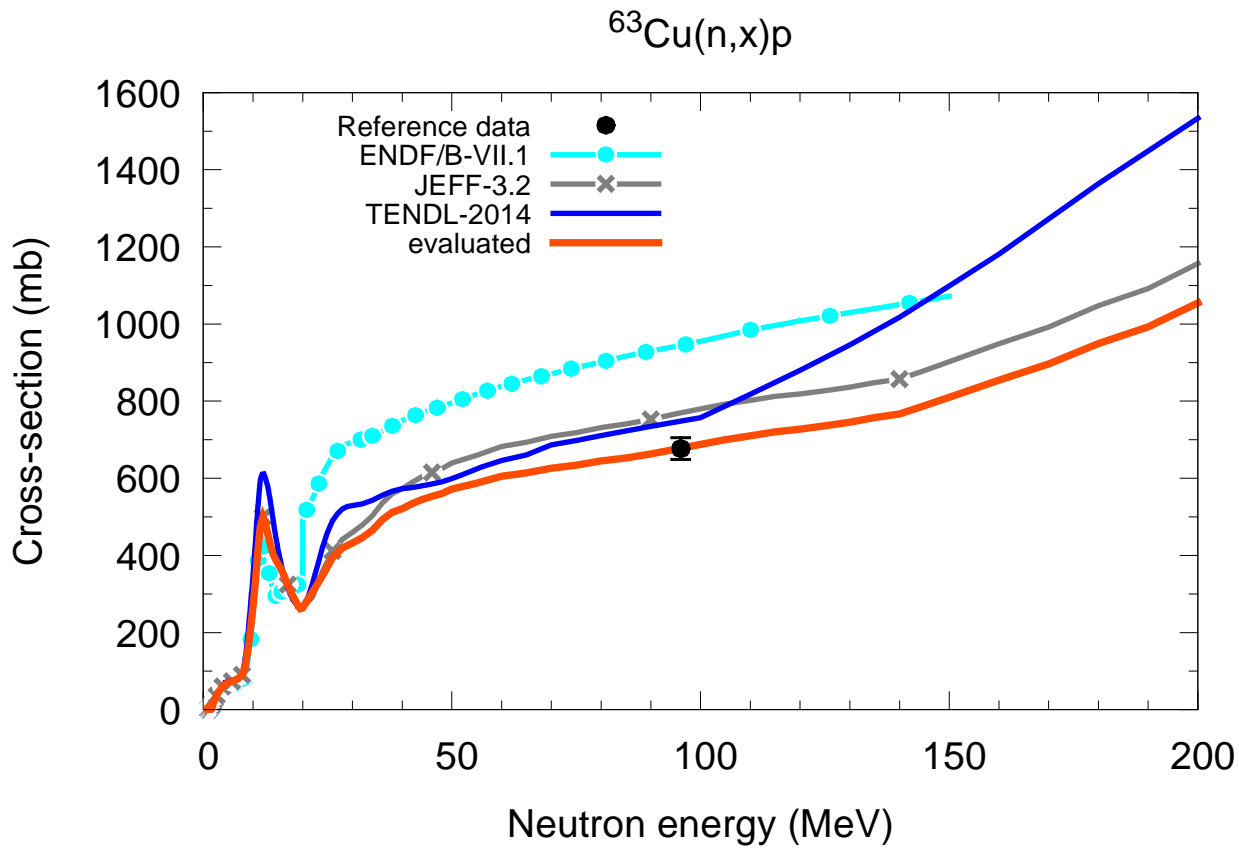
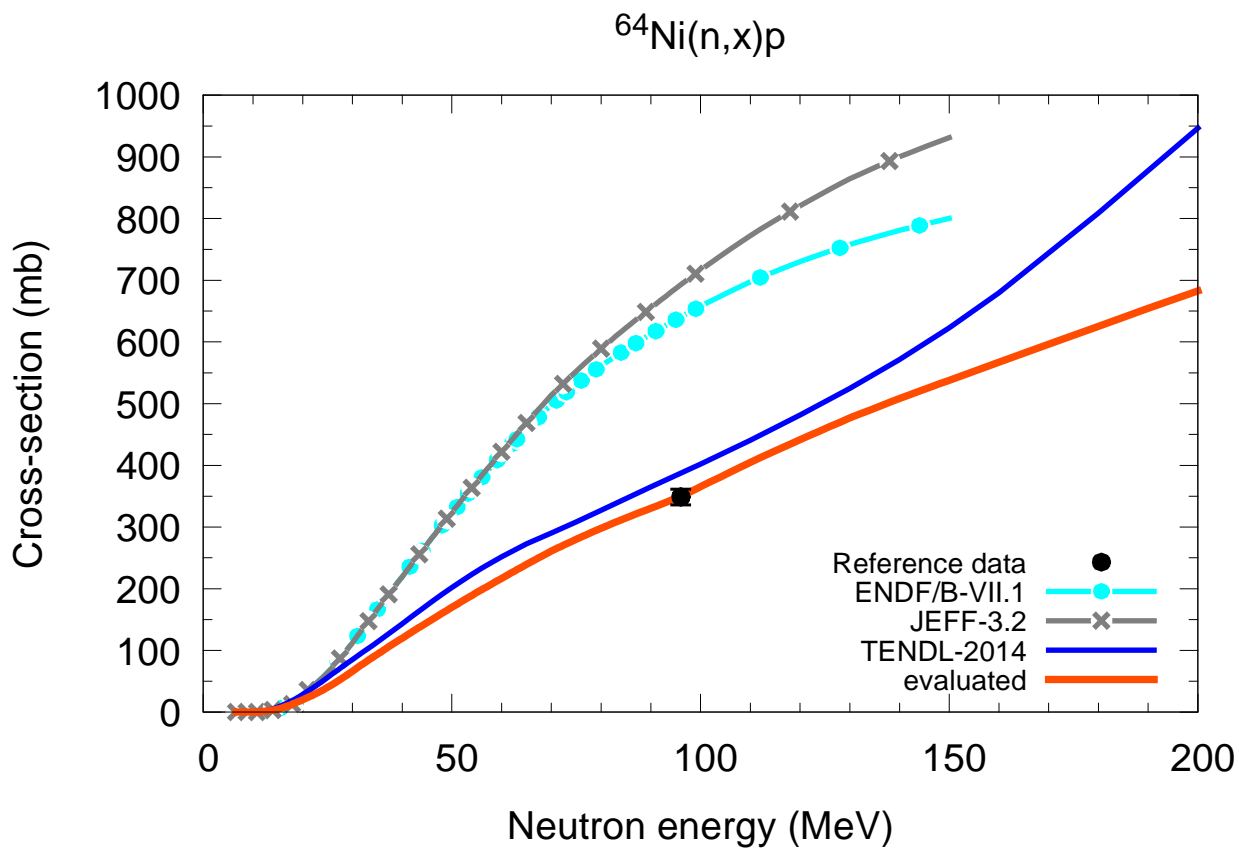




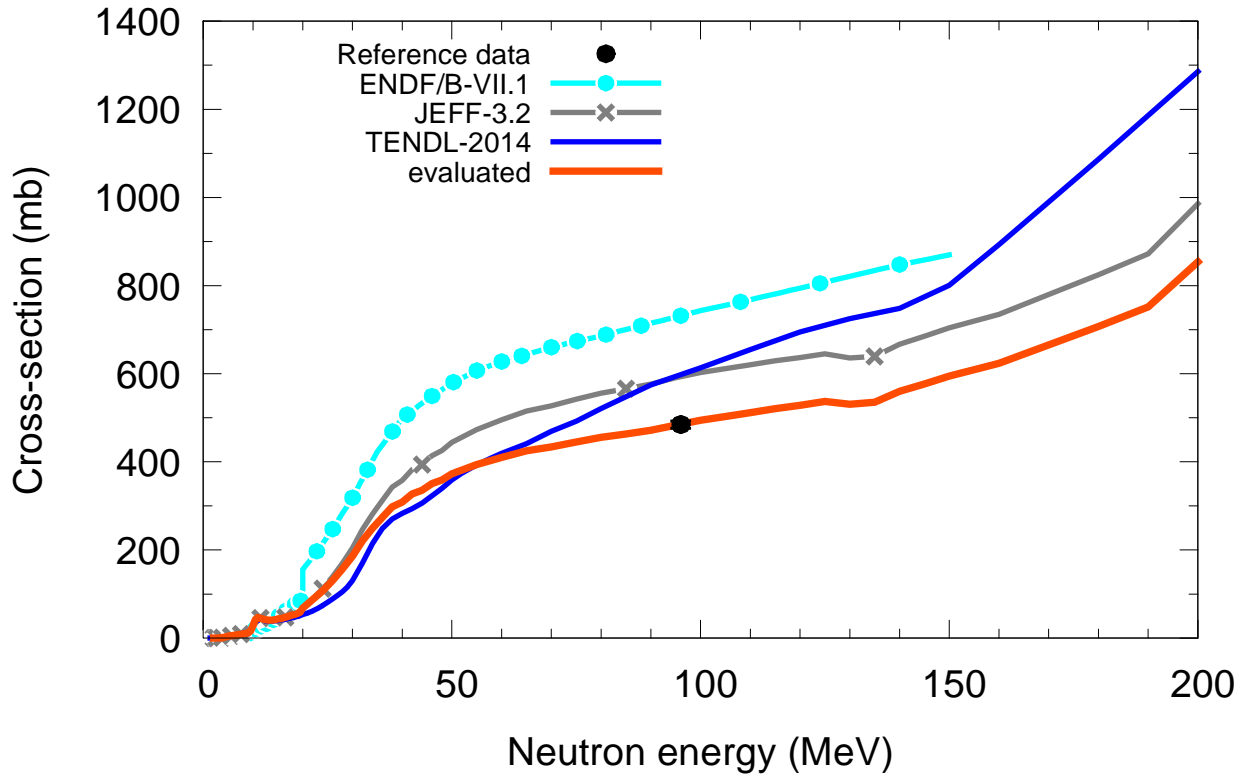




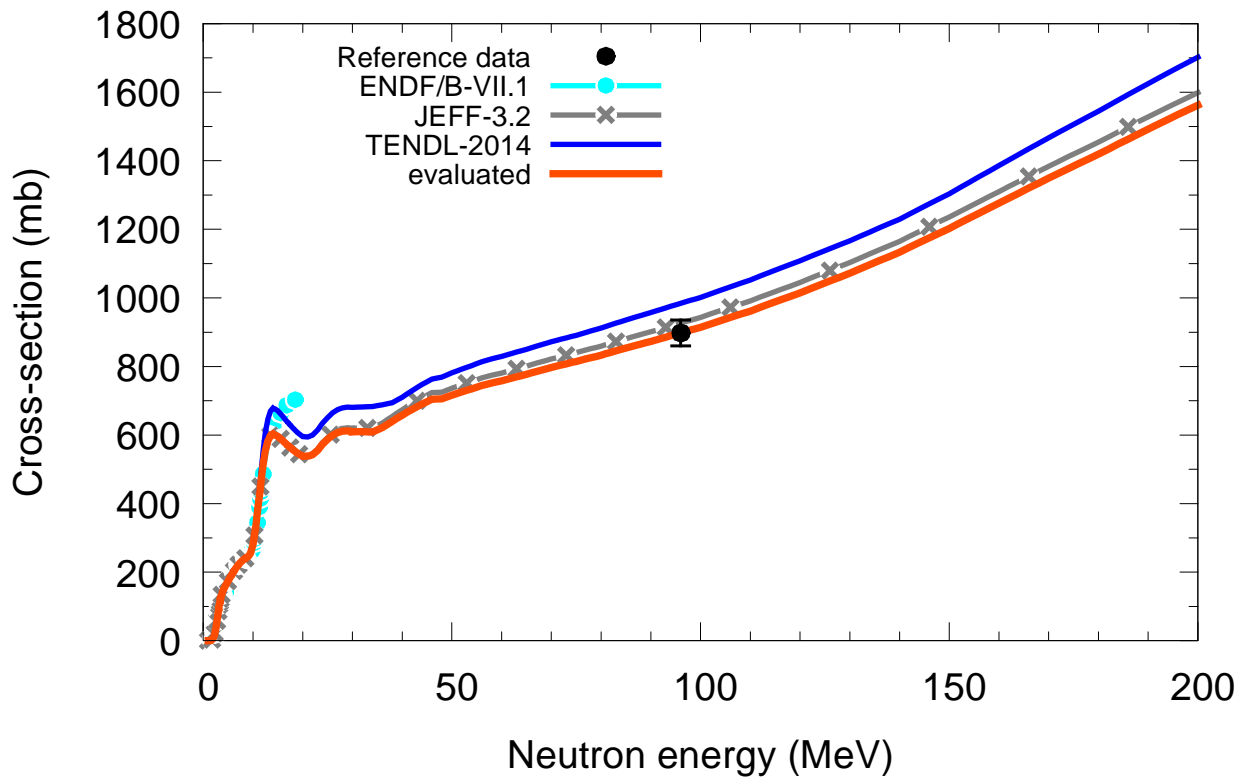


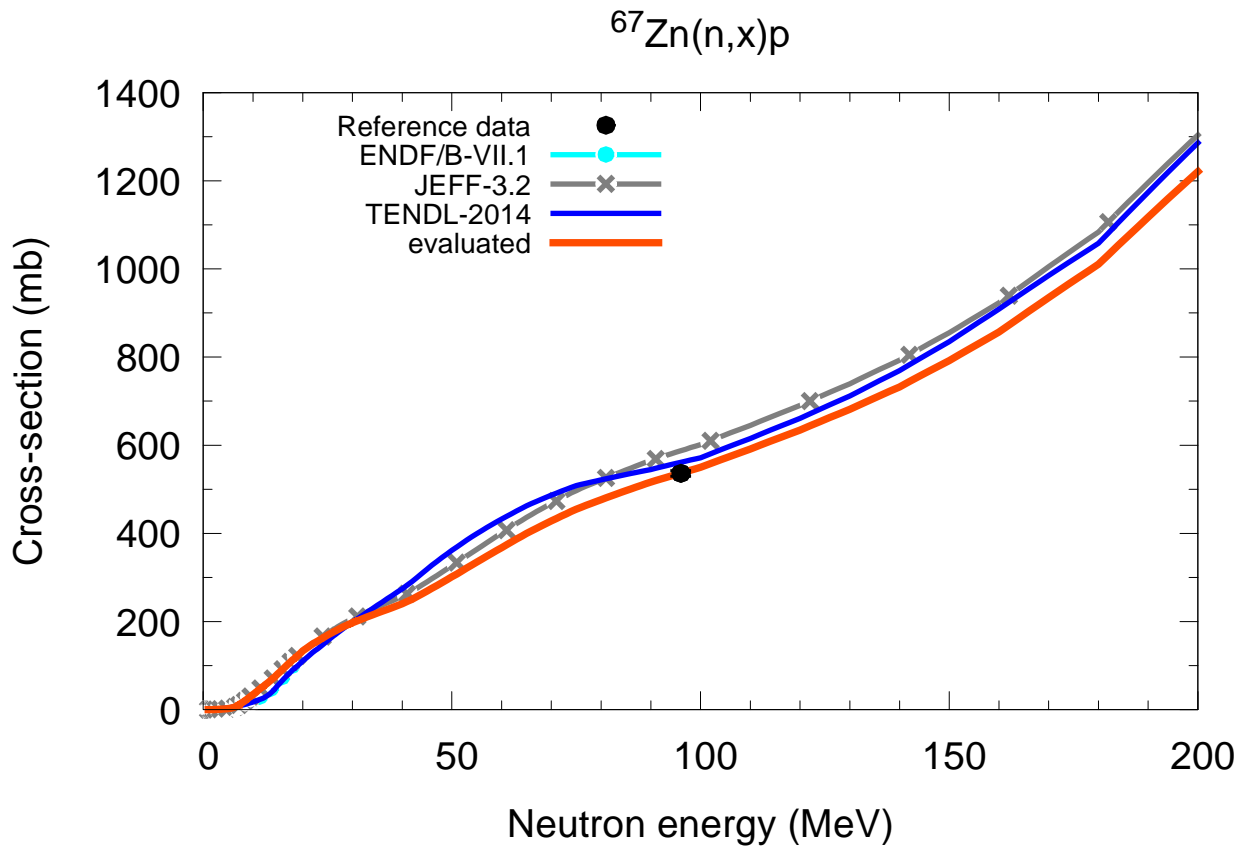
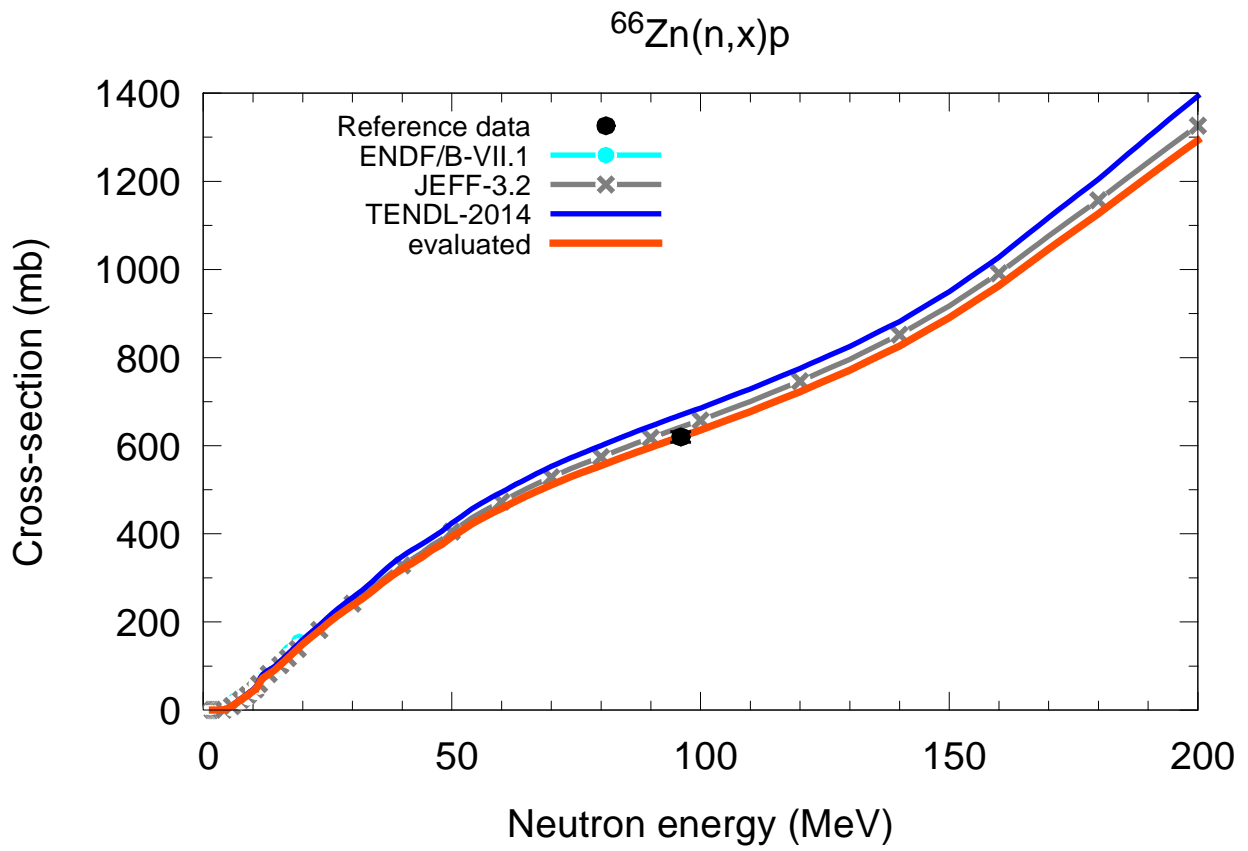


$^{65}\text{Cu}(n,x)p$

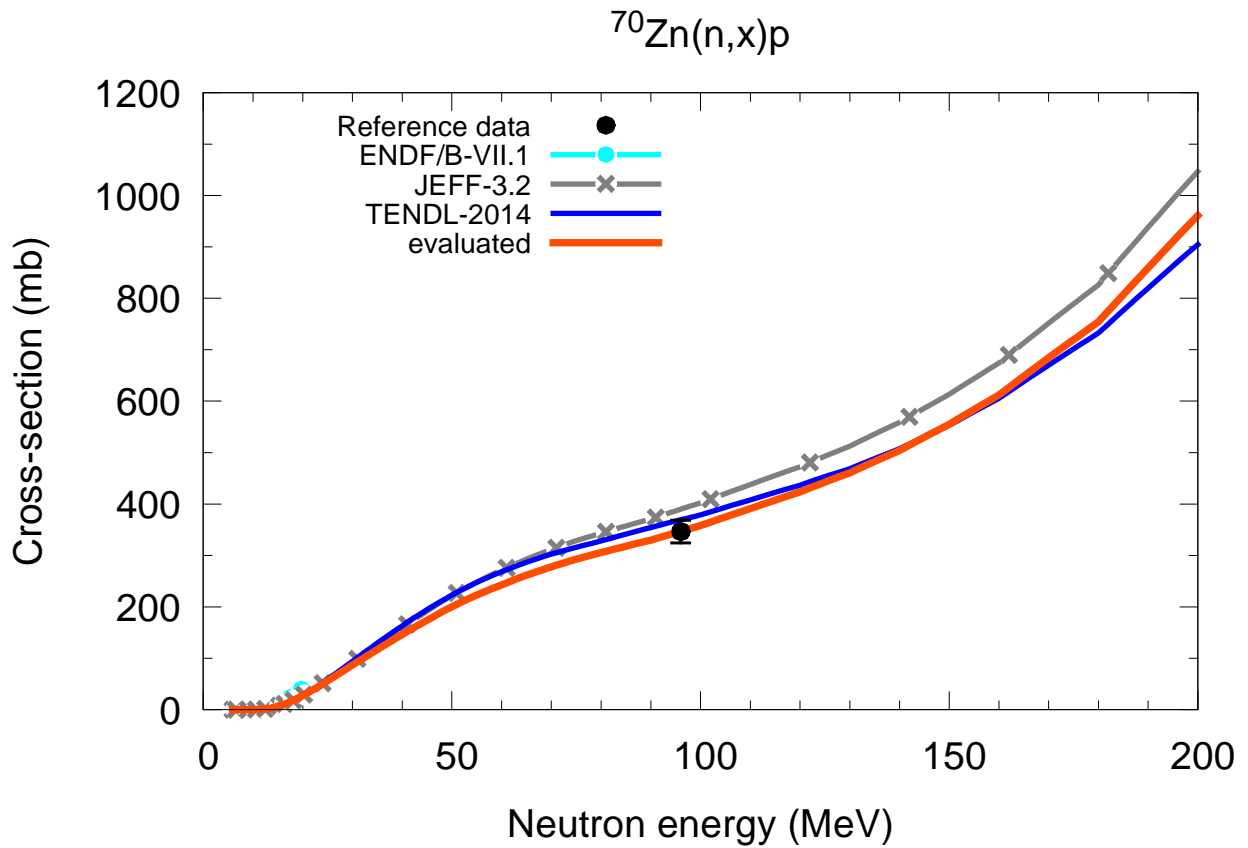
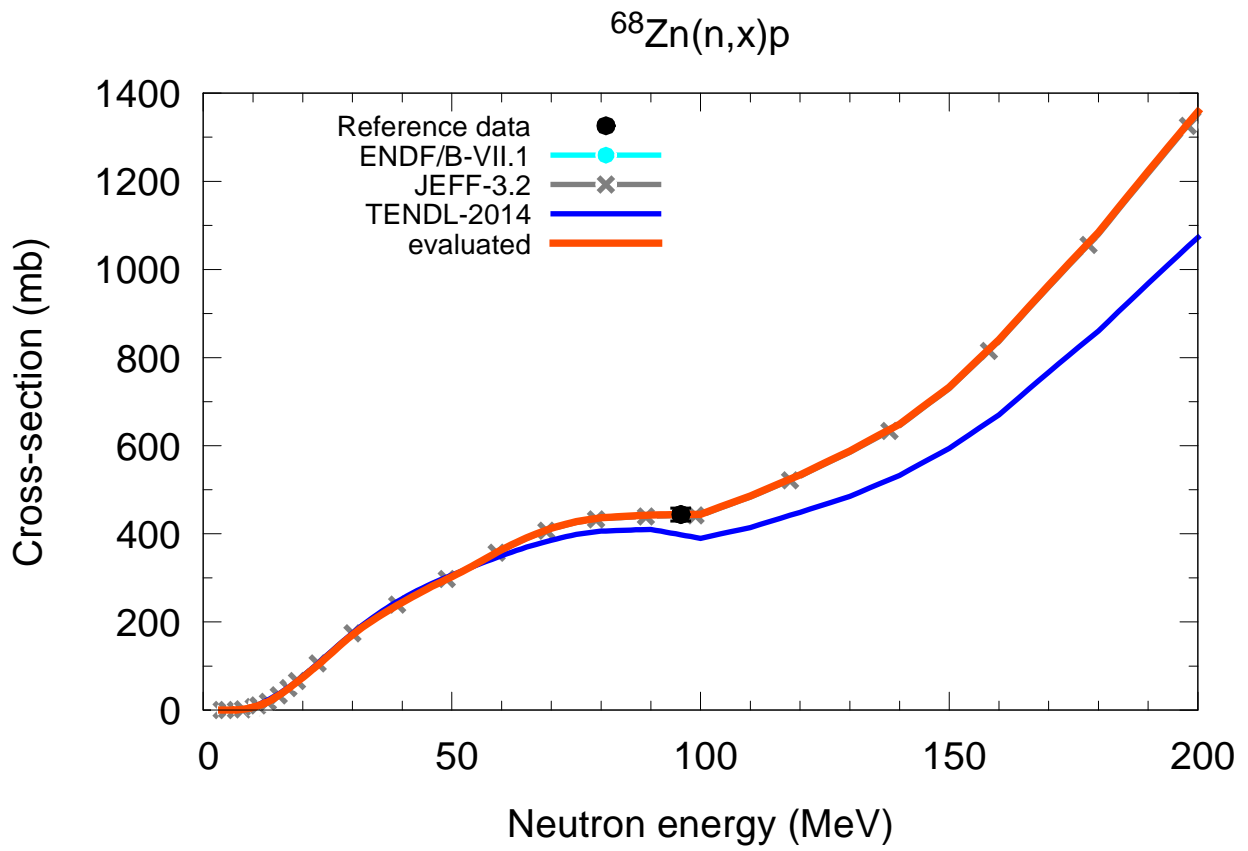


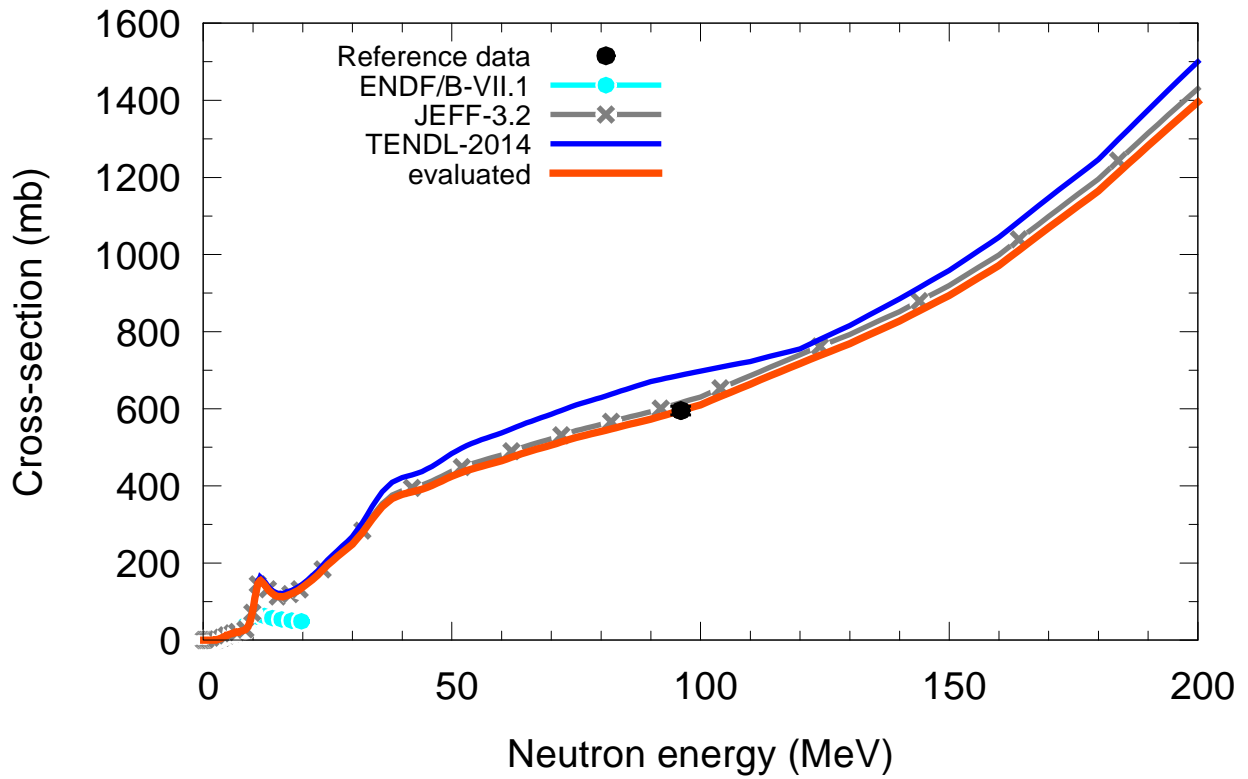
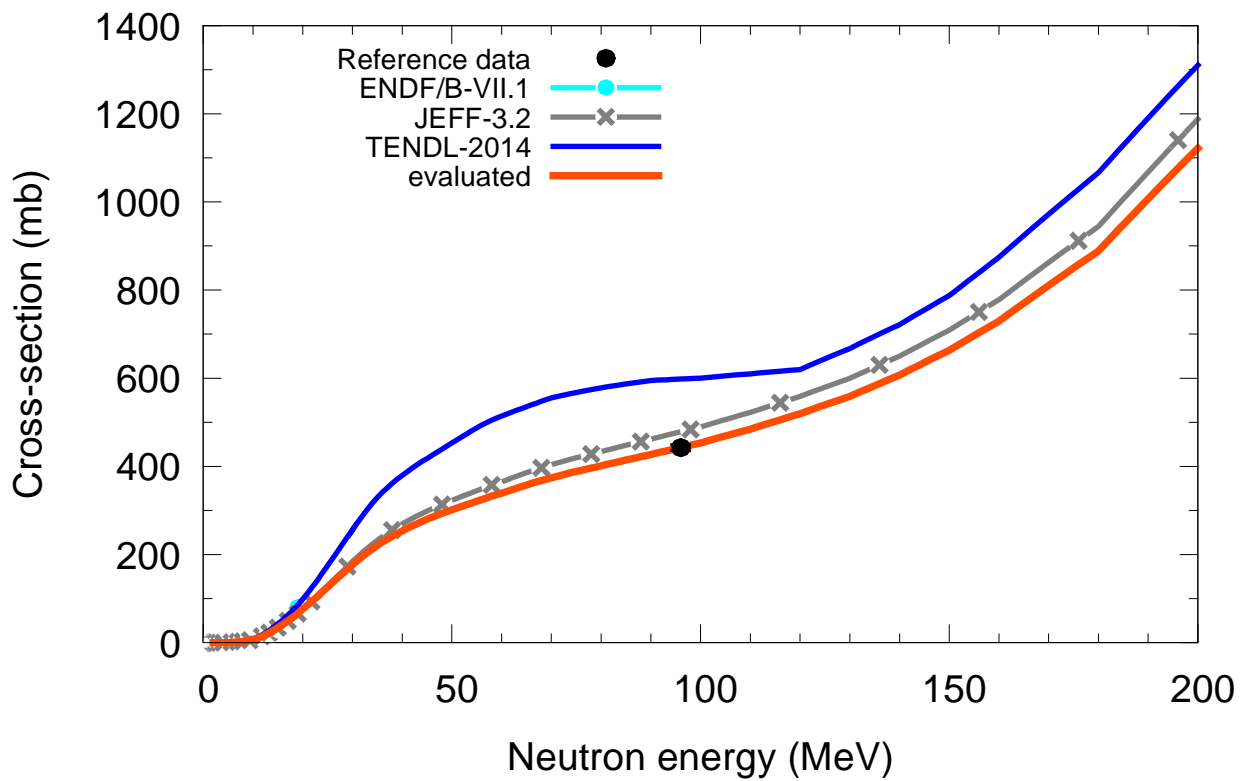
$^{64}\text{Zn}(n,x)p$



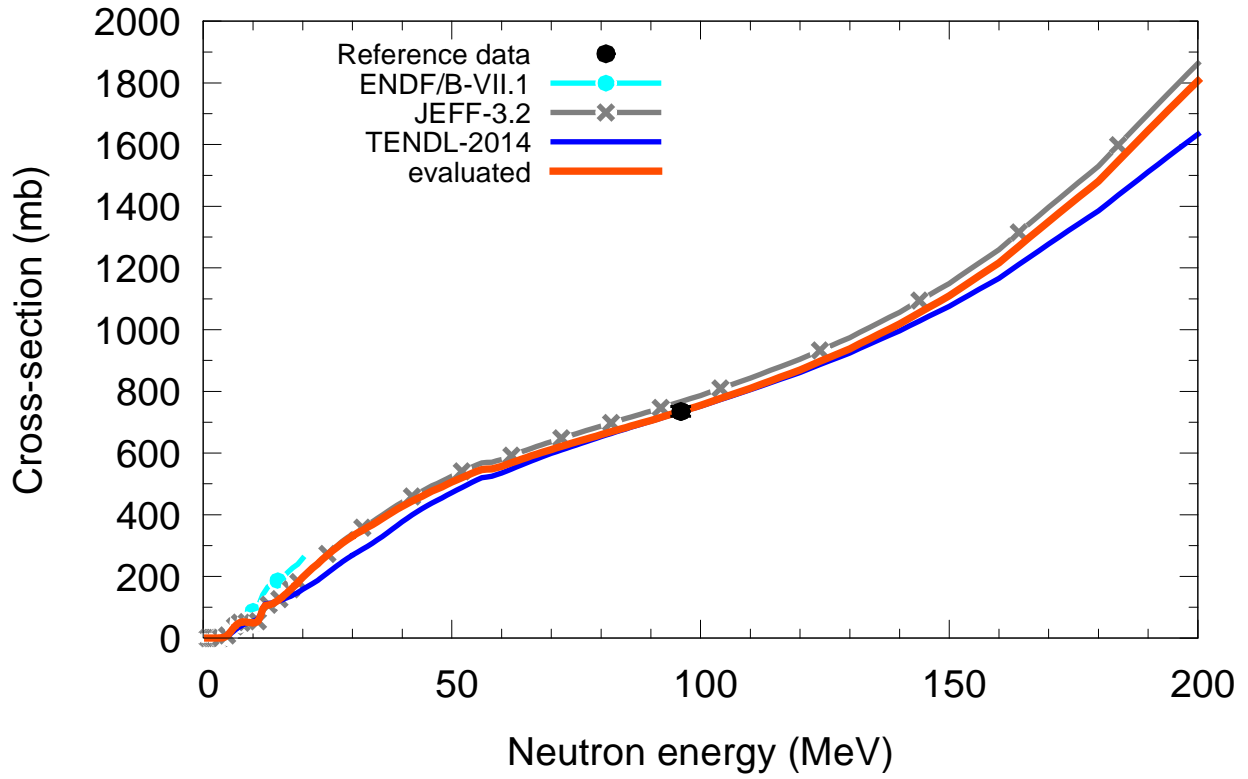




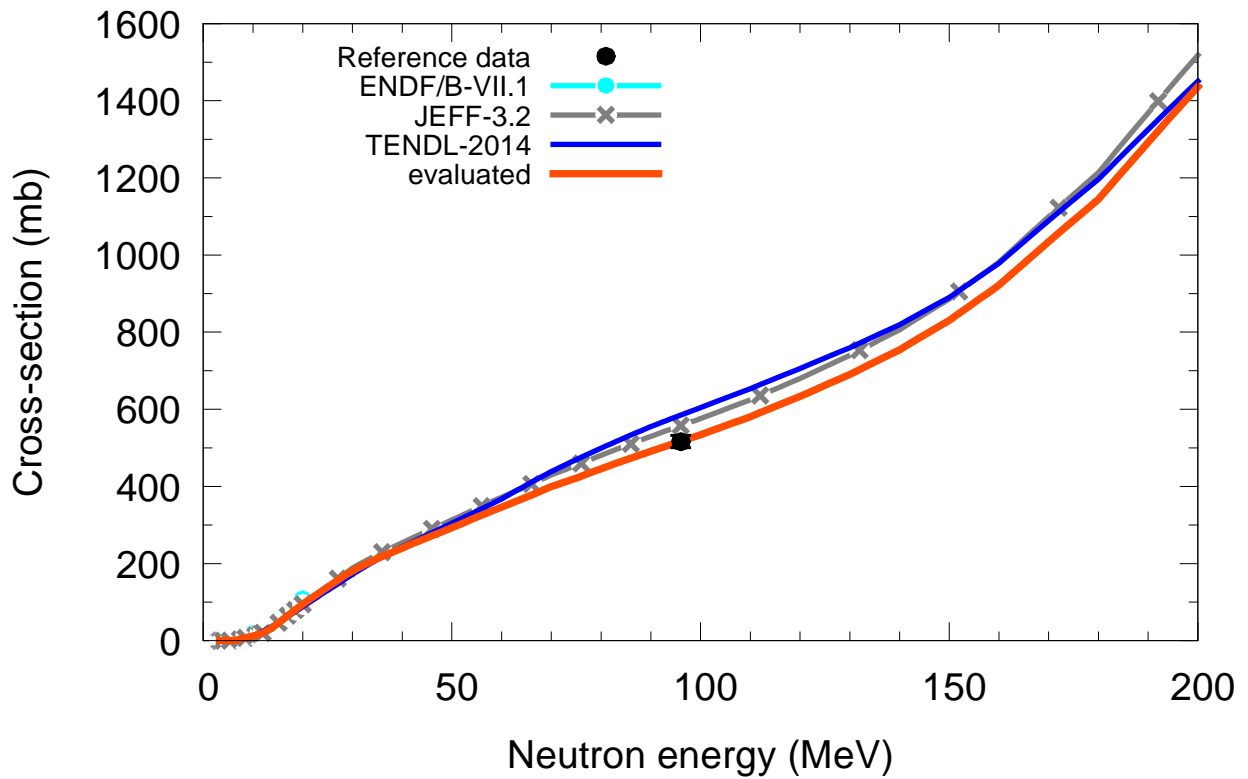


$^{69}\text{Ga}(n,x)p$  $^{71}\text{Ga}(n,x)p$ 

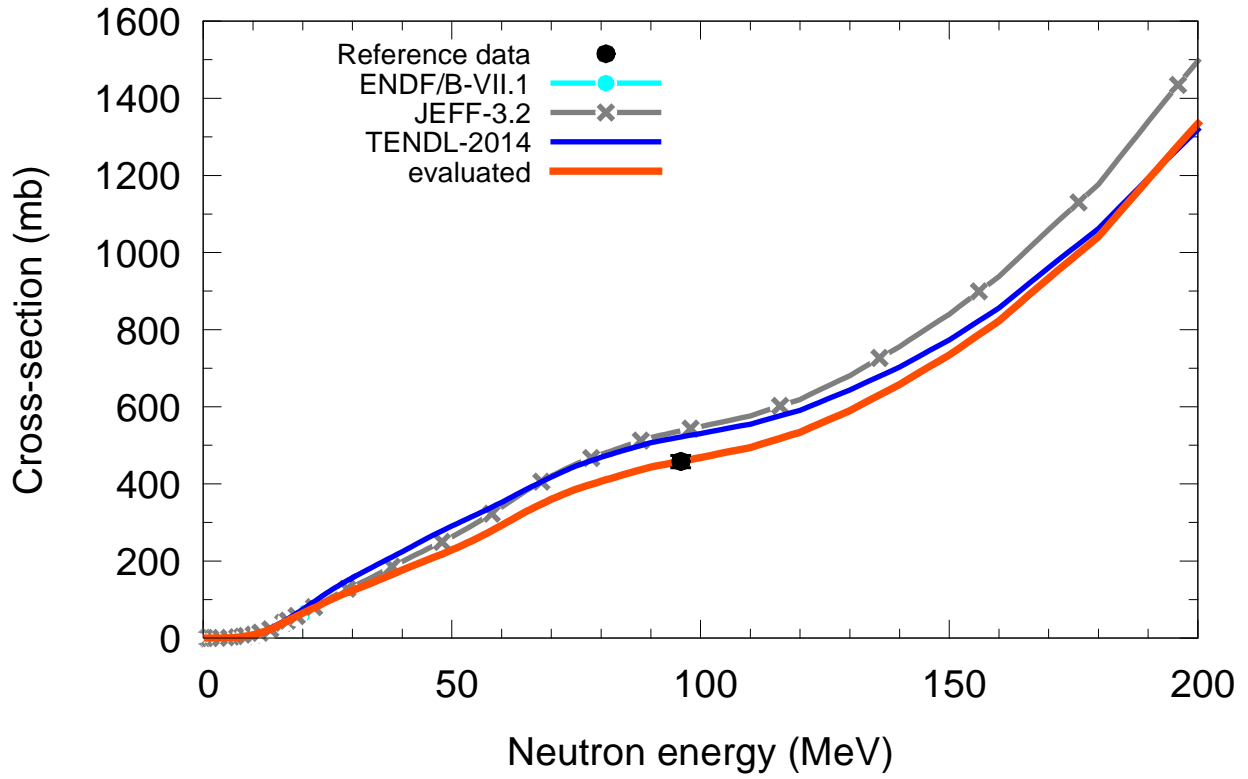
### $^{70}\text{Ge}(n,x)p$



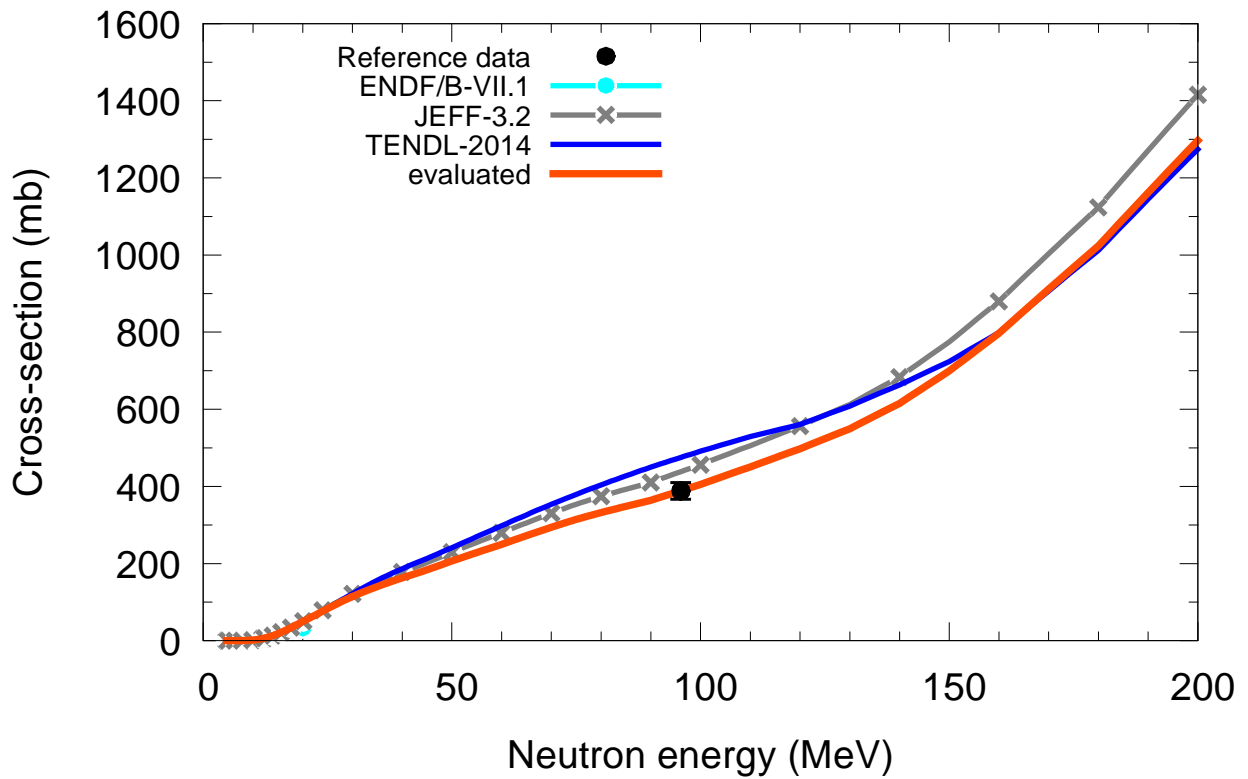
### $^{72}\text{Ge}(n,x)p$



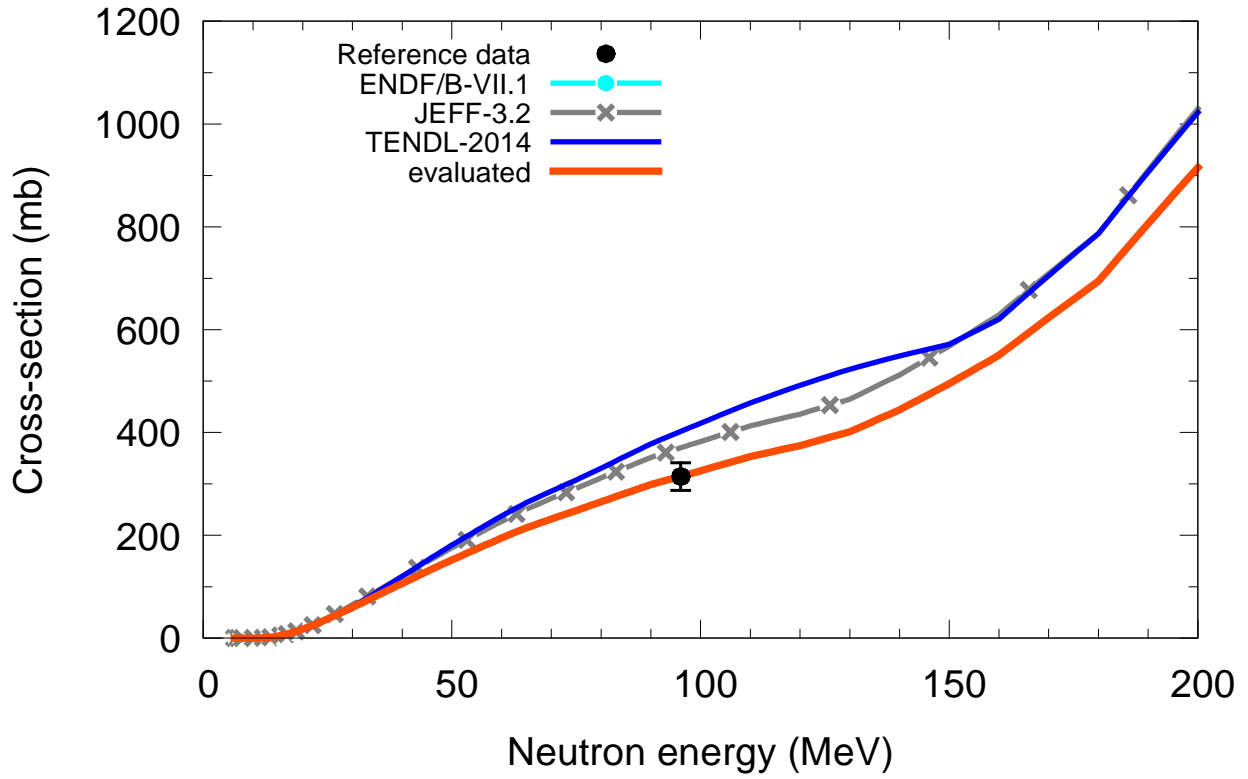
### $^{73}\text{Ge}(n,x)p$



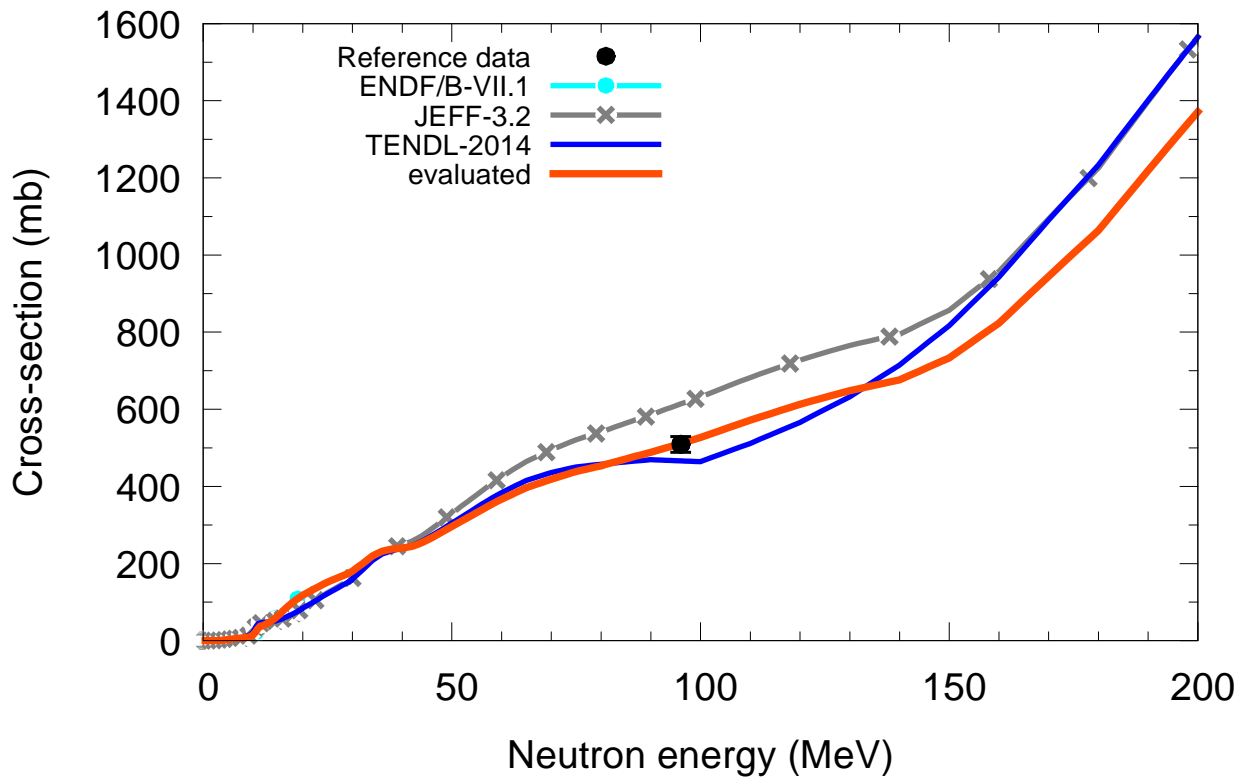
### $^{74}\text{Ge}(n,x)p$



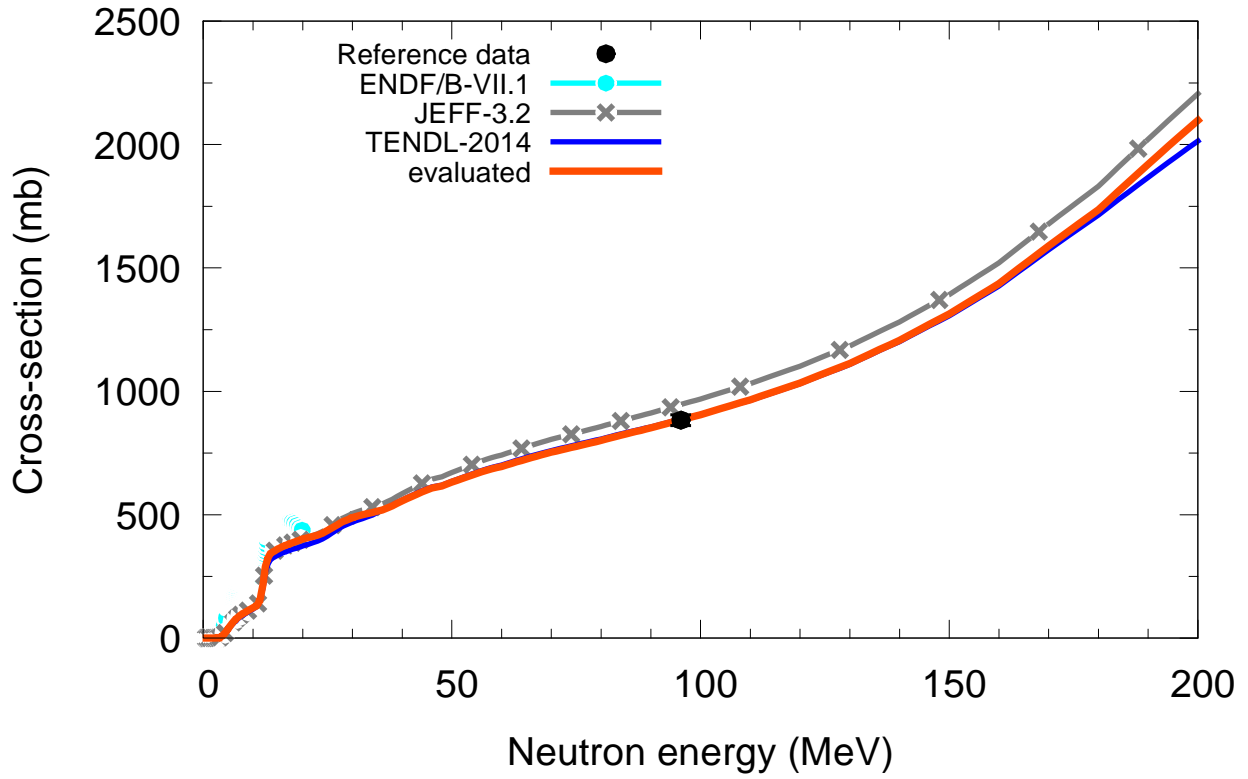
### $^{76}\text{Ge}(n,x)p$



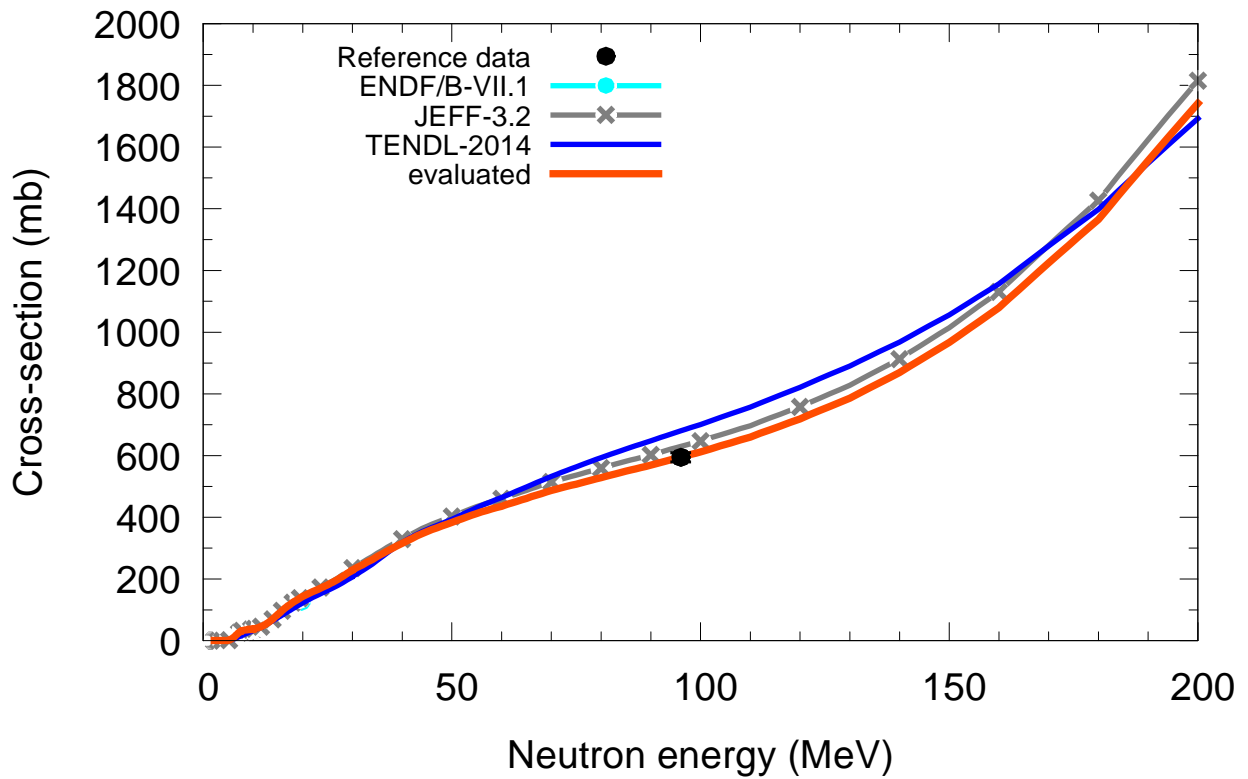
### $^{75}\text{As}(n,x)p$



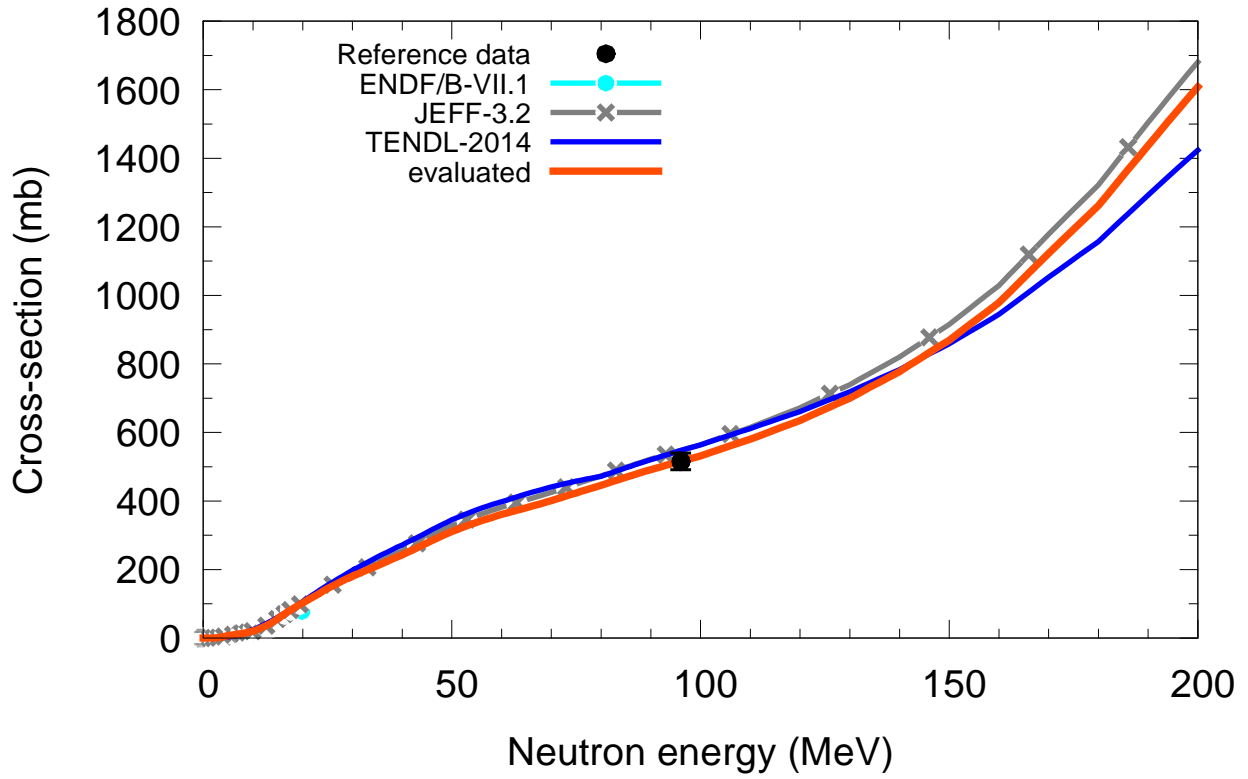
### $^{74}\text{Se}(n,x)p$



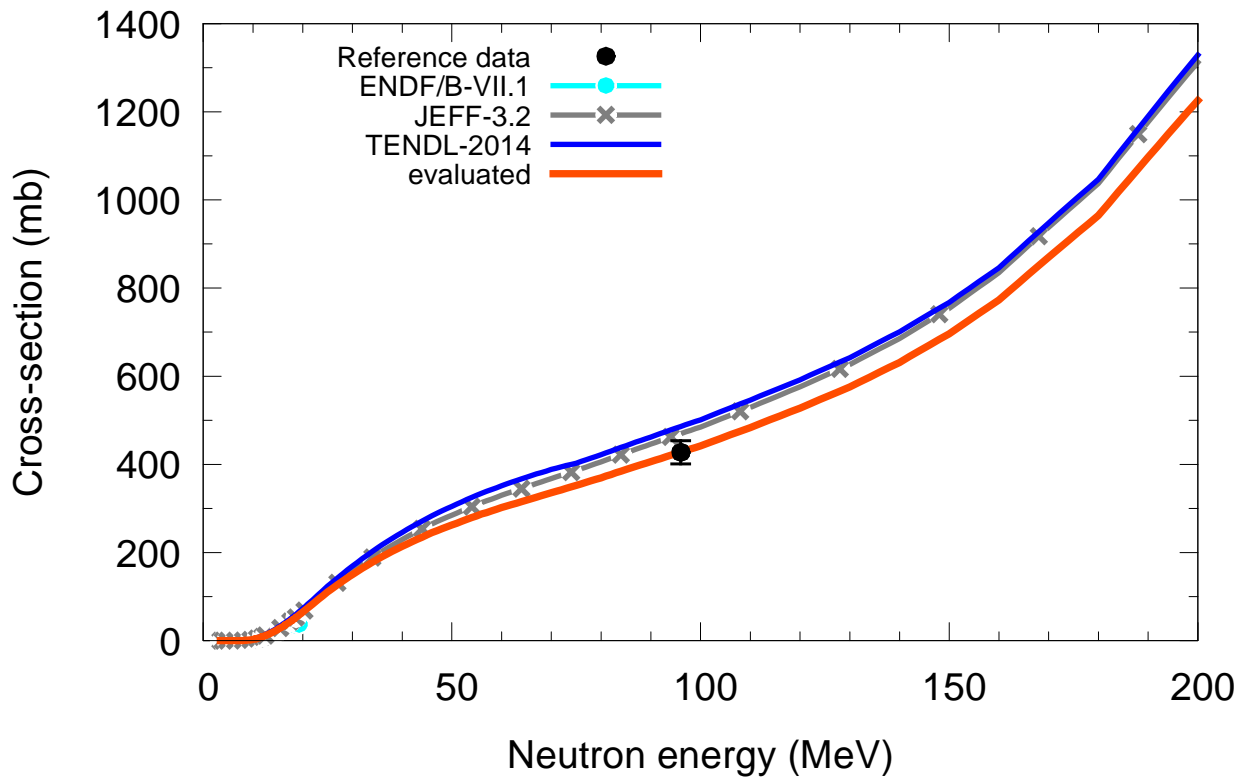
### $^{76}\text{Se}(n,x)p$



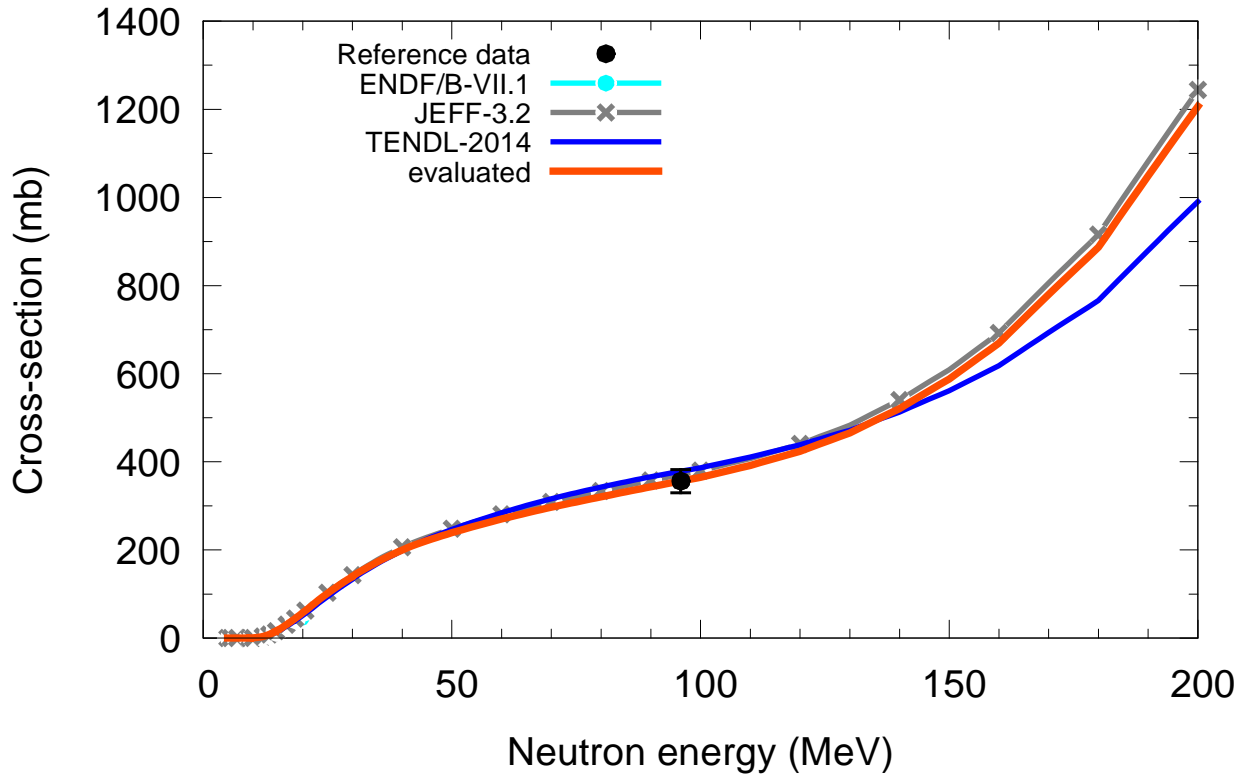
### $^{77}\text{Se}(n,x)p$



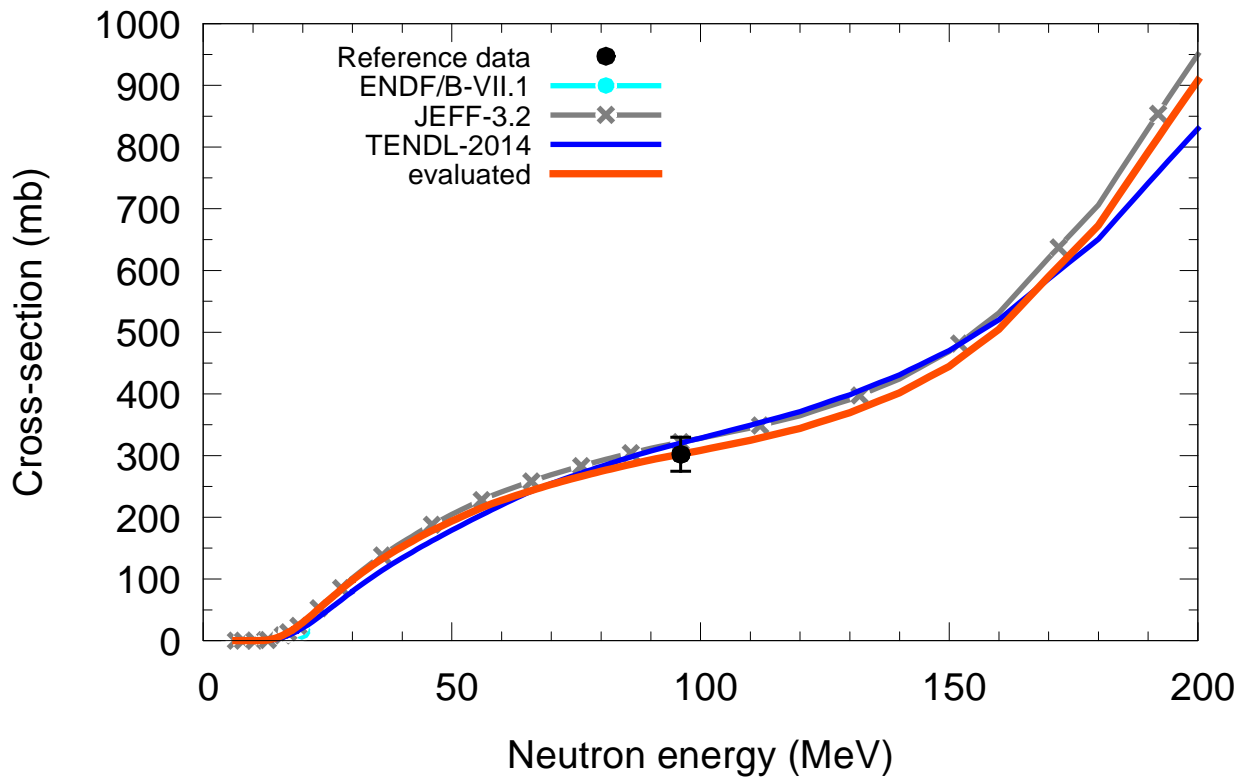
### $^{78}\text{Se}(n,x)p$



### $^{80}\text{Se}(n,x)p$

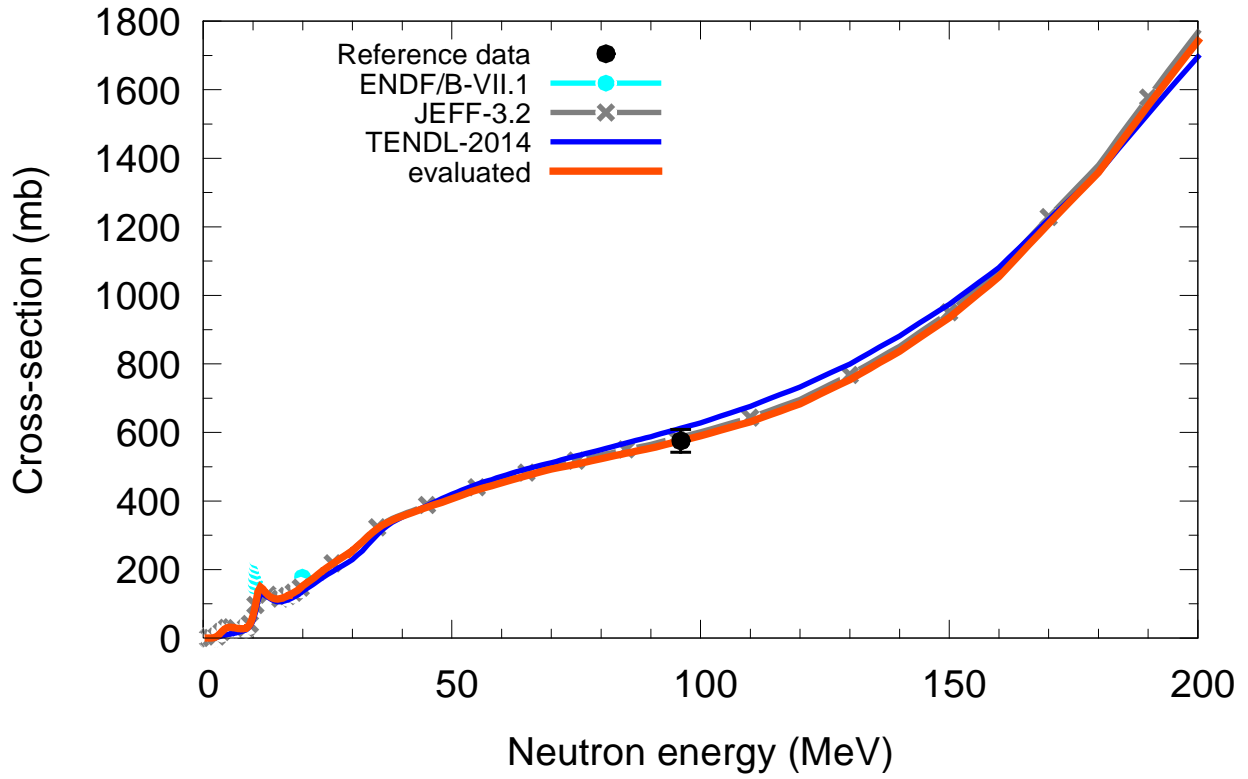


### $^{82}\text{Se}(n,x)p$

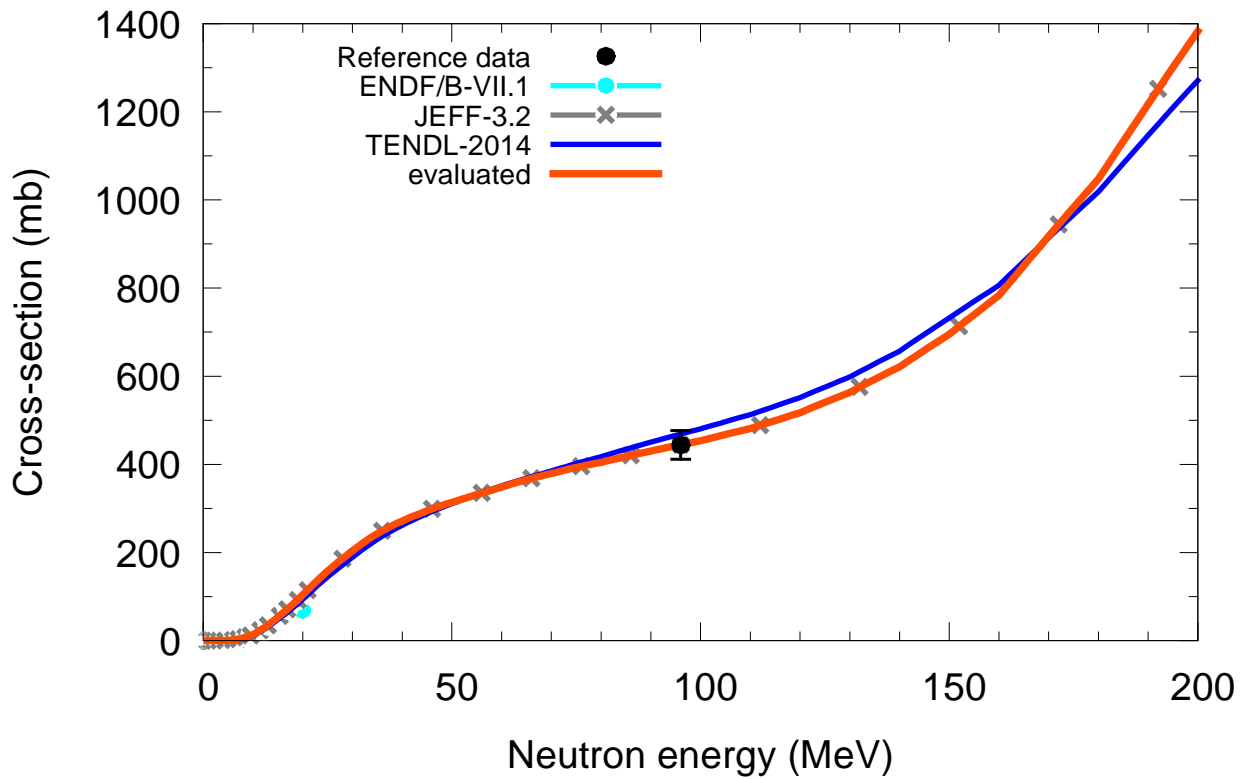




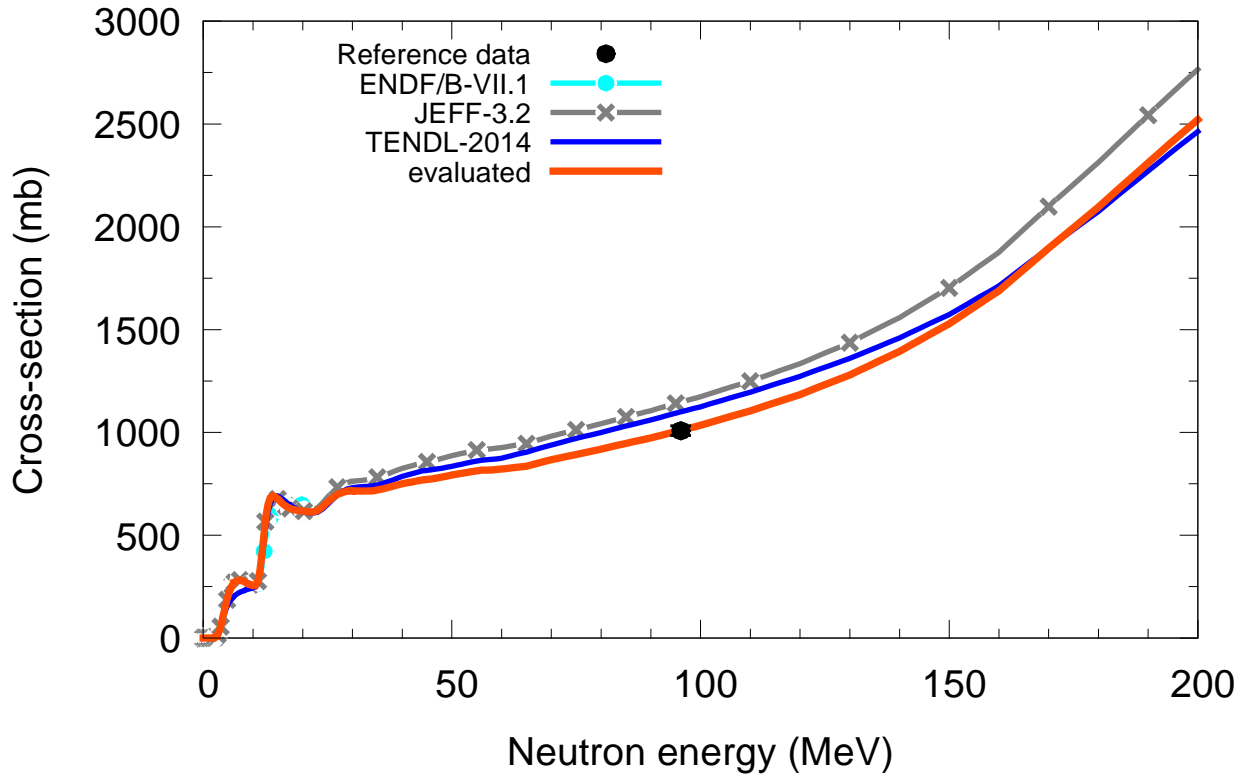
### $^{79}\text{Br}(n,x)p$



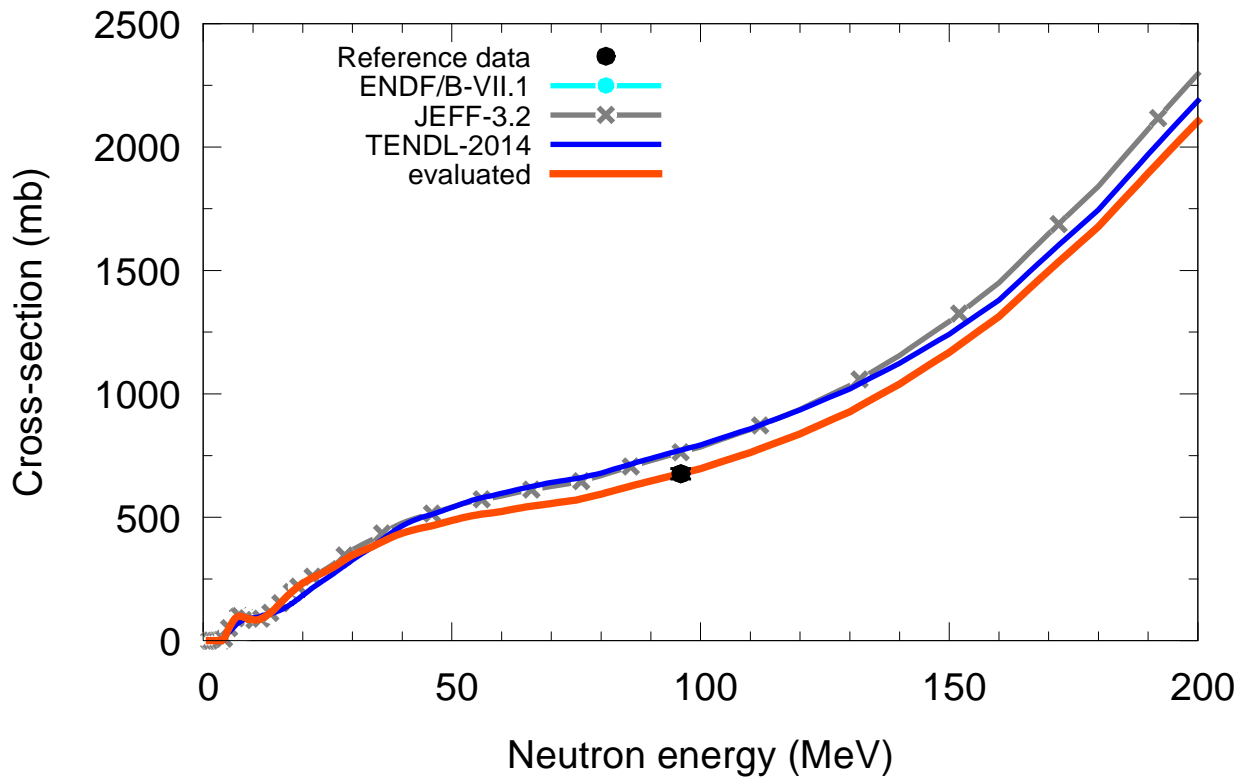
### $^{81}\text{Br}(n,x)p$

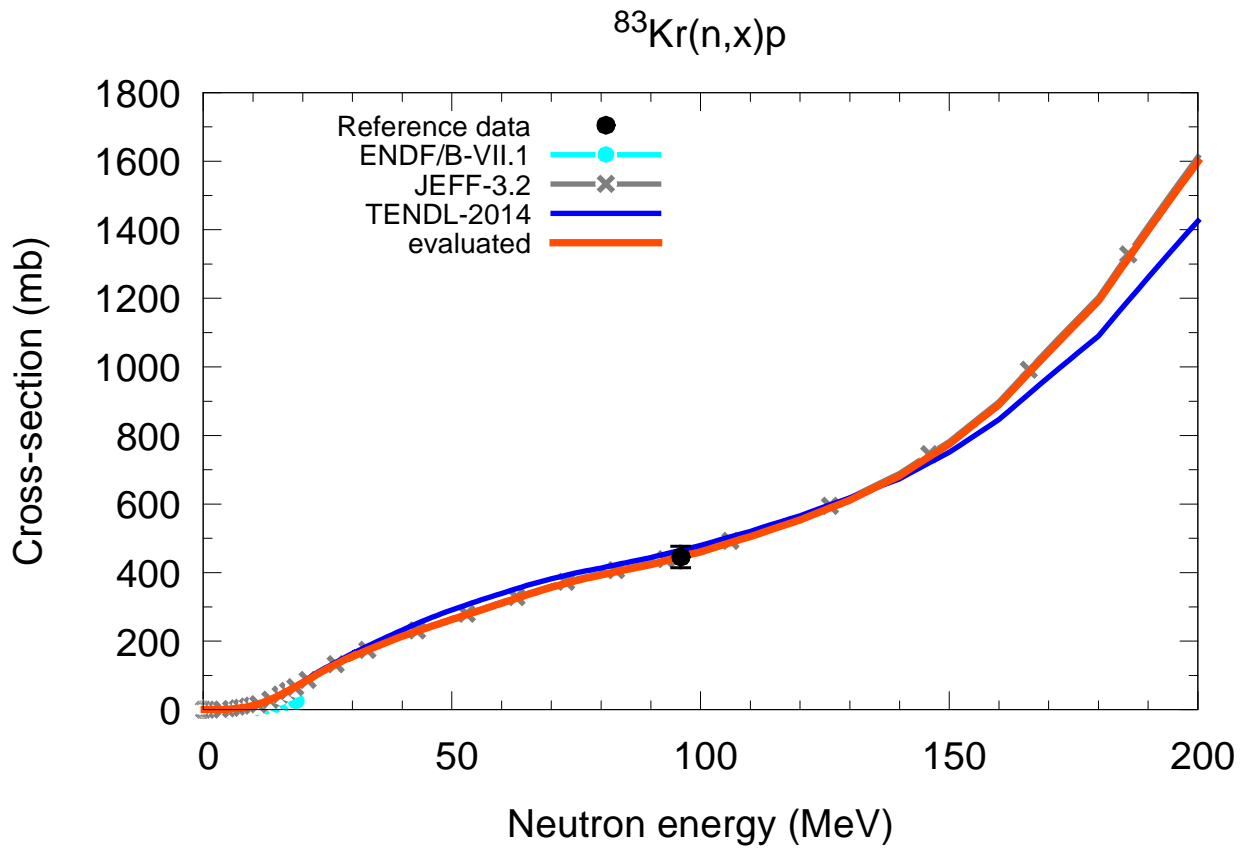
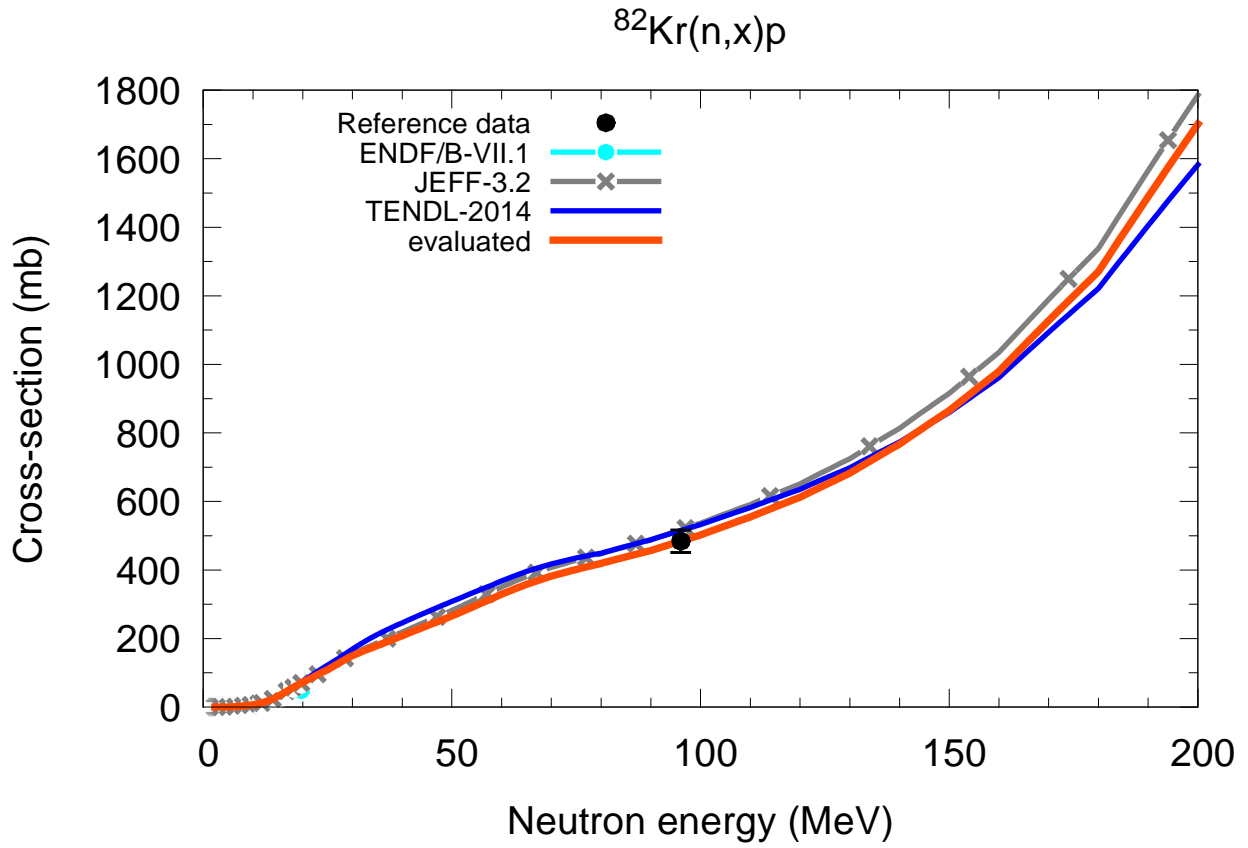


$^{78}\text{Kr}(n,x)p$

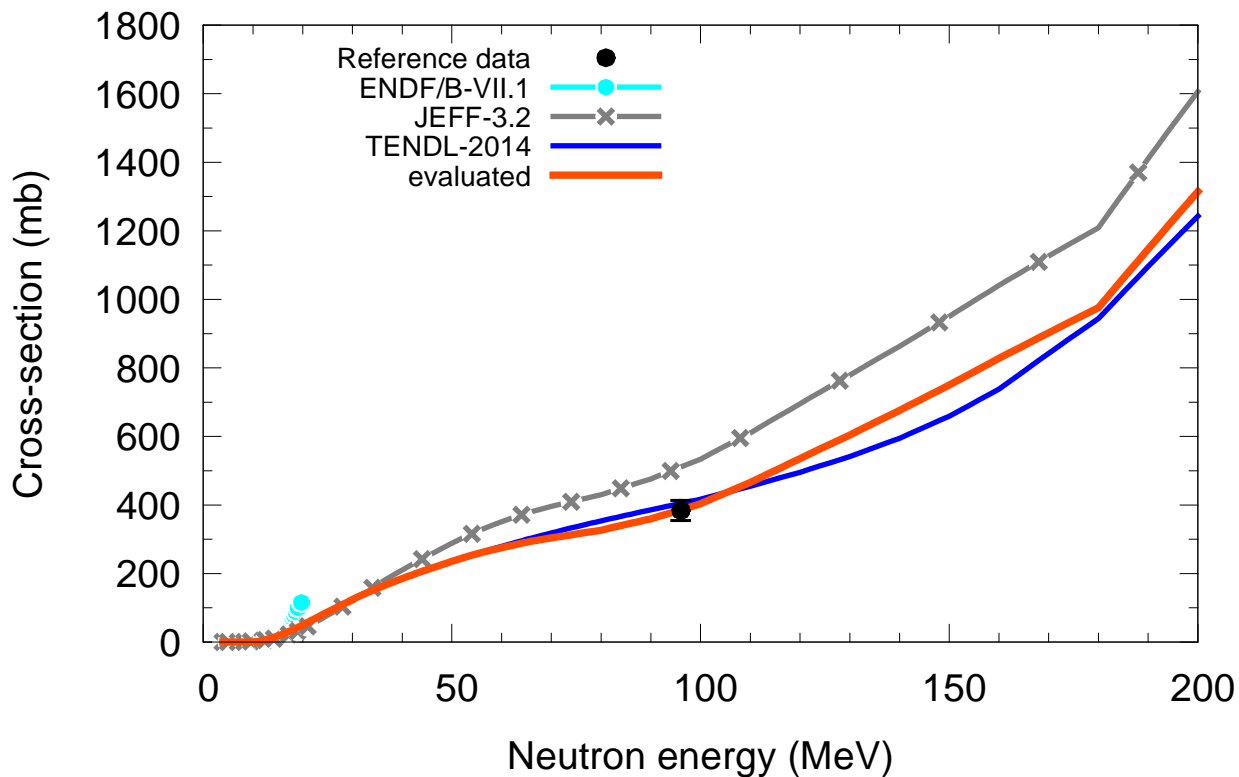


$^{80}\text{Kr}(n,x)p$

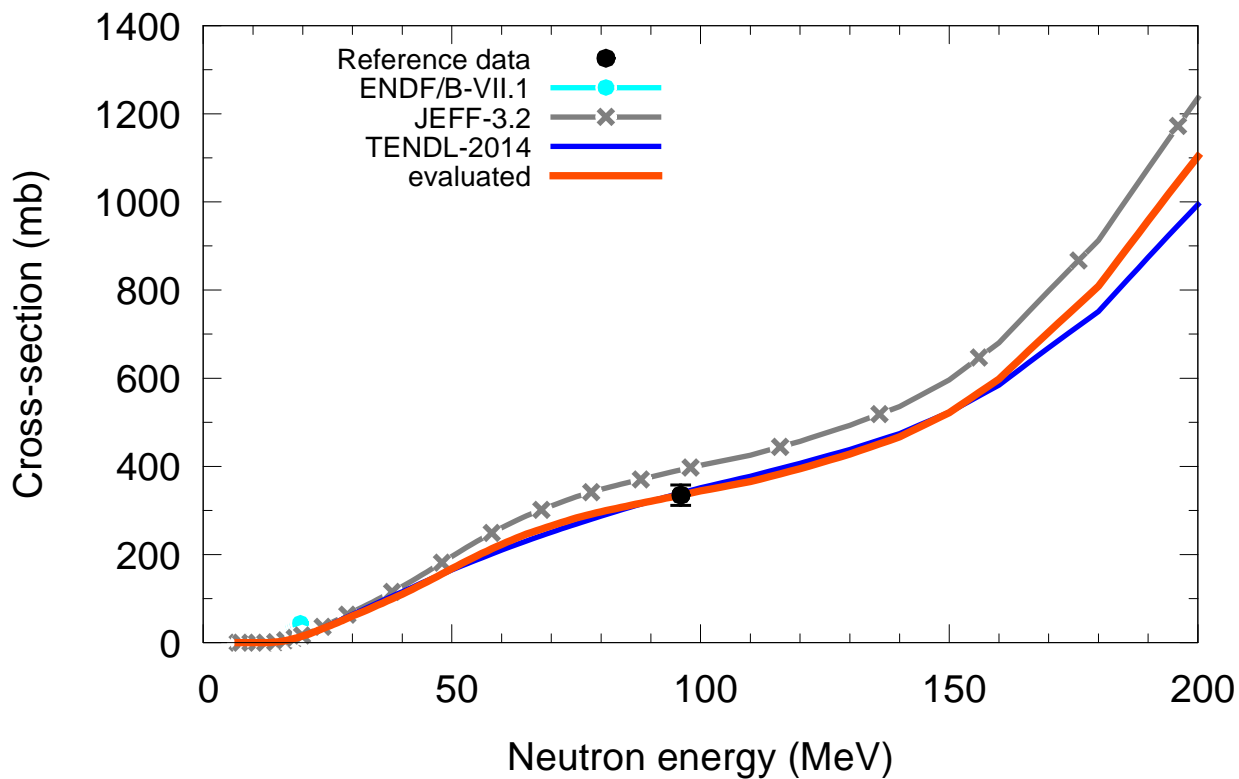




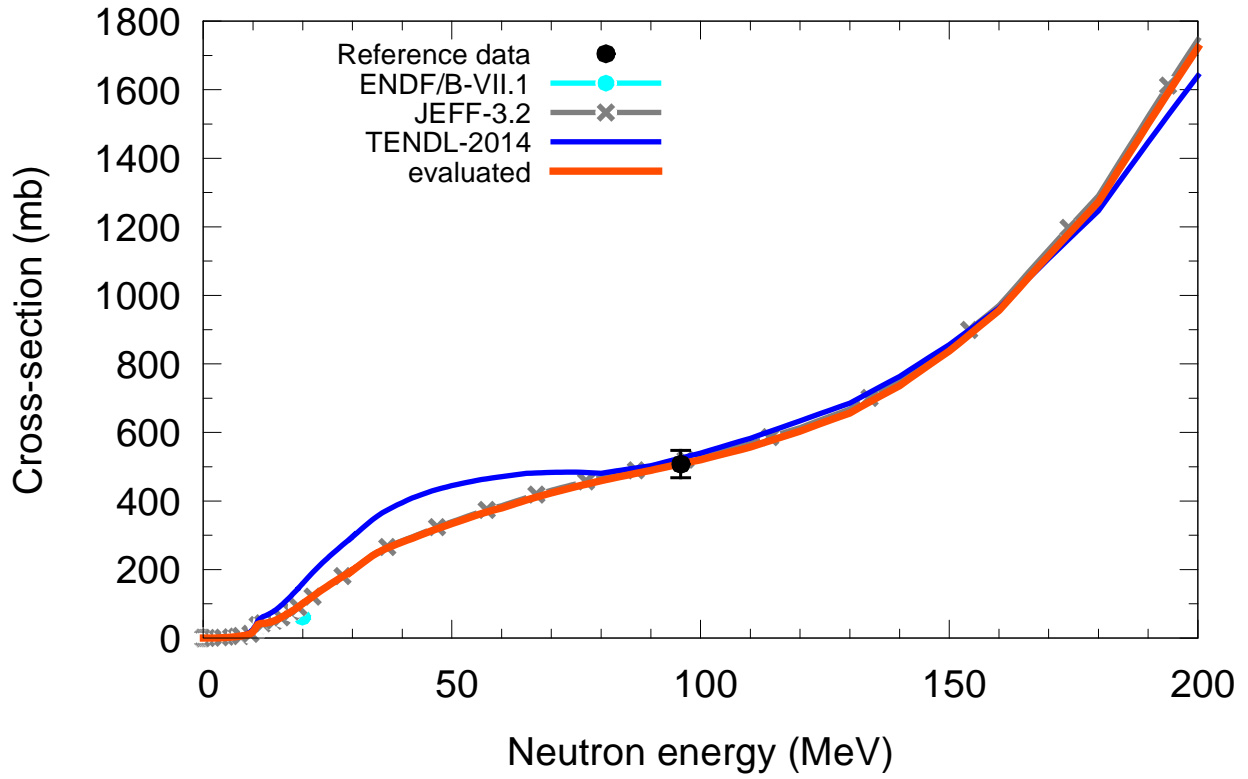
### $^{84}\text{Kr}(n,x)p$



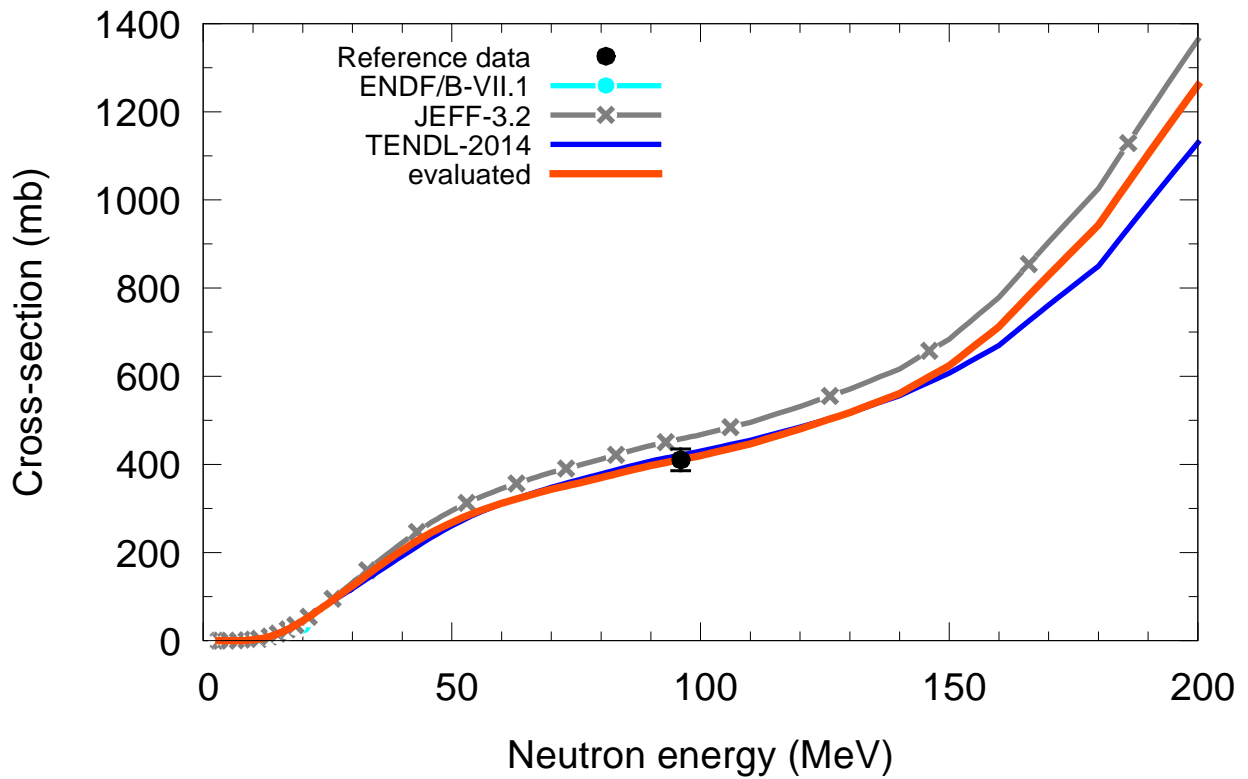
### $^{86}\text{Kr}(n,x)p$



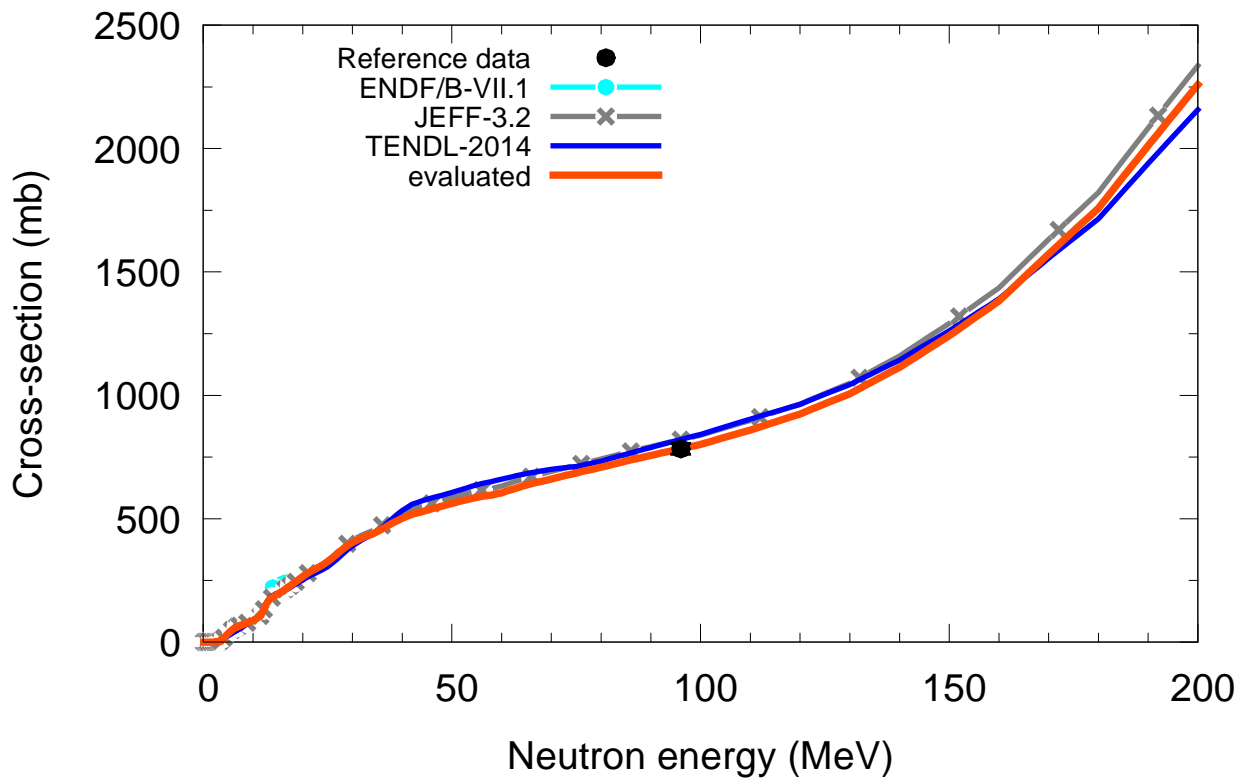
### $^{85}\text{Rb}(n,x)p$



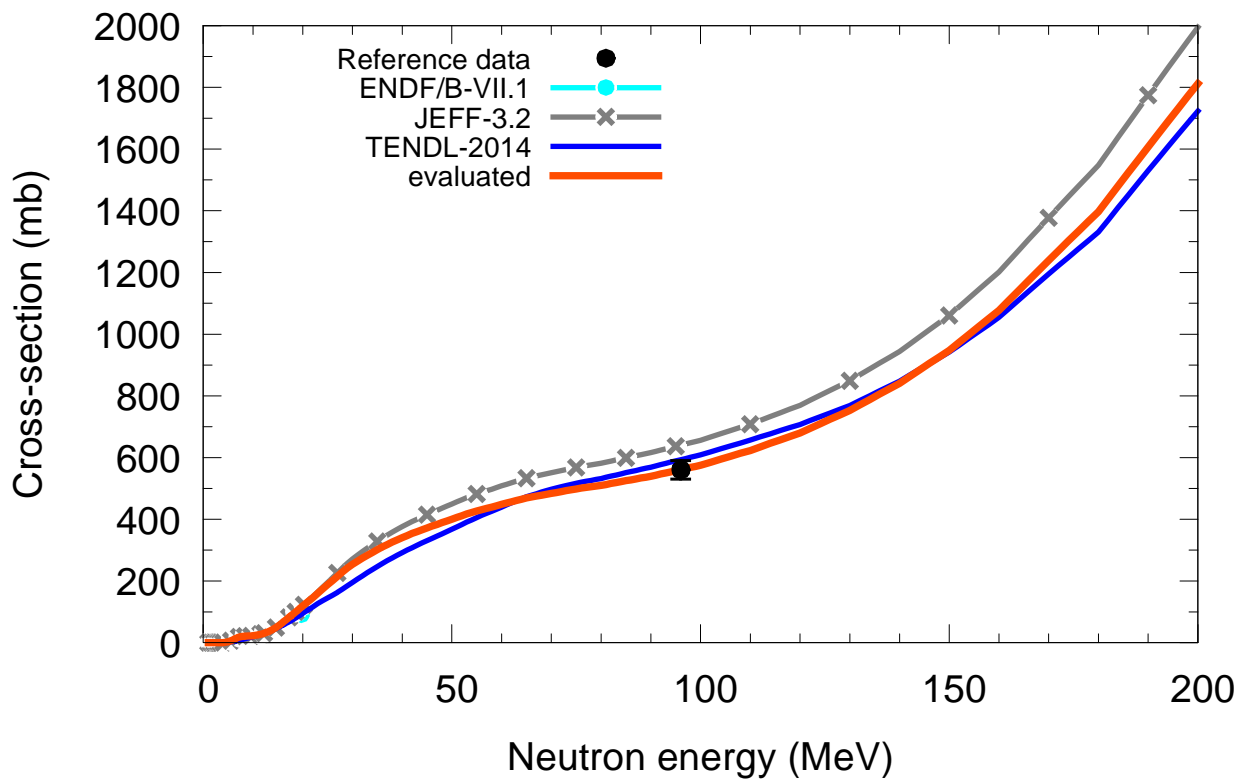
### $^{87}\text{Rb}(n,x)p$



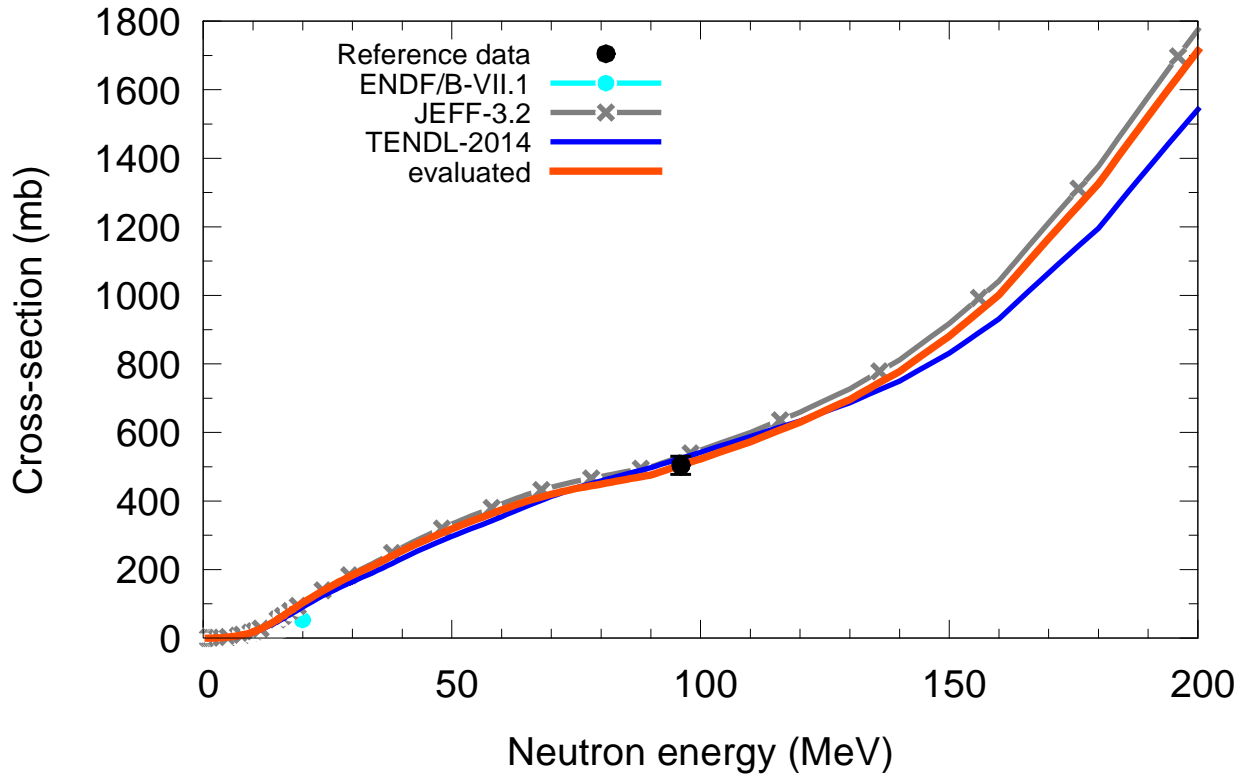
### $^{84}\text{Sr}(n,x)p$



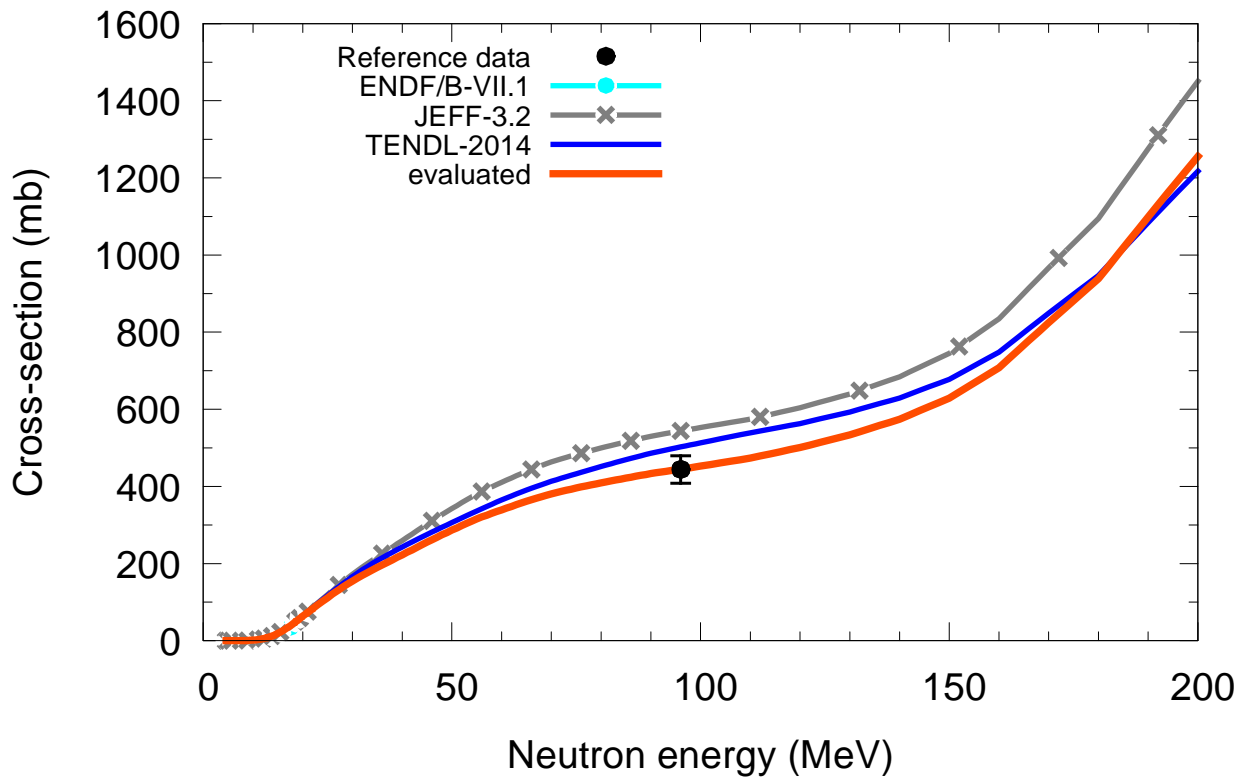
### $^{86}\text{Sr}(n,x)p$

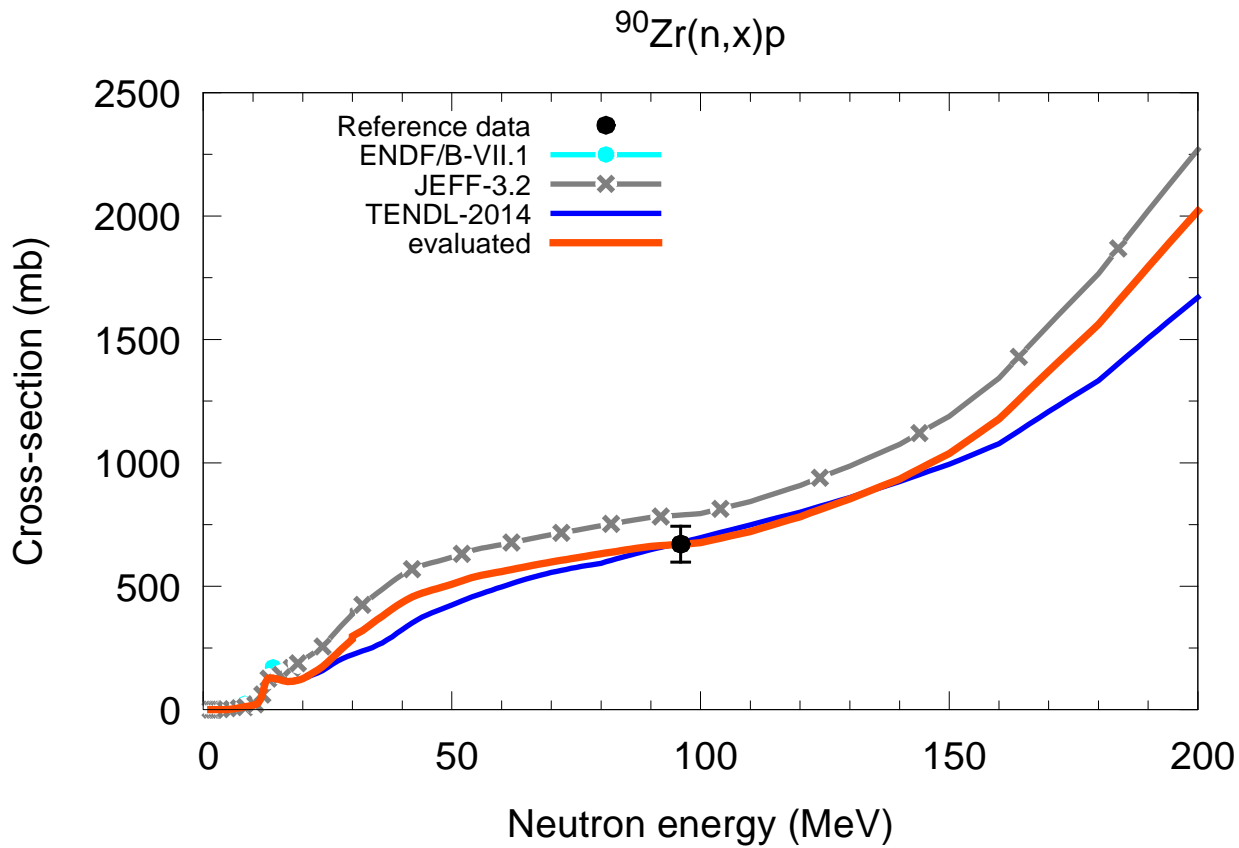
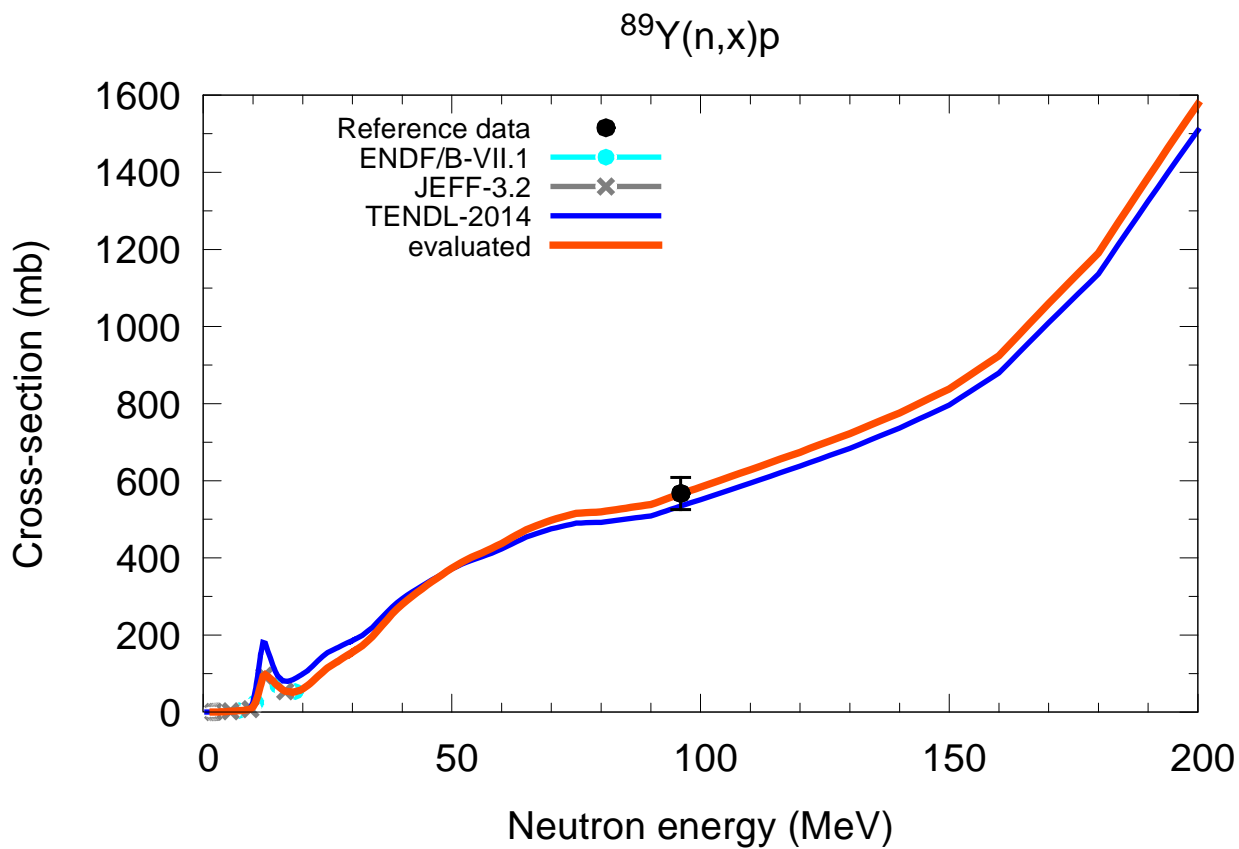


### $^{87}\text{Sr}(n,x)p$



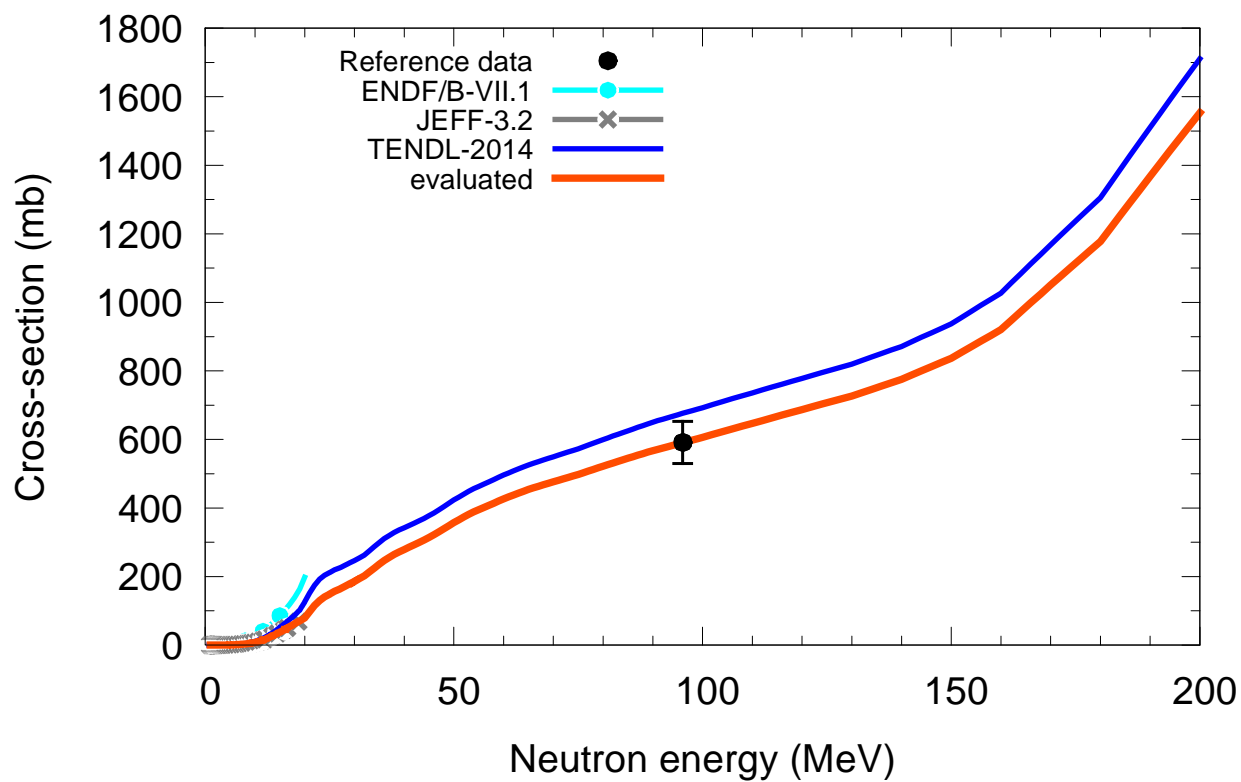
### $^{88}\text{Sr}(n,x)p$



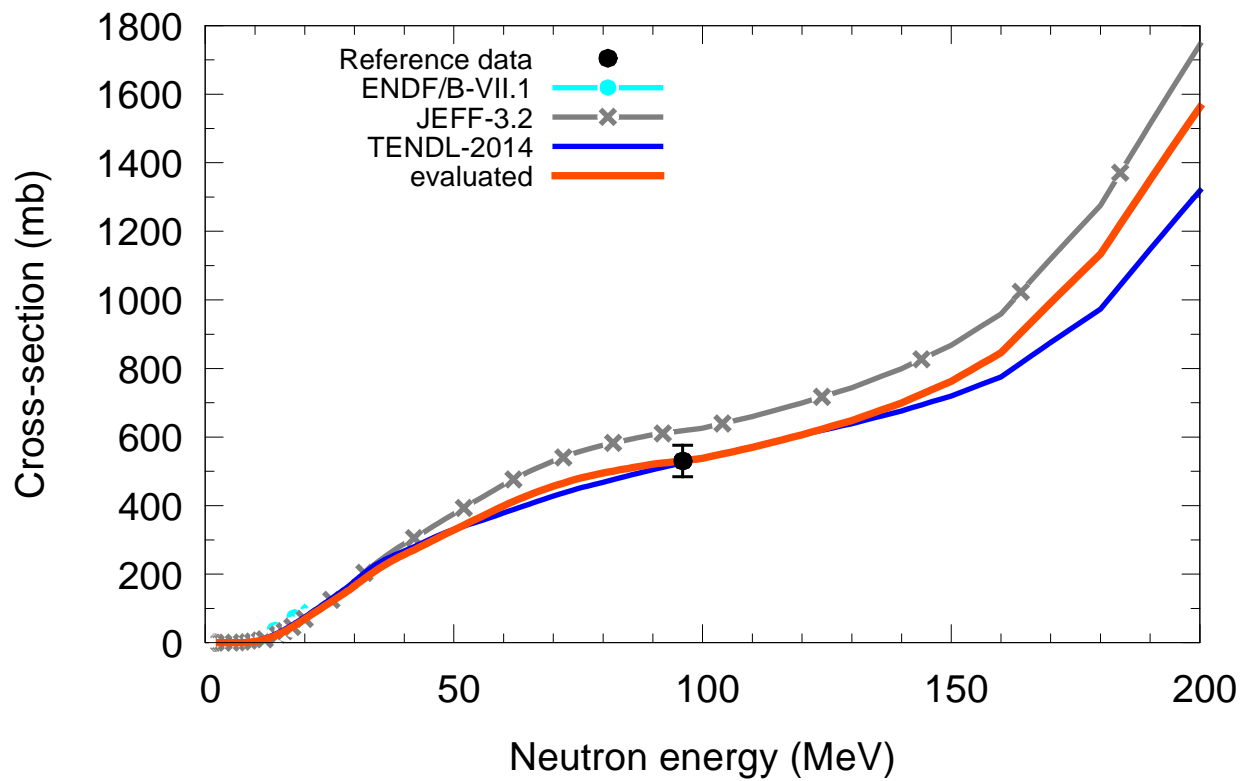




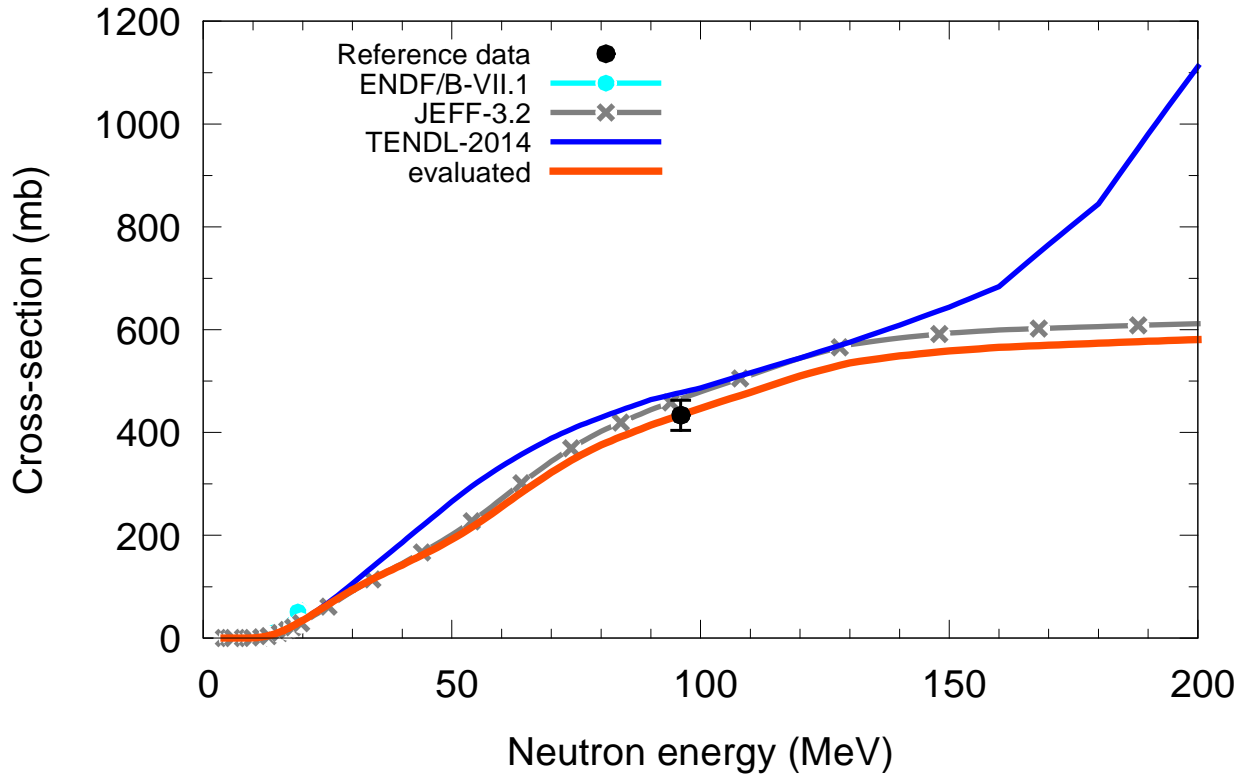
### $^{91}\text{Zr}(n,x)p$



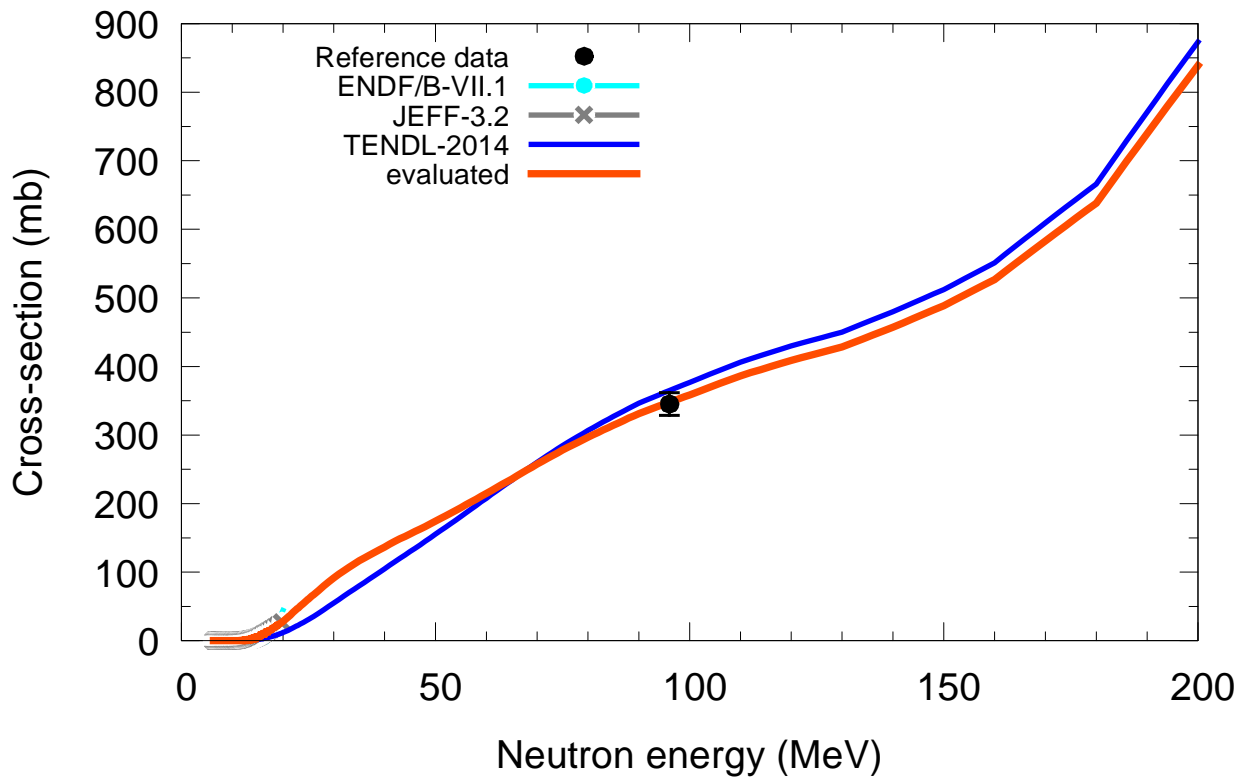
### $^{92}\text{Zr}(n,x)p$

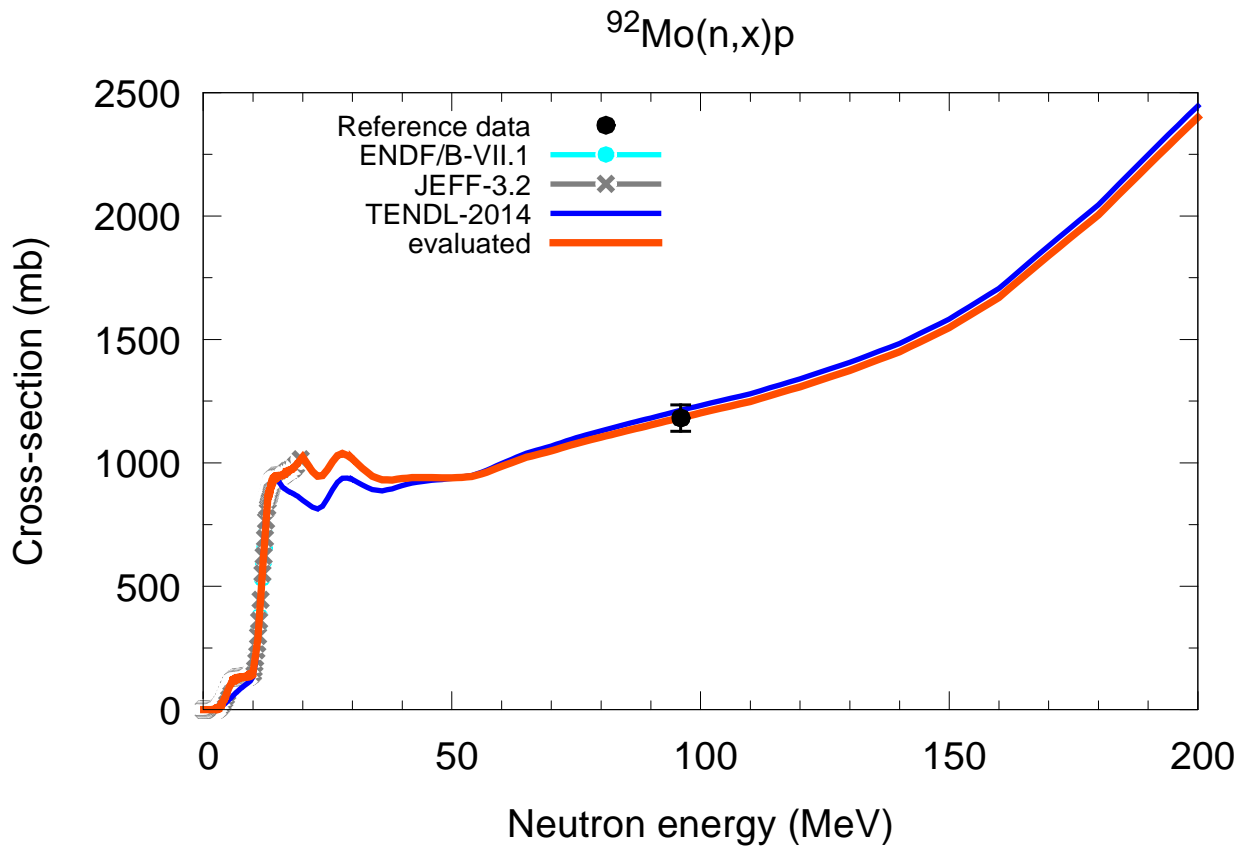
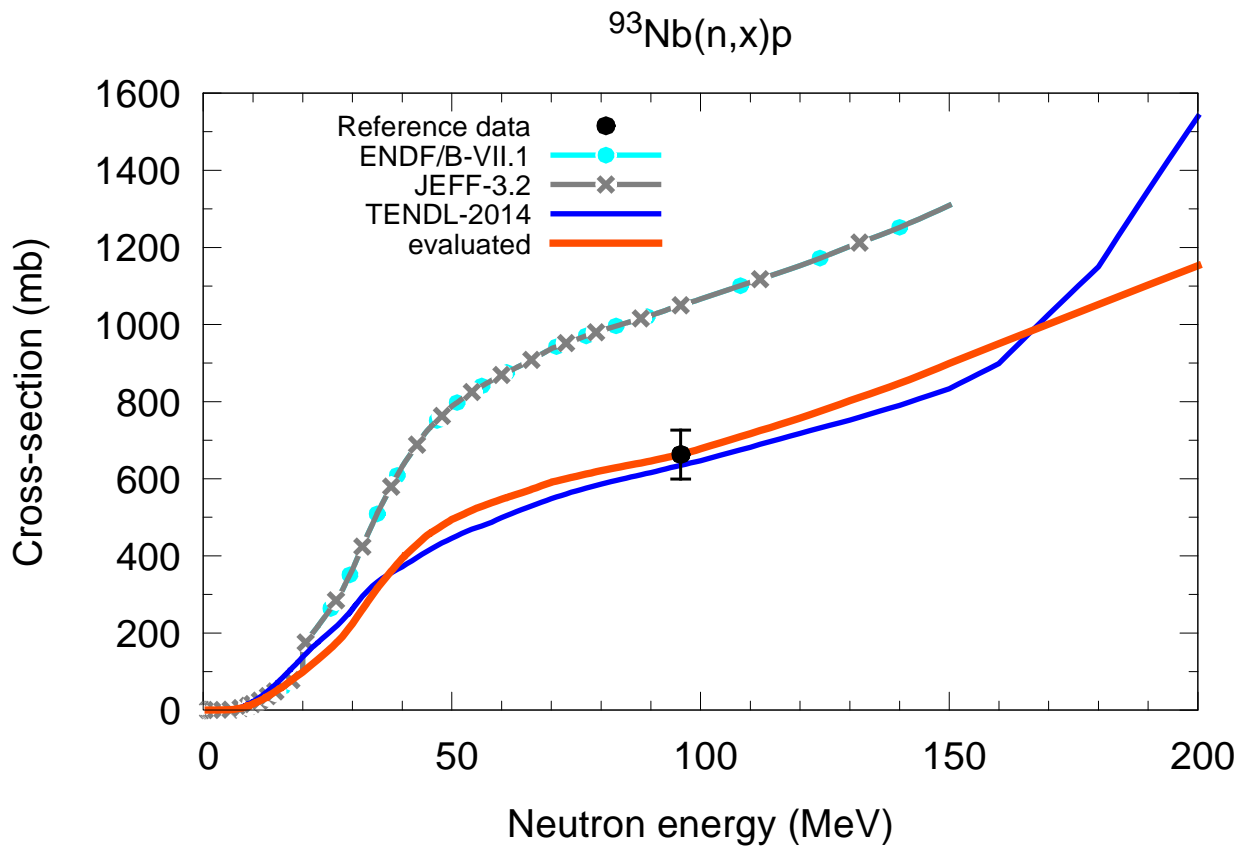


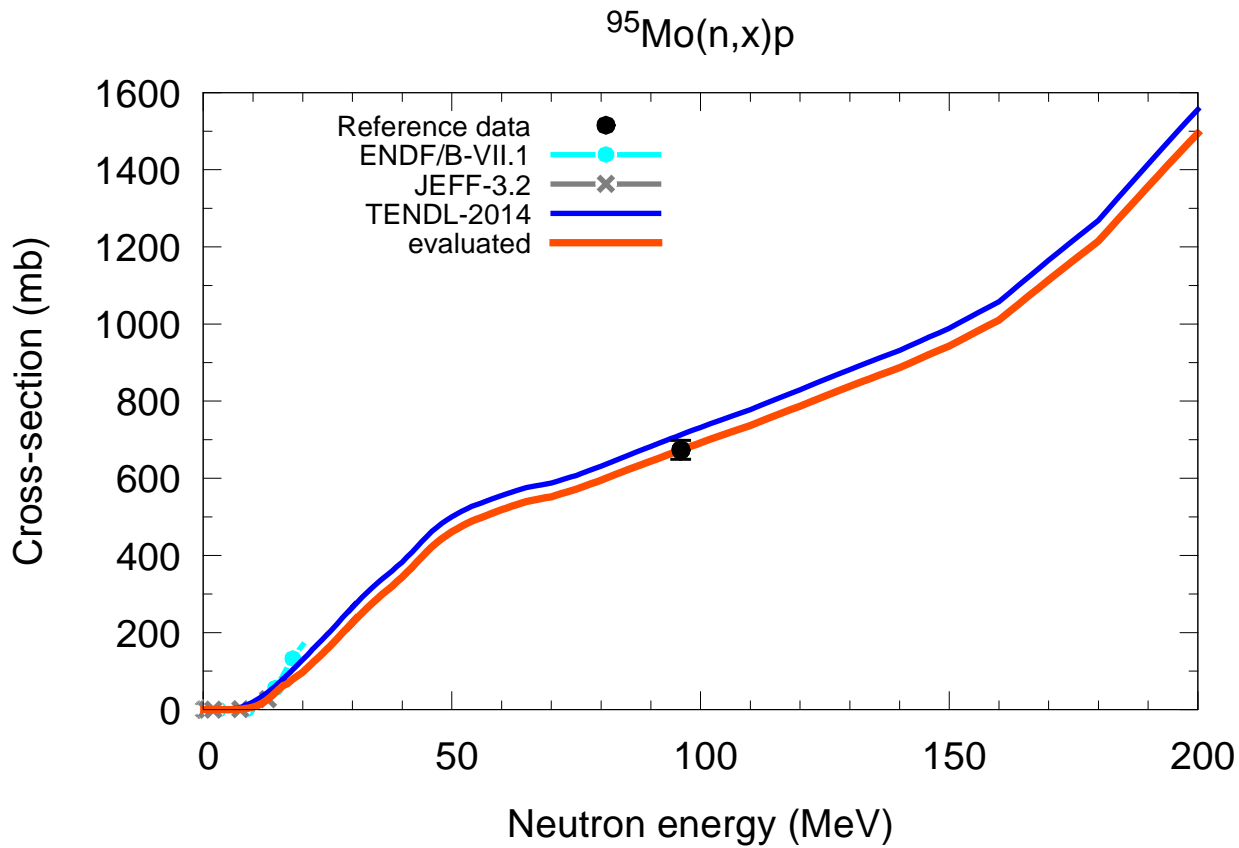
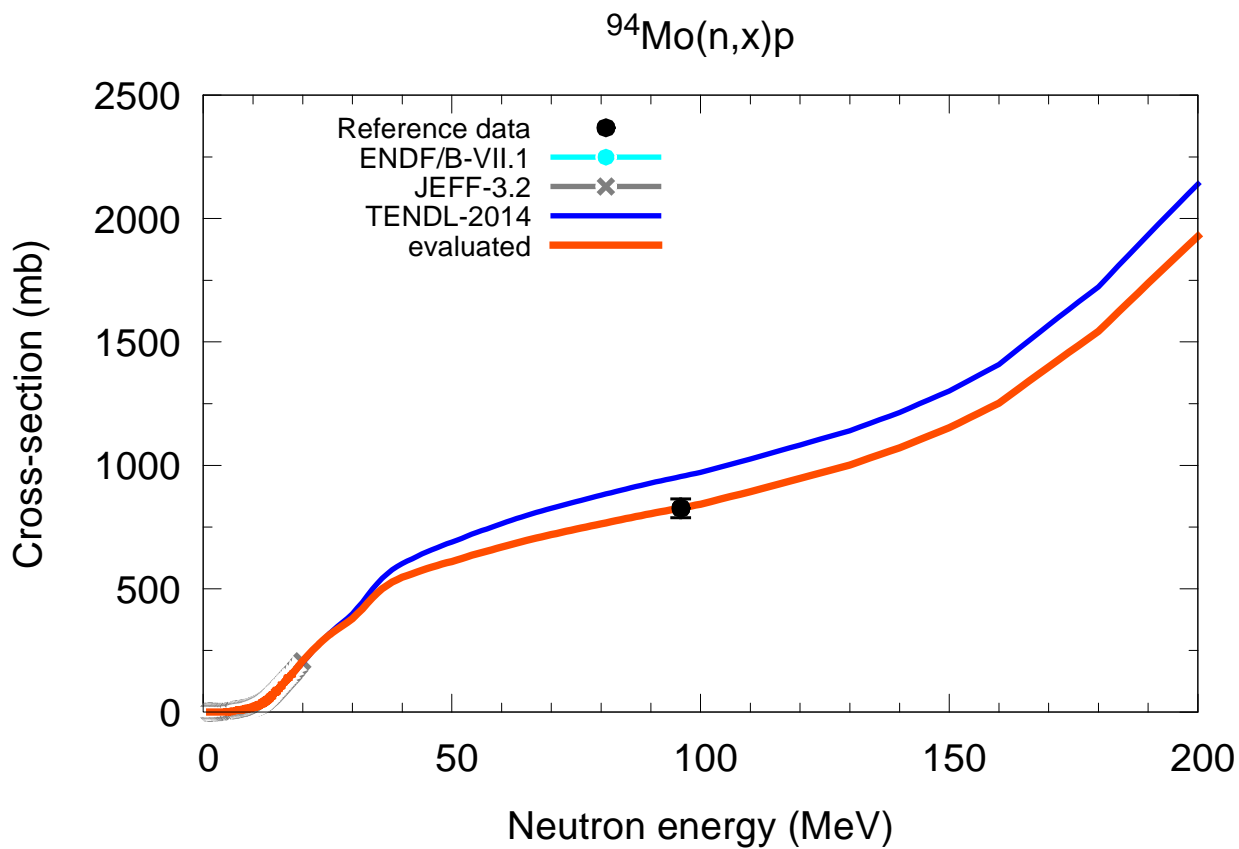
### $^{94}\text{Zr}(n,x)p$

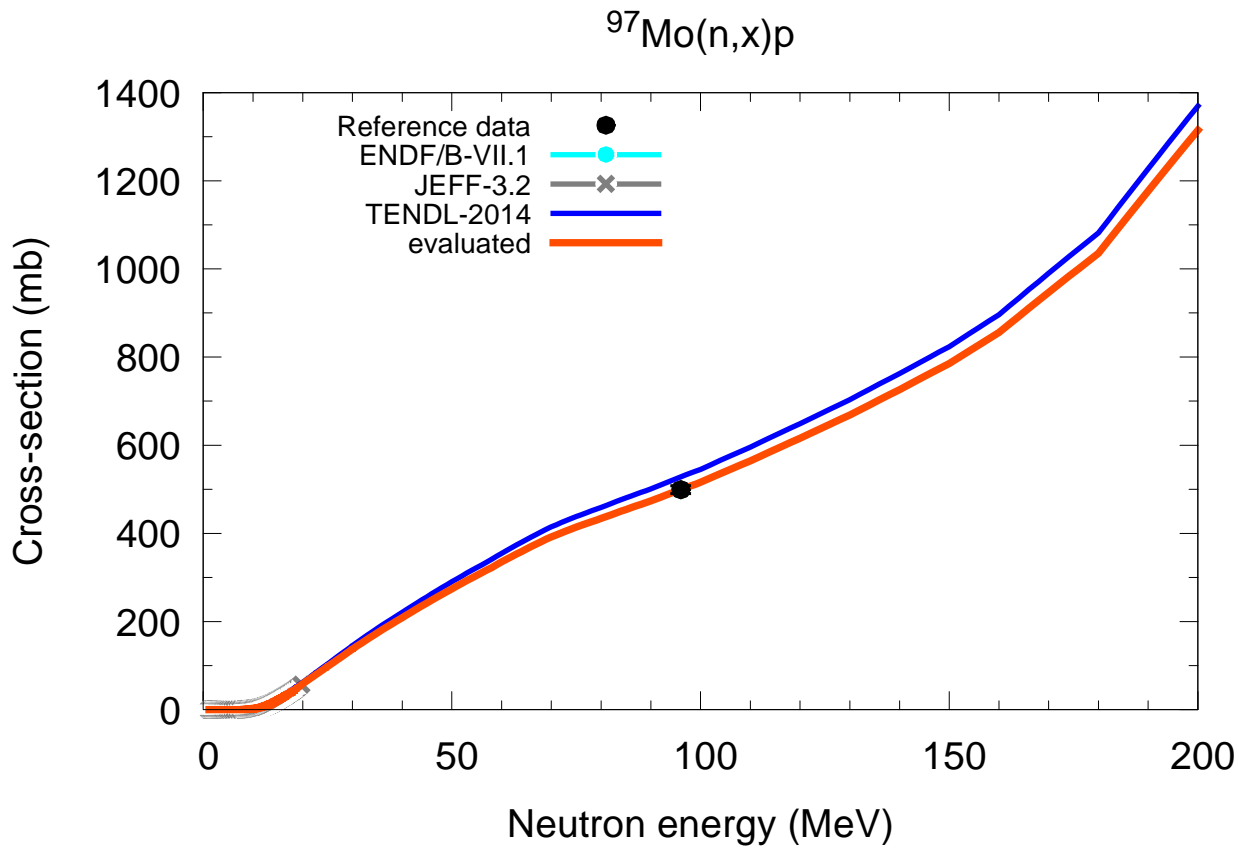
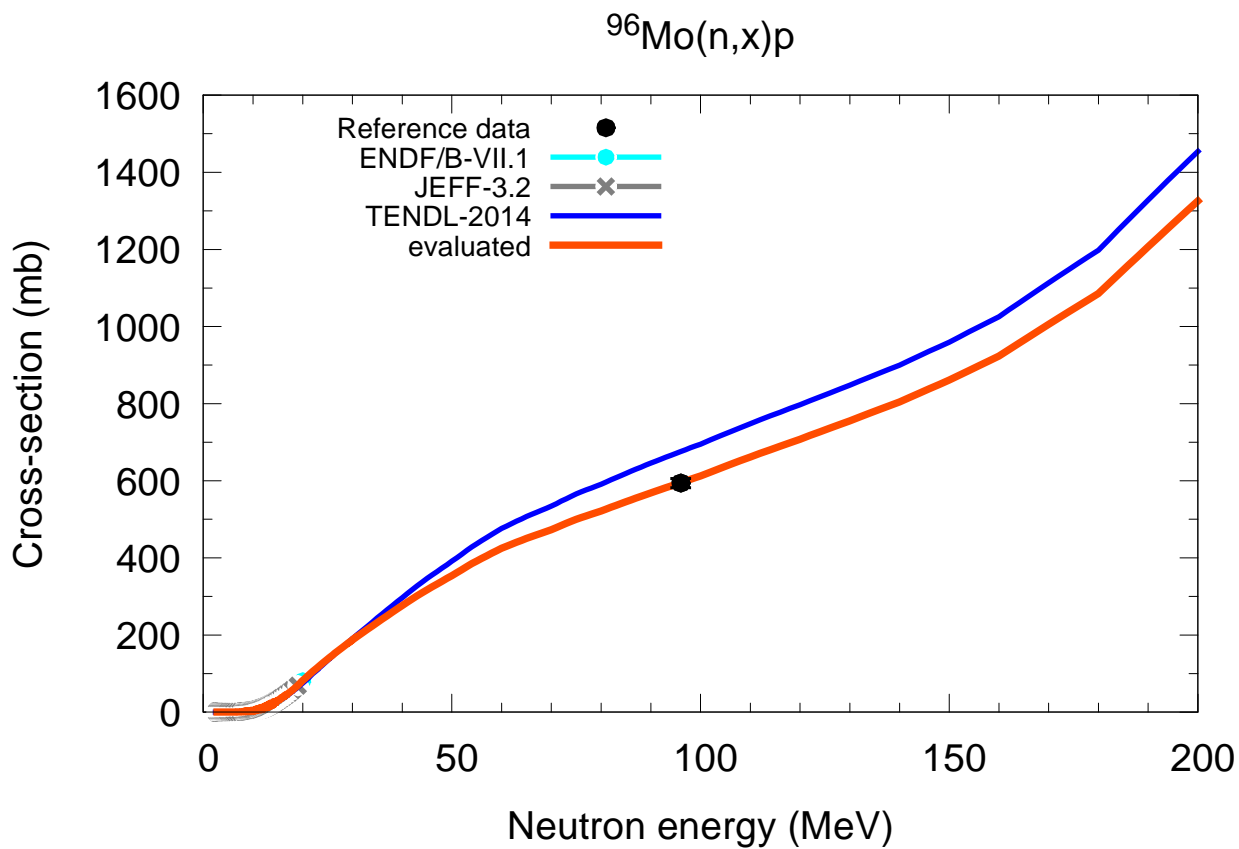


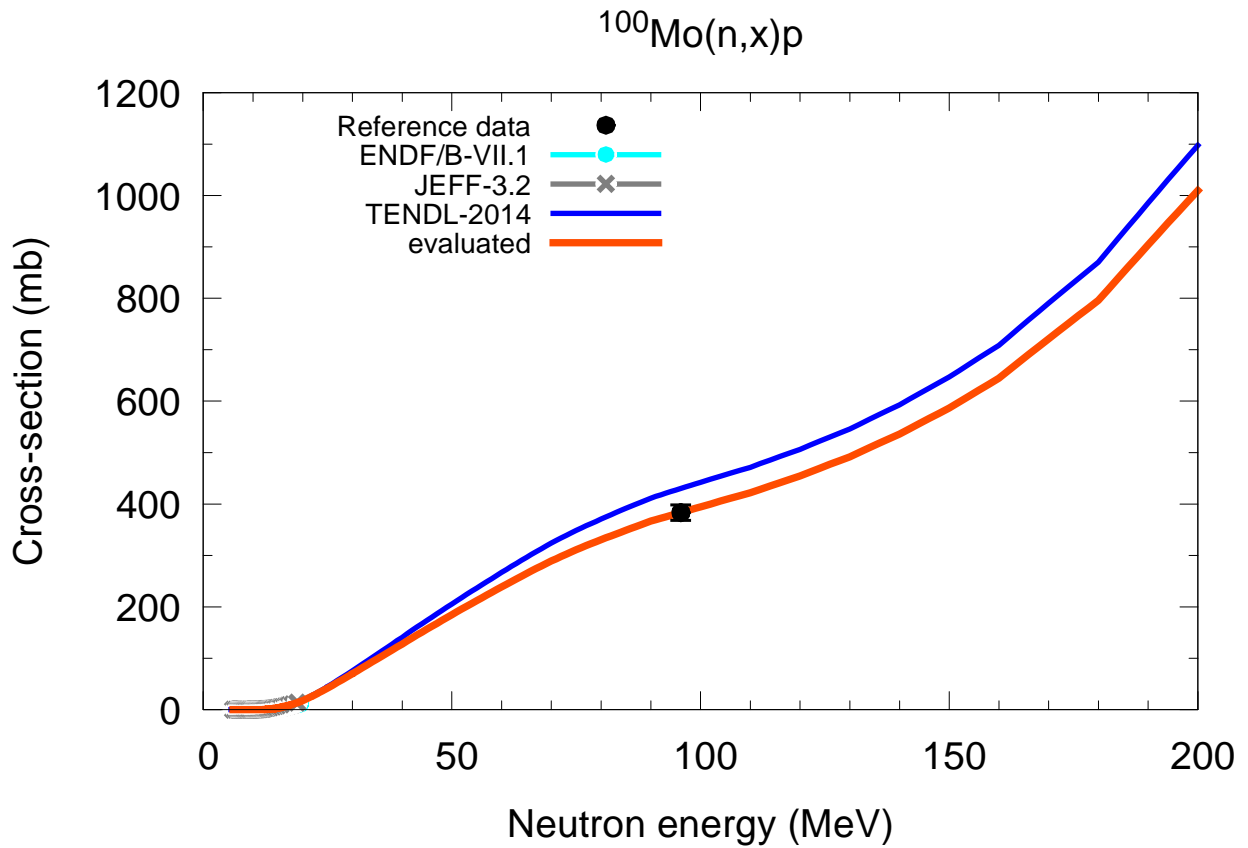
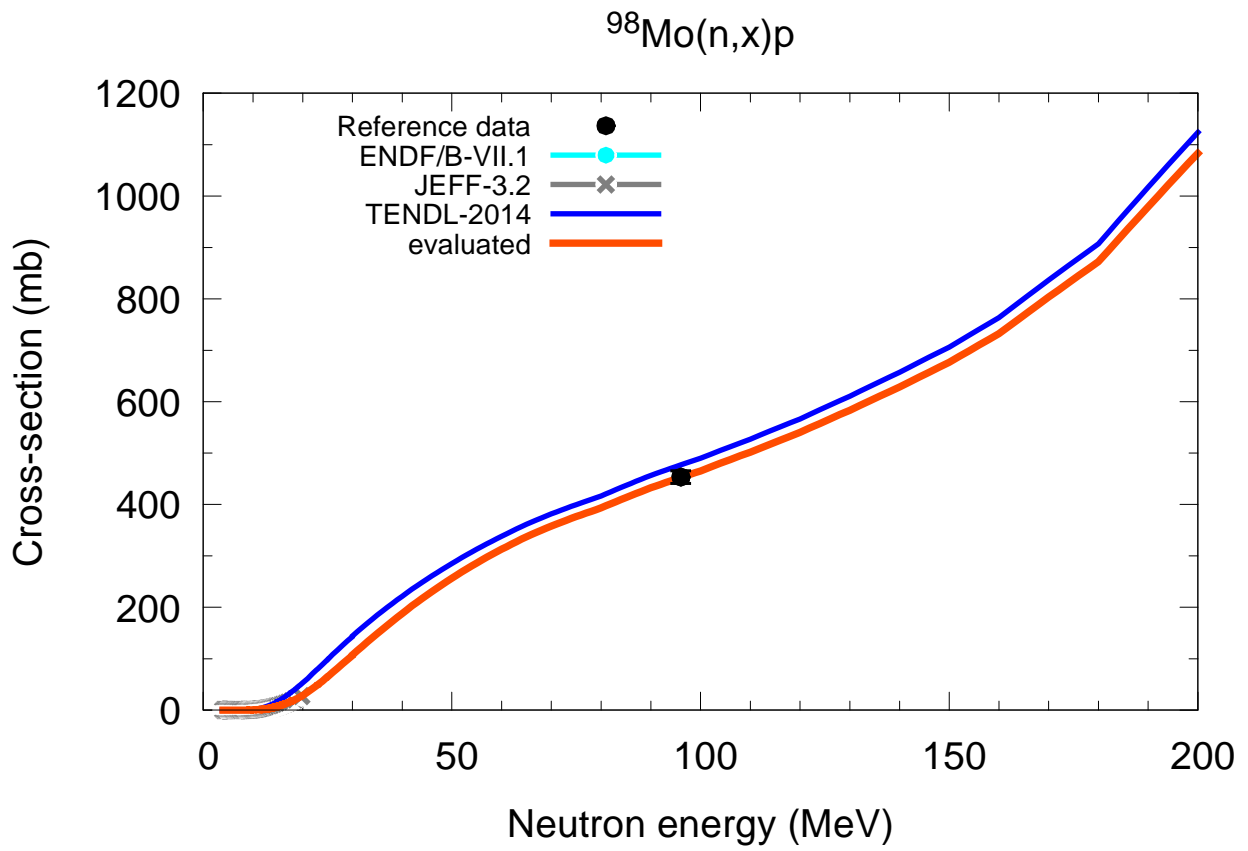
### $^{96}\text{Zr}(n,x)p$

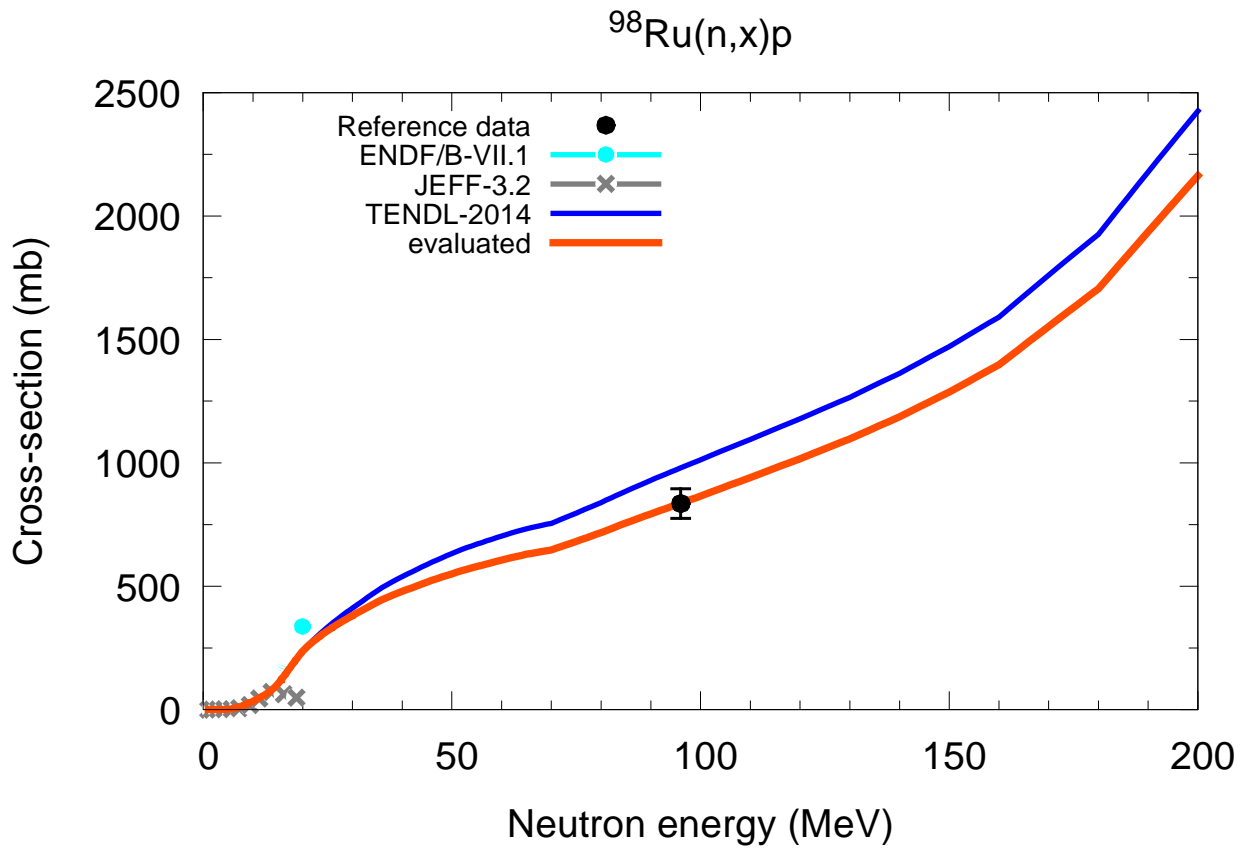
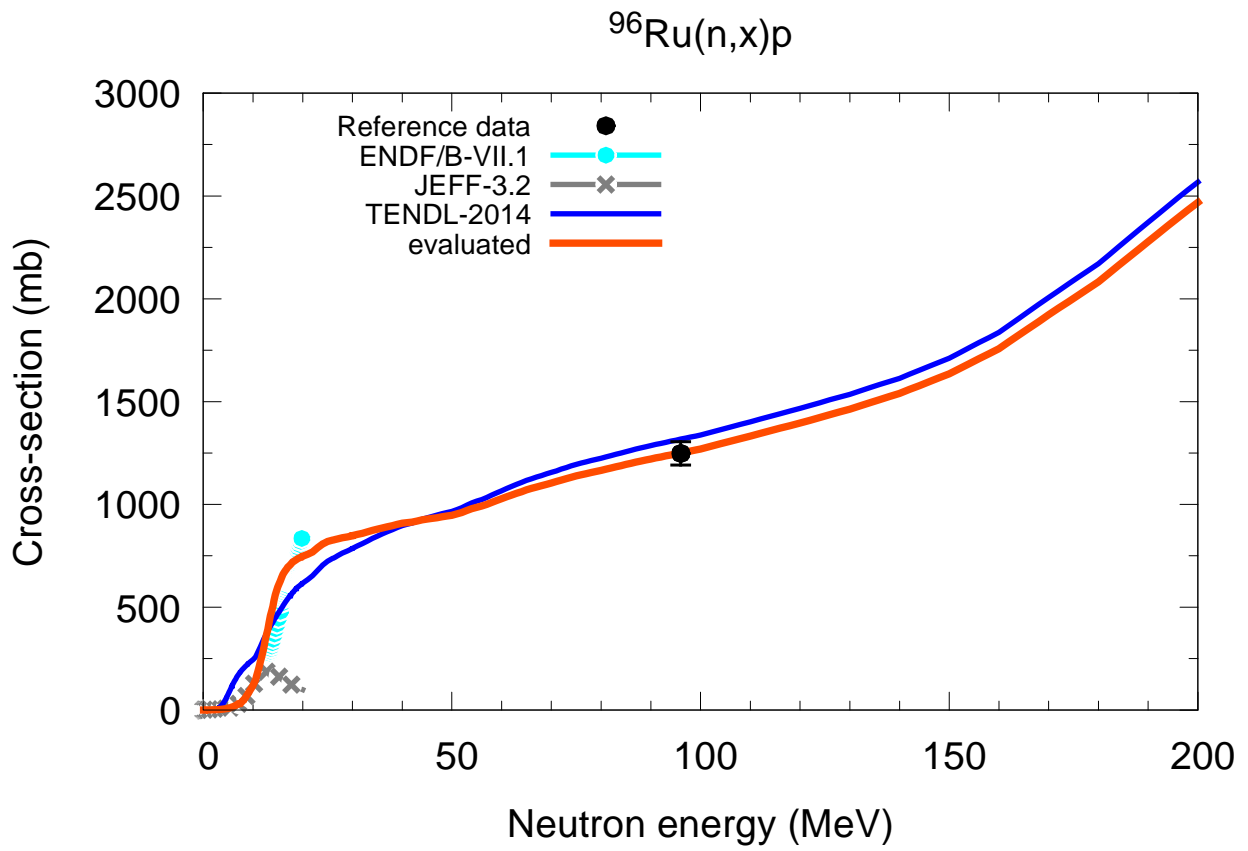


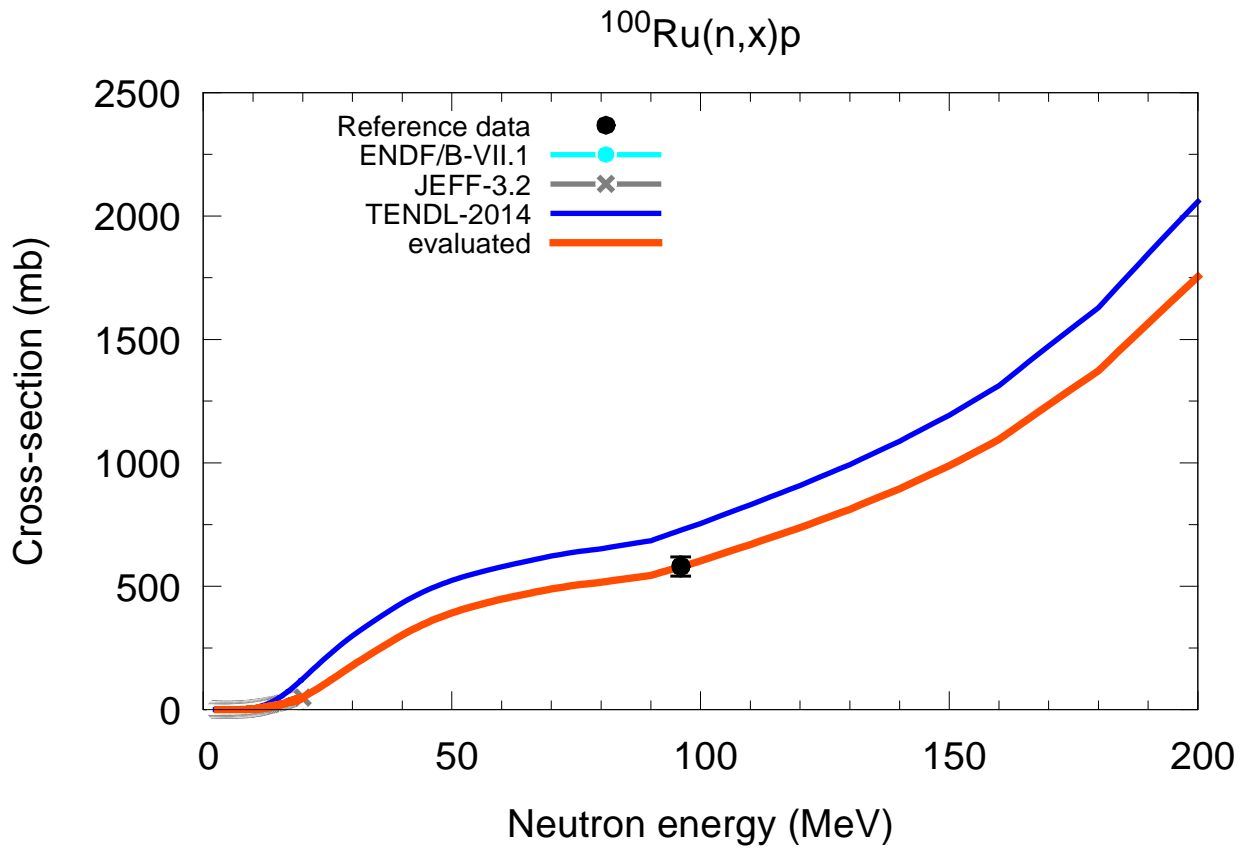
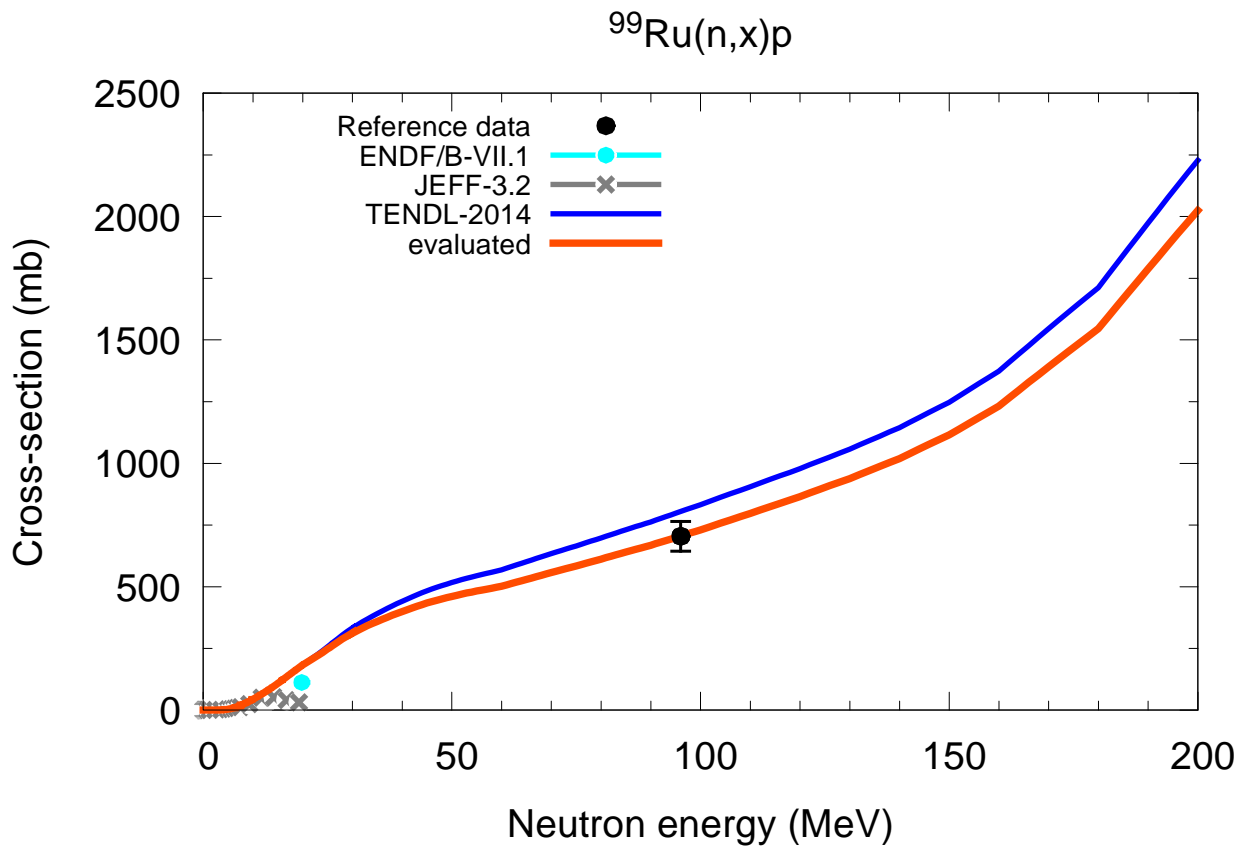






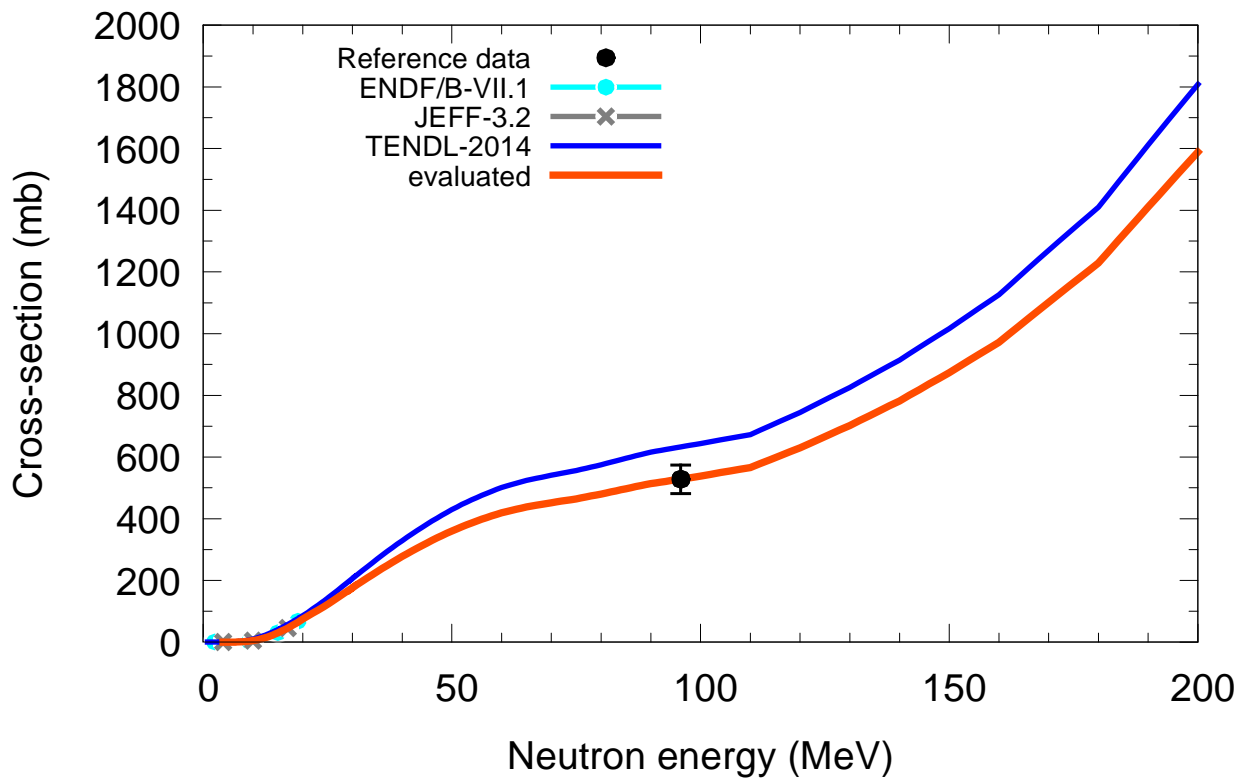




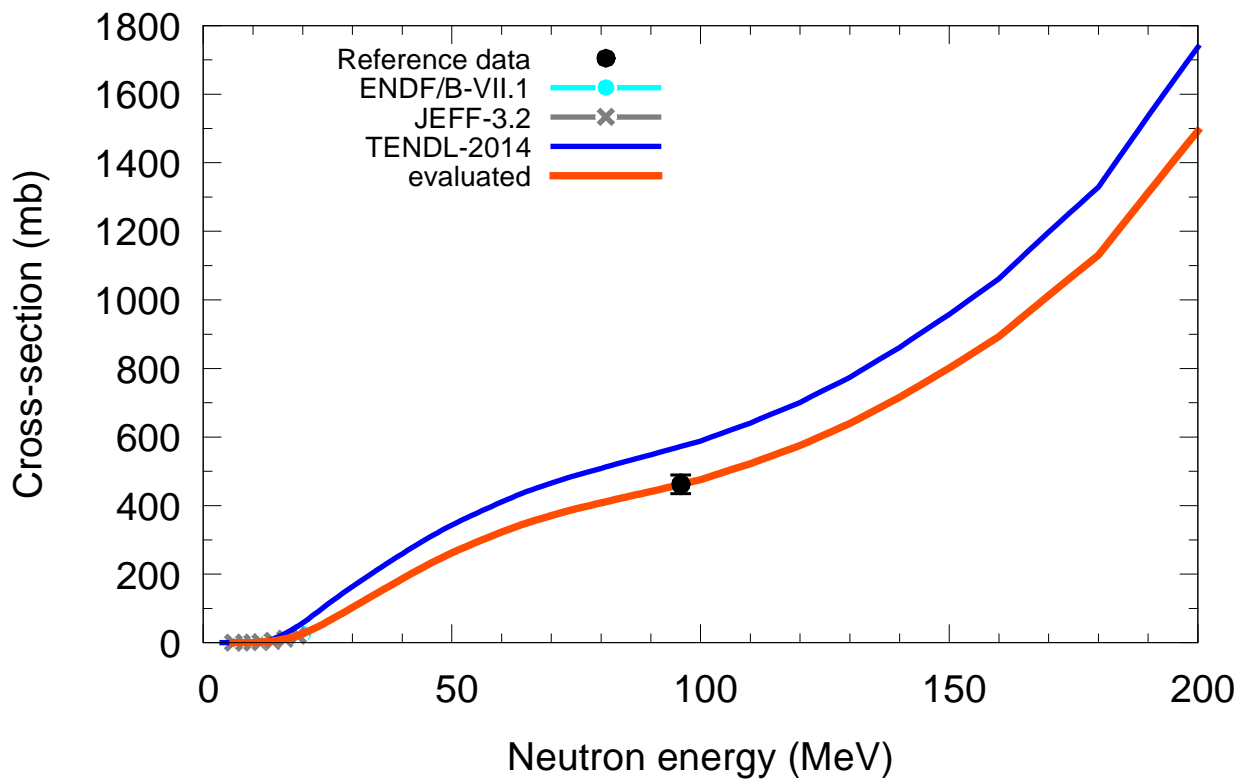




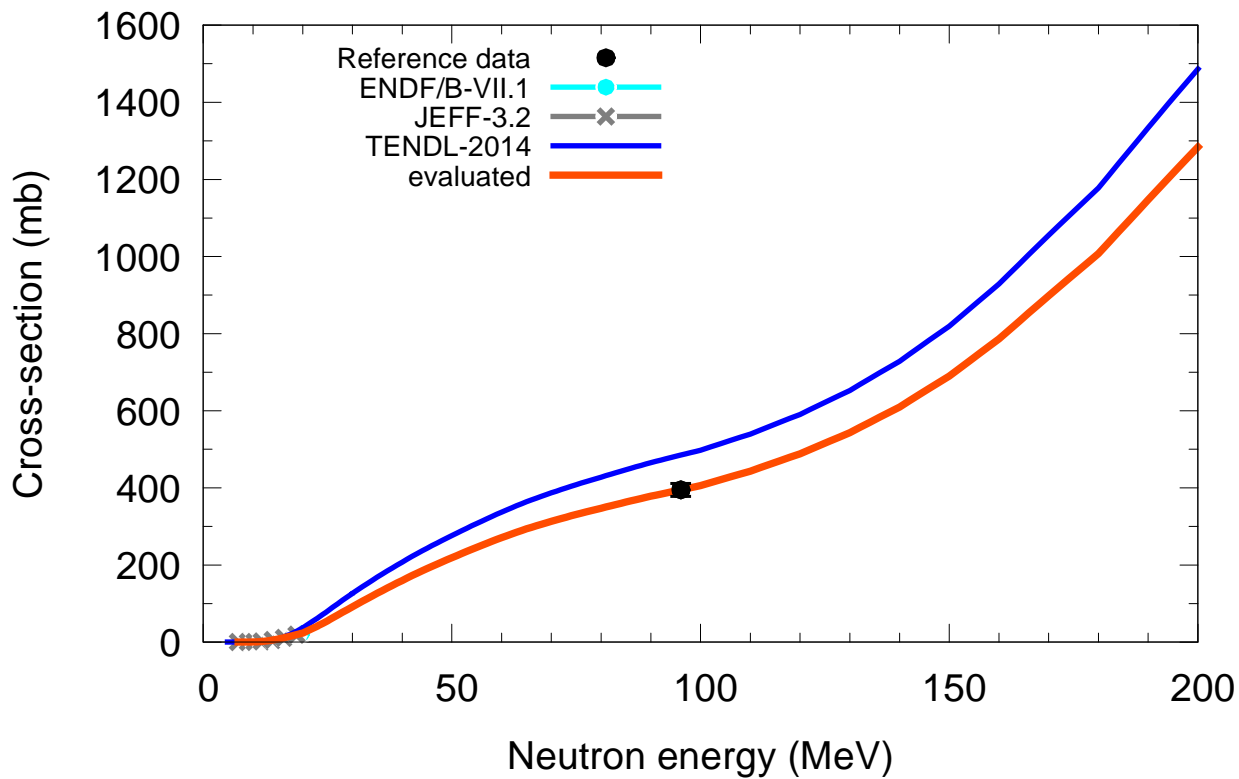
$^{101}\text{Ru}(n,x)p$



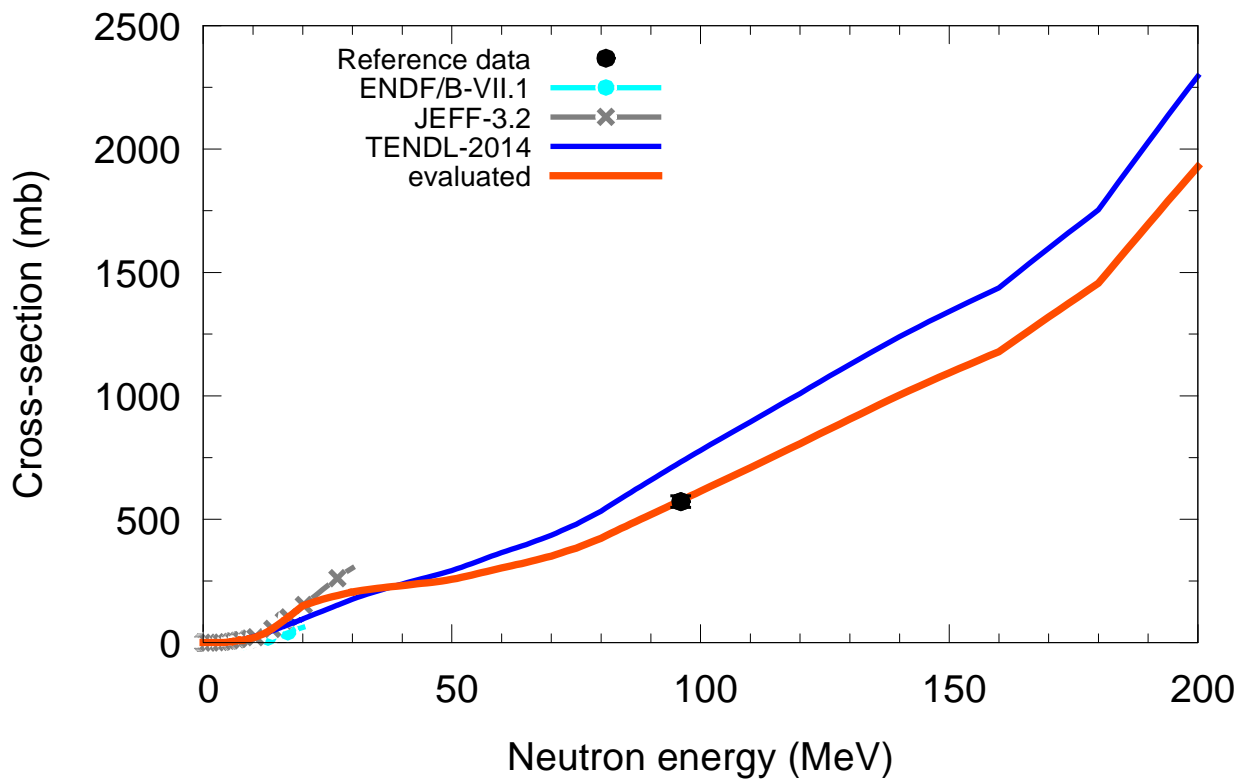
$^{102}\text{Ru}(n,x)p$



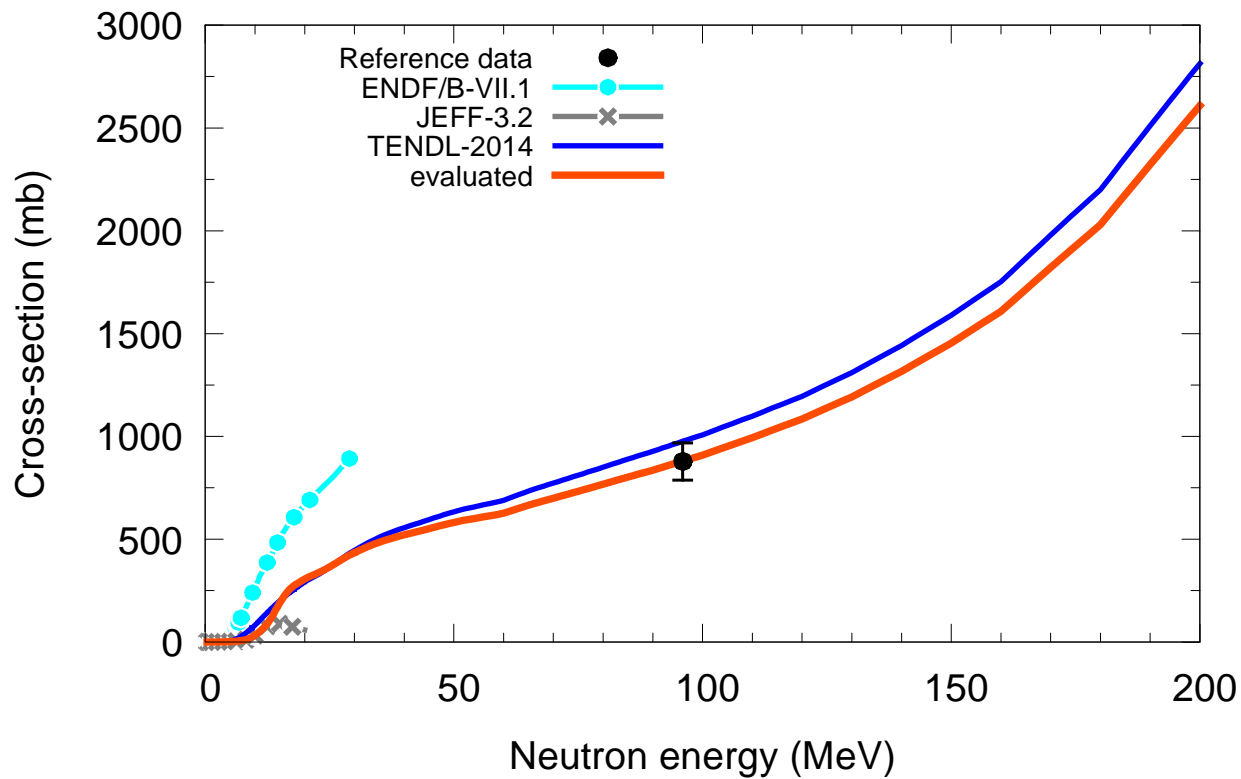
$^{104}\text{Ru}(n,x)p$



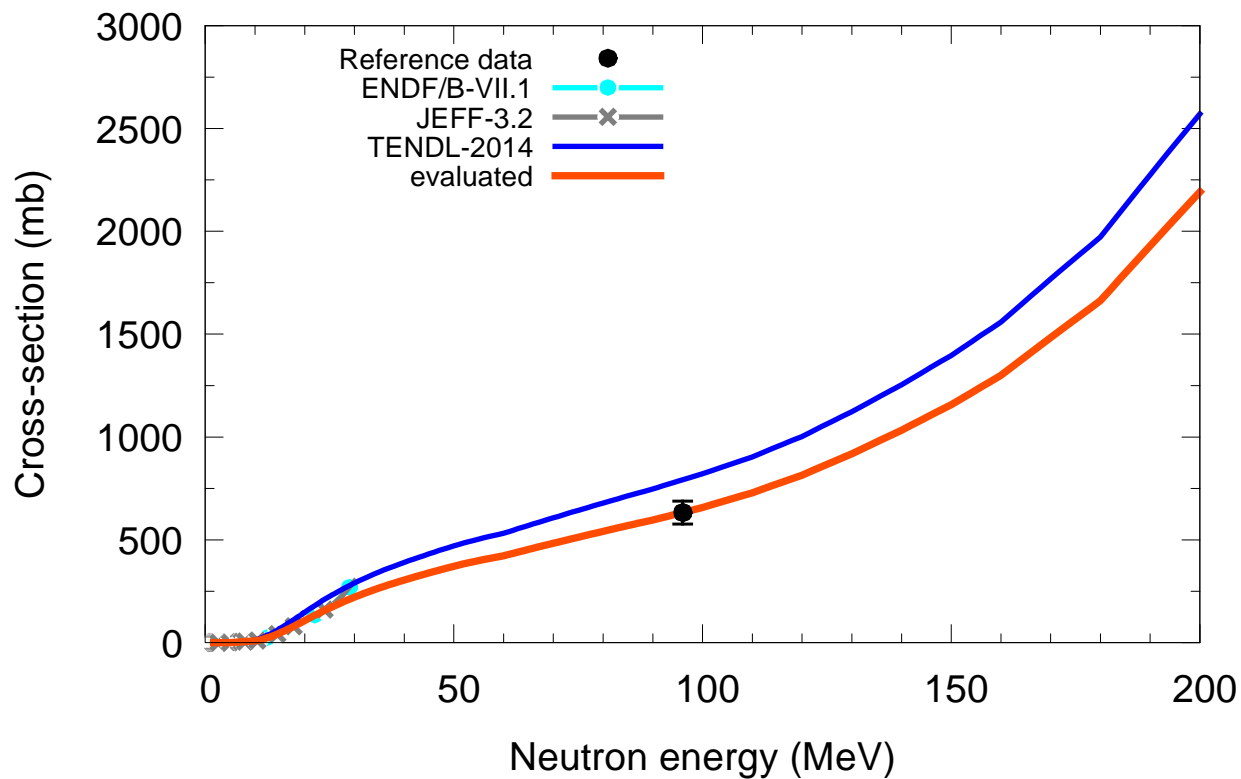
$^{103}\text{Rh}(n,x)p$

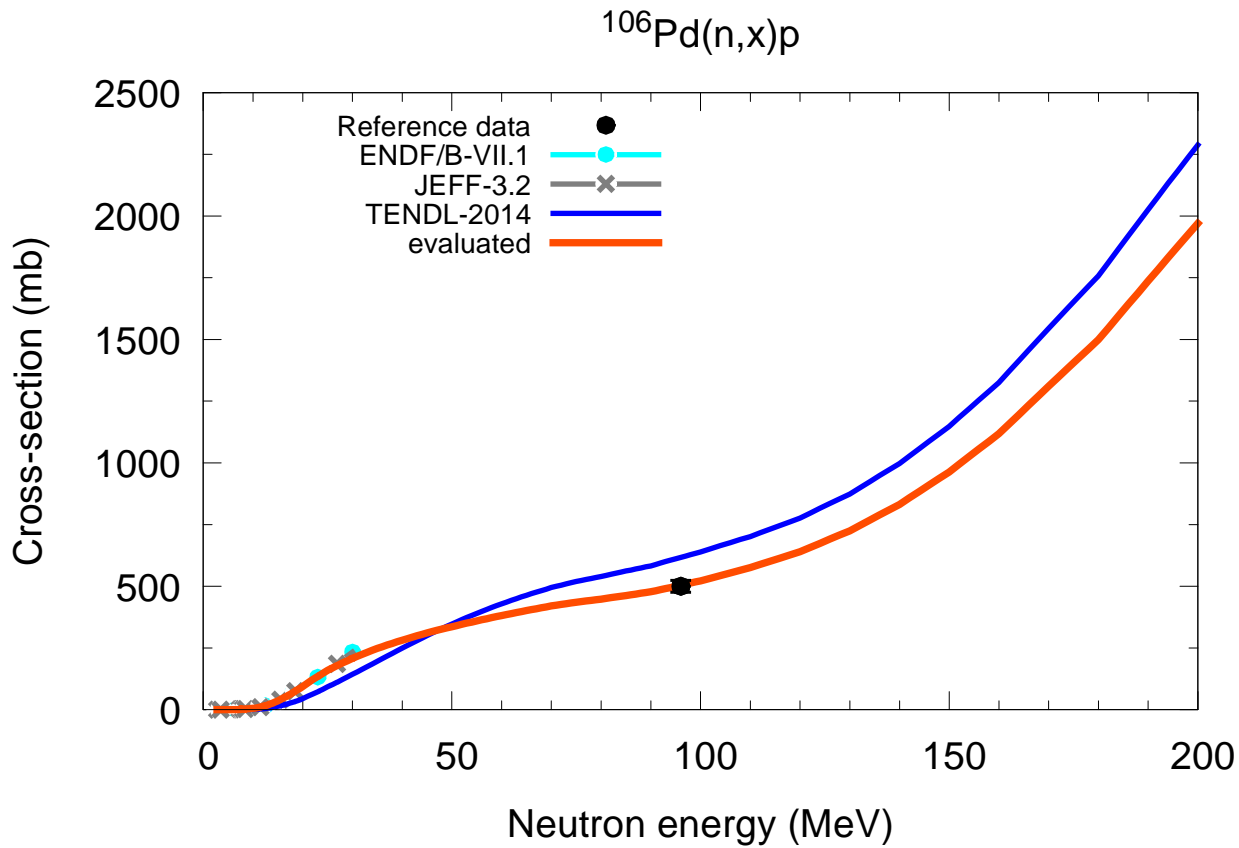
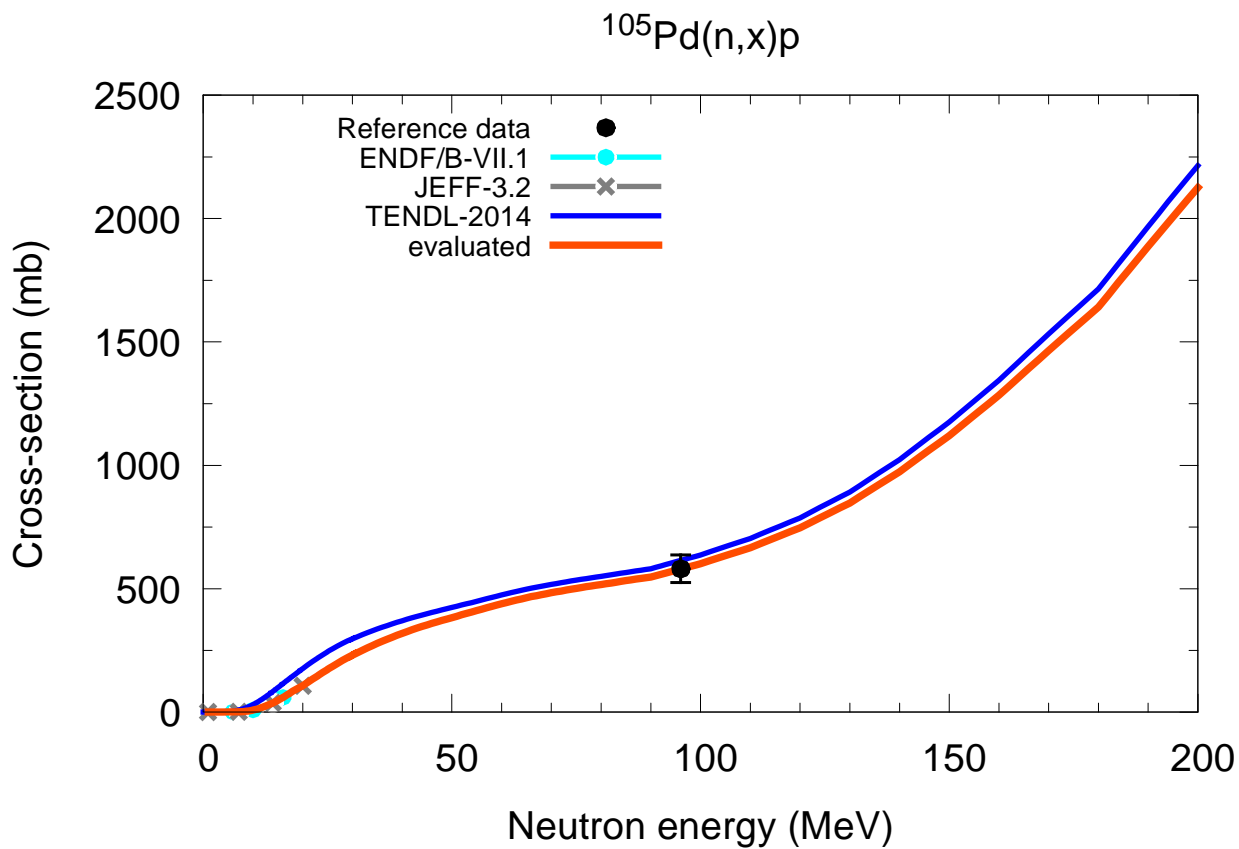


### $^{102}\text{Pd}(n,x)p$

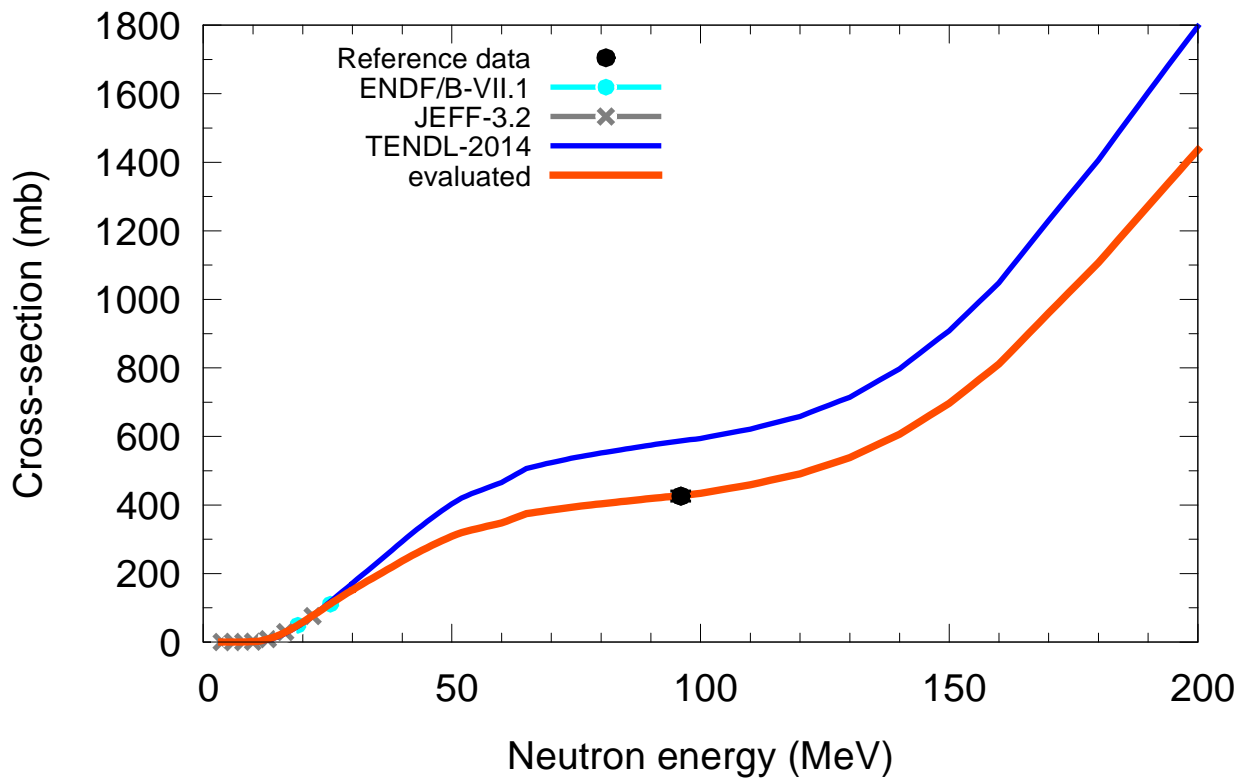


### $^{104}\text{Pd}(n,x)p$

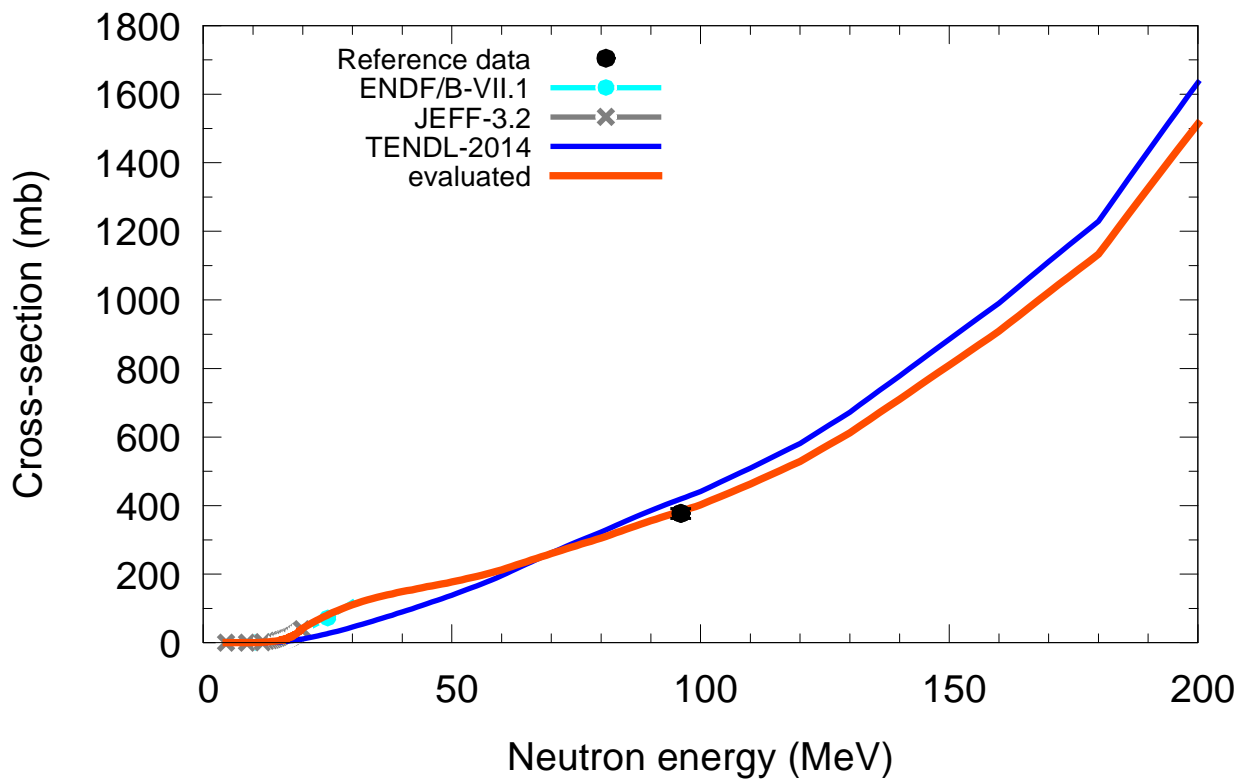




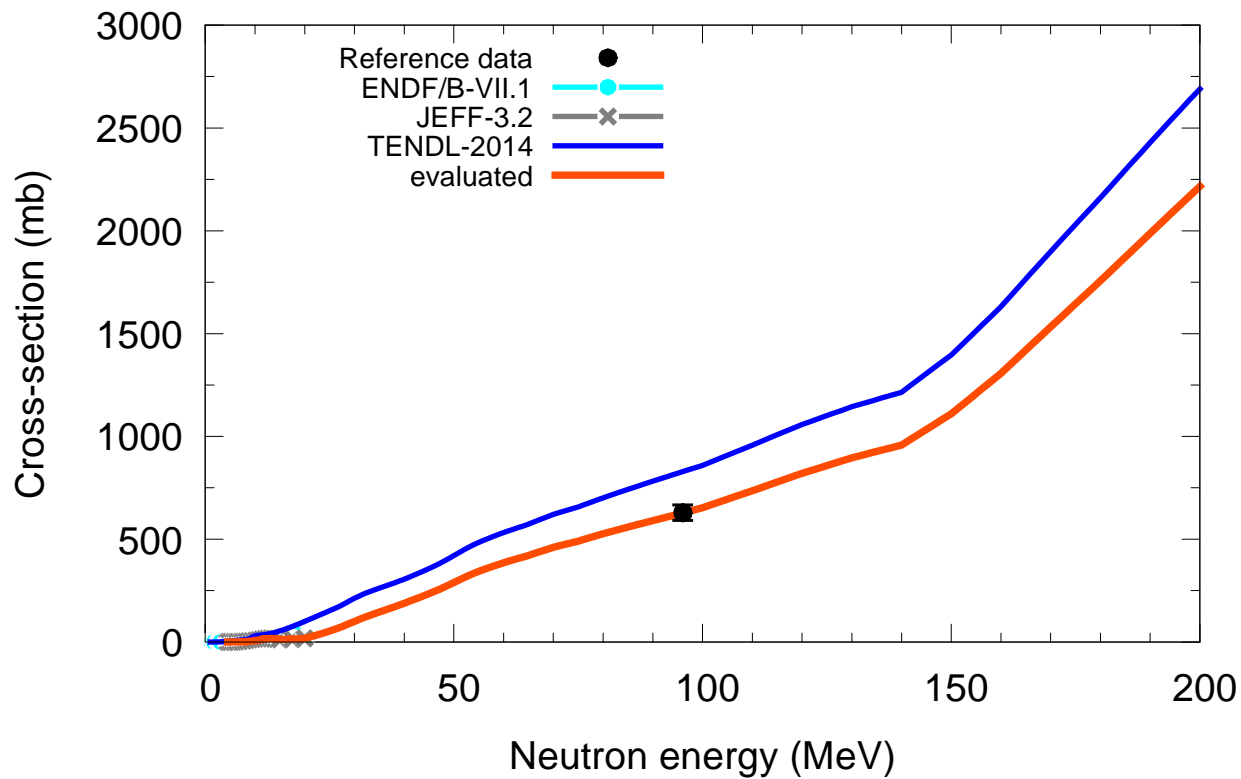
$^{108}\text{Pd}(n,x)p$



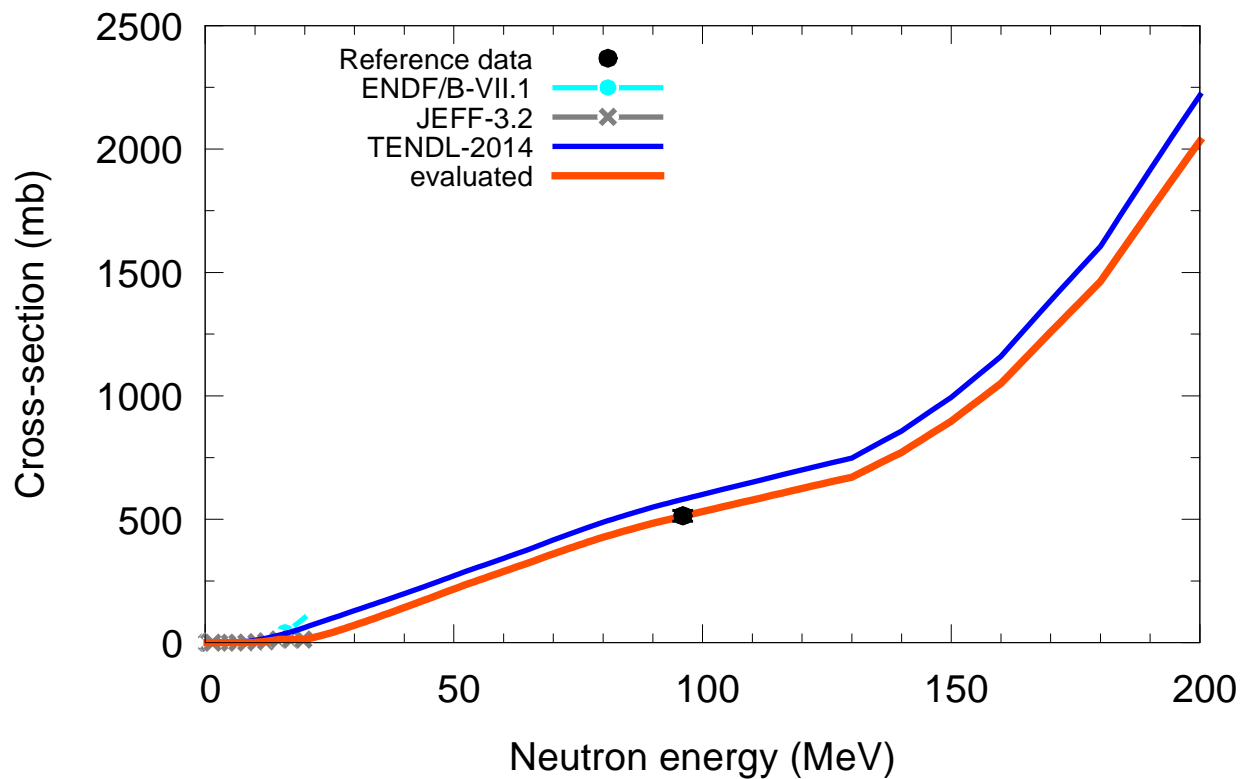
$^{110}\text{Pd}(n,x)p$

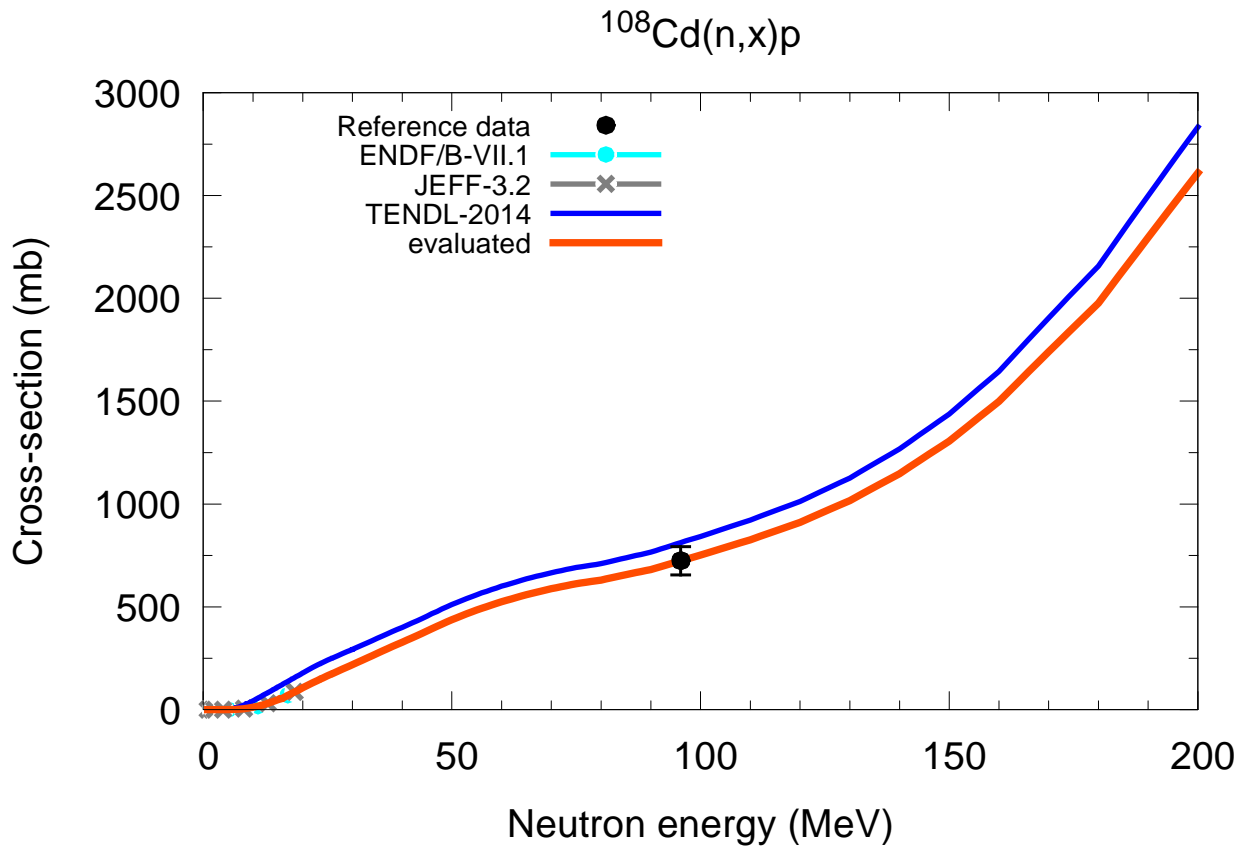
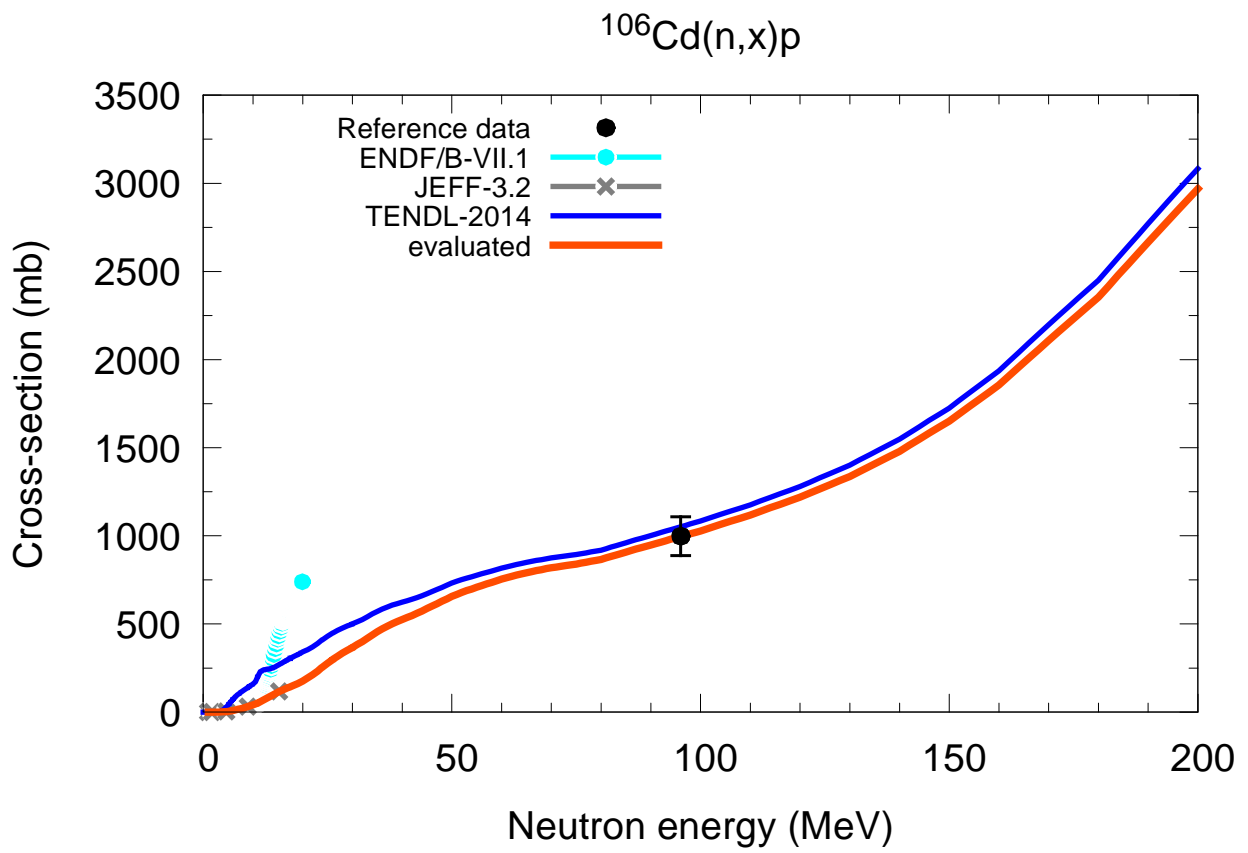


$^{107}\text{Ag}(n,x)p$

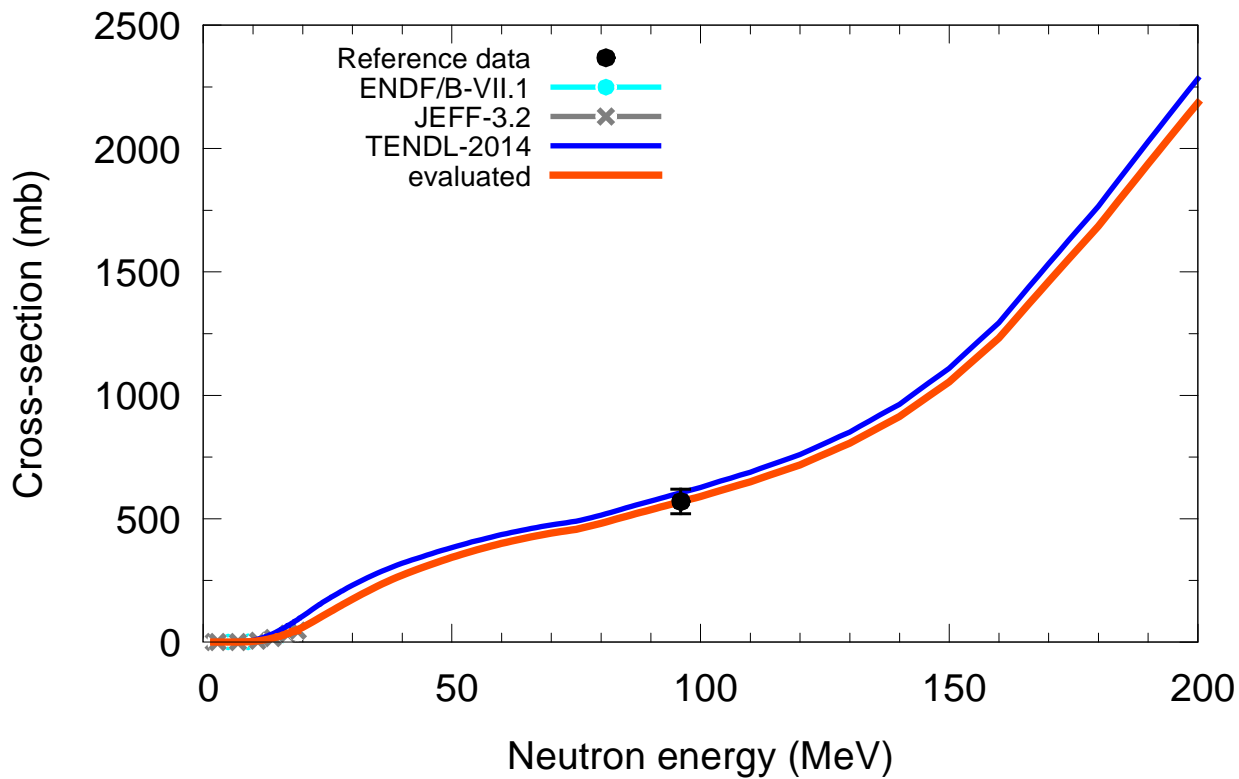


$^{109}\text{Ag}(n,x)p$

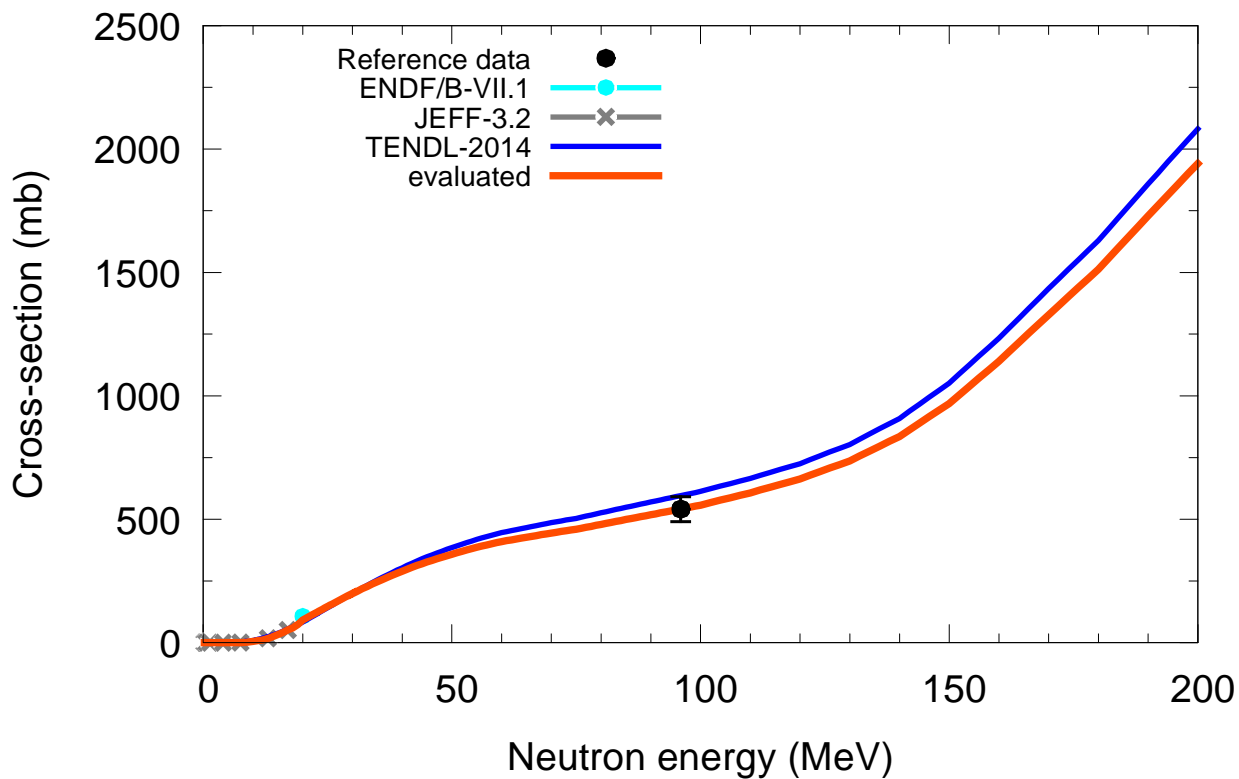




$^{110}\text{Cd}(n,x)p$

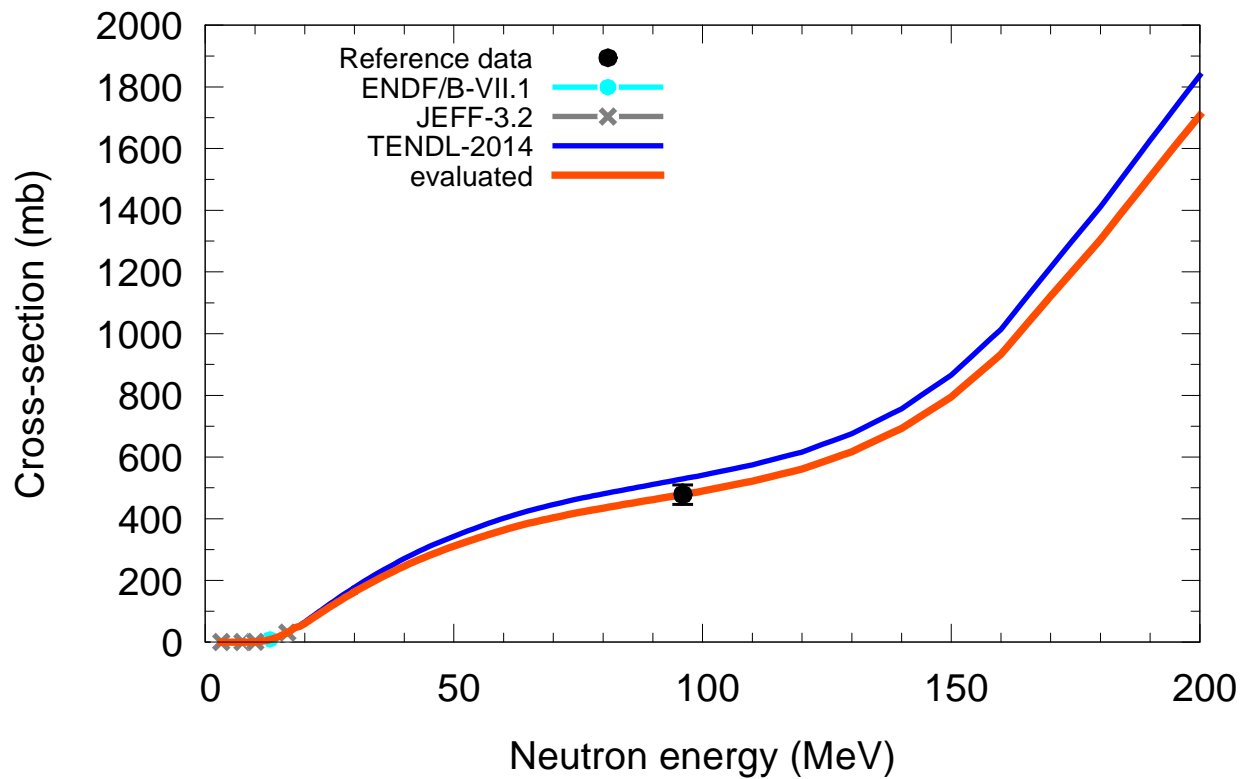


$^{111}\text{Cd}(n,x)p$

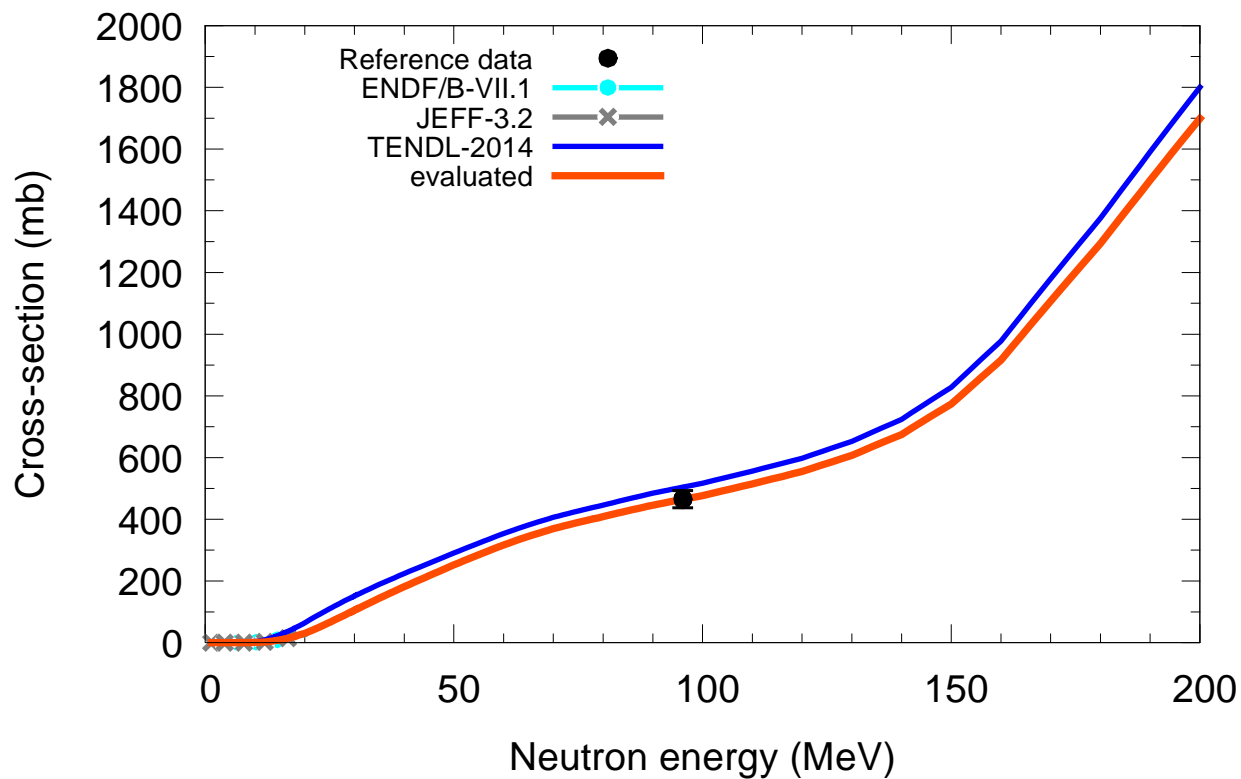




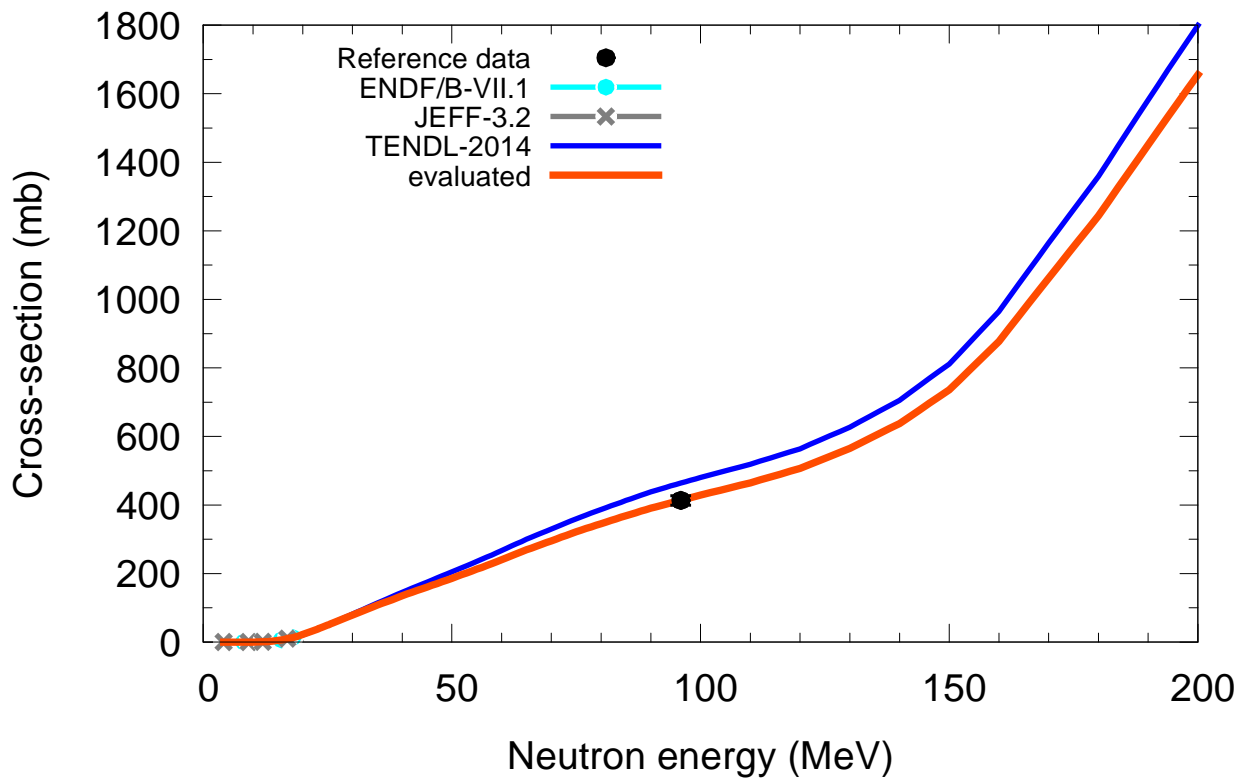
### $^{112}\text{Cd}(n,x)p$



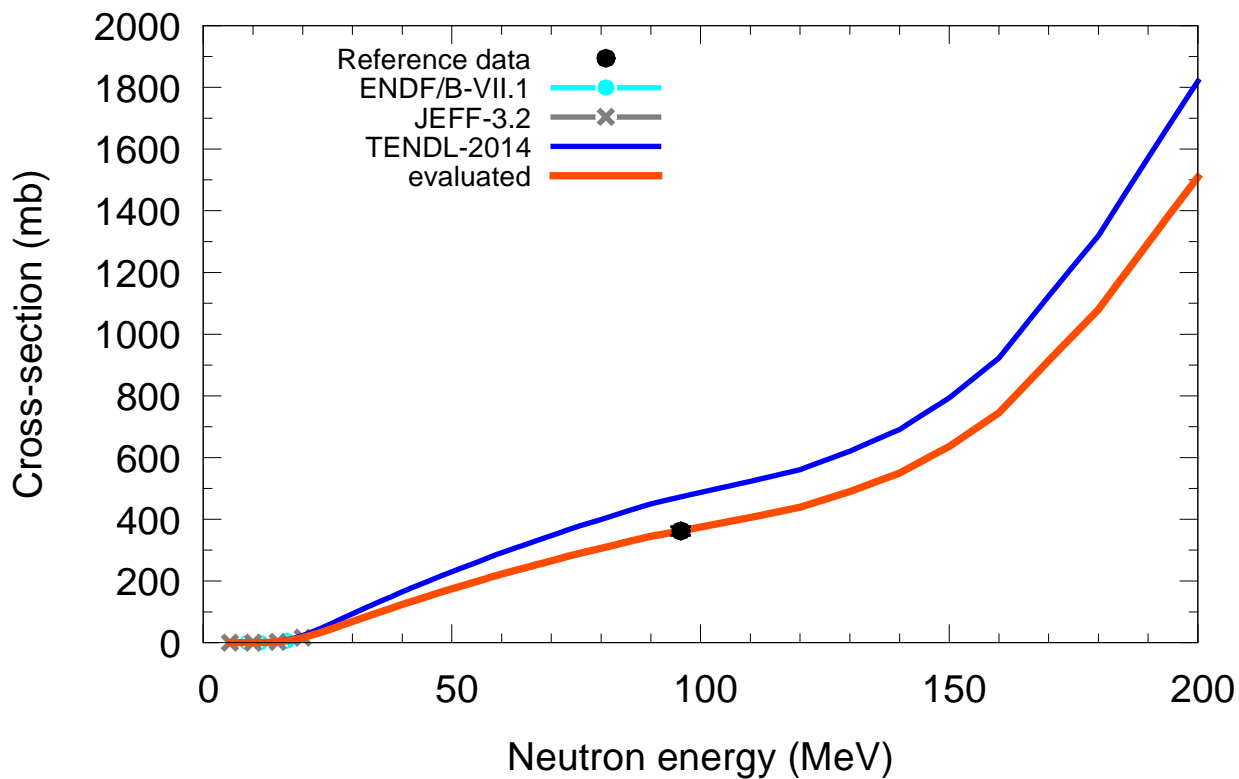
### $^{113}\text{Cd}(n,x)p$



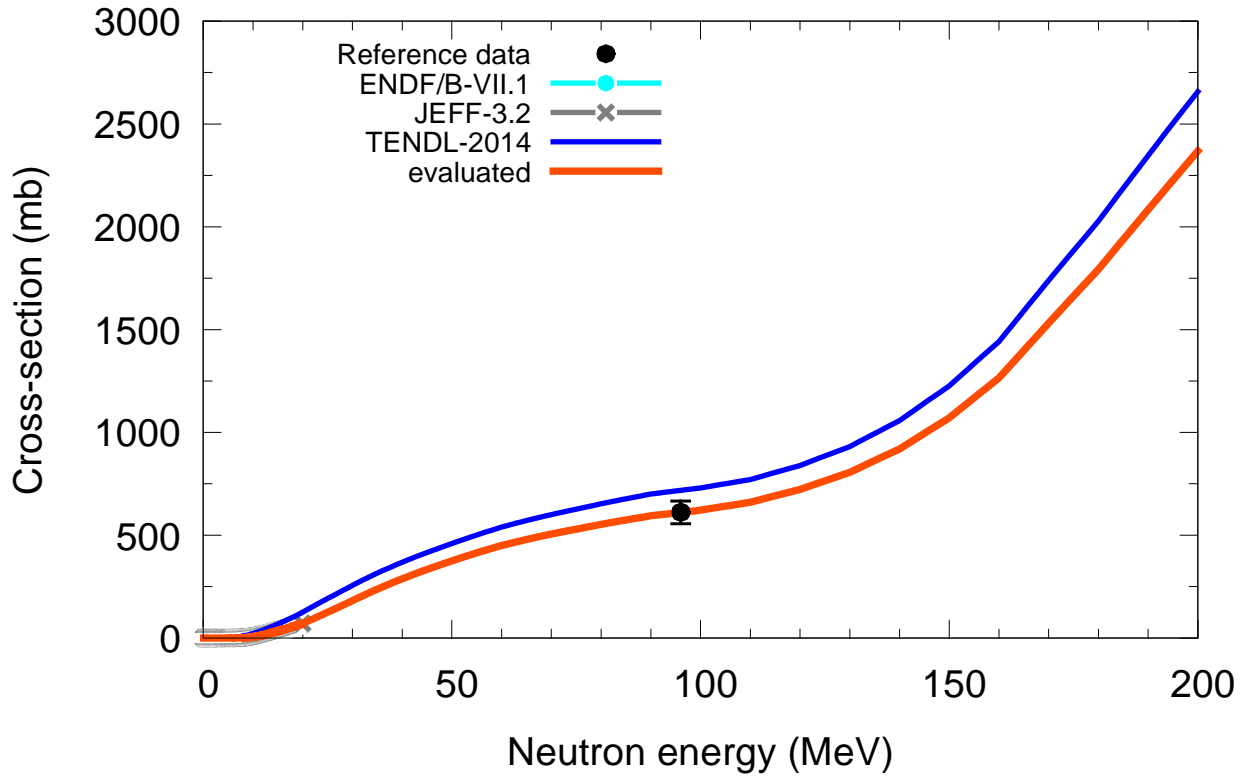
$^{114}\text{Cd}(n,x)p$



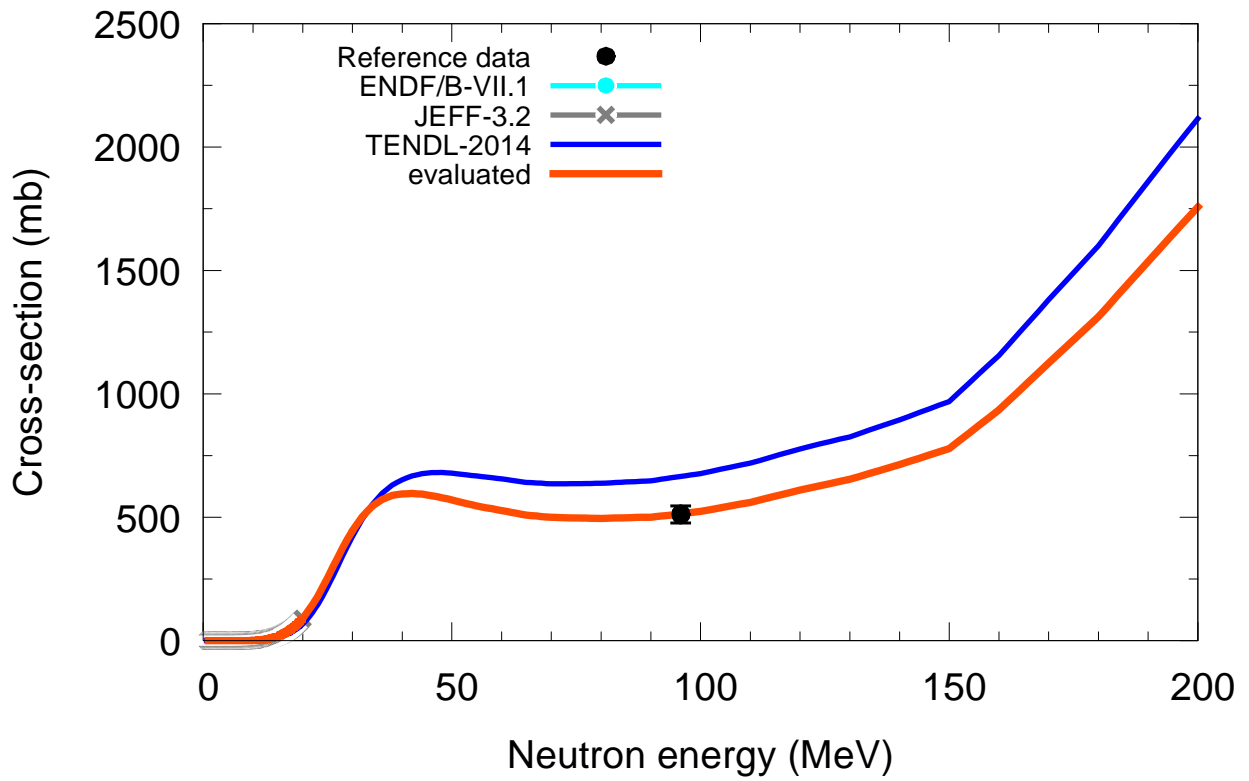
$^{116}\text{Cd}(n,x)p$



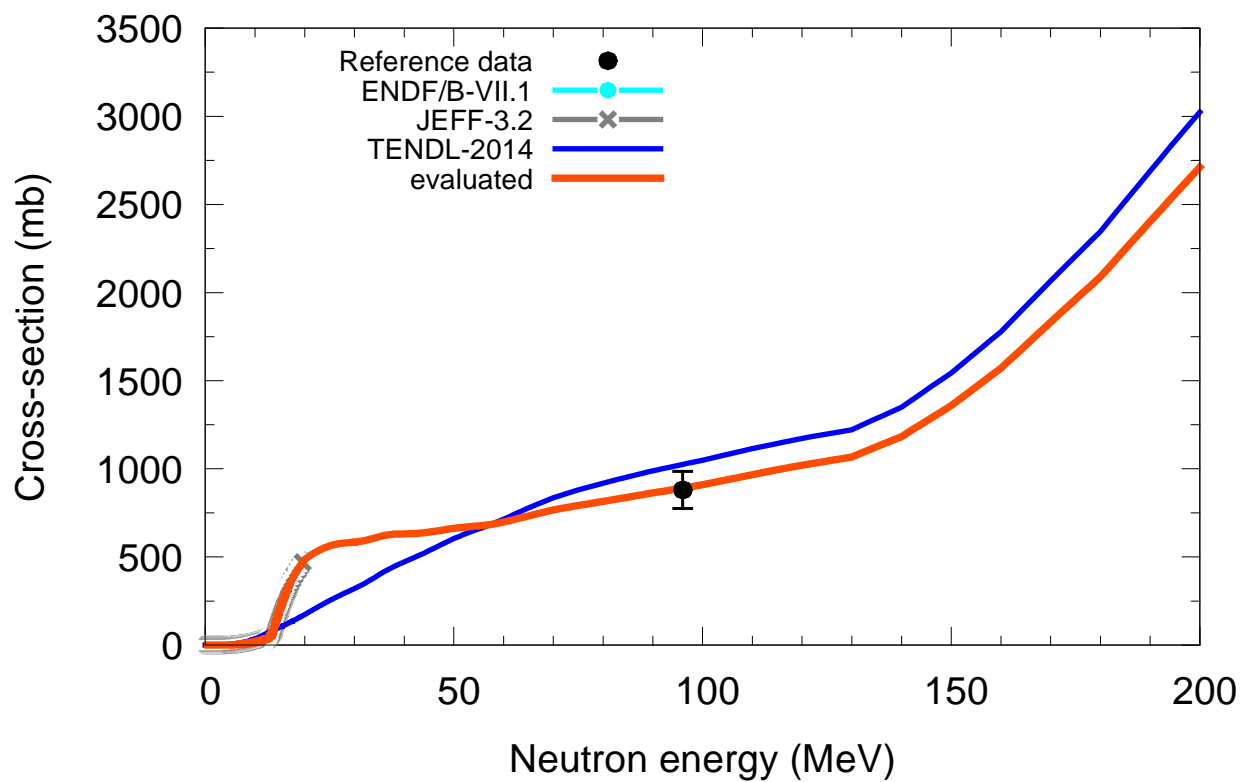
### $^{113}\text{In}(n,x)p$



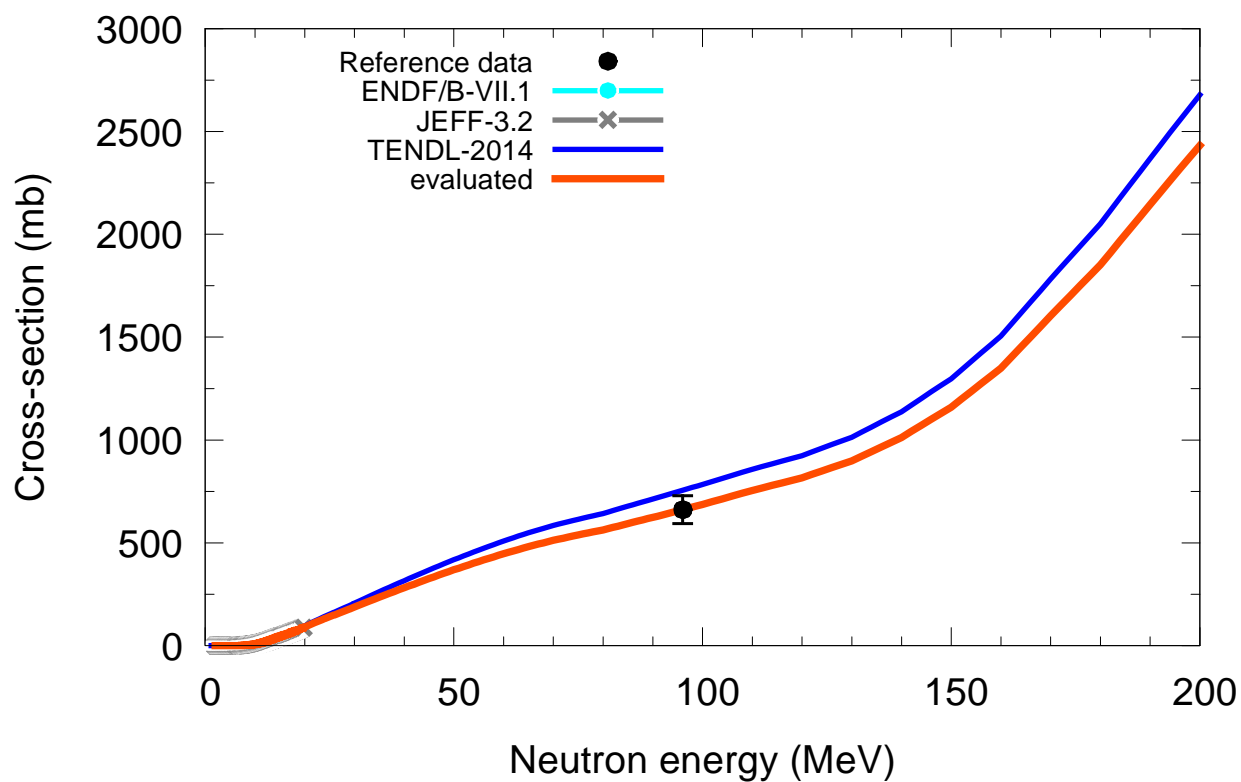
### $^{115}\text{In}(n,x)p$



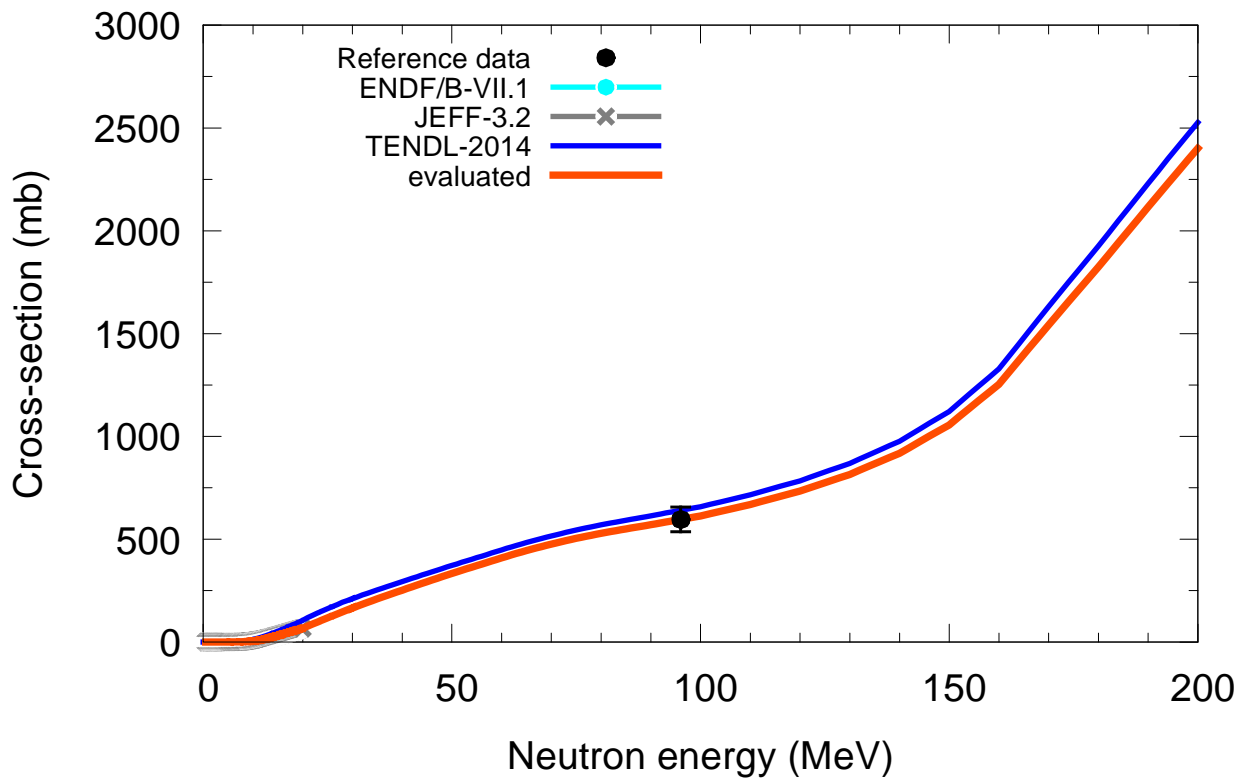
### $^{112}\text{Sn}(n,x)p$



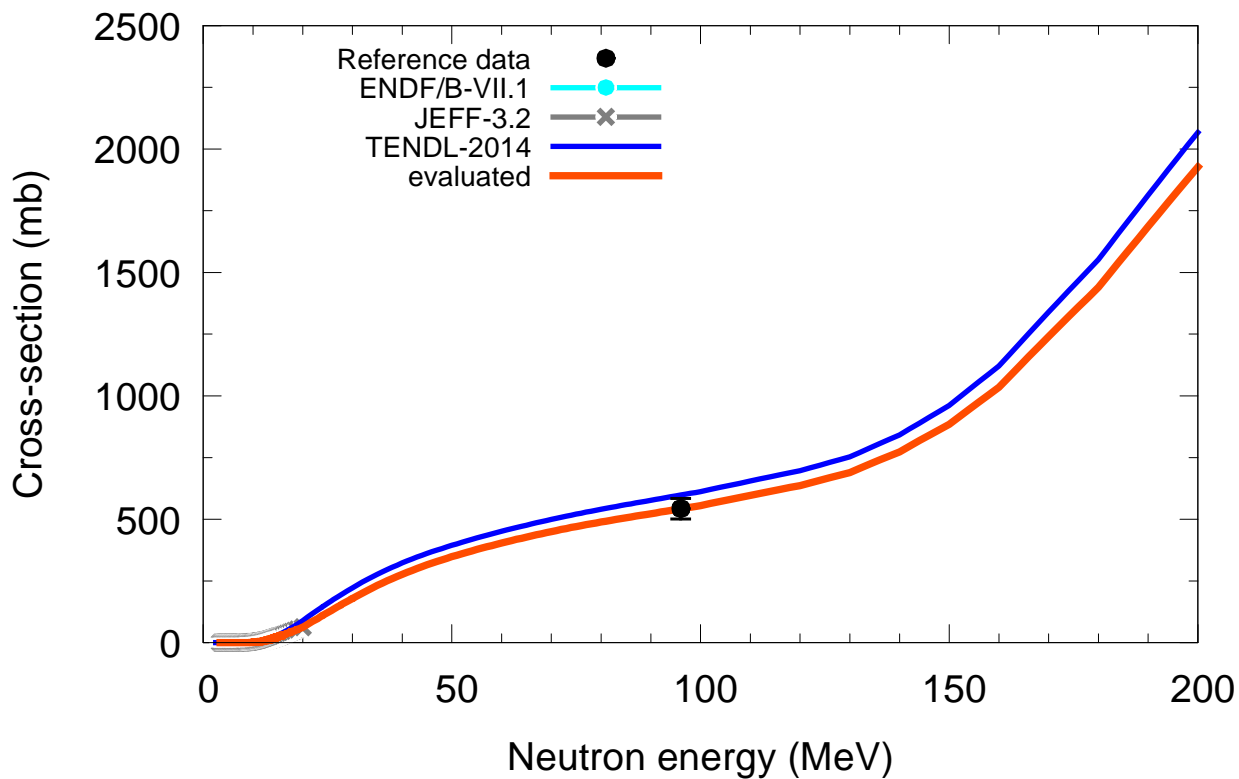
### $^{114}\text{Sn}(n,x)p$



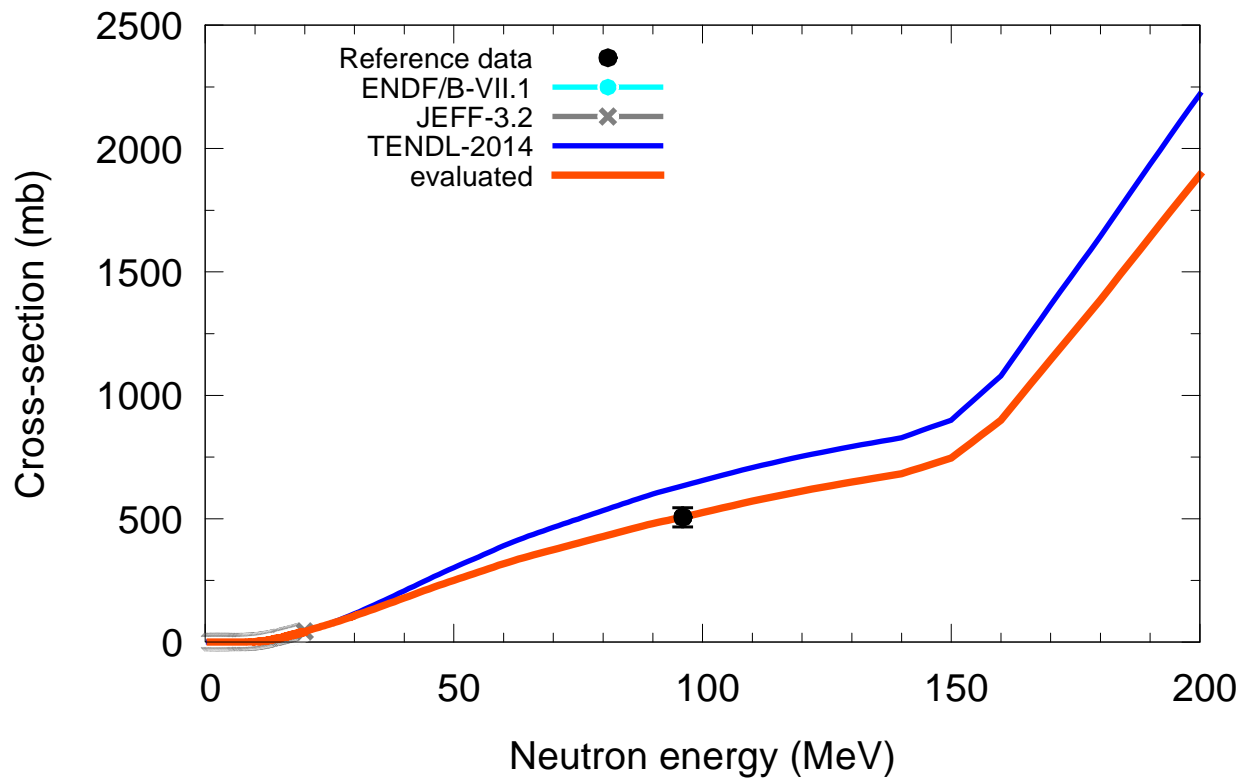
### $^{115}\text{Sn}(n,x)p$



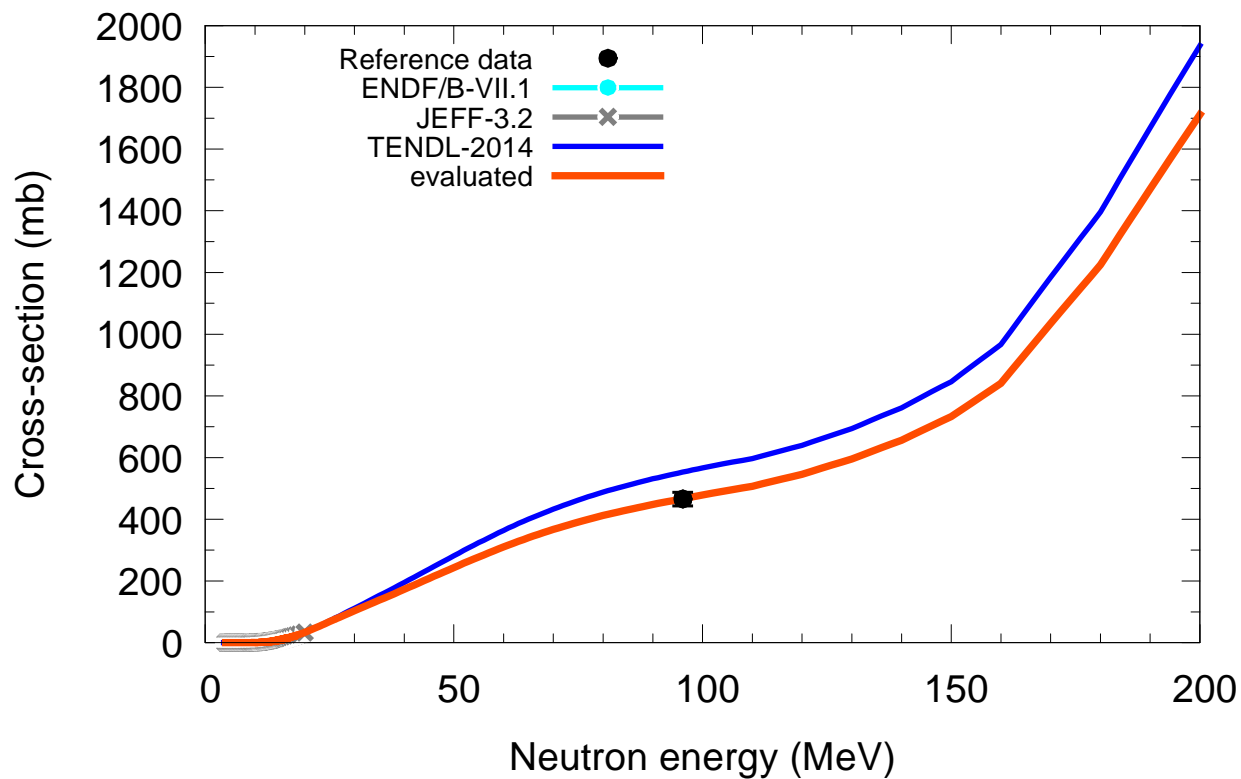
### $^{116}\text{Sn}(n,x)p$



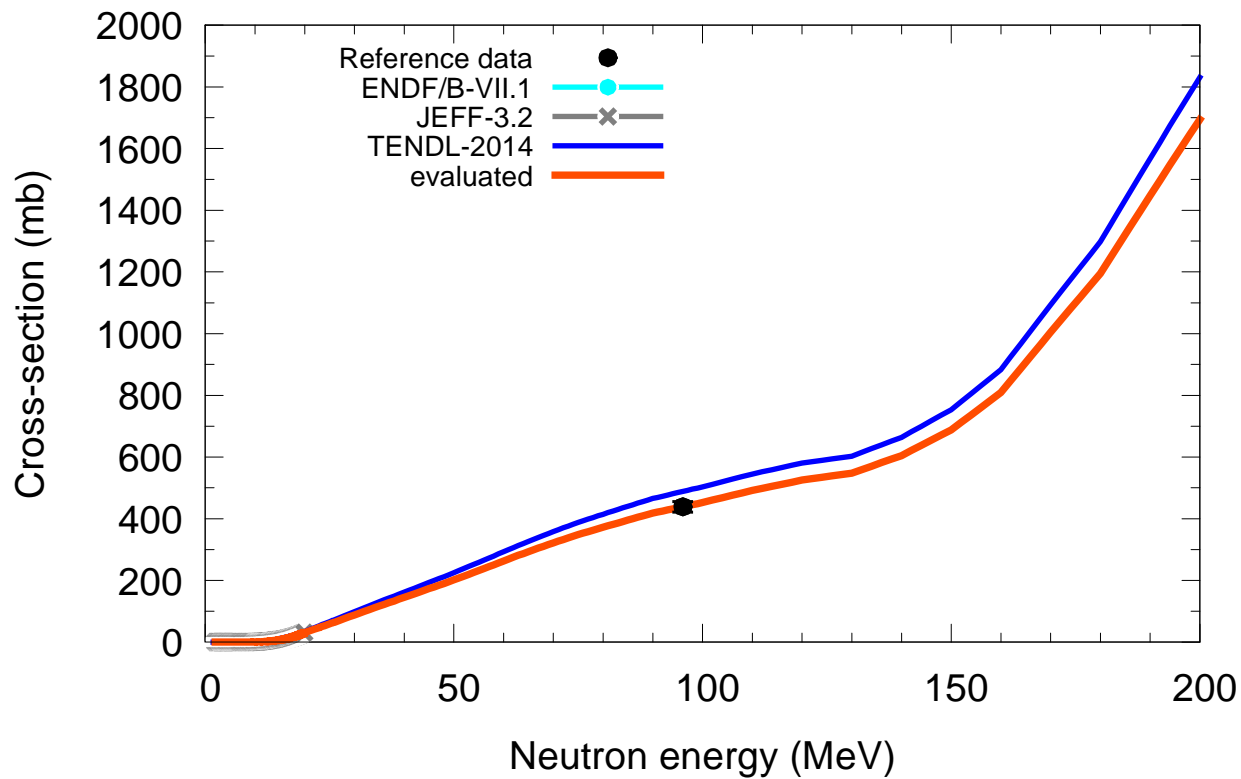
### $^{117}\text{Sn}(n,x)p$



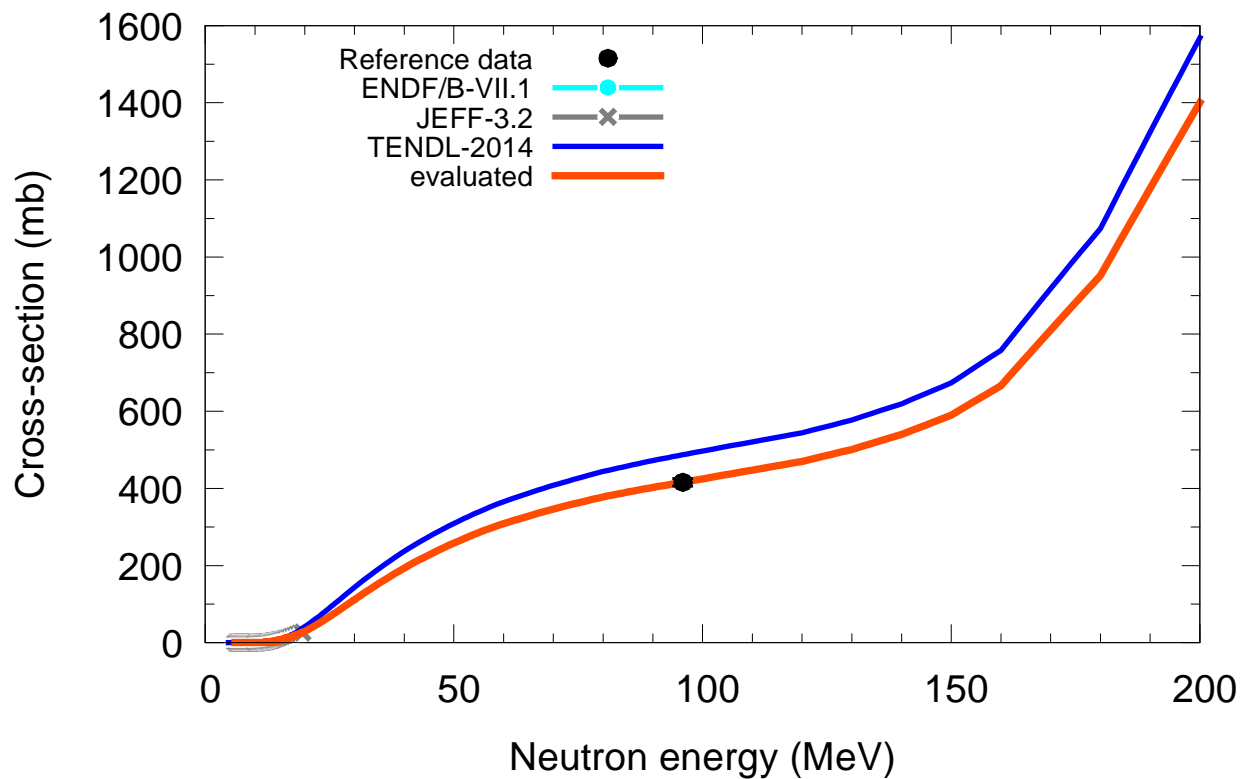
### $^{118}\text{Sn}(n,x)p$



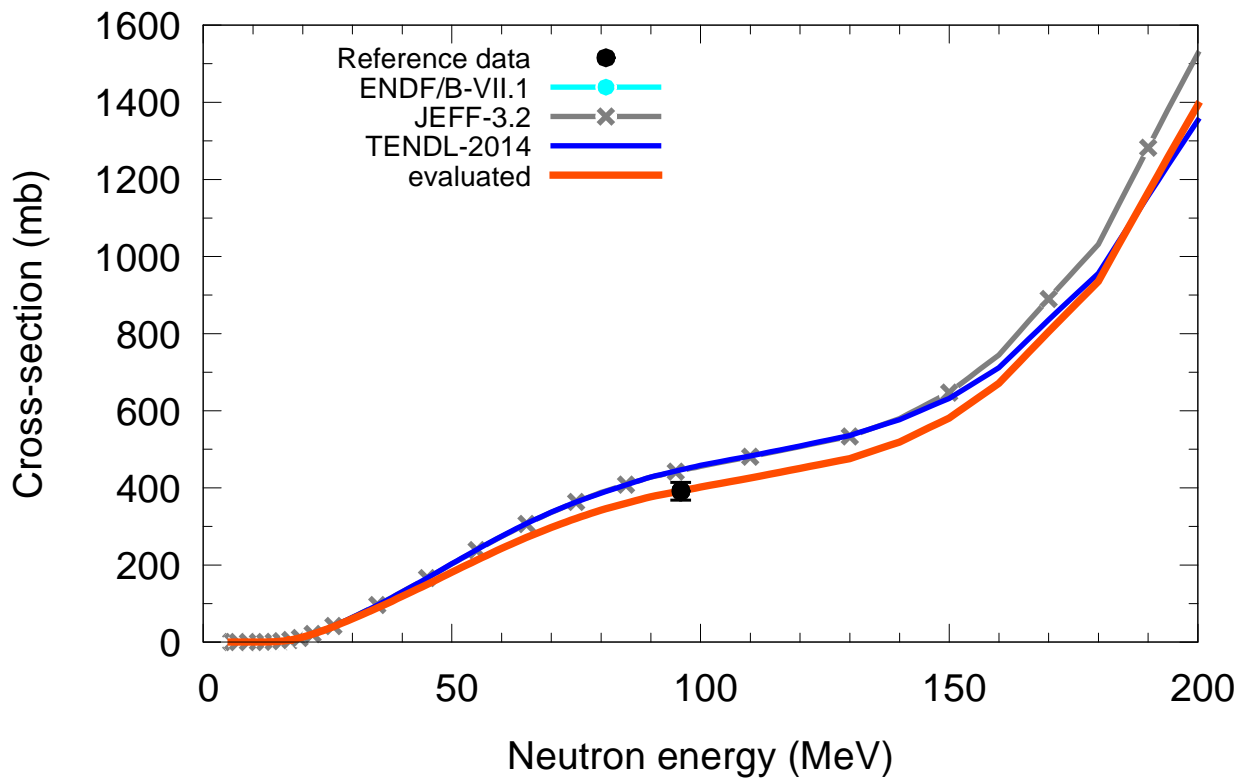
$^{119}\text{Sn}(n,x)p$



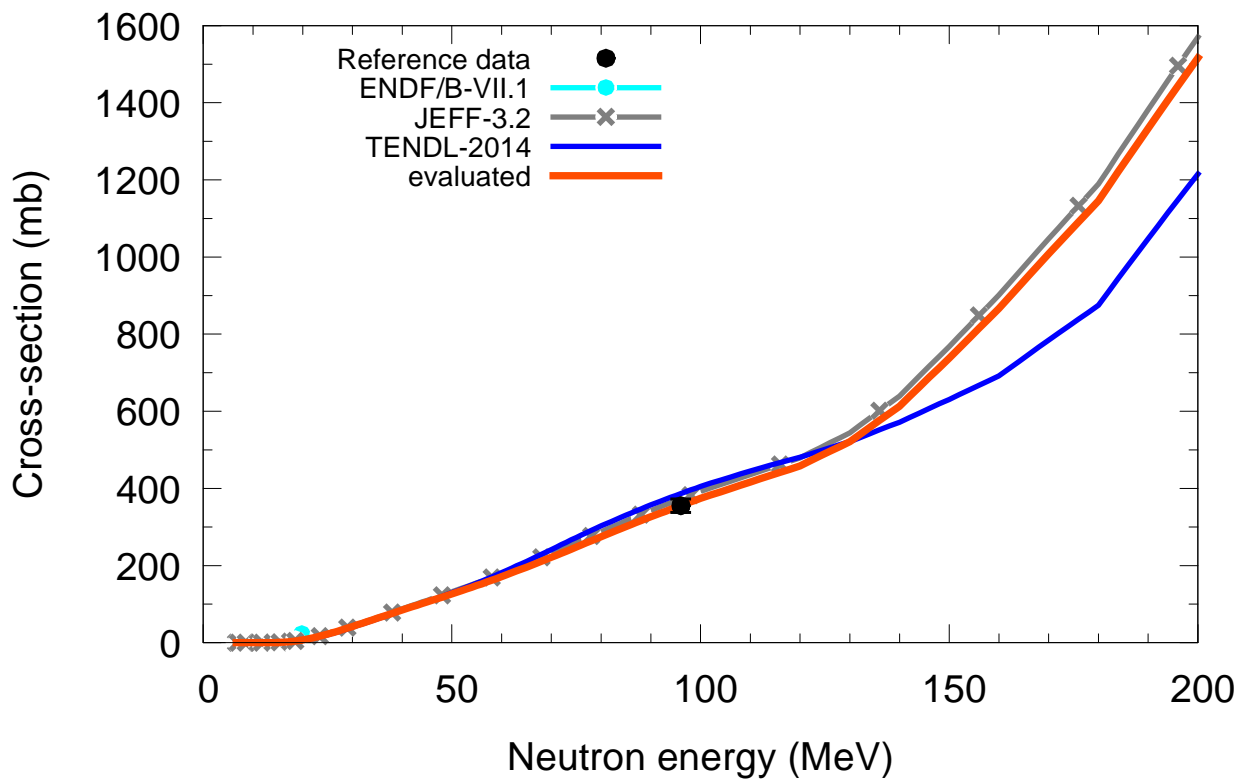
$^{120}\text{Sn}(n,x)p$



### $^{122}\text{Sn}(n,x)p$

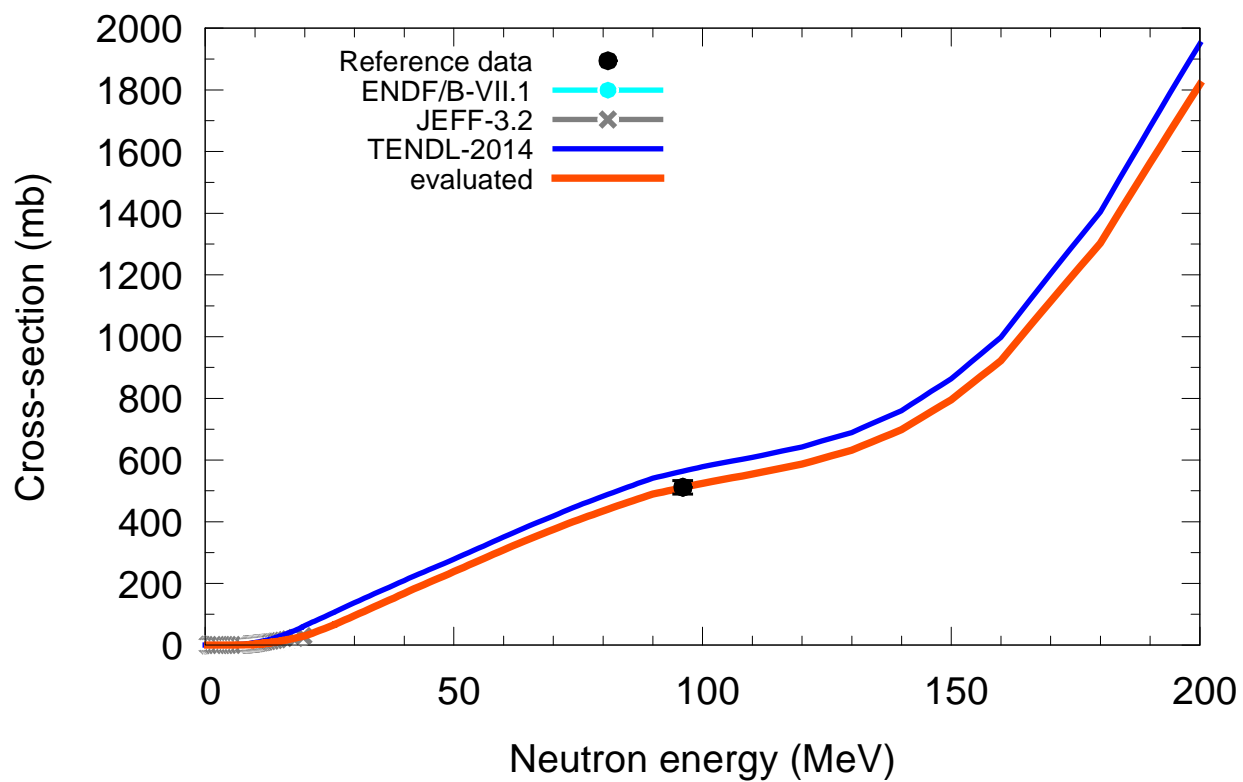


### $^{124}\text{Sn}(n,x)p$

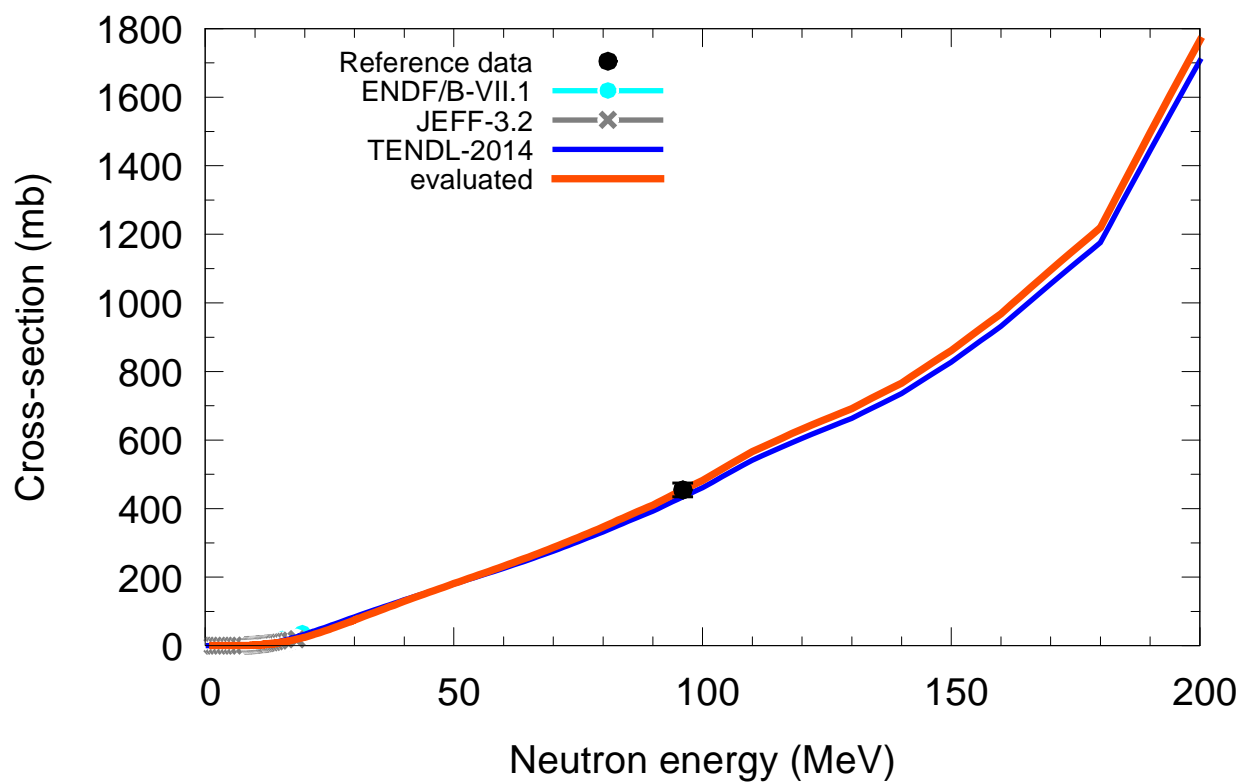


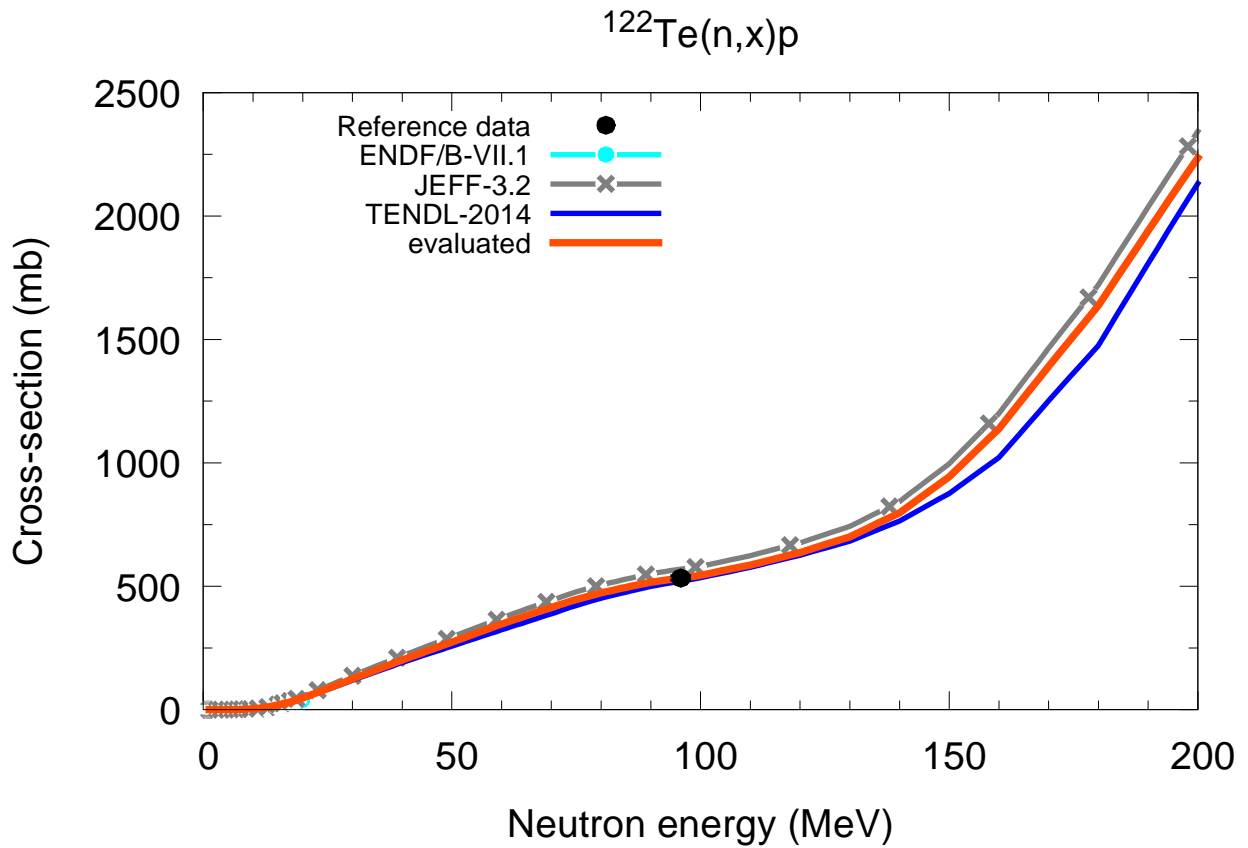
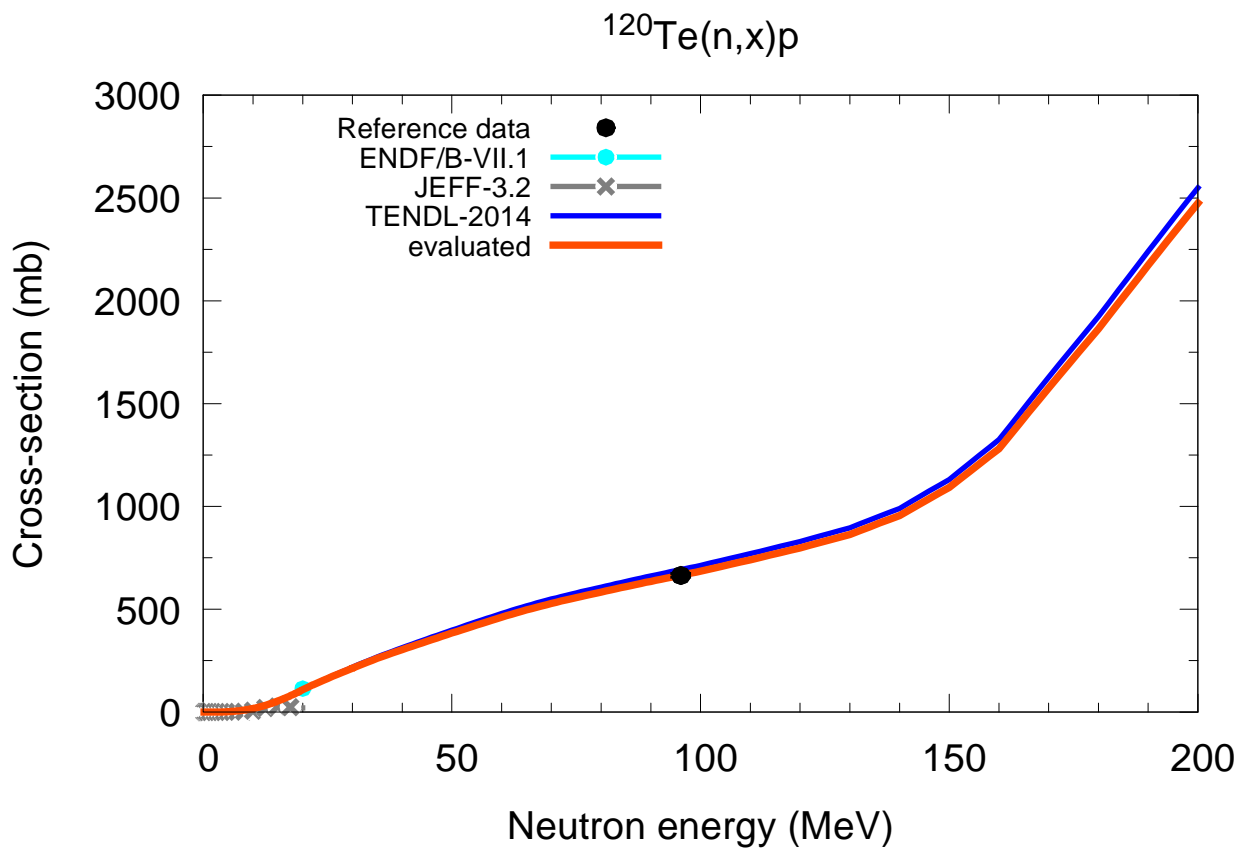


### $^{121}\text{Sb}(n,x)p$

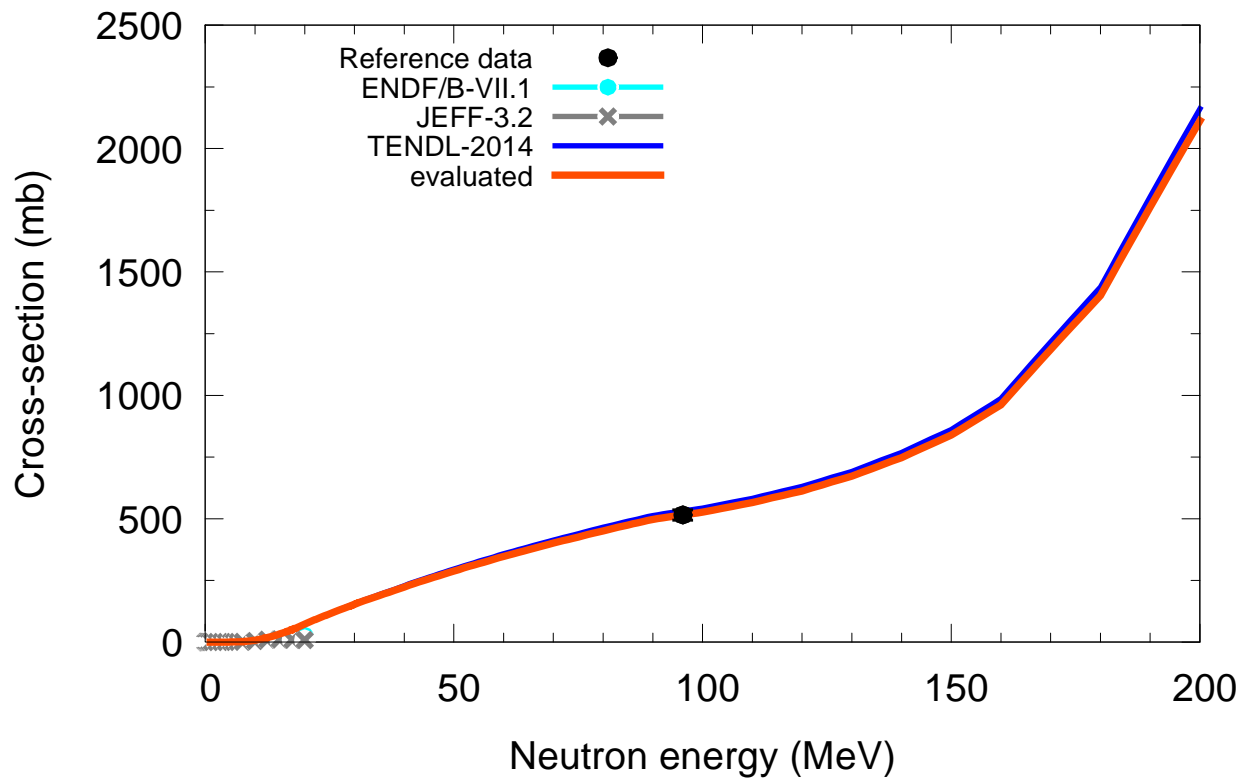


### $^{123}\text{Sb}(n,x)p$

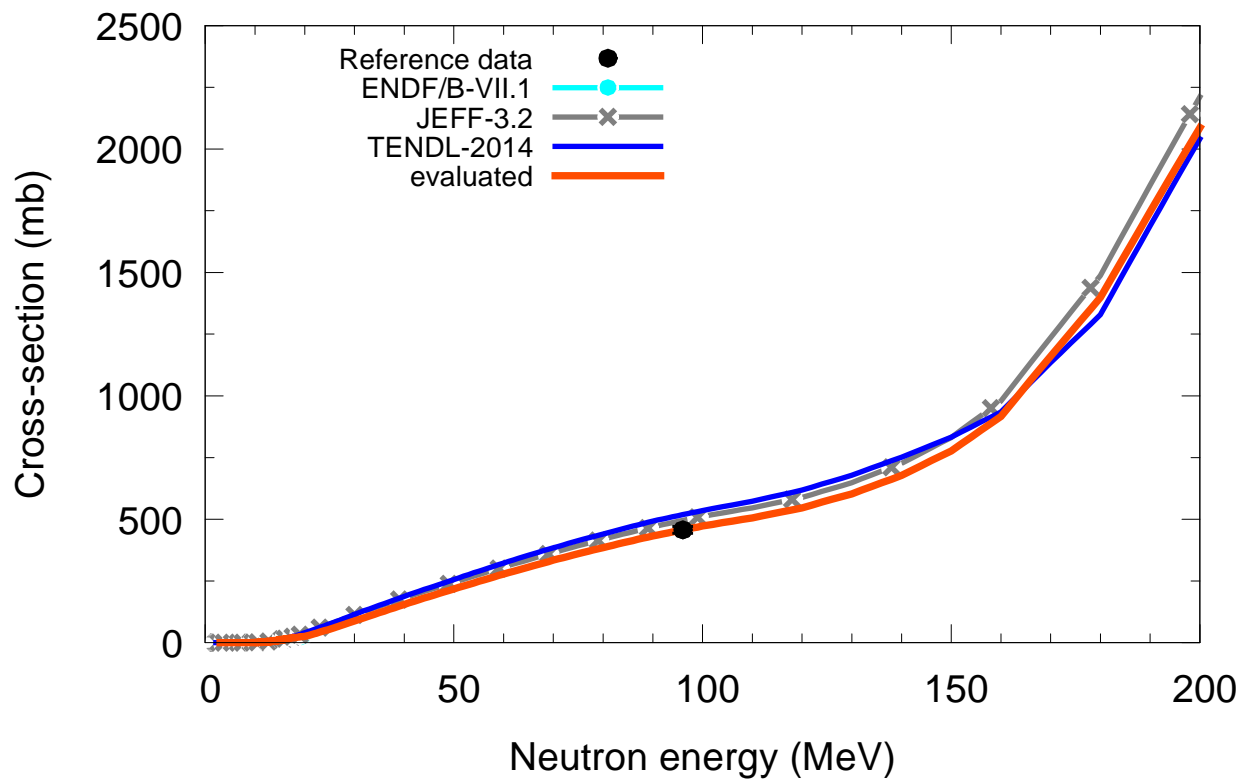




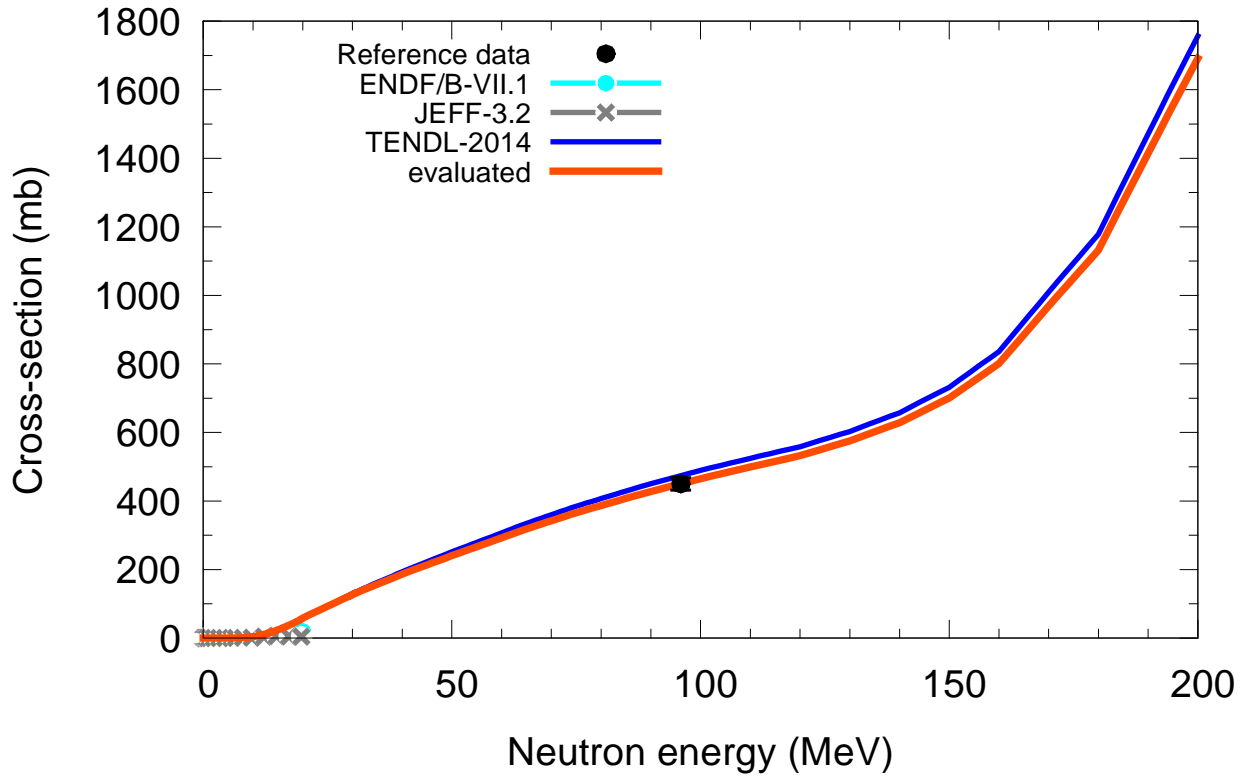
$^{123}\text{Te}(n,x)p$



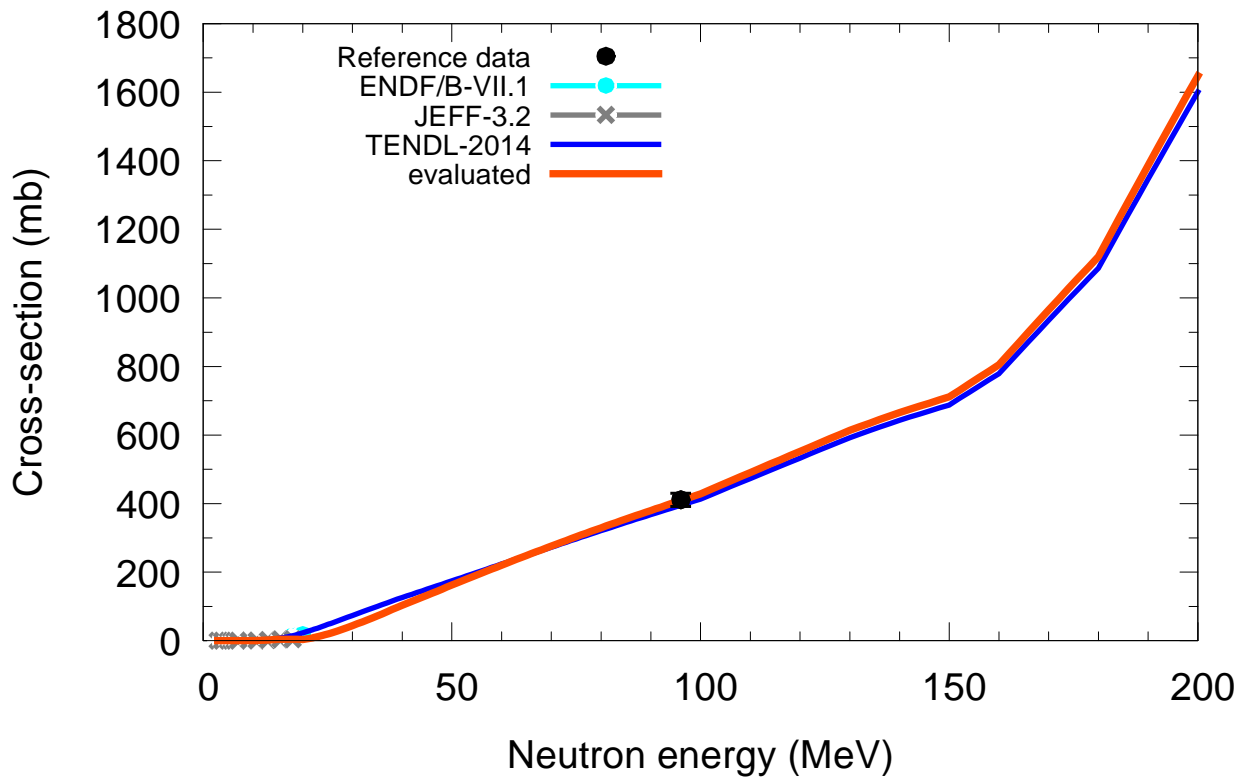
$^{124}\text{Te}(n,x)p$



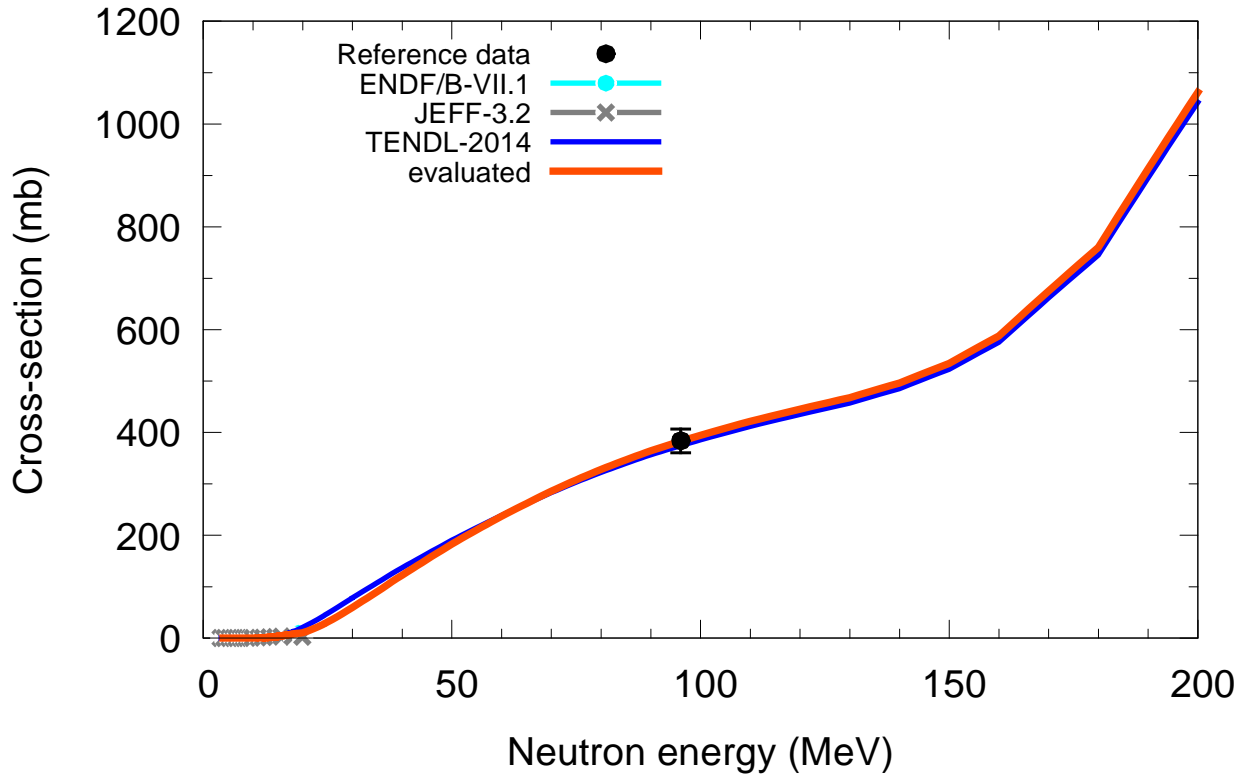
$^{125}\text{Te}(n,x)p$



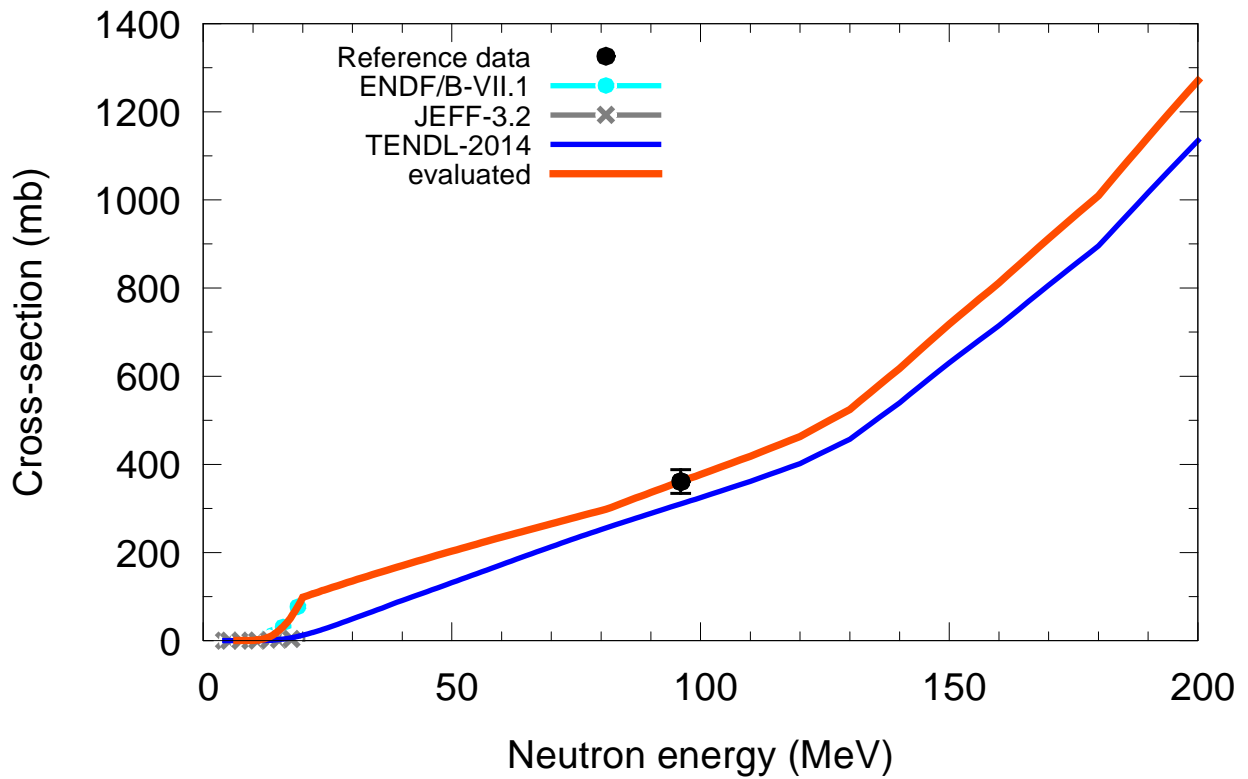
$^{126}\text{Te}(n,x)p$



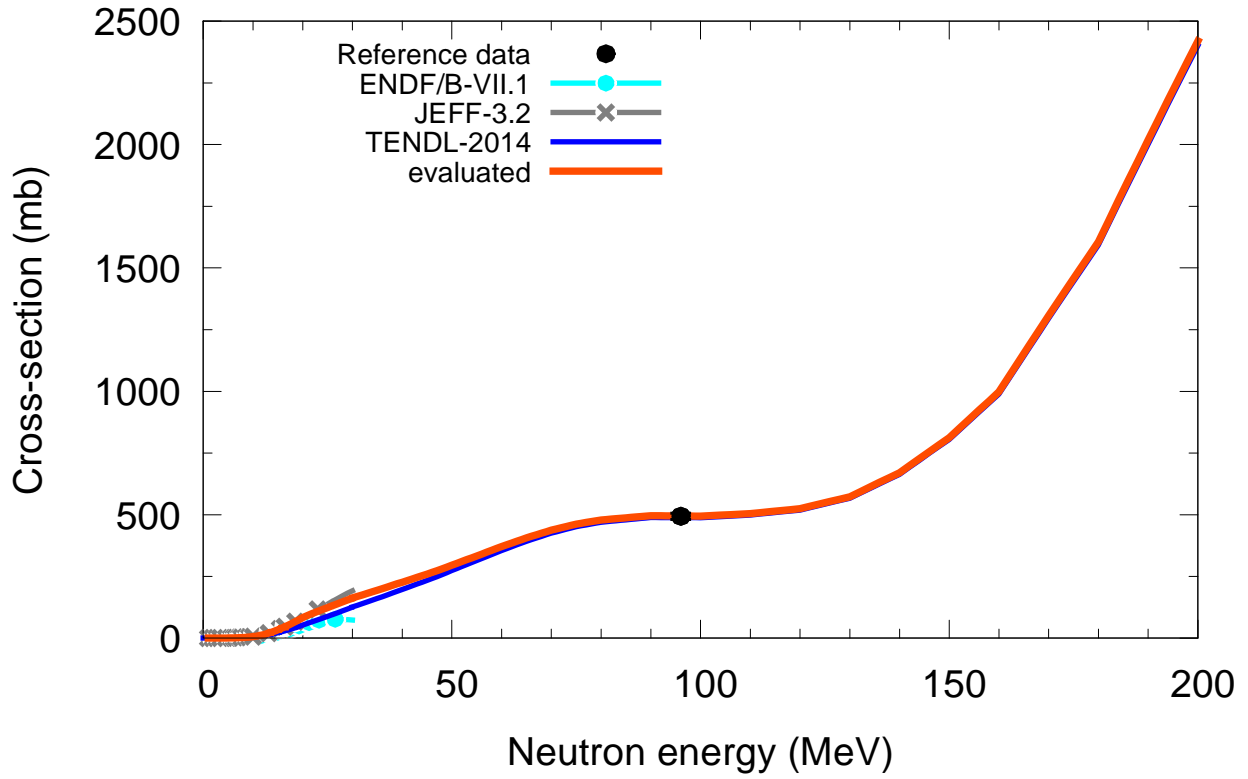
$^{128}\text{Te}(n,x)p$



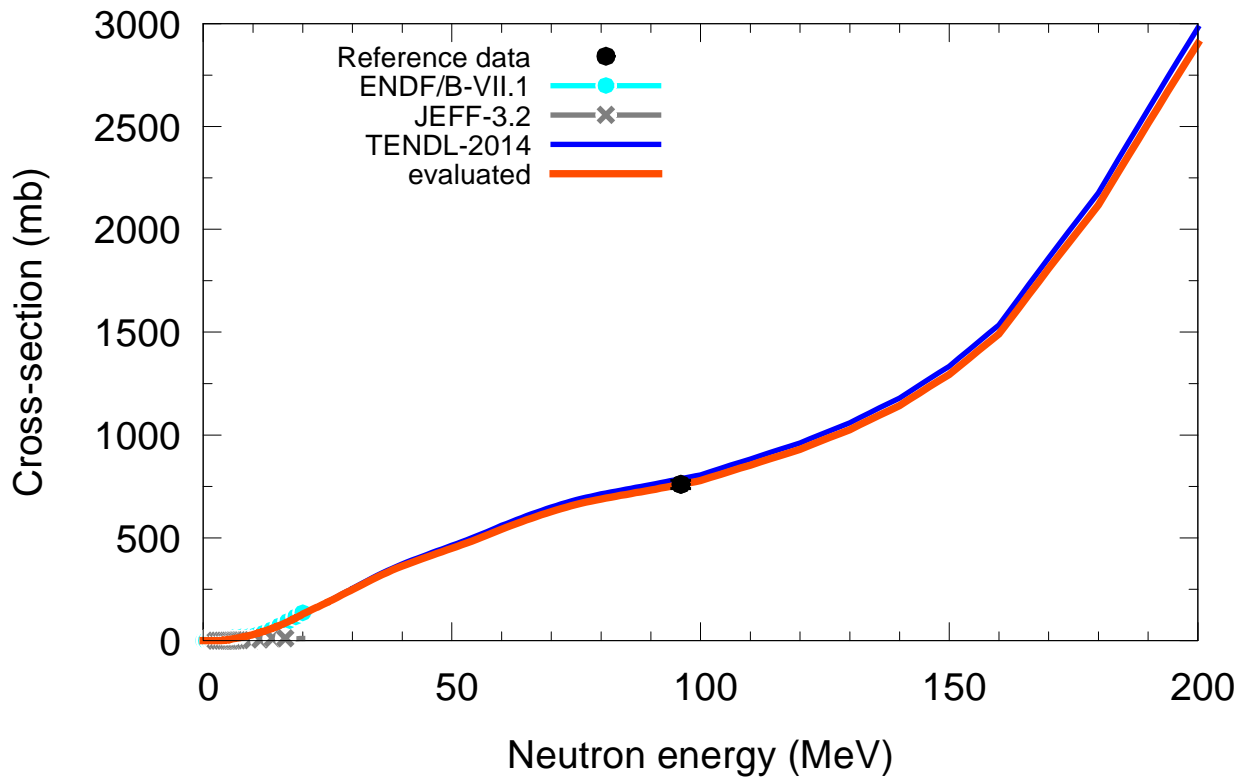
$^{130}\text{Te}(n,x)p$



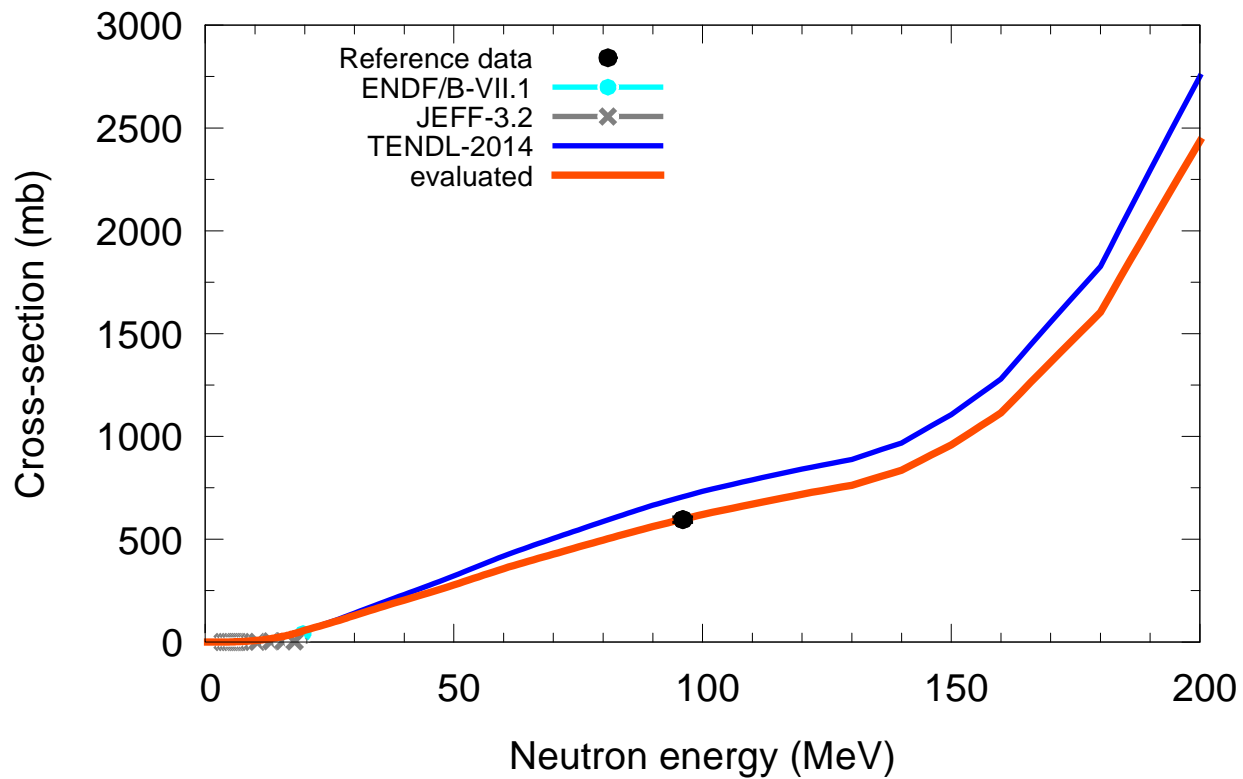
$^{127}\text{I}(n,x)p$



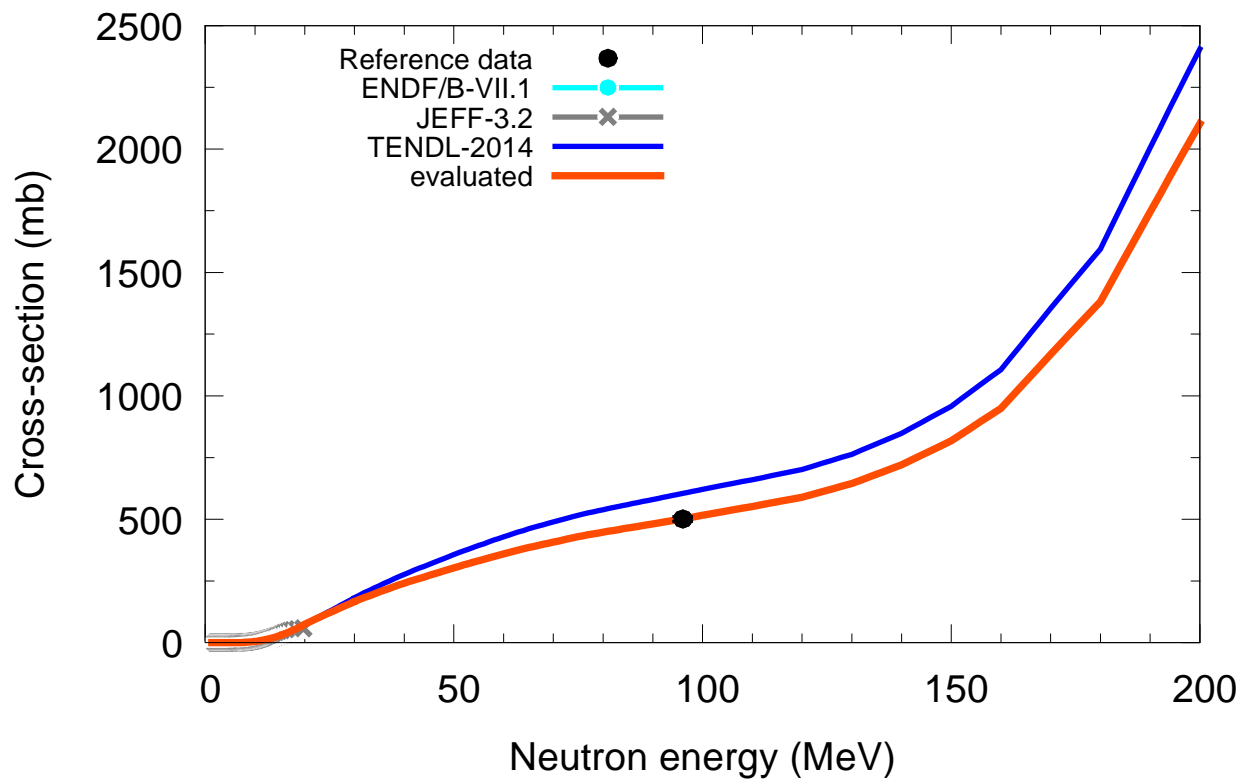
$^{124}\text{Xe}(n,x)p$



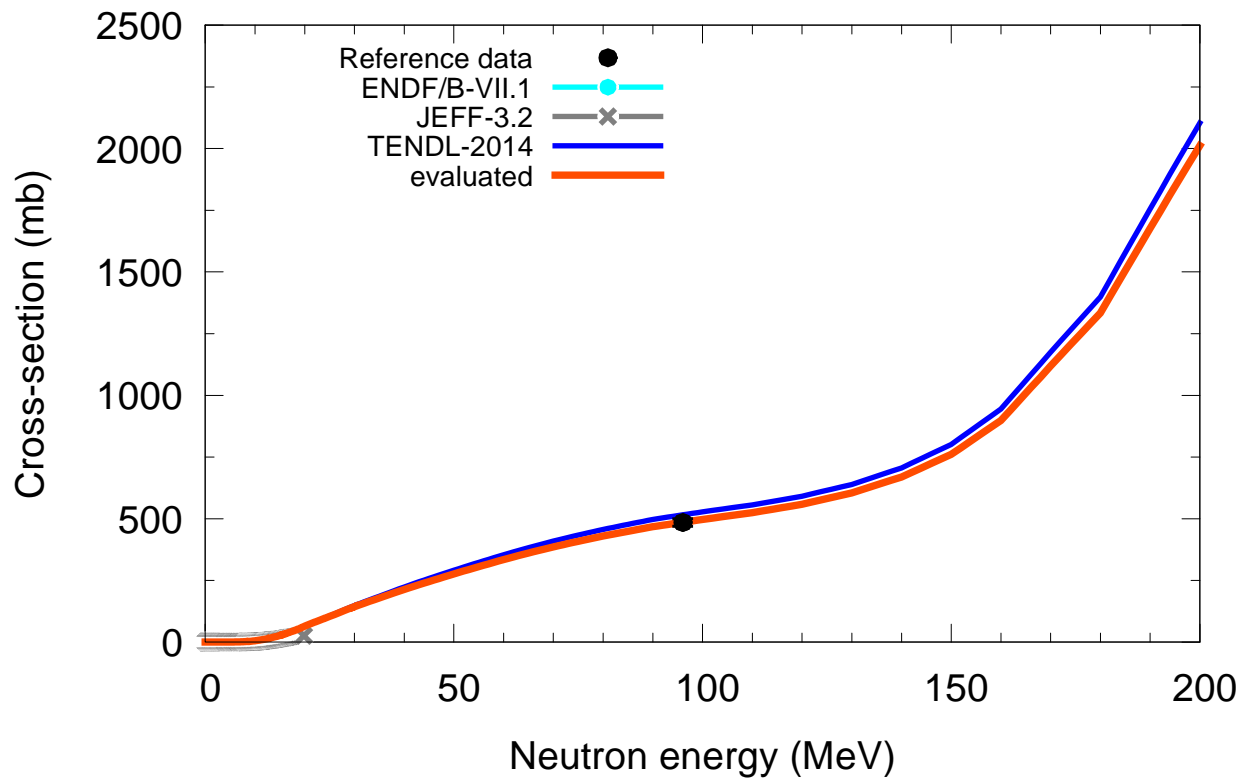
$^{126}\text{Xe}(n,x)p$



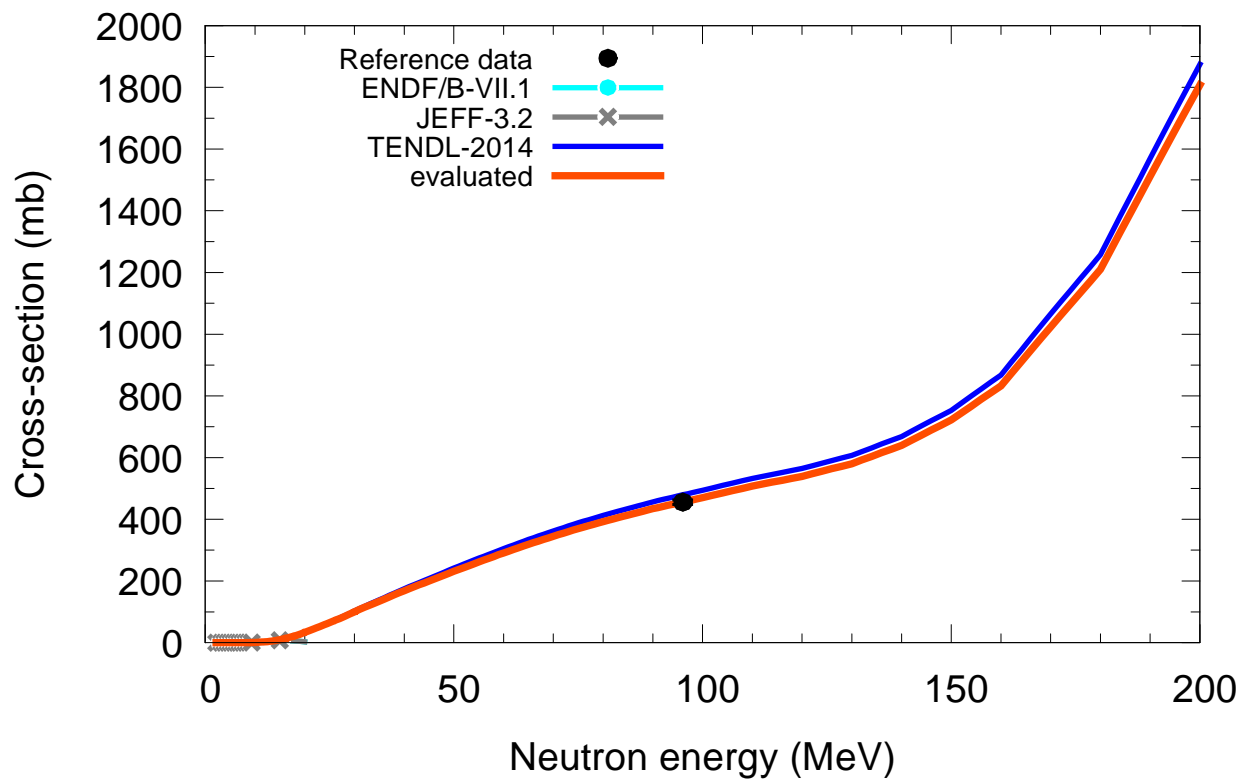
$^{128}\text{Xe}(n,x)p$



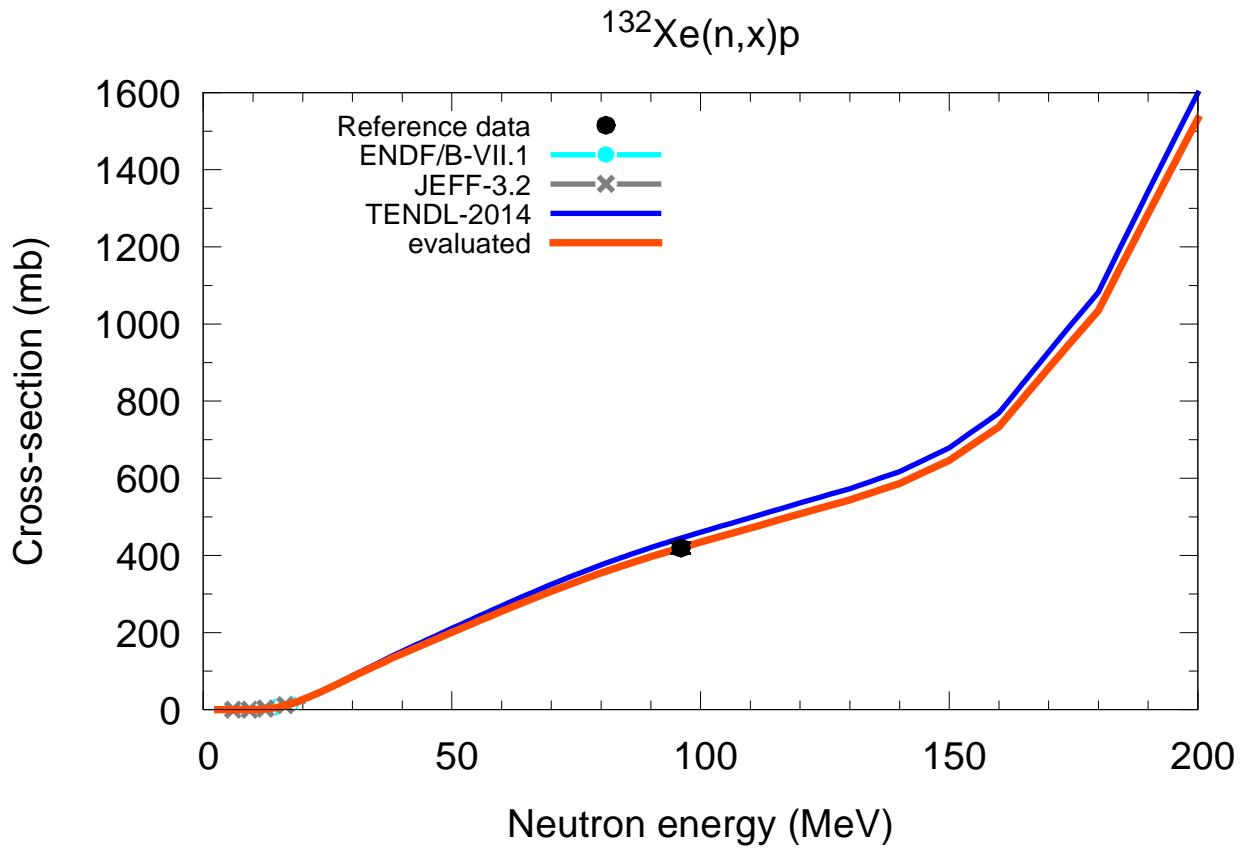
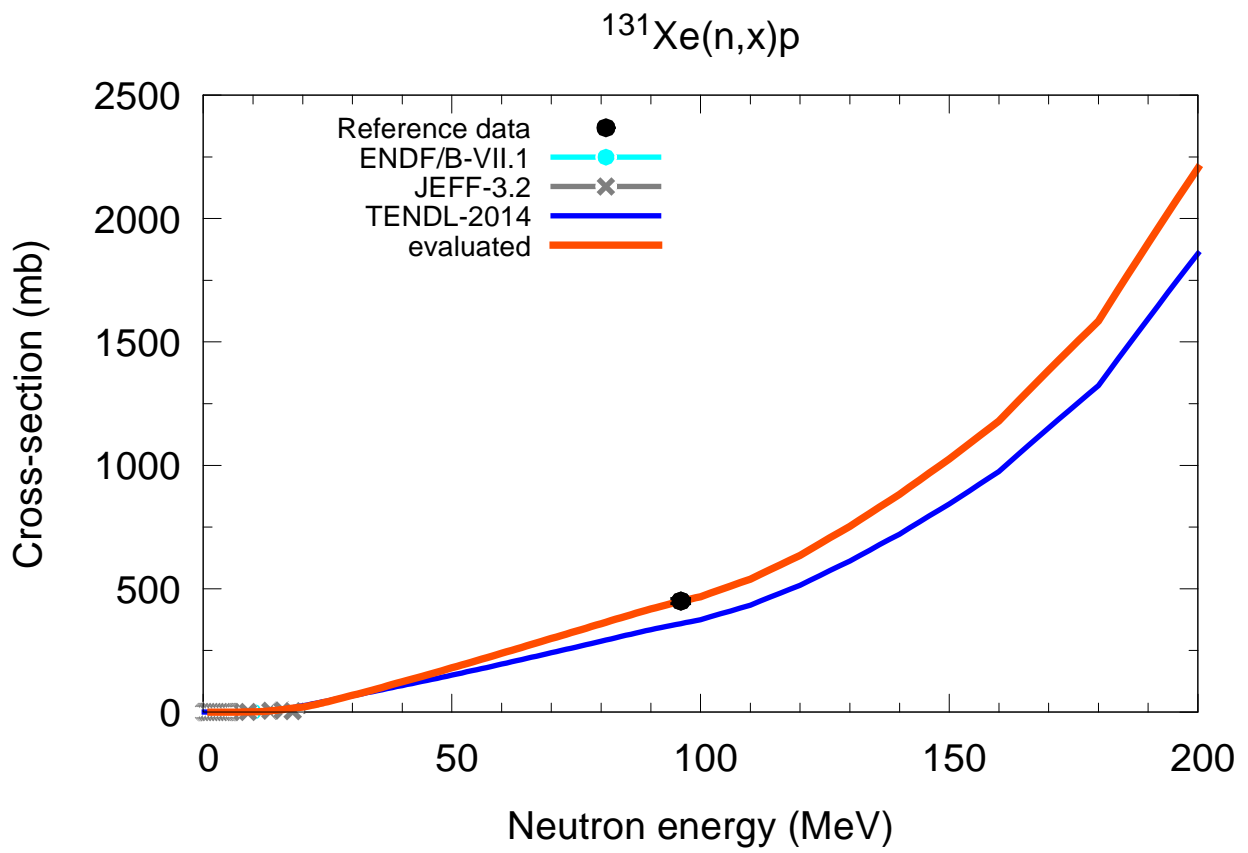
$^{129}\text{Xe}(n,x)p$

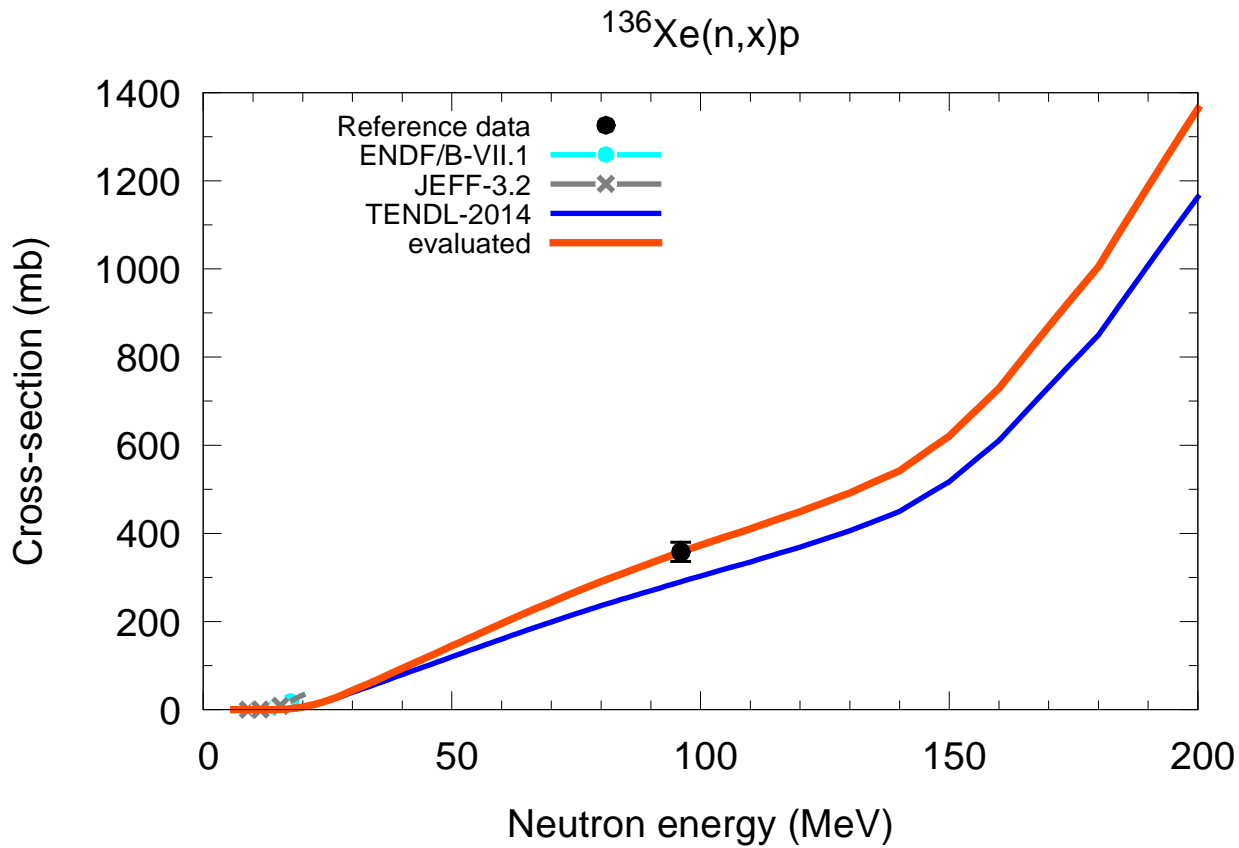
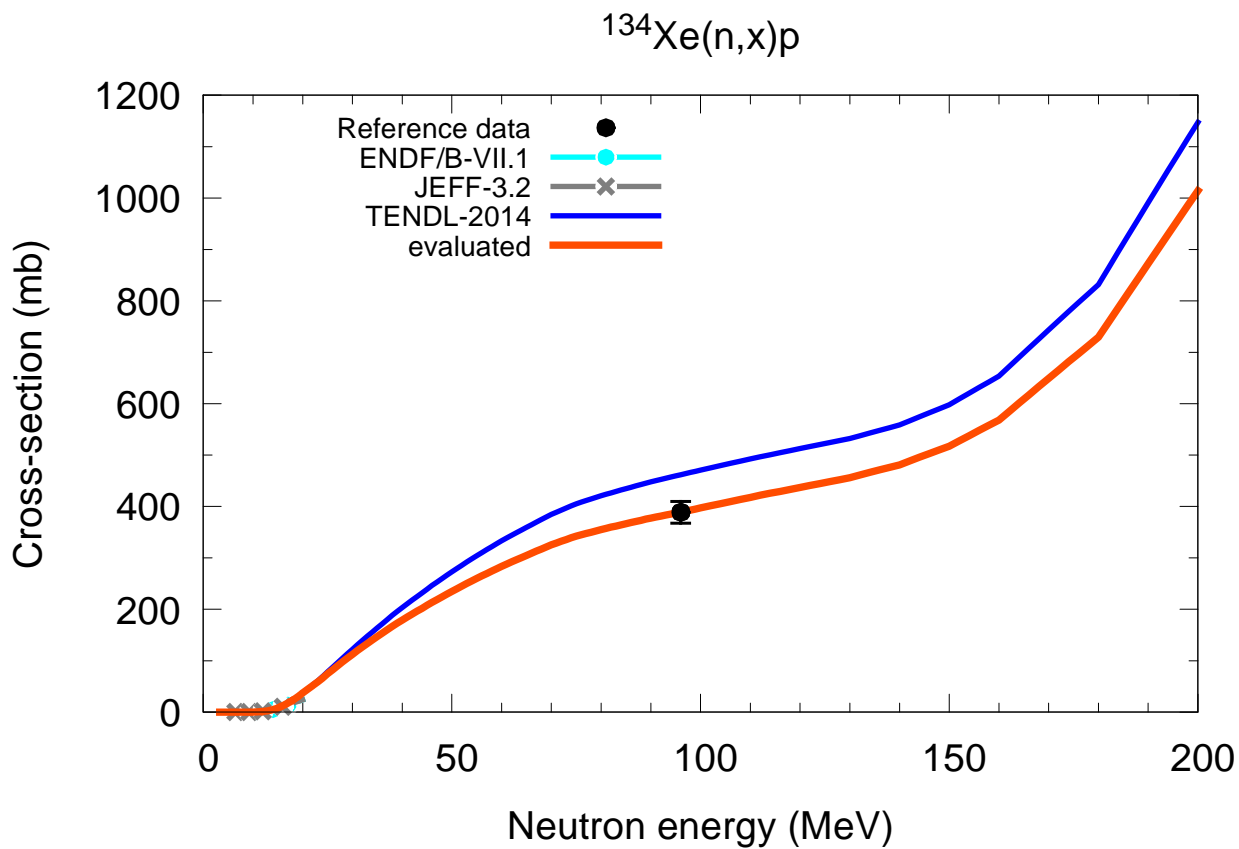


$^{130}\text{Xe}(n,x)p$

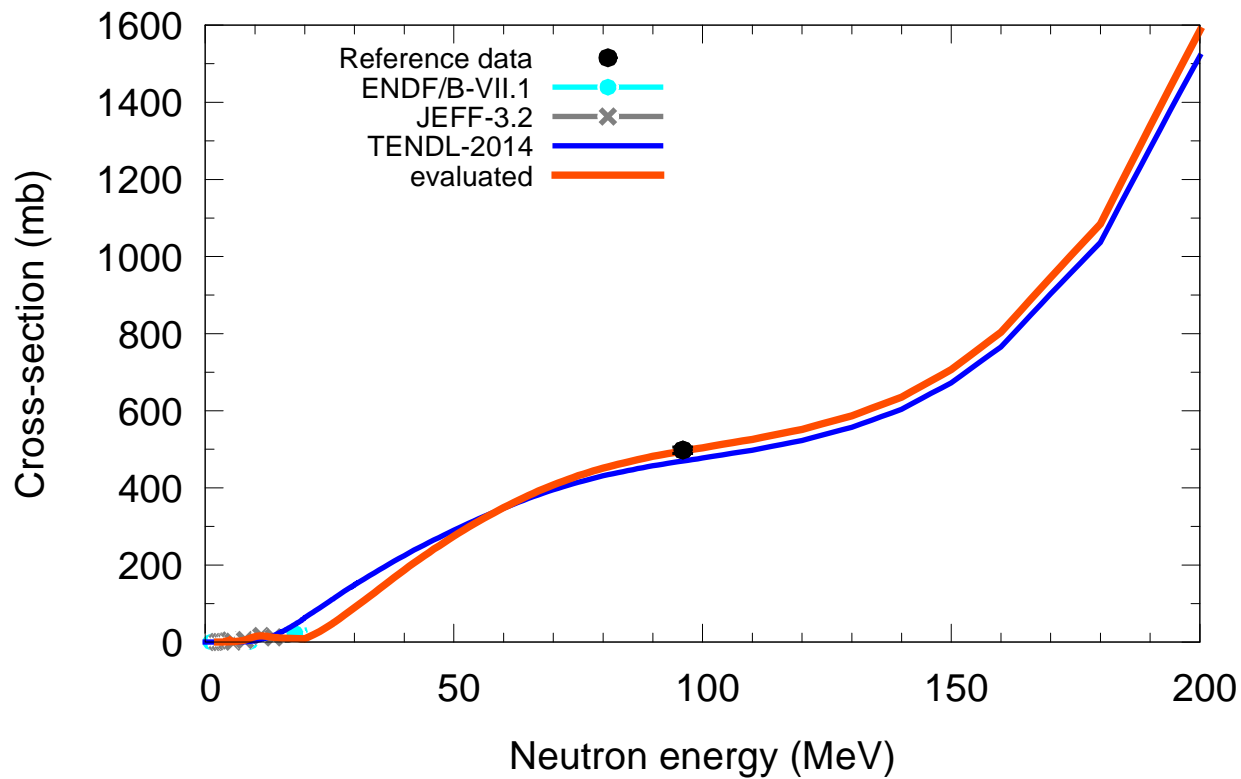




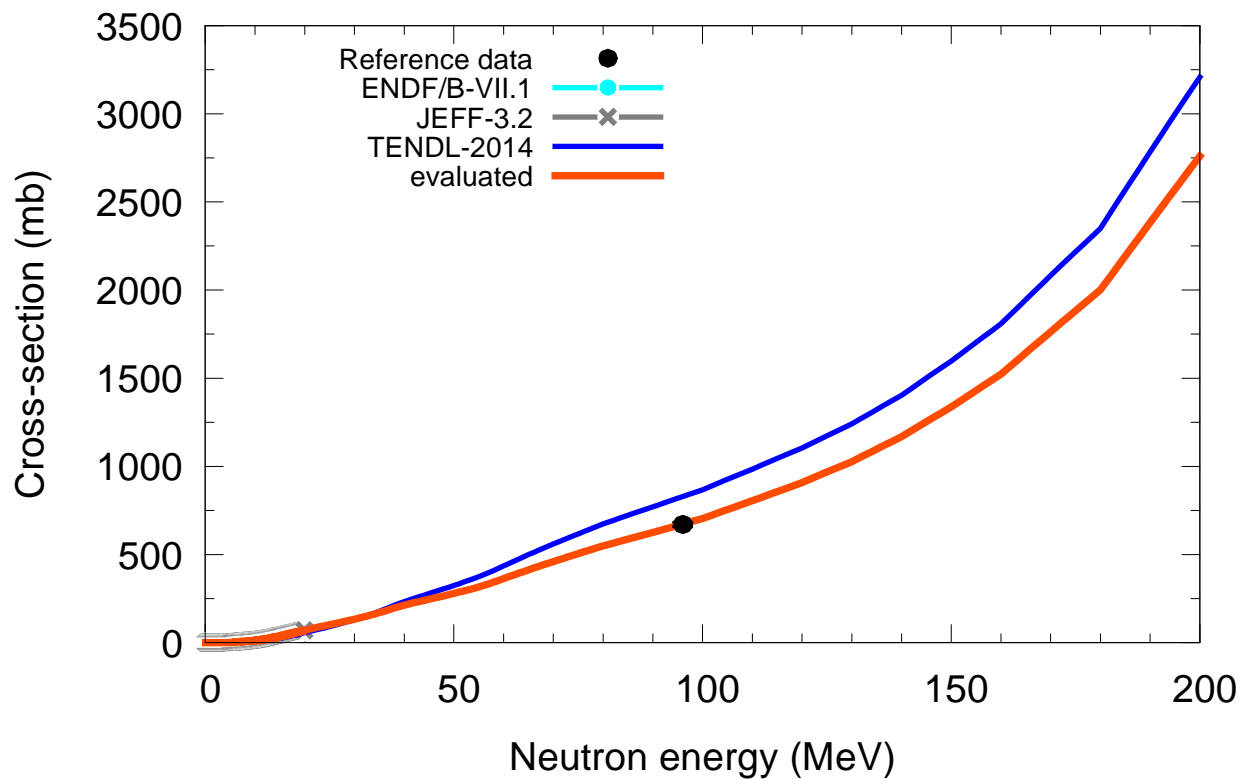




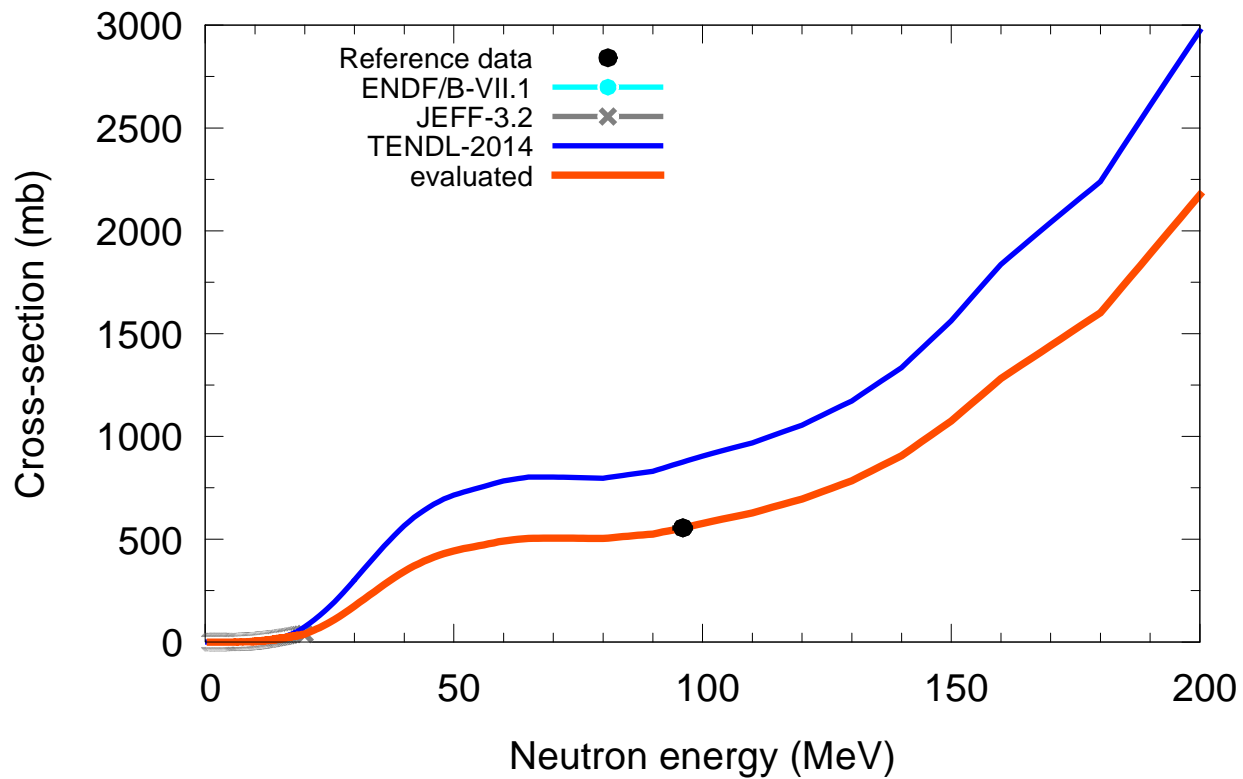
$^{133}\text{Cs}(n,x)p$



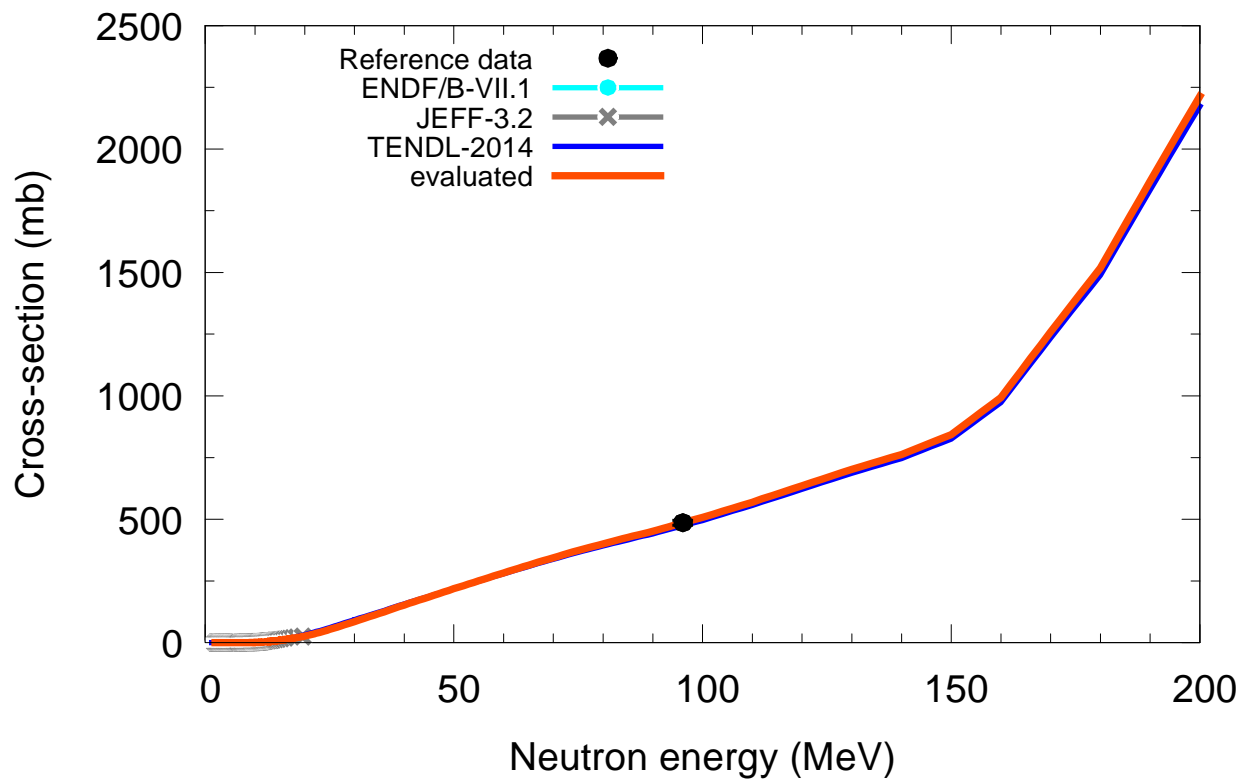
$^{130}\text{Ba}(n,x)p$



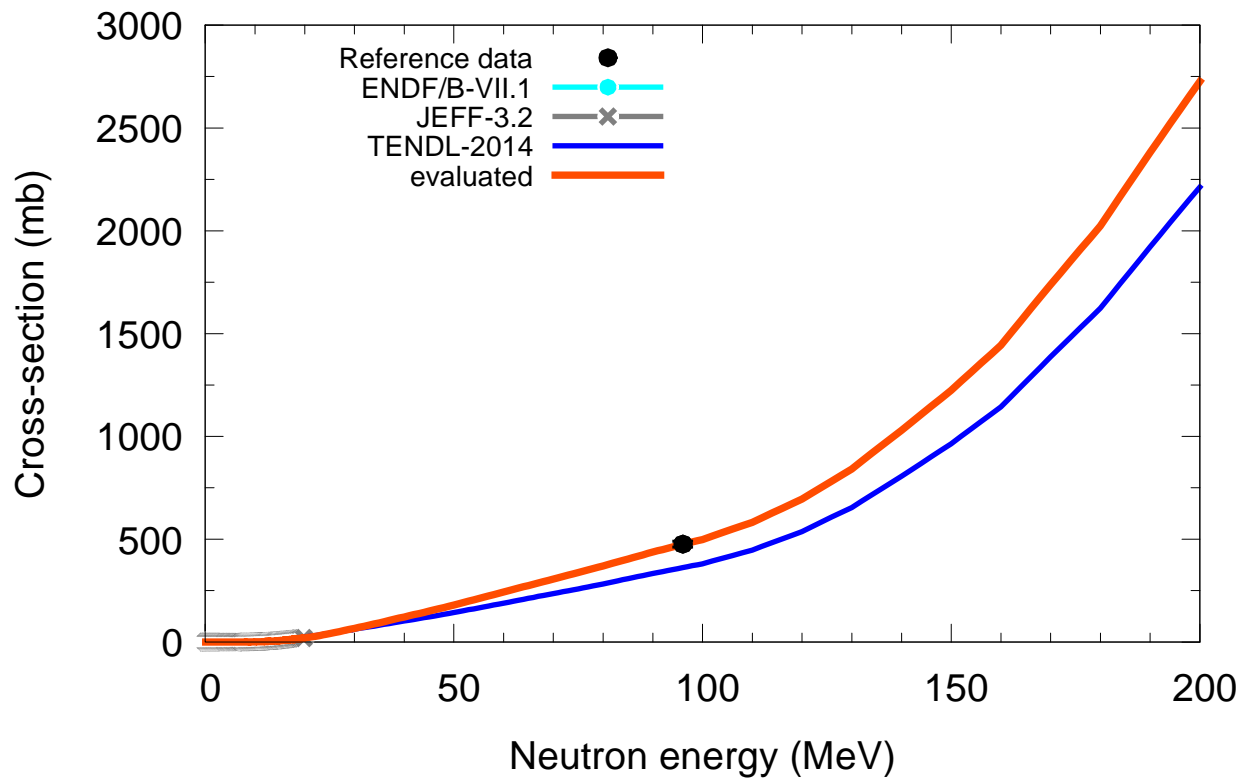
$^{132}\text{Ba}(n,x)p$



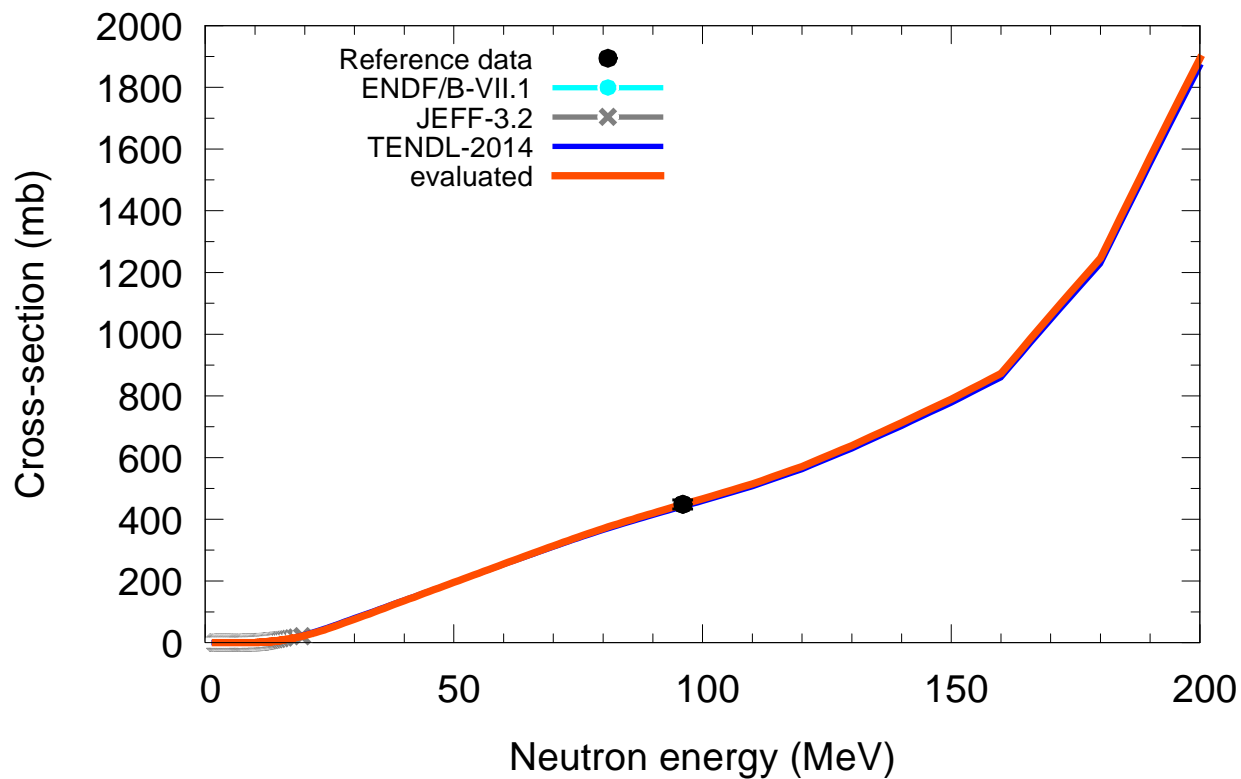
$^{134}\text{Ba}(n,x)p$



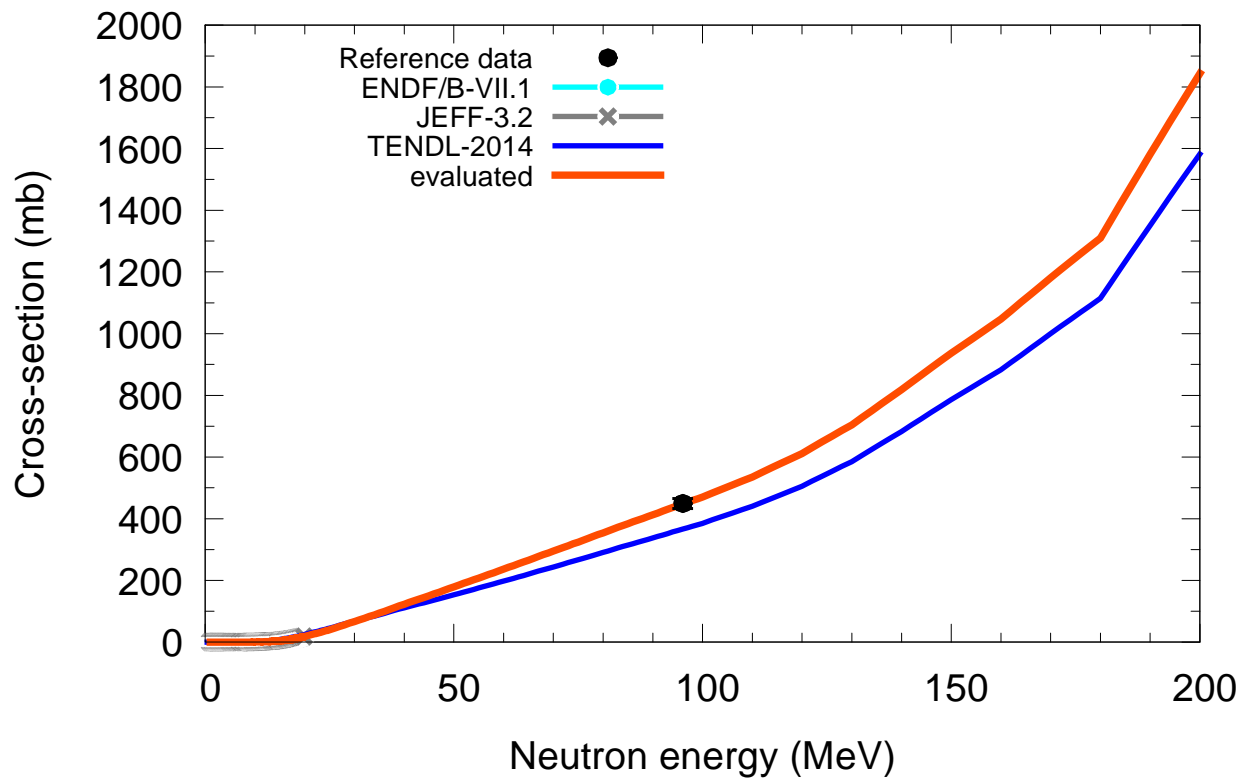
$^{135}\text{Ba}(n,x)p$



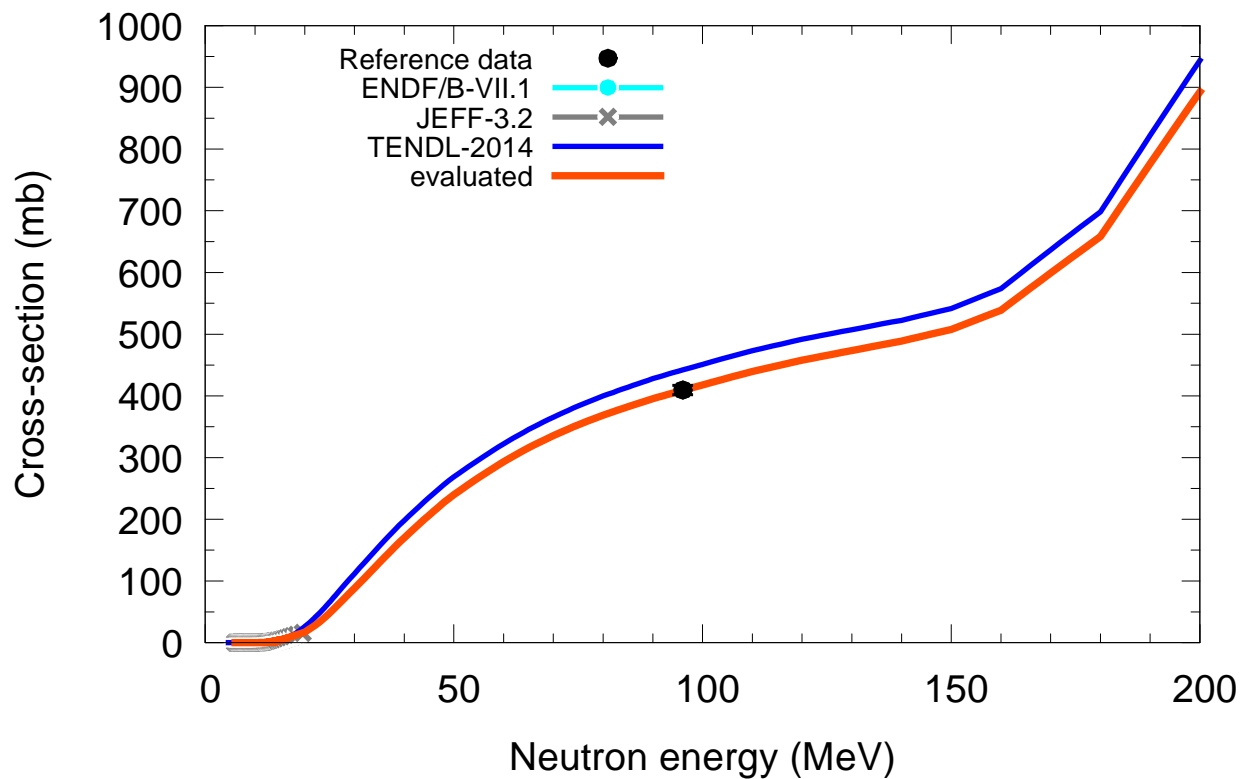
$^{136}\text{Ba}(n,x)p$

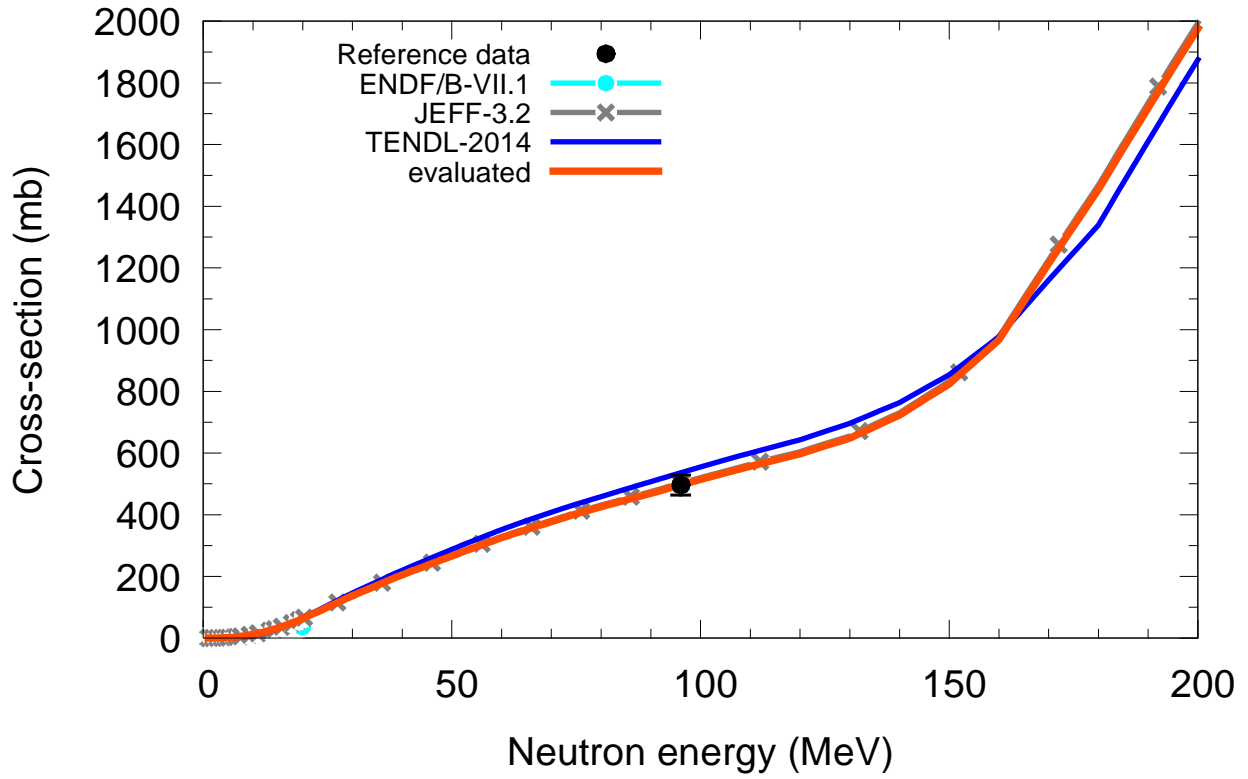
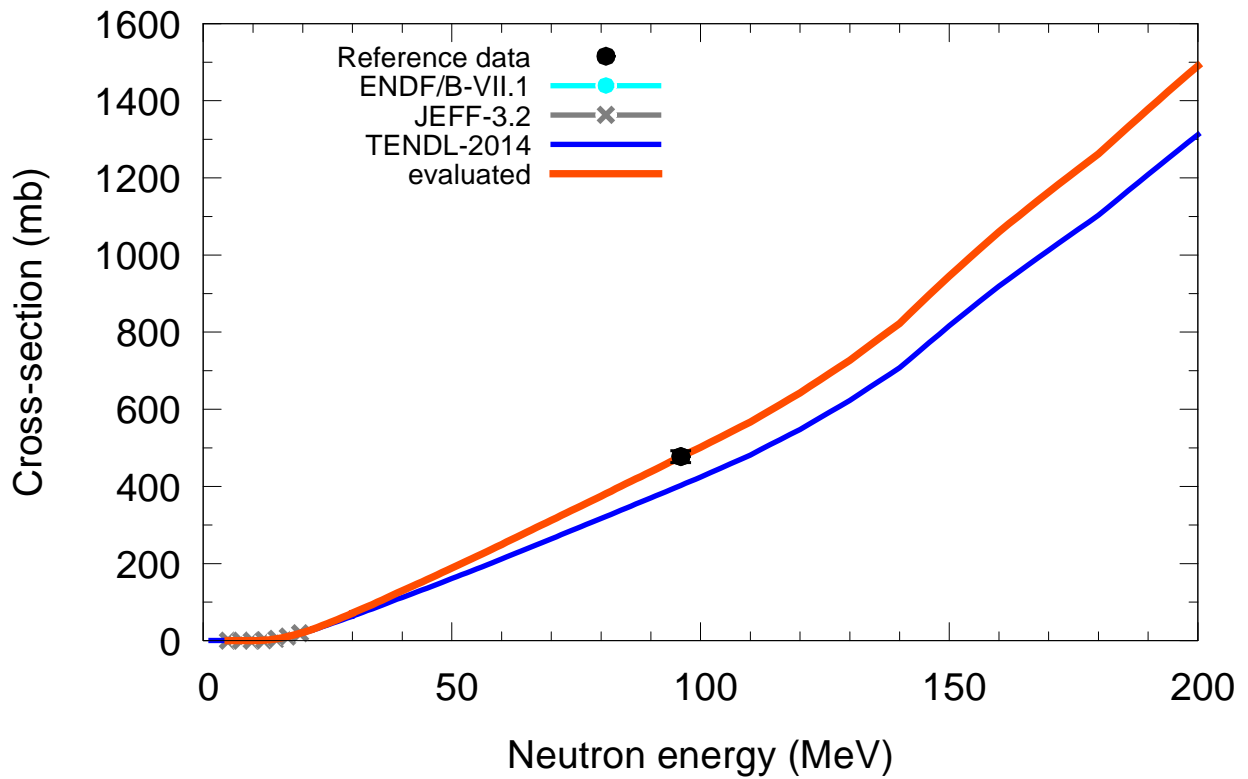


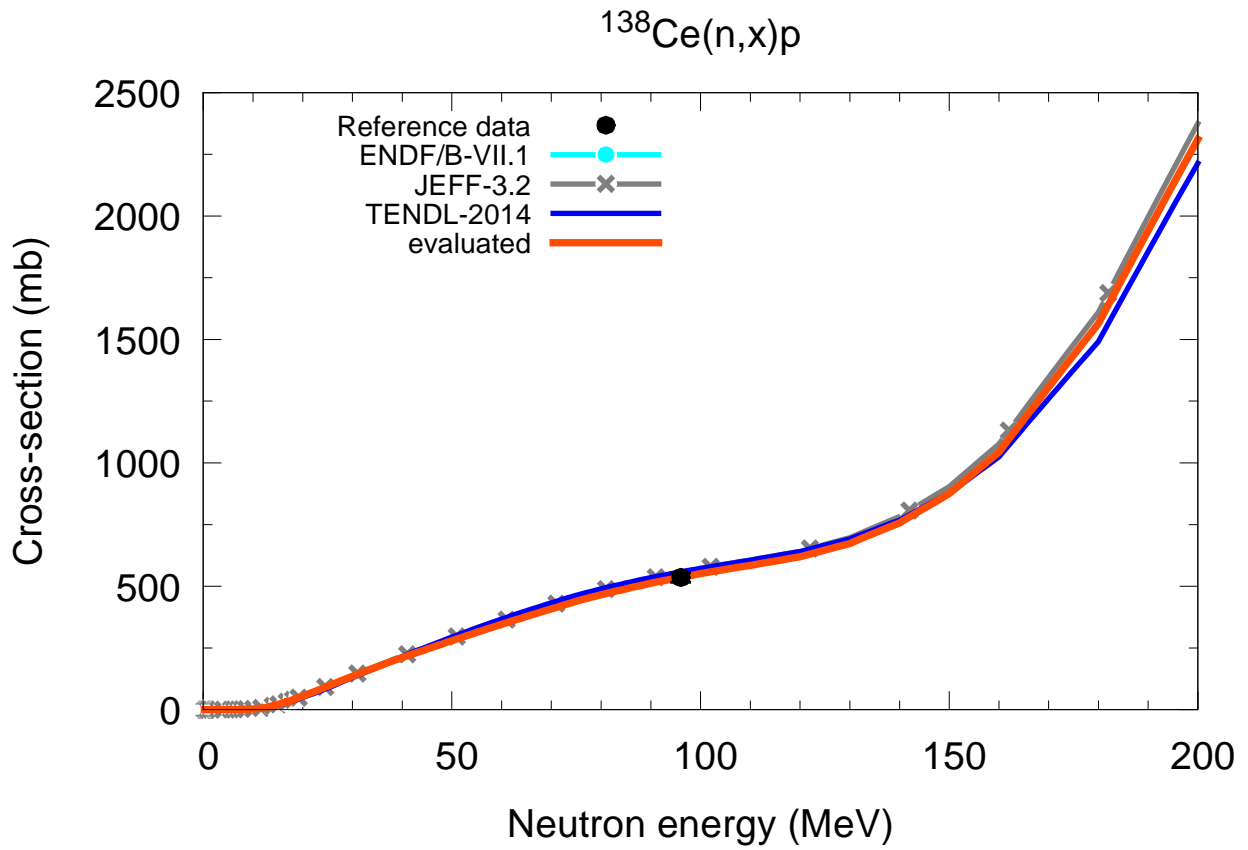
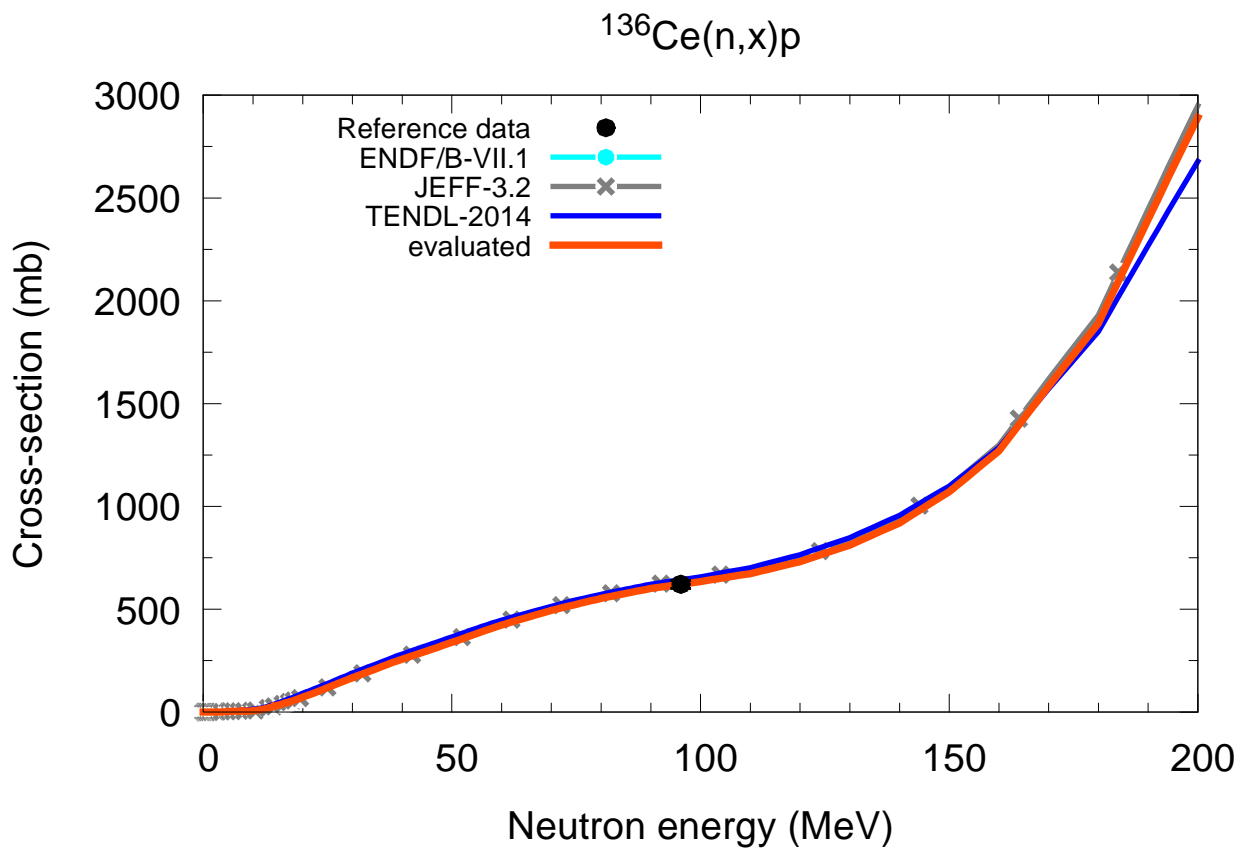
$^{137}\text{Ba}(n,x)p$



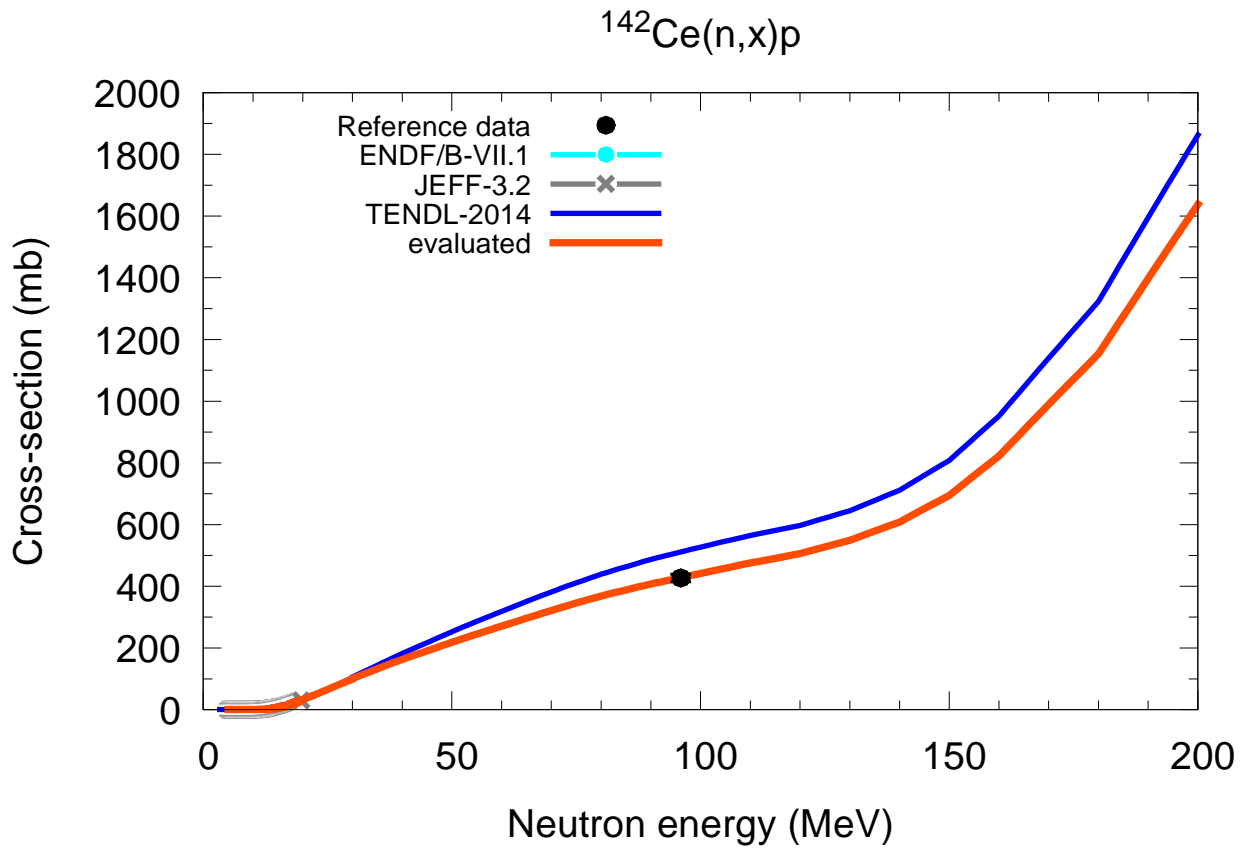
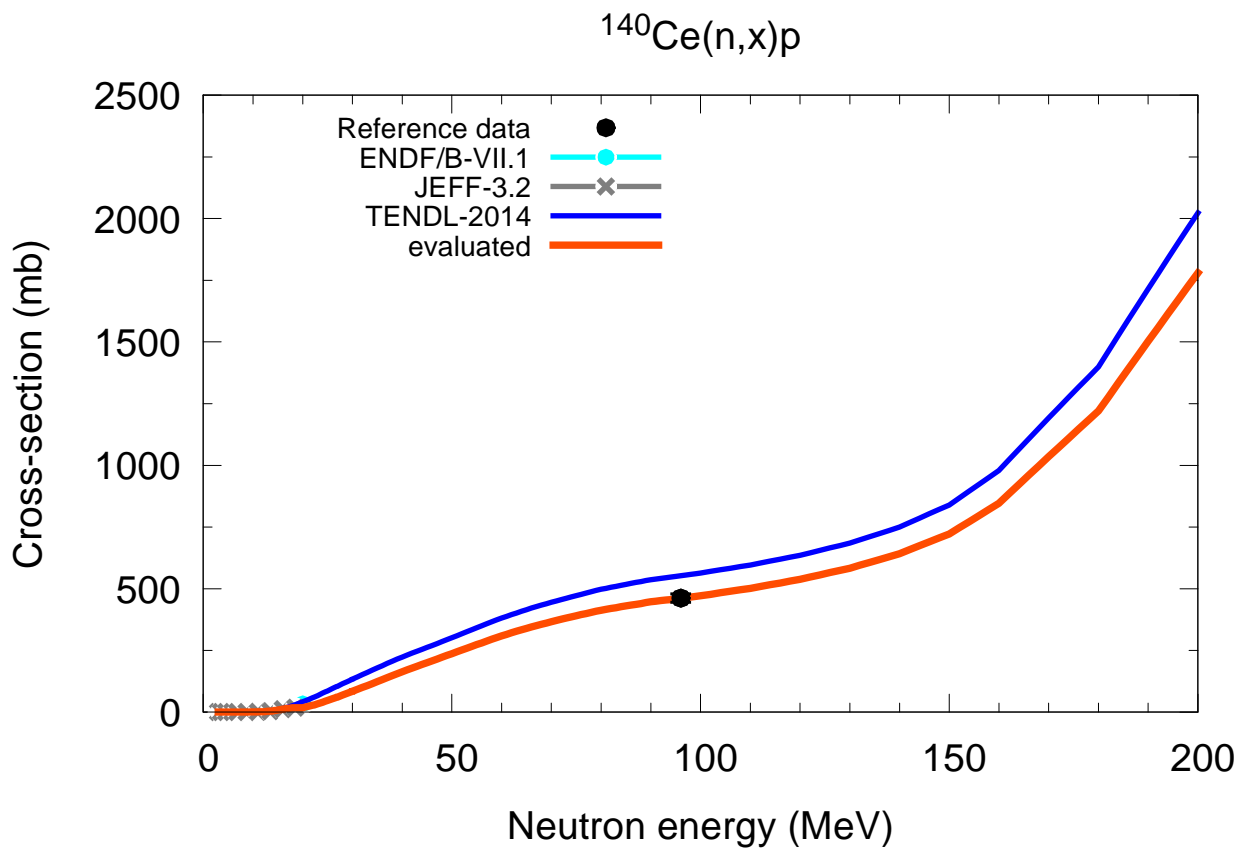
$^{138}\text{Ba}(n,x)p$



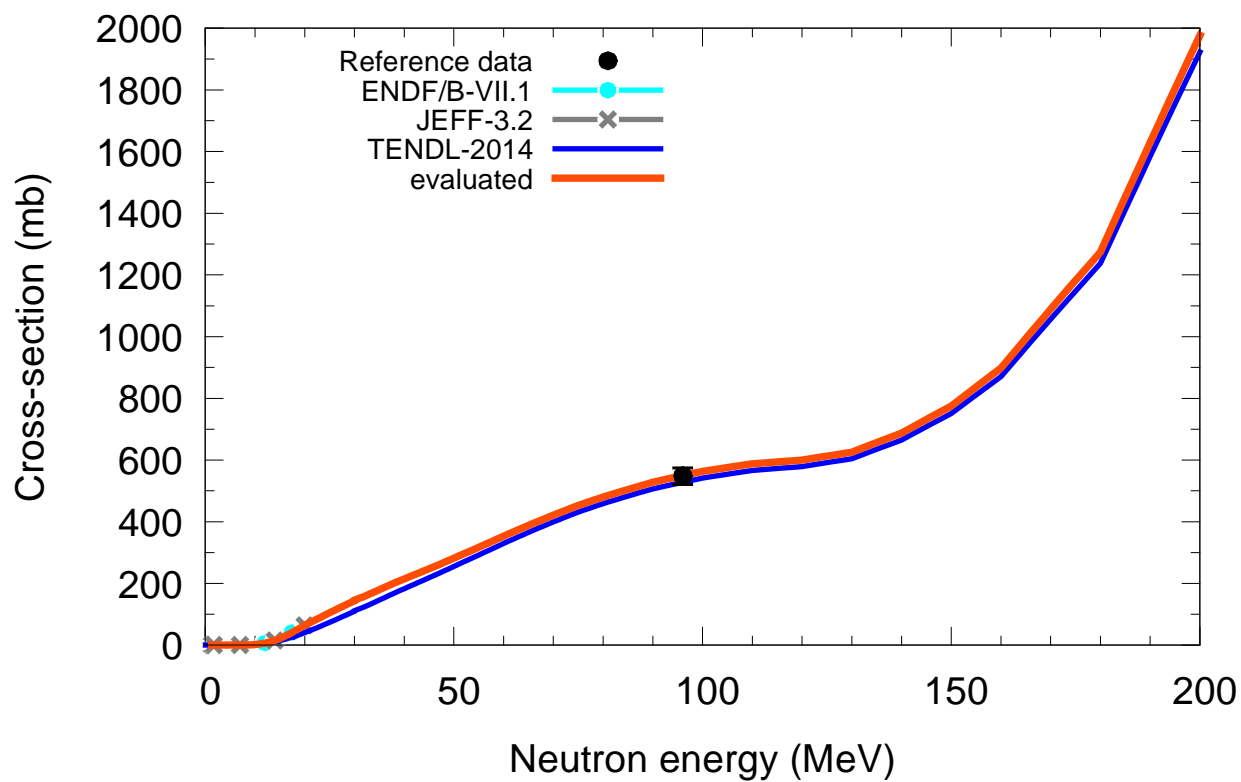
$^{138}\text{La}(n,x)p$  $^{139}\text{La}(n,x)p$ 



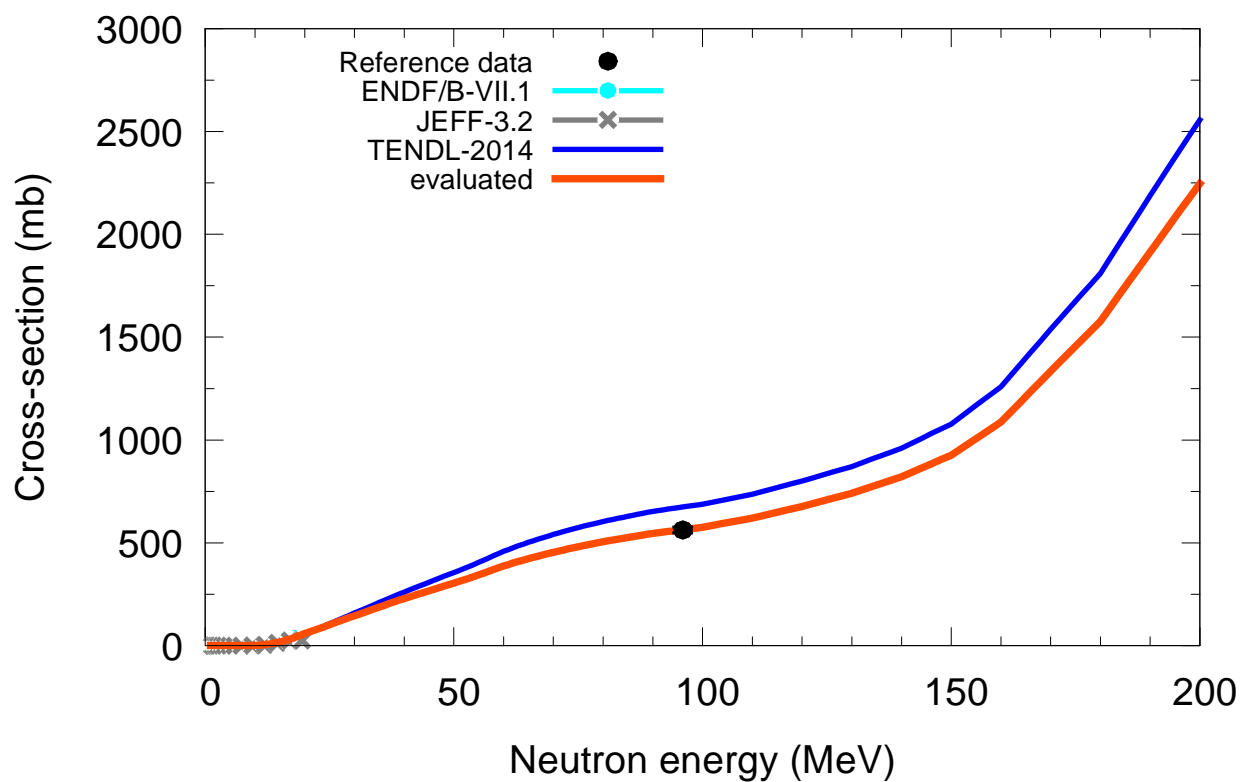




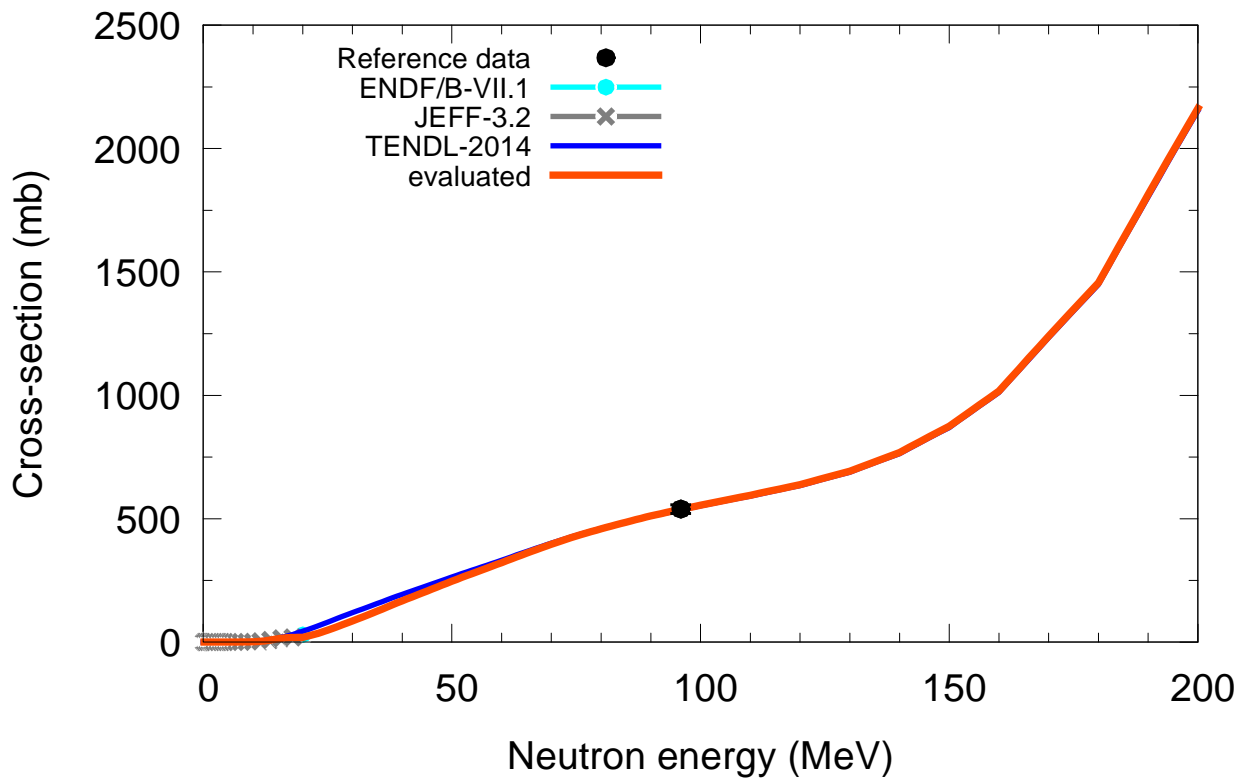
### $^{141}\text{Pr}(n,x)p$



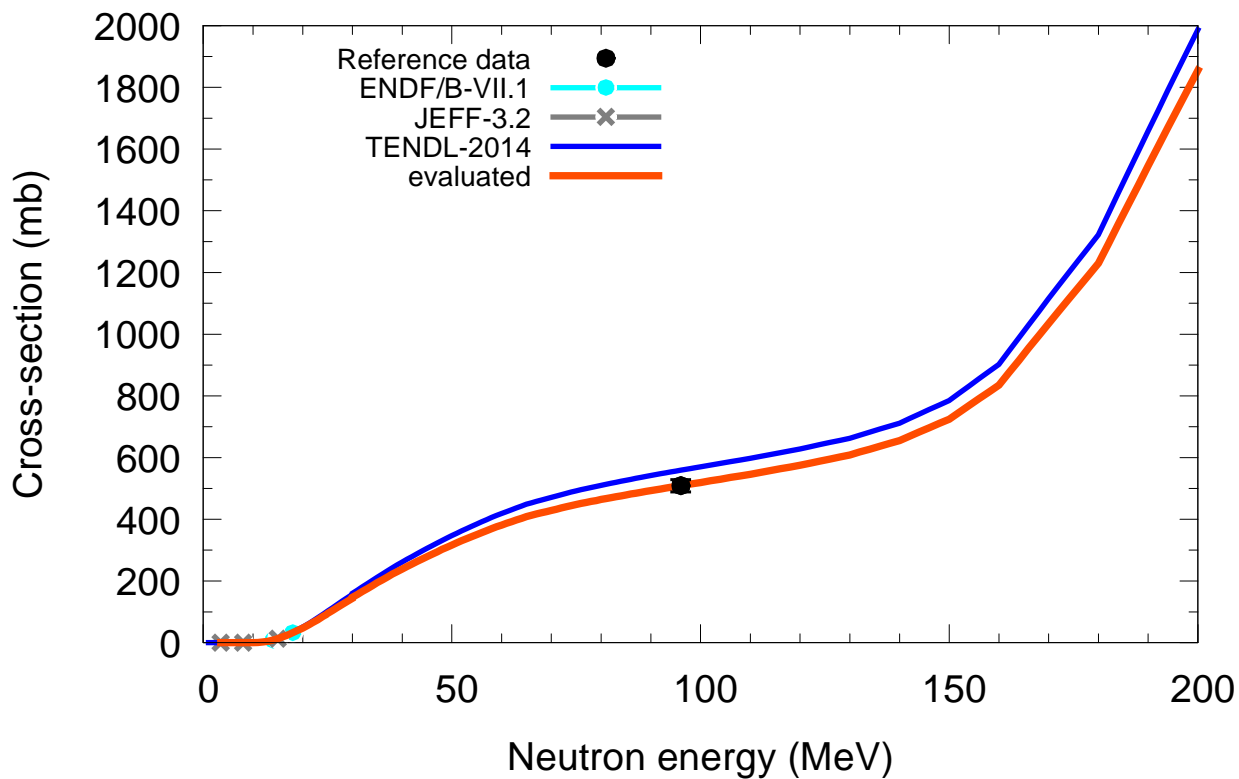
### $^{142}\text{Nd}(n,x)p$



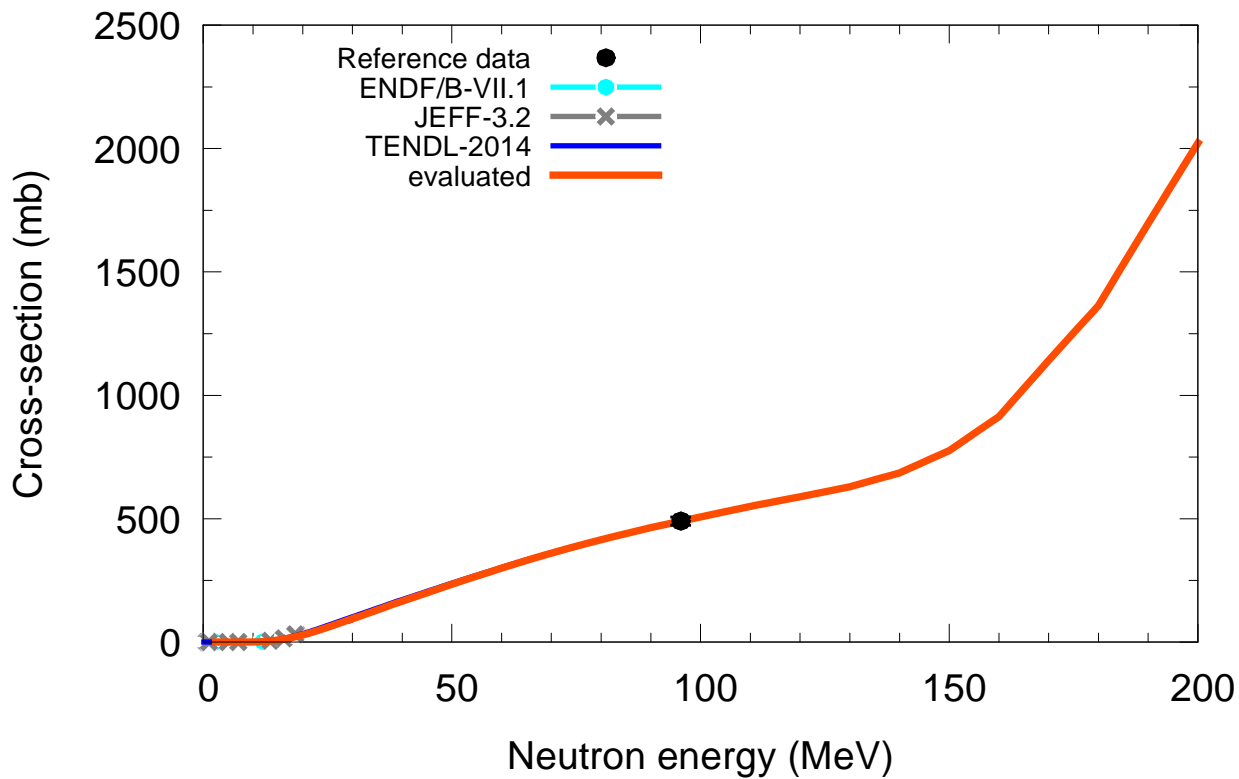
$^{143}\text{Nd}(n,x)p$



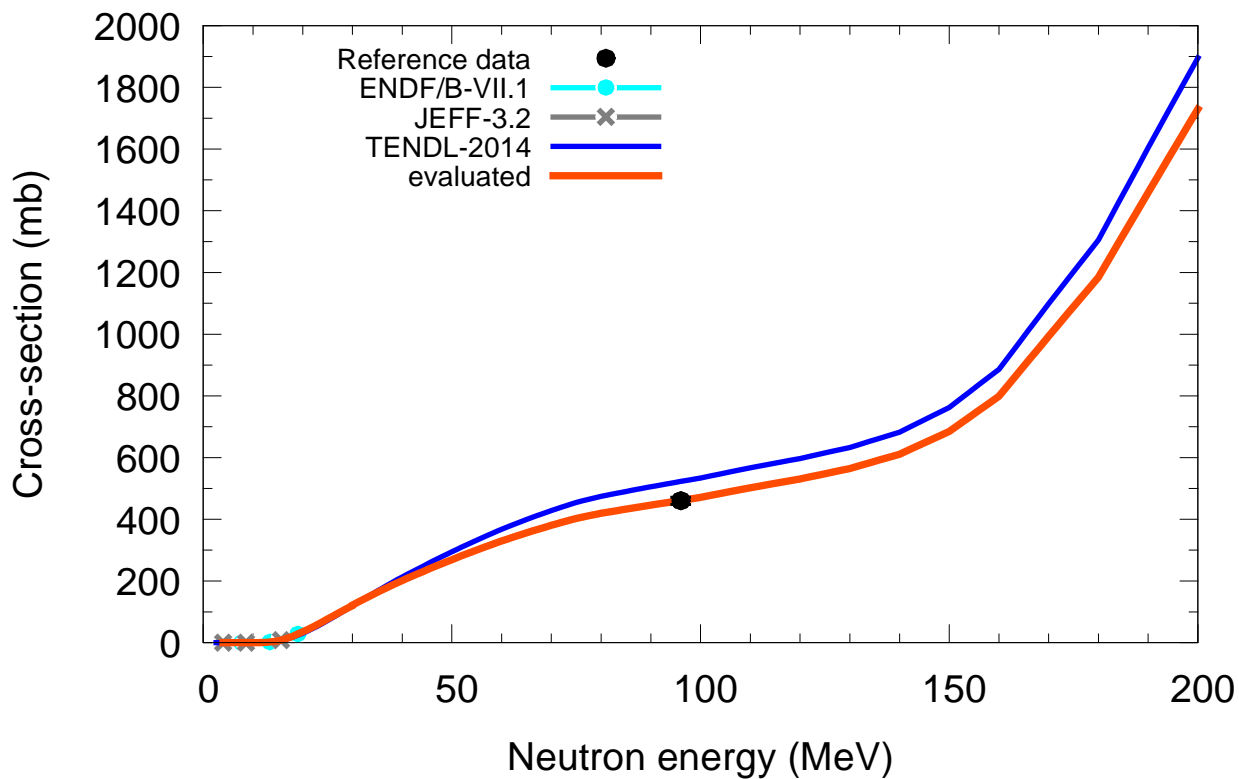
$^{144}\text{Nd}(n,x)p$



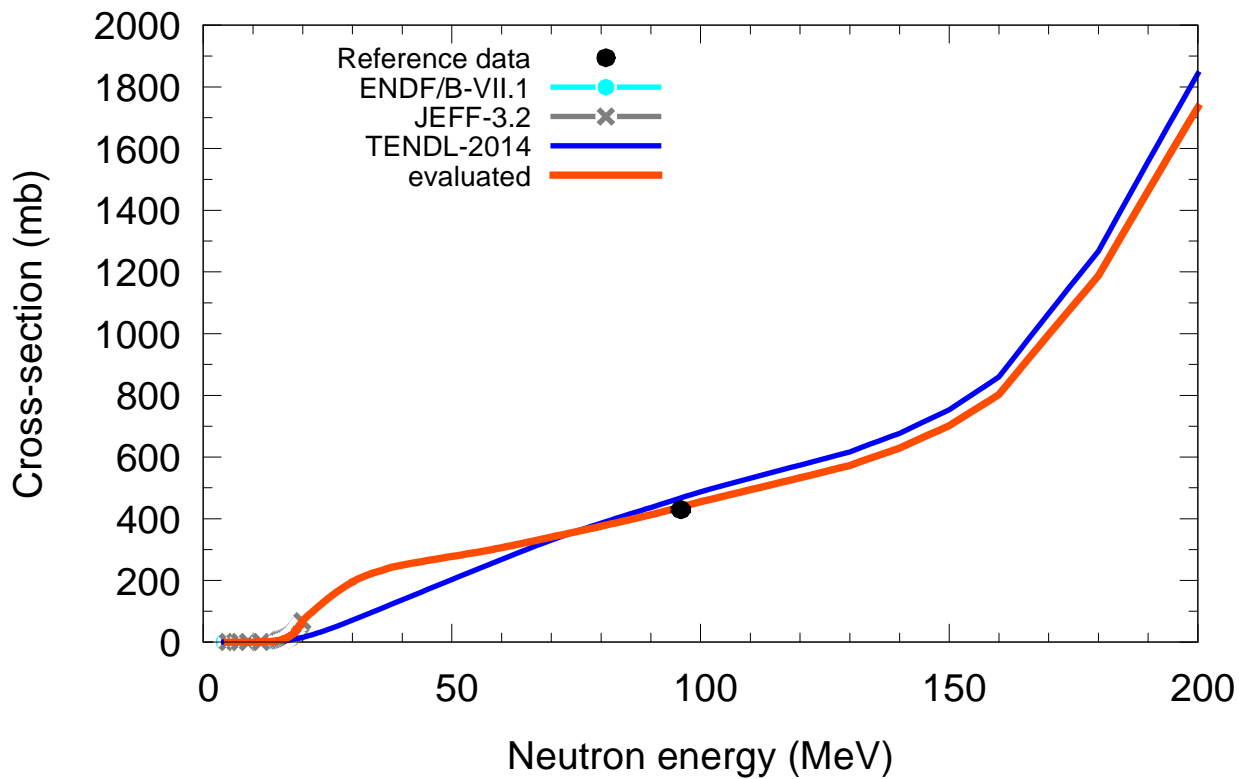
$^{145}\text{Nd}(n,x)p$



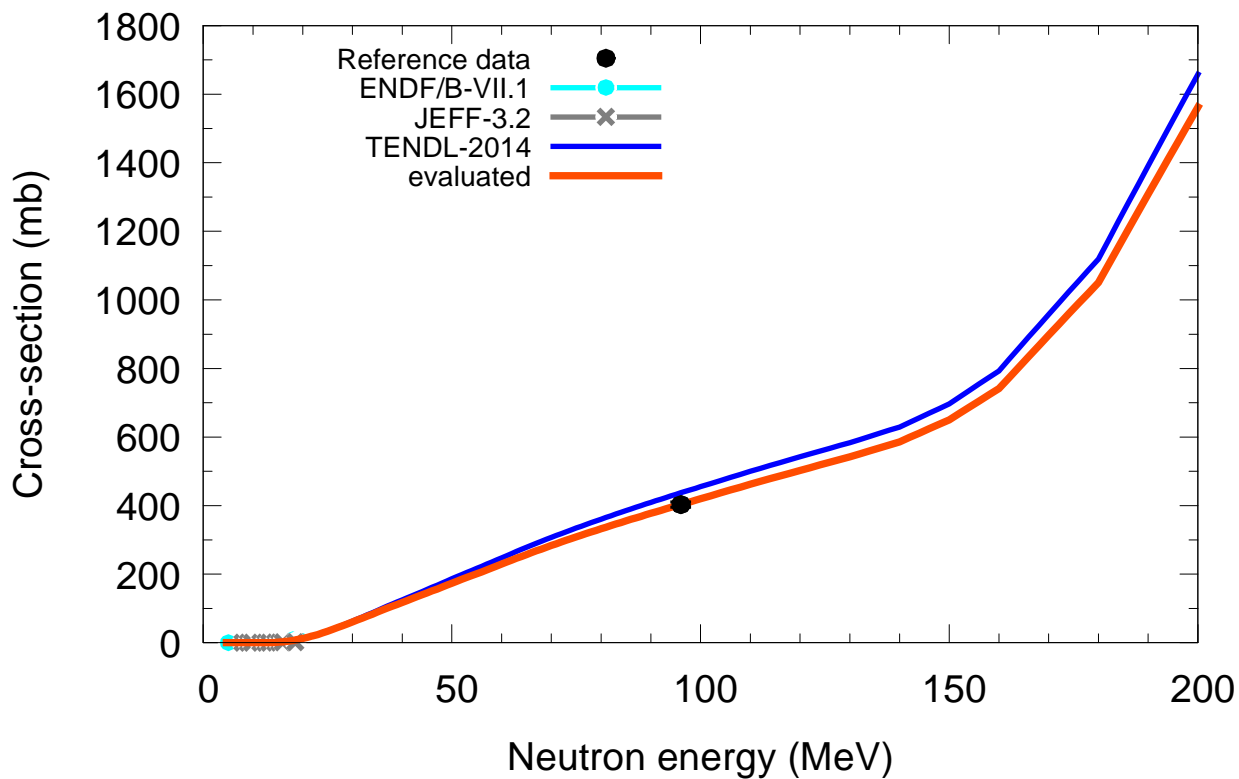
$^{146}\text{Nd}(n,x)p$



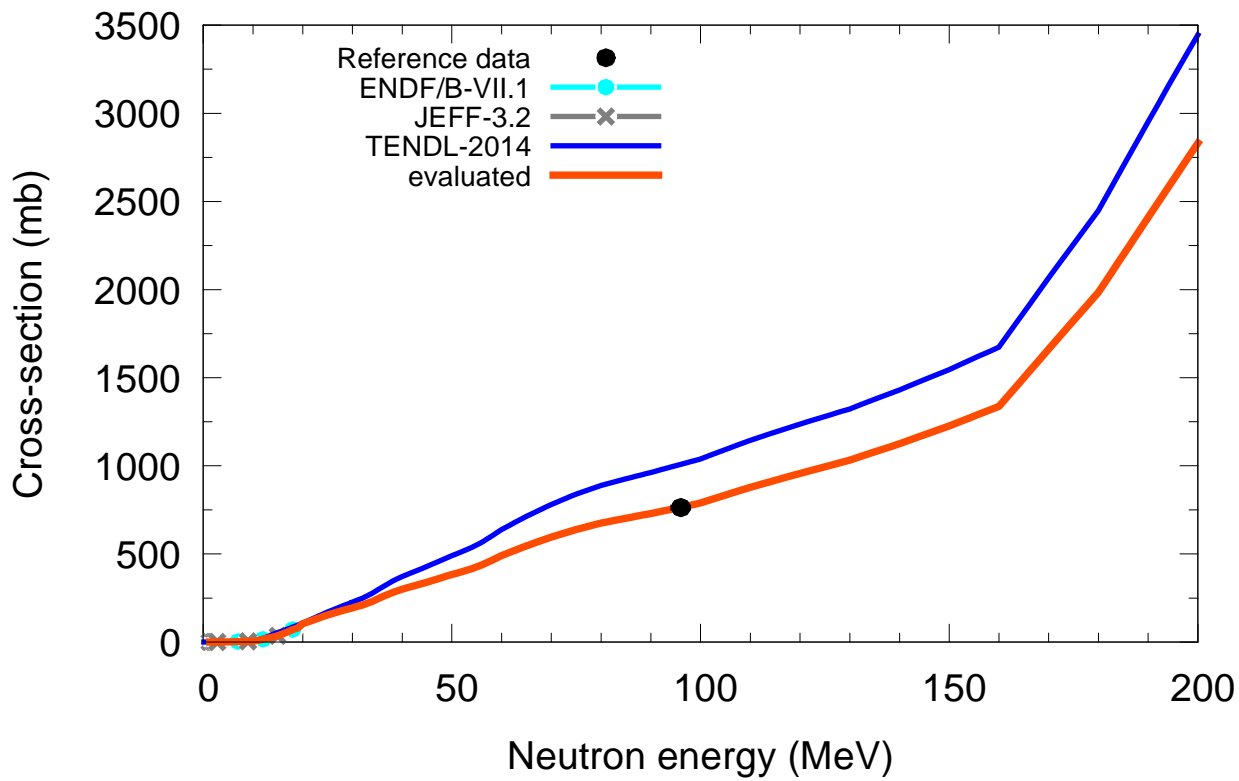
$^{148}\text{Nd}(n,x)p$



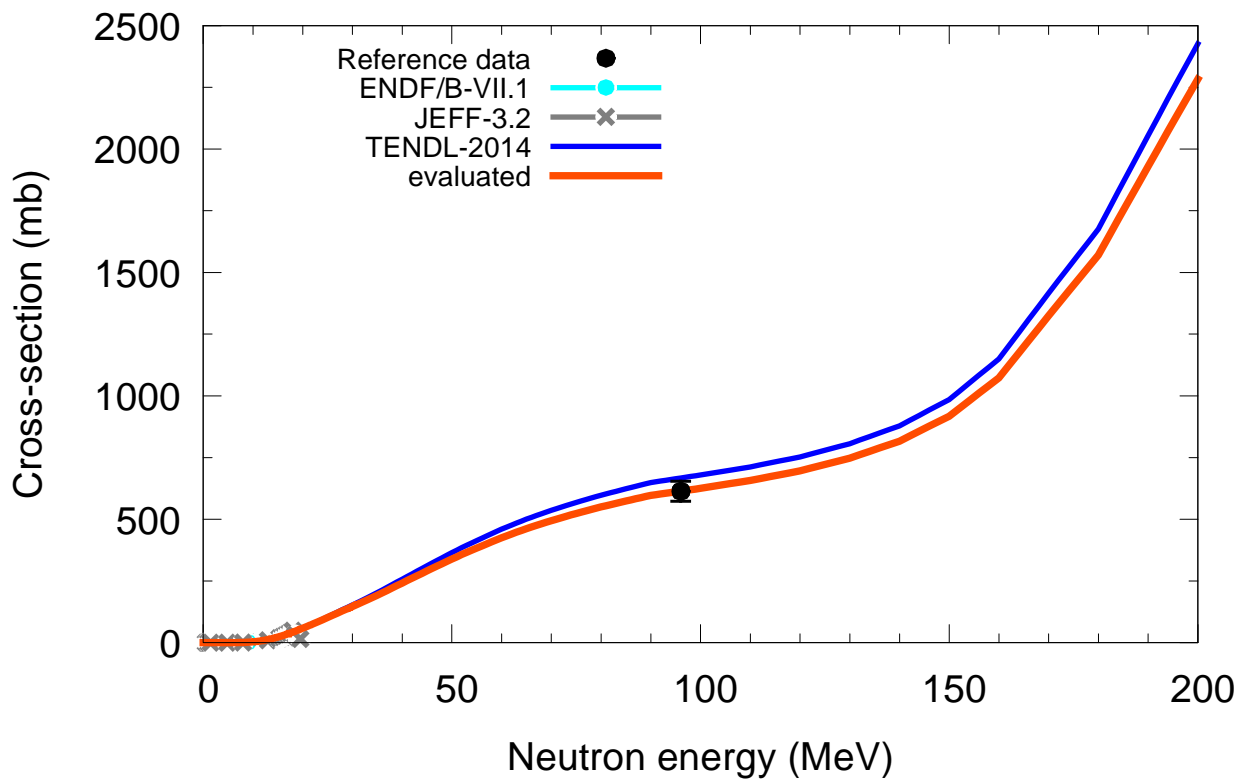
$^{150}\text{Nd}(n,x)p$



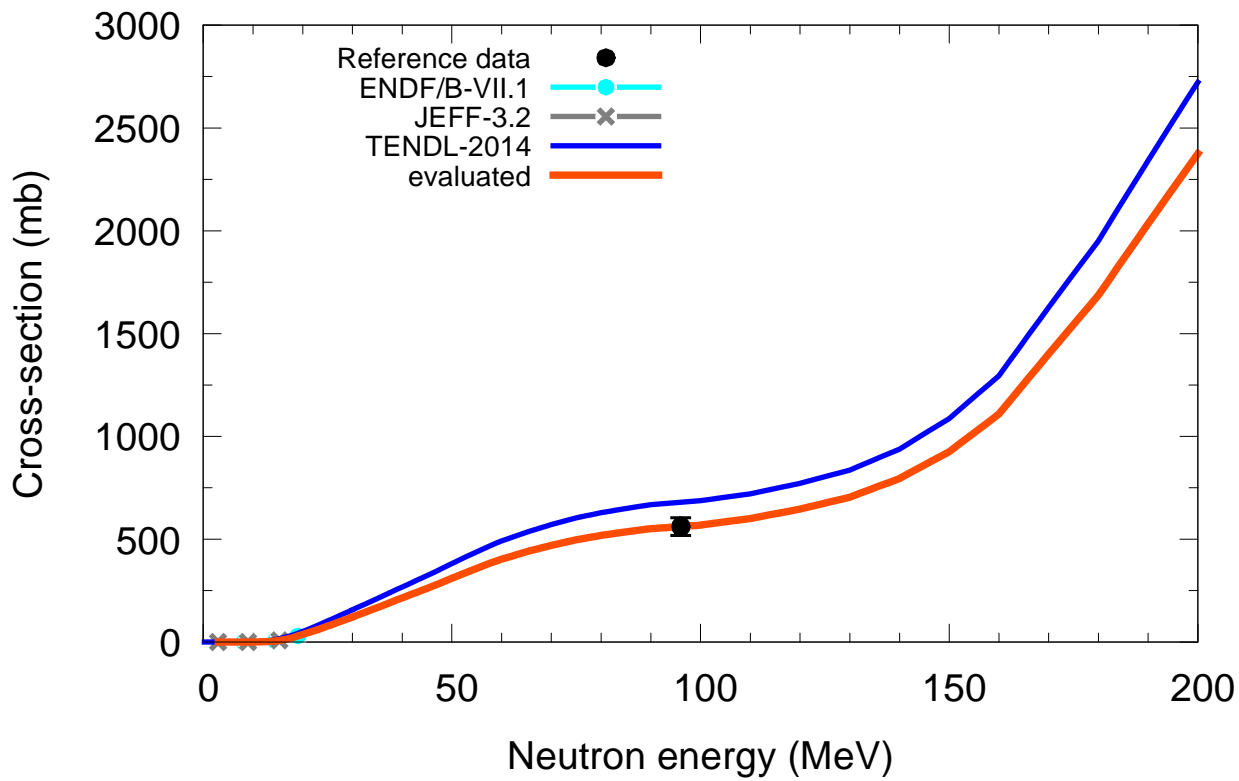
### $^{144}\text{Sm}(n,x)p$



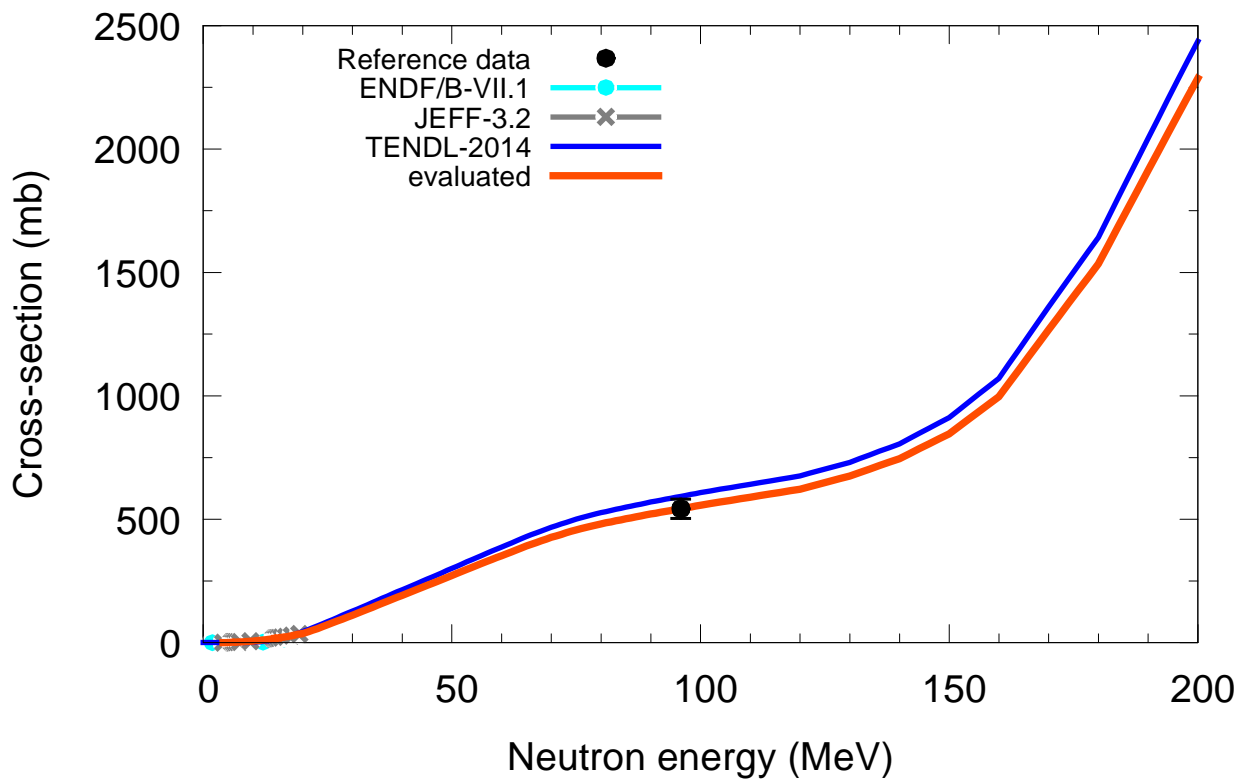
### $^{147}\text{Sm}(n,x)p$



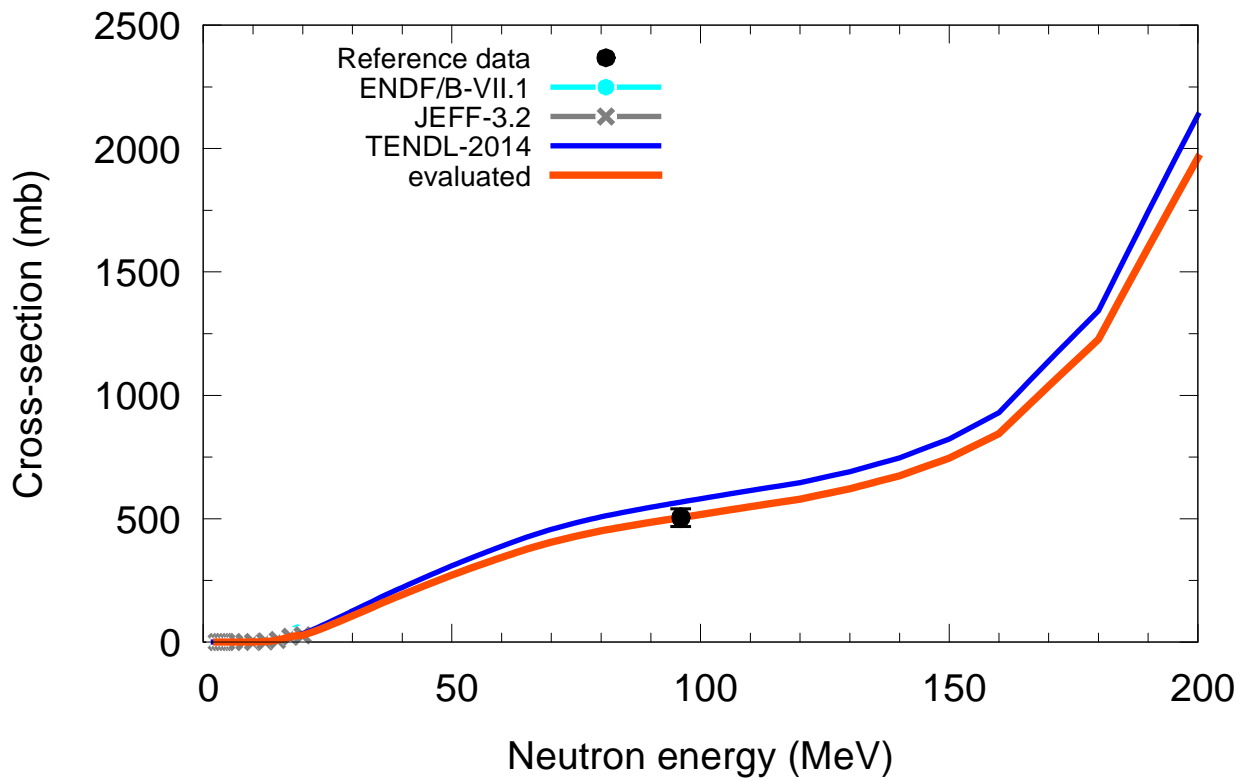
$^{148}\text{Sm}(n,x)p$



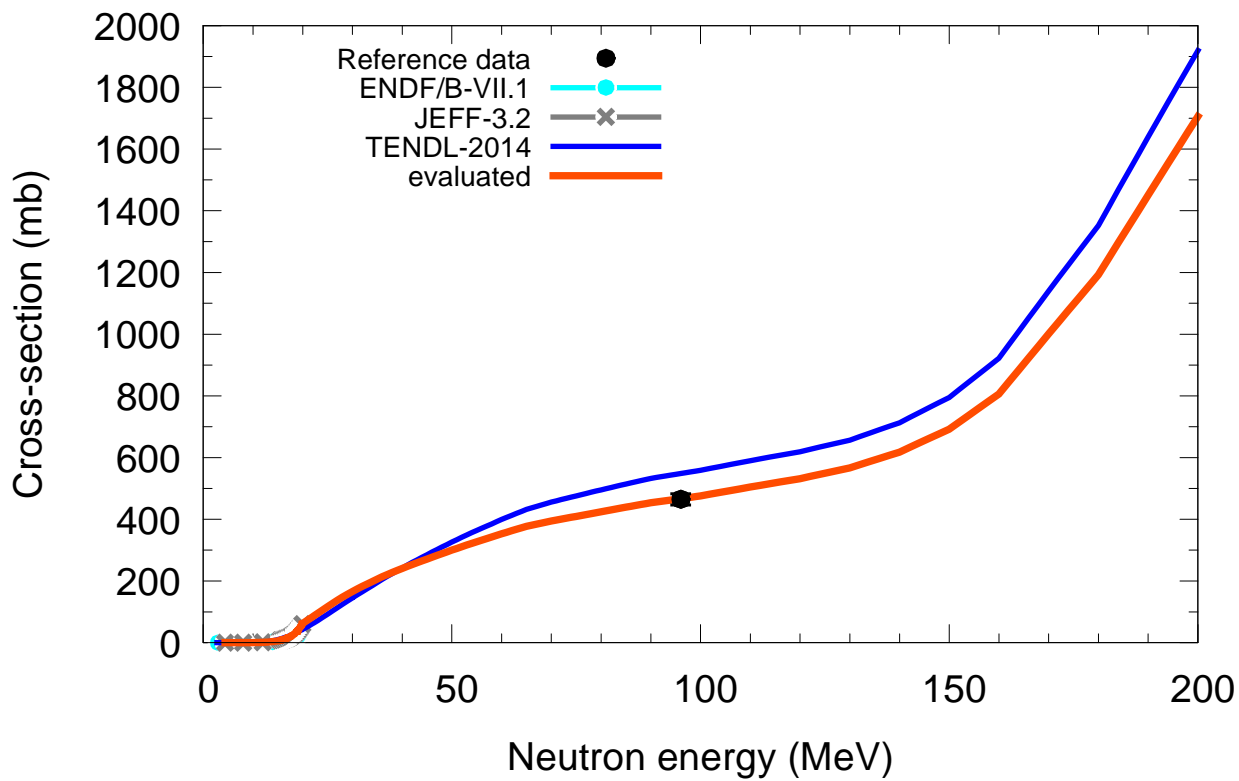
$^{149}\text{Sm}(n,x)p$



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

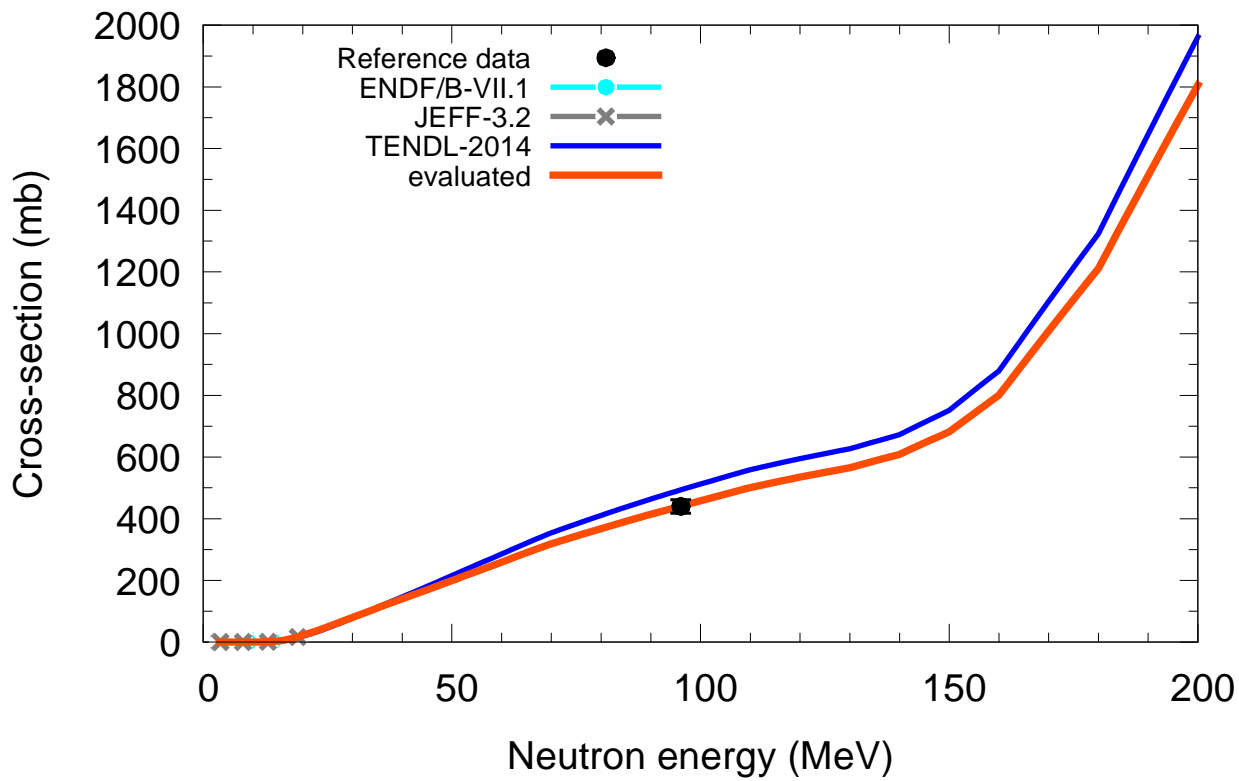


### $^{152}\text{Sm}(n,x)p$

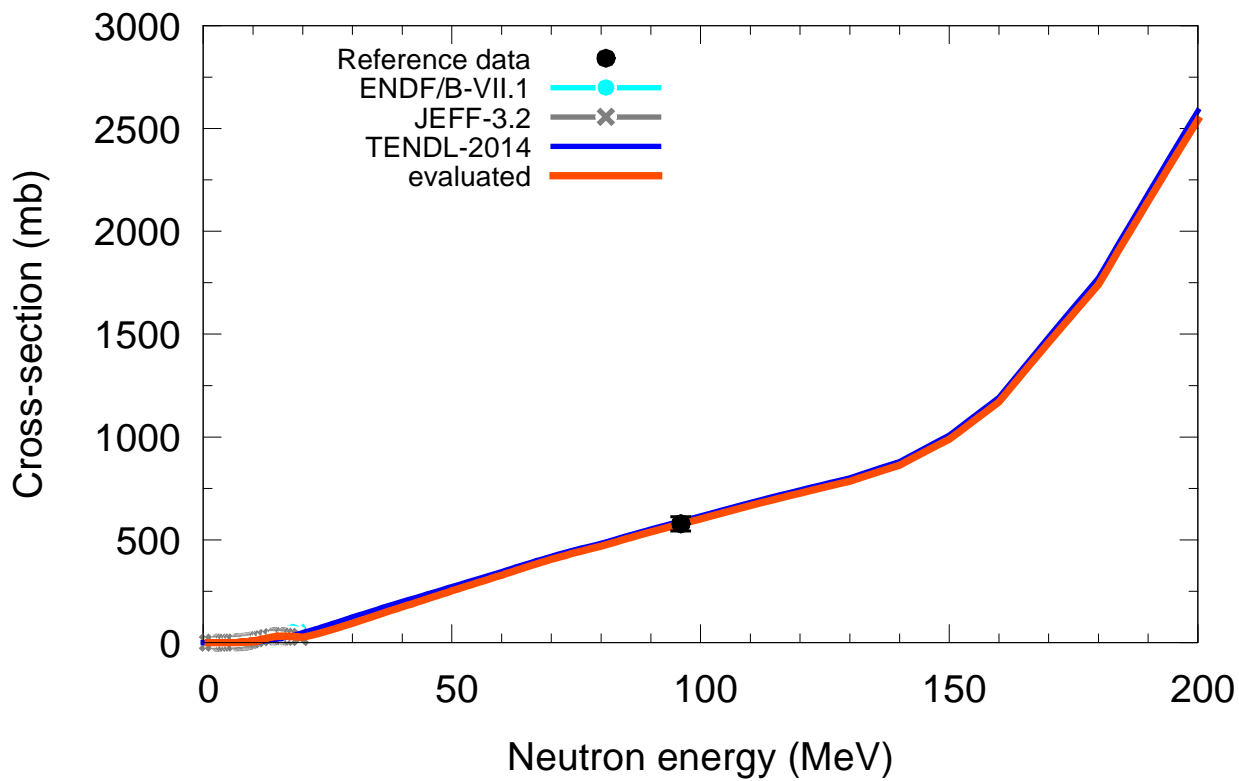




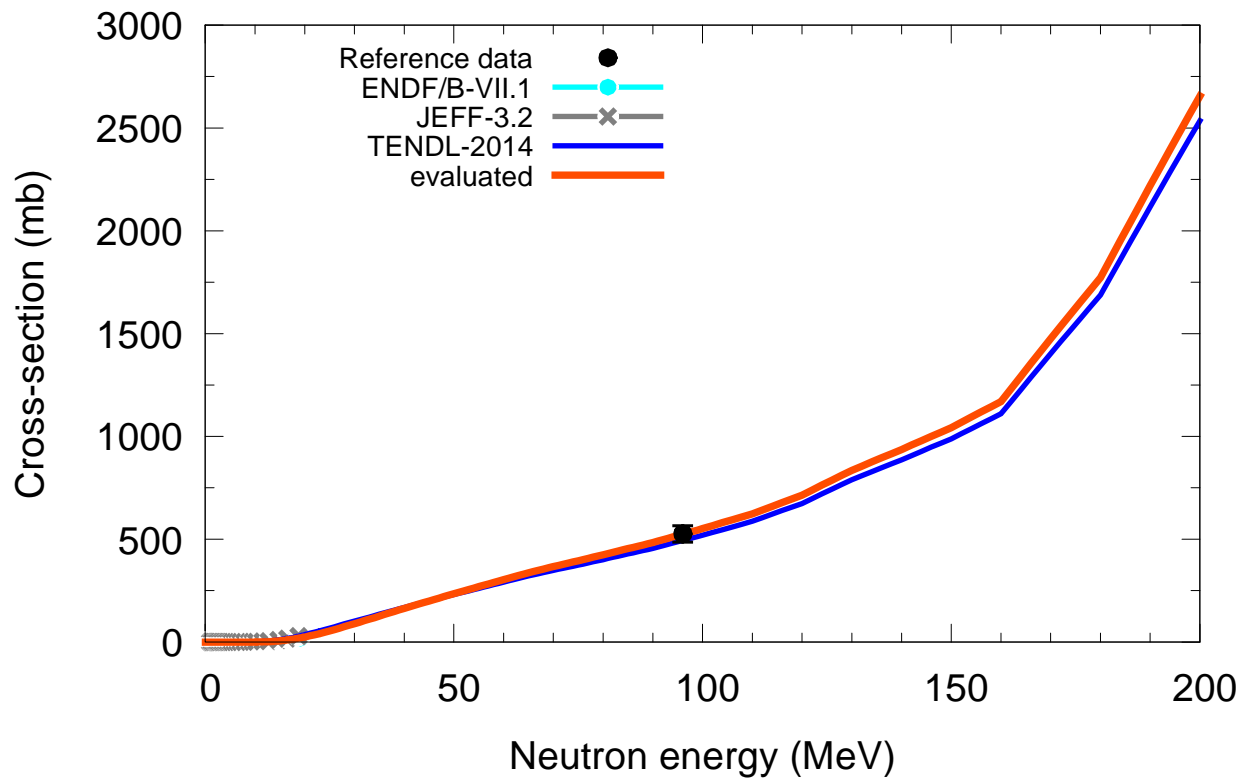
### $^{154}\text{Sm}(n,x)p$



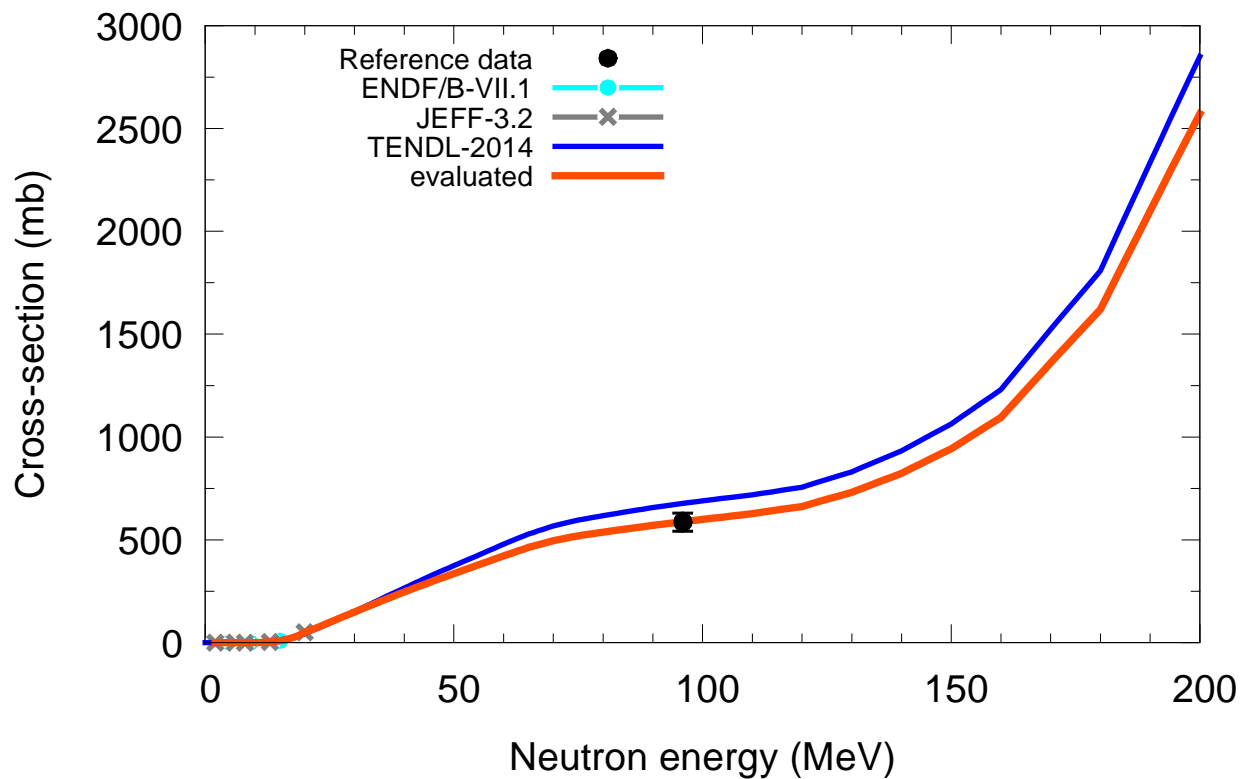
### $^{151}\text{Eu}(n,x)p$



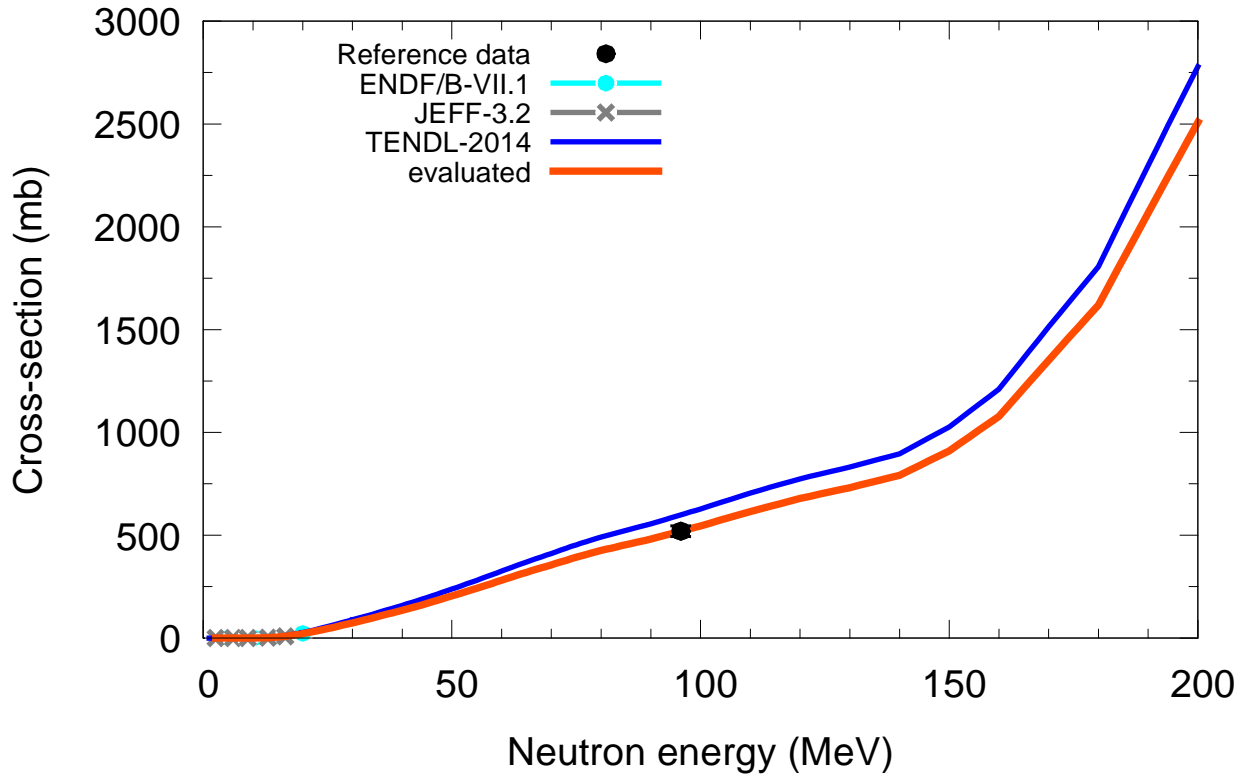
$^{153}\text{Eu}(n,x)p$



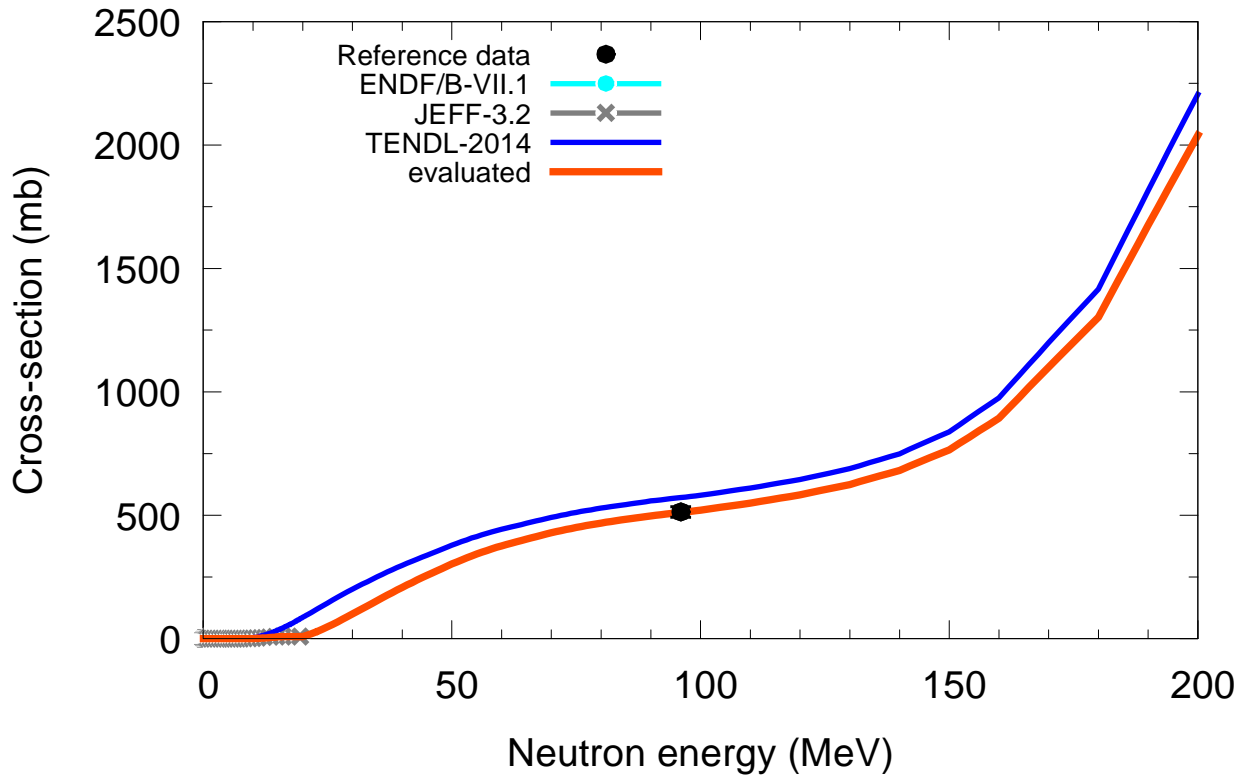
$^{152}\text{Gd}(n,x)p$



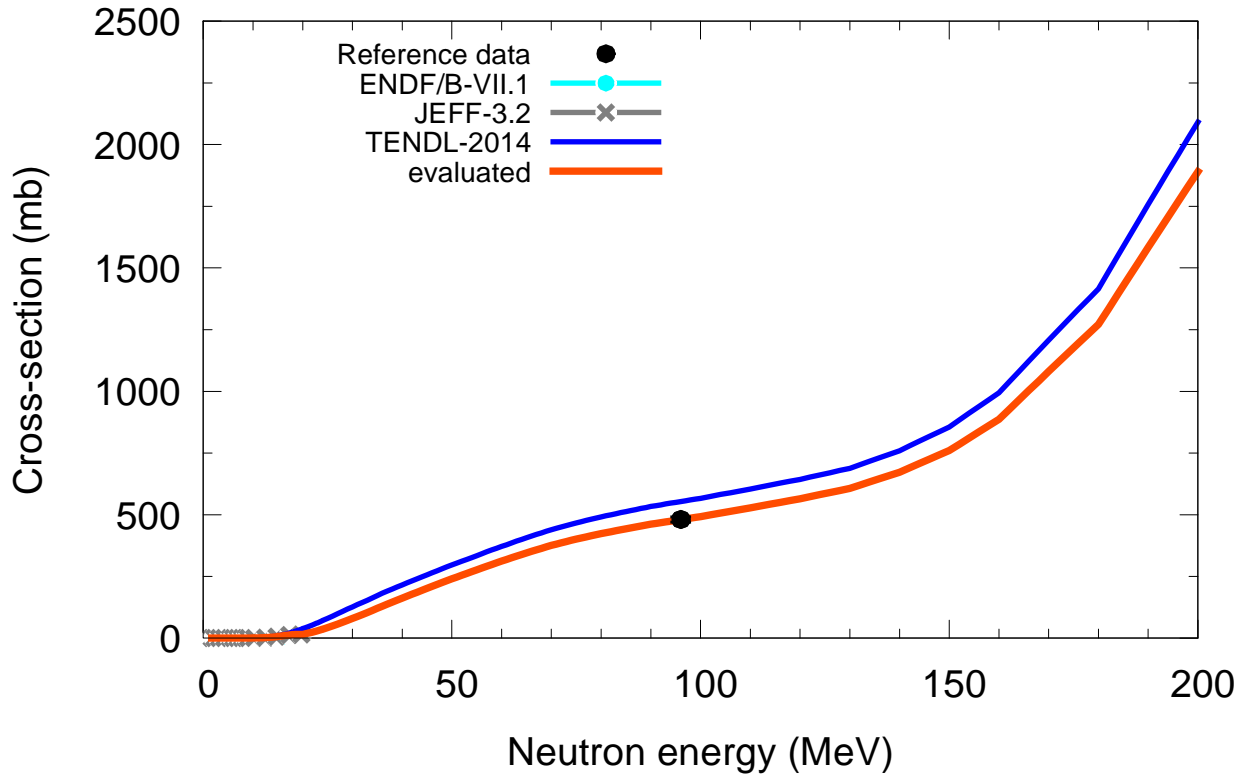
$^{154}\text{Gd}(n,x)p$



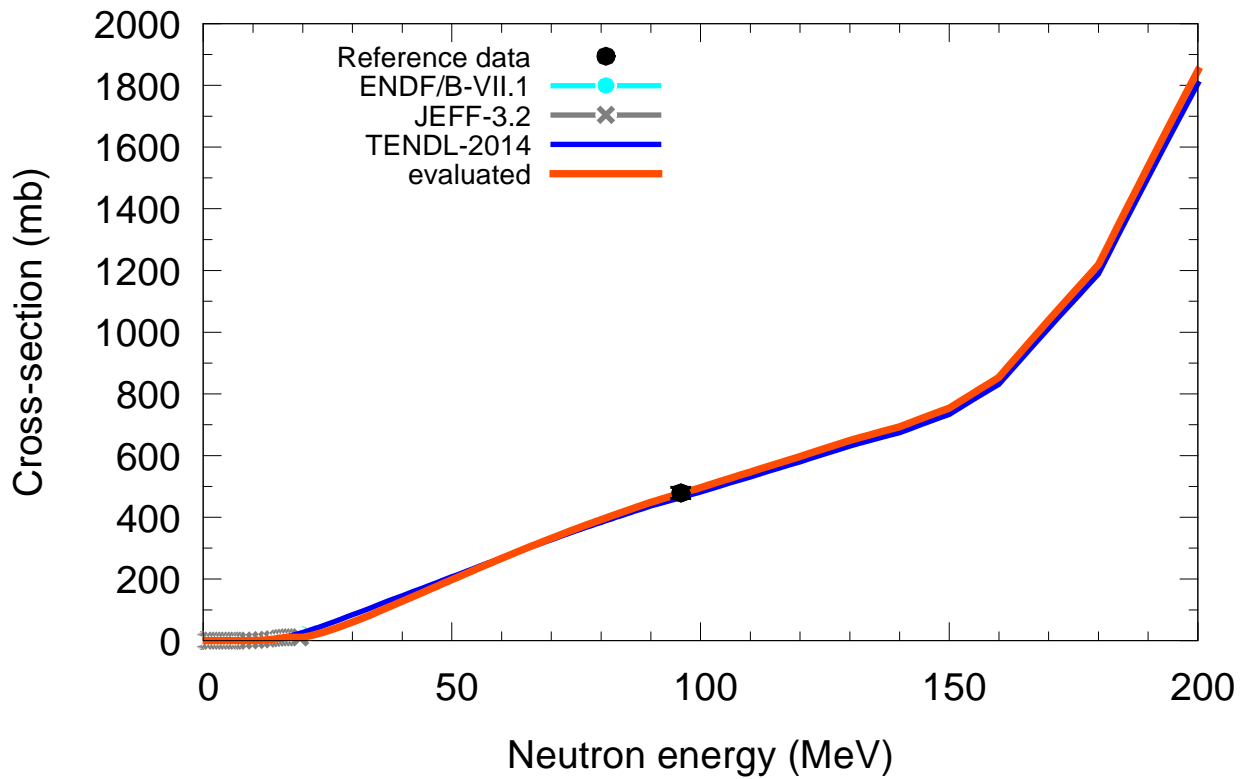
$^{155}\text{Gd}(n,x)p$



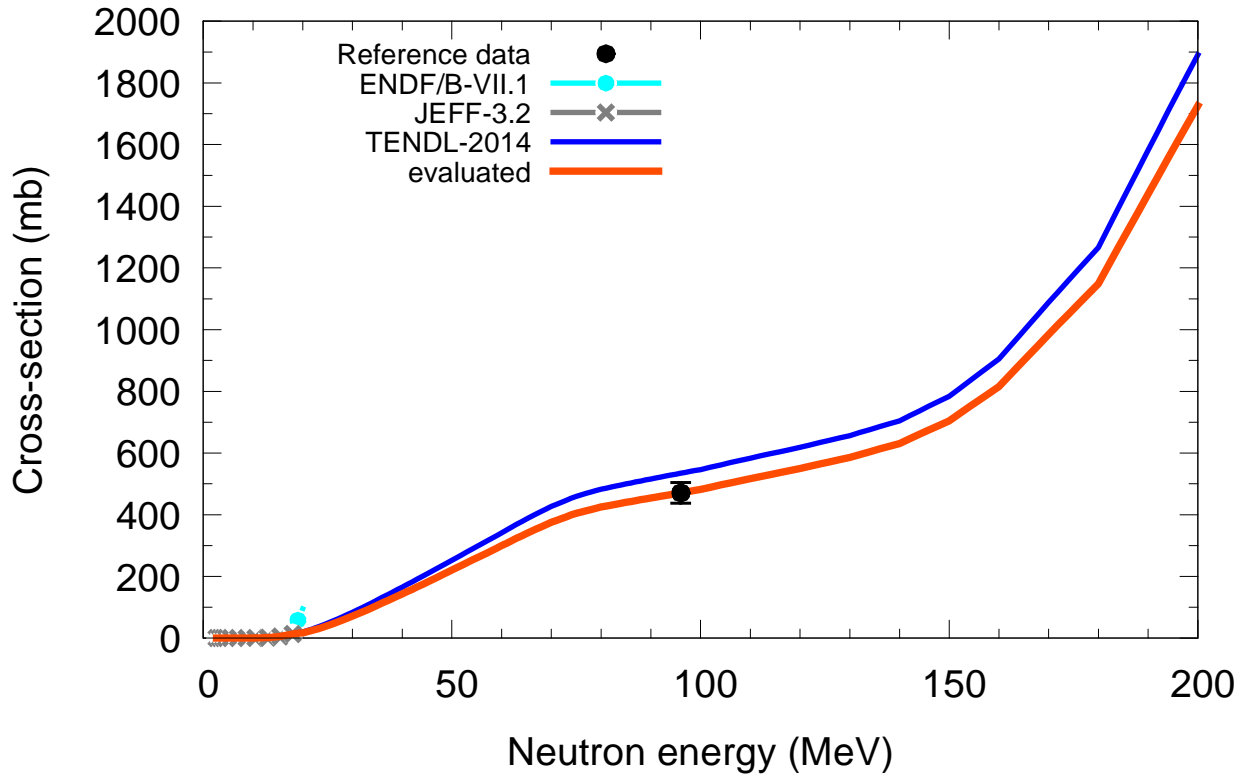
$^{156}\text{Gd}(n,x)p$



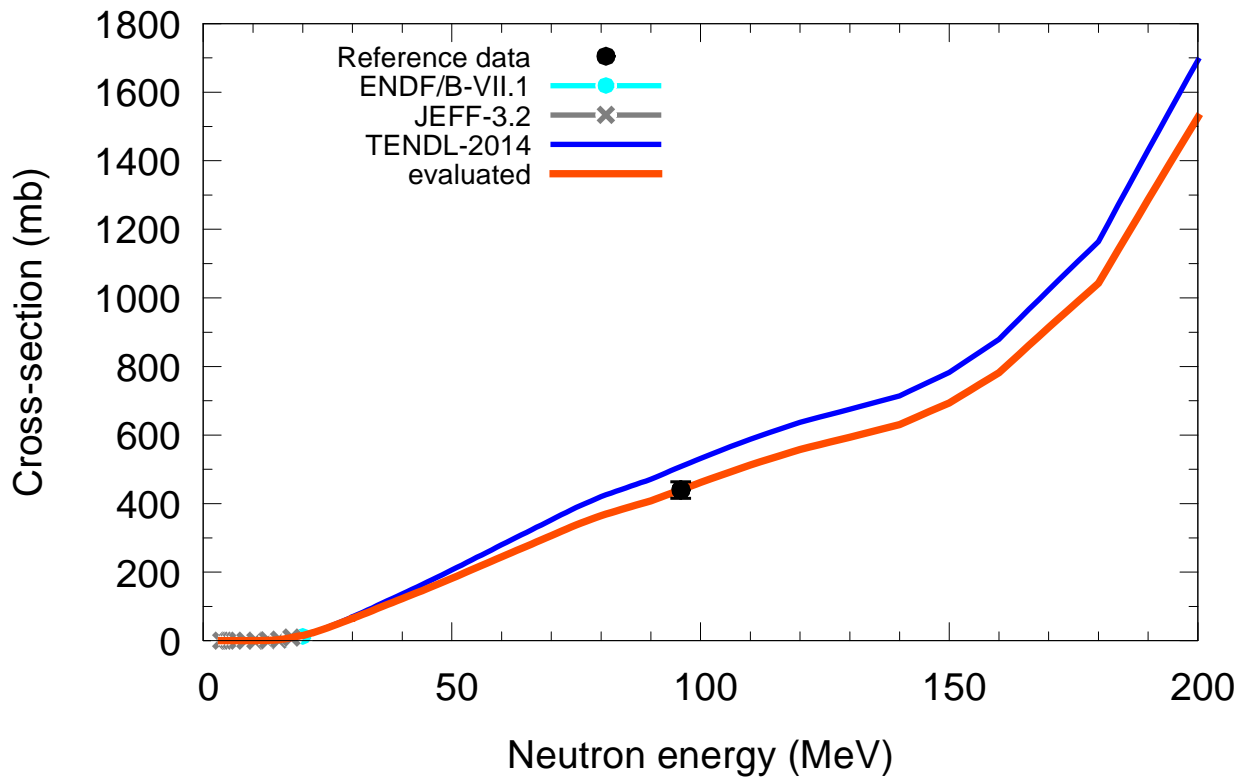
$^{157}\text{Gd}(n,x)p$



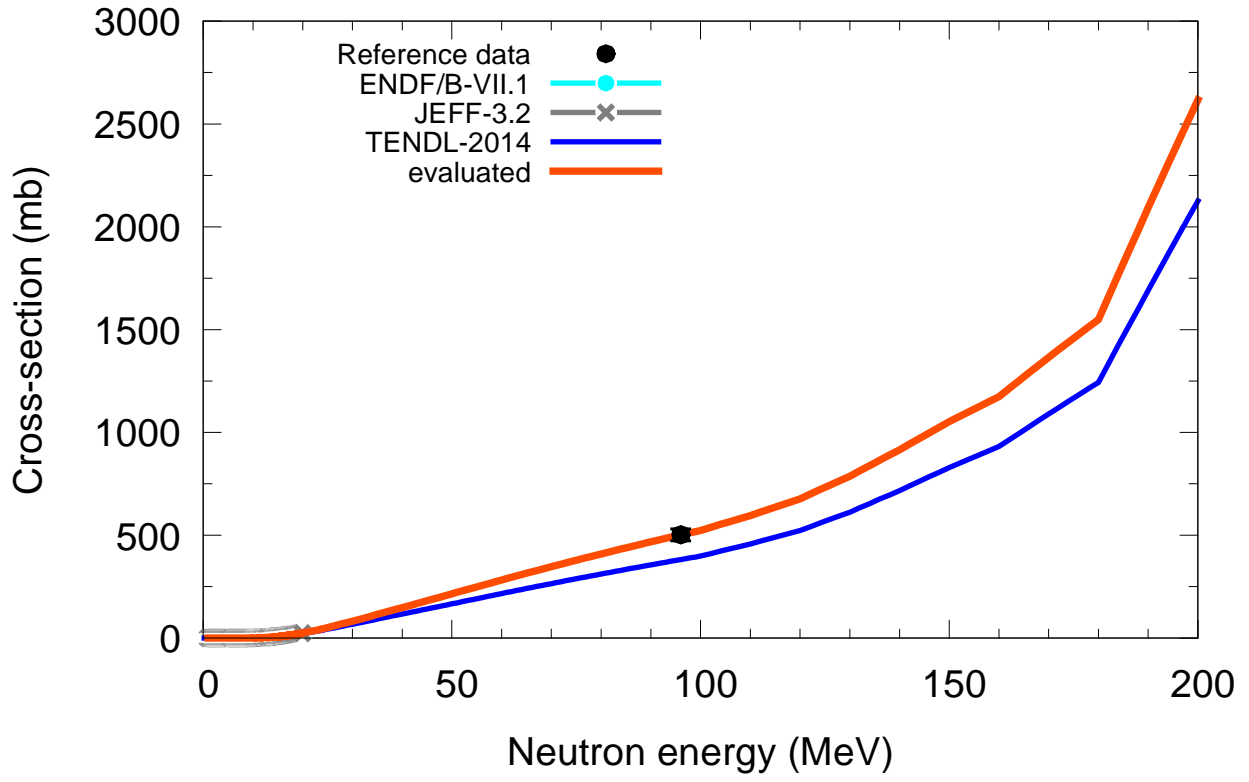
$^{158}\text{Gd}(n,x)p$



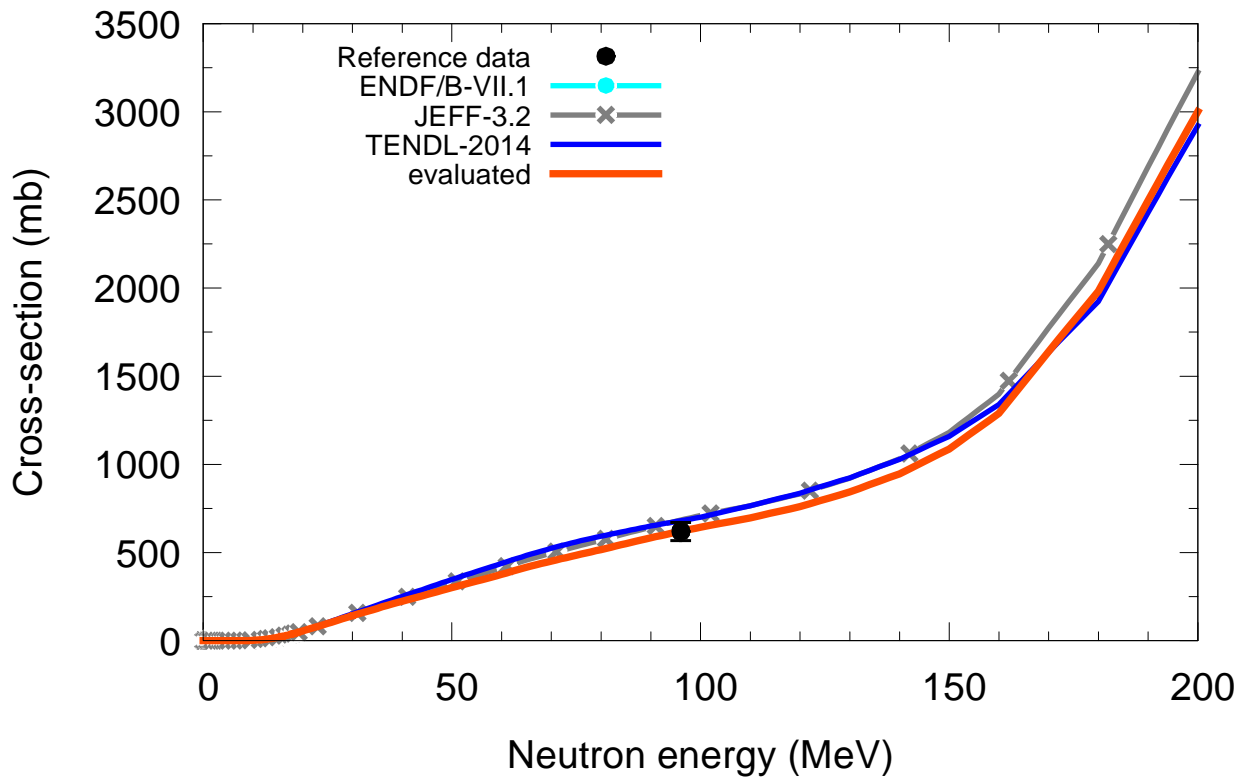
$^{160}\text{Gd}(n,x)p$

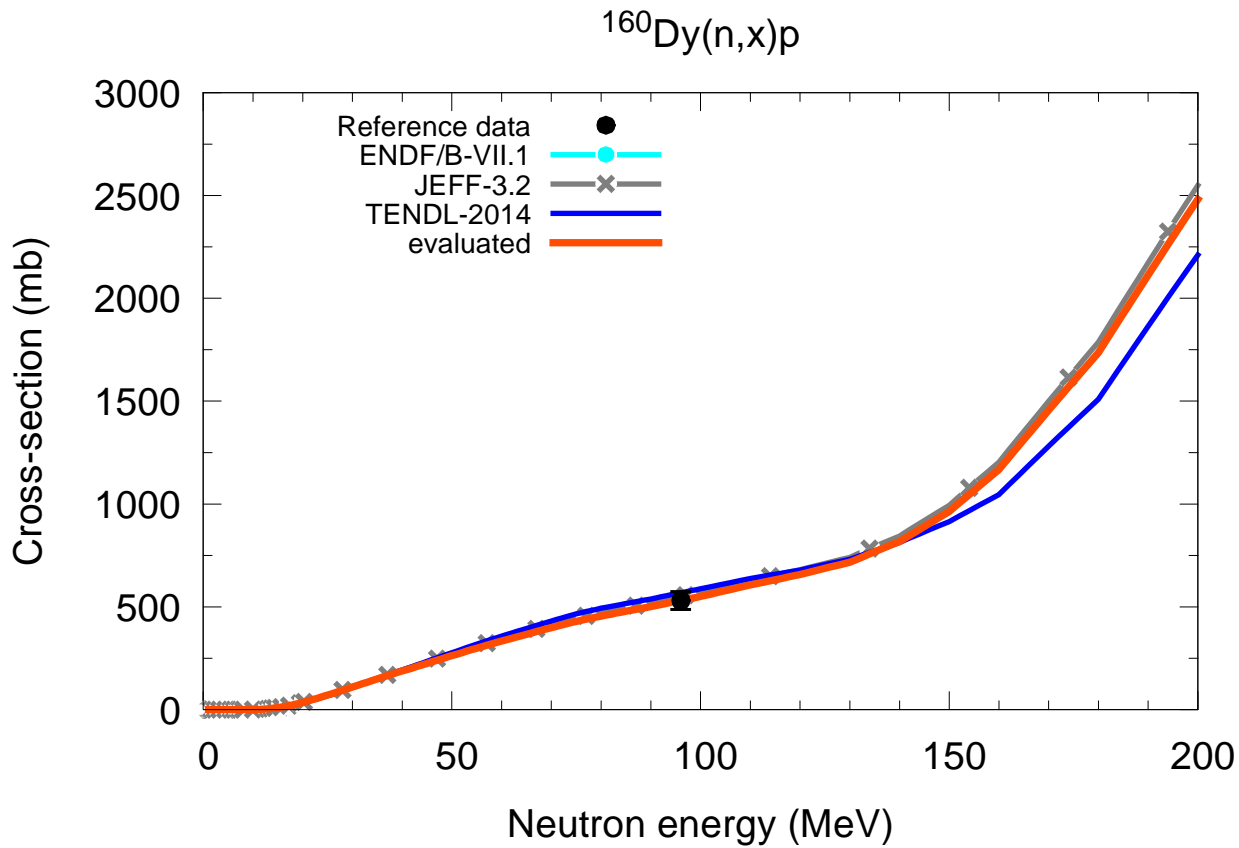
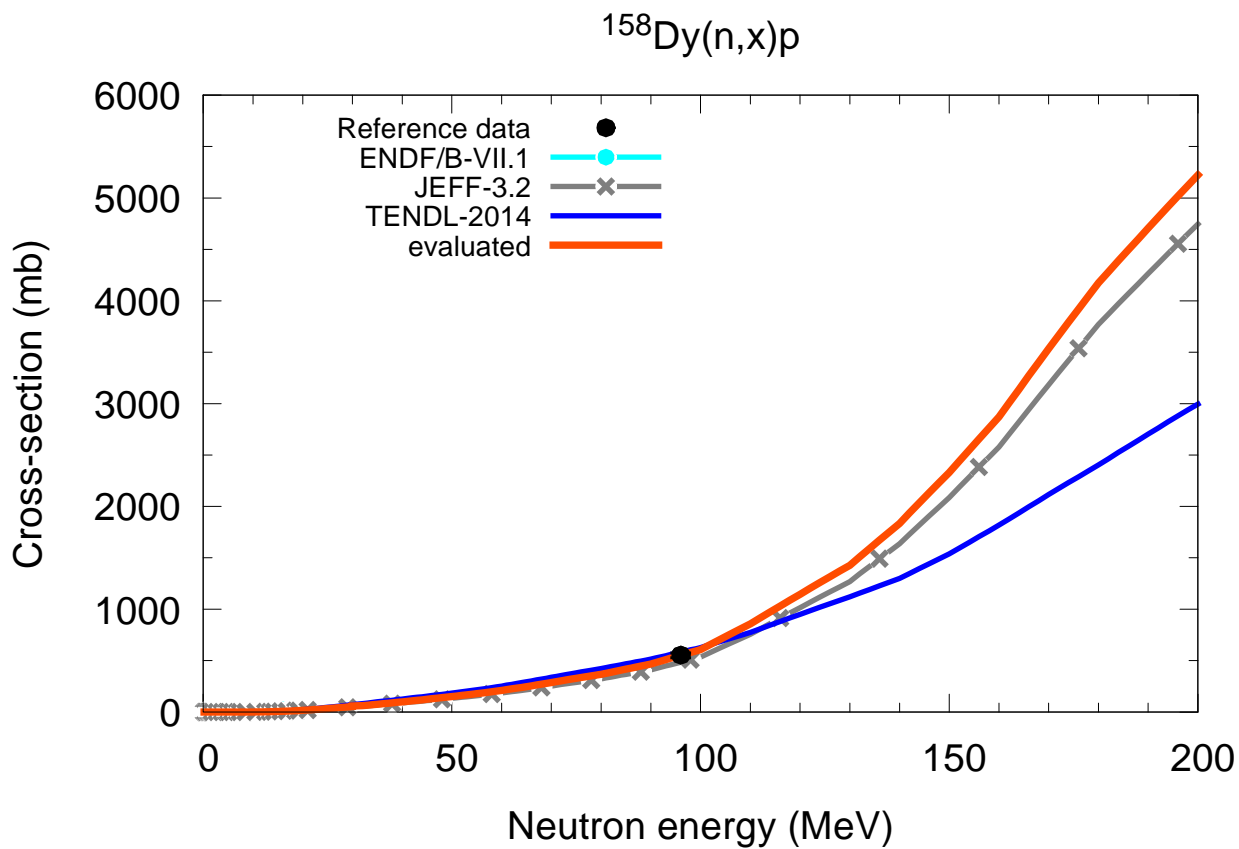


$^{159}\text{Tb}(n,x)p$

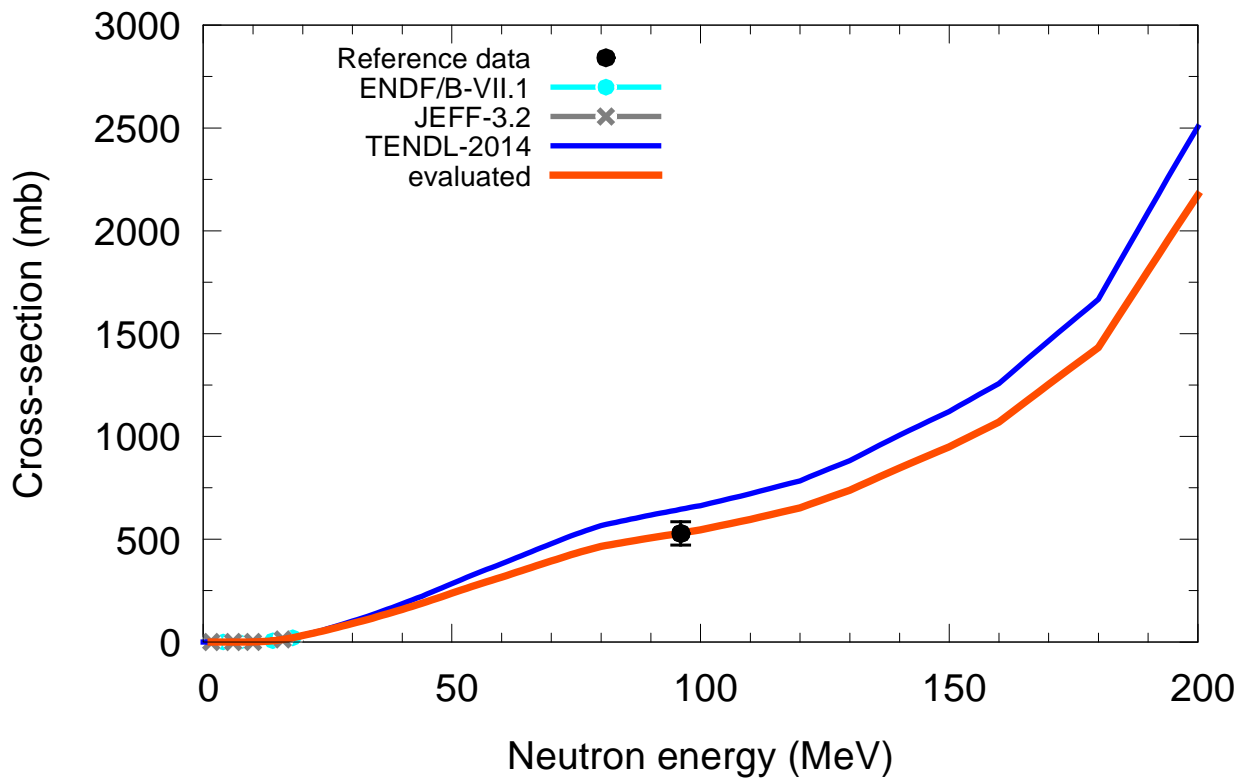


$^{156}\text{Dy}(n,x)p$

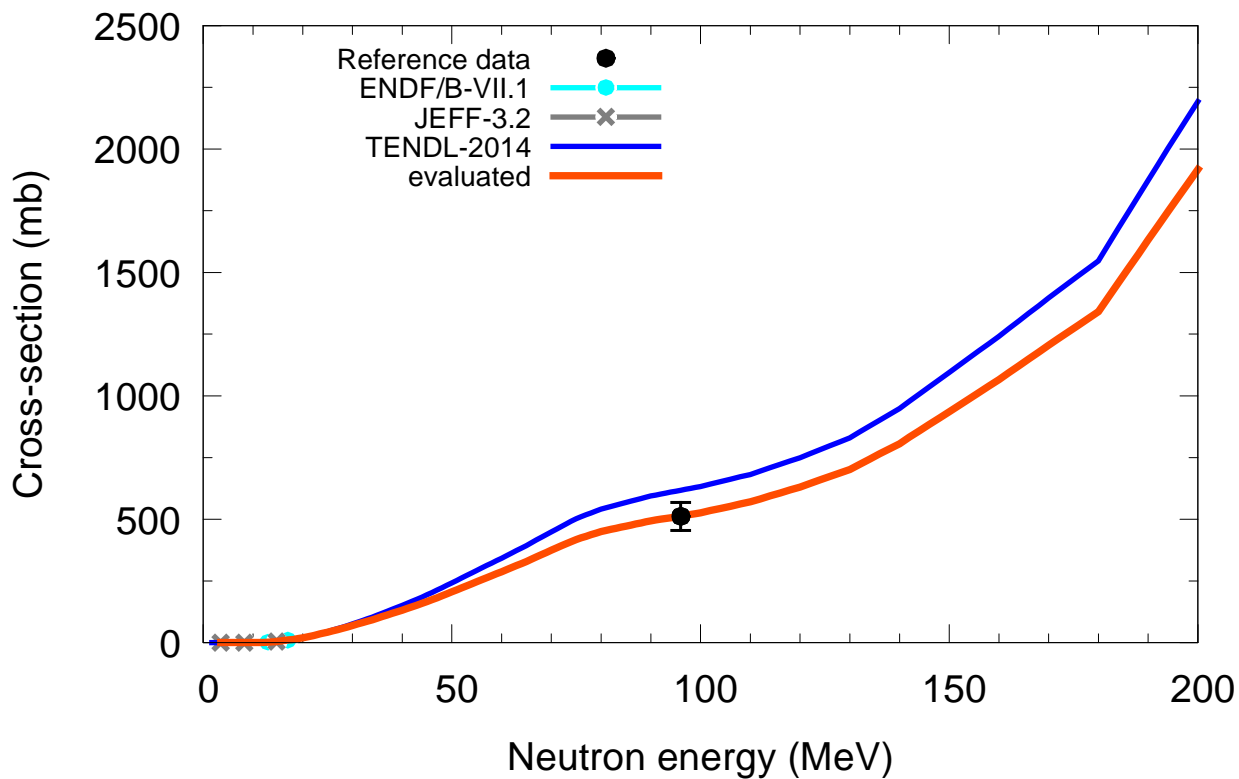




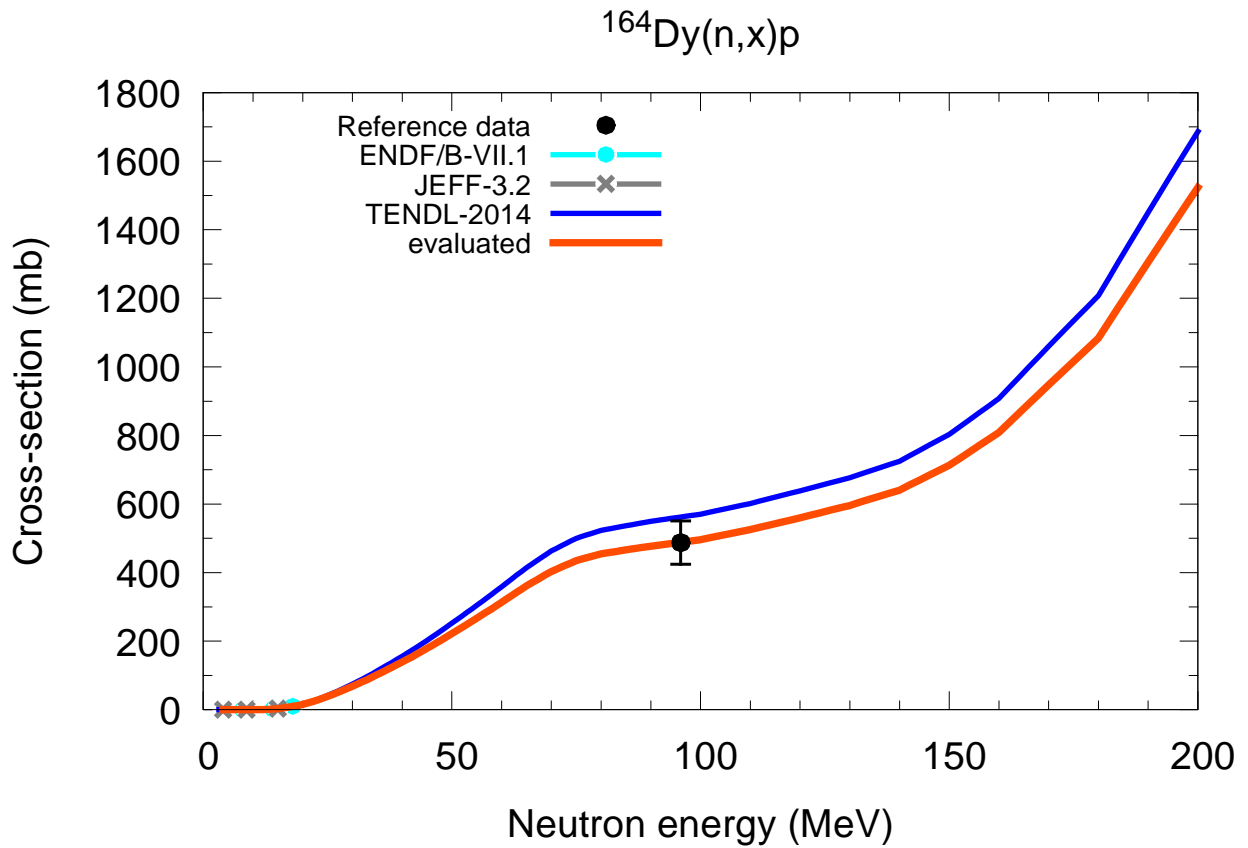
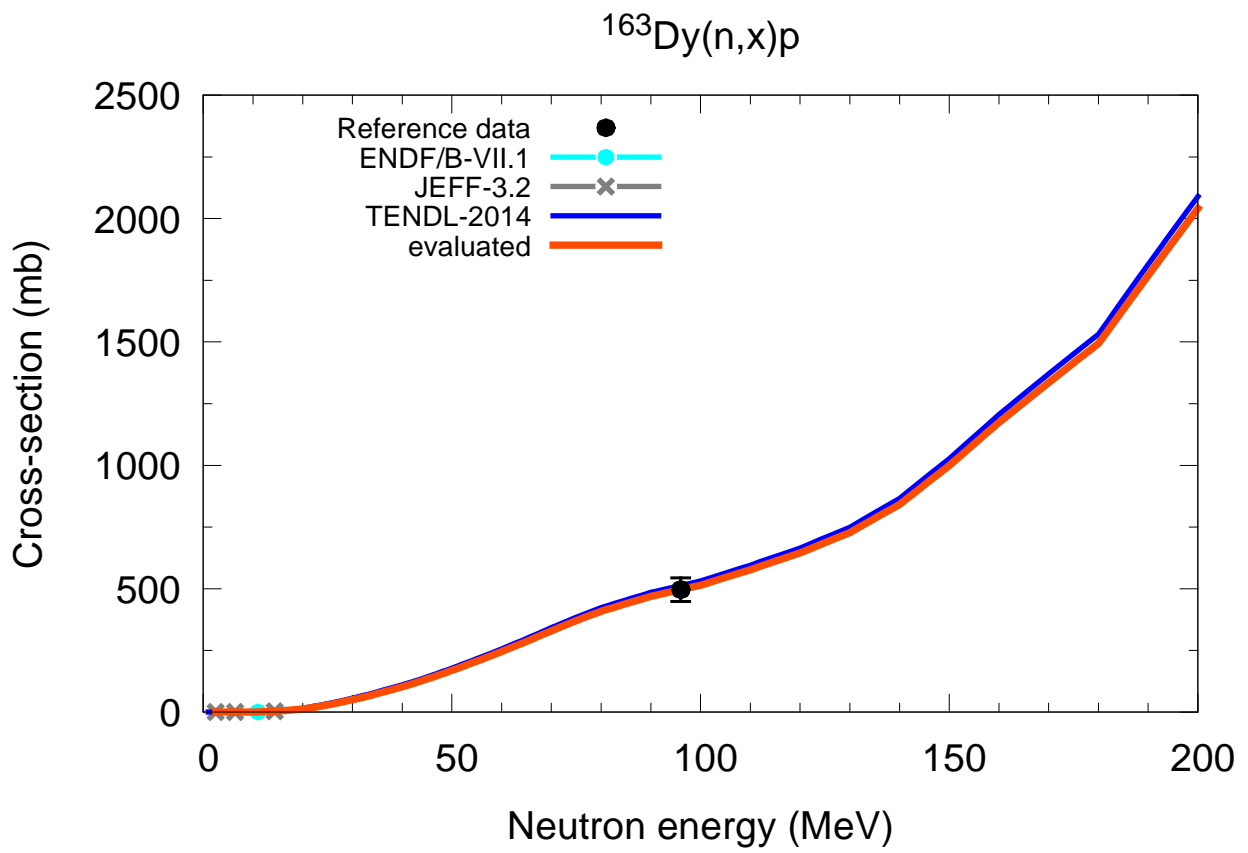
$^{161}\text{Dy}(n,x)p$

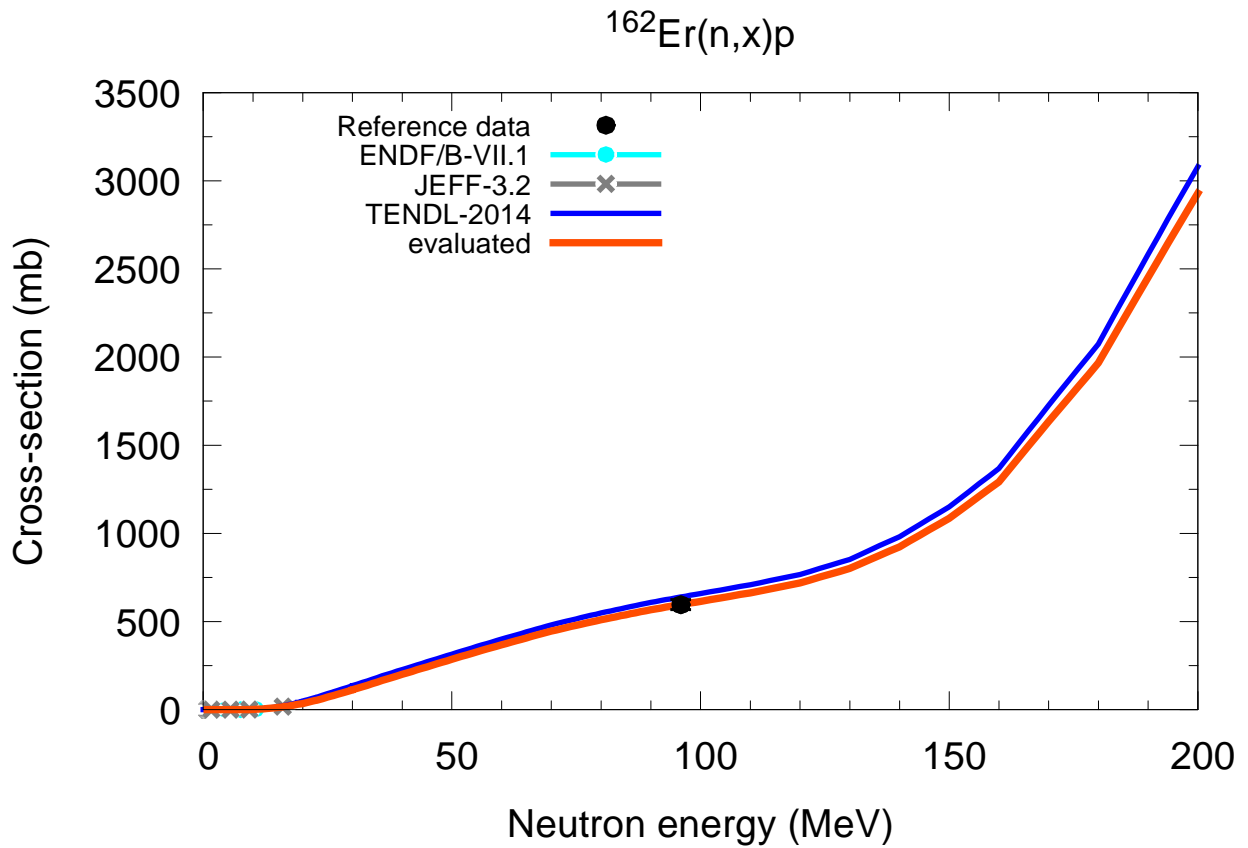
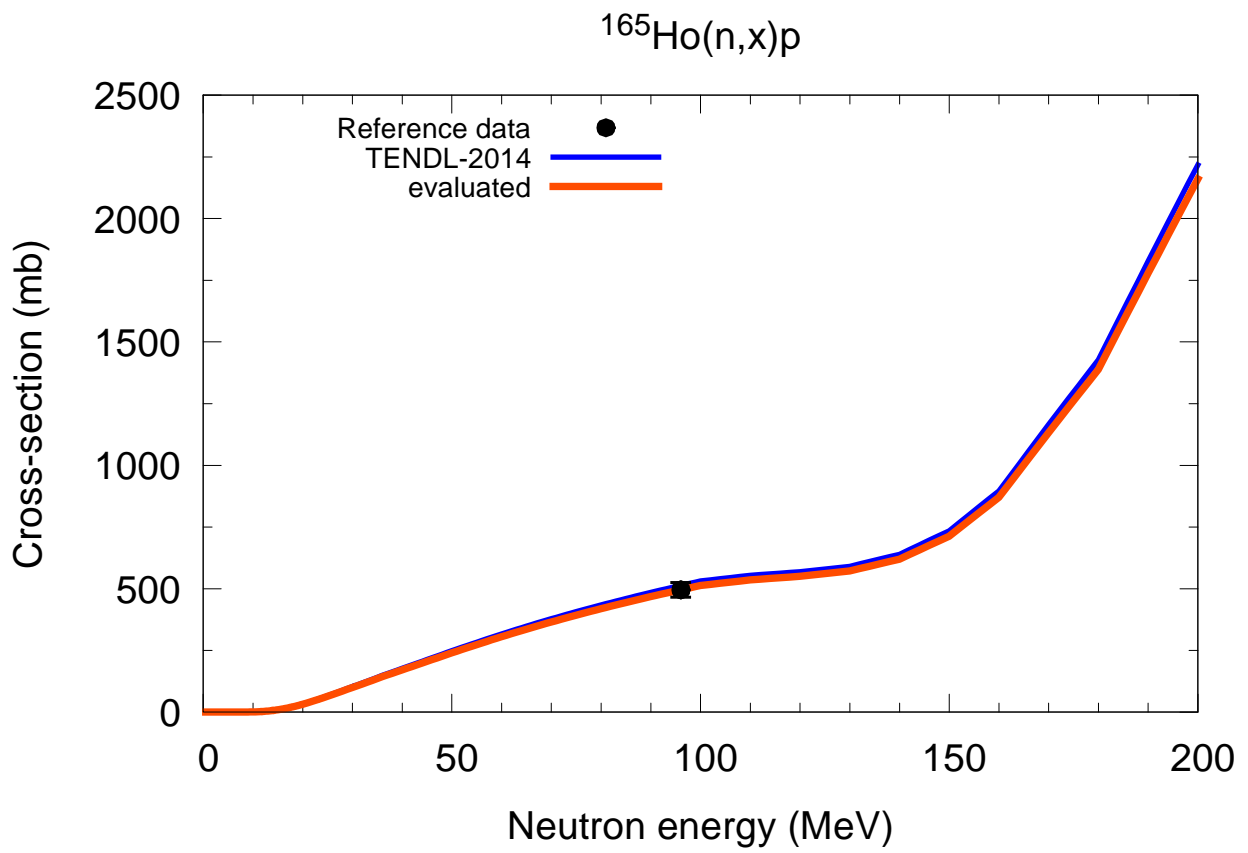


$^{162}\text{Dy}(n,x)p$

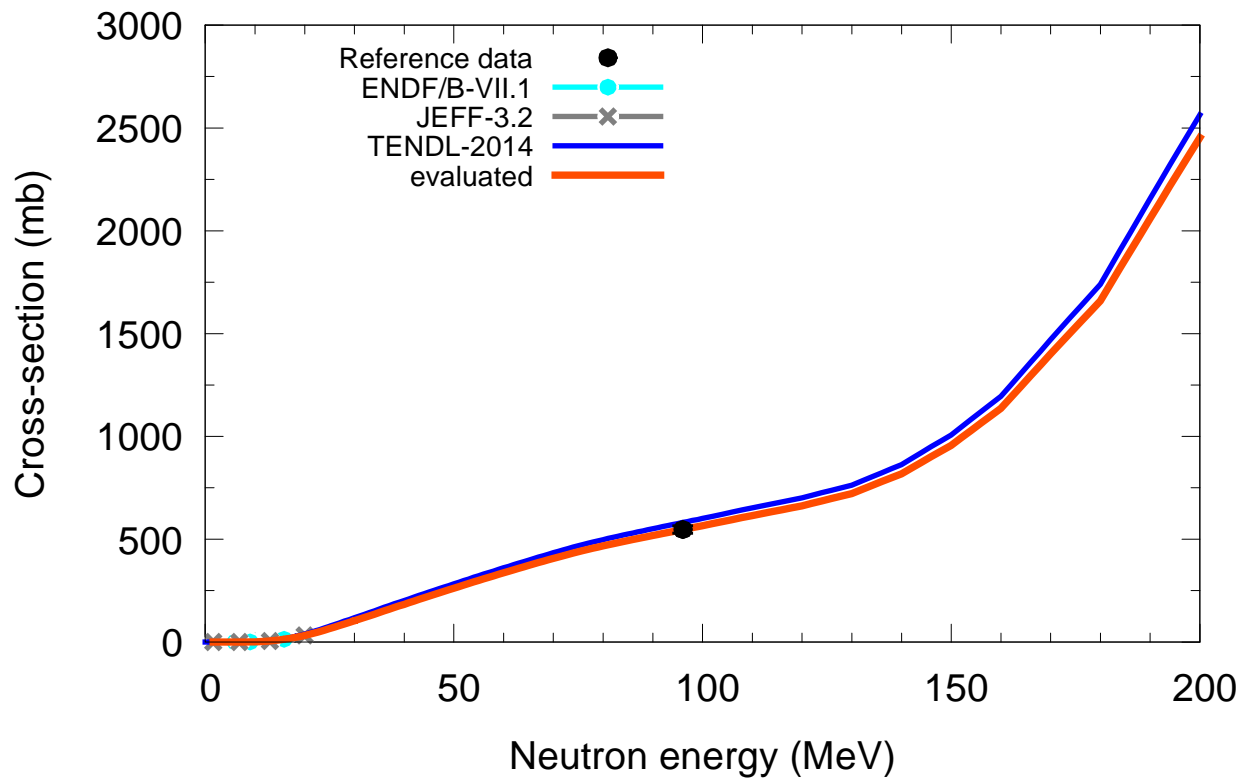




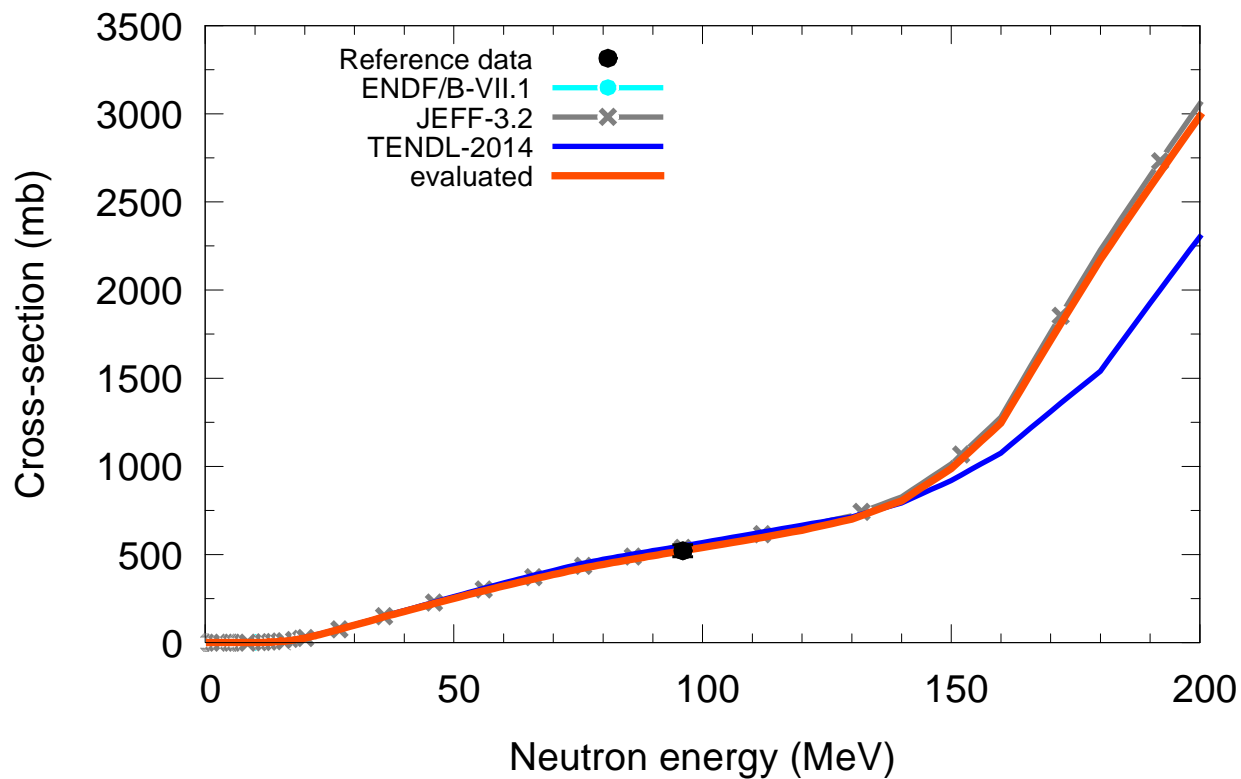




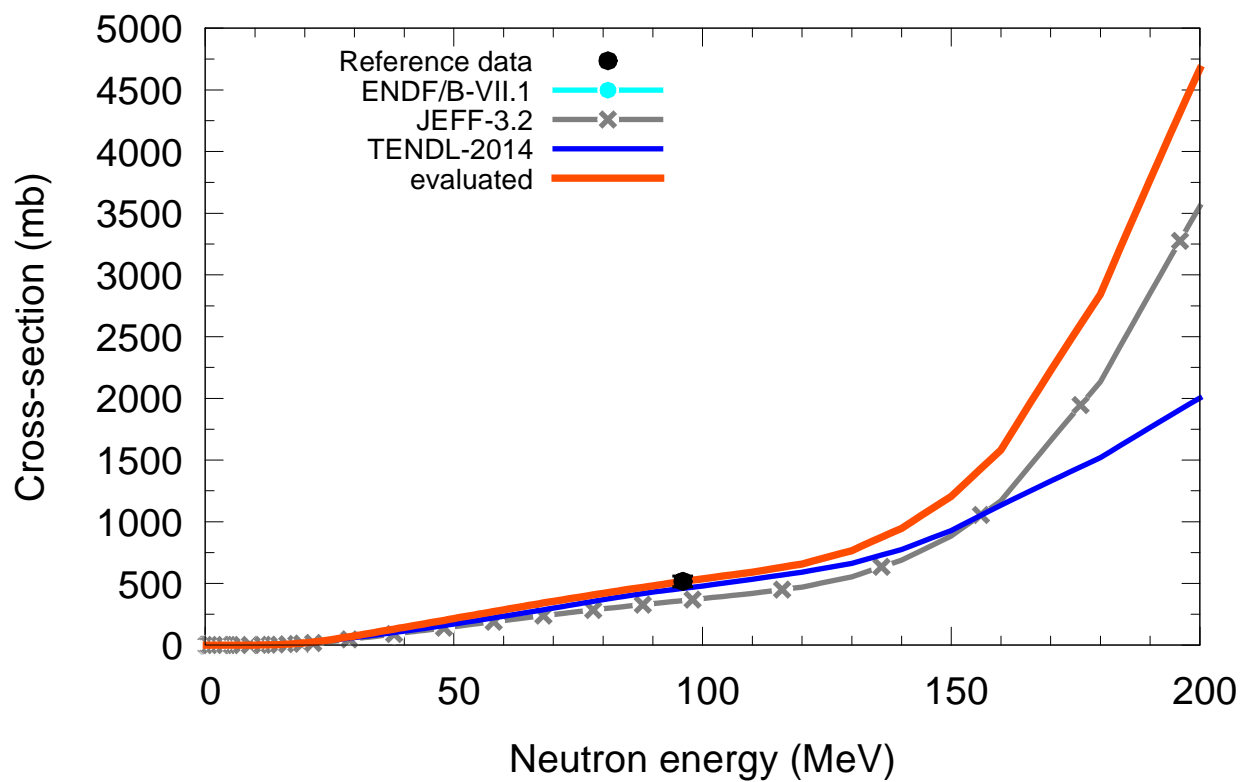
$^{164}\text{Er}(n,x)p$



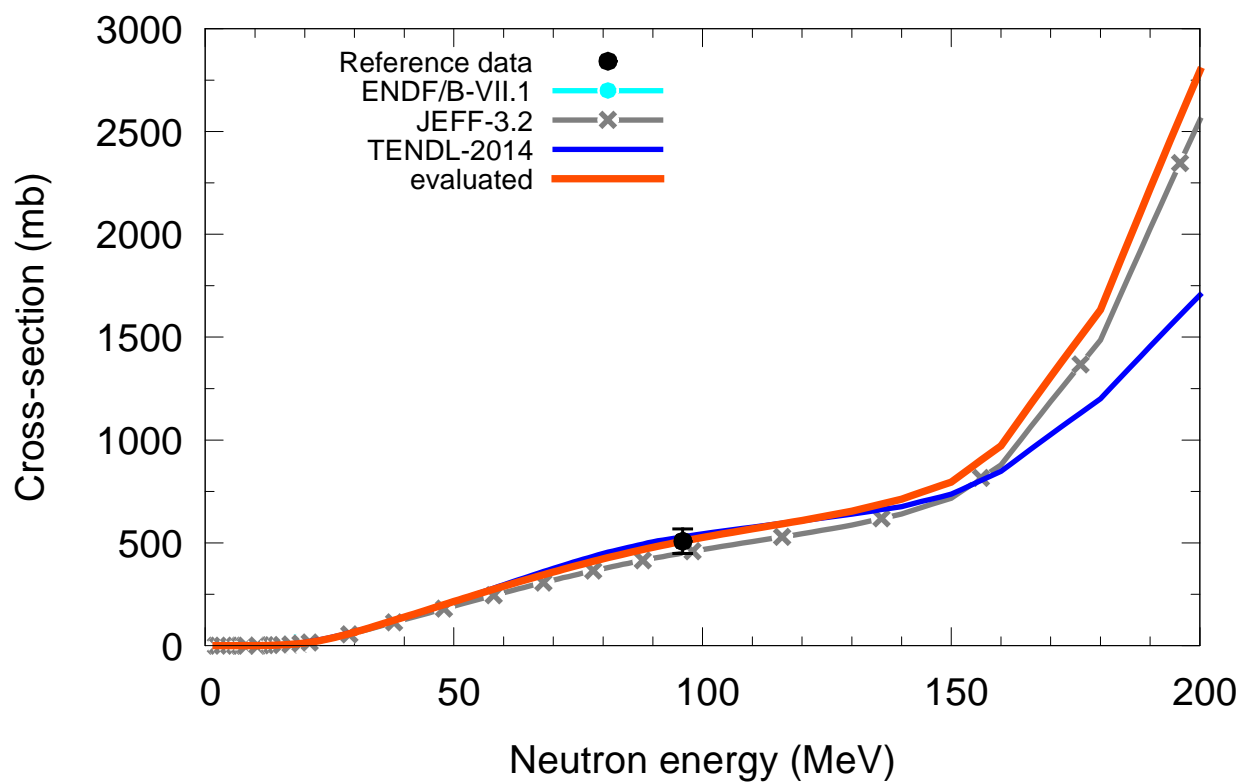
$^{166}\text{Er}(n,x)p$

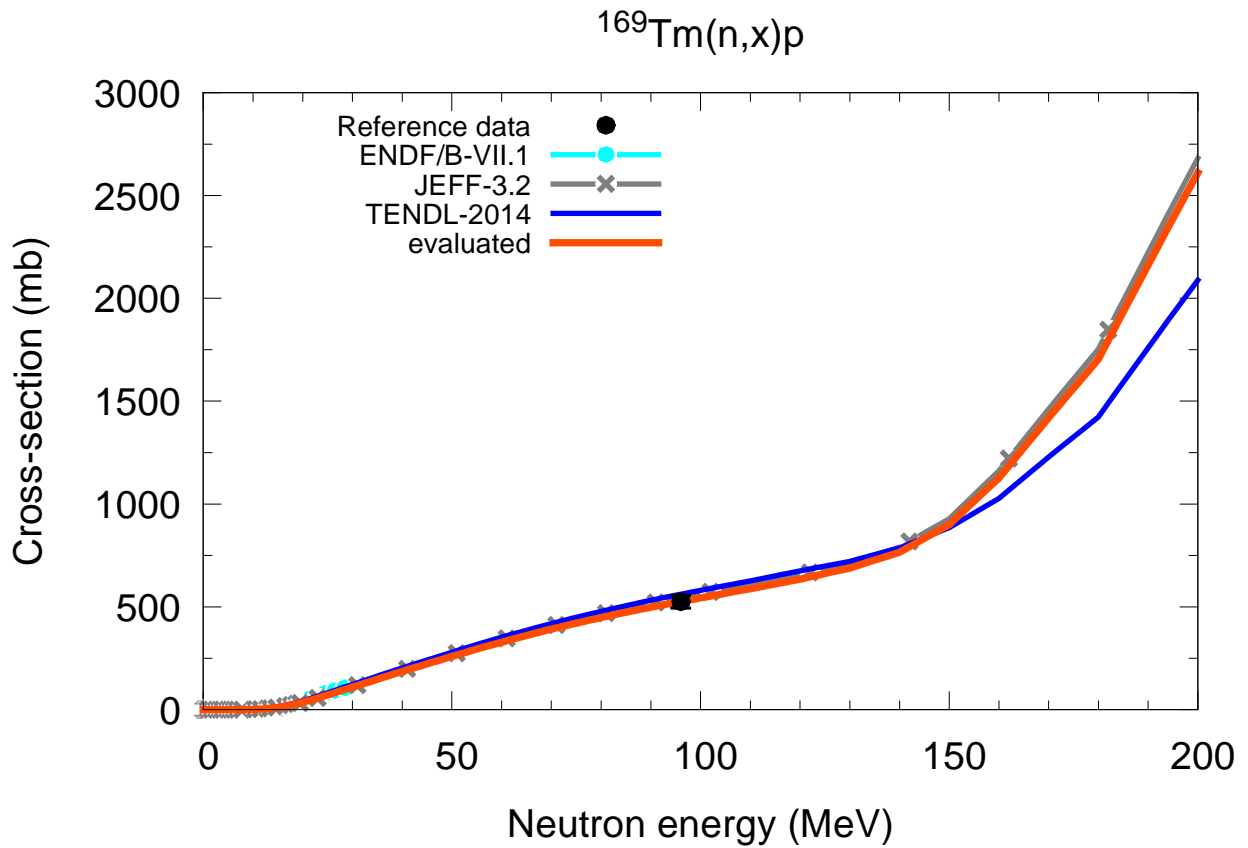
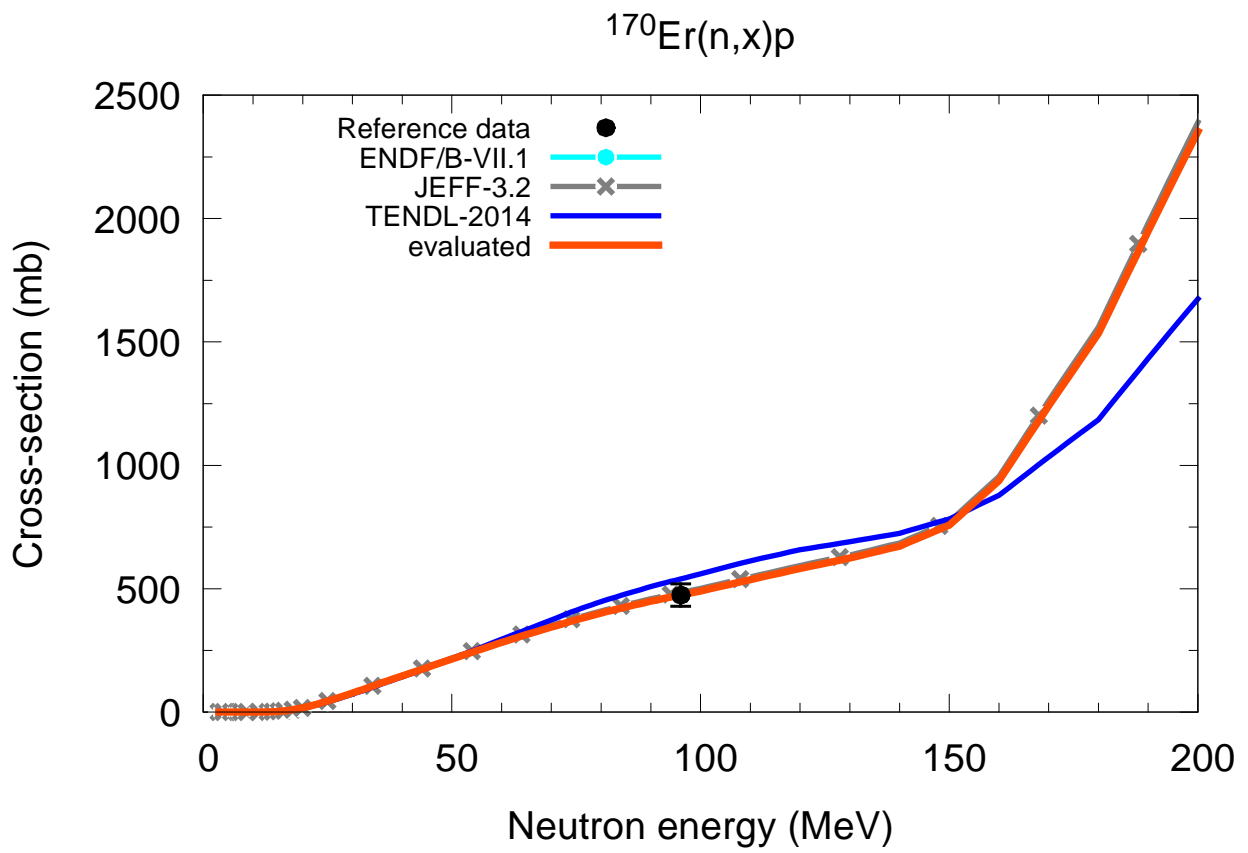


### $^{167}\text{Er}(n,x)p$

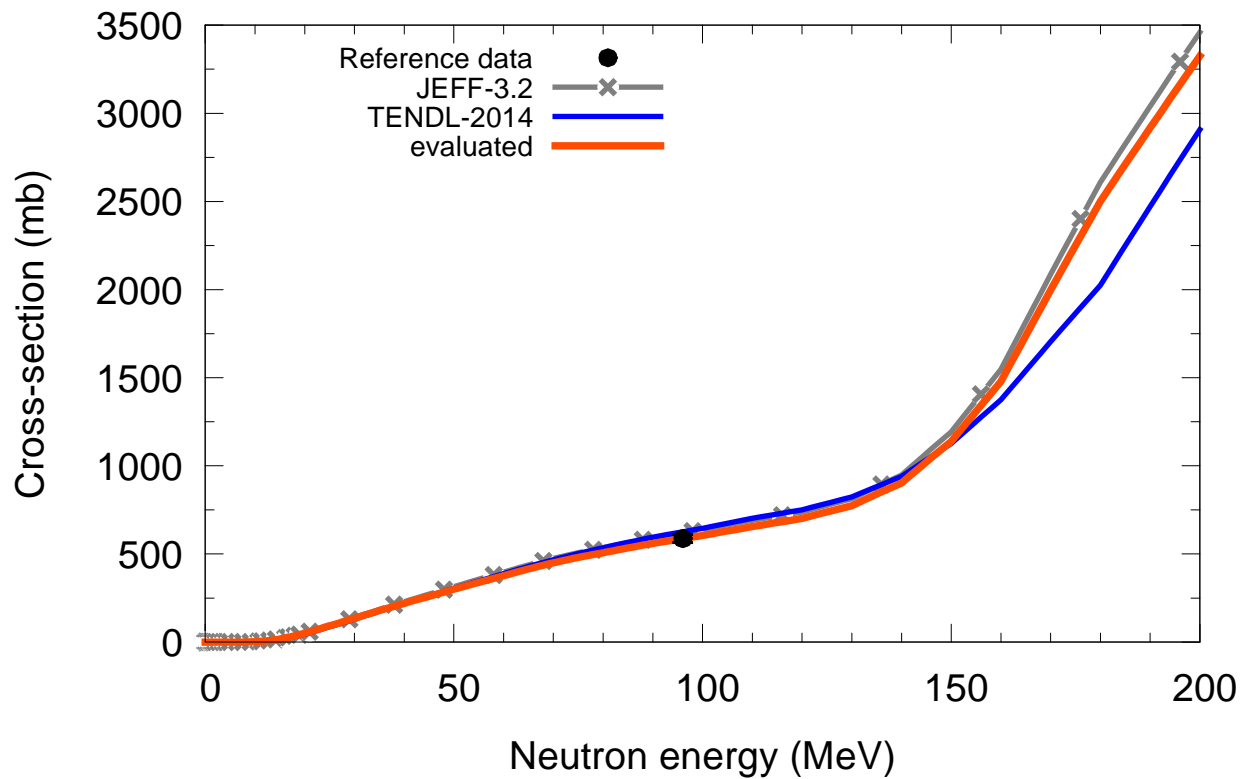


### $^{168}\text{Er}(n,x)p$

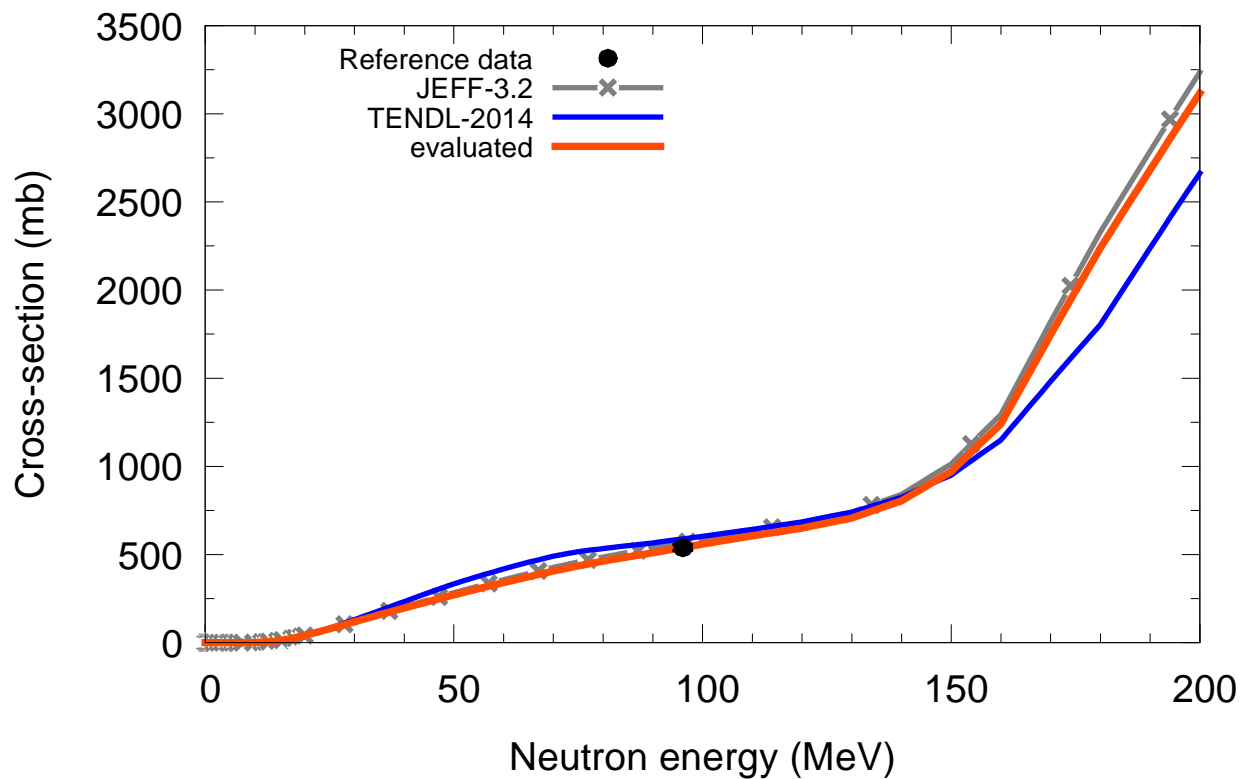




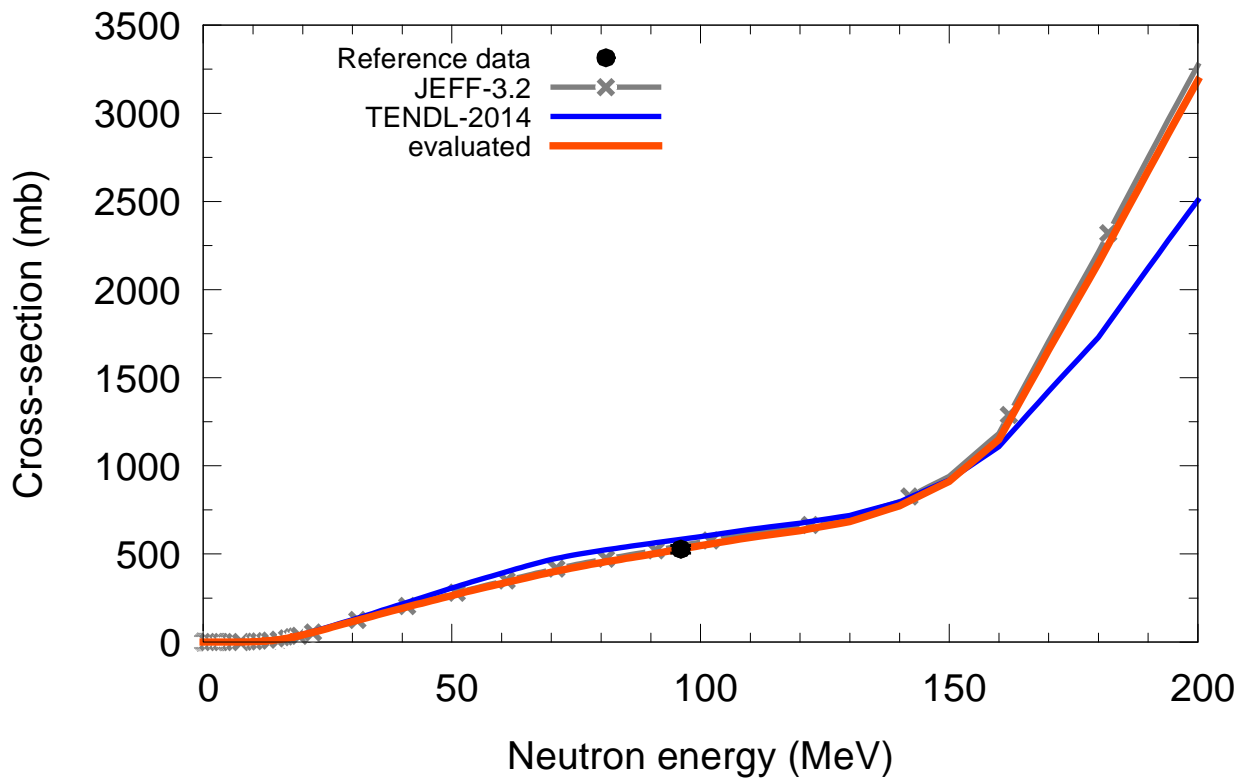
$^{168}\text{Yb}(n,x)p$



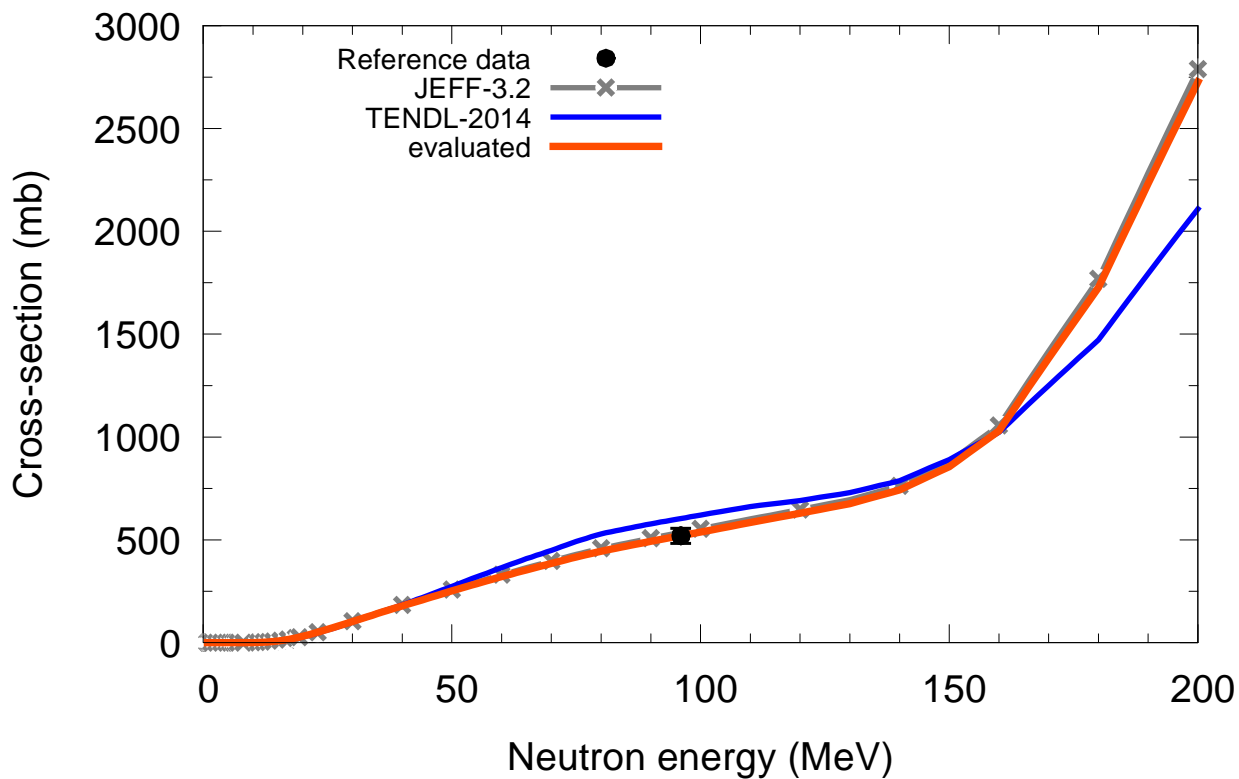
$^{170}\text{Yb}(n,x)p$



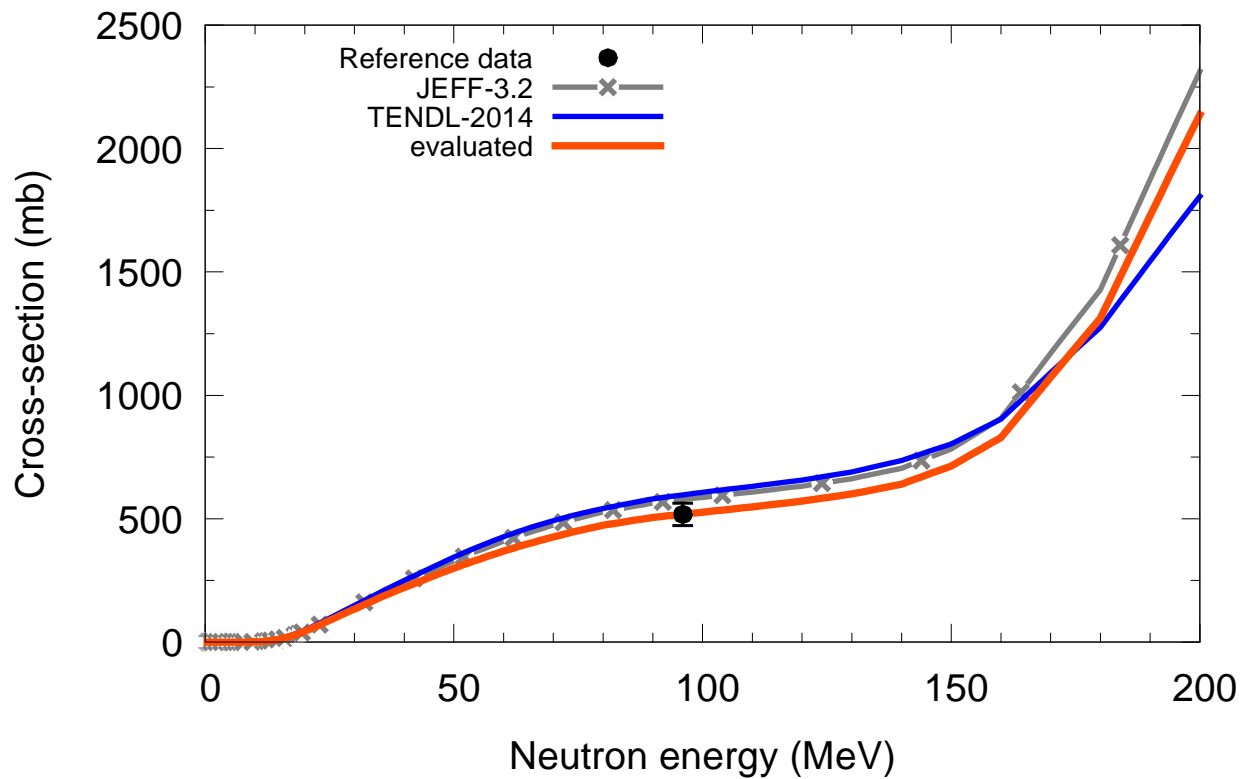
$^{171}\text{Yb}(n,x)p$



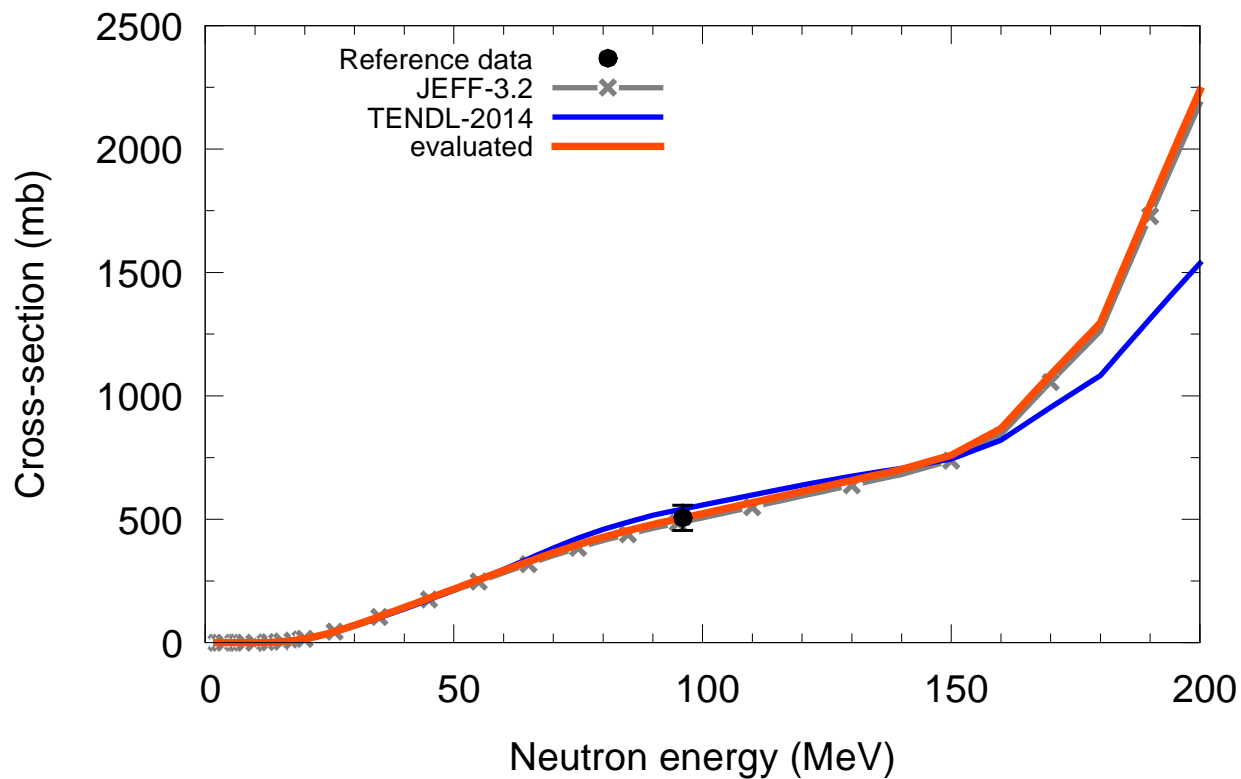
$^{172}\text{Yb}(n,x)p$



$^{173}\text{Yb}(n,x)p$

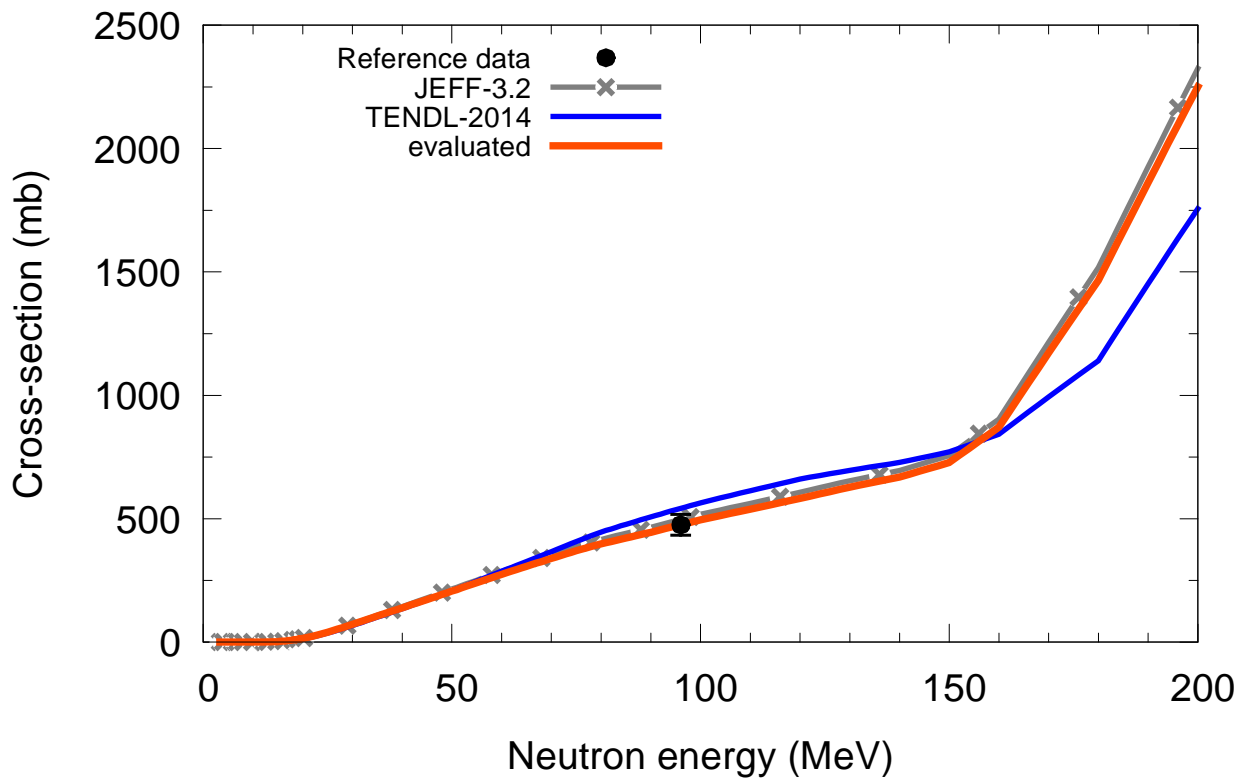


$^{174}\text{Yb}(n,x)p$

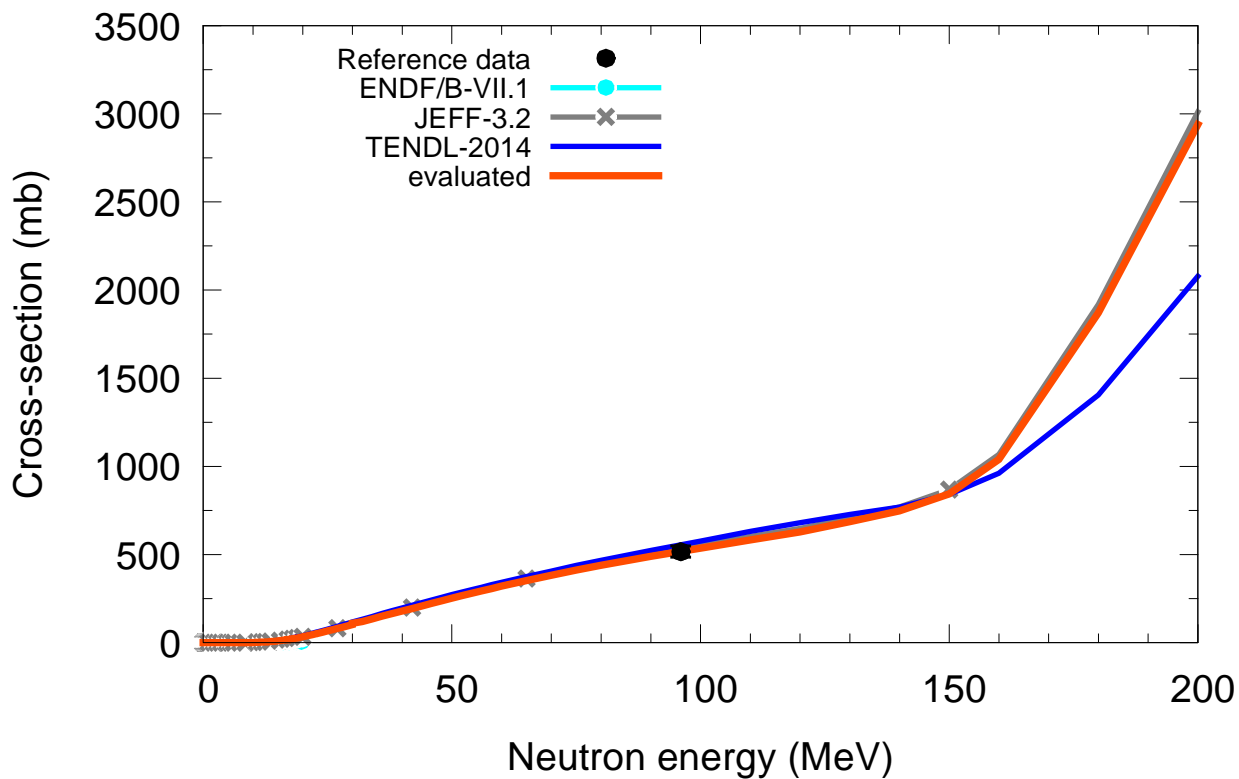




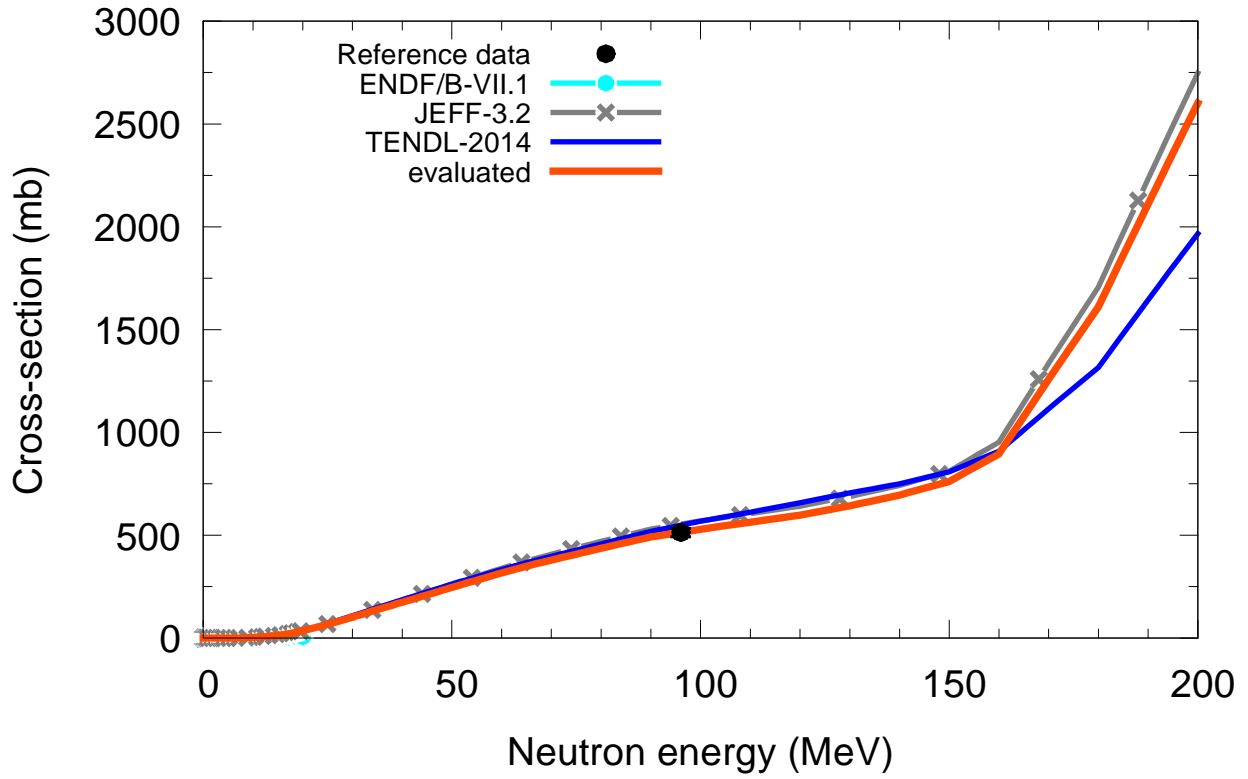
$^{176}\text{Yb}(n,x)p$



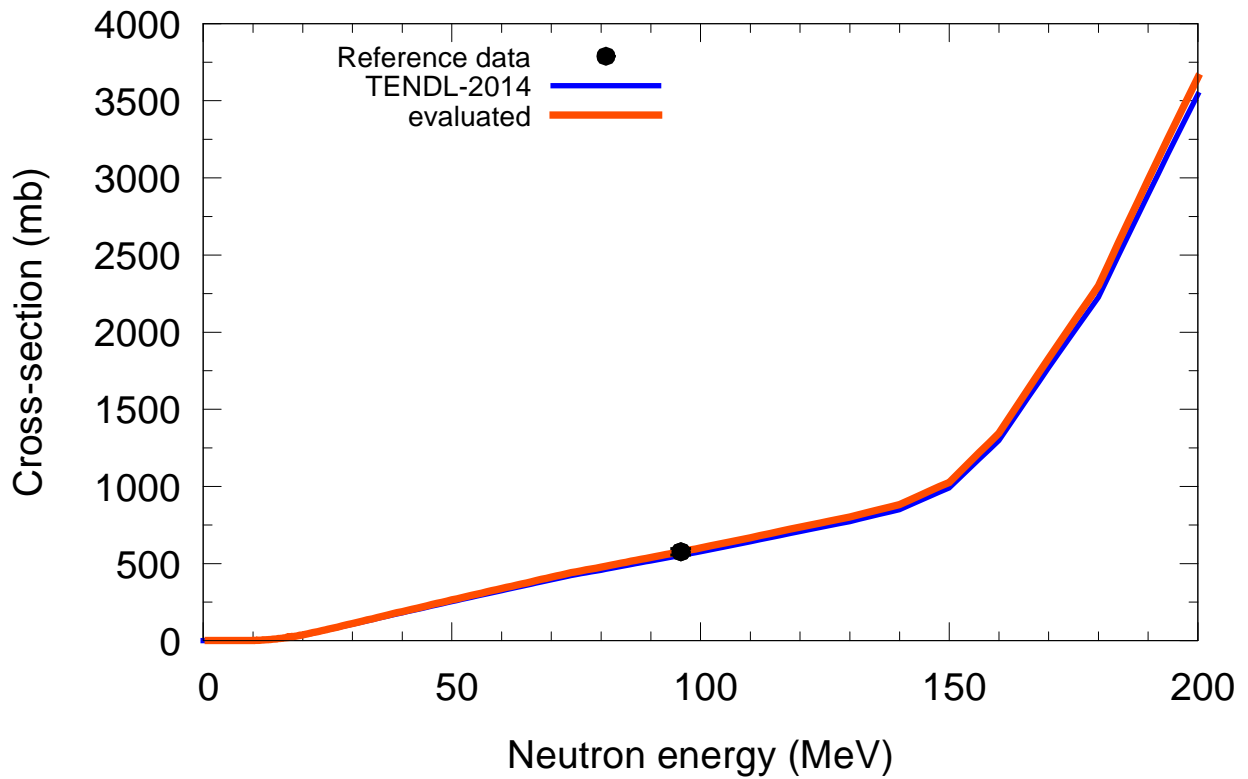
$^{175}\text{Lu}(n,x)p$



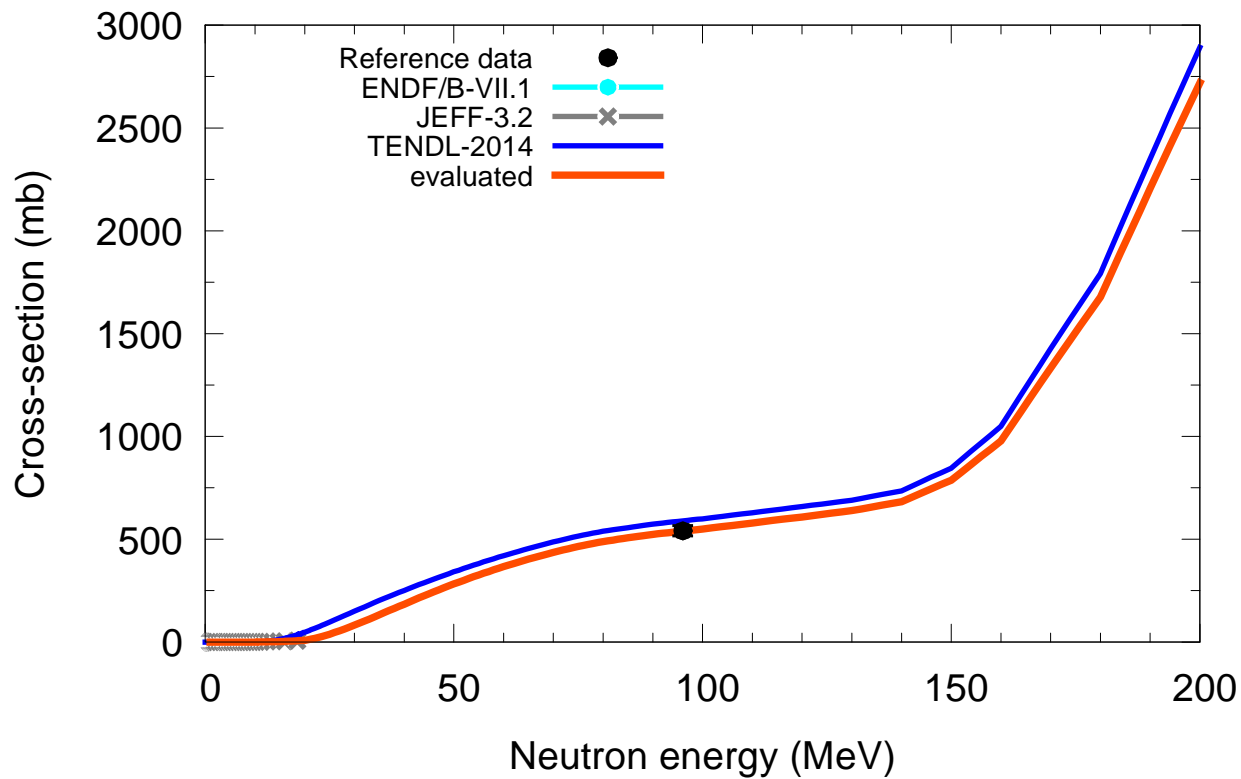
$^{176}\text{Lu}(n,x)p$



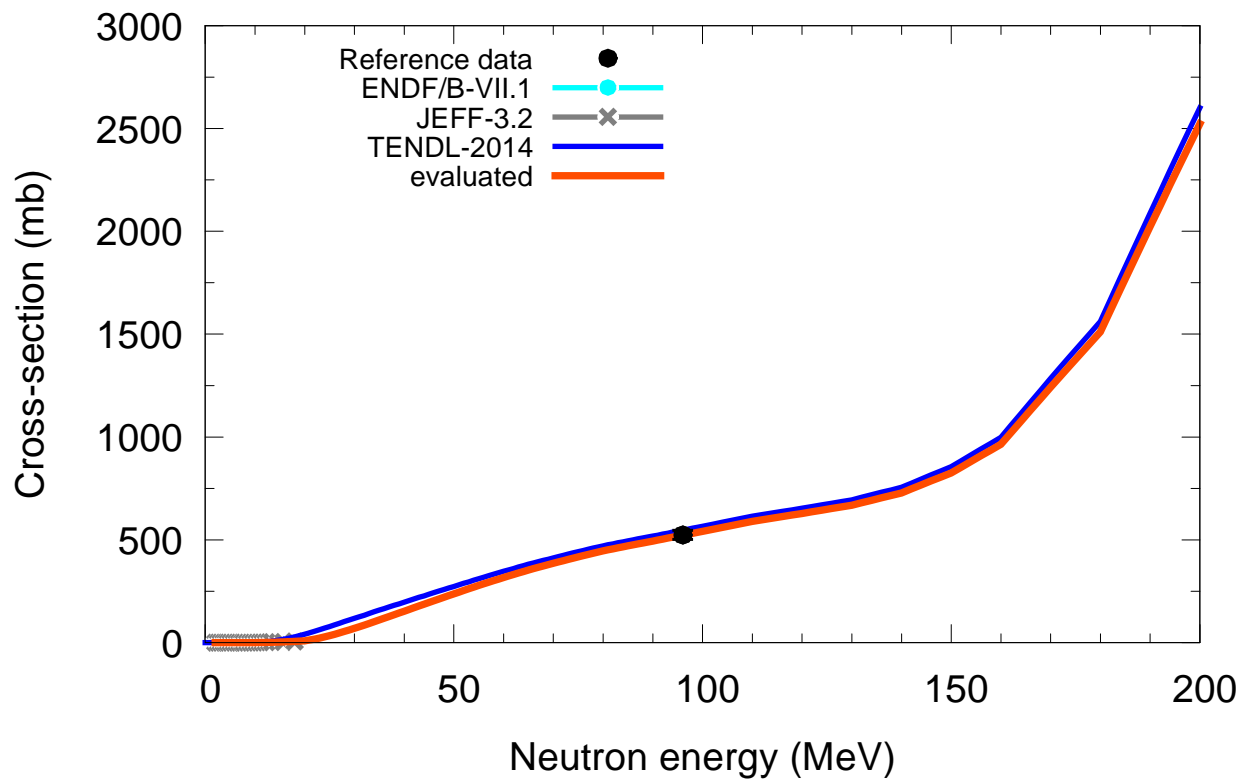
$^{174}\text{Hf}(n,x)p$



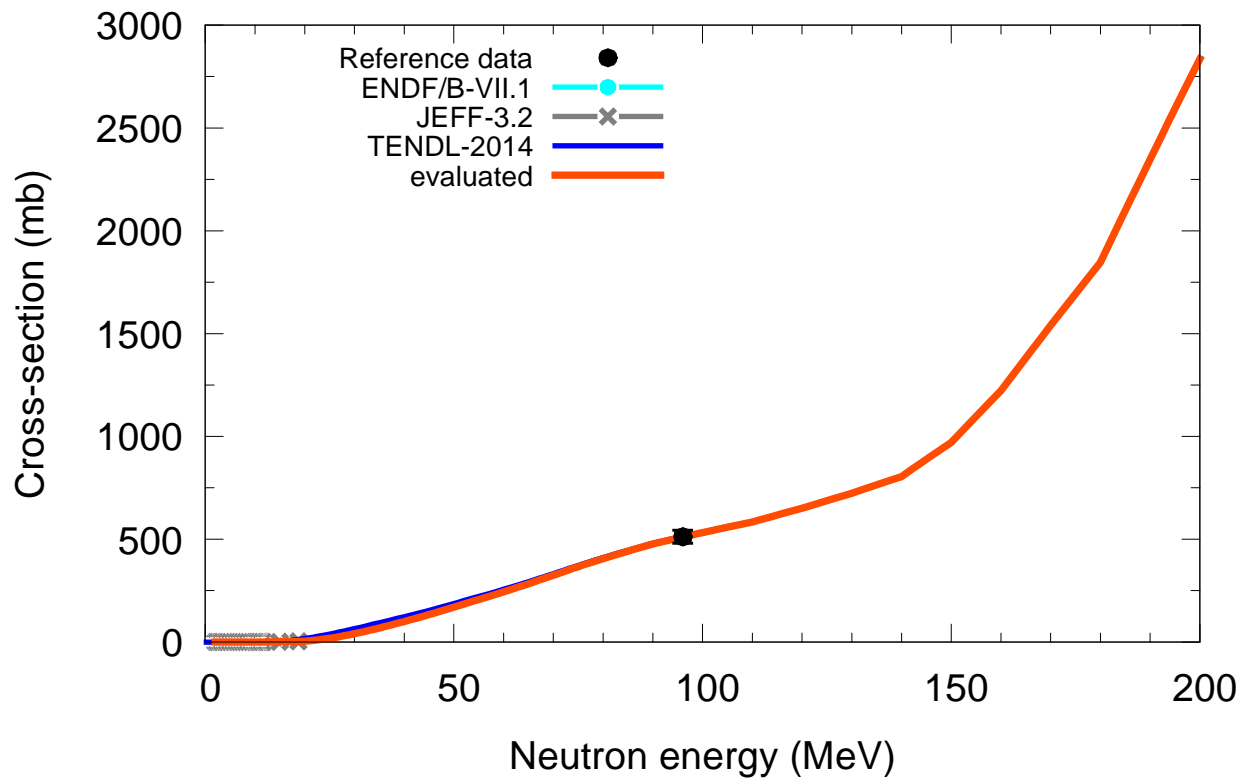
$^{176}\text{Hf}(n,x)p$



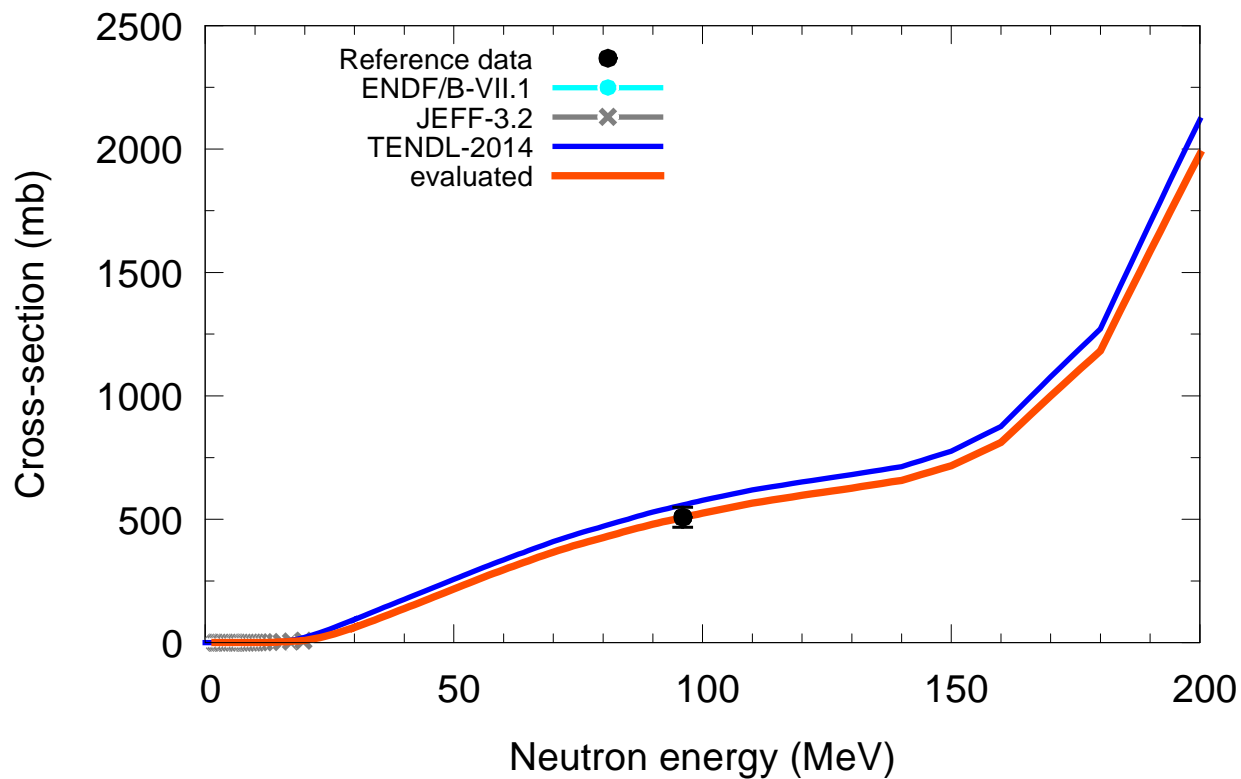
$^{177}\text{Hf}(n,x)p$

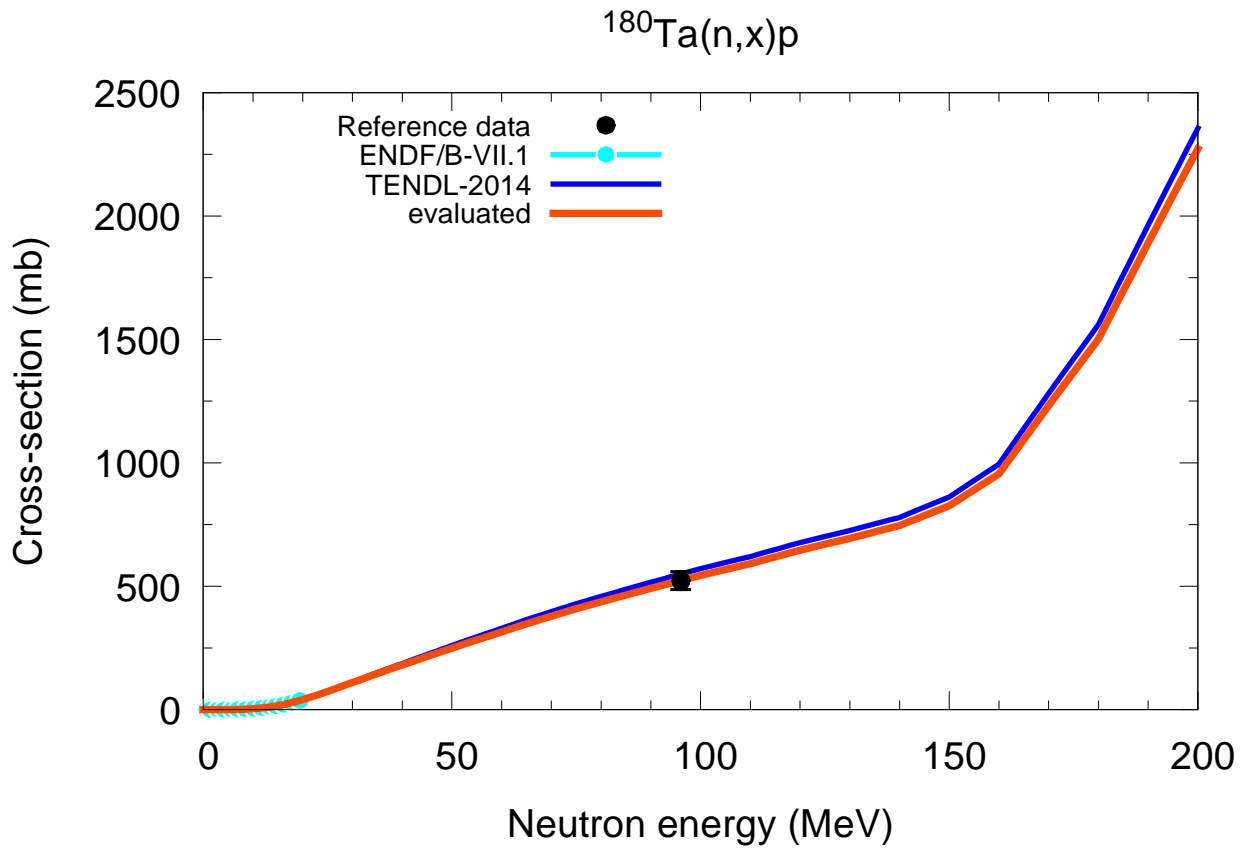
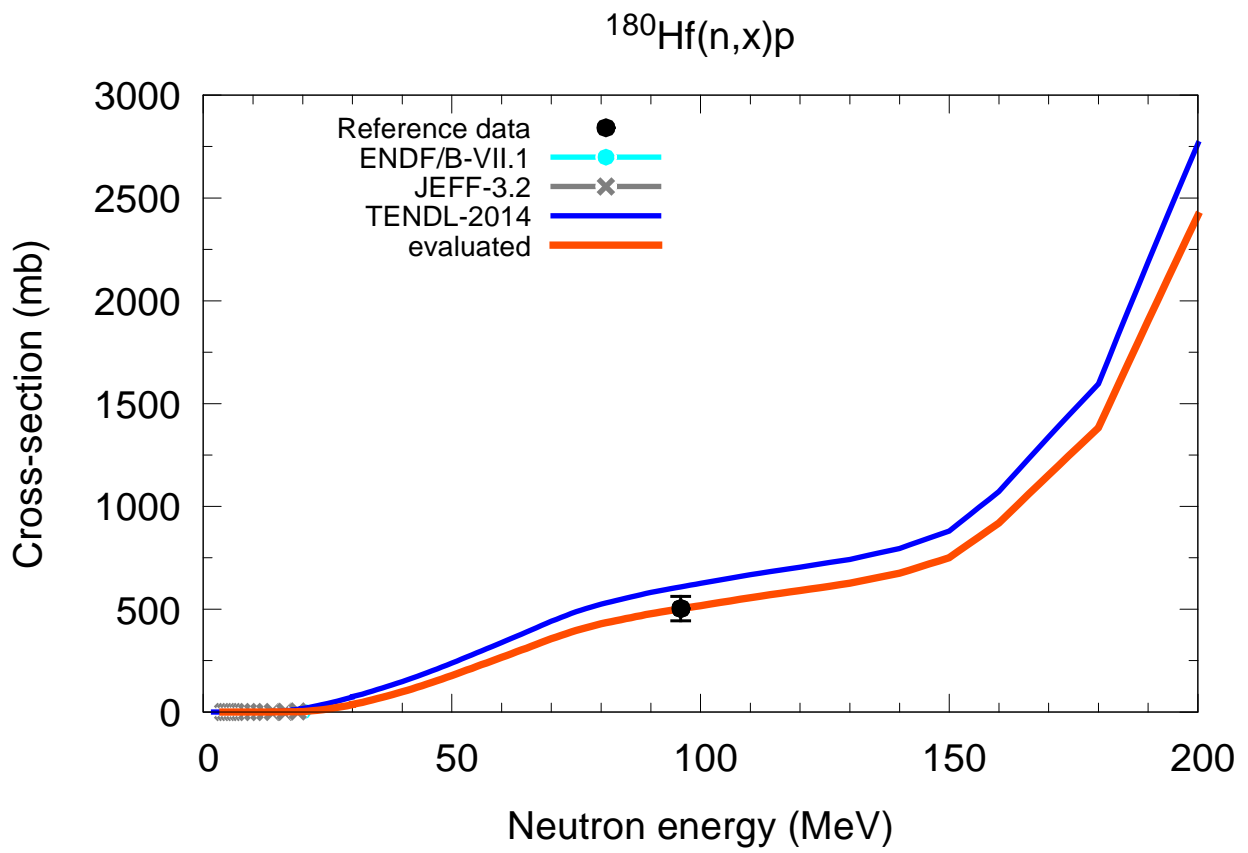


$^{178}\text{Hf}(n,x)p$

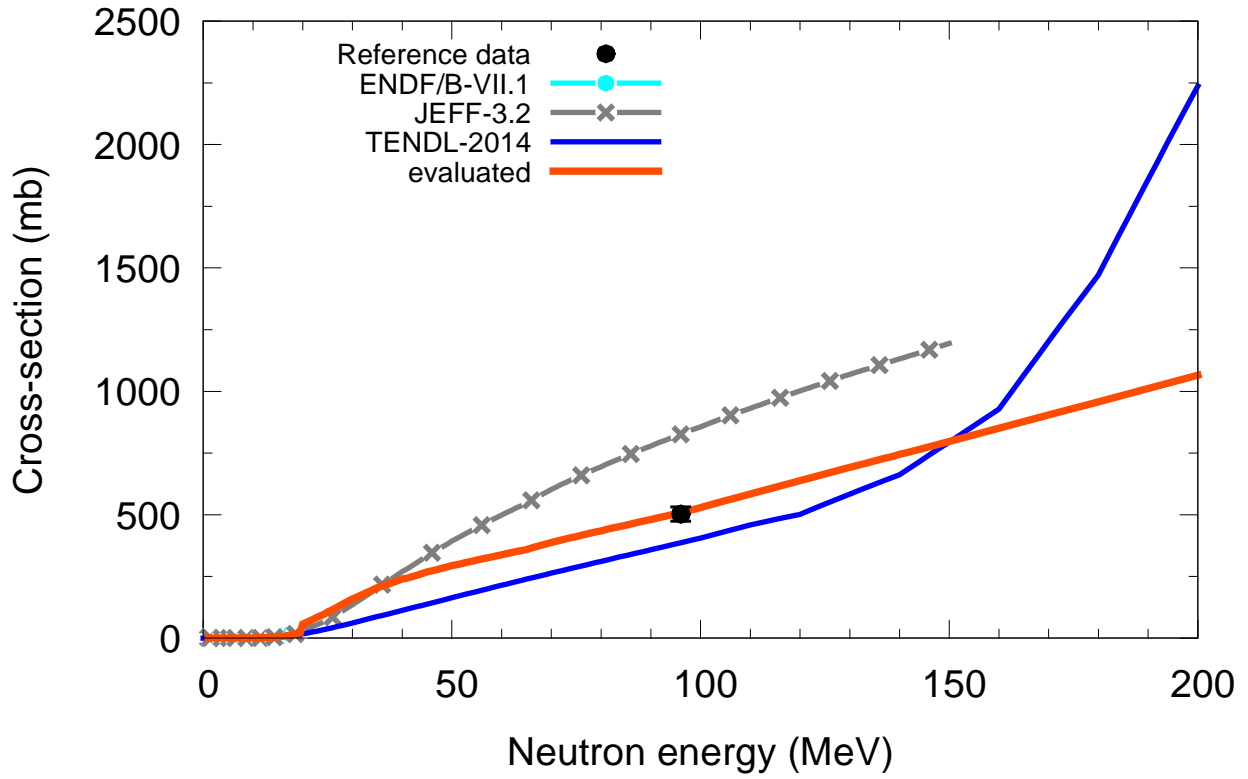


$^{179}\text{Hf}(n,x)p$

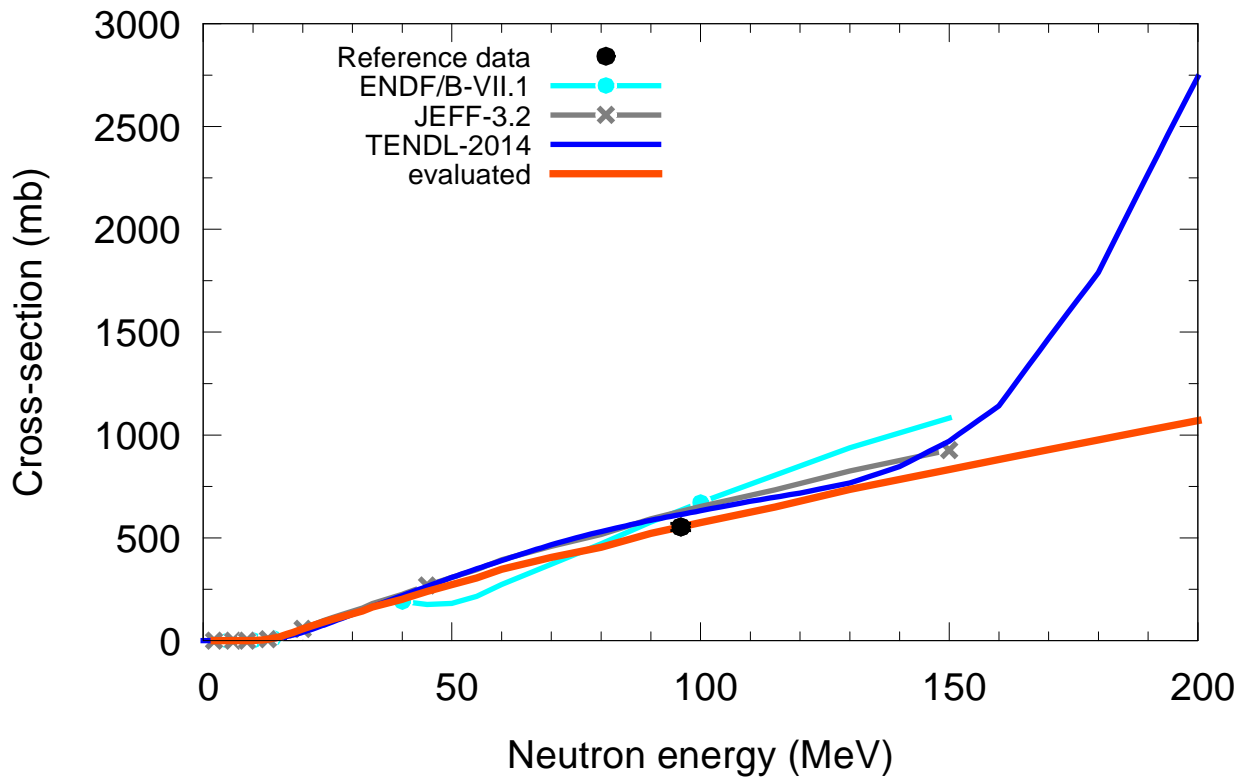


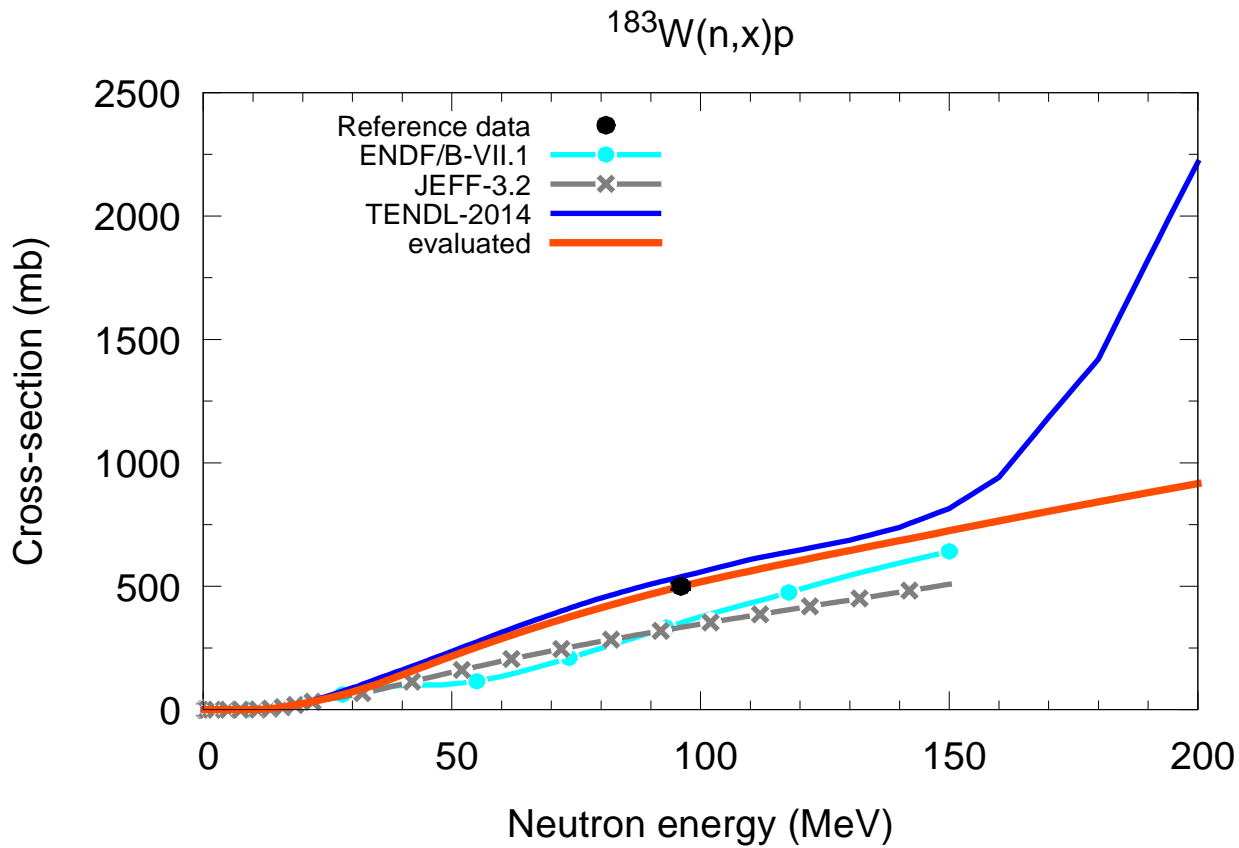
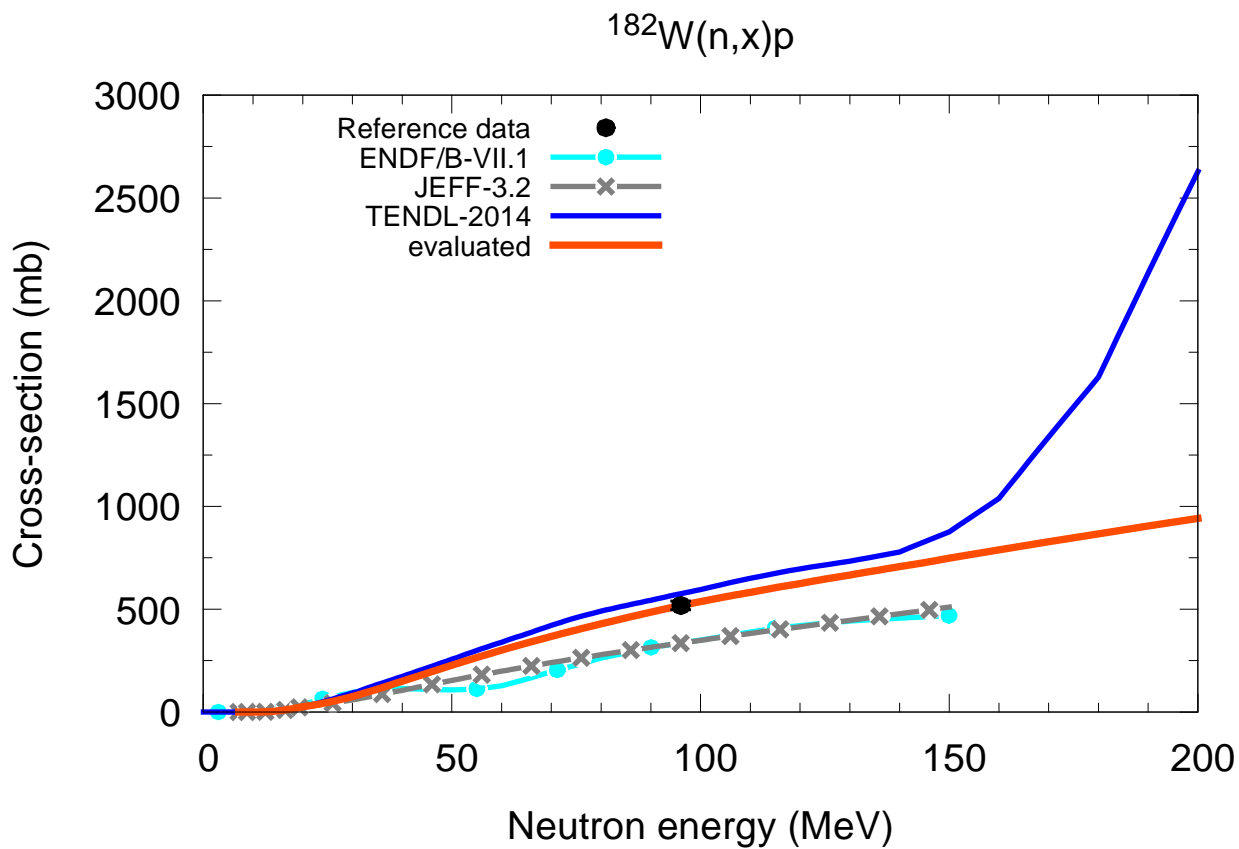


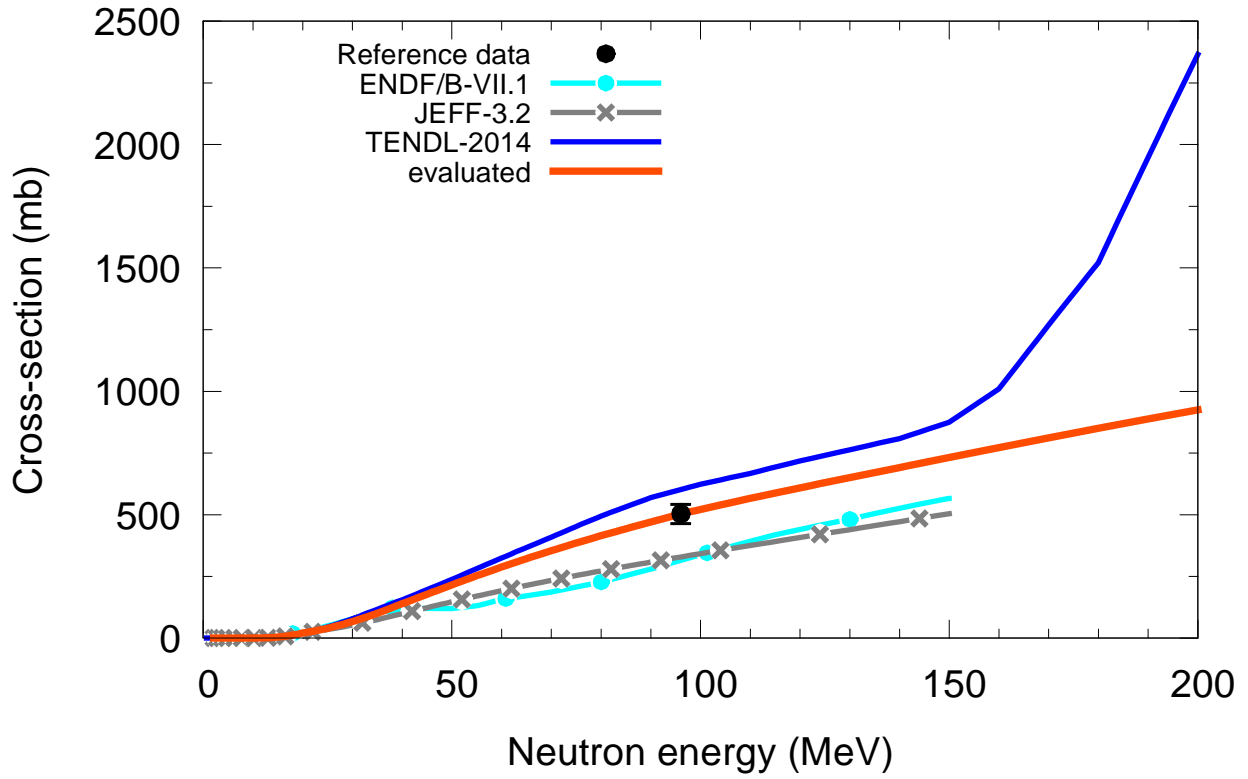
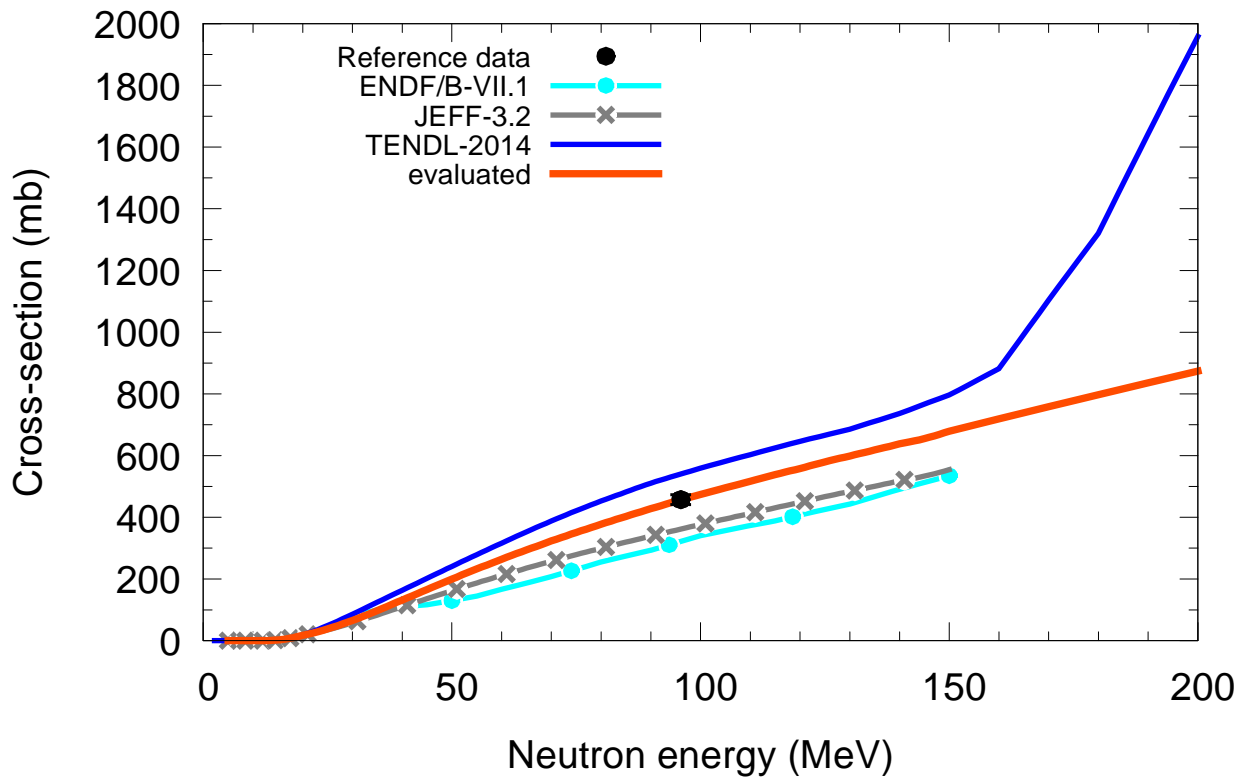
$^{181}\text{Ta}(n,x)p$



$^{180}\text{W}(n,x)p$

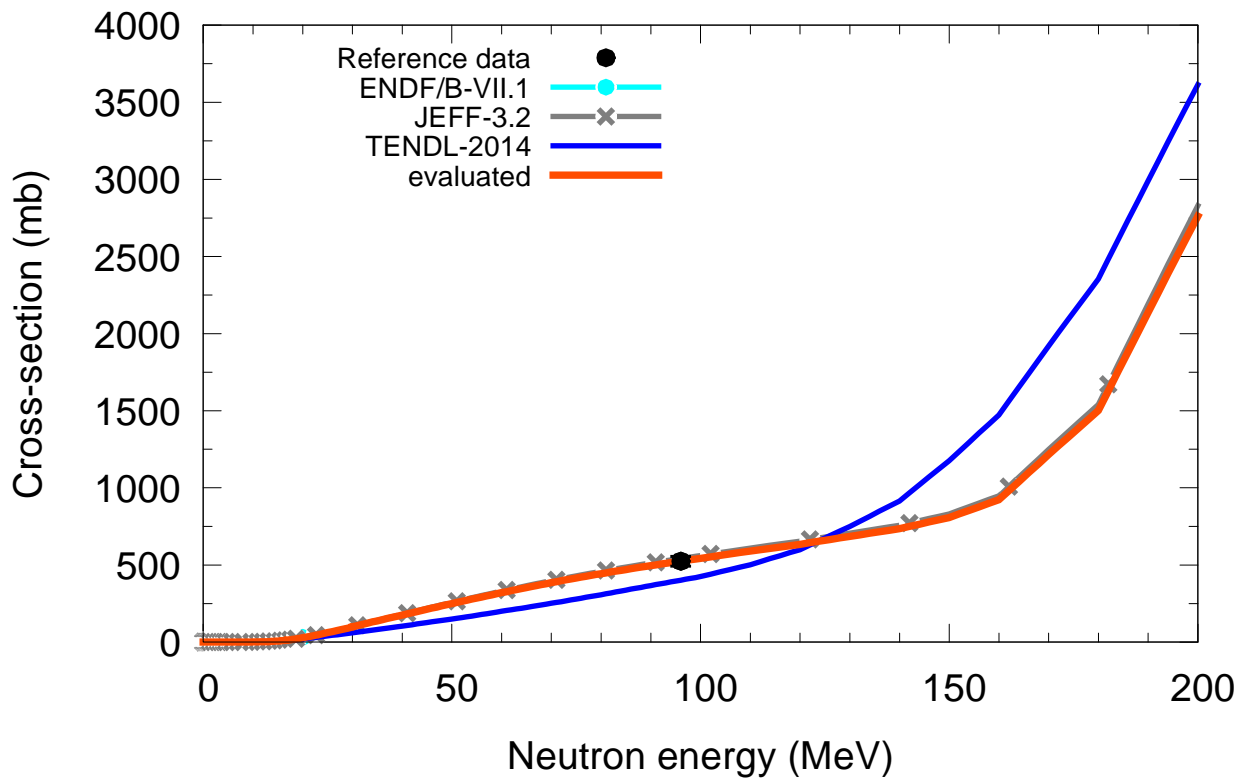




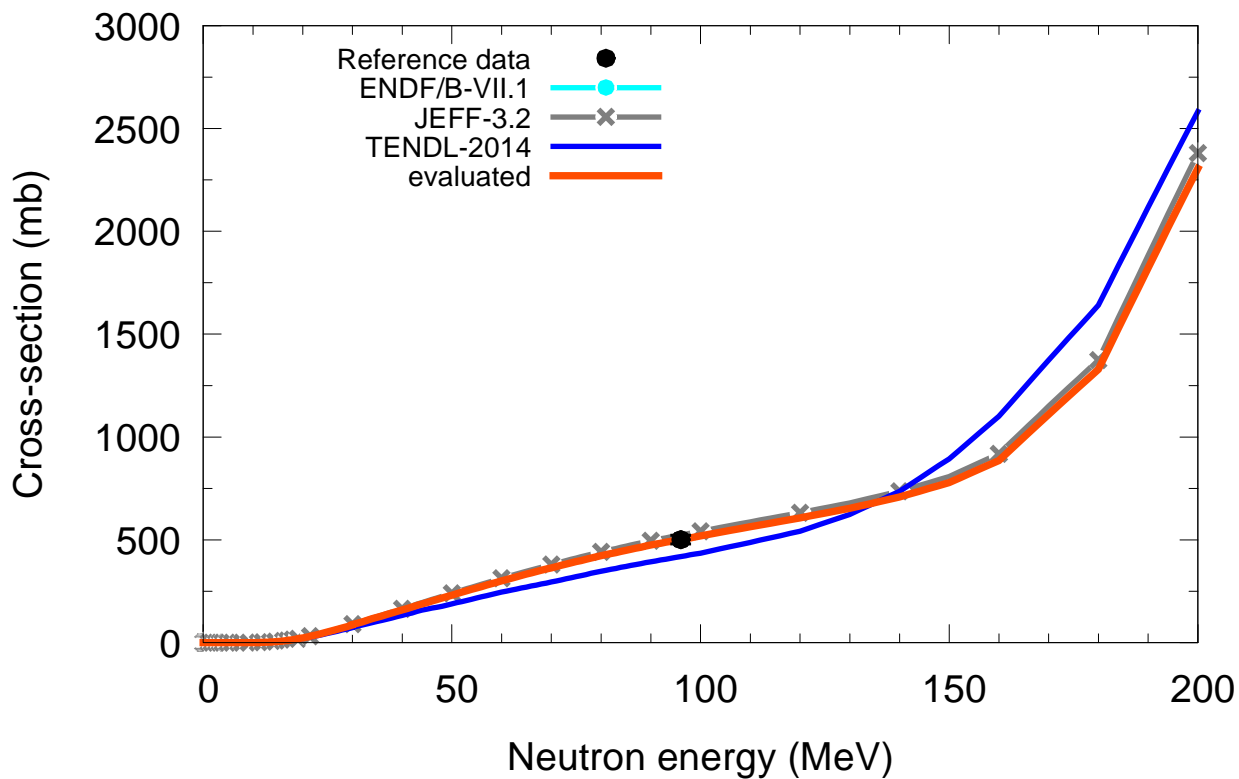
$^{184}\text{W}(n,x)p$  $^{186}\text{W}(n,x)p$ 



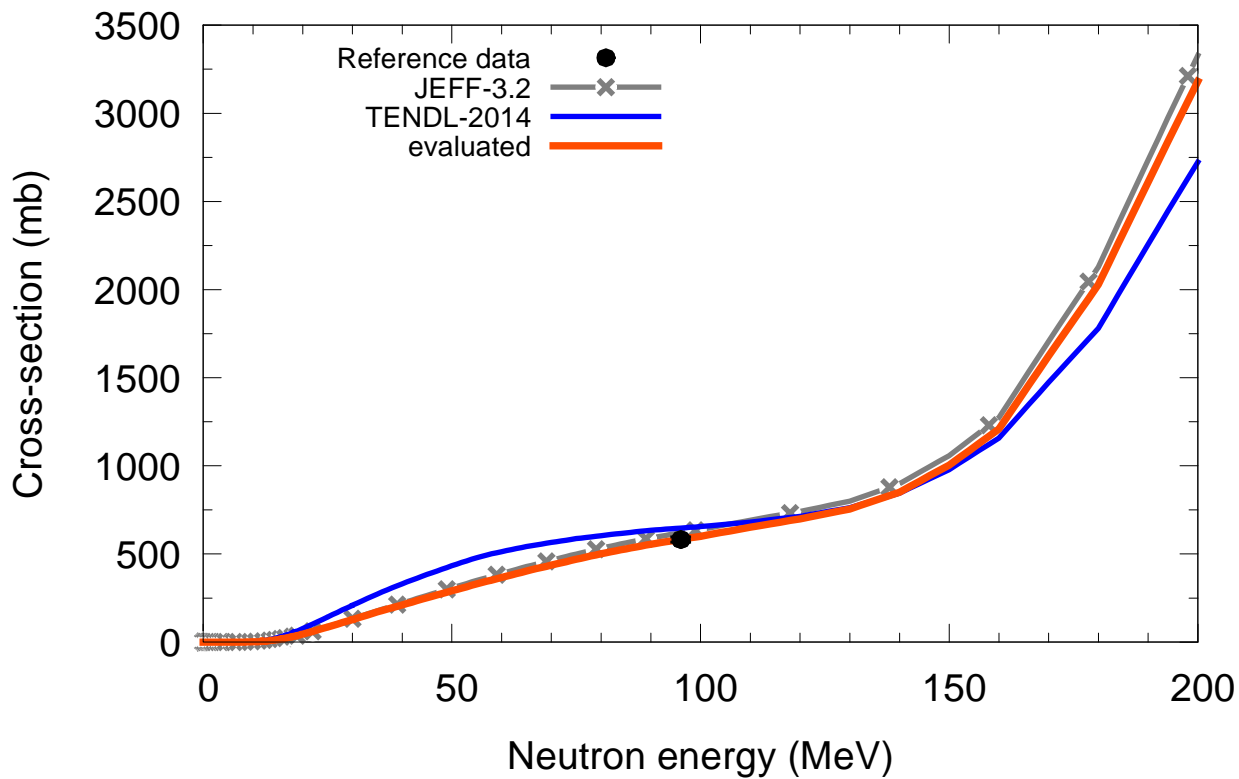
$^{185}\text{Re}(n,x)p$



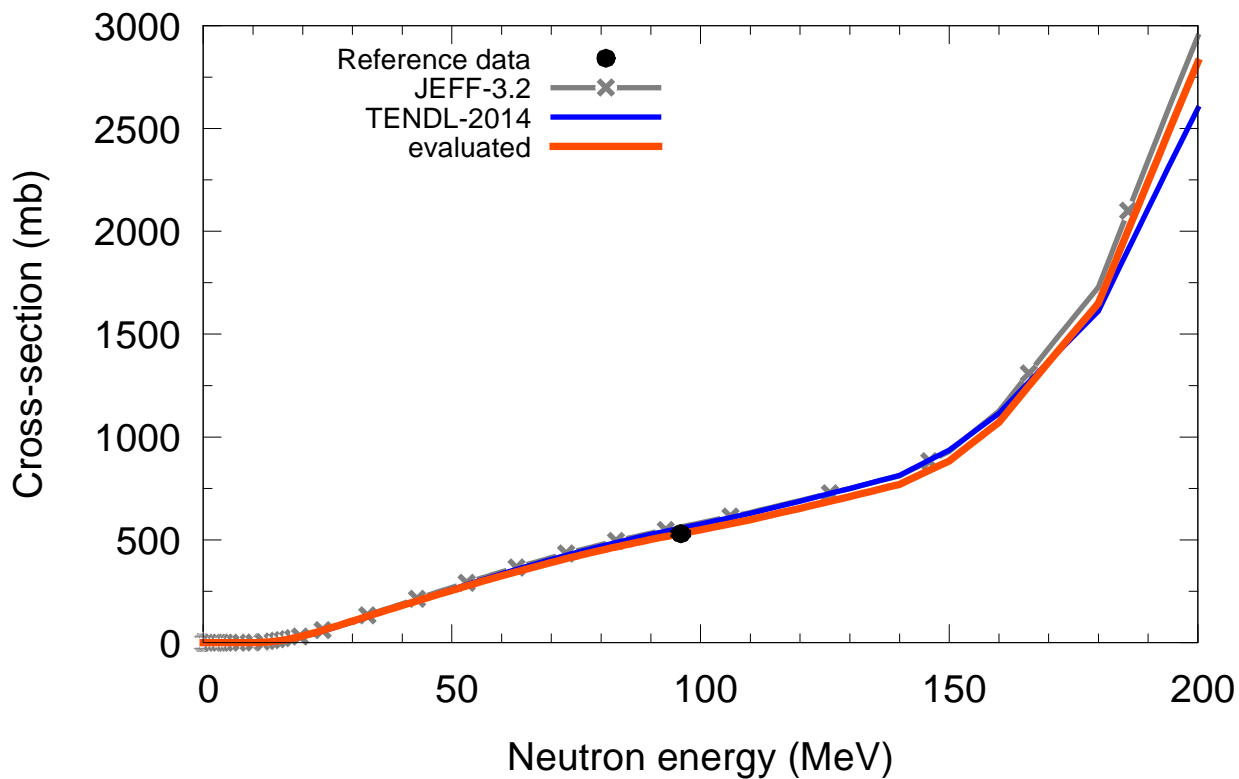
$^{187}\text{Re}(n,x)p$



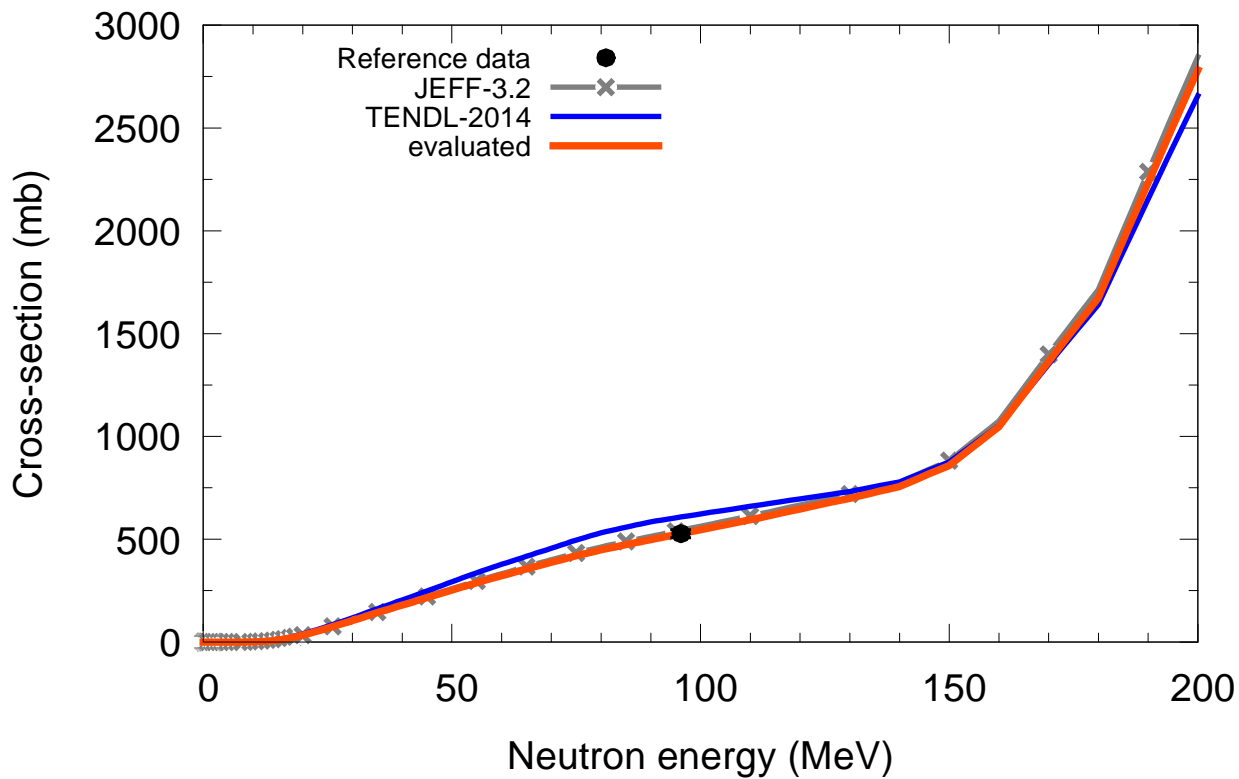
$^{184}\text{Os}(n,x)p$



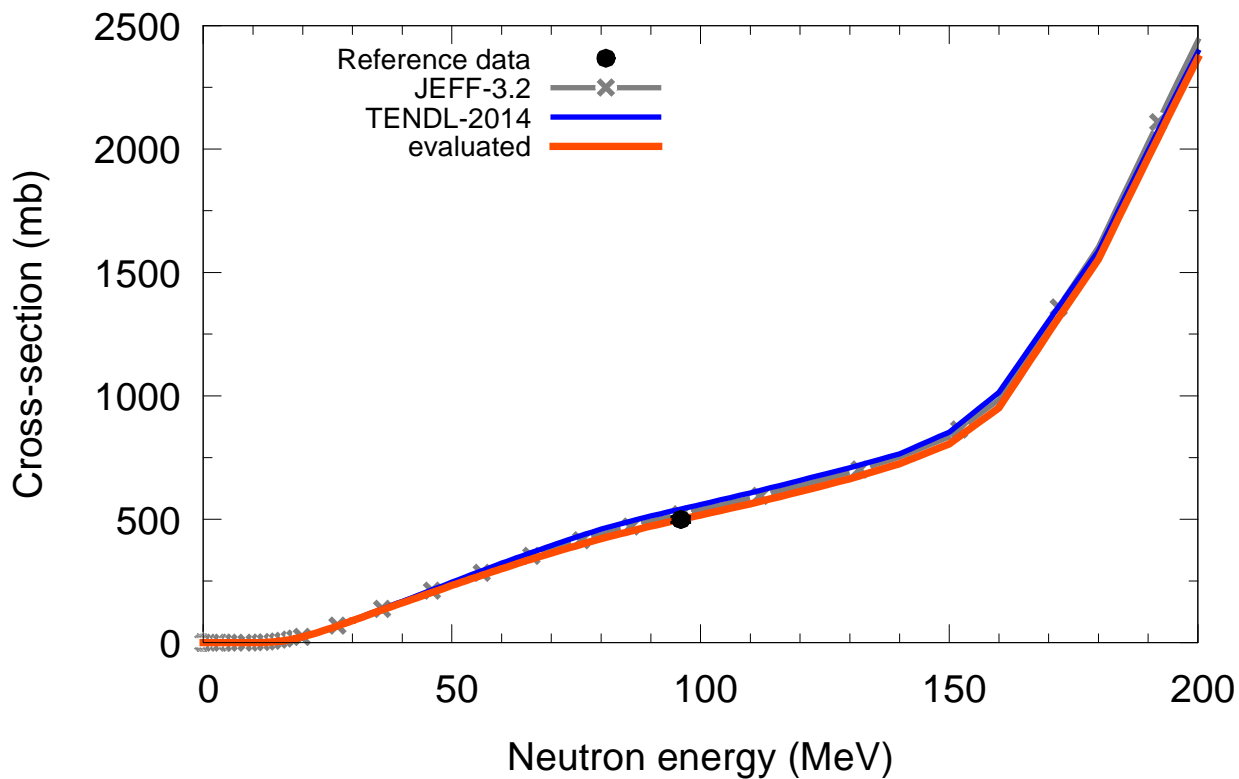
$^{186}\text{Os}(n,x)p$



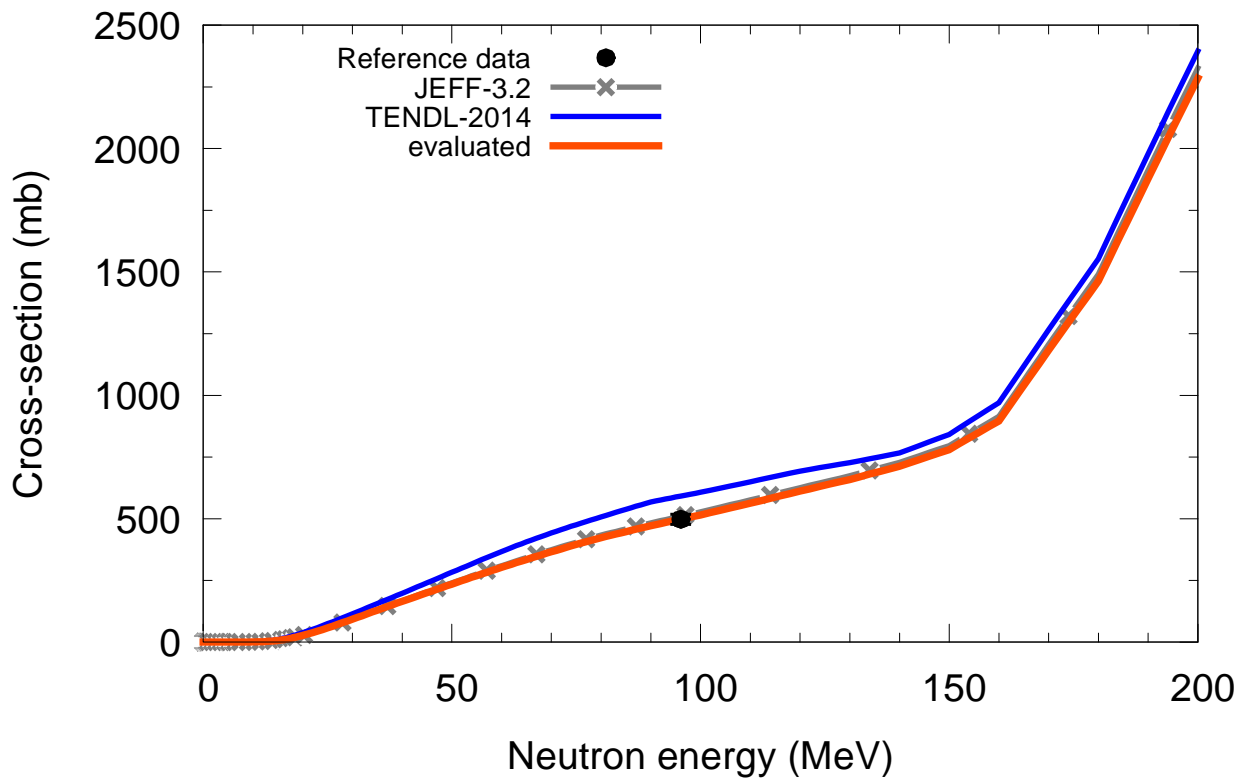
$^{187}\text{Os}(n,x)p$



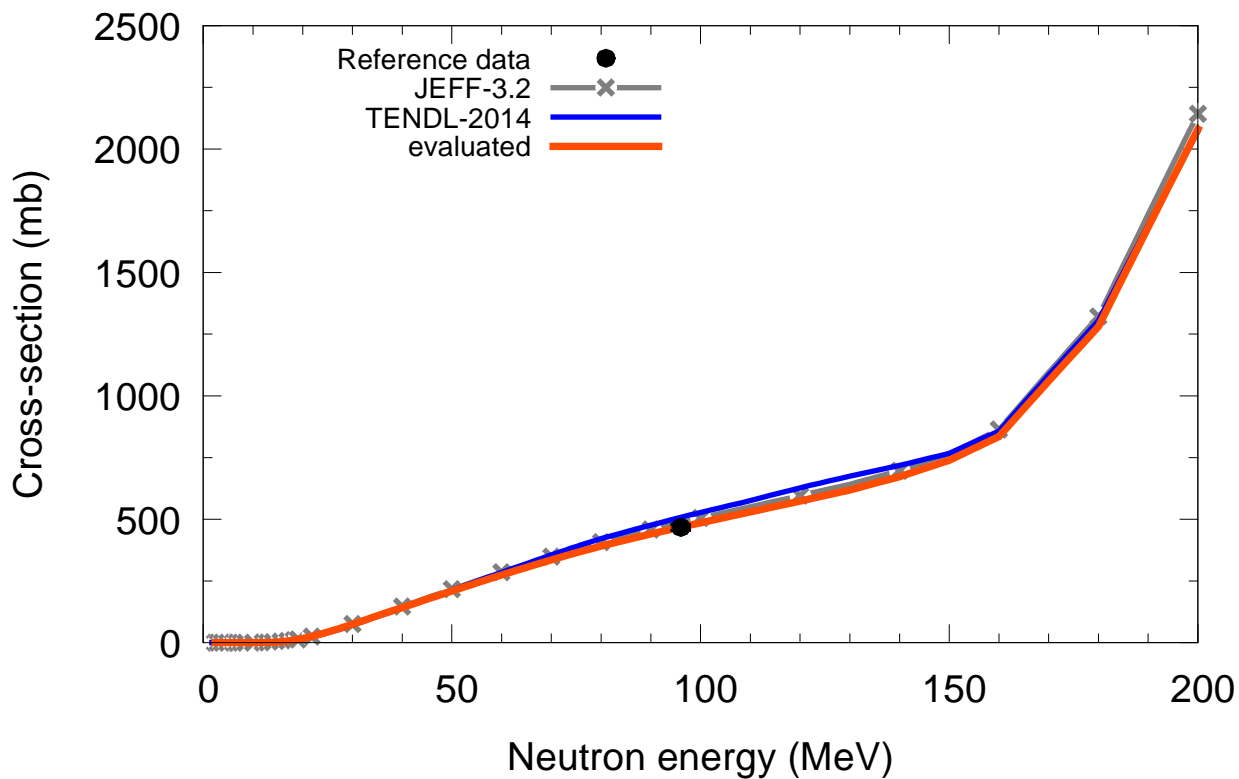
$^{188}\text{Os}(n,x)p$



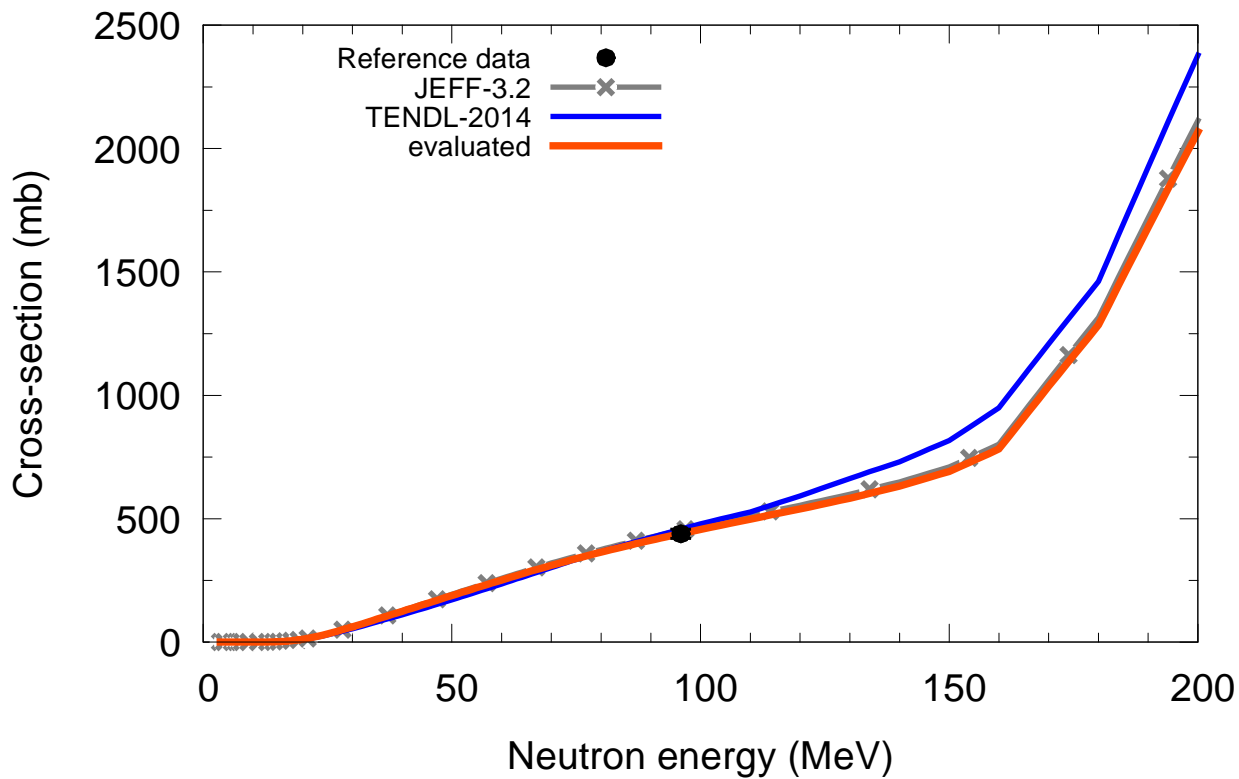
$^{189}\text{Os}(n,x)p$



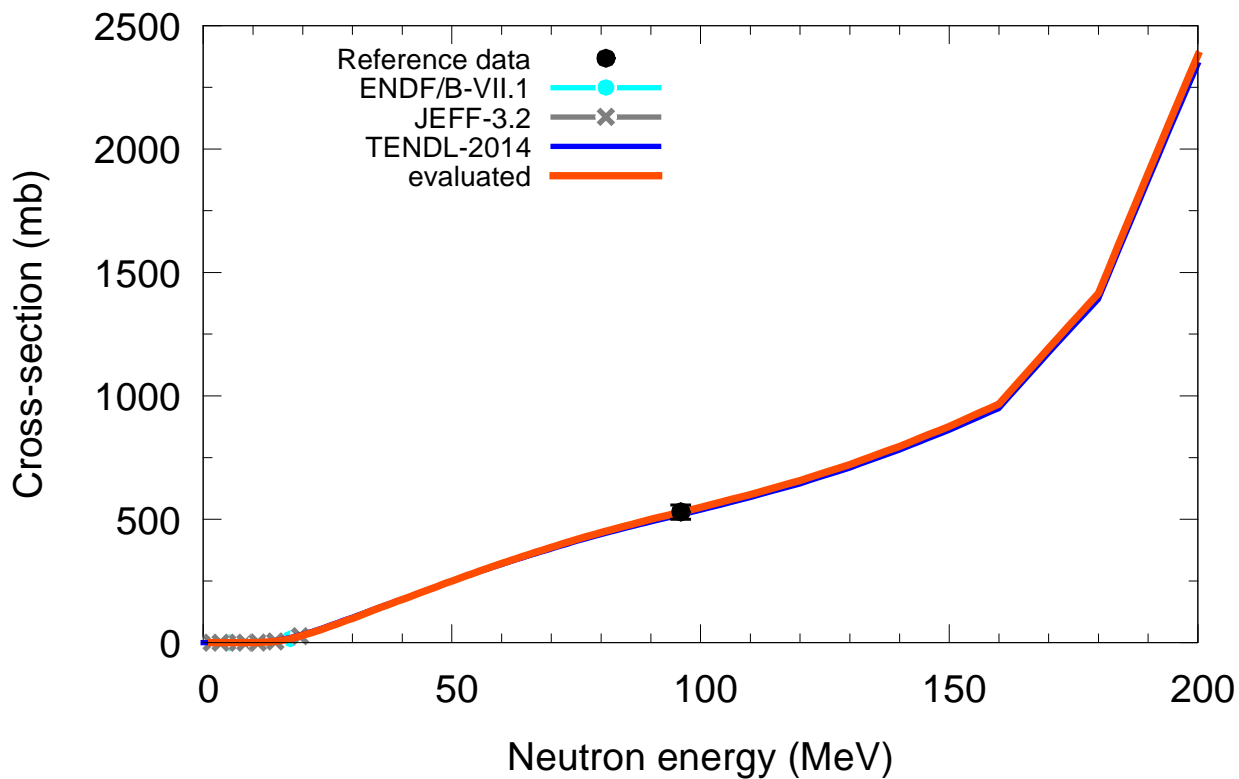
$^{190}\text{Os}(n,x)p$

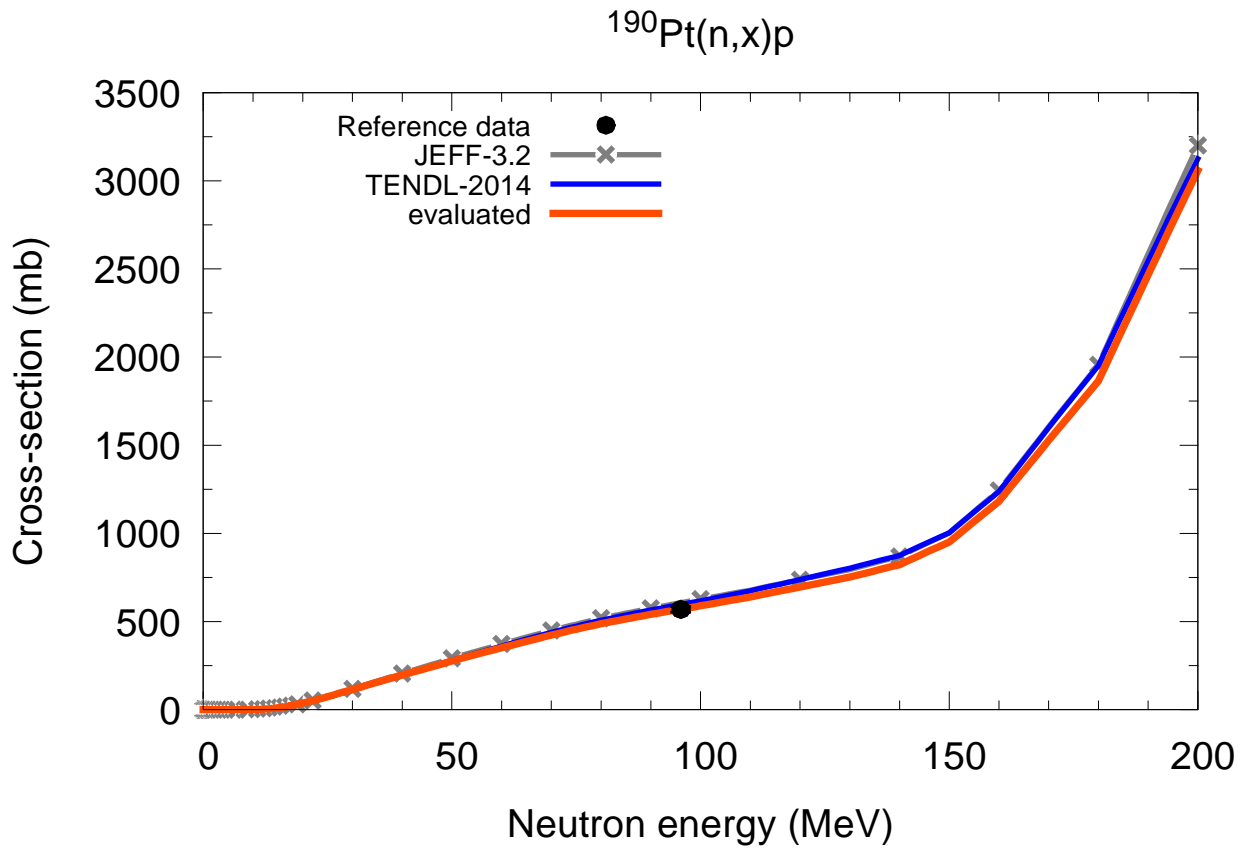
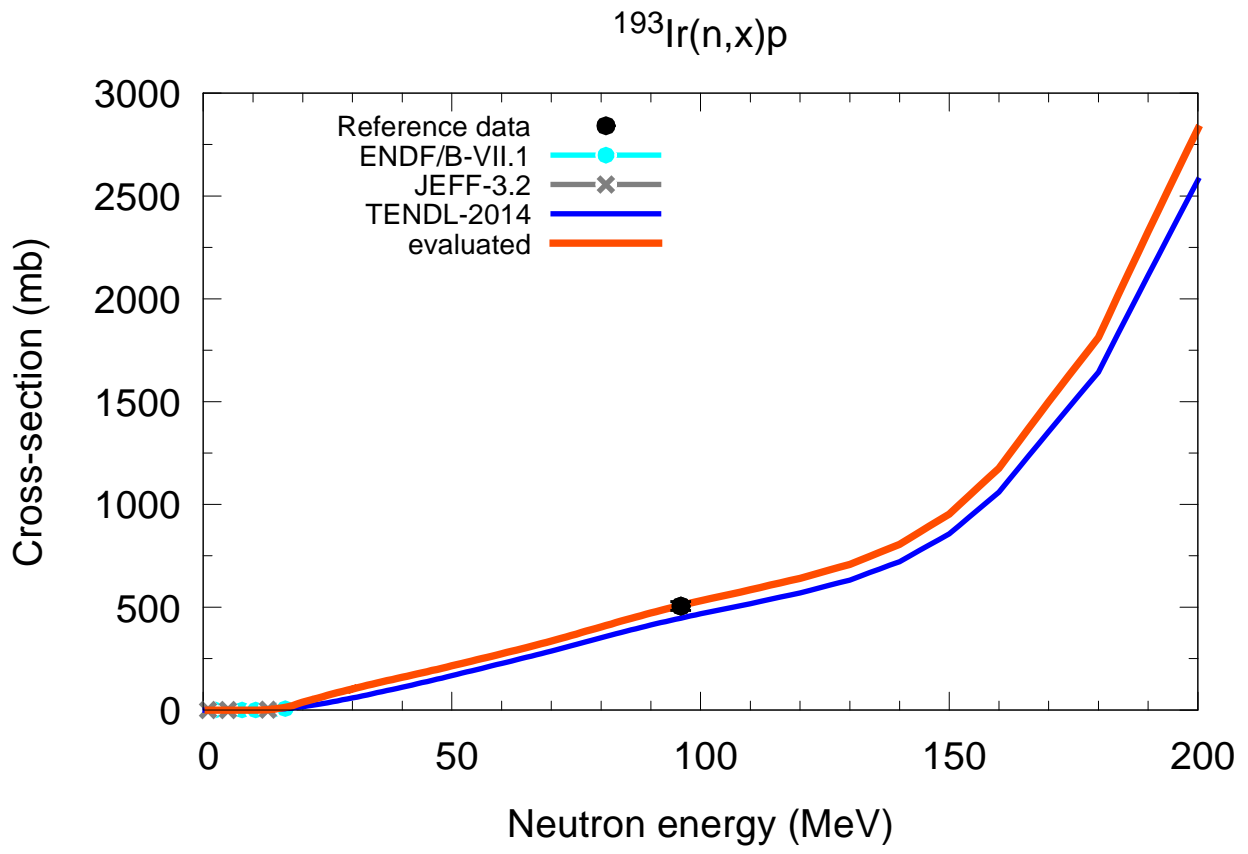


$^{192}\text{Os}(n,x)p$

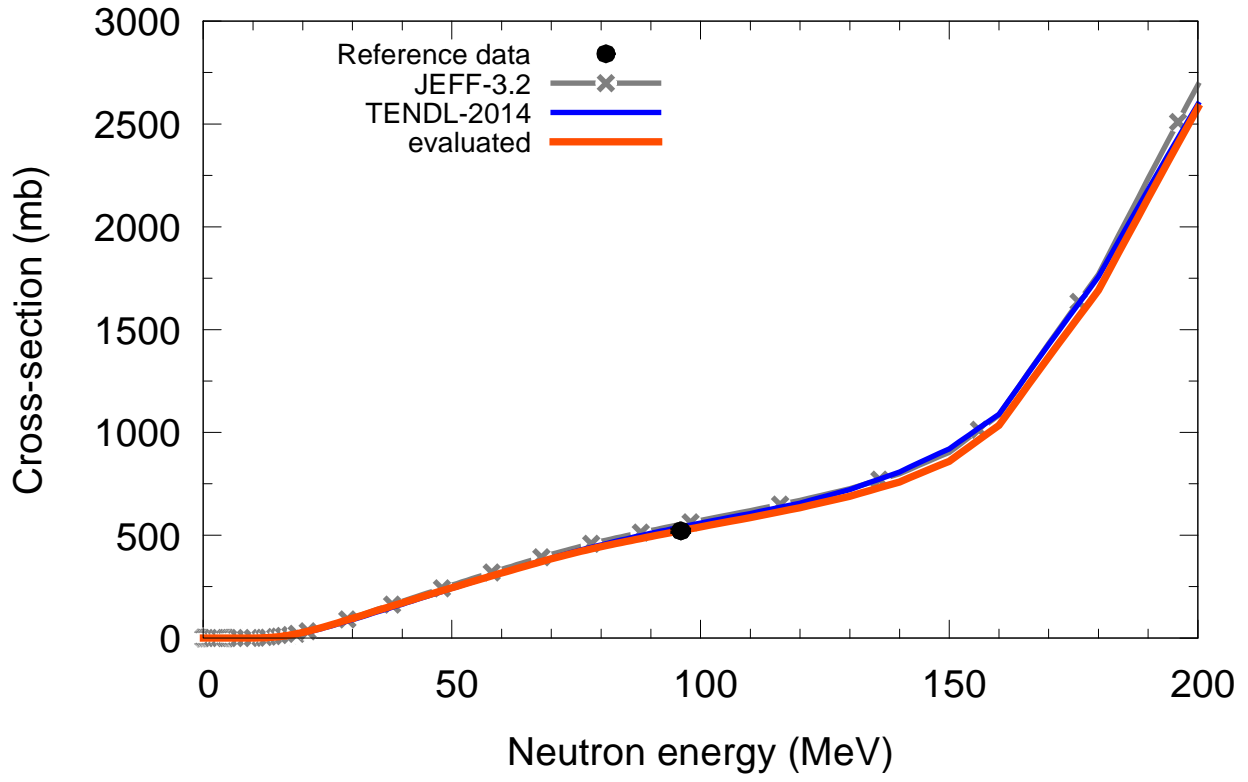


$^{191}\text{Ir}(n,x)p$

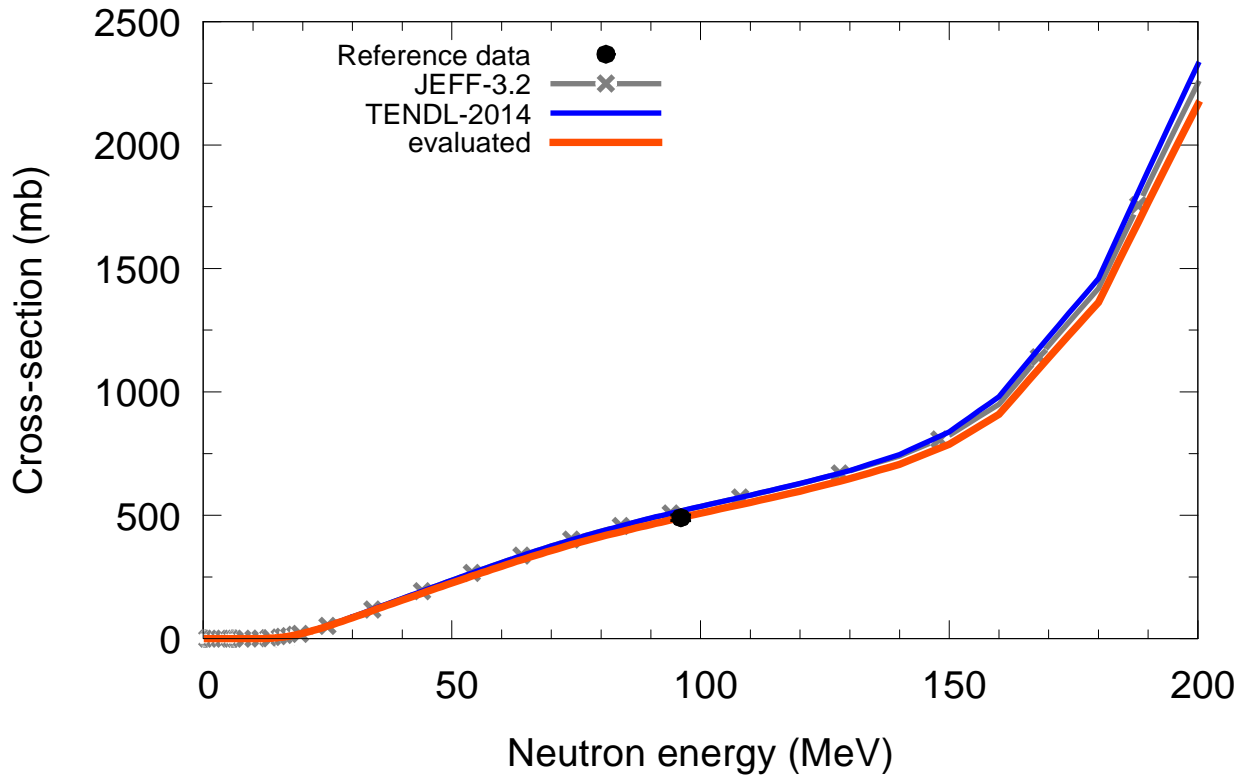


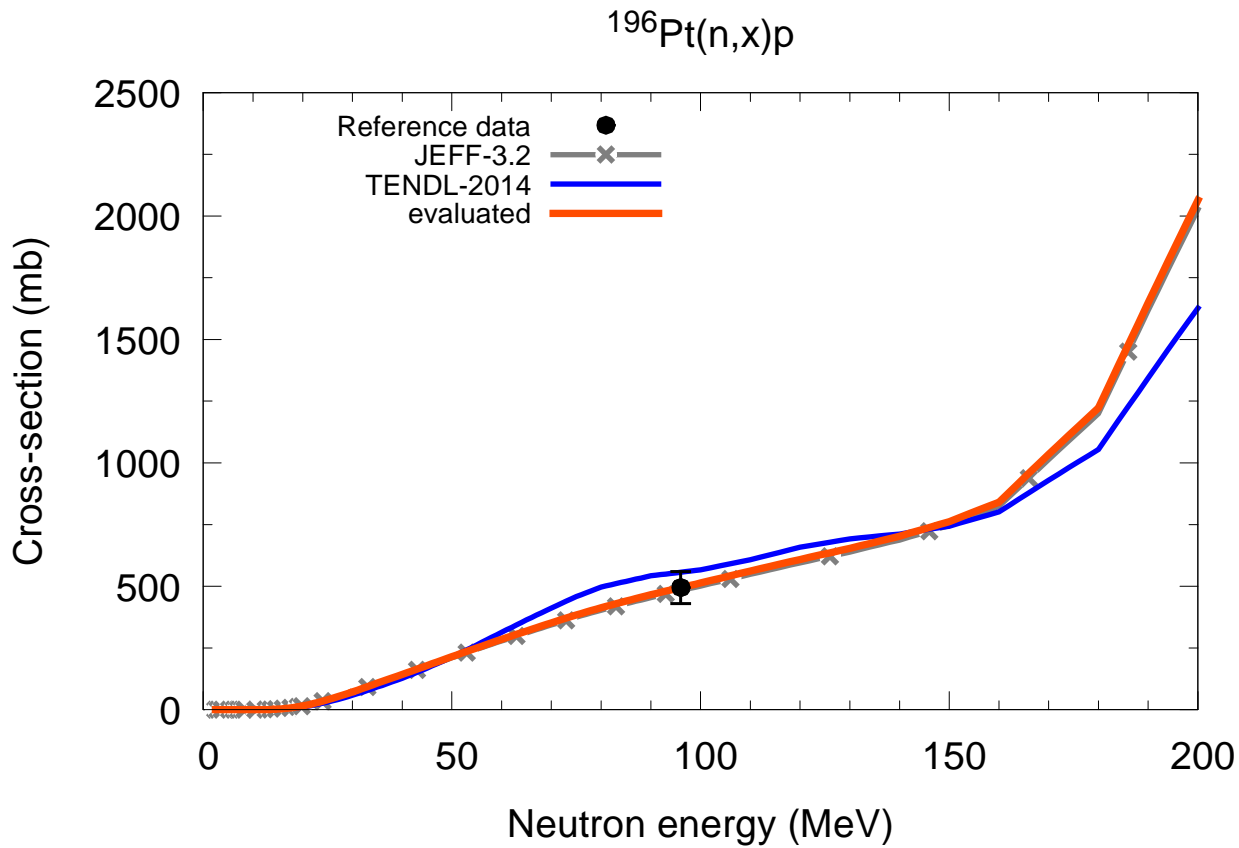
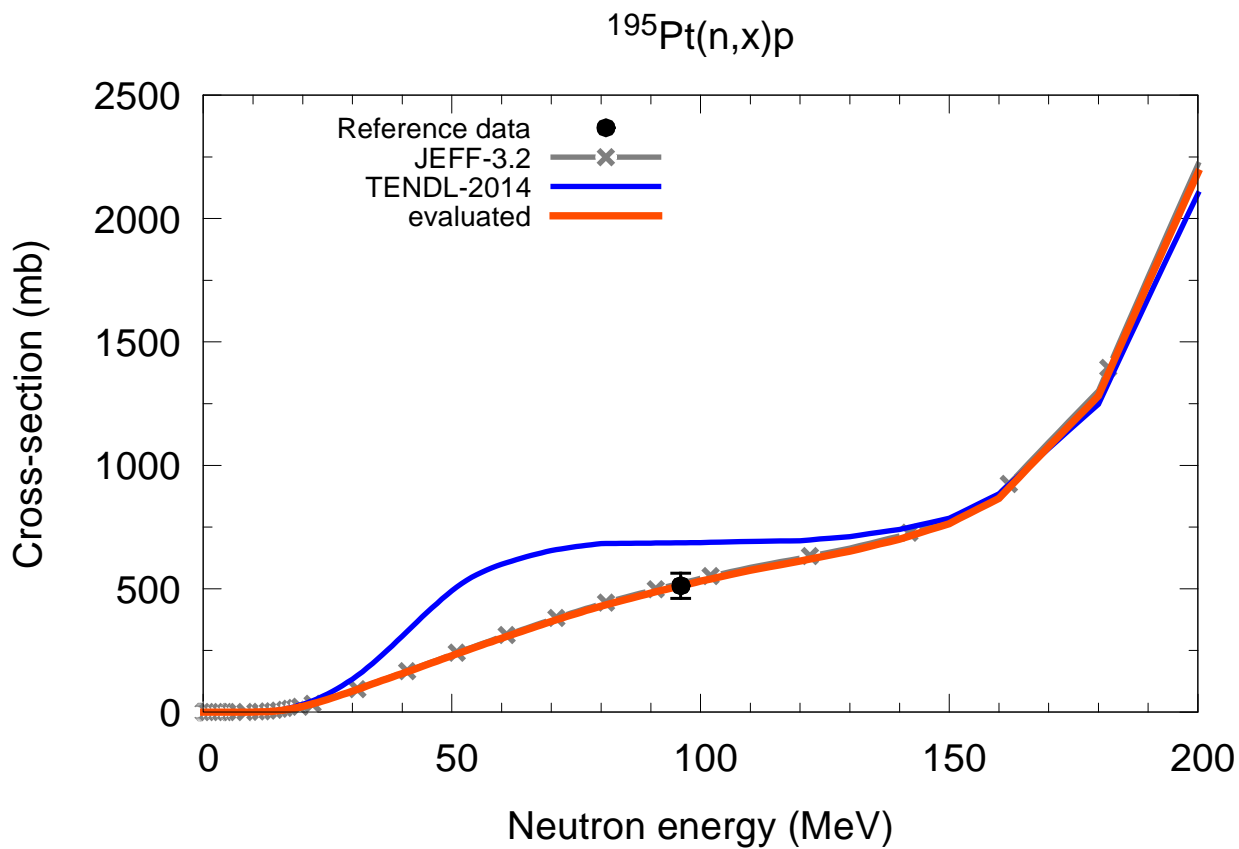


$^{192}\text{Pt}(n,x)p$

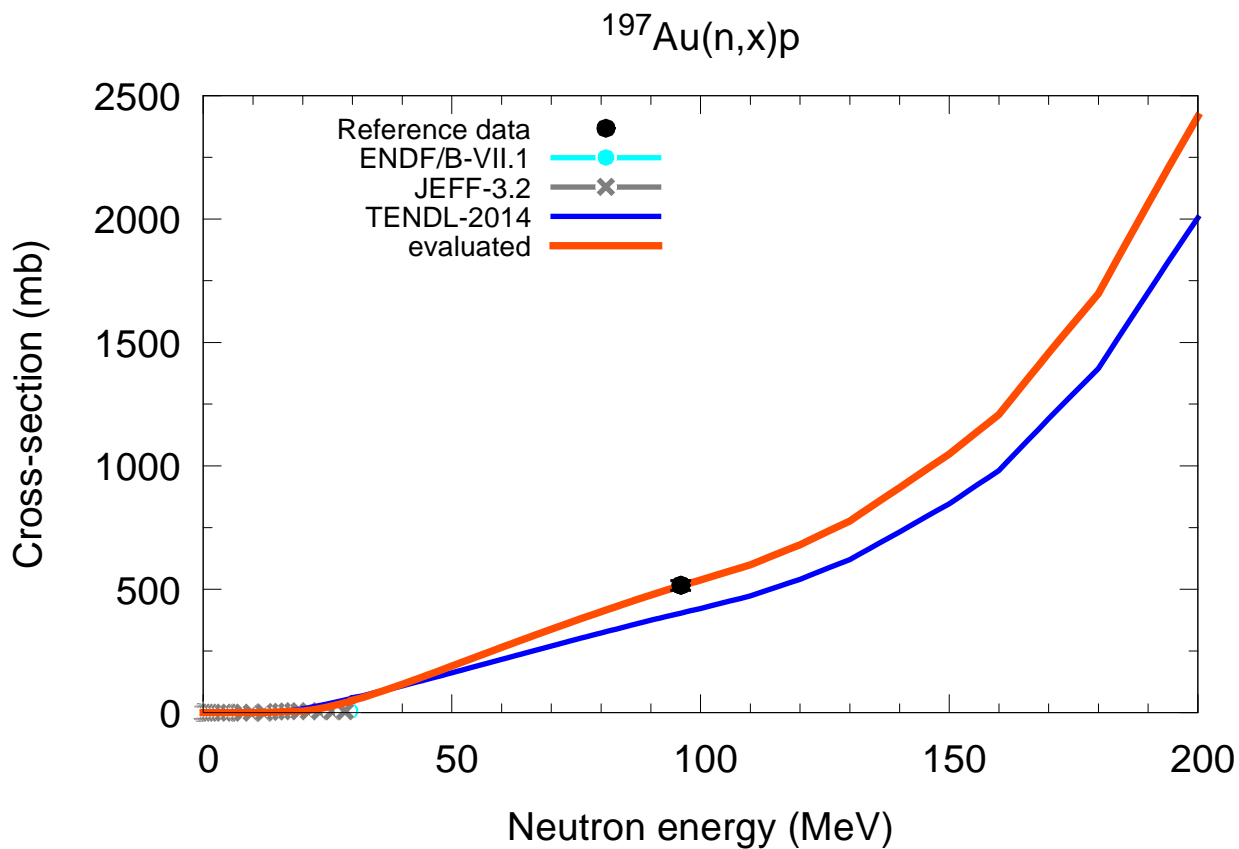
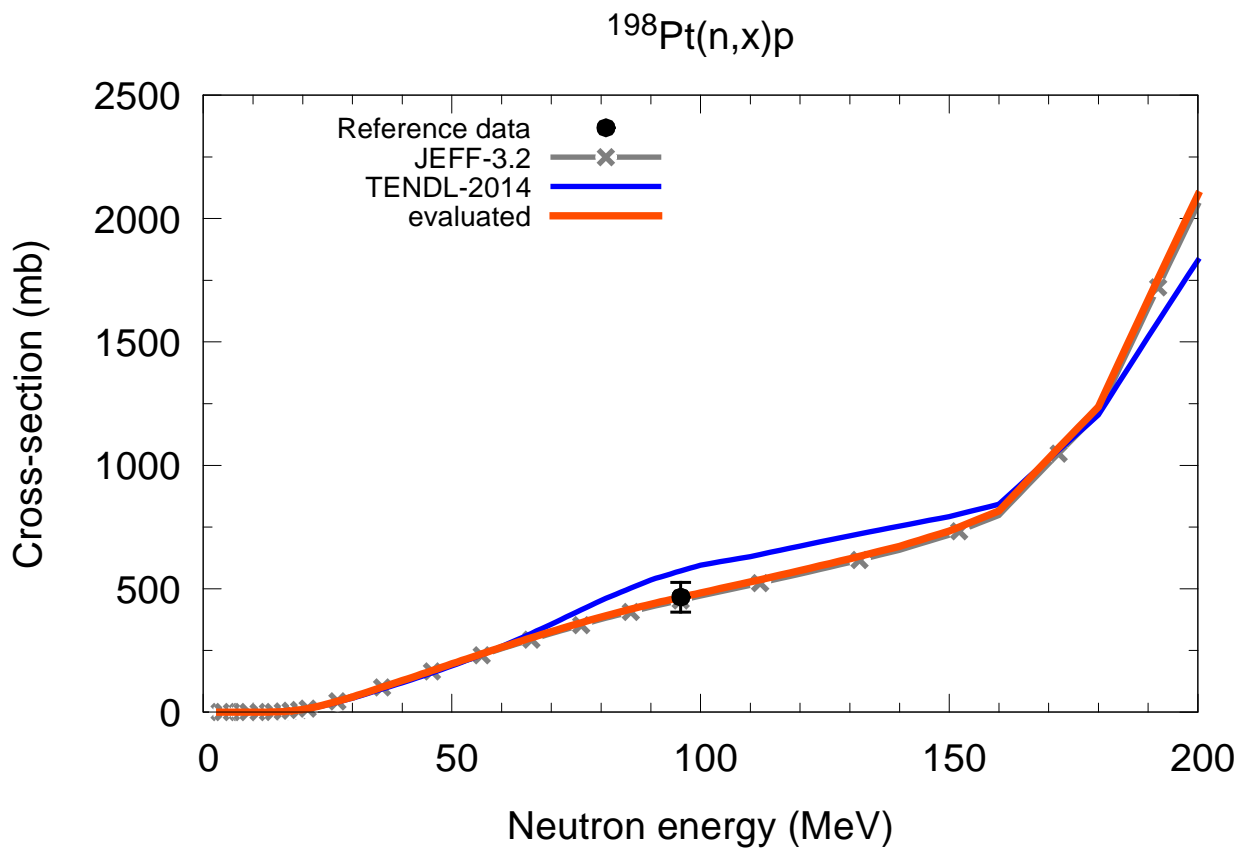


$^{194}\text{Pt}(n,x)p$

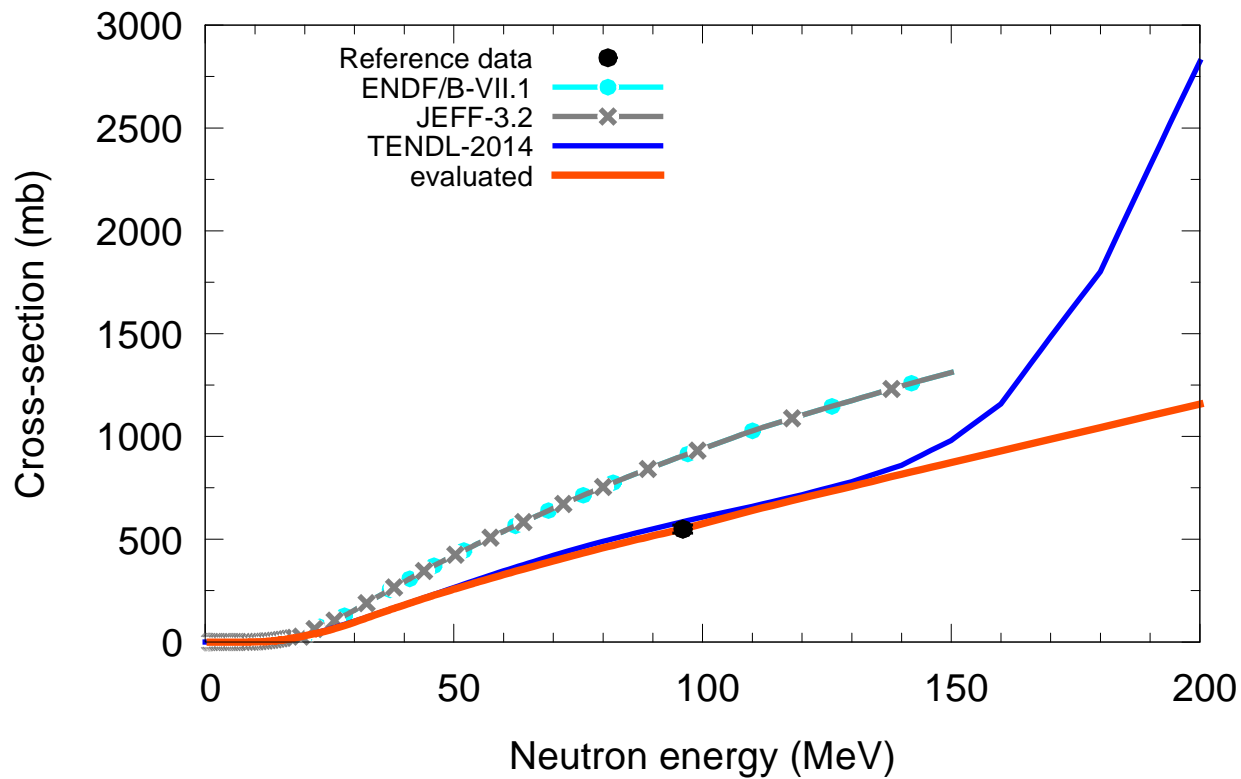




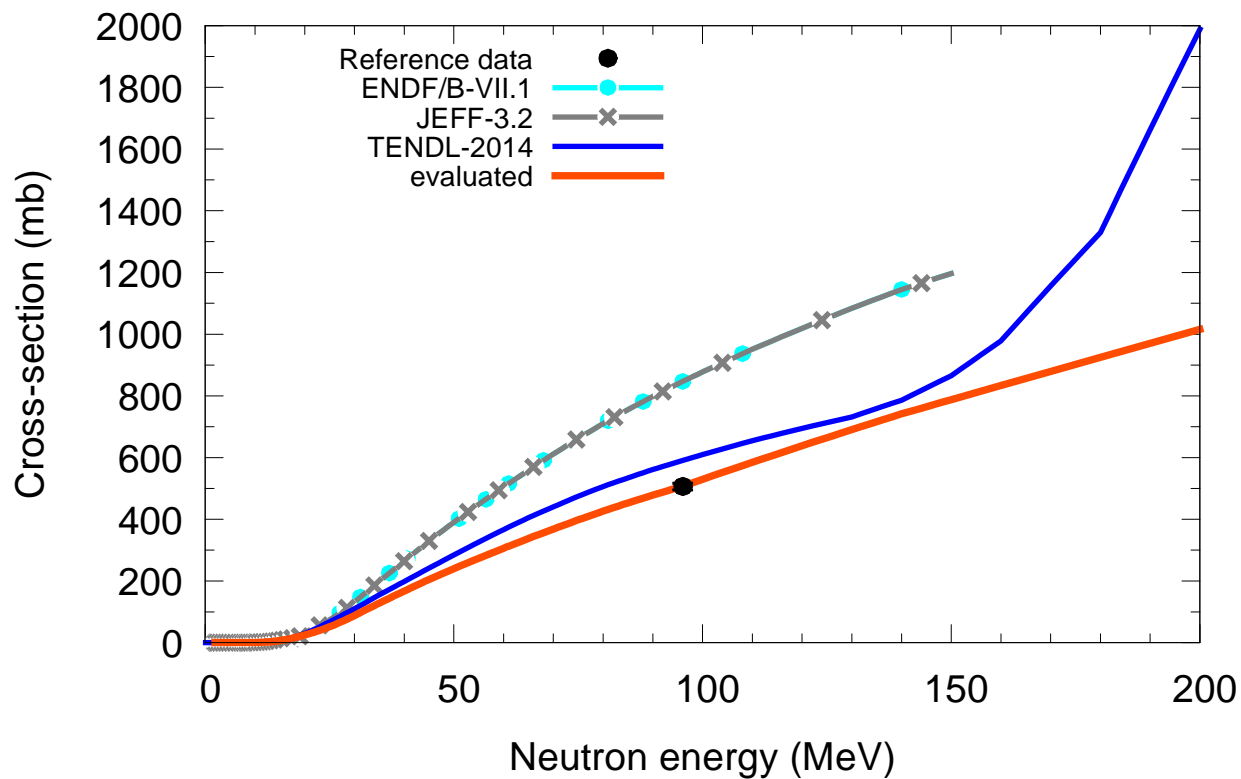




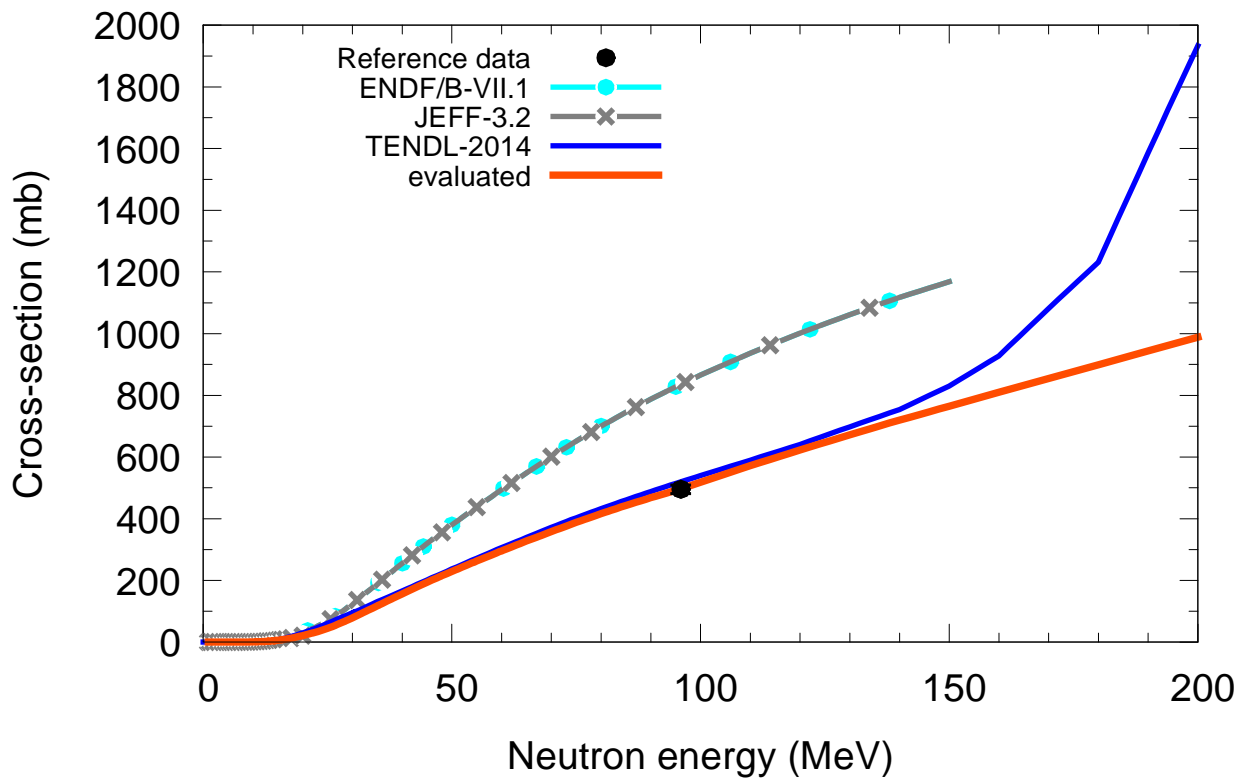
$^{196}\text{Hg}(n,x)p$



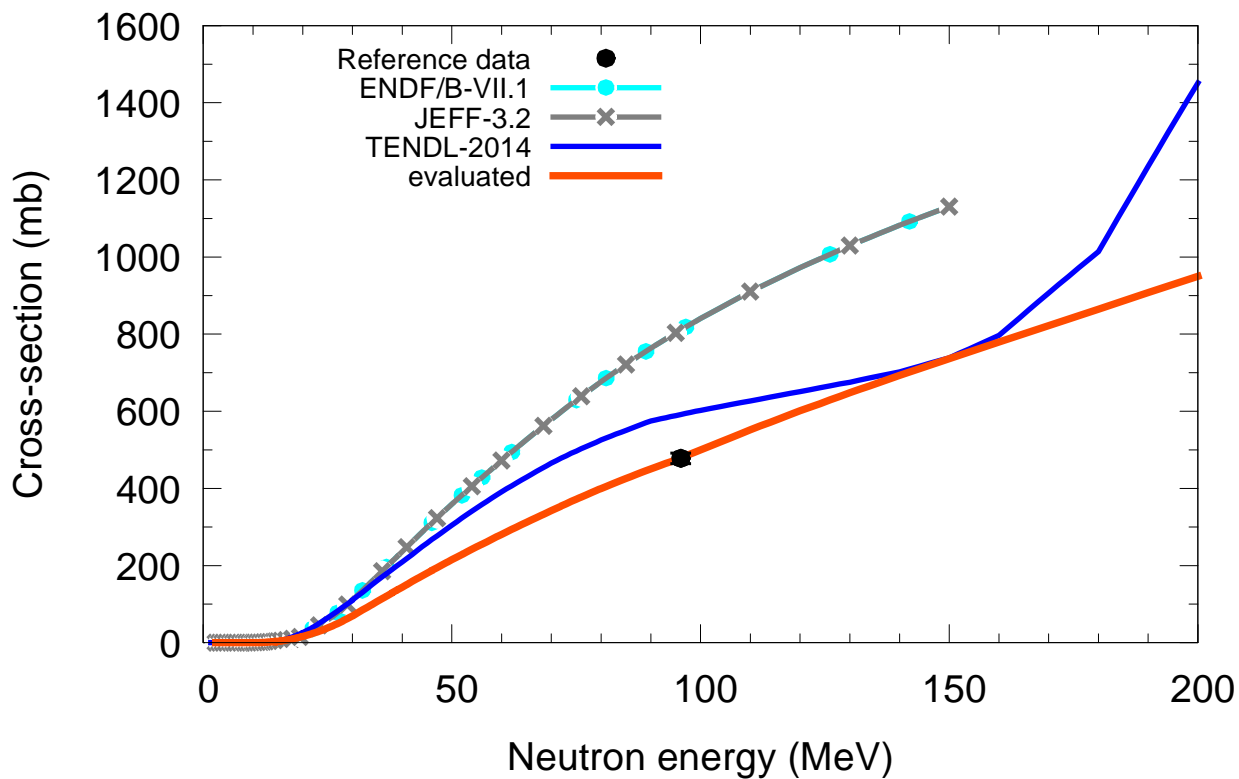
$^{198}\text{Hg}(n,x)p$



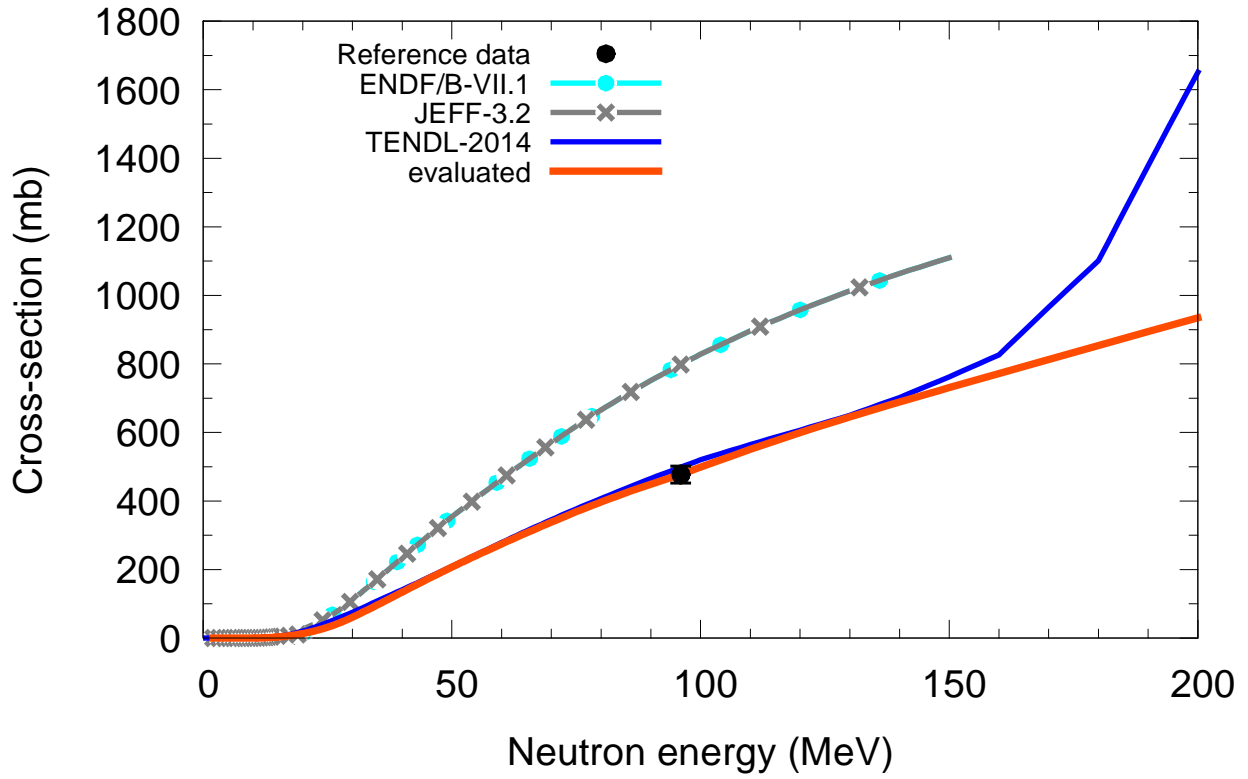
$^{199}\text{Hg}(n,x)p$



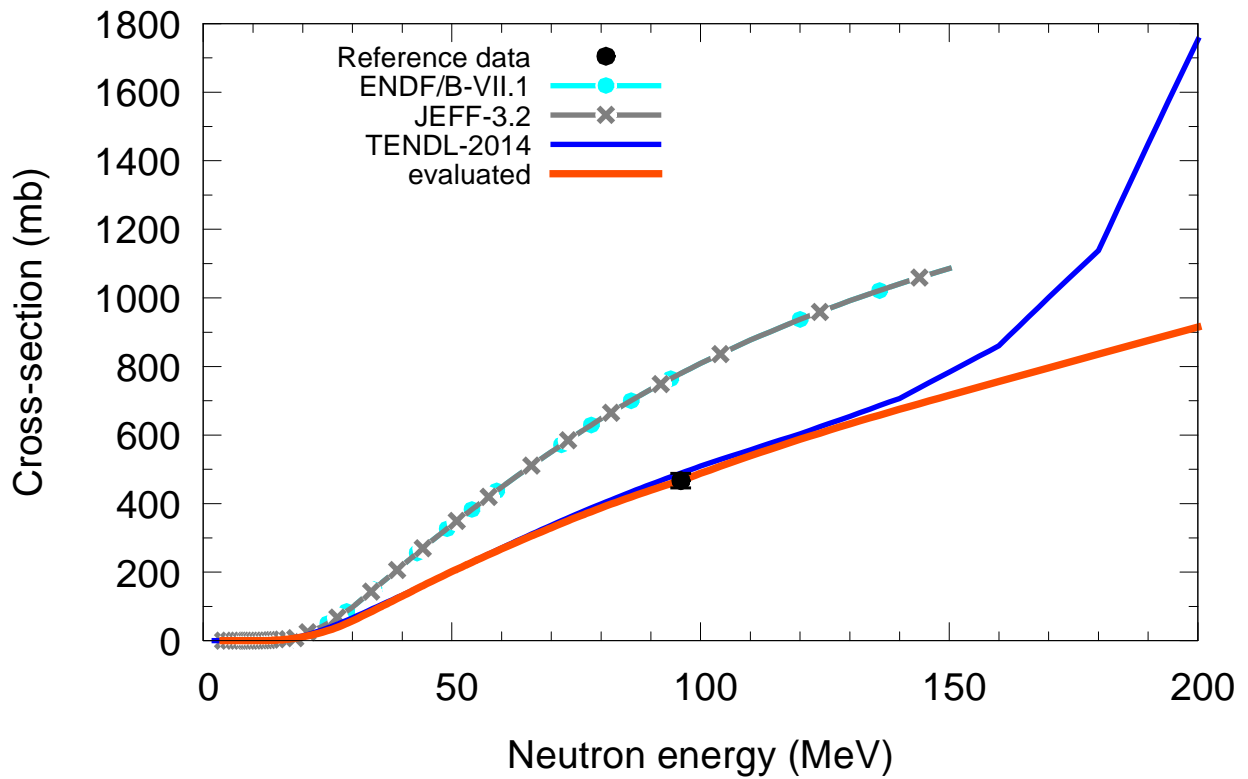
$^{200}\text{Hg}(n,x)p$



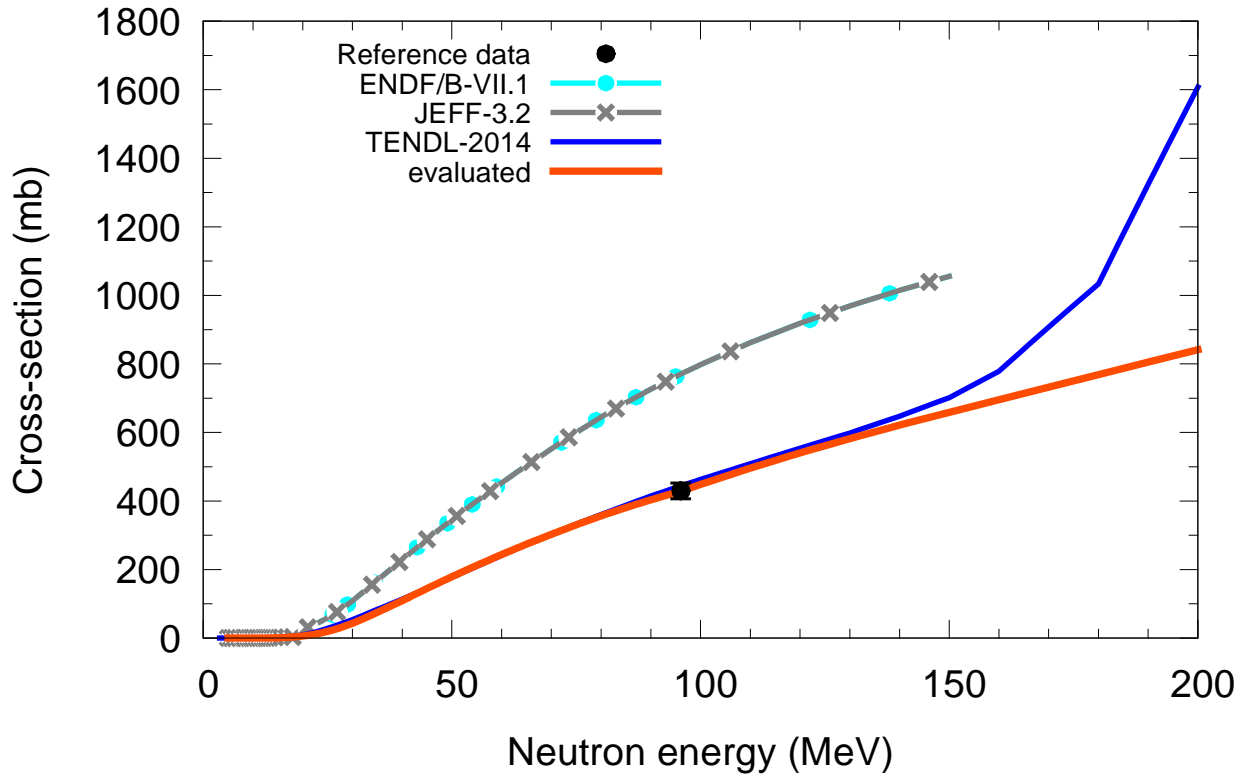
$^{201}\text{Hg}(n,x)p$



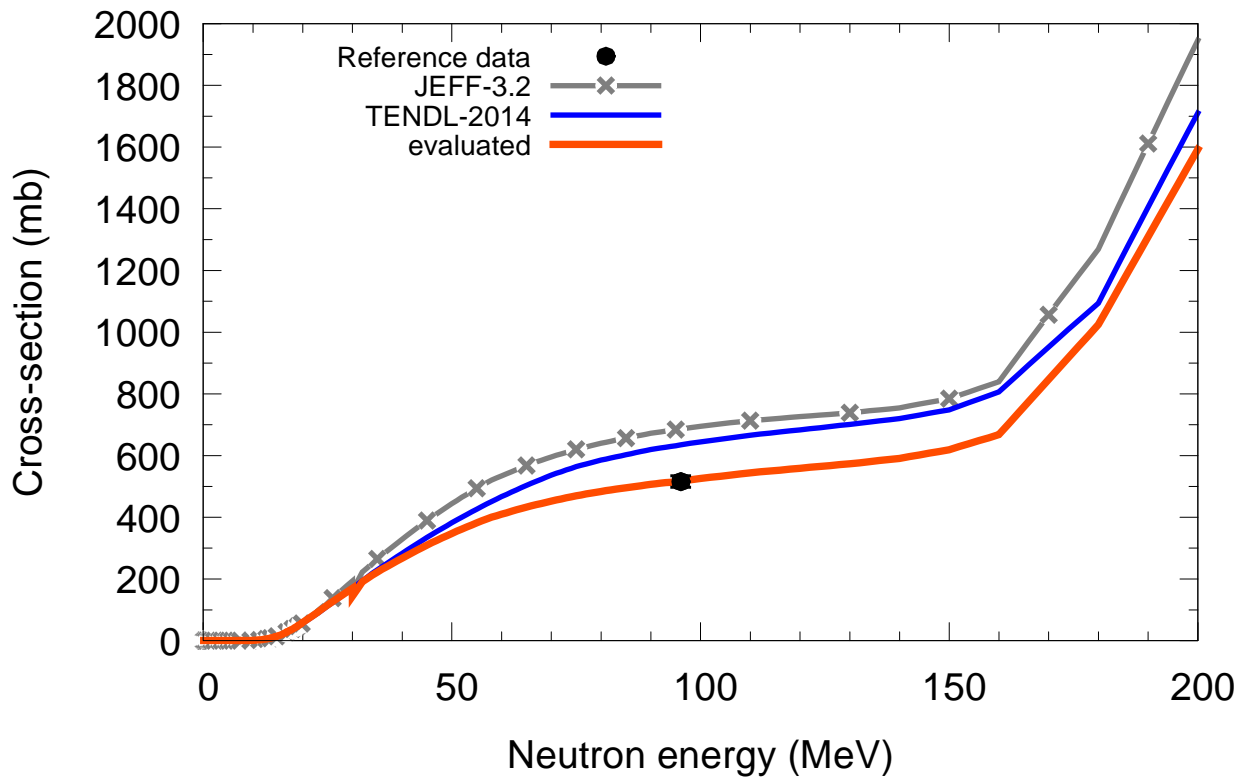
$^{202}\text{Hg}(n,x)p$



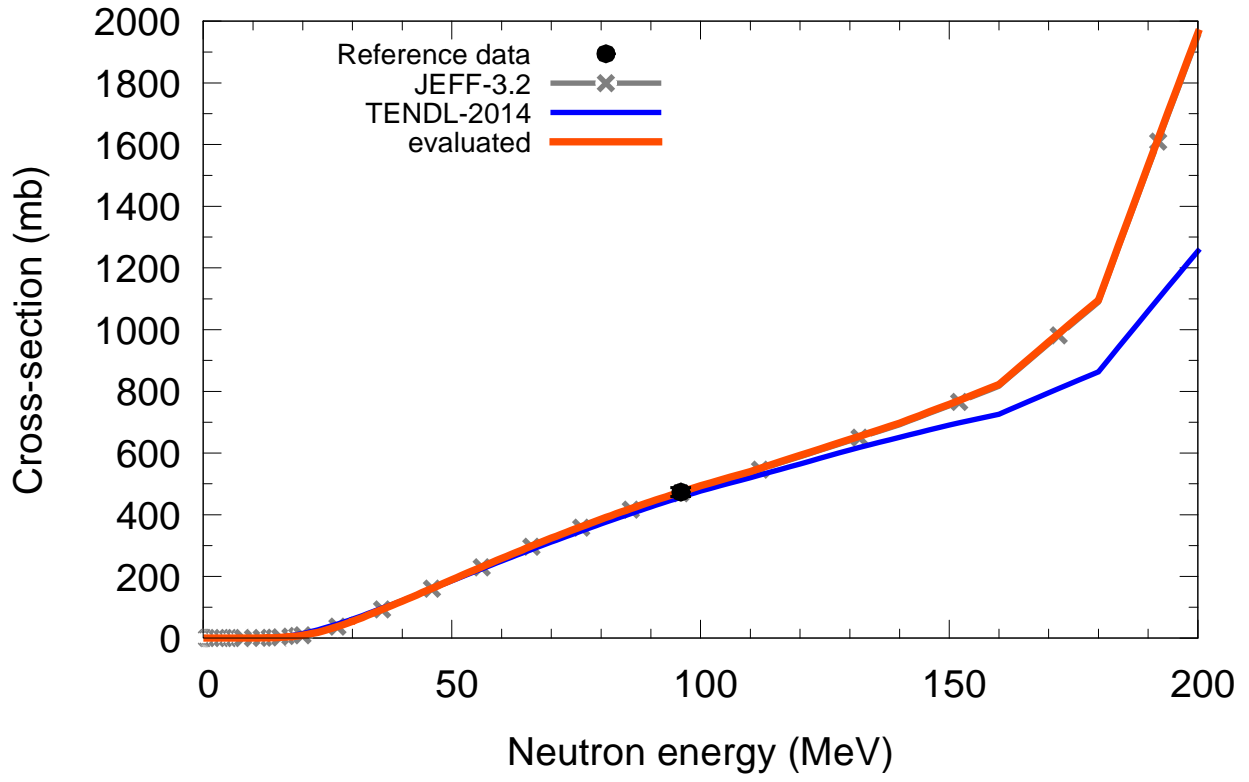
$^{204}\text{Hg}(n,x)p$



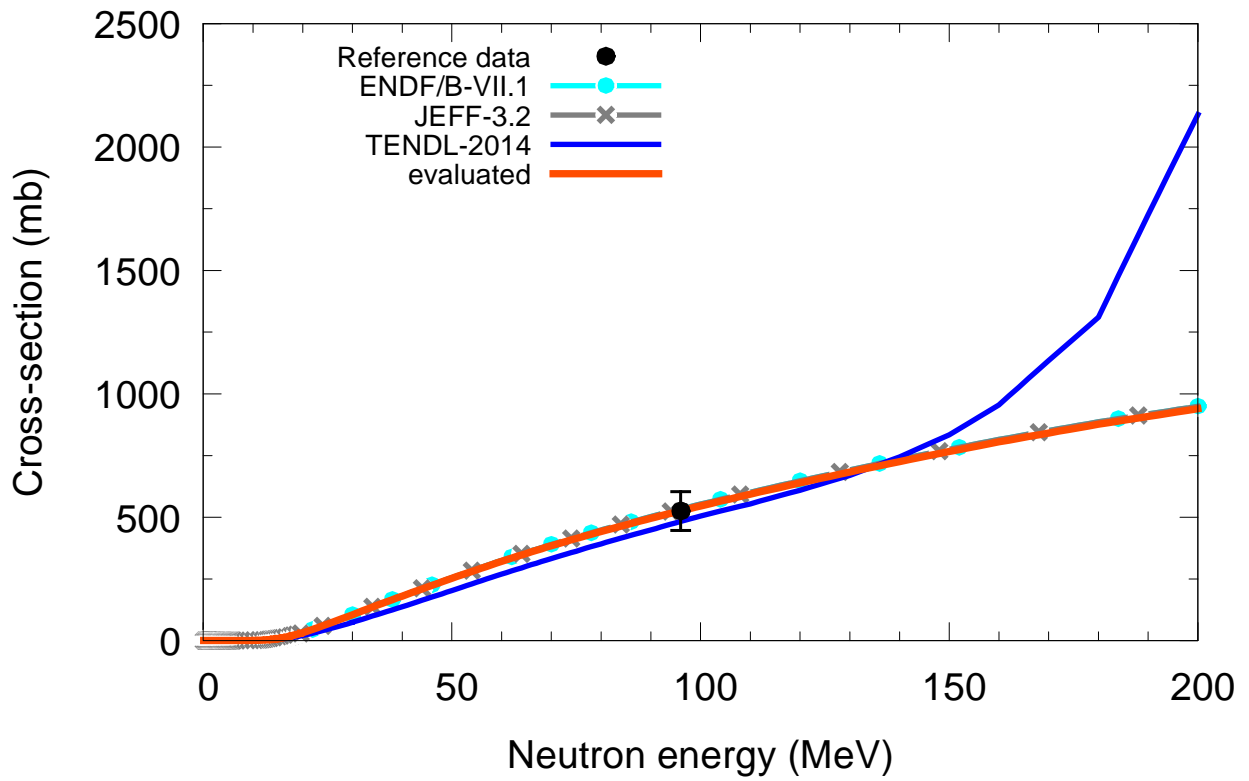
$^{203}\text{Tl}(n,x)p$

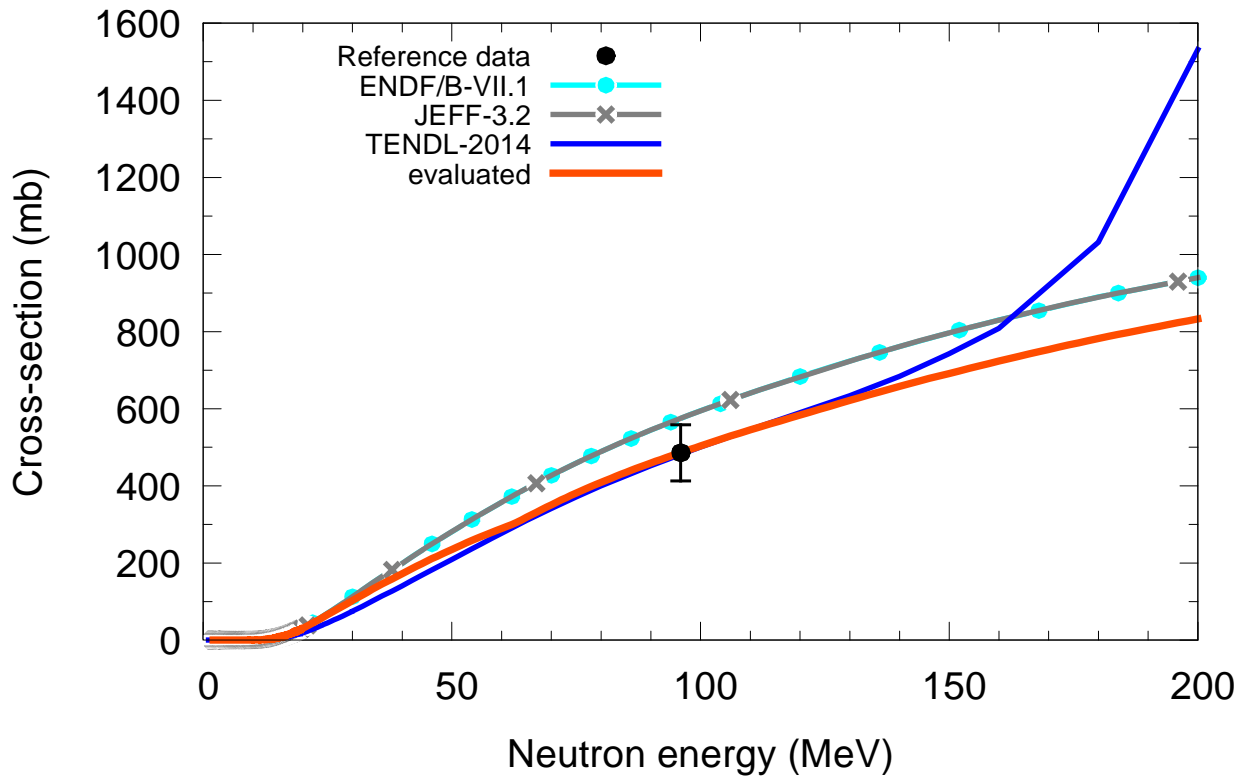
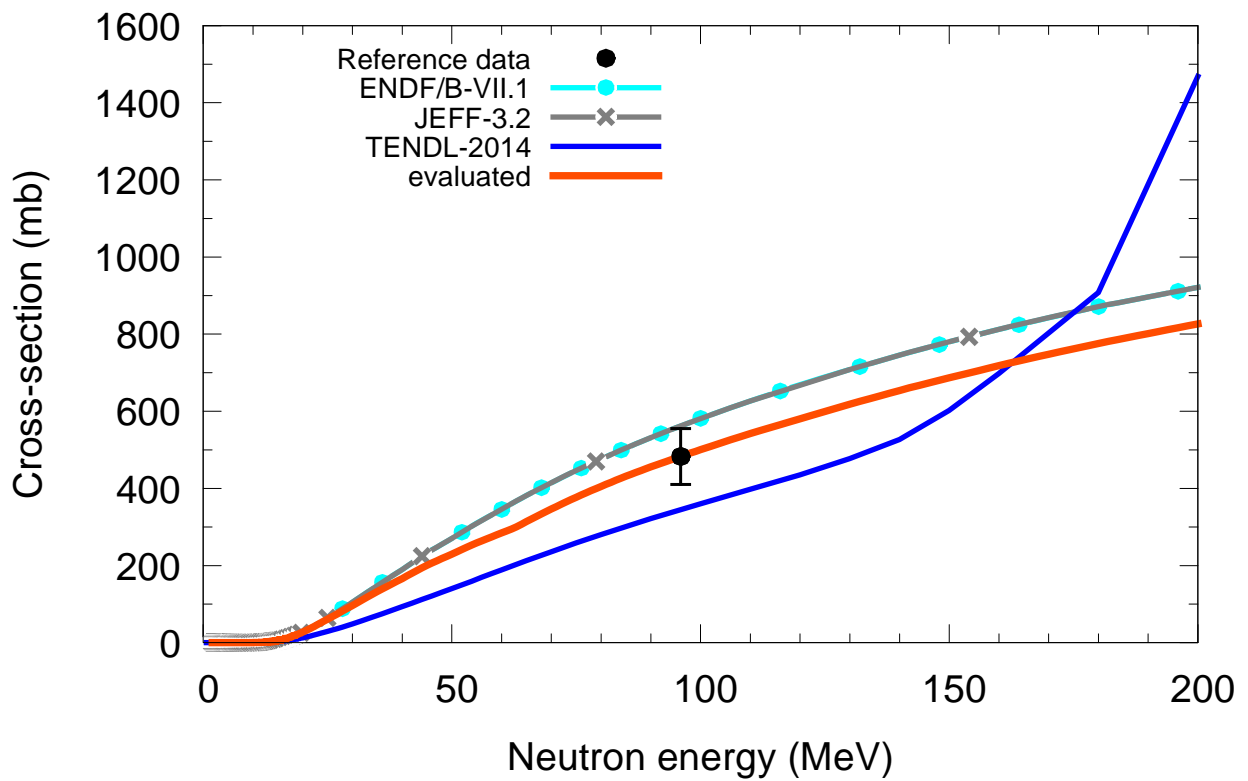


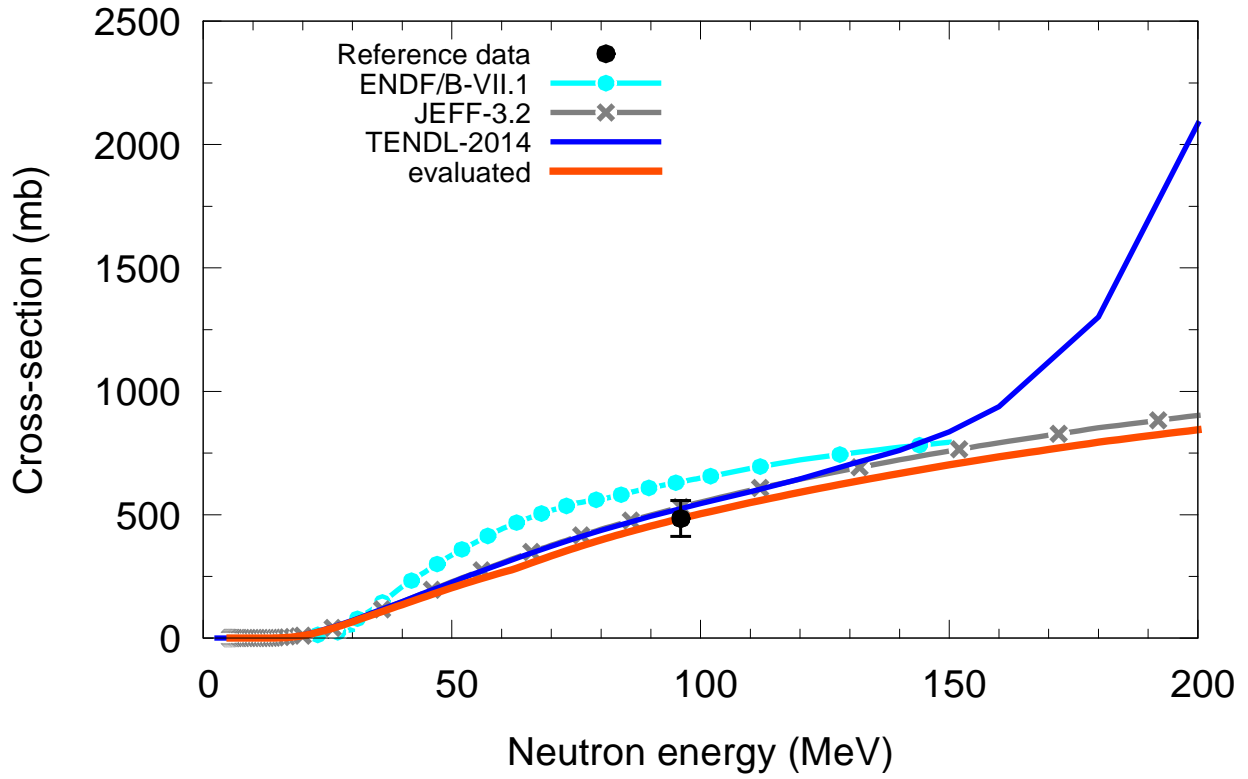
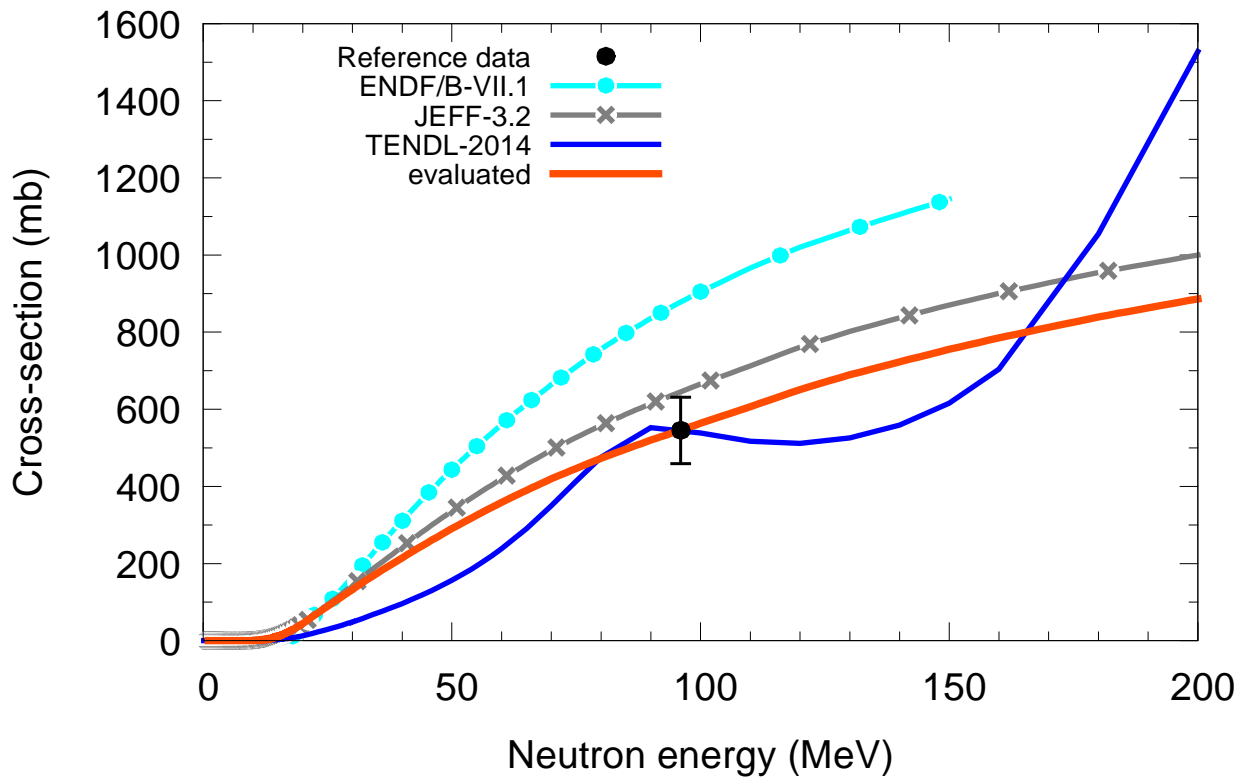
$^{205}\text{Tl}(n,x)p$



$^{204}\text{Pb}(n,x)p$



$^{206}\text{Pb}(n,x)p$  $^{207}\text{Pb}(n,x)p$ 

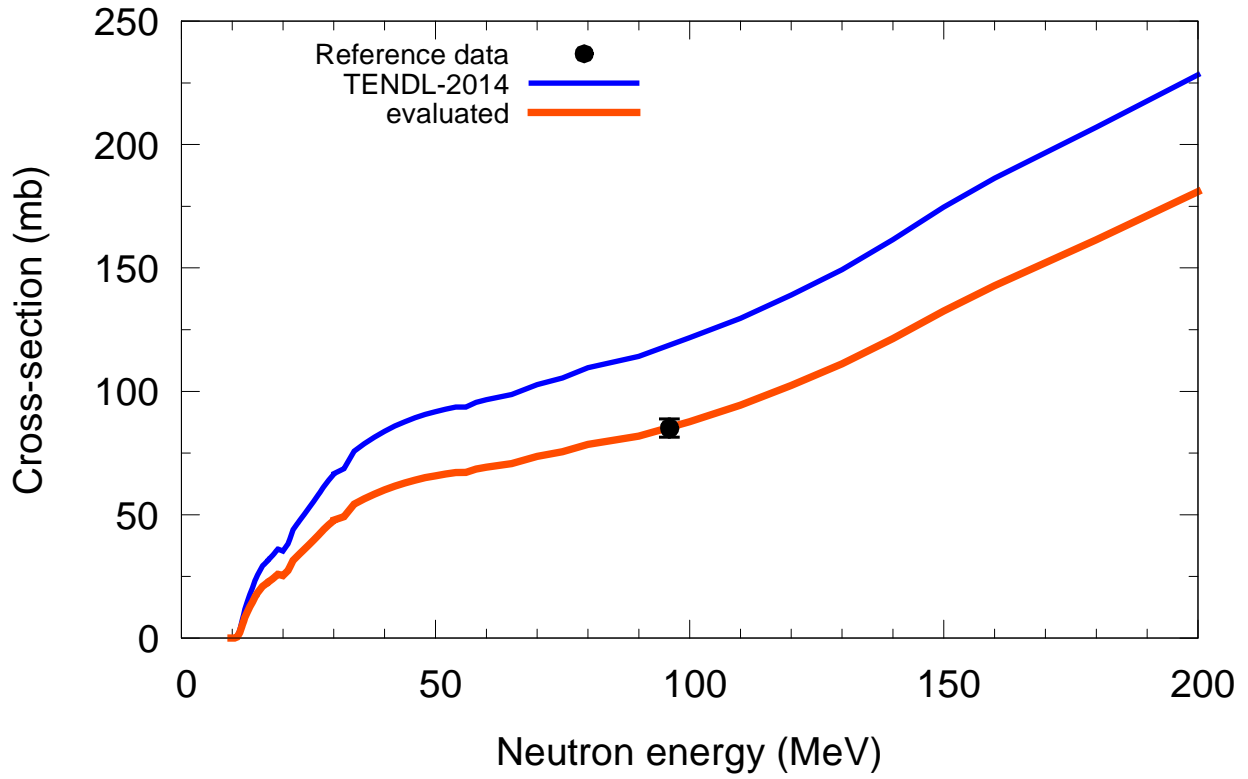
$^{208}\text{Pb}(n,x)p$  $^{209}\text{Bi}(n,x)p$ 



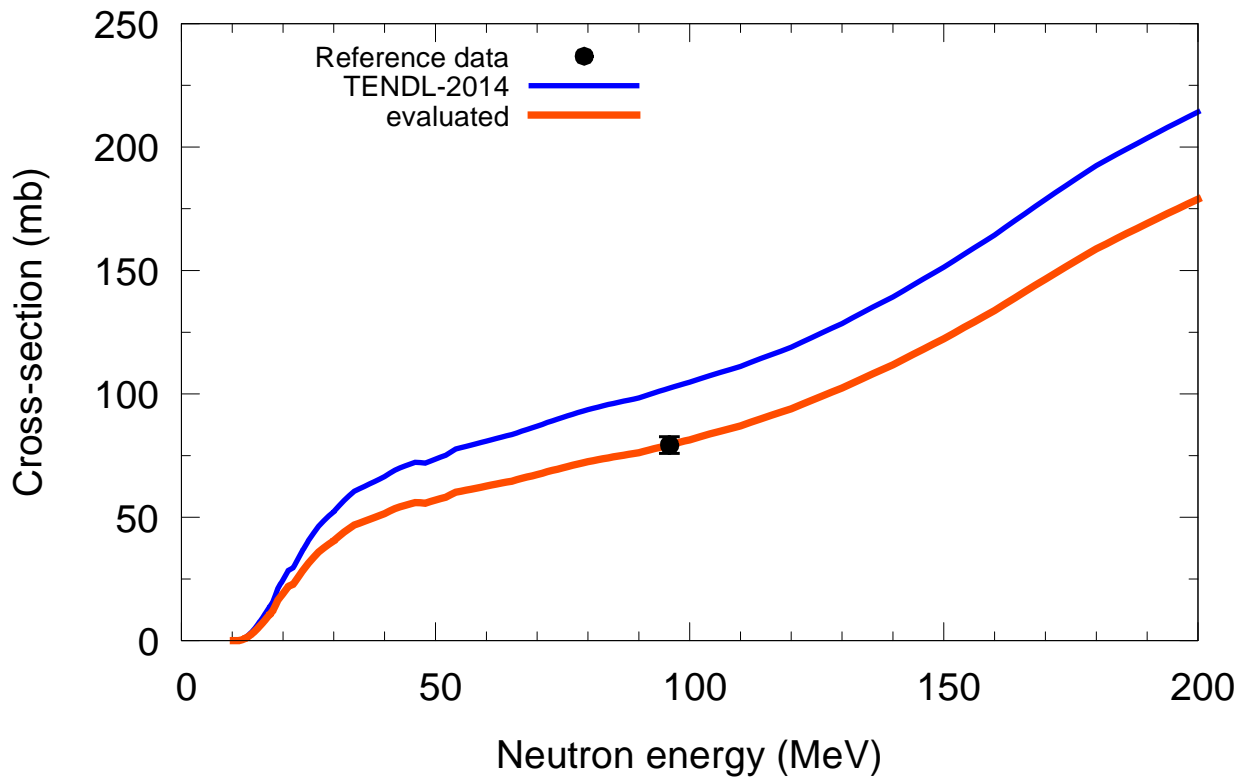
## Appendix B

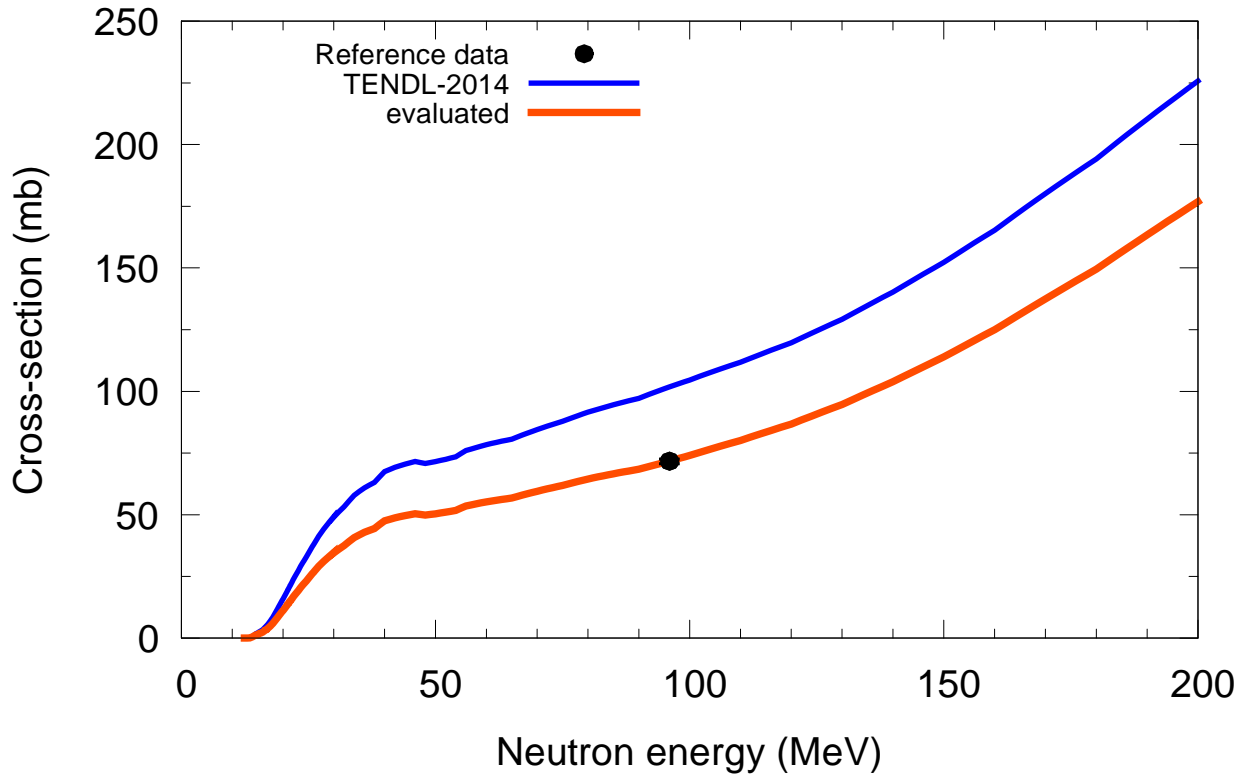
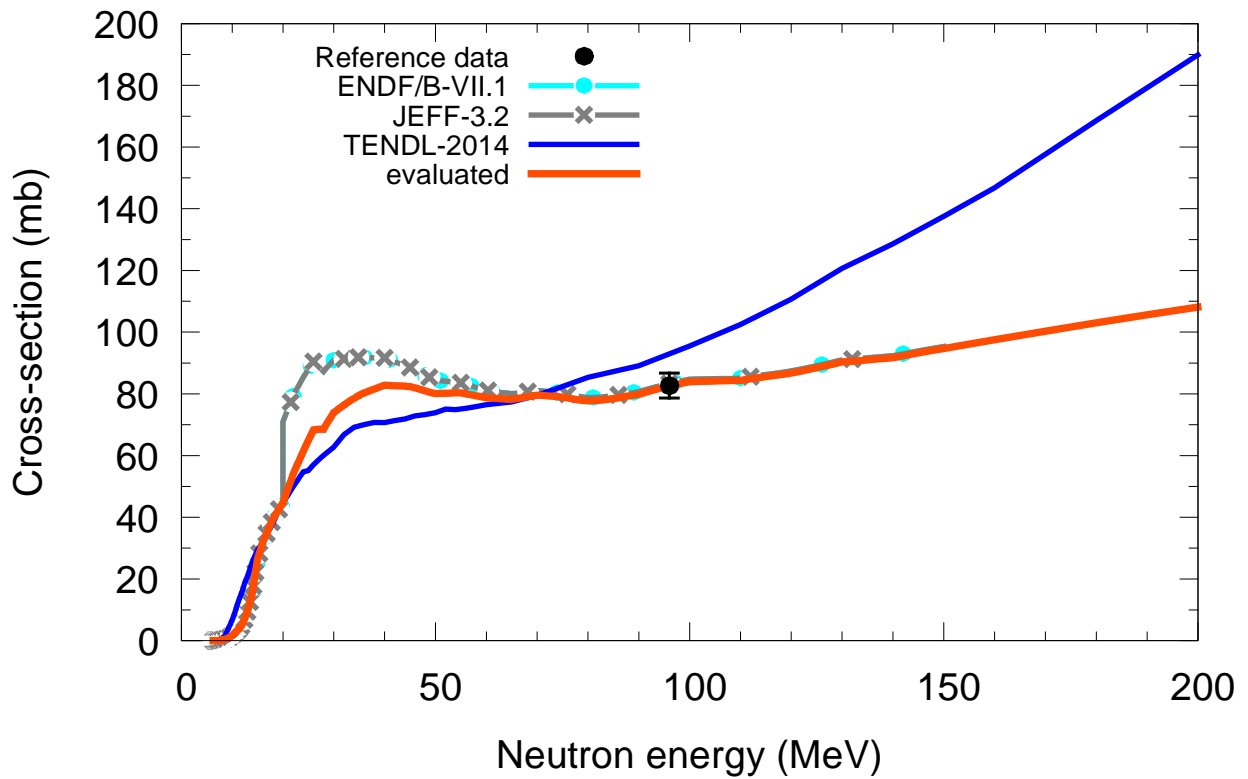
**Evaluated deuteron production cross-sections, data from ENDF/B-VII.1, JEFF-3.2, and TENDL-2014, and cross-sections at 96 MeV estimated using the  $\sigma(A)$ -dependence**

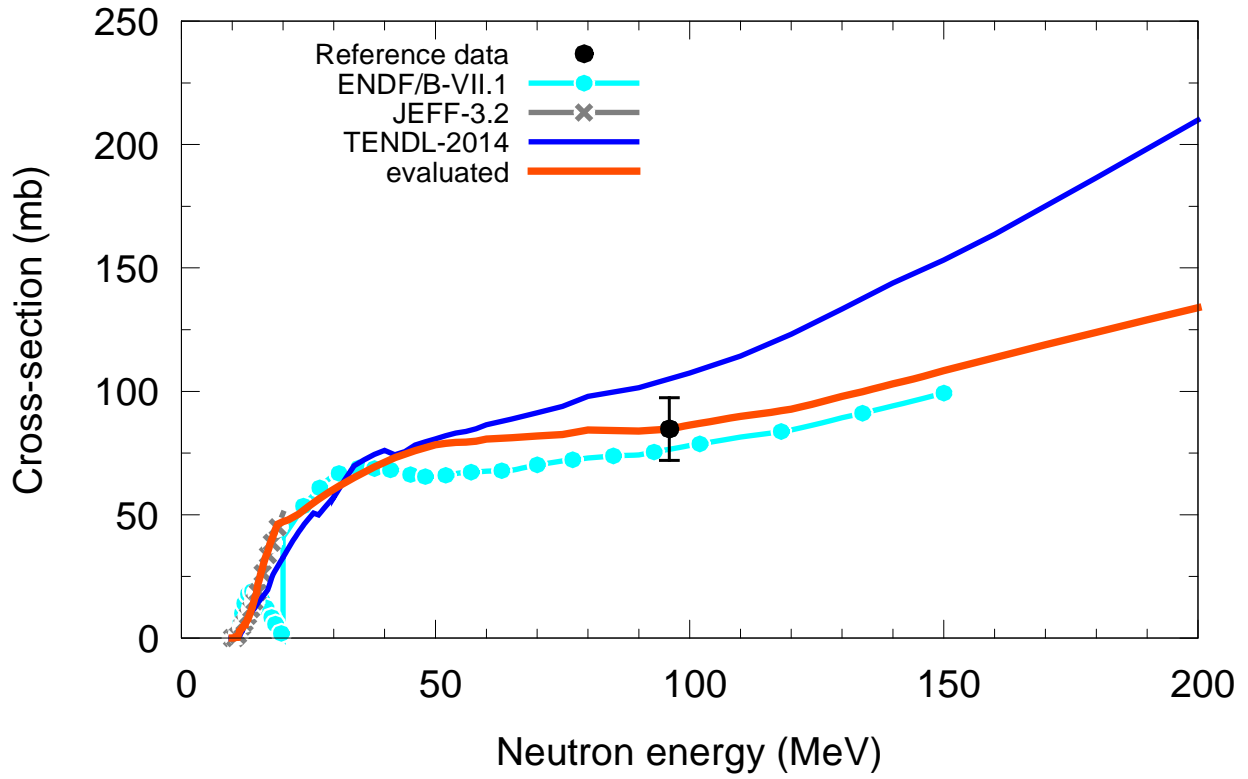
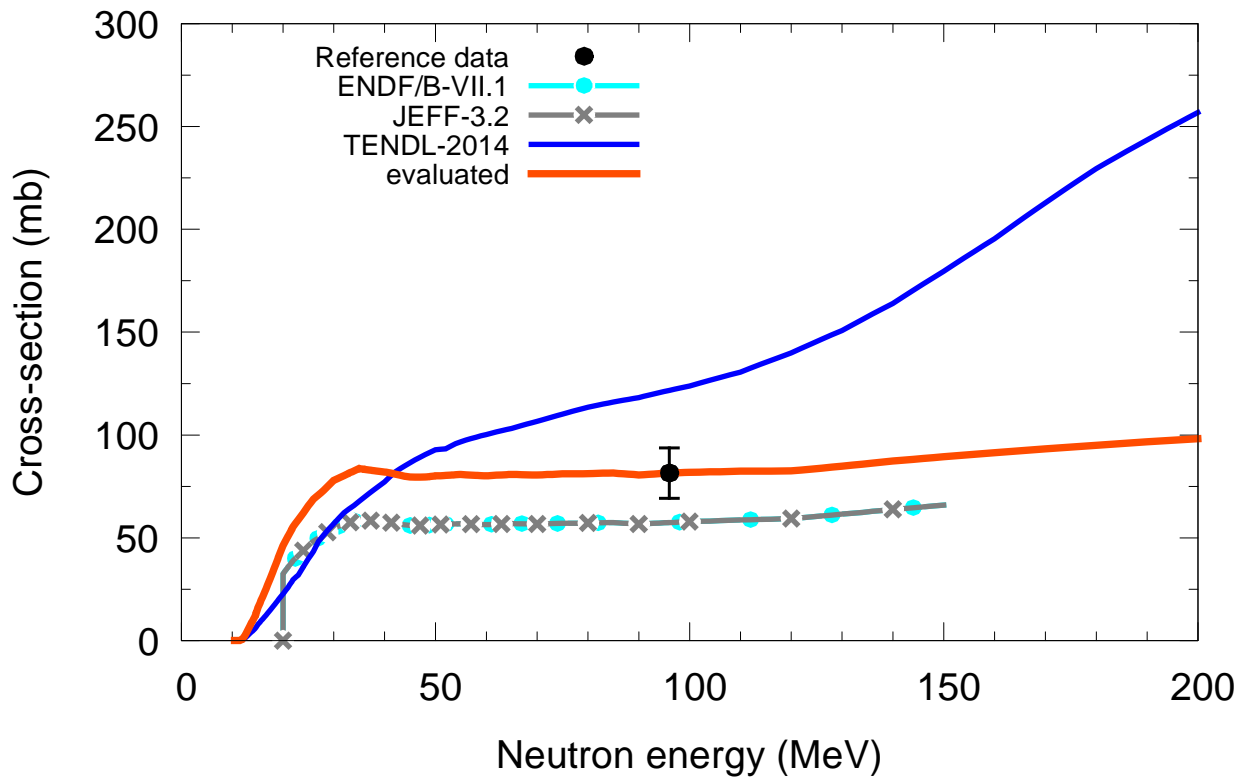
### $^{24}\text{Mg}(n,x)d$

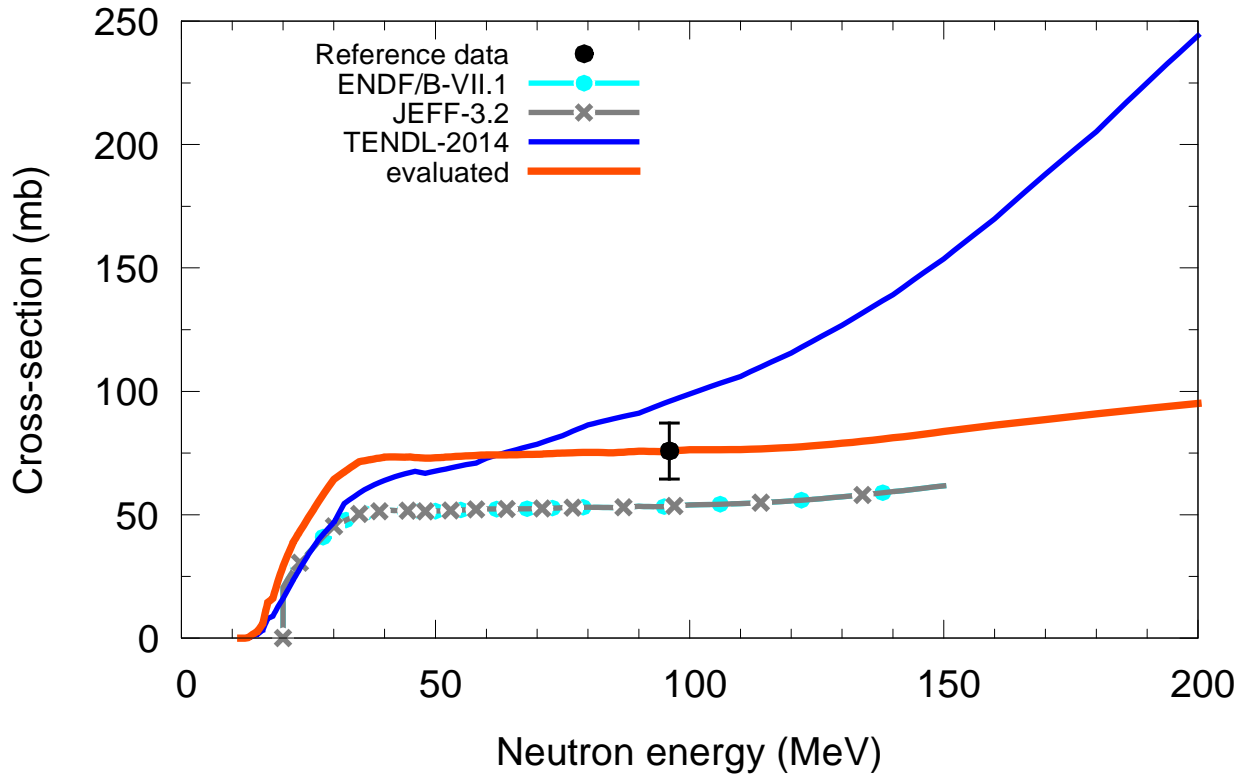
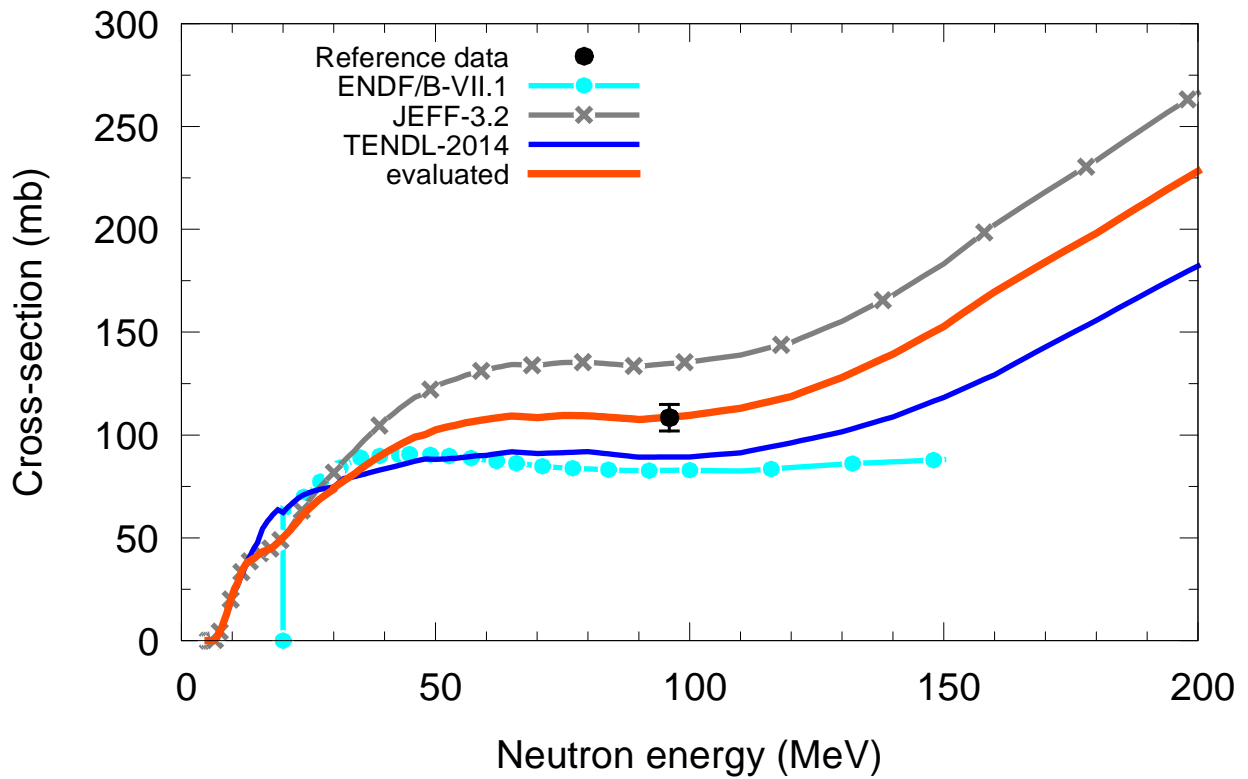


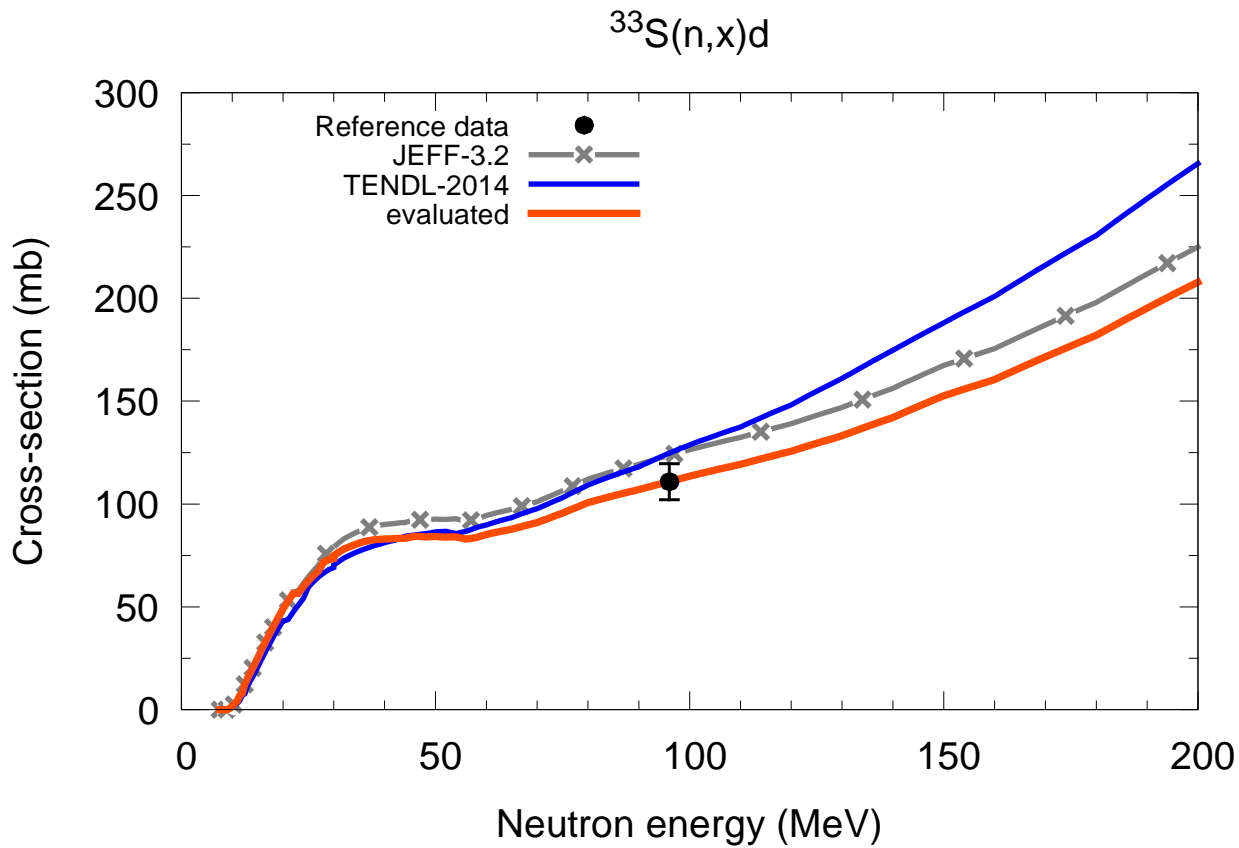
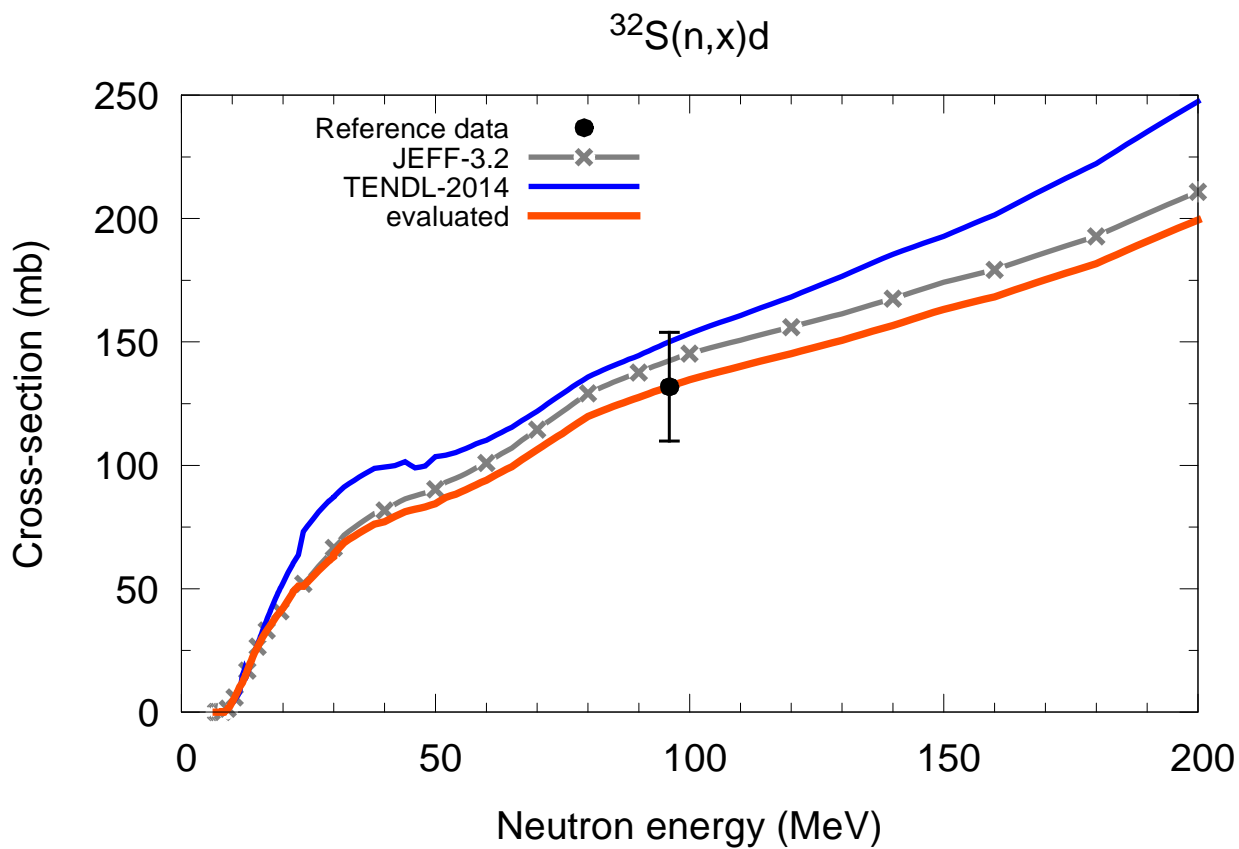
### $^{25}\text{Mg}(n,x)d$



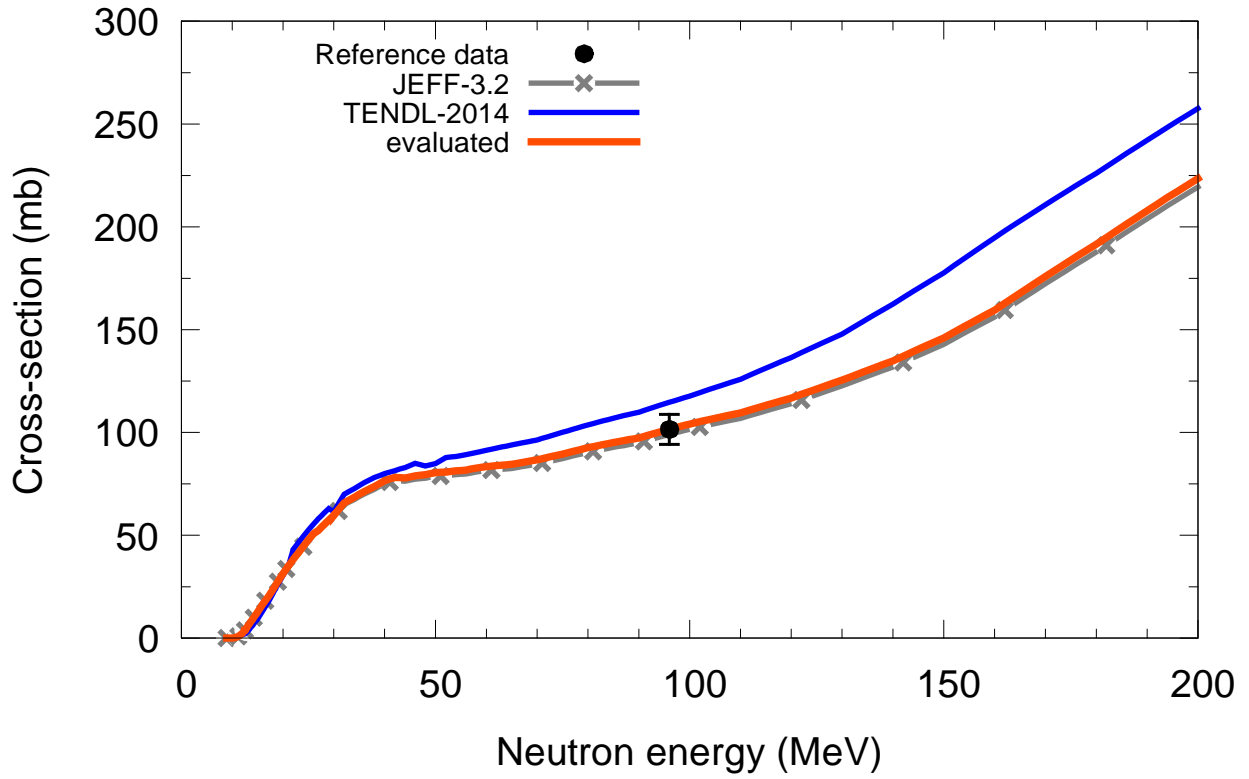
$^{26}\text{Mg}(n,x)d$  $^{27}\text{Al}(n,x)d$ 

$^{28}\text{Si}(n,x)d$  $^{29}\text{Si}(n,x)d$ 

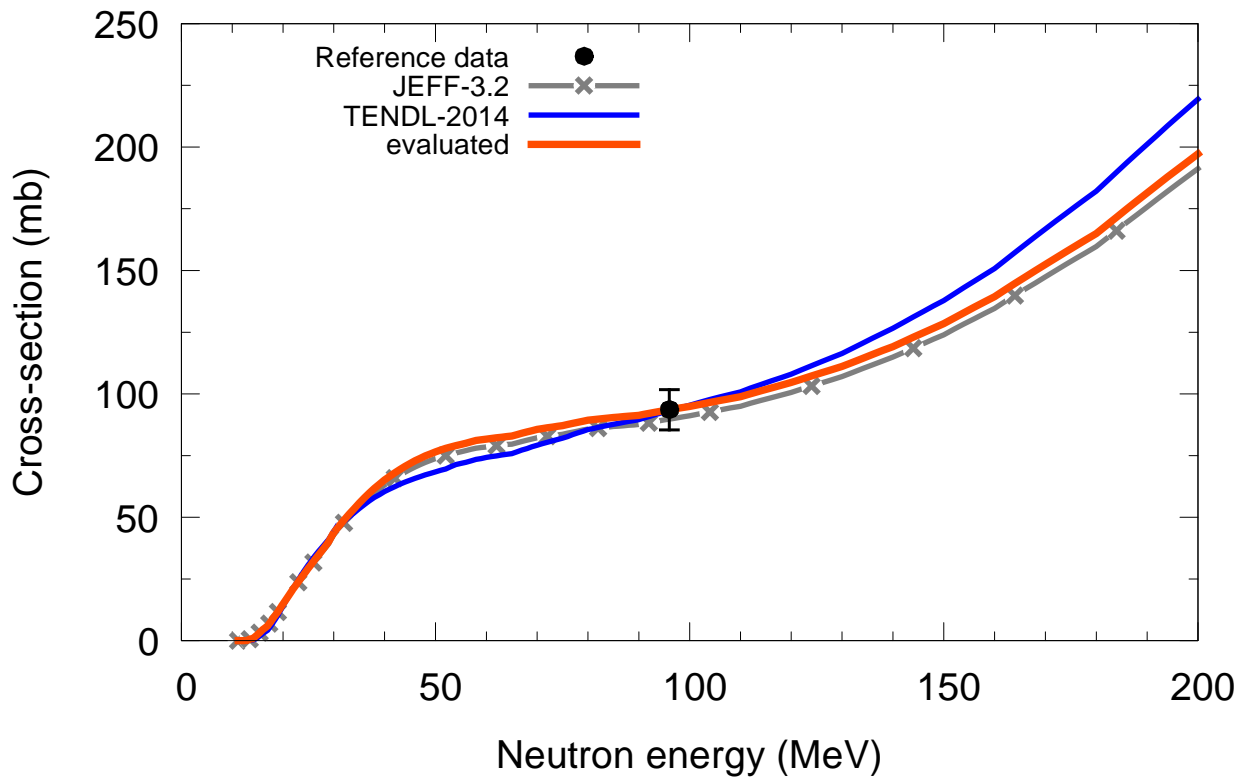
$^{30}\text{Si}(n,x)d$  $^{31}\text{P}(n,x)d$ 

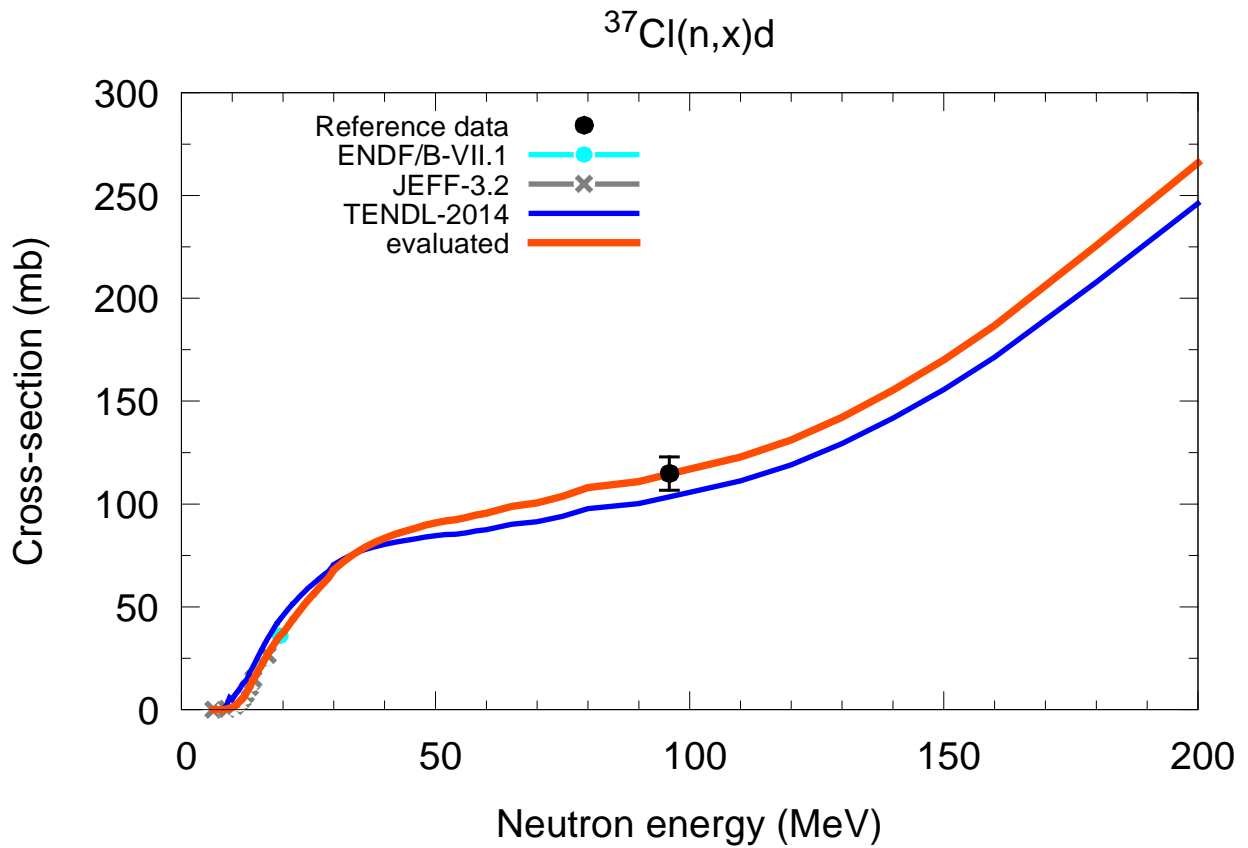
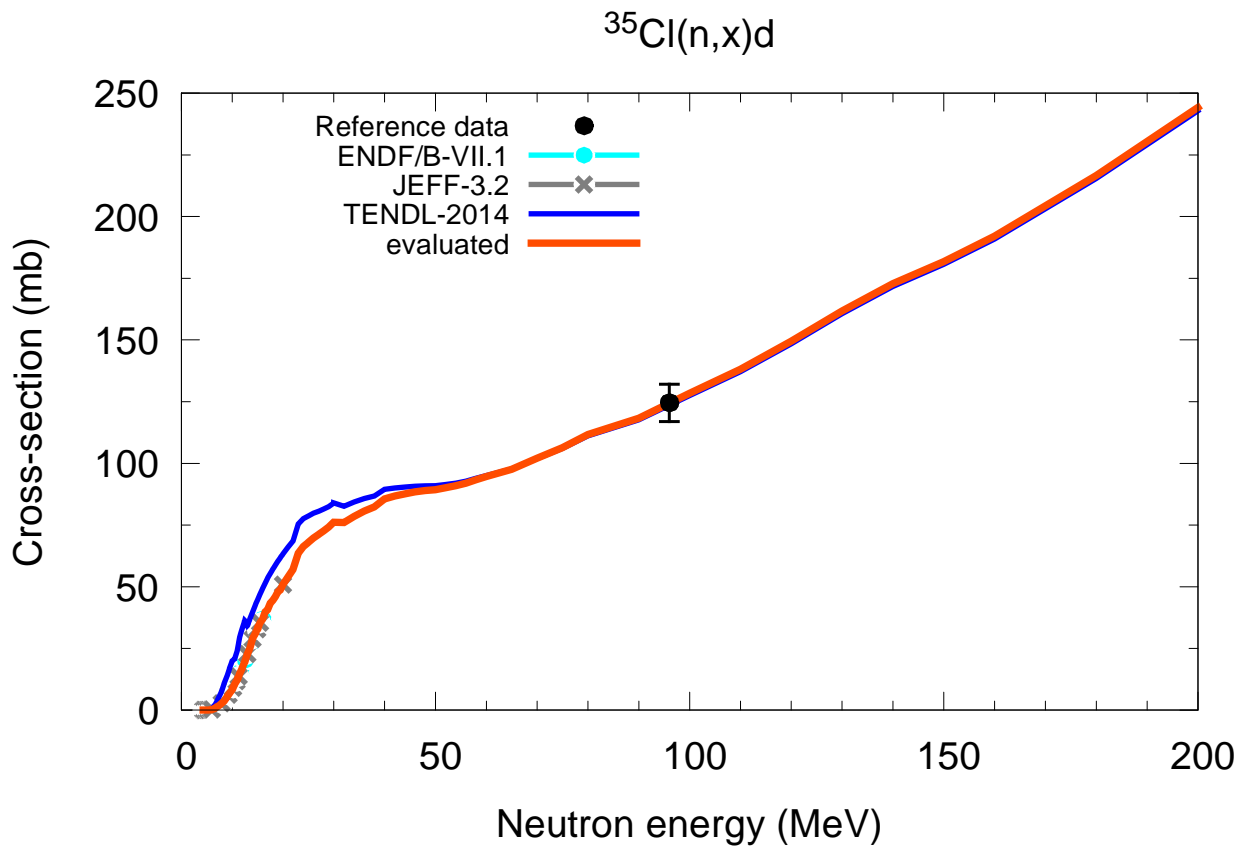


### $^{34}\text{S}(n,x)d$



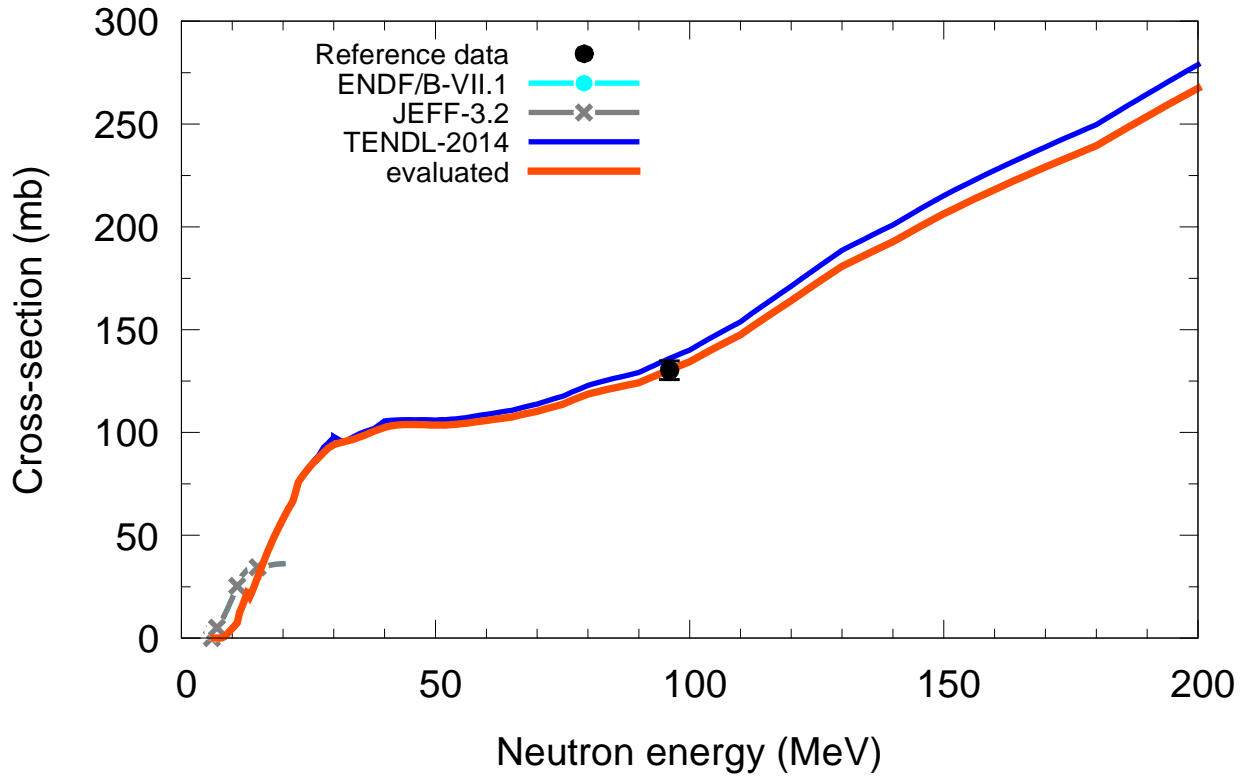
### $^{36}\text{S}(n,x)d$



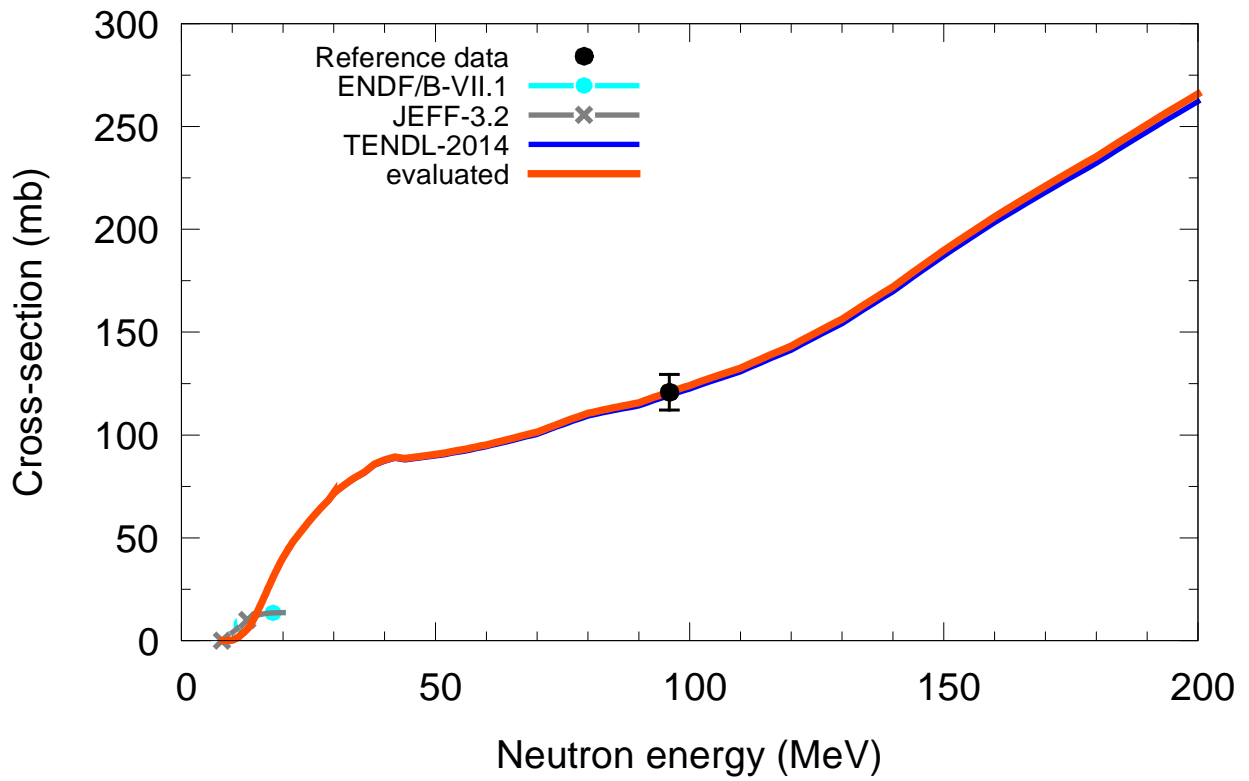


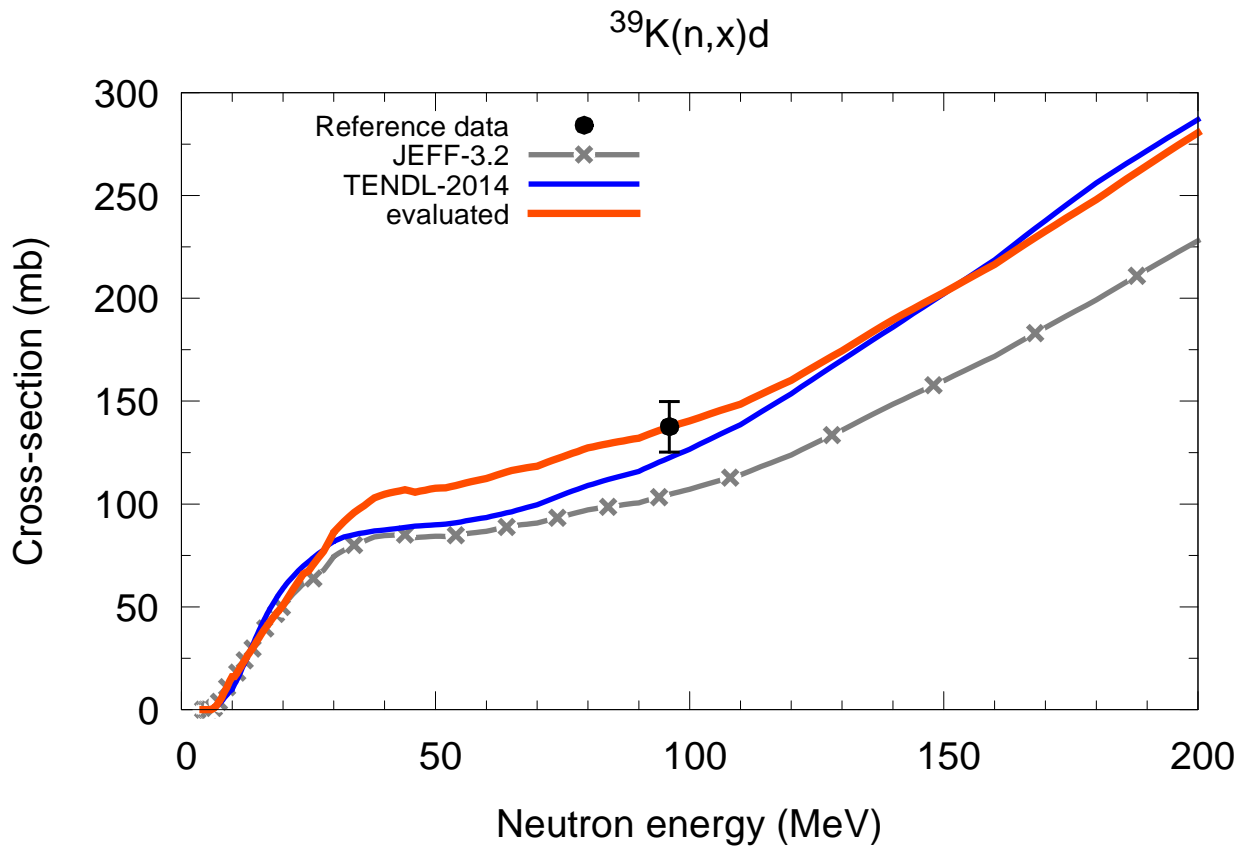
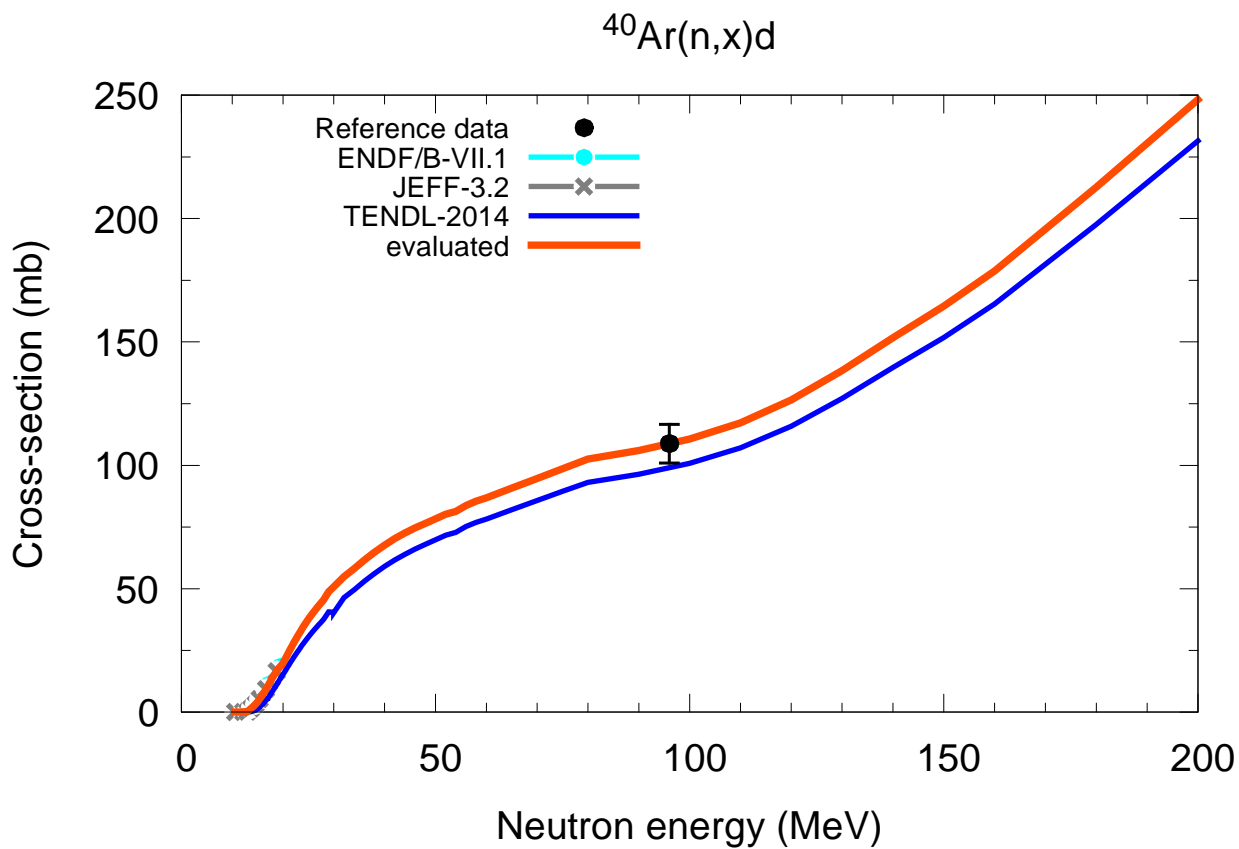


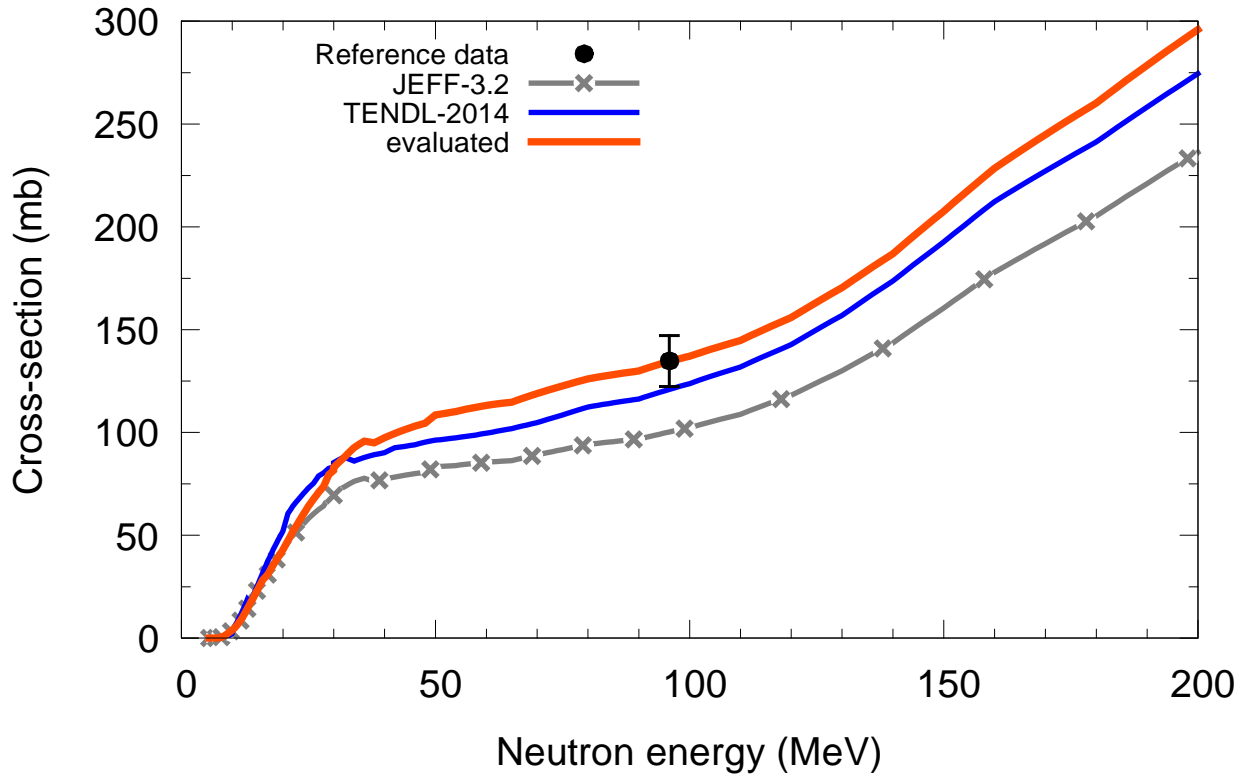
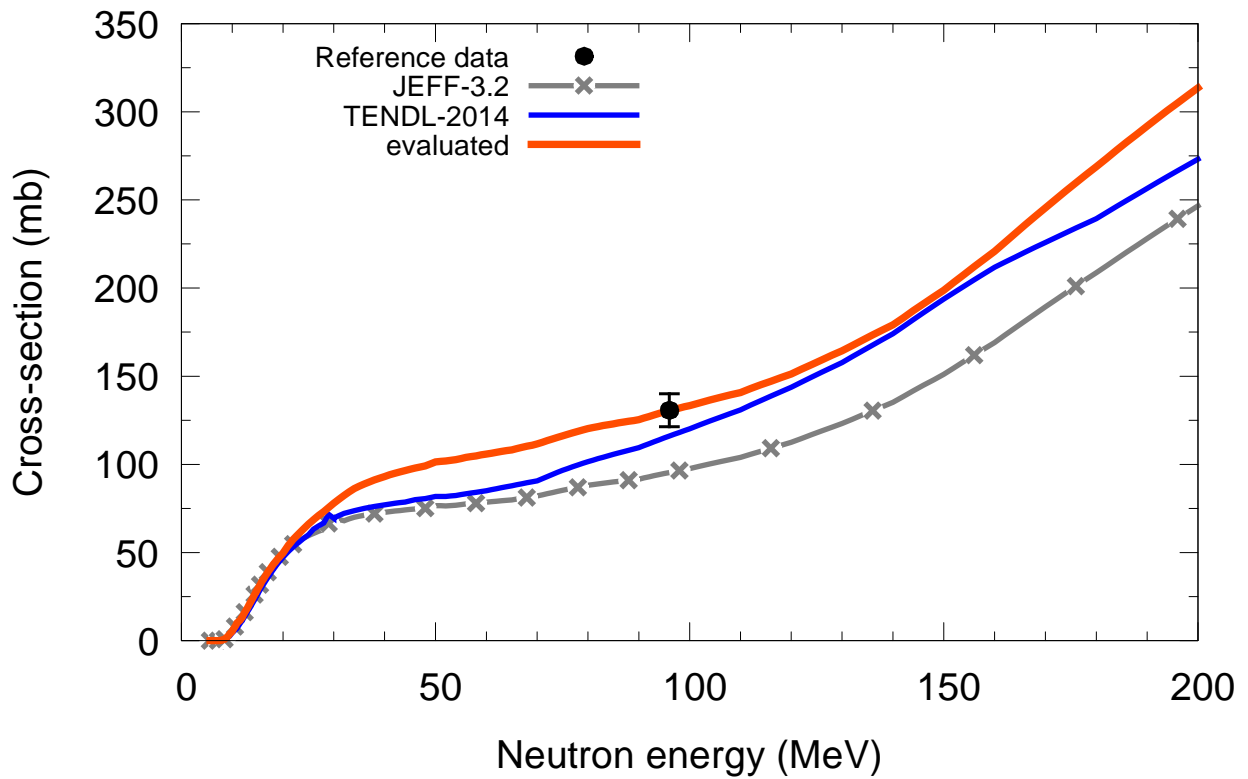
### $^{36}\text{Ar}(n,x)d$



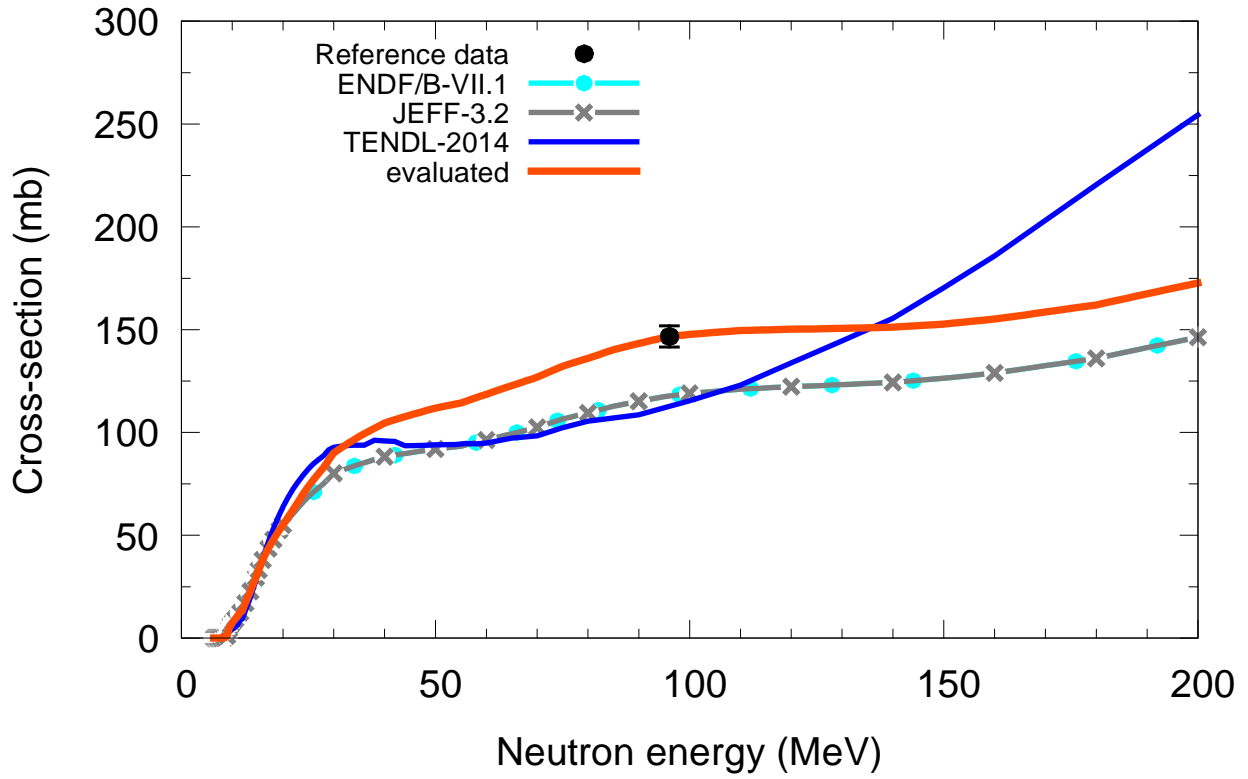
### $^{38}\text{Ar}(n,x)d$



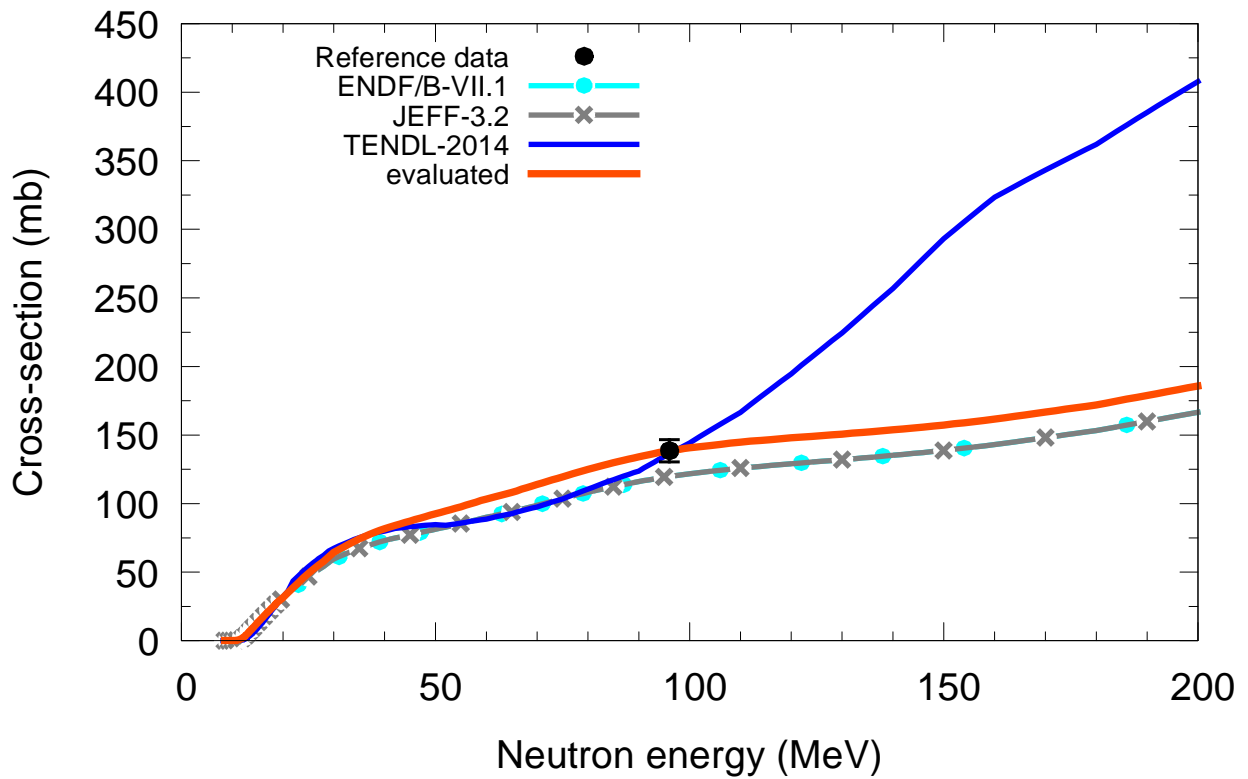


$^{40}\text{K}(n,x)d$  $^{41}\text{K}(n,x)d$ 

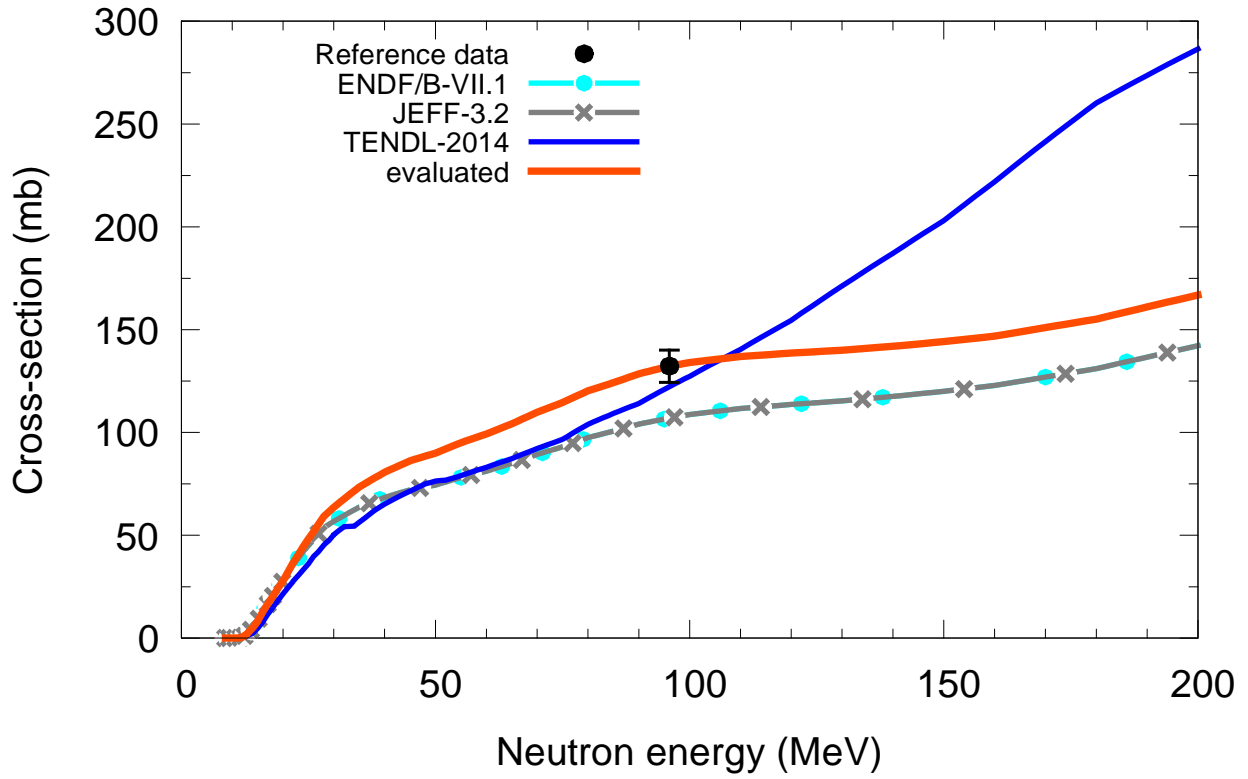
### $^{40}\text{Ca}(n,x)d$



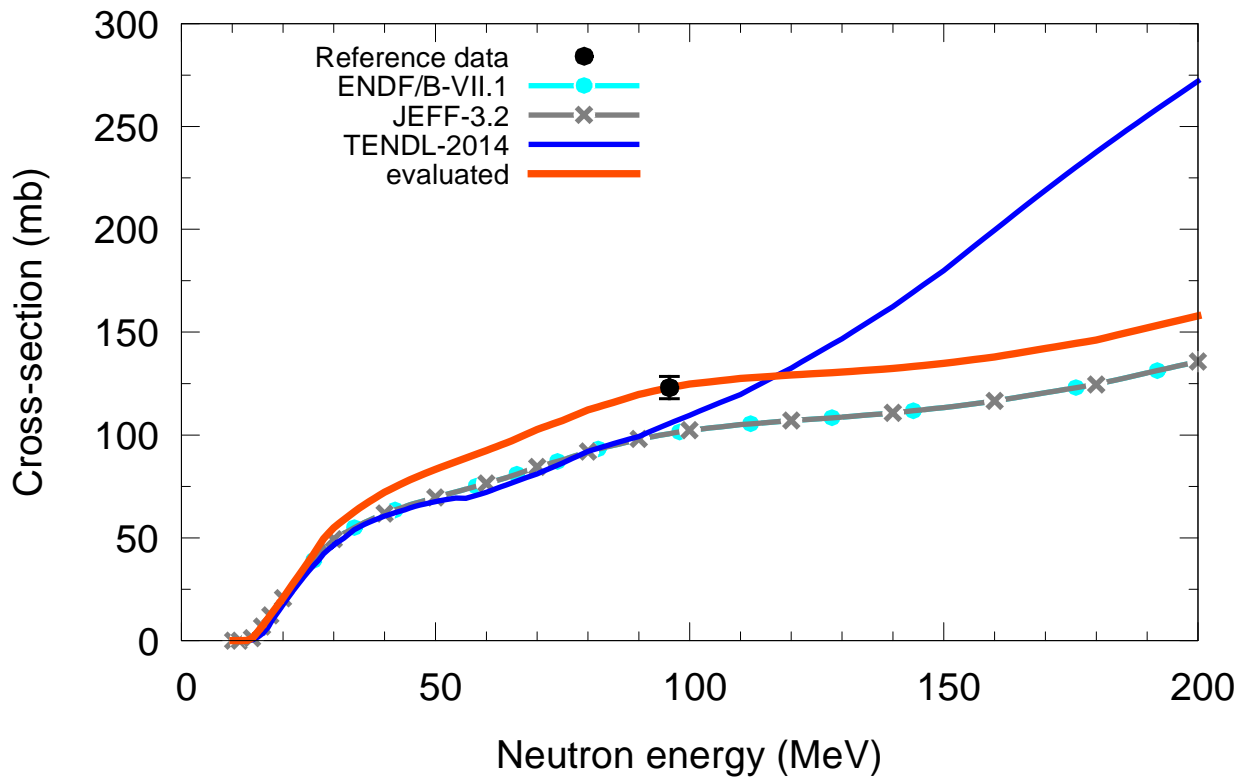
### $^{42}\text{Ca}(n,x)d$



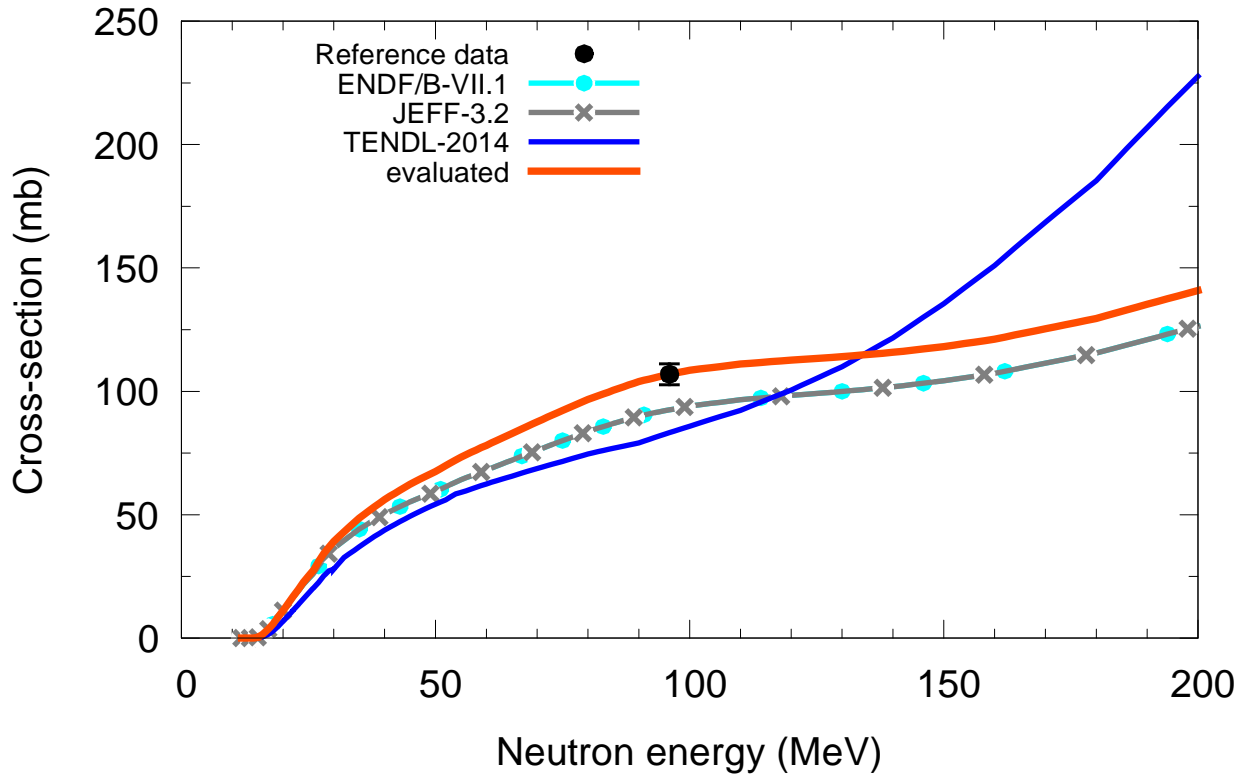
### $^{43}\text{Ca}(n,x)d$



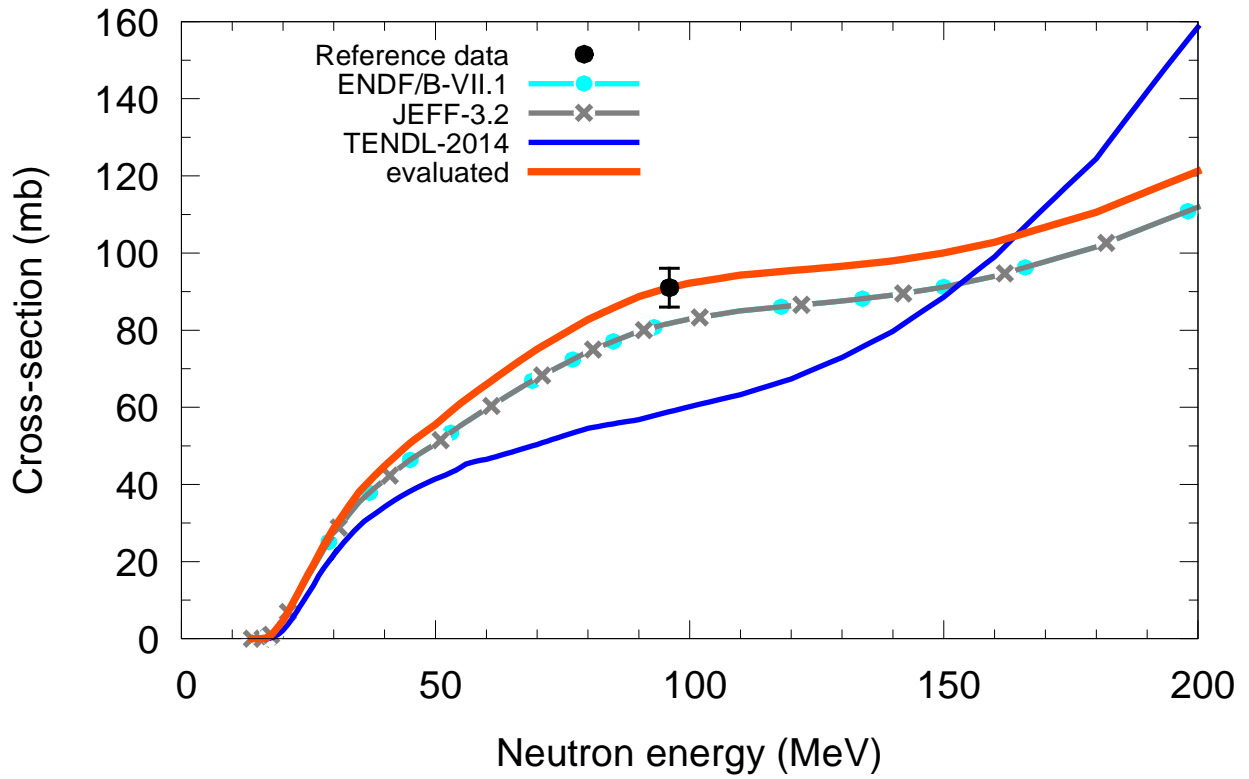
### $^{44}\text{Ca}(n,x)d$



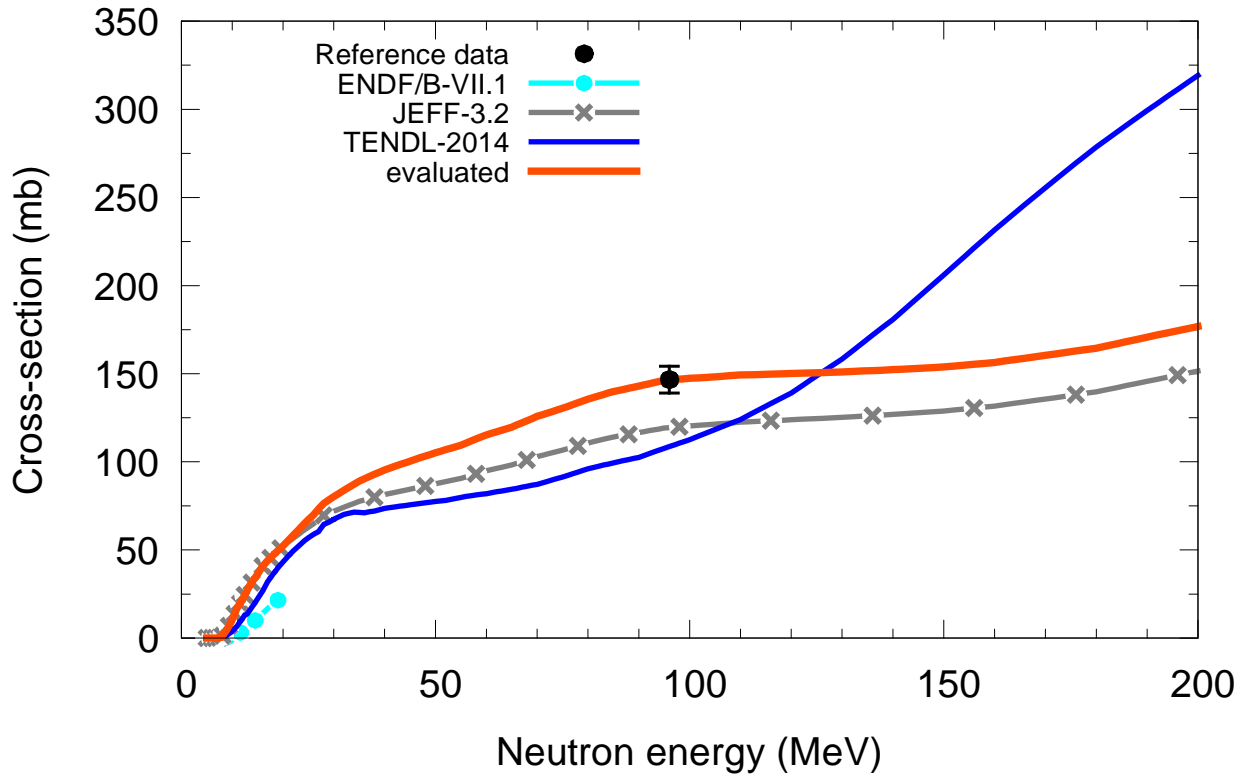
### $^{46}\text{Ca}(n,x)d$



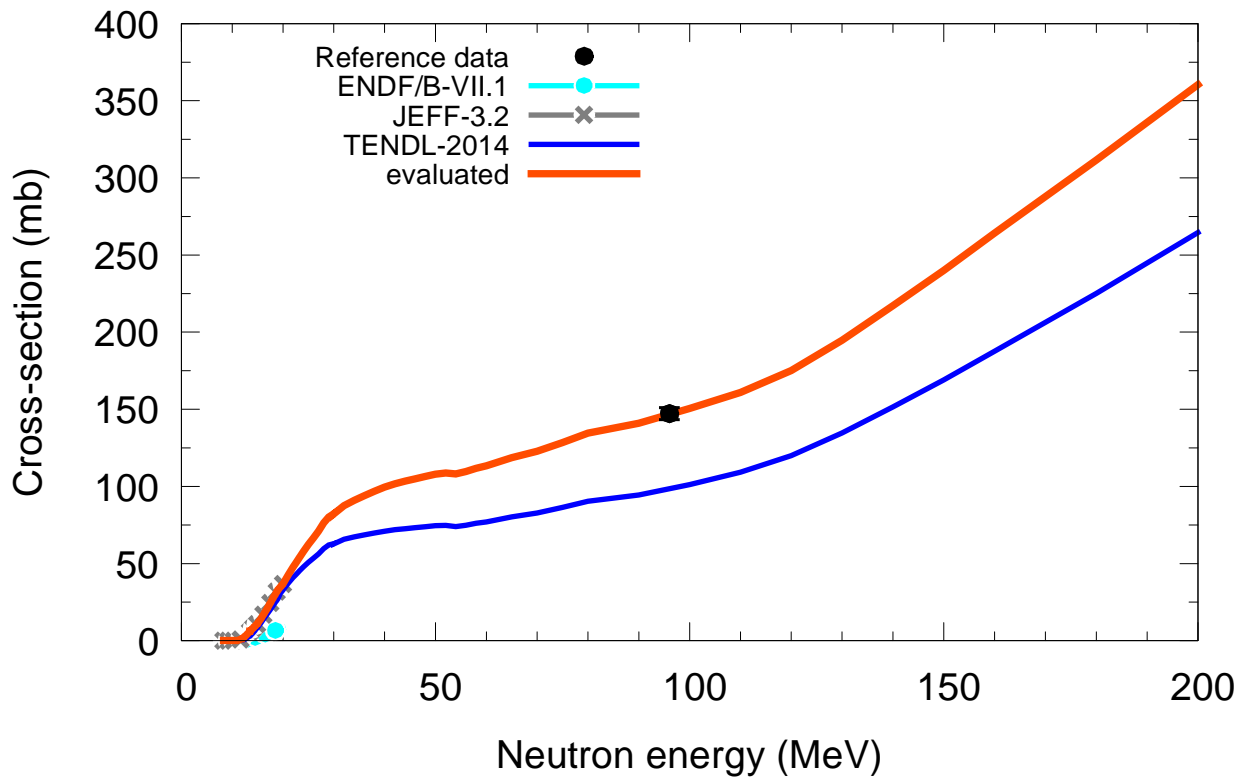
### $^{48}\text{Ca}(n,x)d$



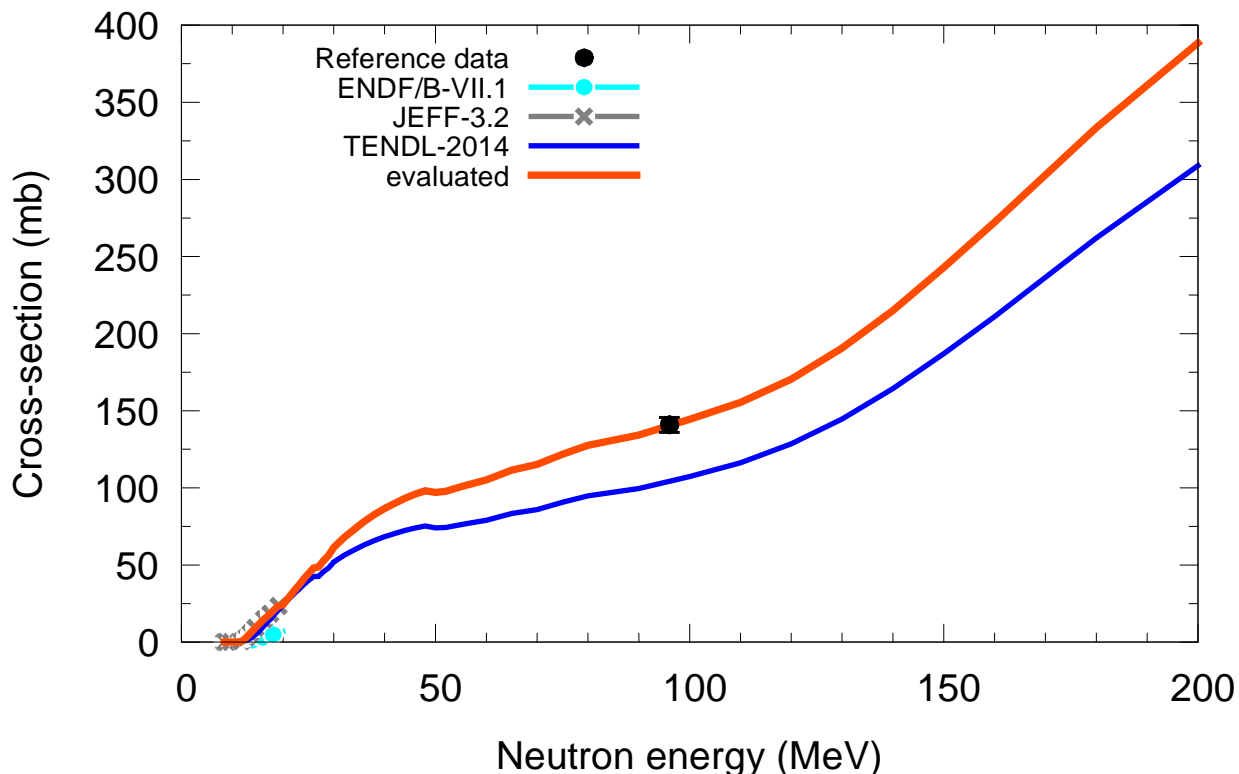
$^{45}\text{Sc}(n,x)d$



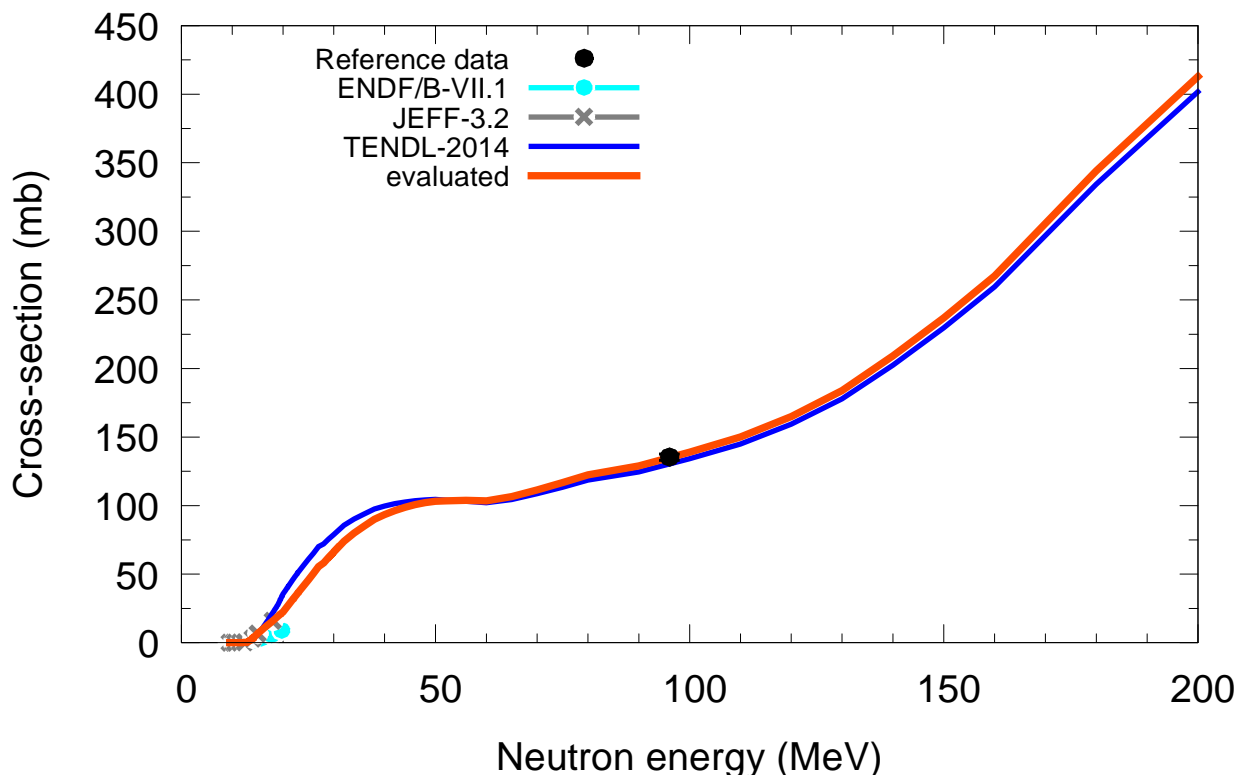
$^{46}\text{Ti}(n,x)d$



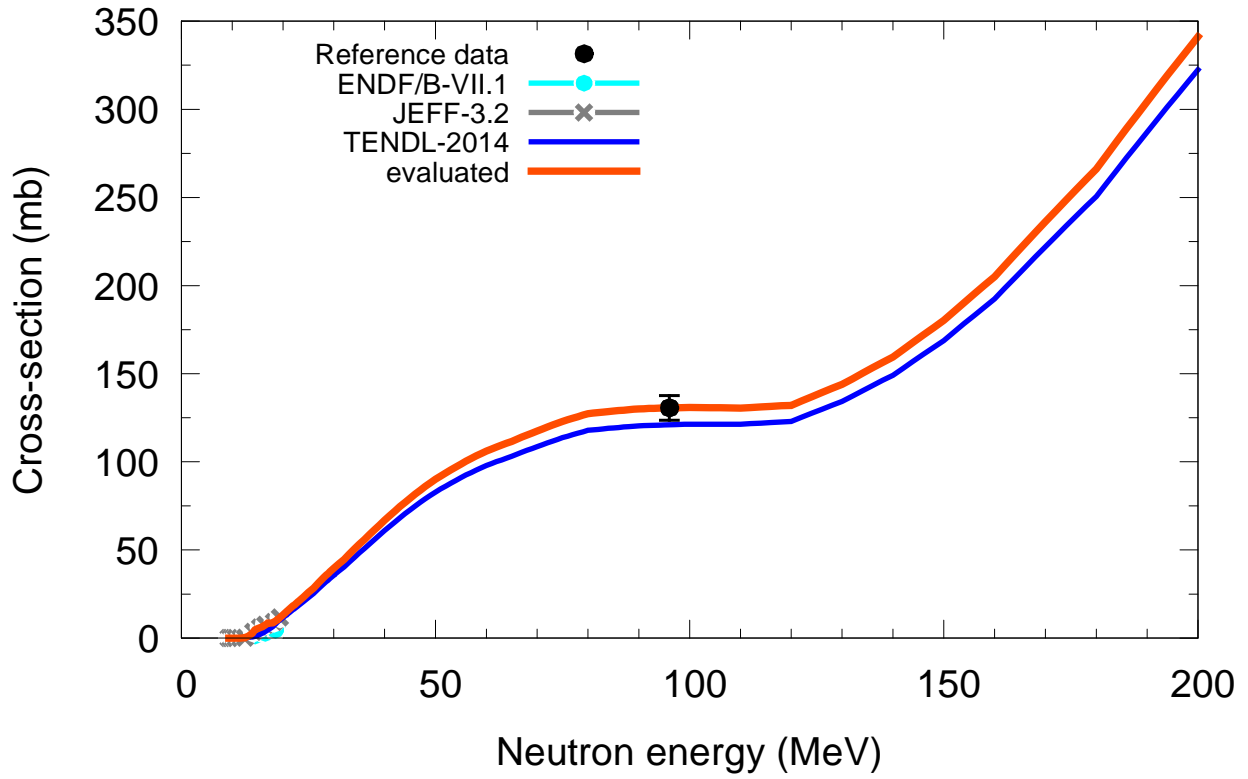
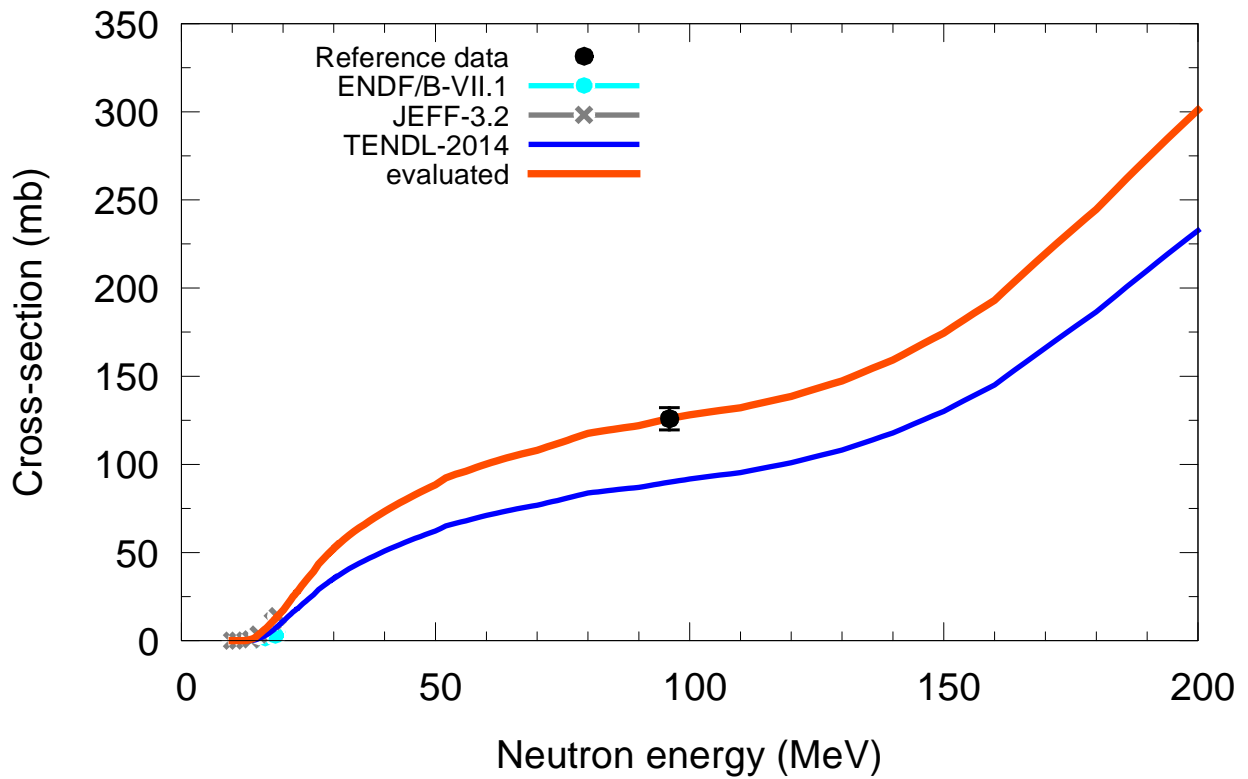
$^{47}\text{Ti}(n,x)d$

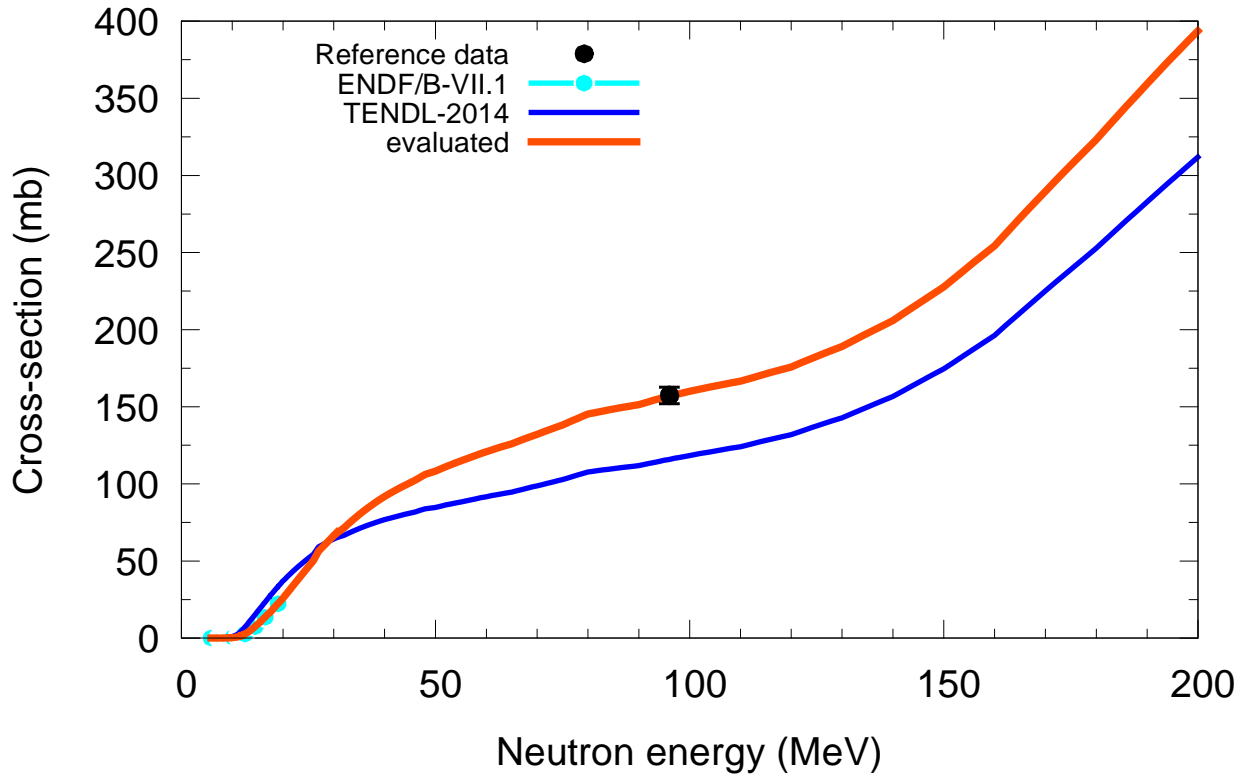
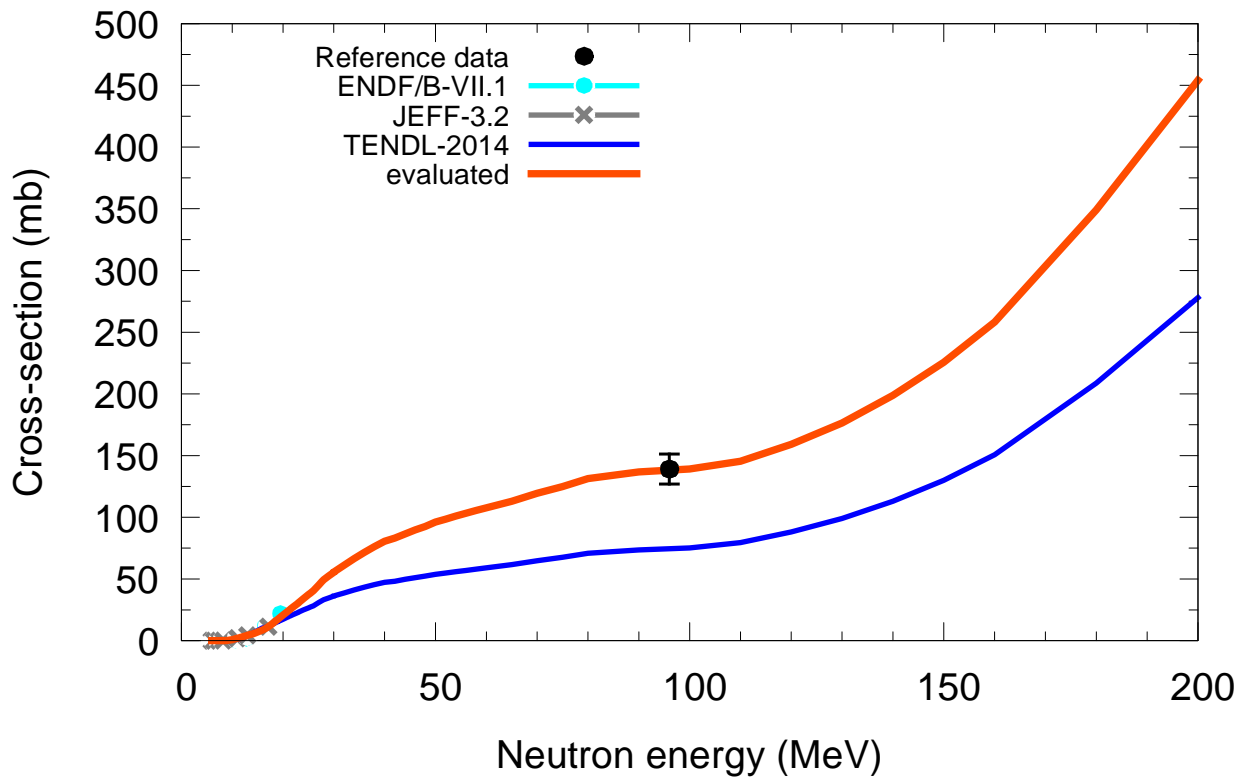


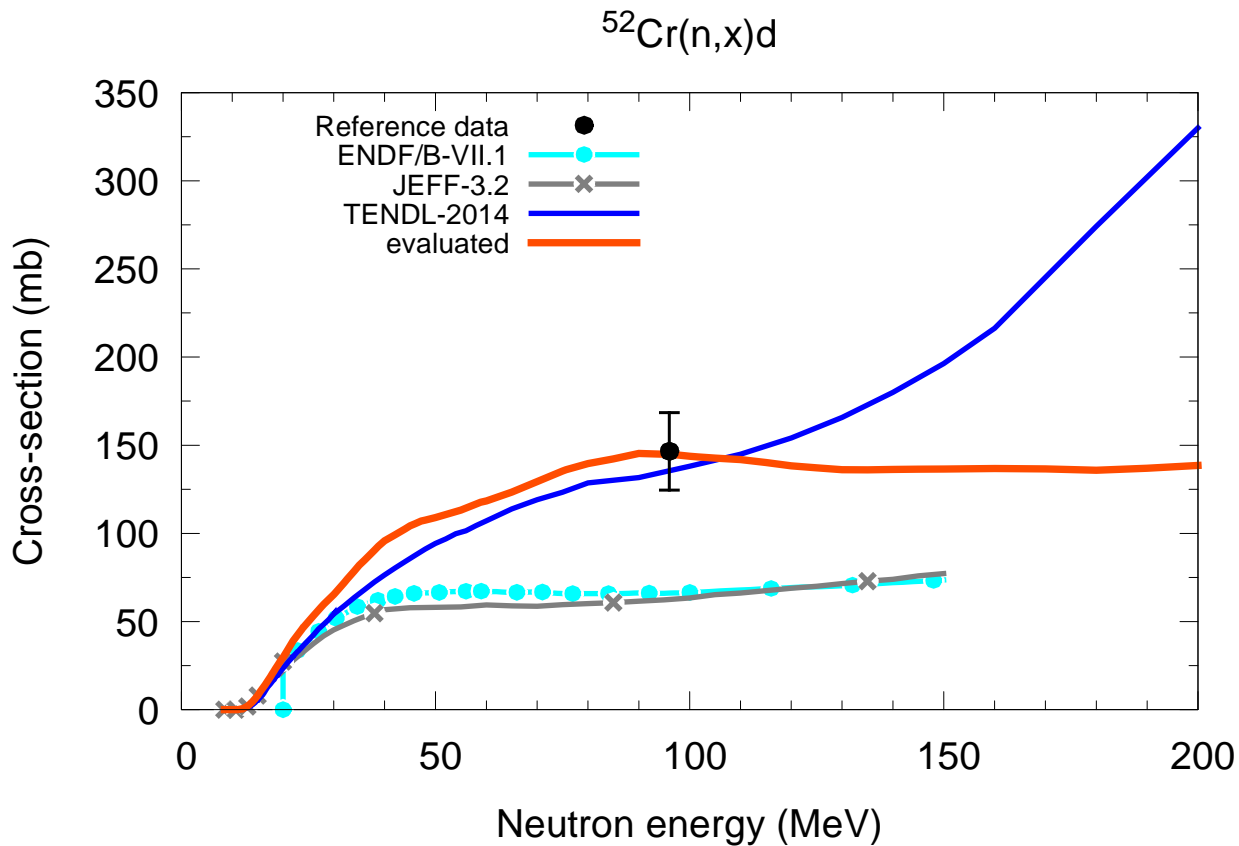
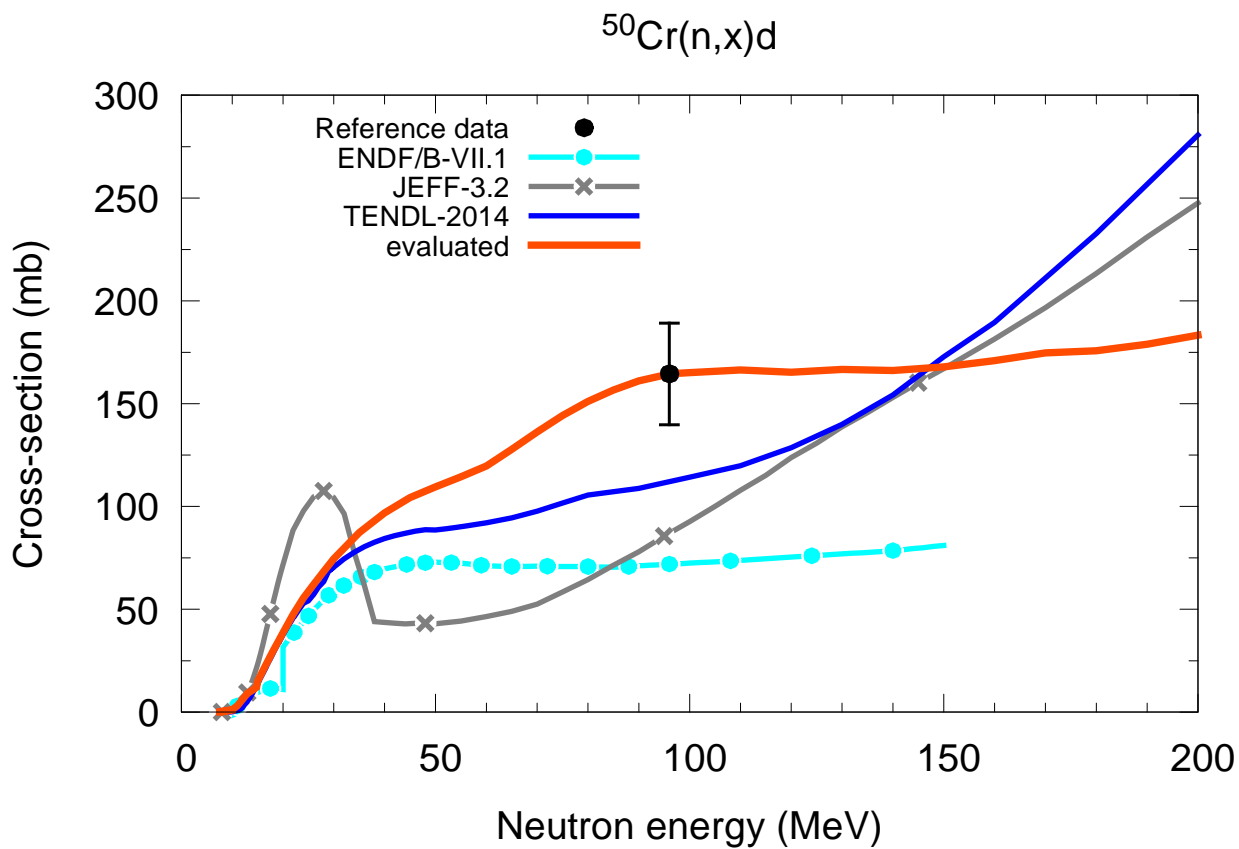
$^{48}\text{Ti}(n,x)d$



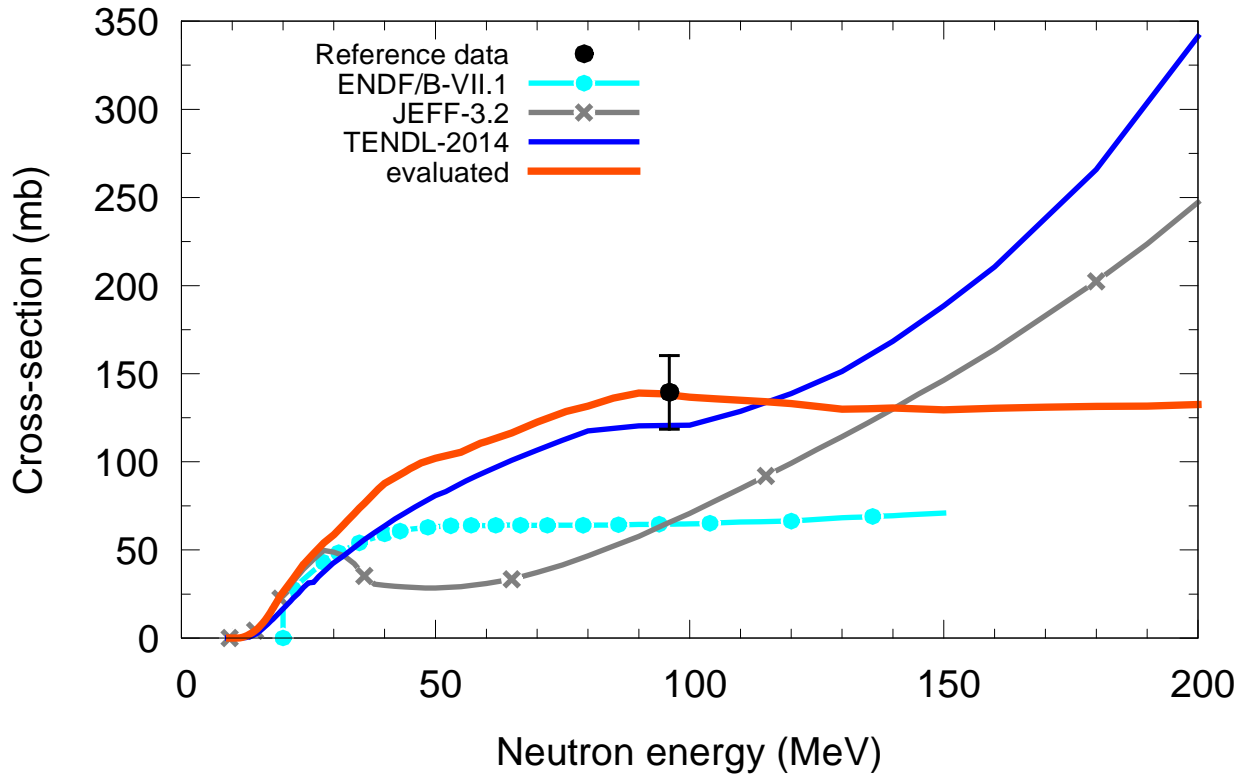


$^{49}\text{Ti}(n,x)d$  $^{50}\text{Ti}(n,x)d$ 

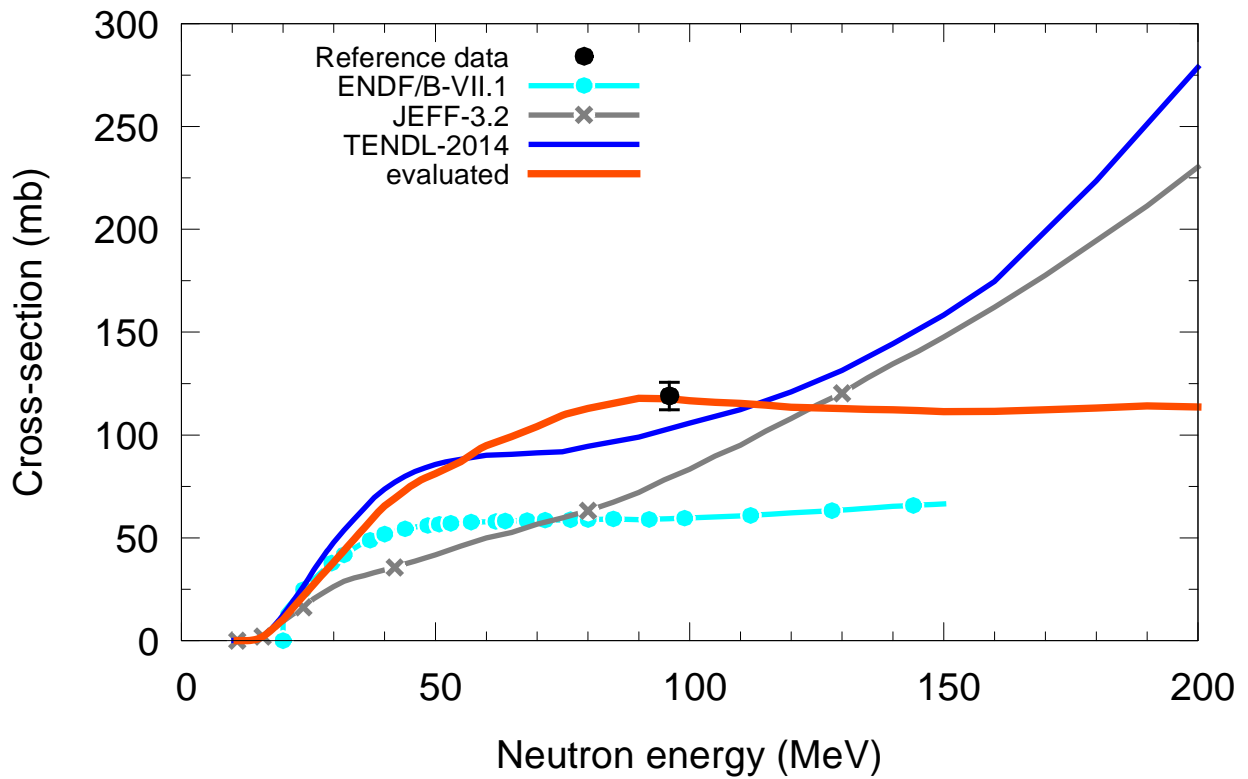
$^{50}\text{V}(n,x)d$  $^{51}\text{V}(n,x)d$ 

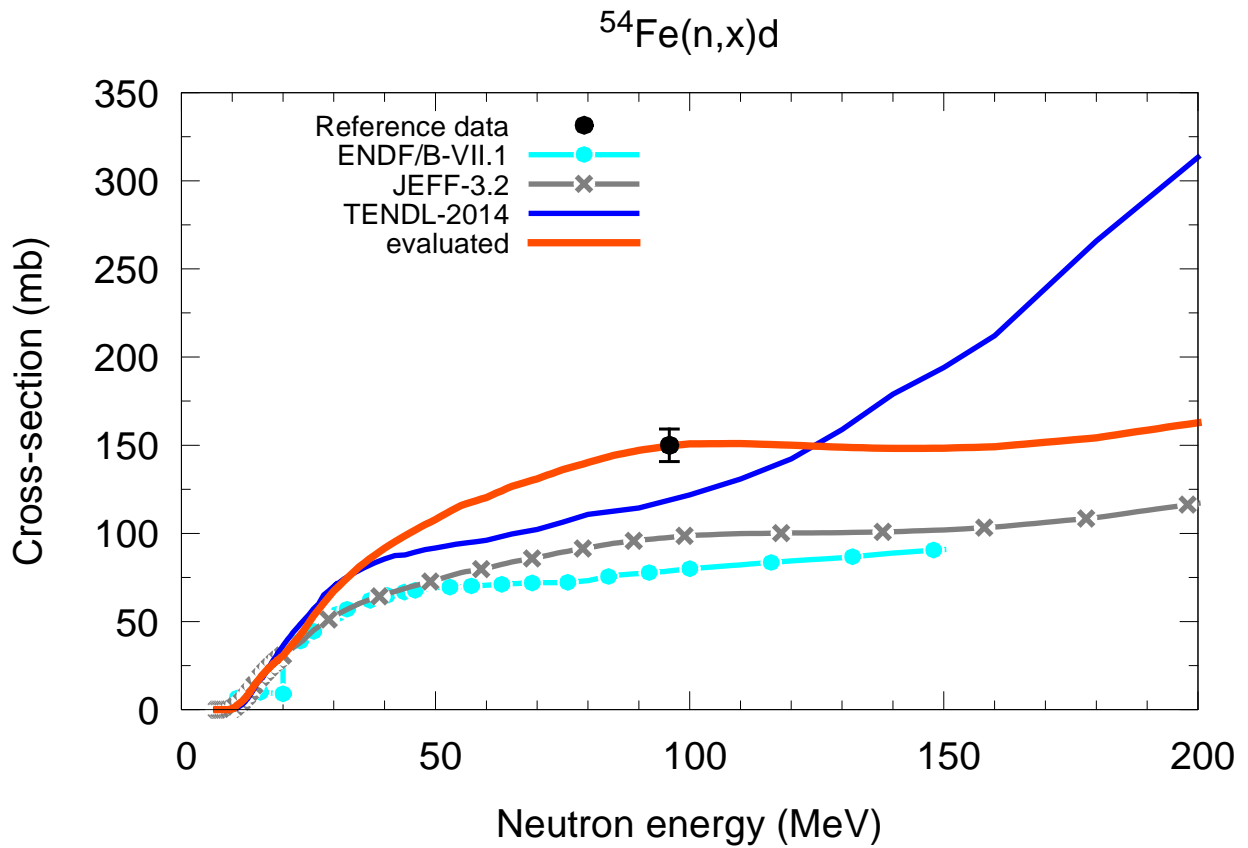
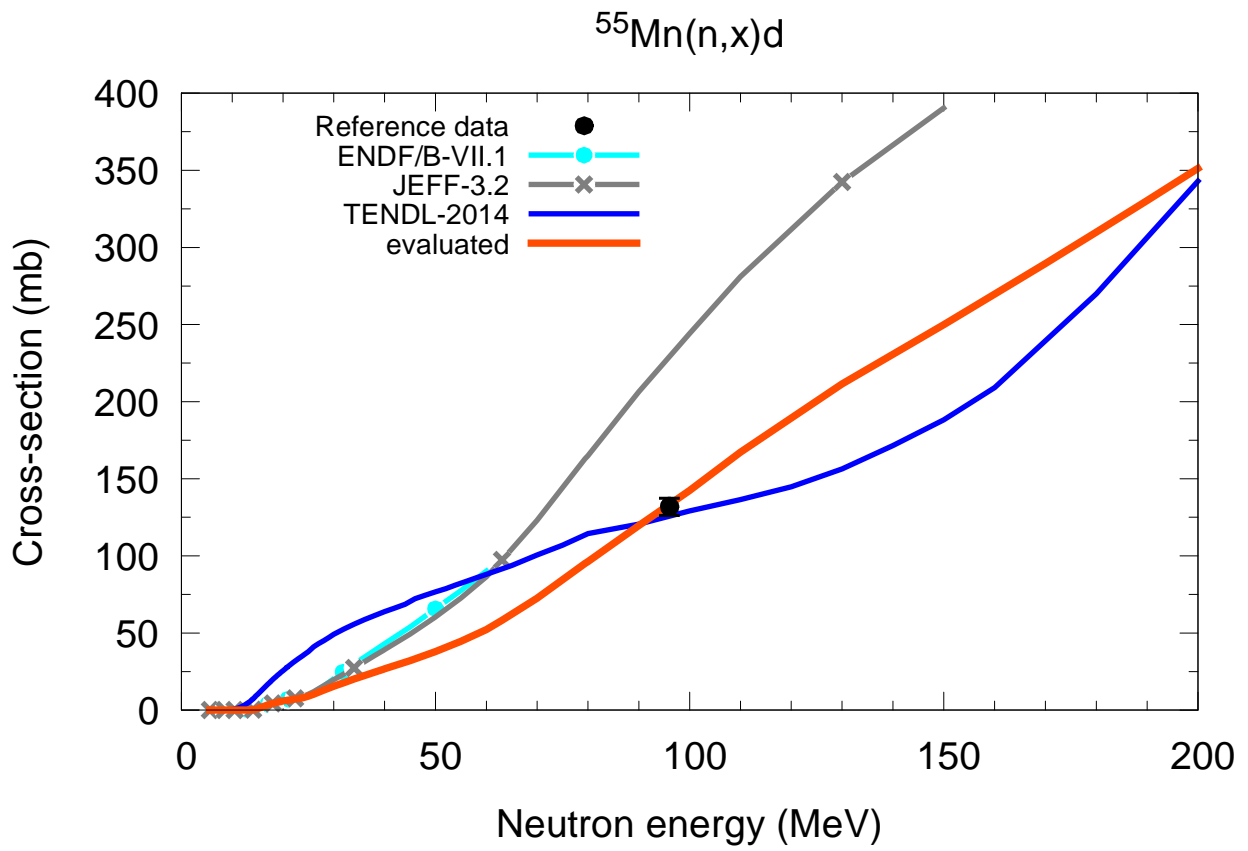


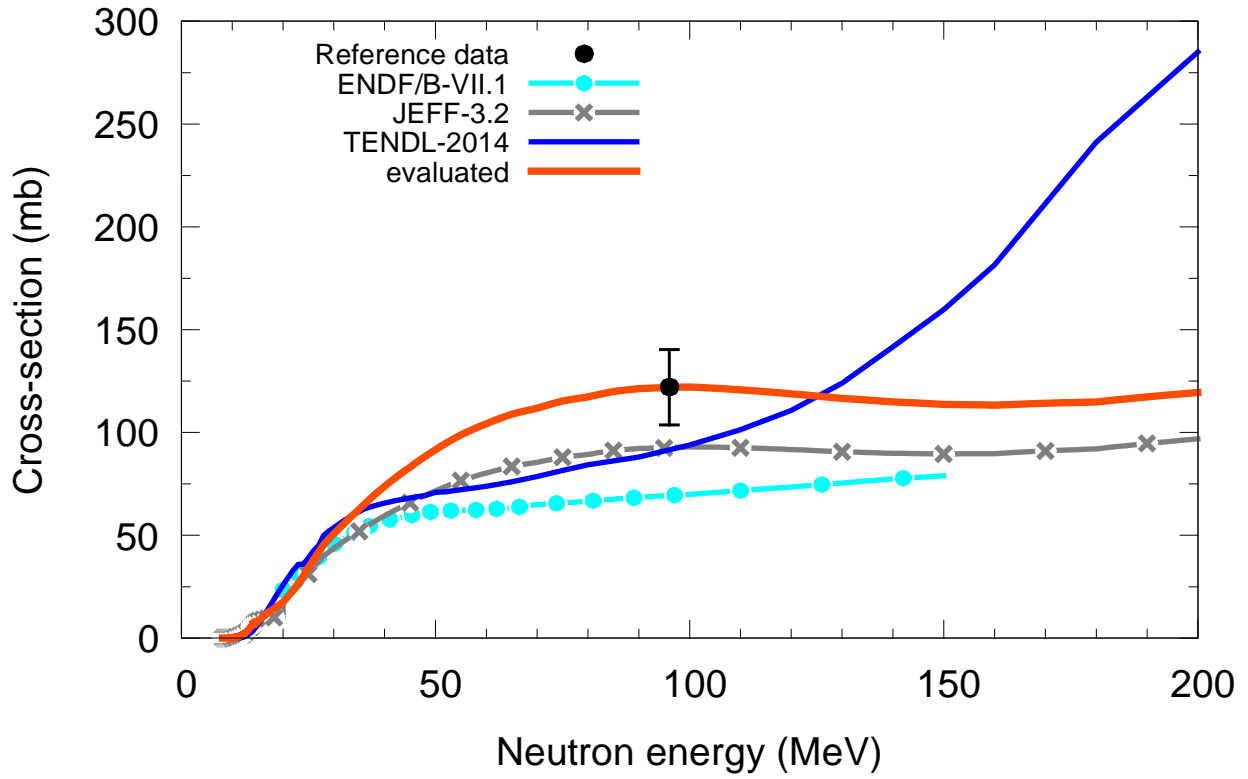
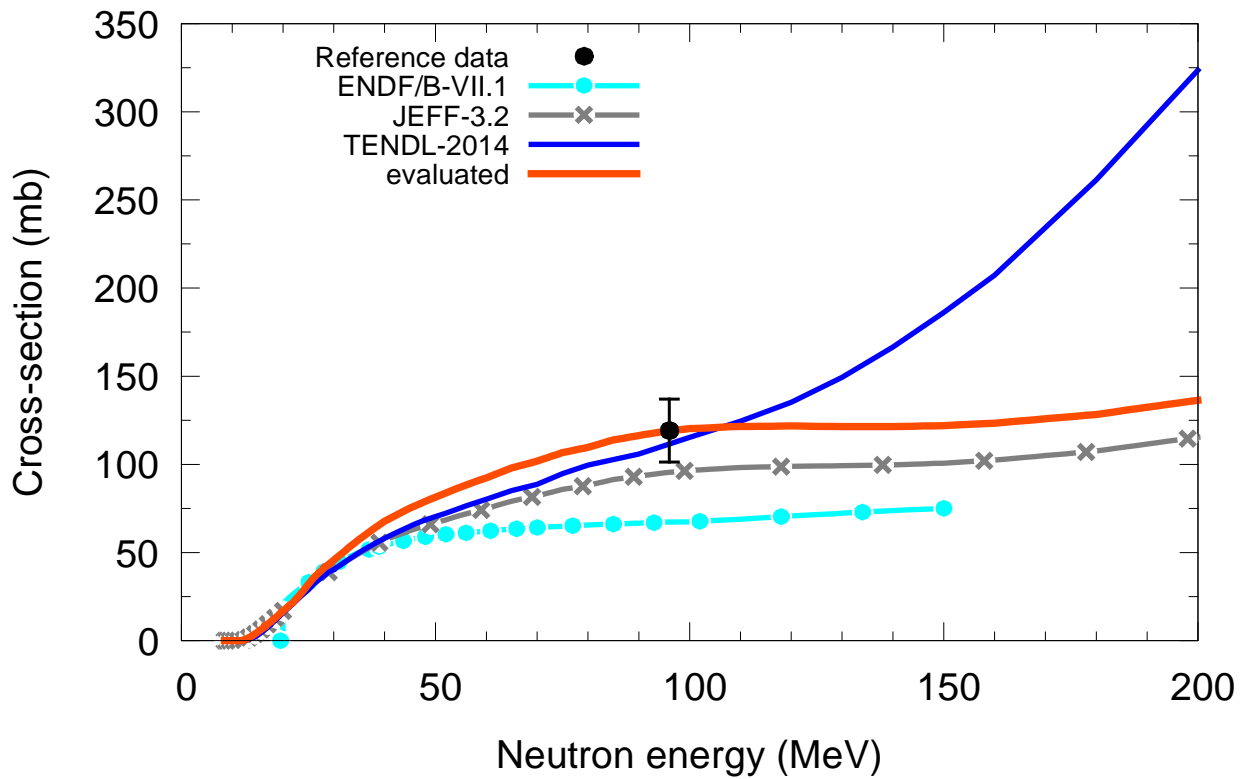
### $^{53}\text{Cr}(n,x)d$



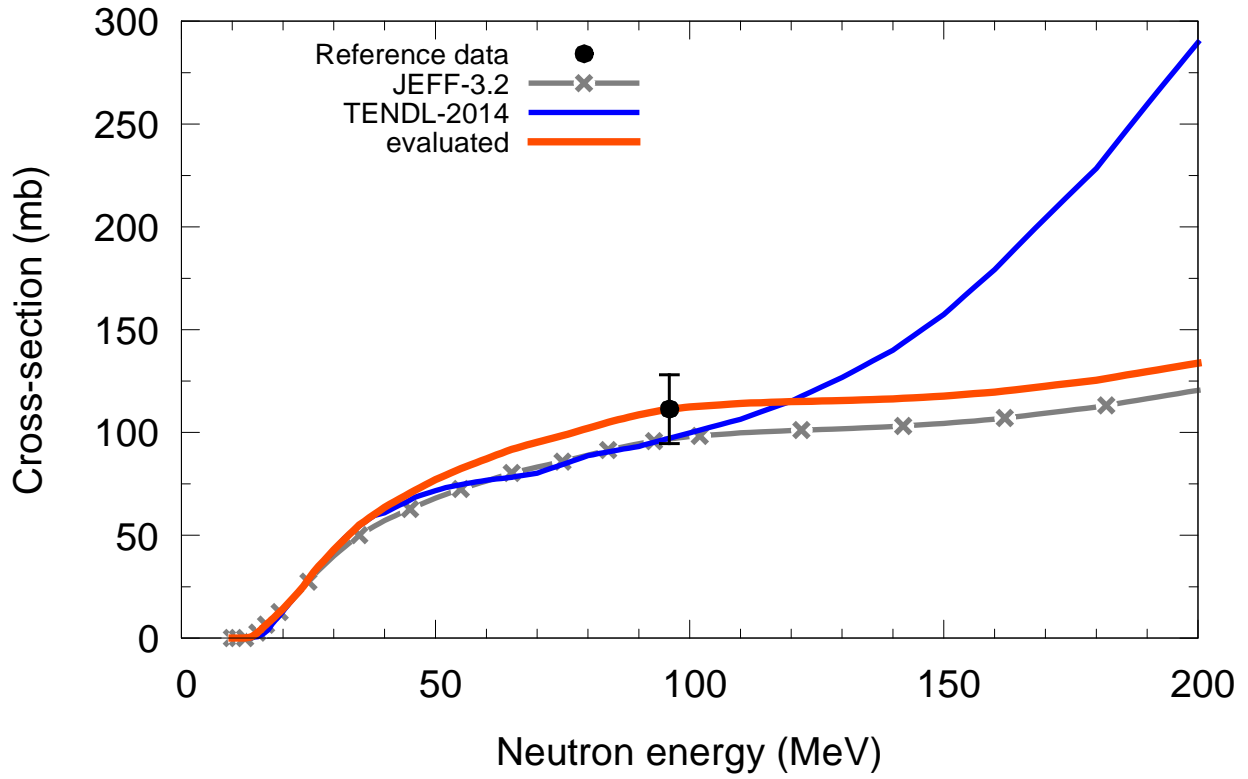
### $^{54}\text{Cr}(n,x)d$



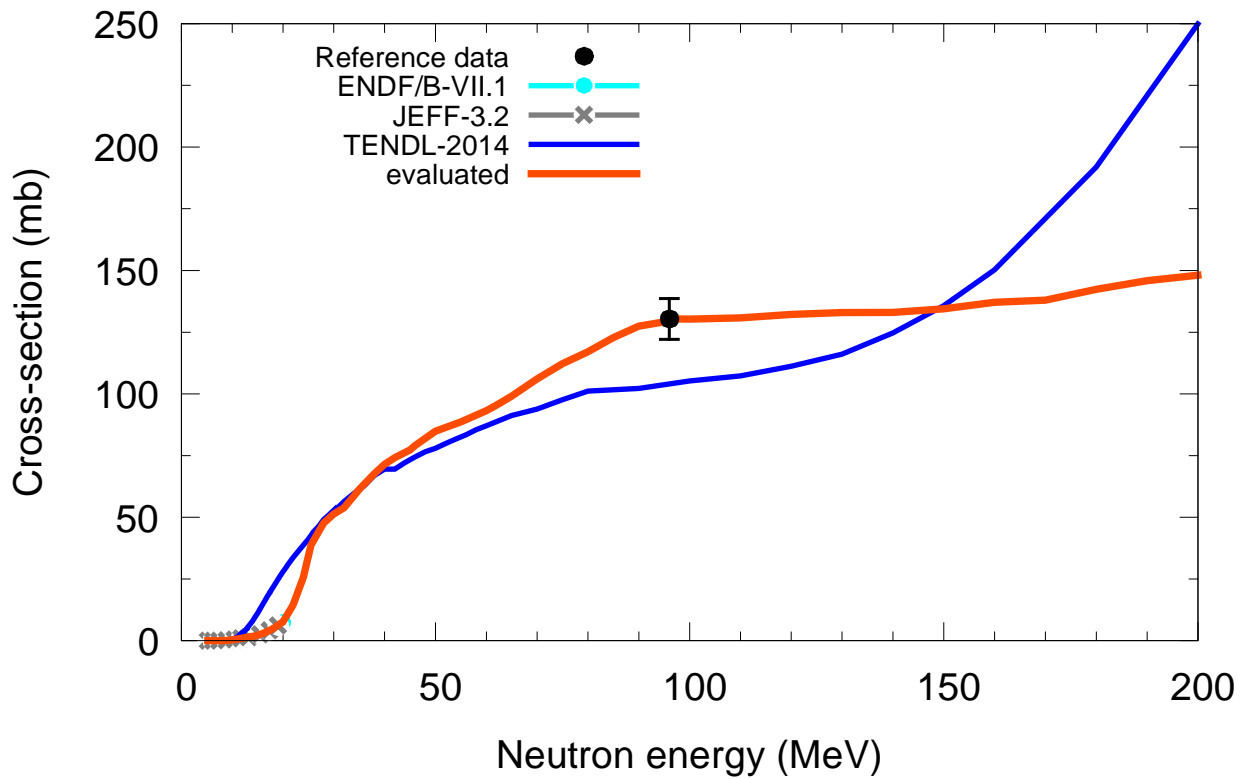


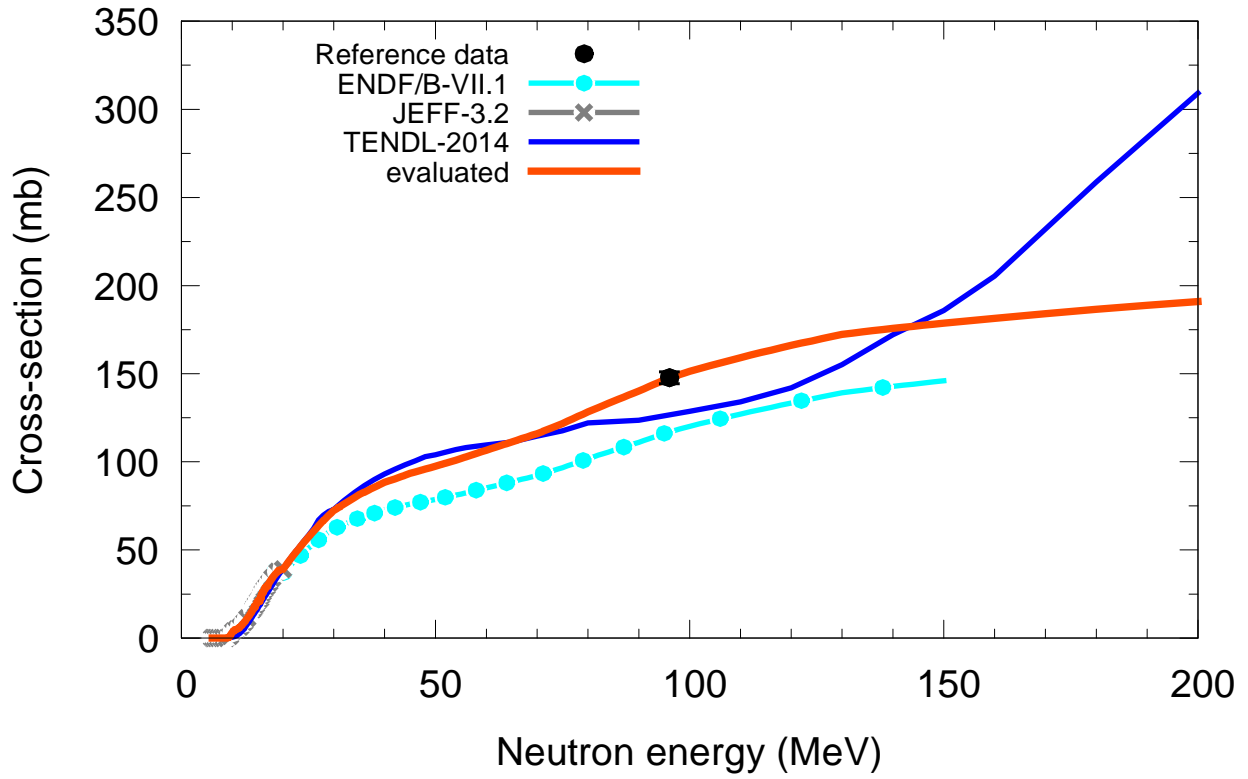
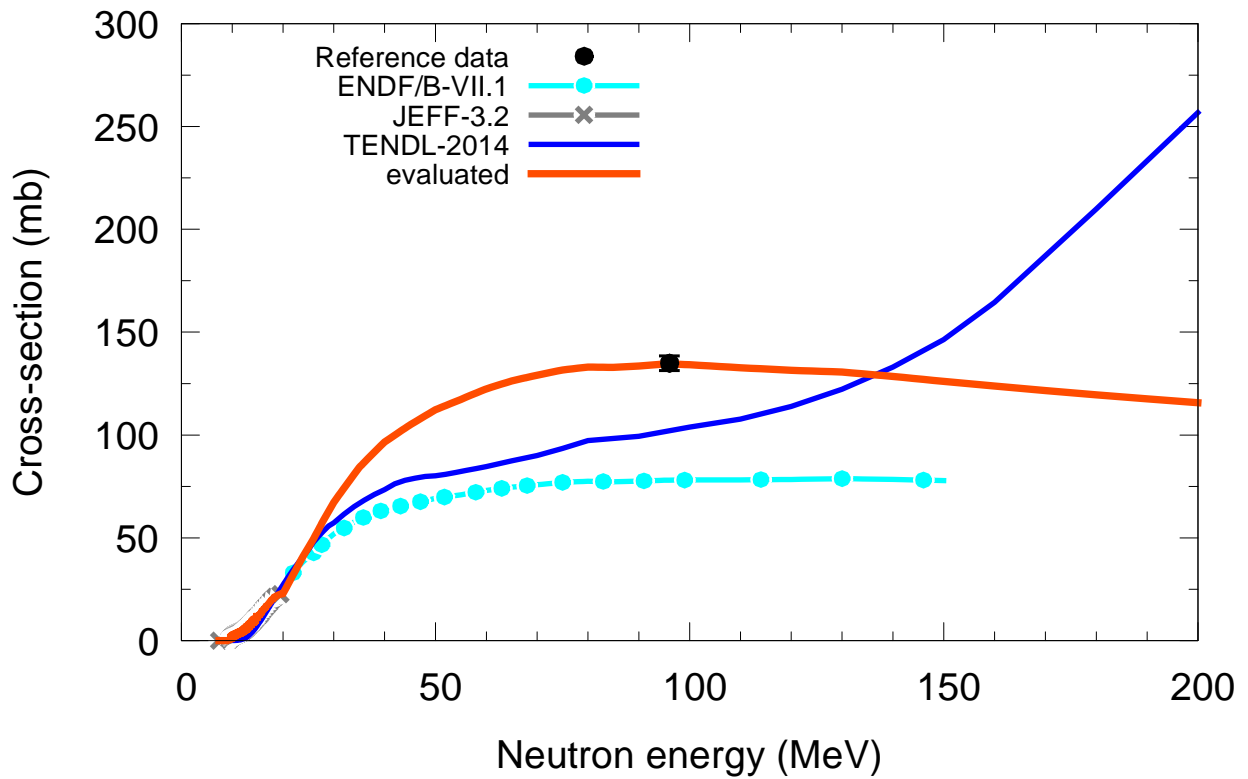
$^{56}\text{Fe}(n,x)d$  $^{57}\text{Fe}(n,x)d$ 

$^{58}\text{Fe}(n,x)d$



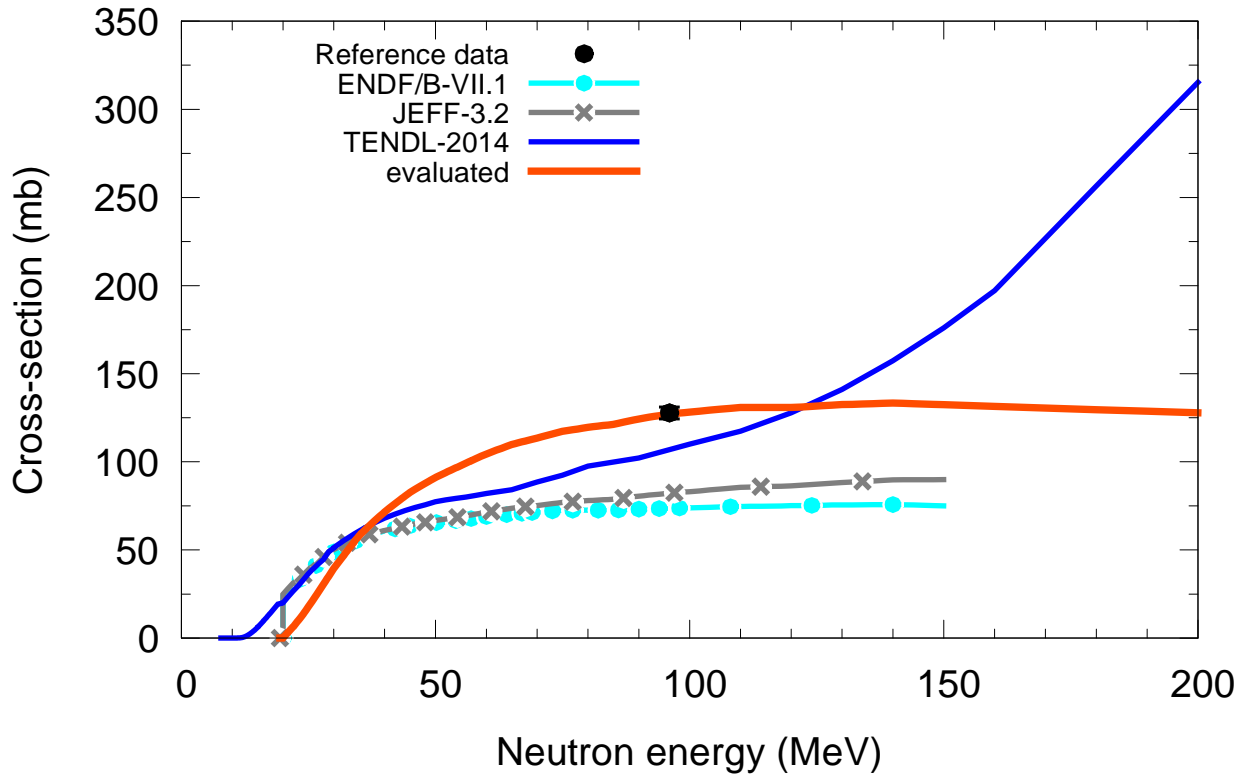
$^{59}\text{Co}(n,x)d$



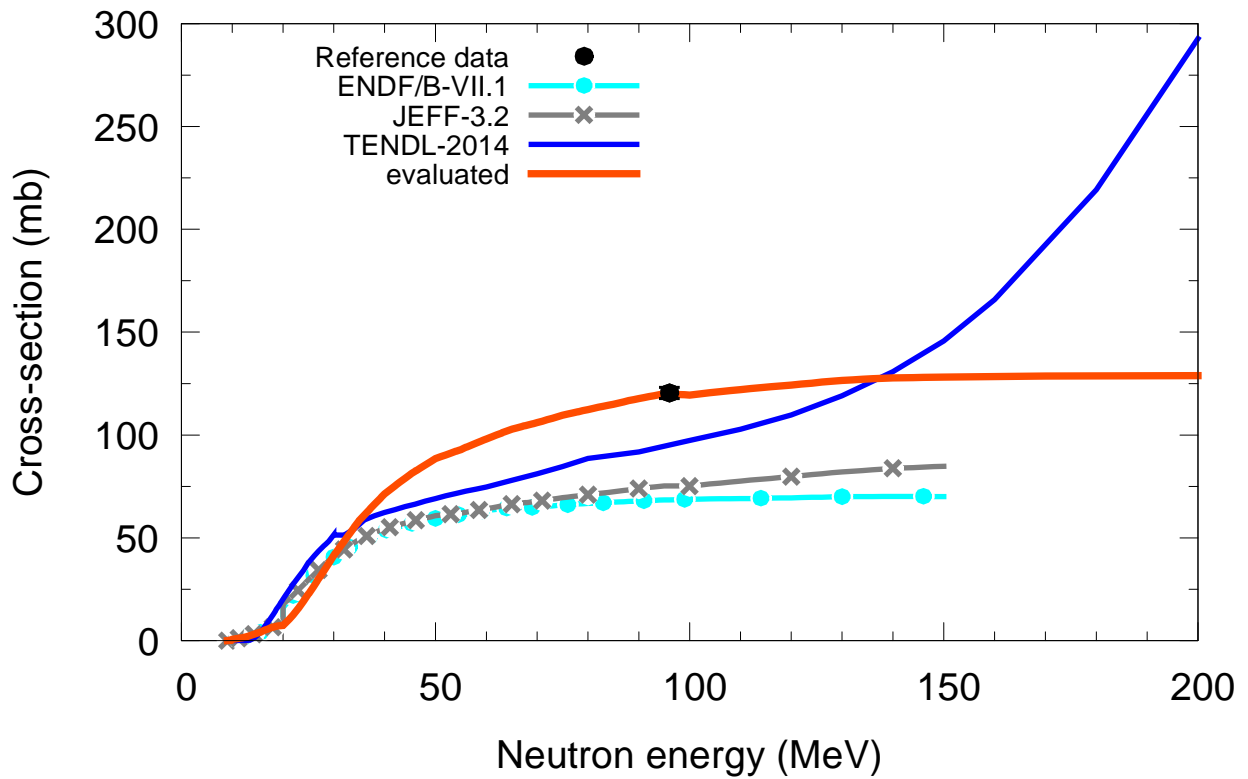
$^{58}\text{Ni}(n,x)d$  $^{60}\text{Ni}(n,x)d$ 



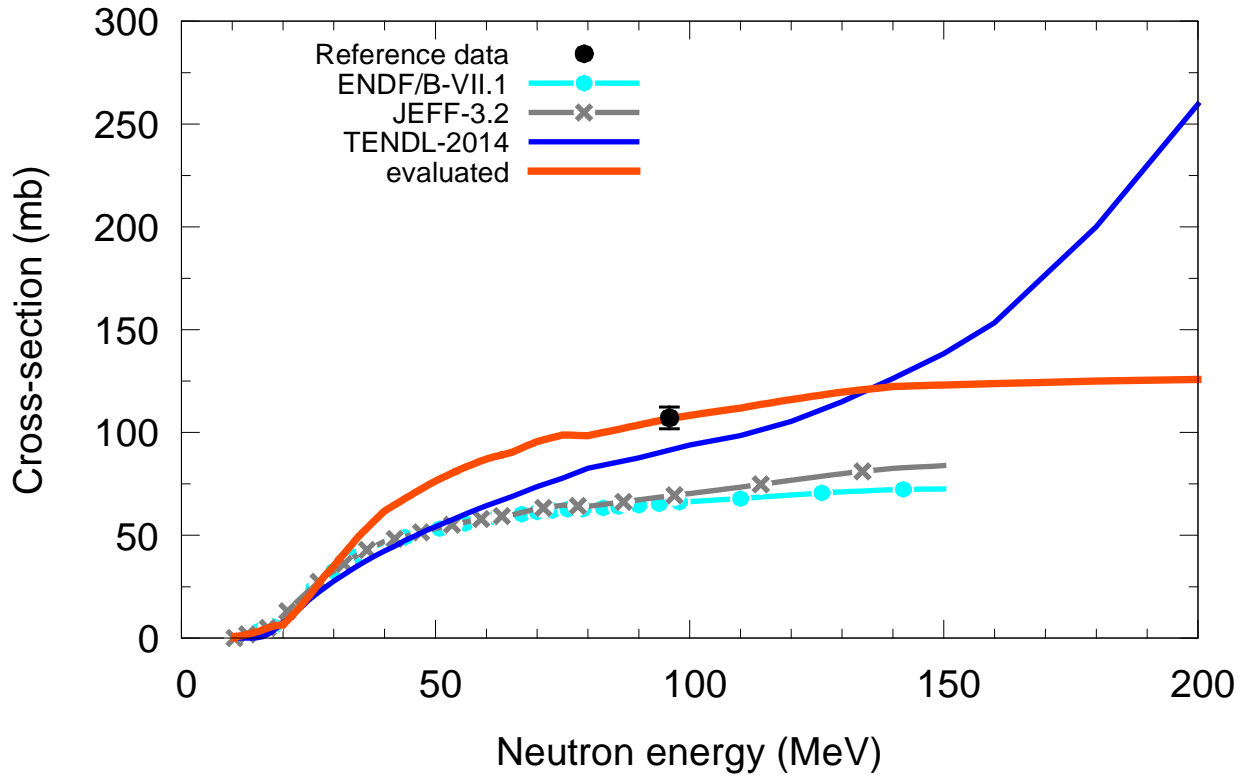
### $^{61}\text{Ni}(n,x)d$



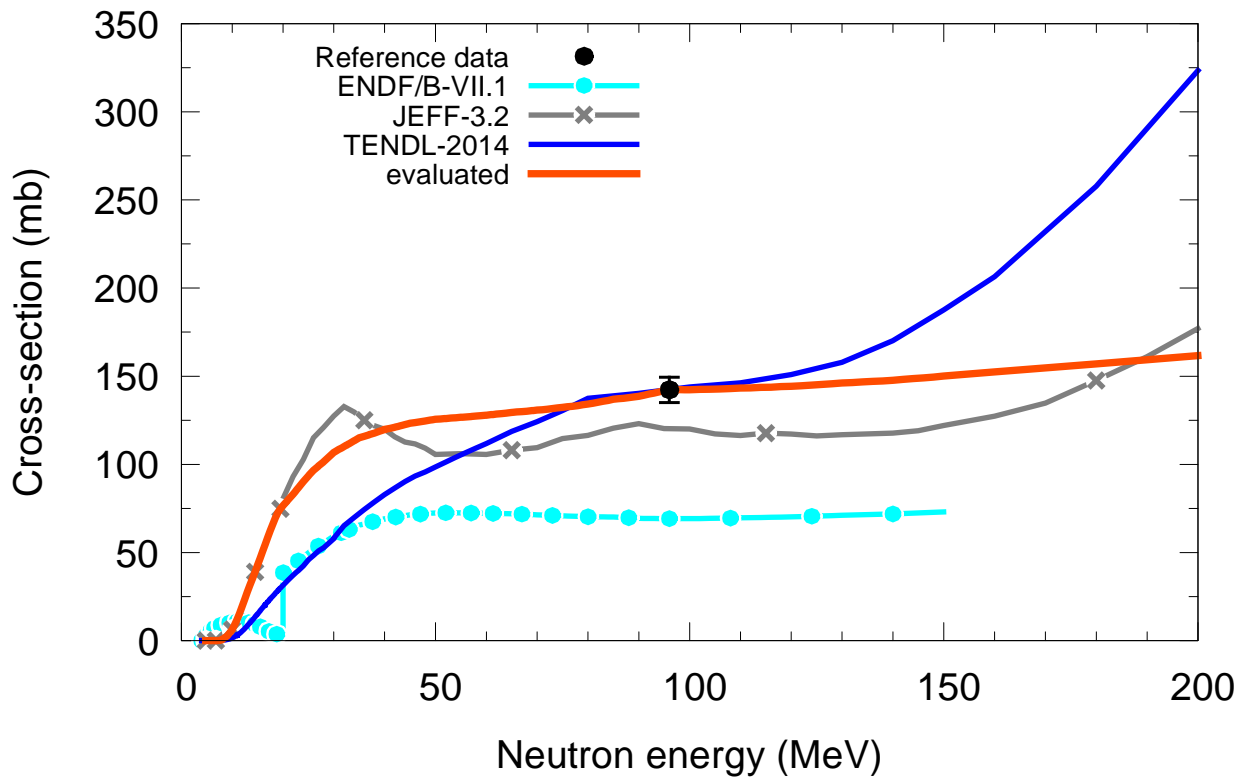
### $^{62}\text{Ni}(n,x)d$



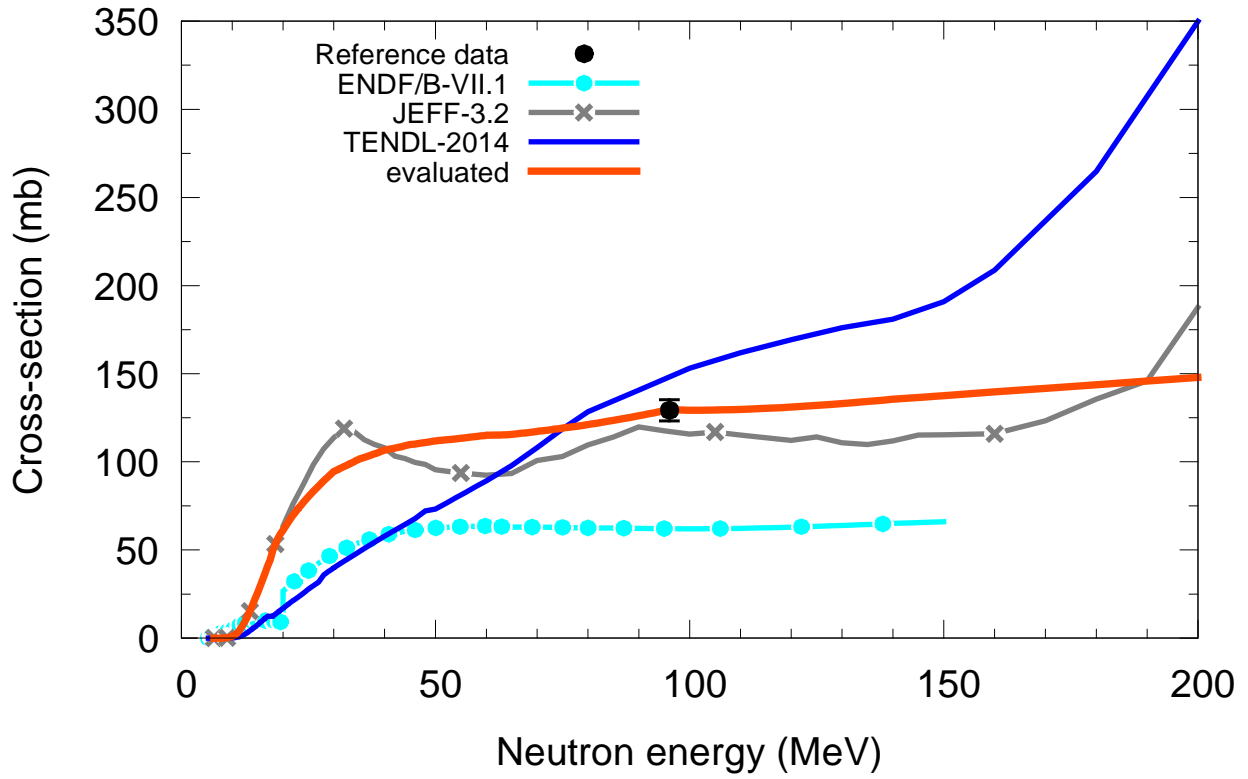
### $^{64}\text{Ni}(n,x)d$



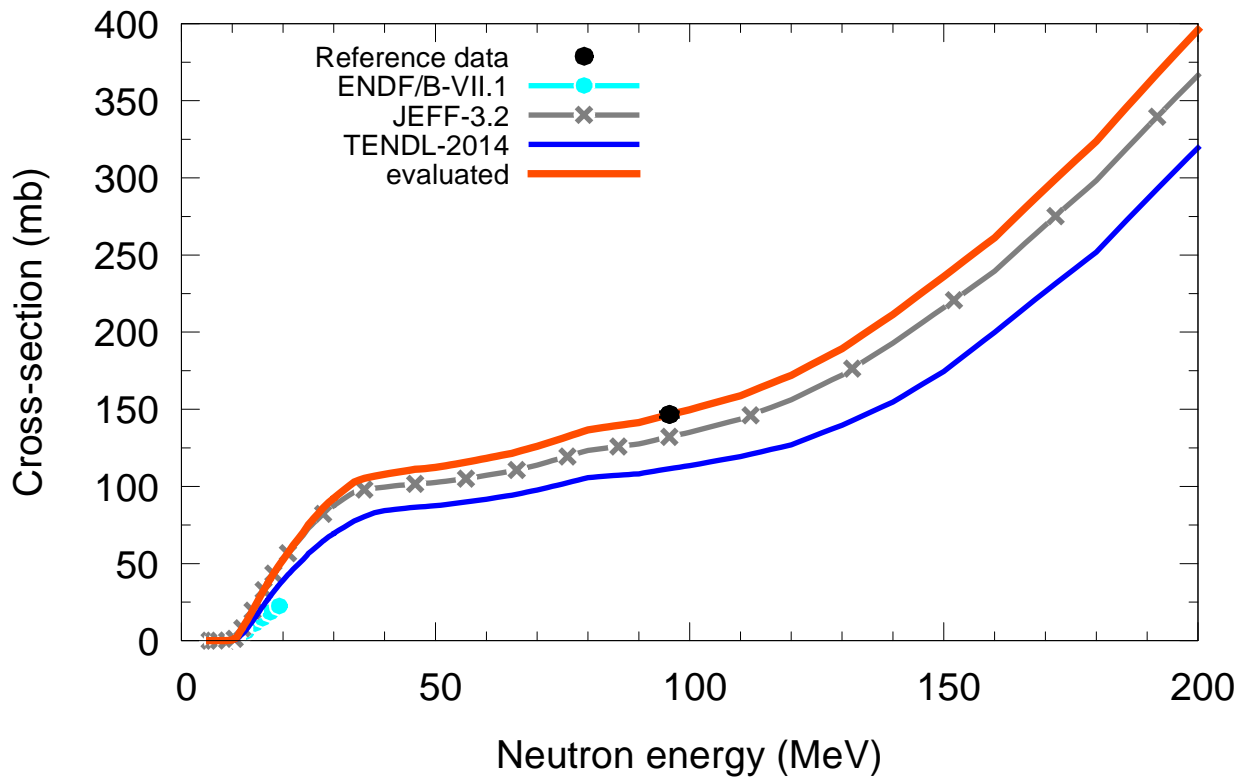
### $^{63}\text{Cu}(n,x)d$



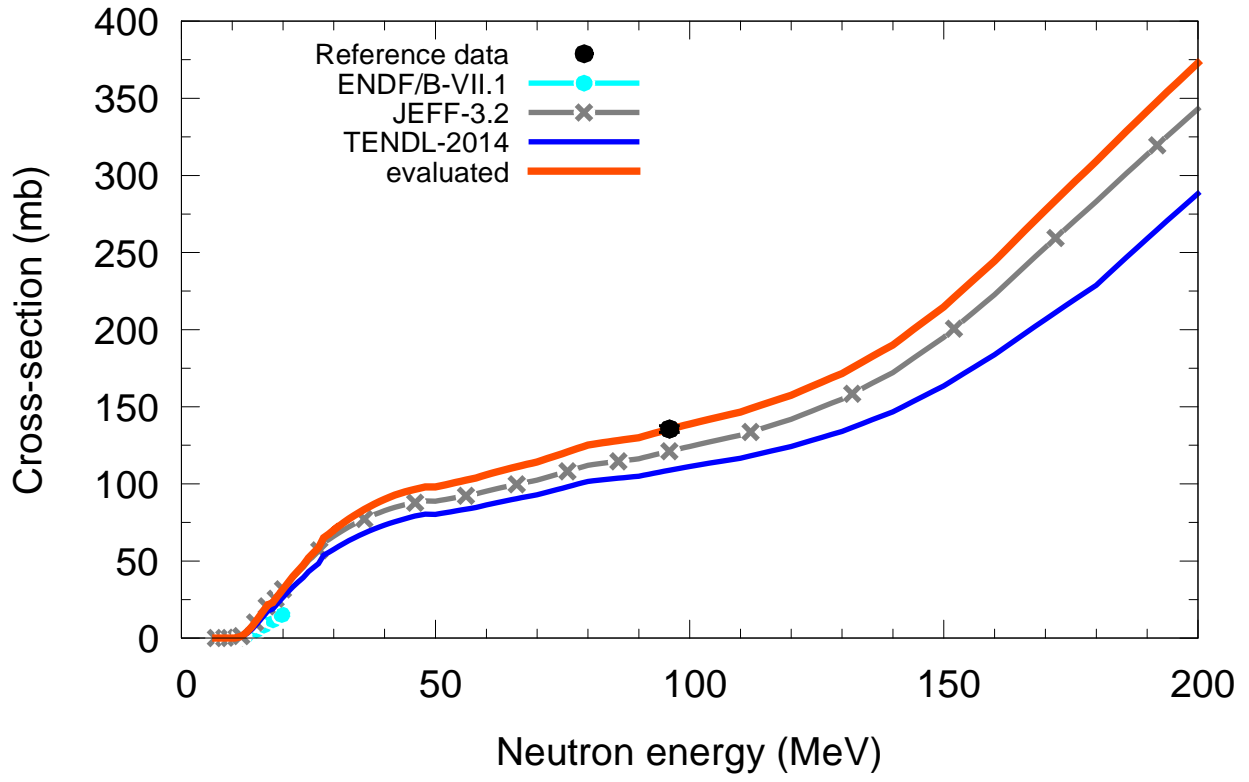
### $^{65}\text{Cu}(n,x)d$



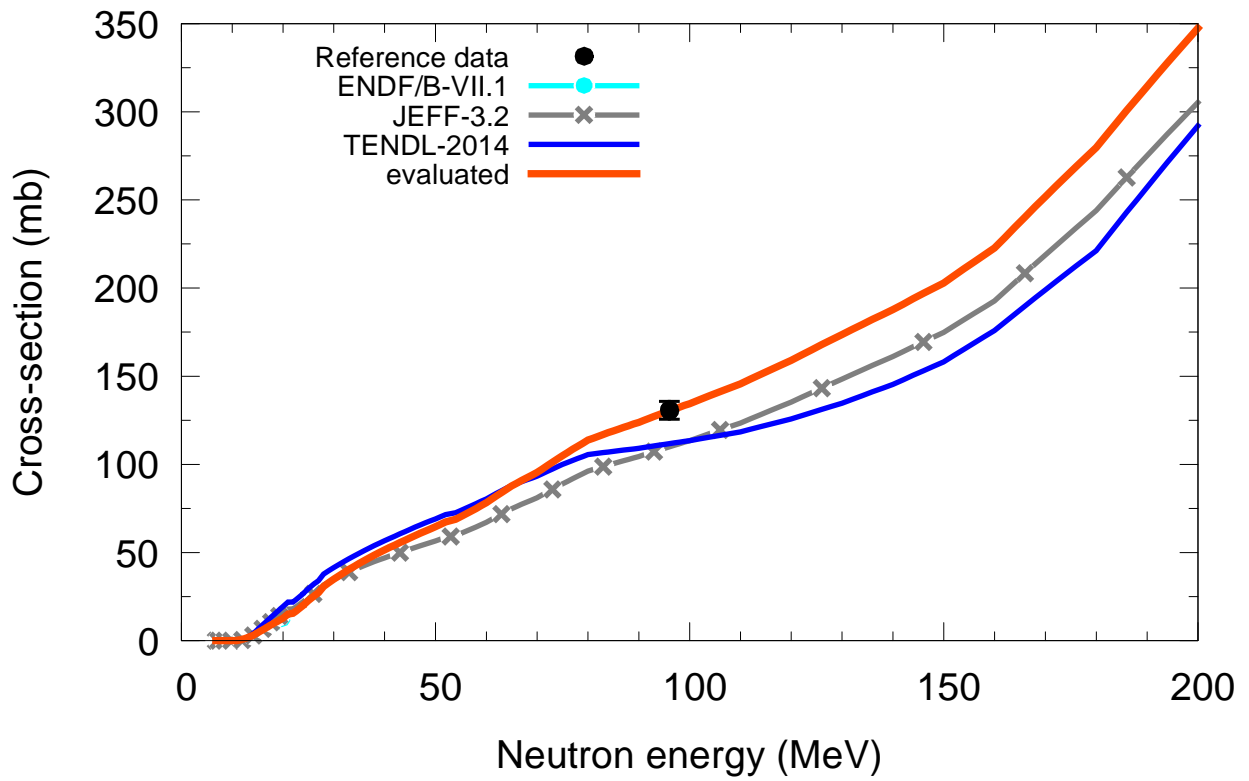
### $^{64}\text{Zn}(n,x)d$

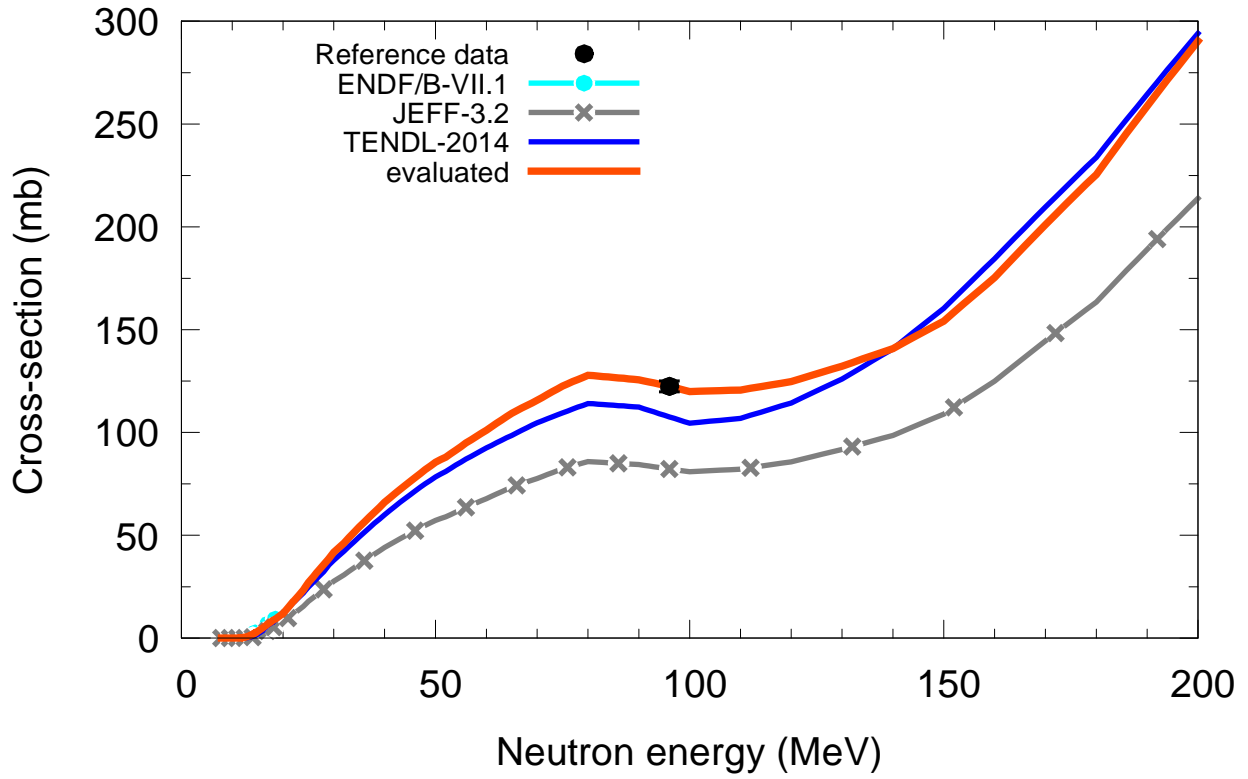
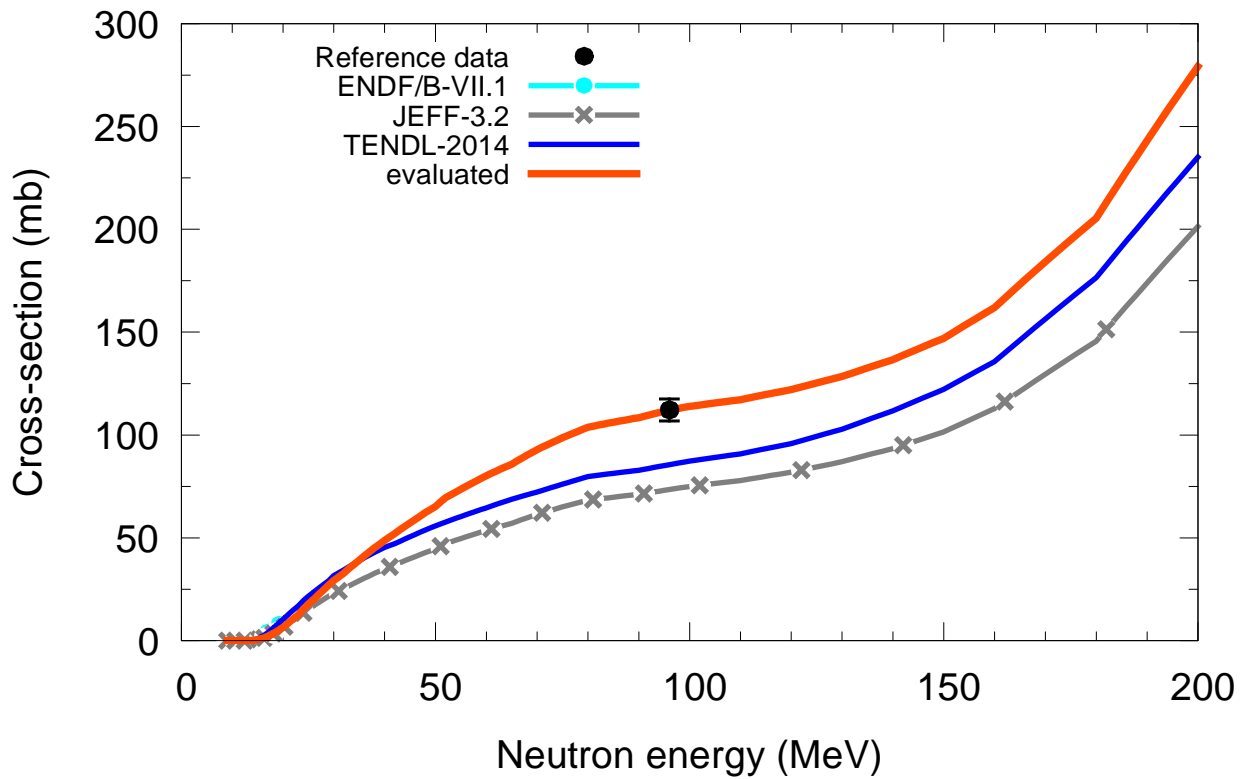


### $^{66}\text{Zn}(n,x)d$

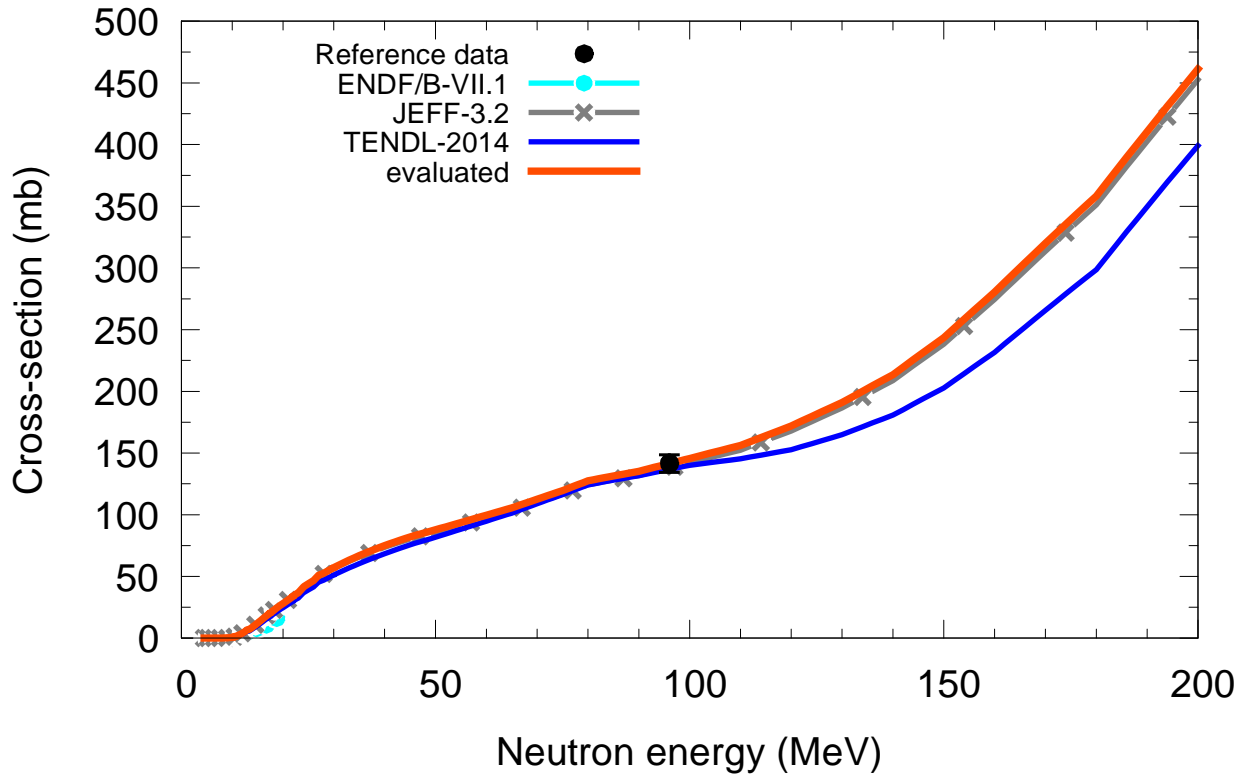


### $^{67}\text{Zn}(n,x)d$

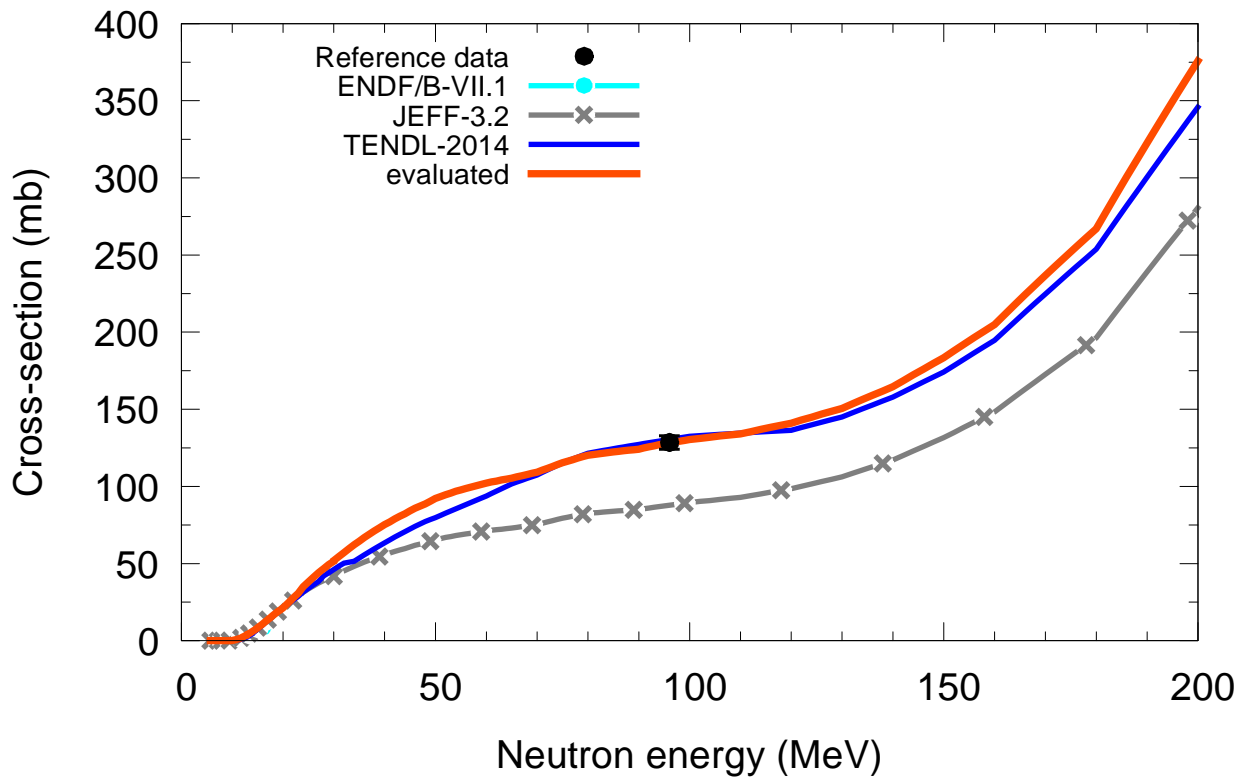


$^{68}\text{Zn}(n,x)d$  $^{70}\text{Zn}(n,x)d$ 

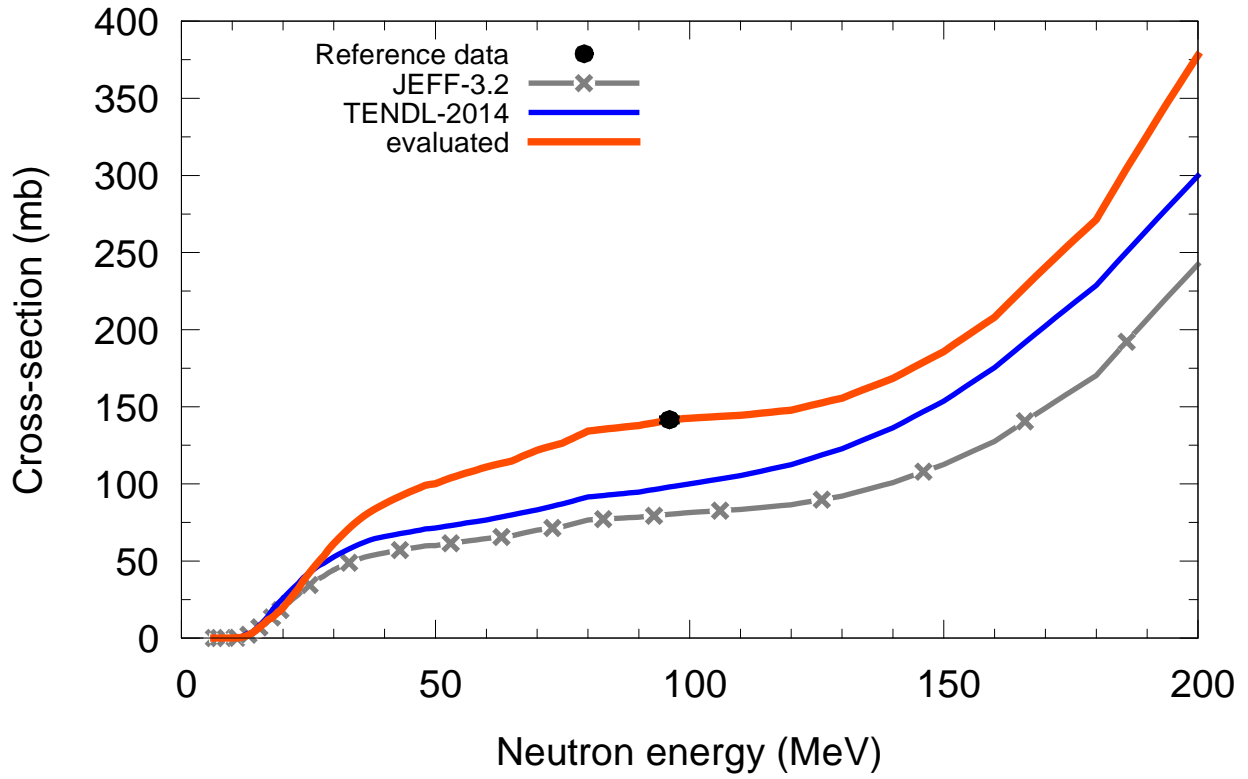
### $^{69}\text{Ga}(n,x)d$



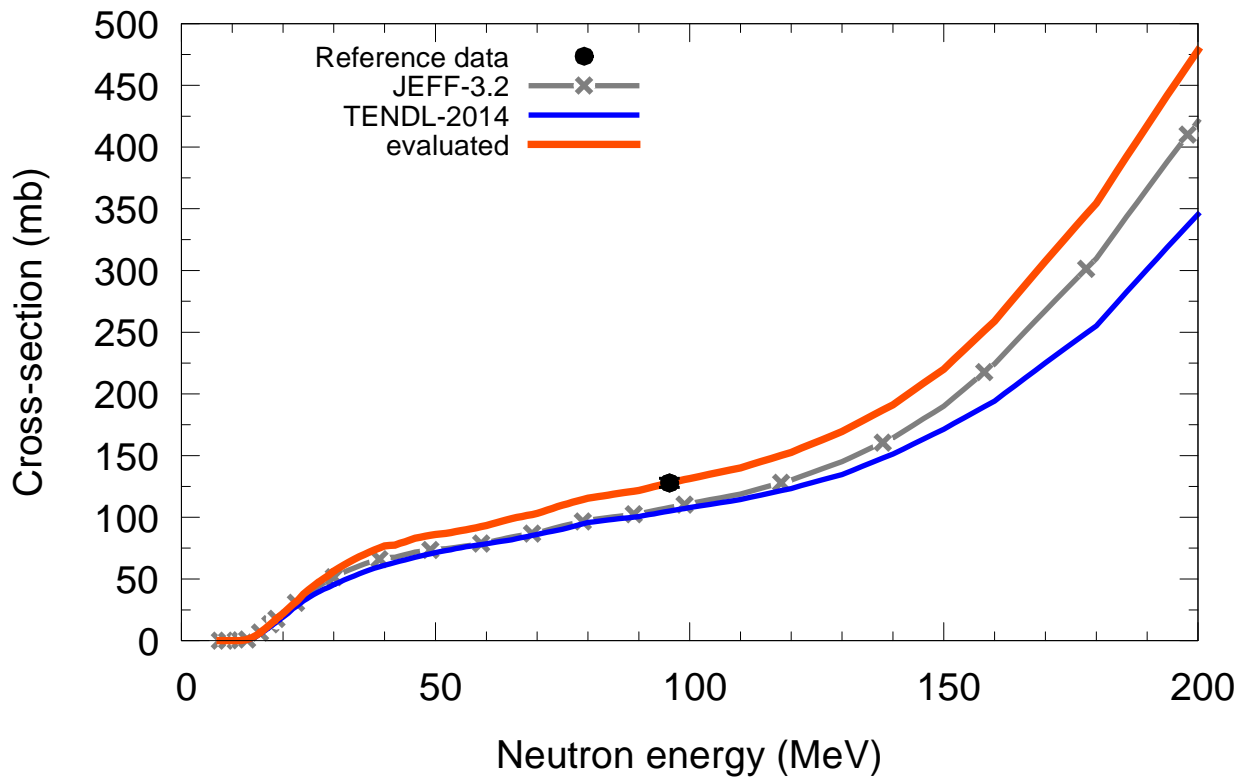
### $^{71}\text{Ga}(n,x)d$



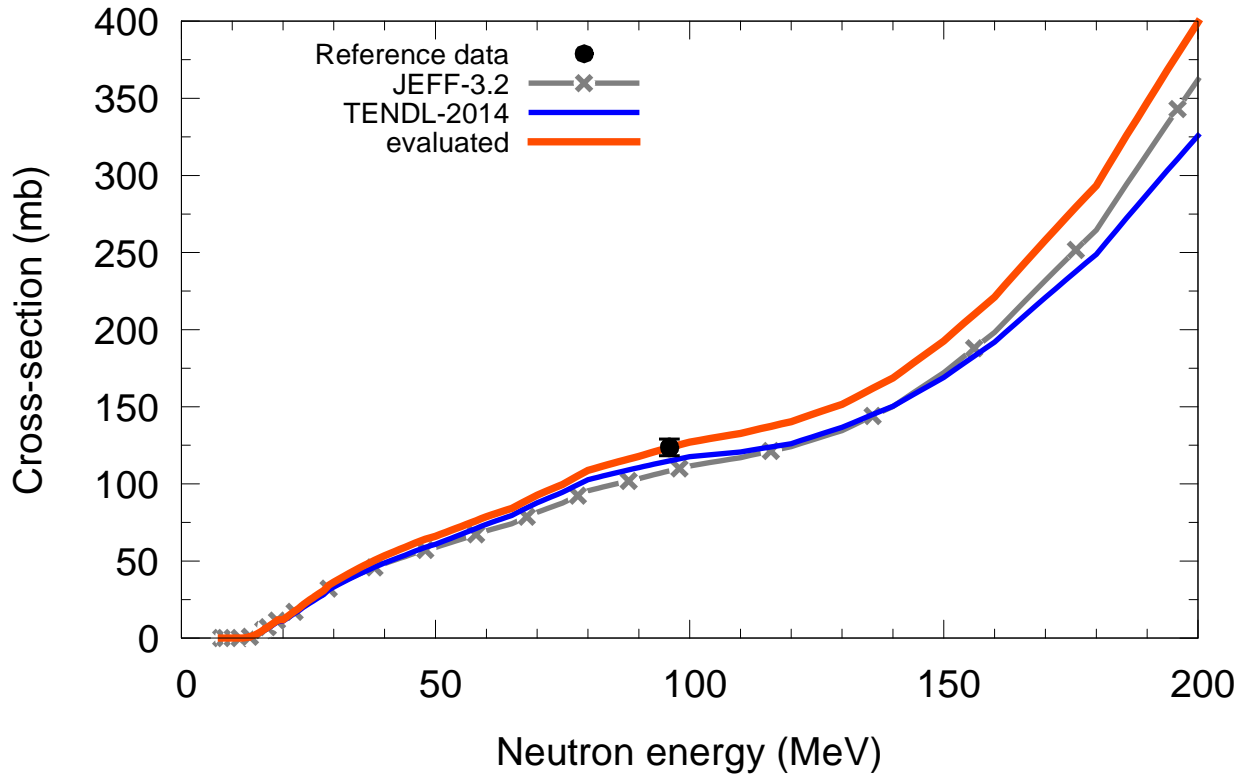
### $^{70}\text{Ge}(n,x)d$



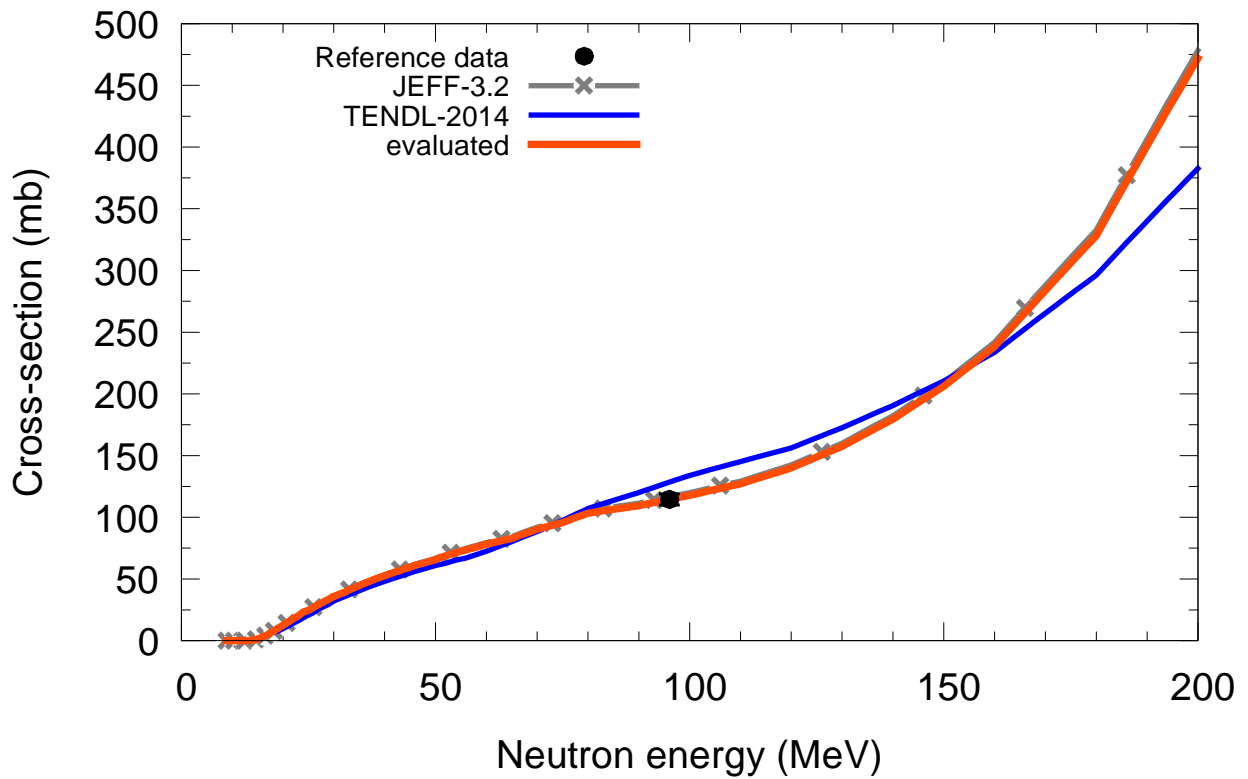
### $^{72}\text{Ge}(n,x)d$



### $^{73}\text{Ge}(n,x)d$

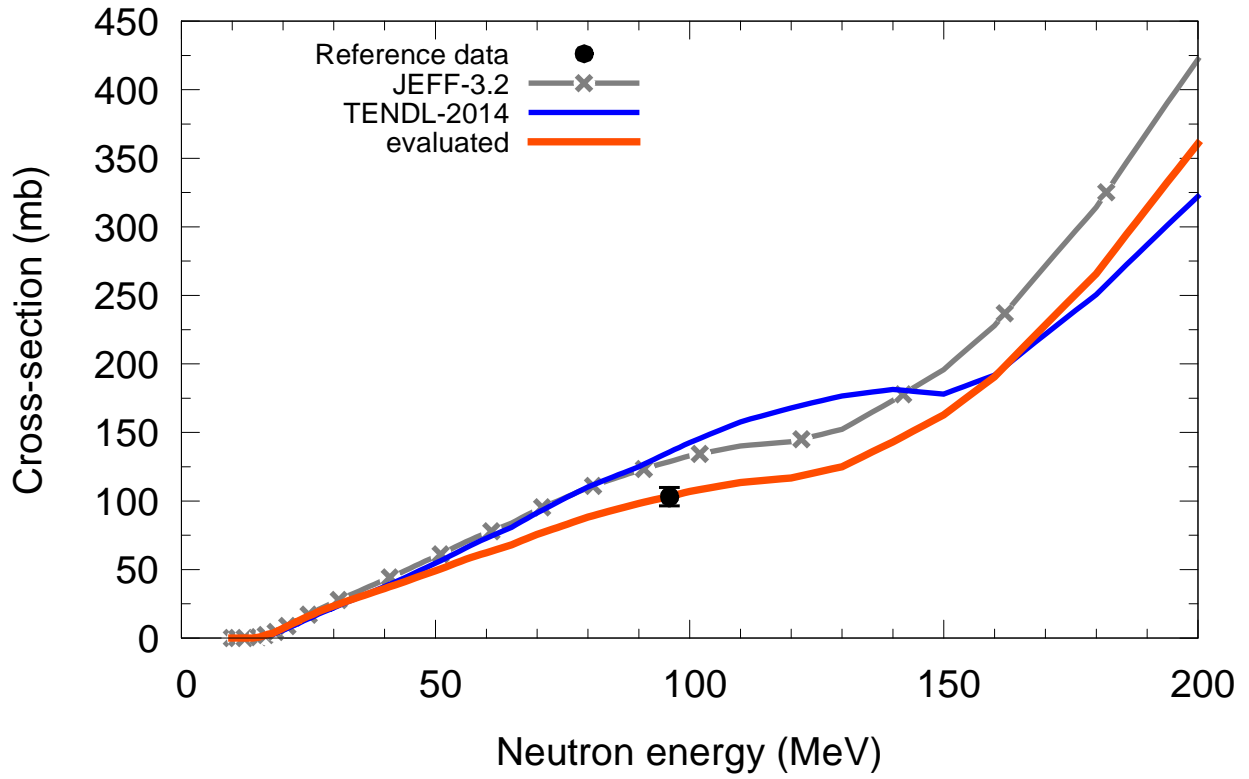


### $^{74}\text{Ge}(n,x)d$

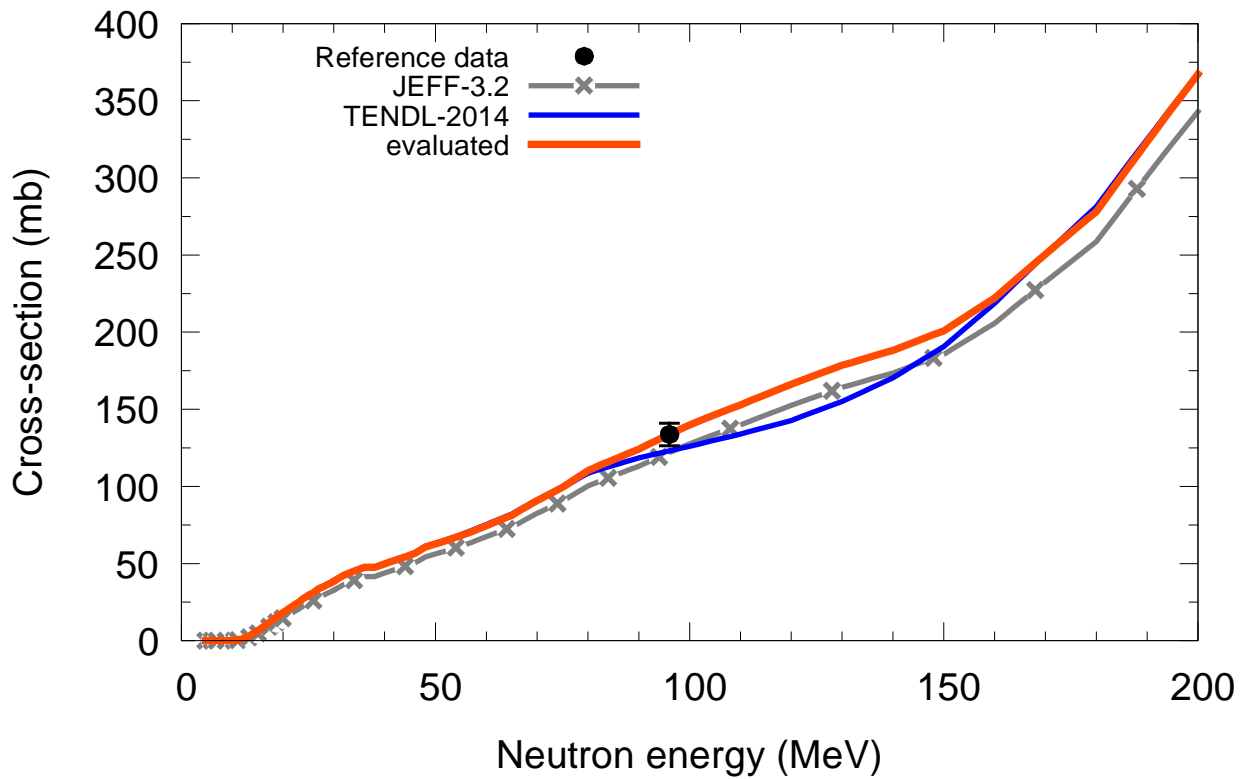




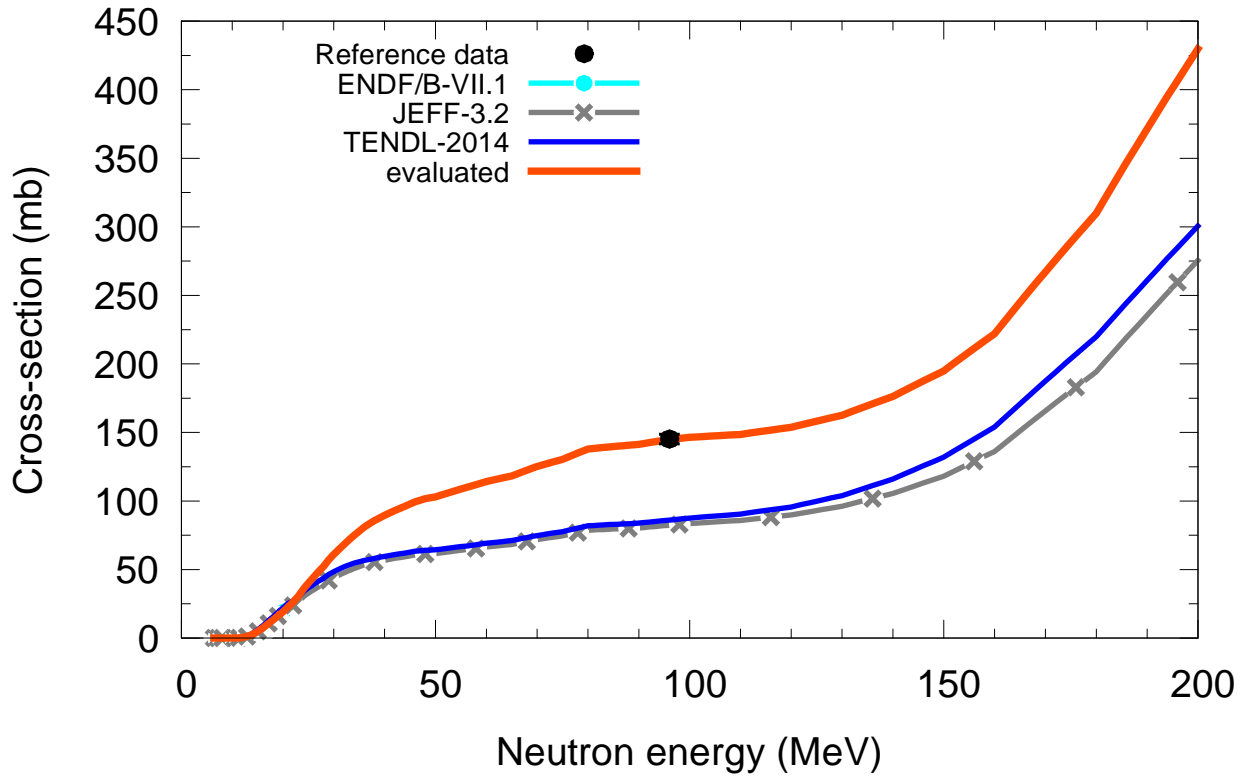
$^{76}\text{Ge}(n,x)d$



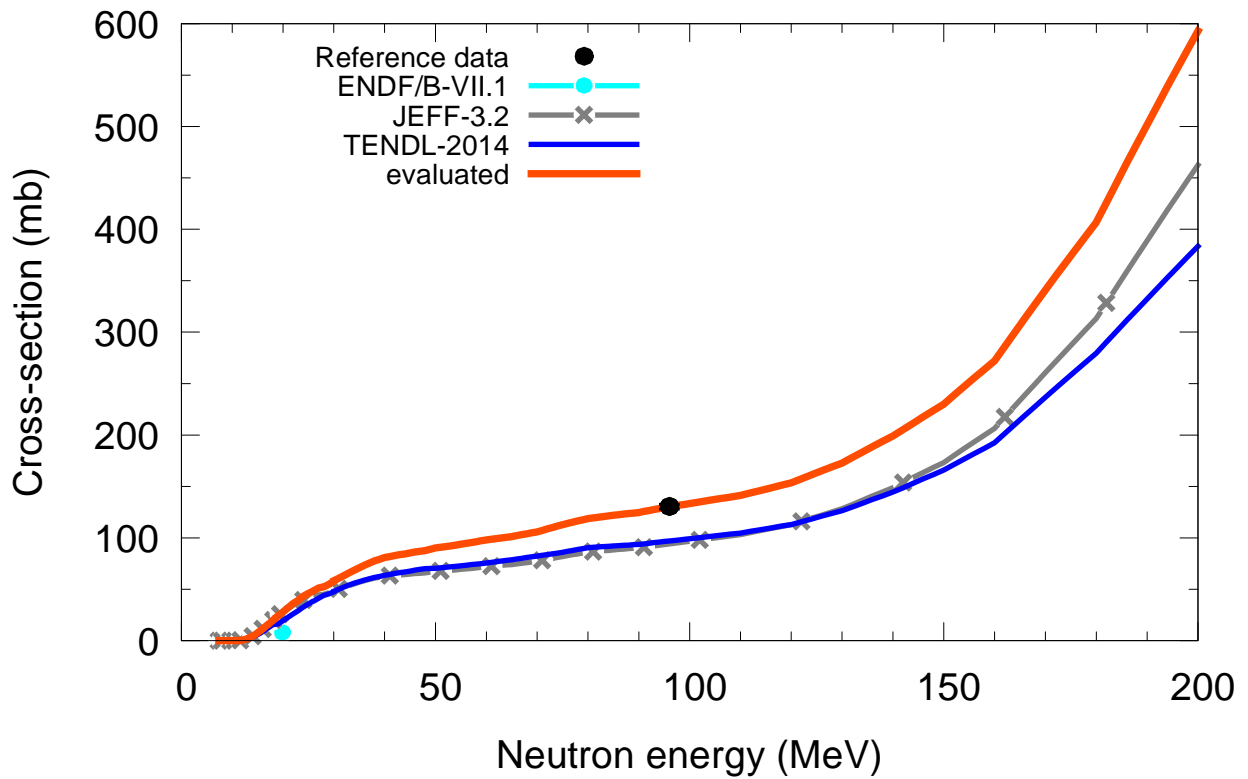
$^{75}\text{As}(n,x)d$



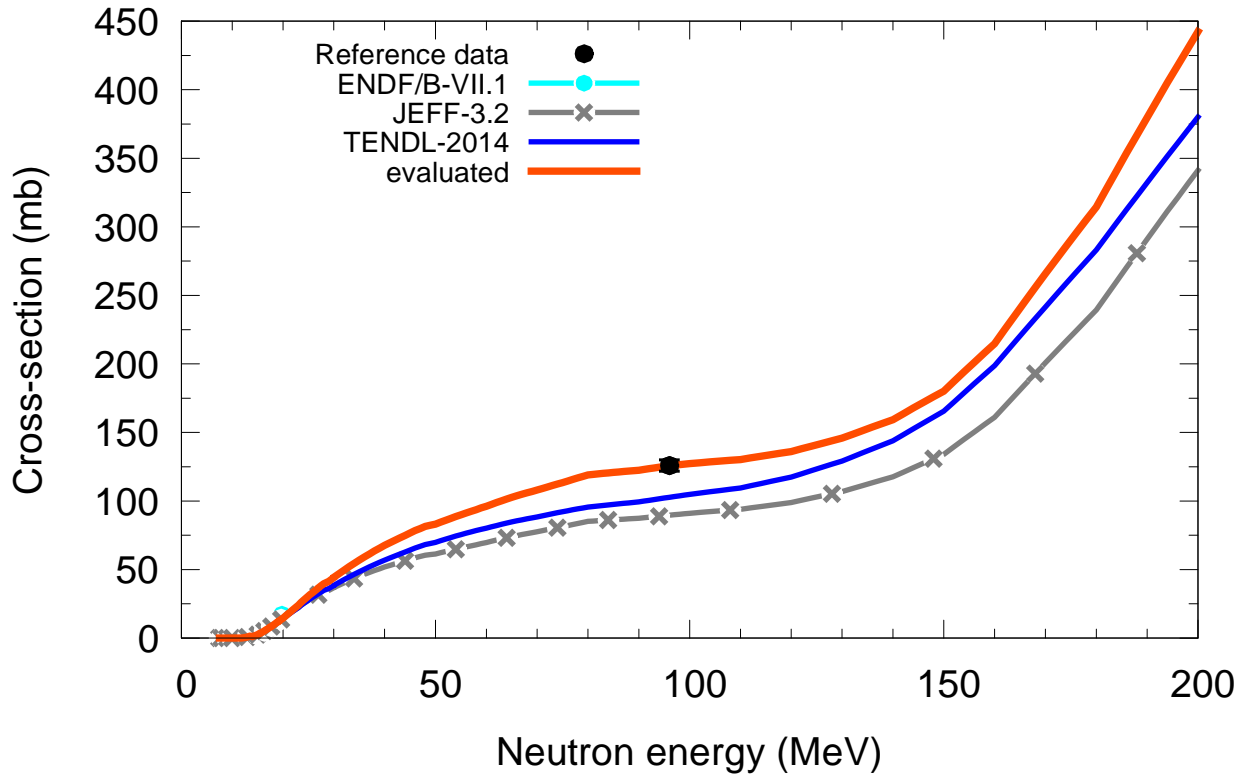
### $^{74}\text{Se}(n,x)d$



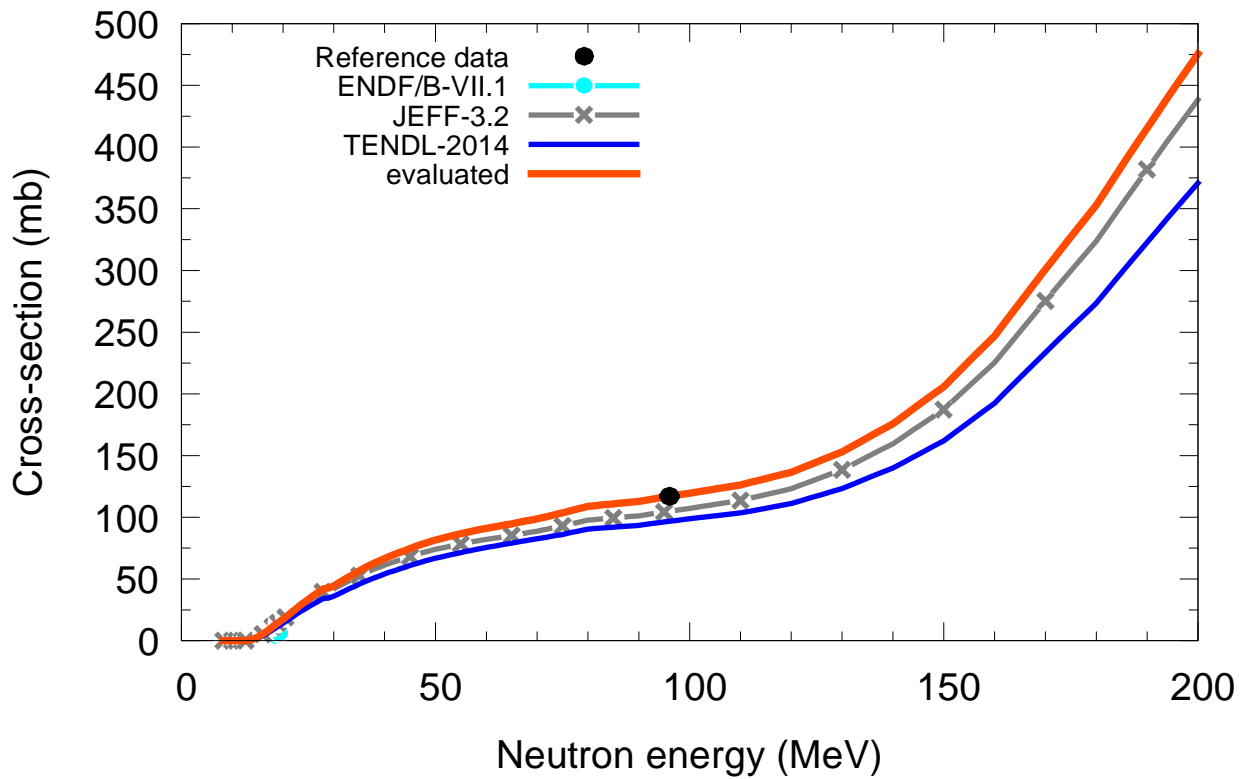
### $^{76}\text{Se}(n,x)d$



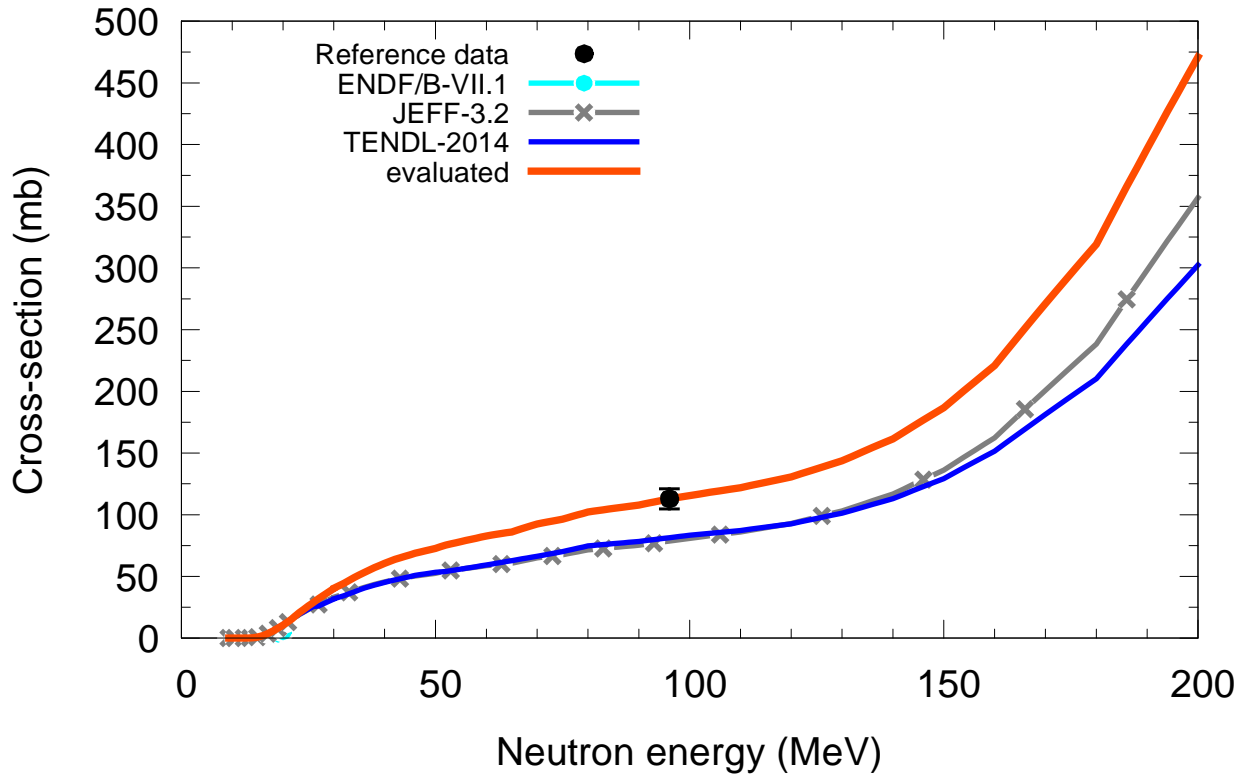
### $^{77}\text{Se}(n,x)d$



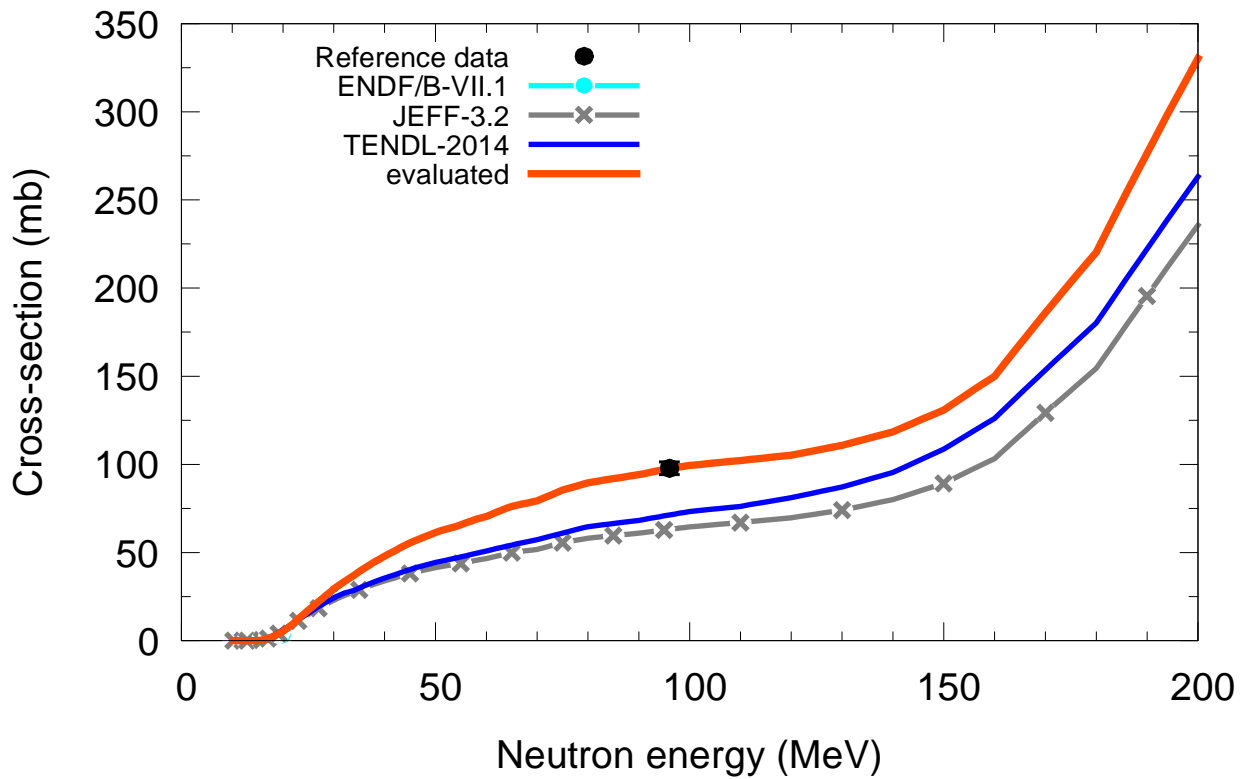
### $^{78}\text{Se}(n,x)d$



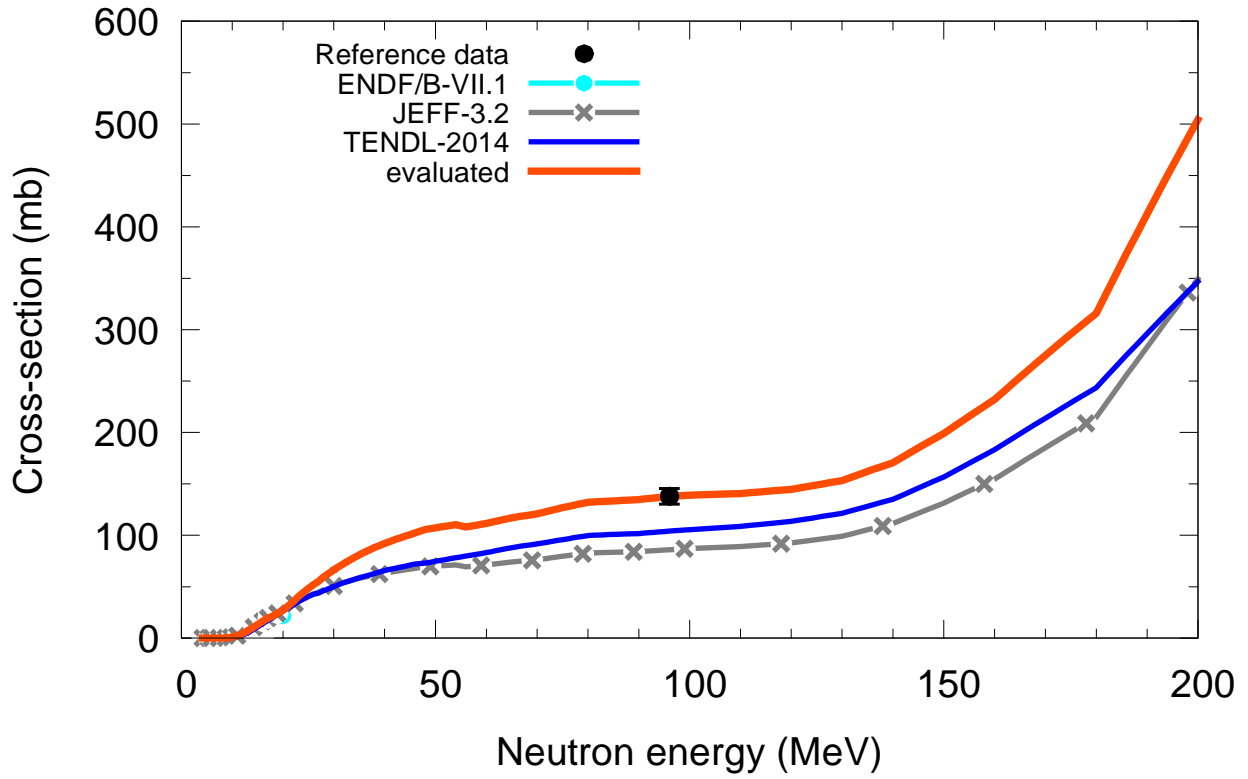
### $^{80}\text{Se}(n,x)d$



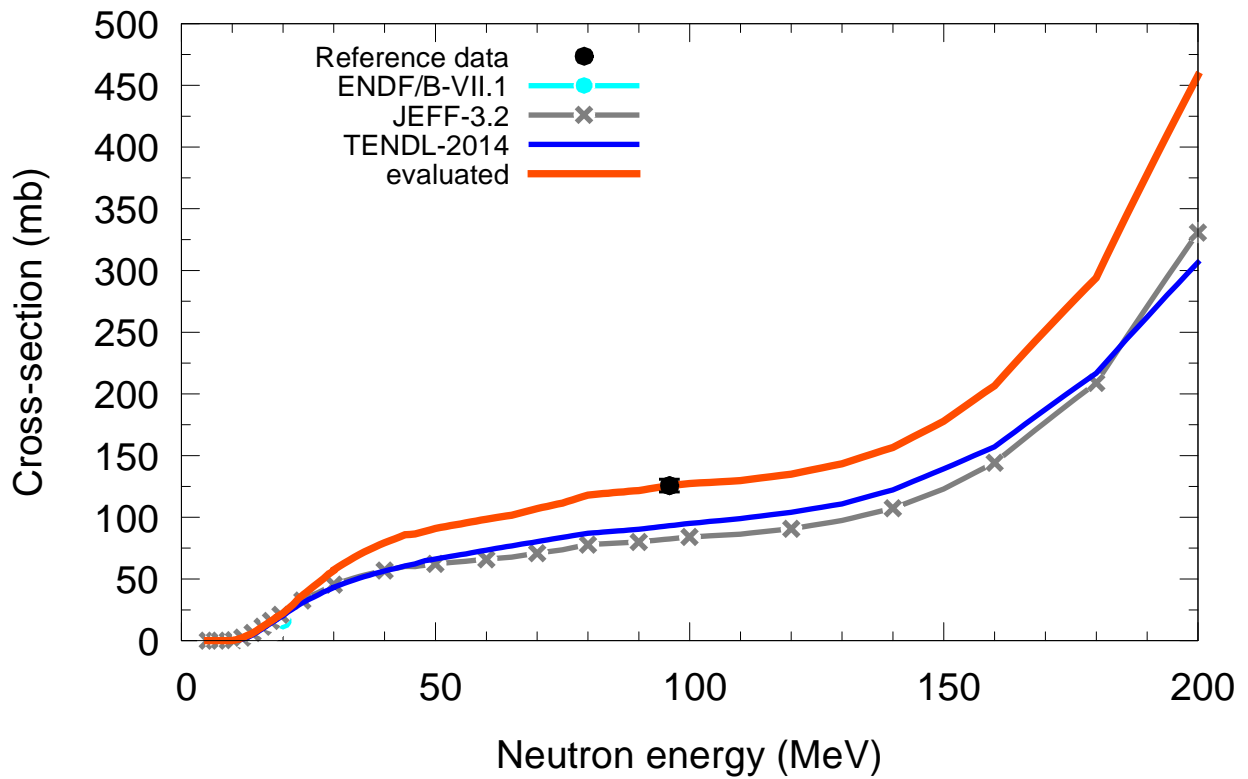
### $^{82}\text{Se}(n,x)d$



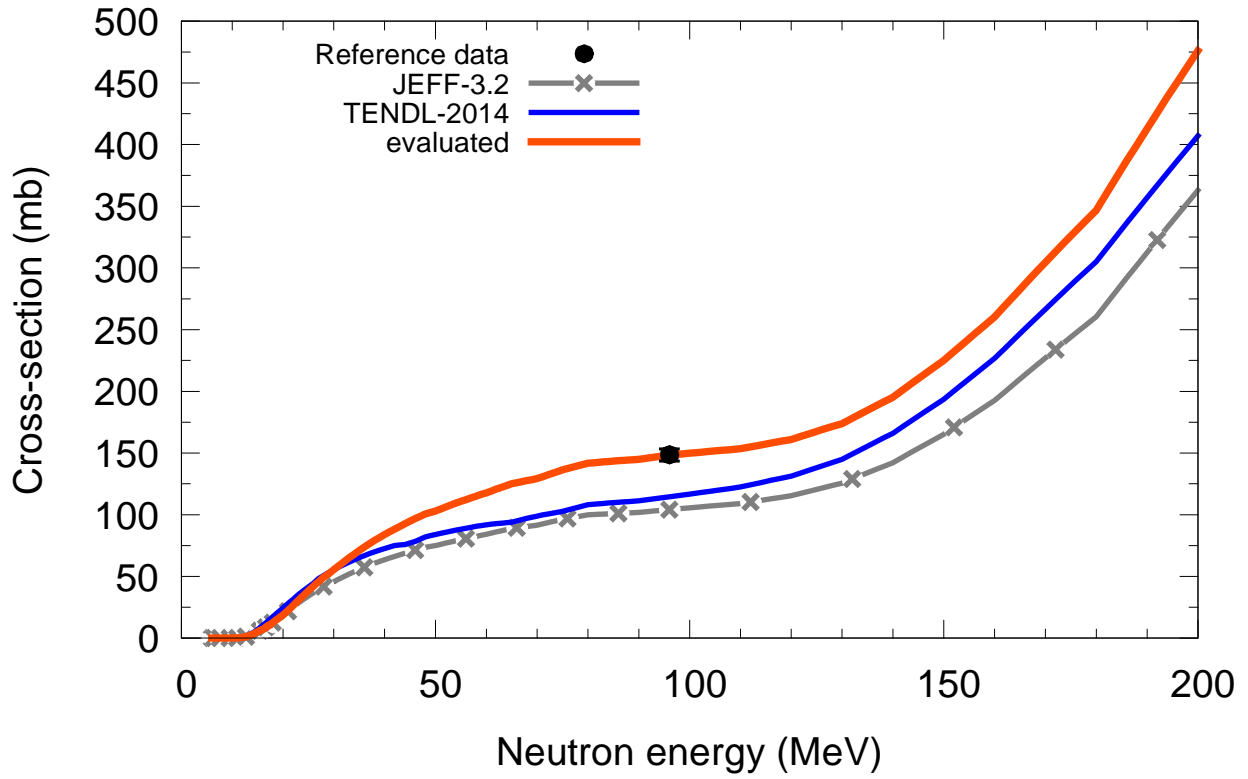
$^{79}\text{Br}(n,x)d$



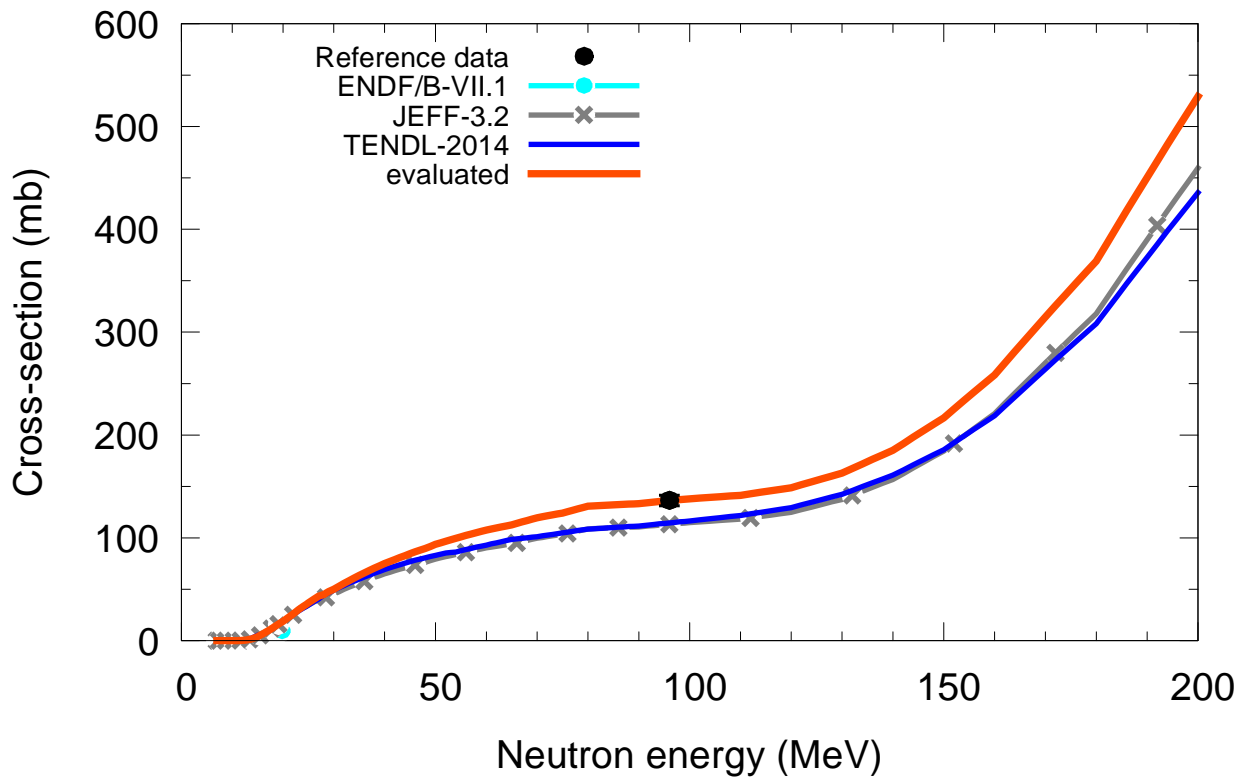
$^{81}\text{Br}(n,x)d$

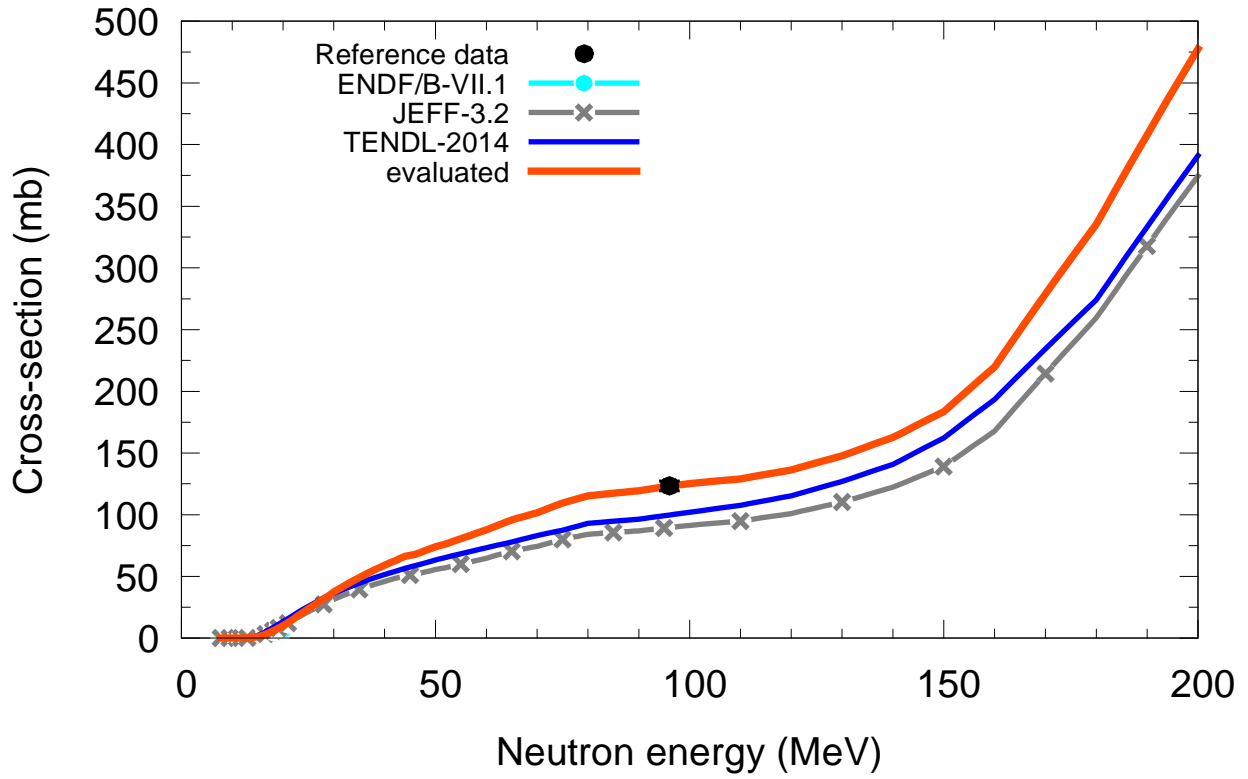
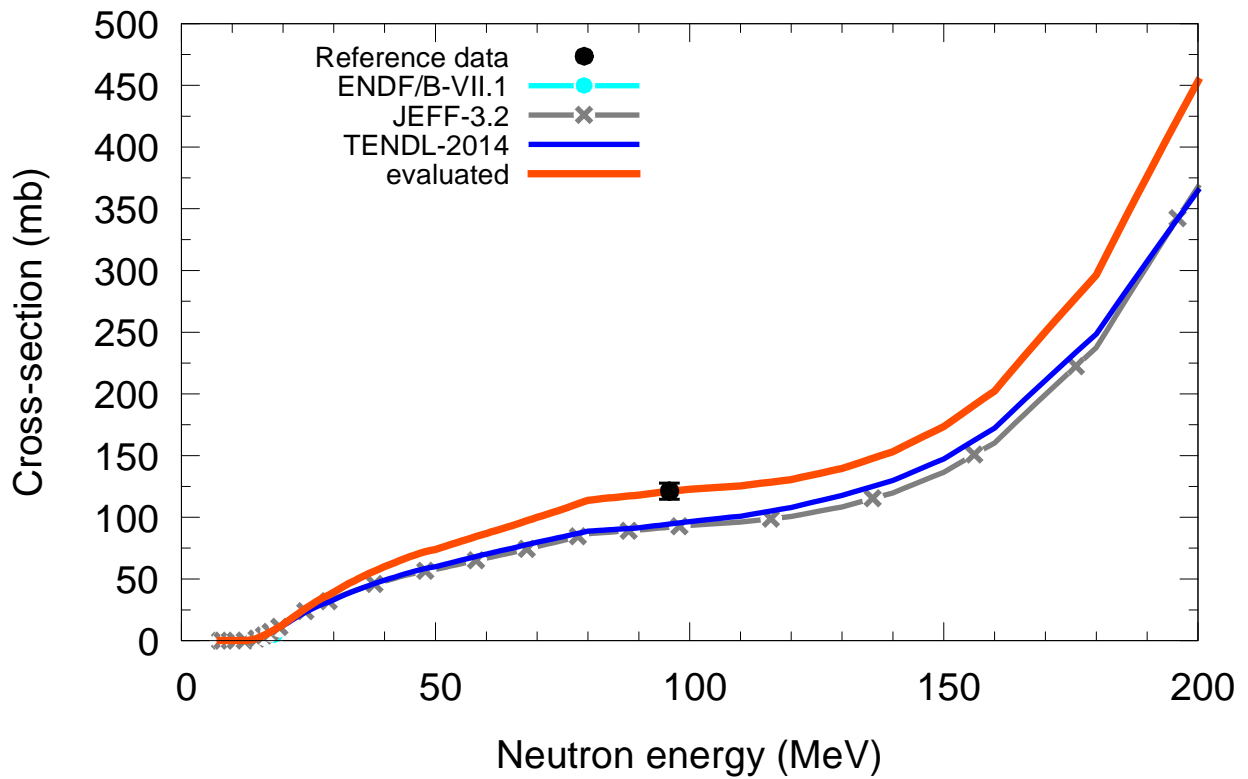


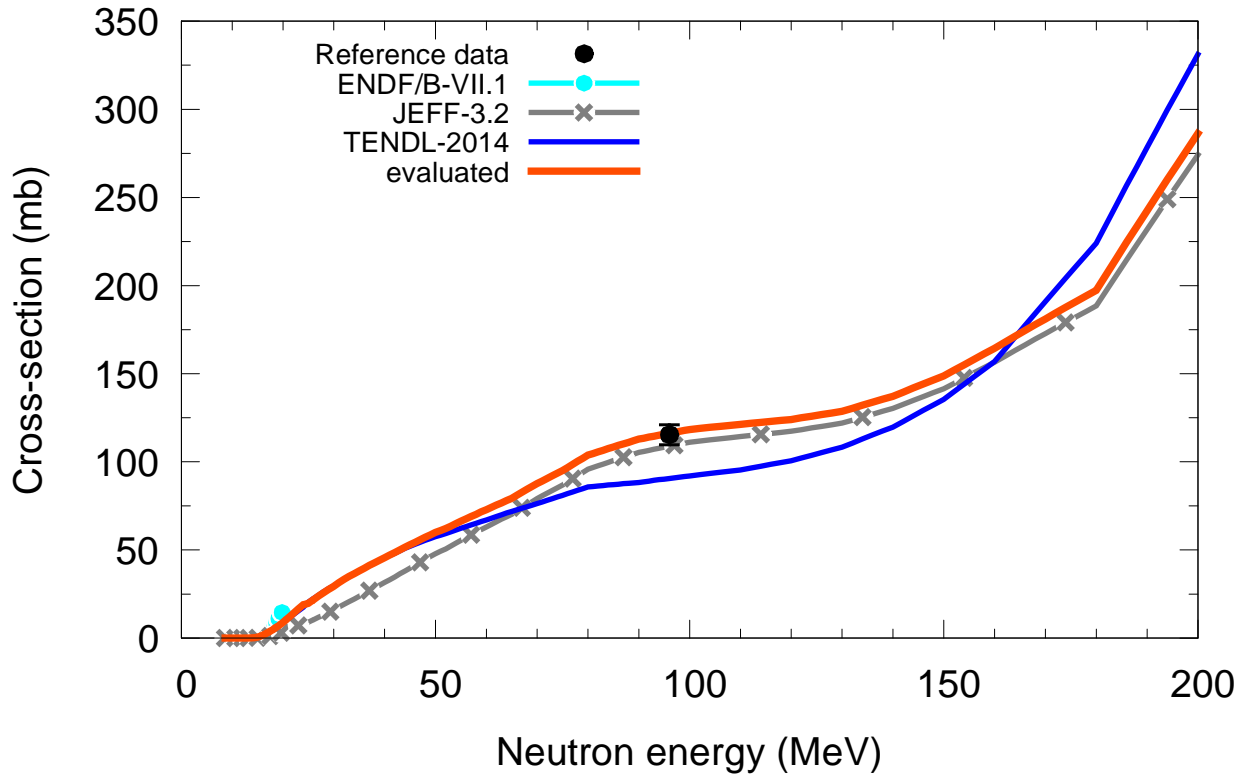
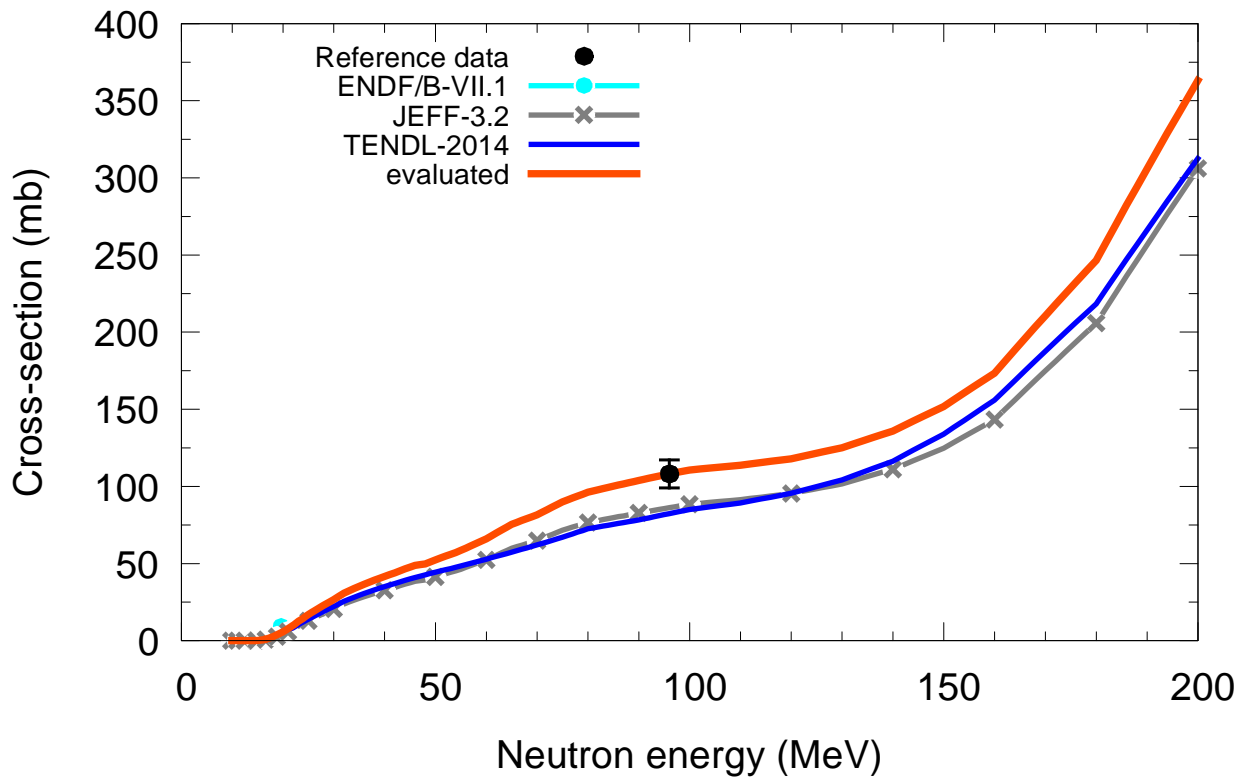
$^{78}\text{Kr}(n,x)d$



$^{80}\text{Kr}(n,x)d$

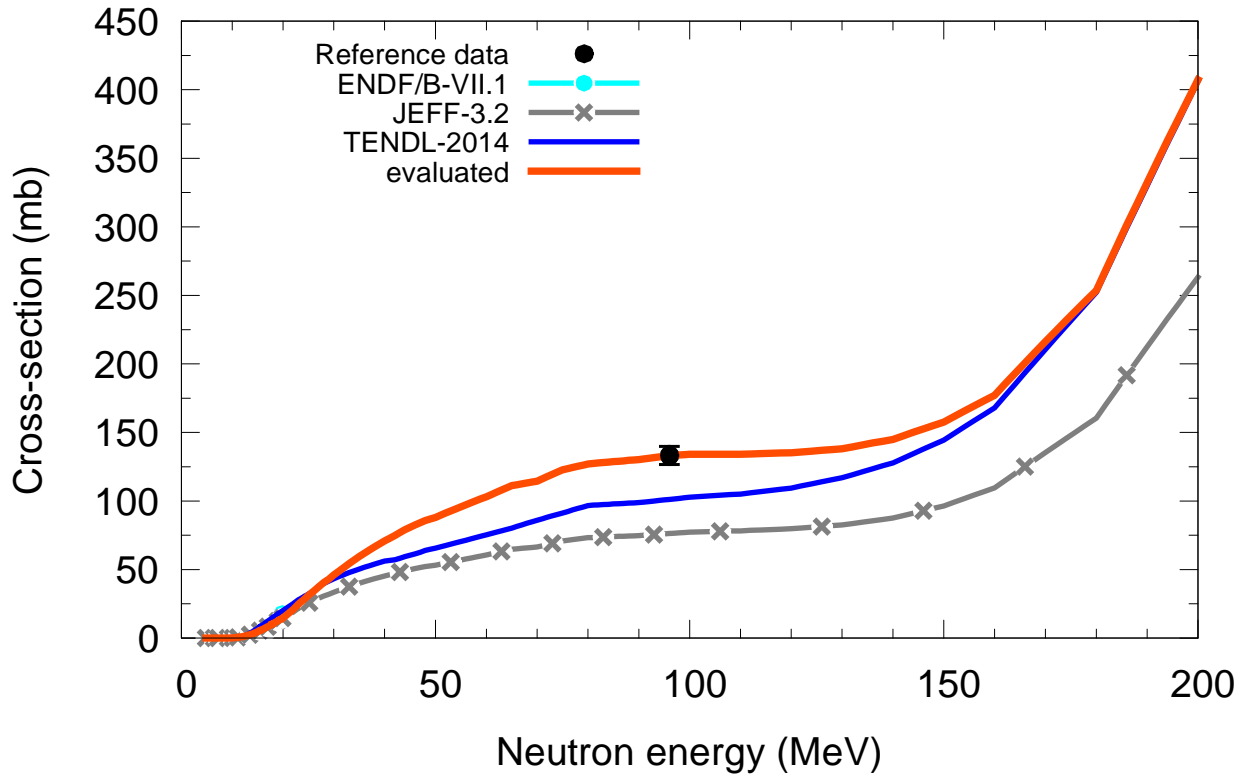


$^{82}\text{Kr}(n,x)d$  $^{83}\text{Kr}(n,x)d$ 

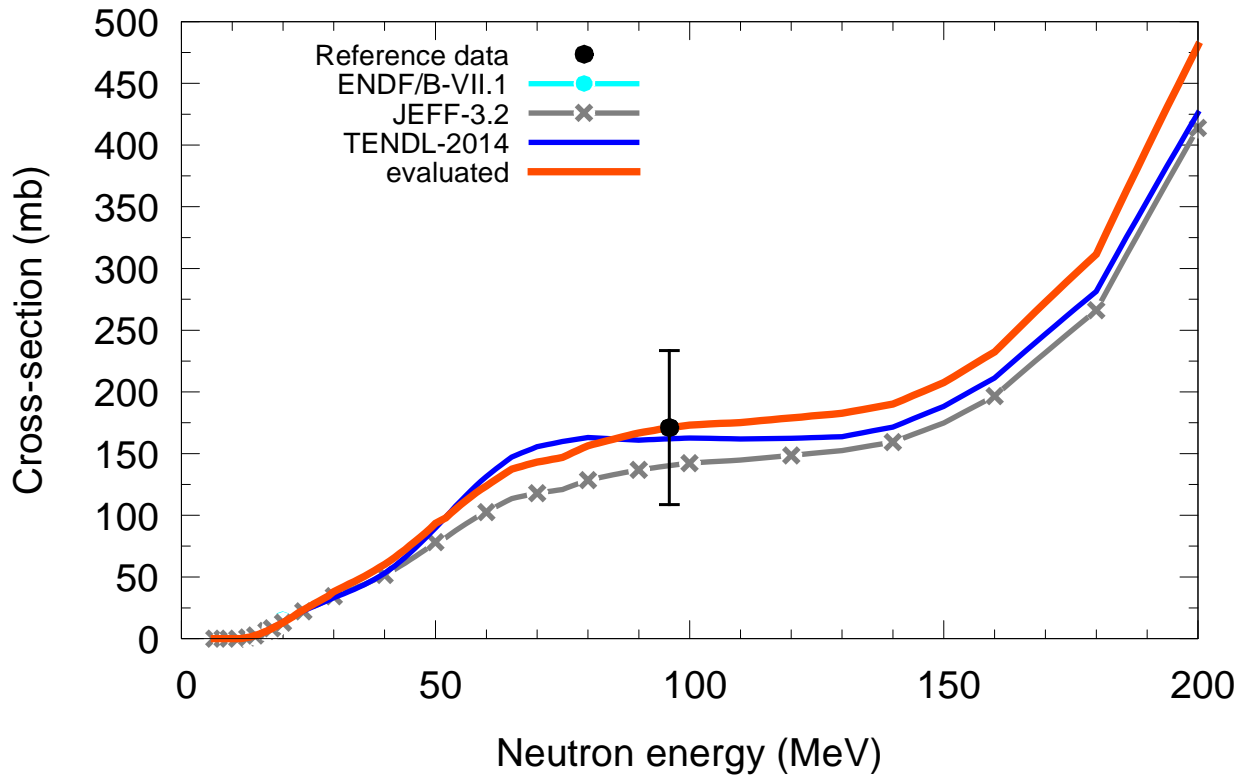
$^{84}\text{Kr}(n,x)d$  $^{86}\text{Kr}(n,x)d$ 



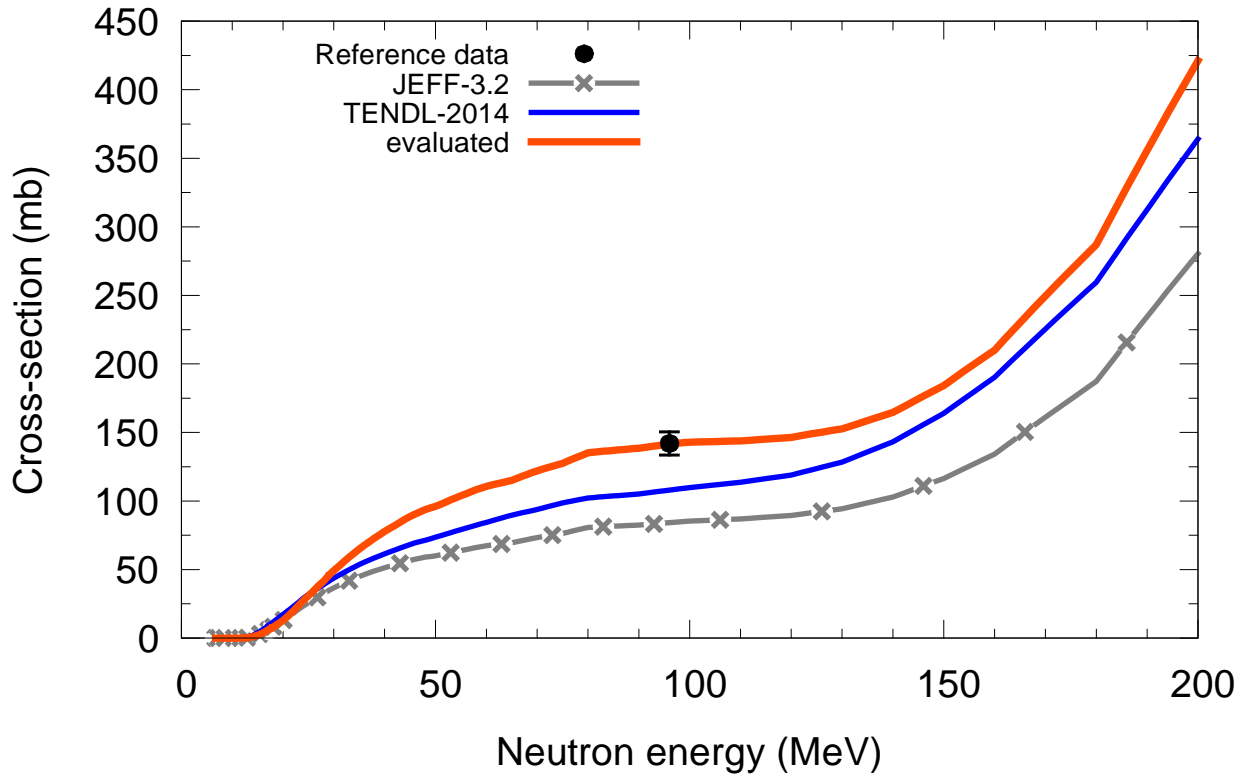
### $^{85}\text{Rb}(n,x)d$



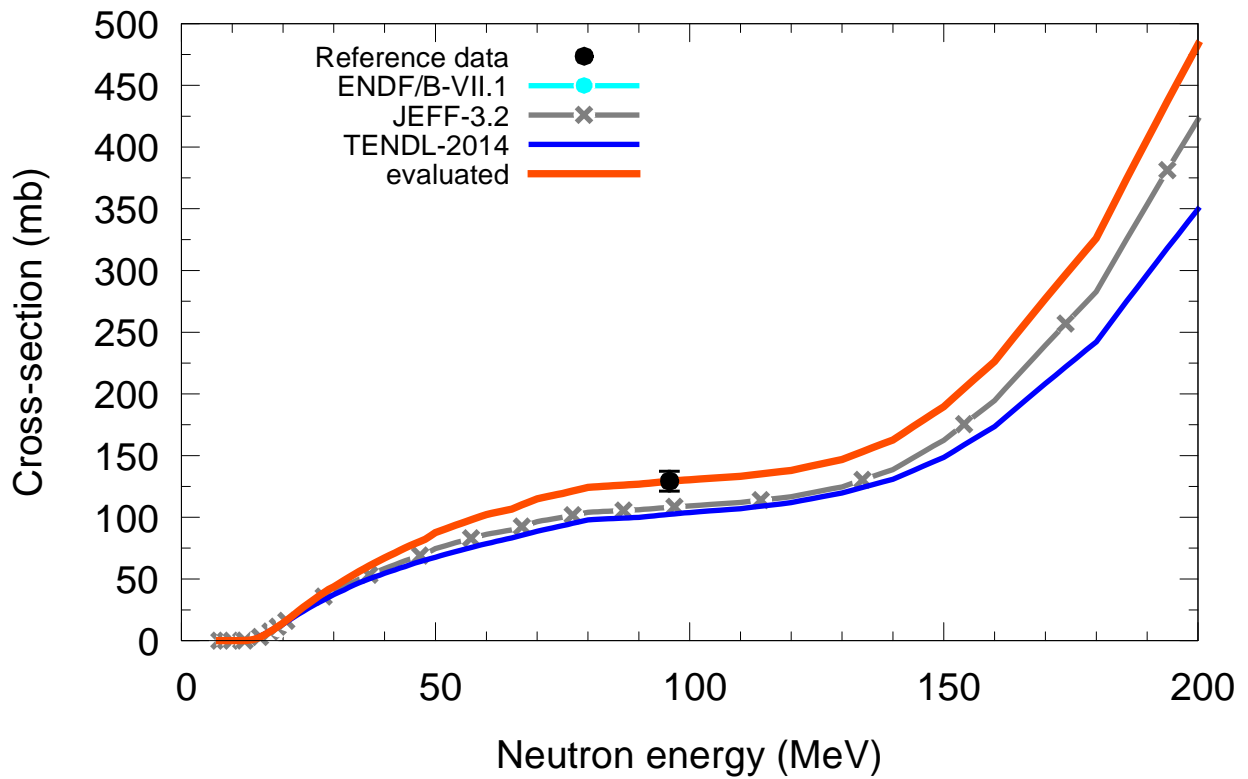
### $^{87}\text{Rb}(n,x)d$



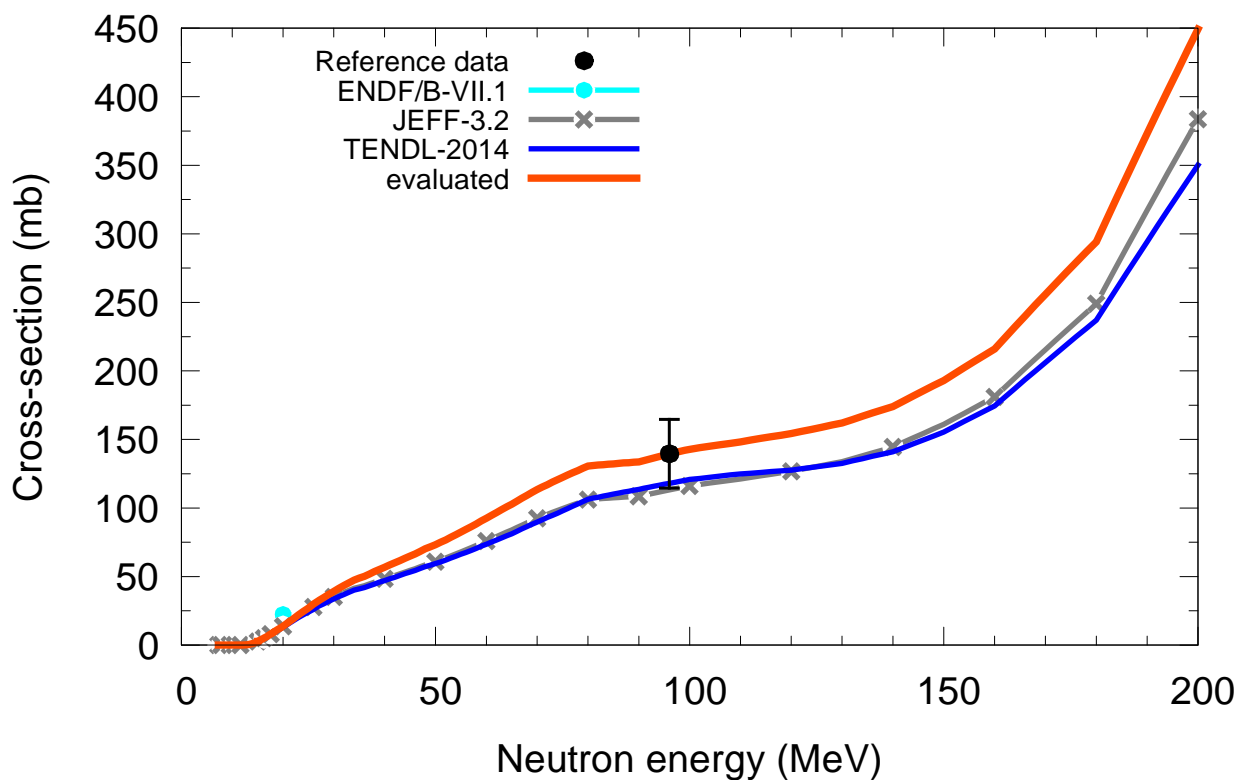
### $^{84}\text{Sr}(n,x)d$



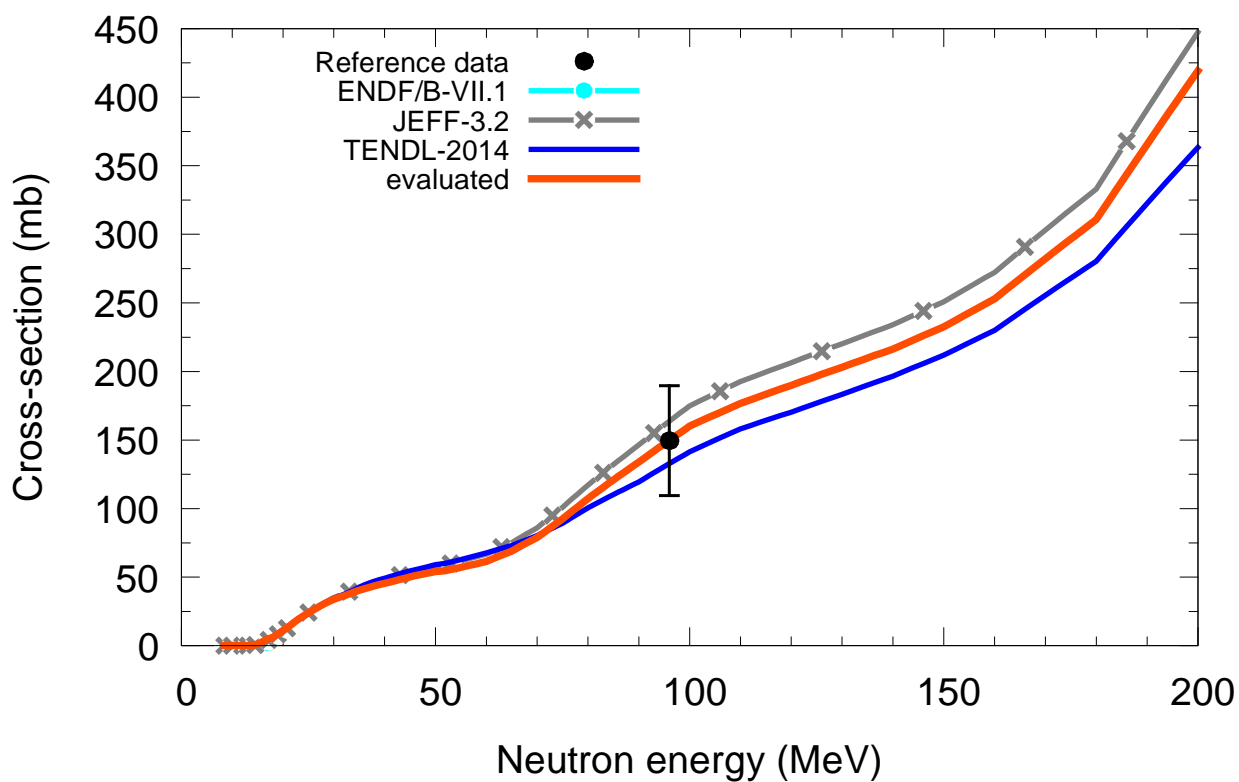
### $^{86}\text{Sr}(n,x)d$



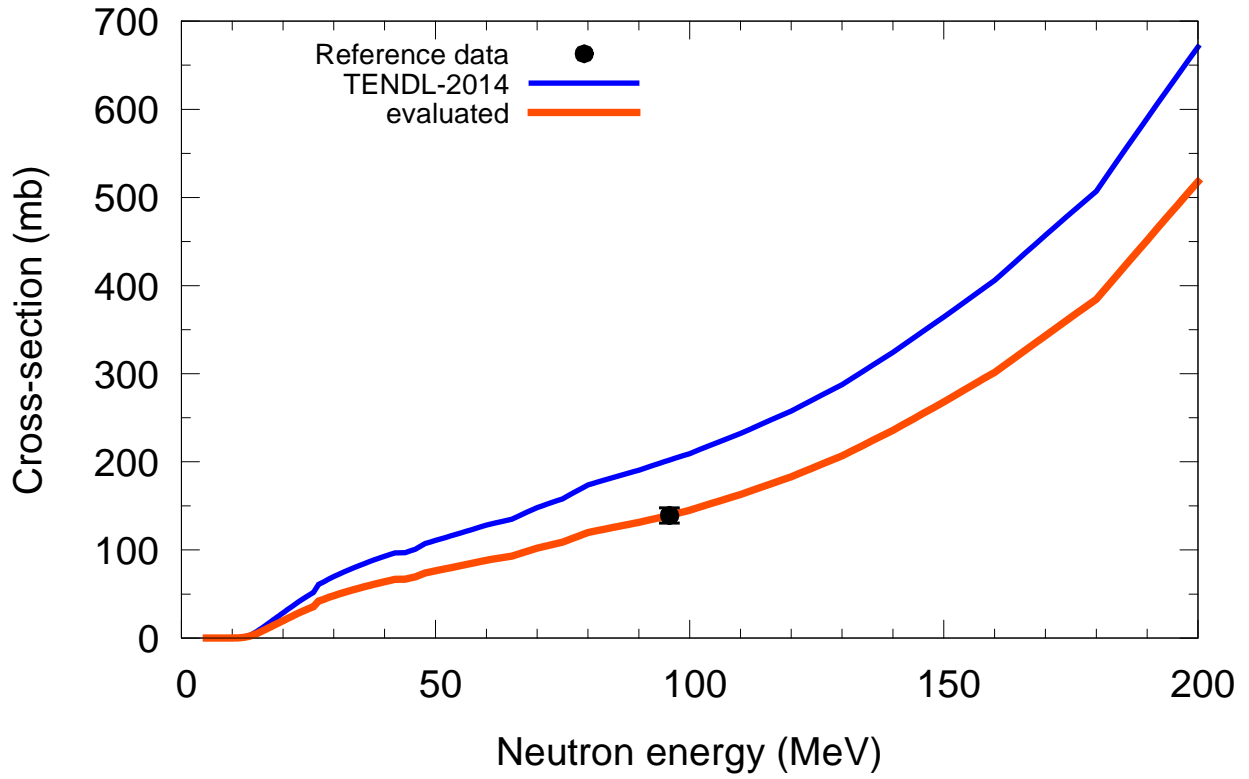
### $^{87}\text{Sr}(n,x)d$



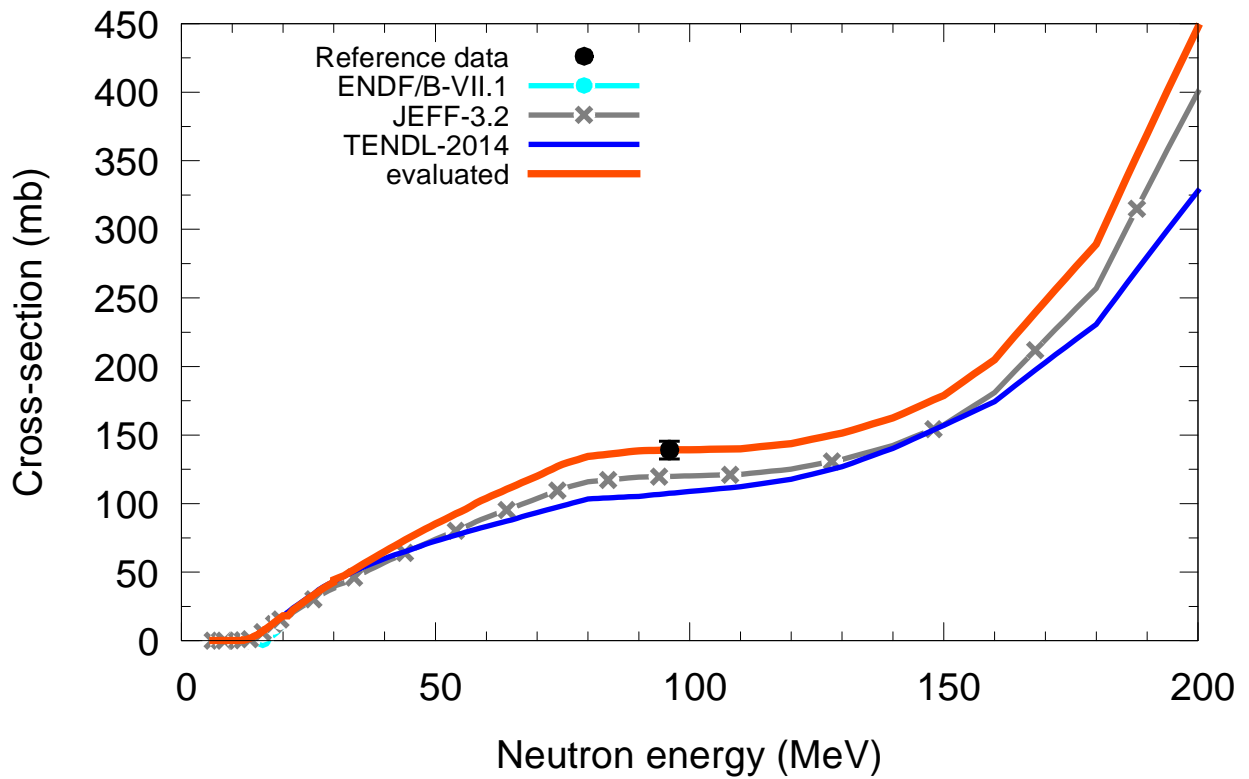
### $^{88}\text{Sr}(n,x)d$



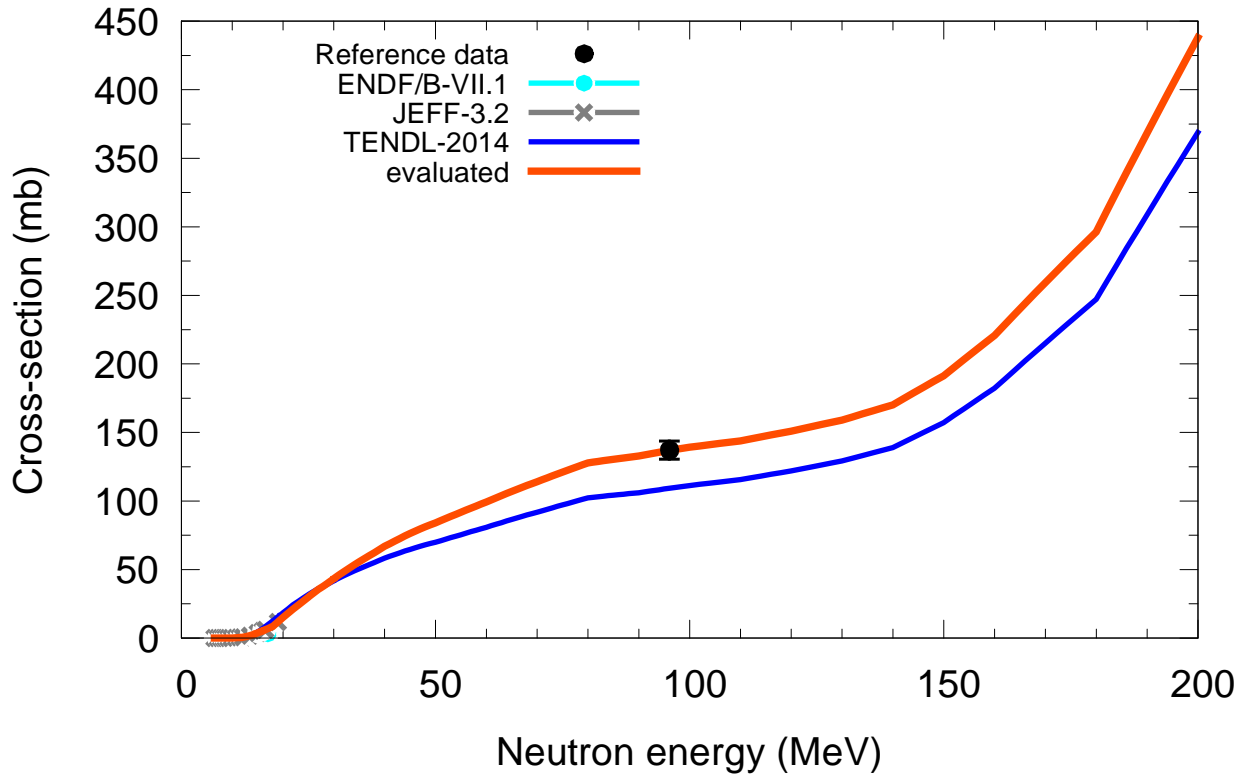
$^{89}\text{Y}(n,x)d$



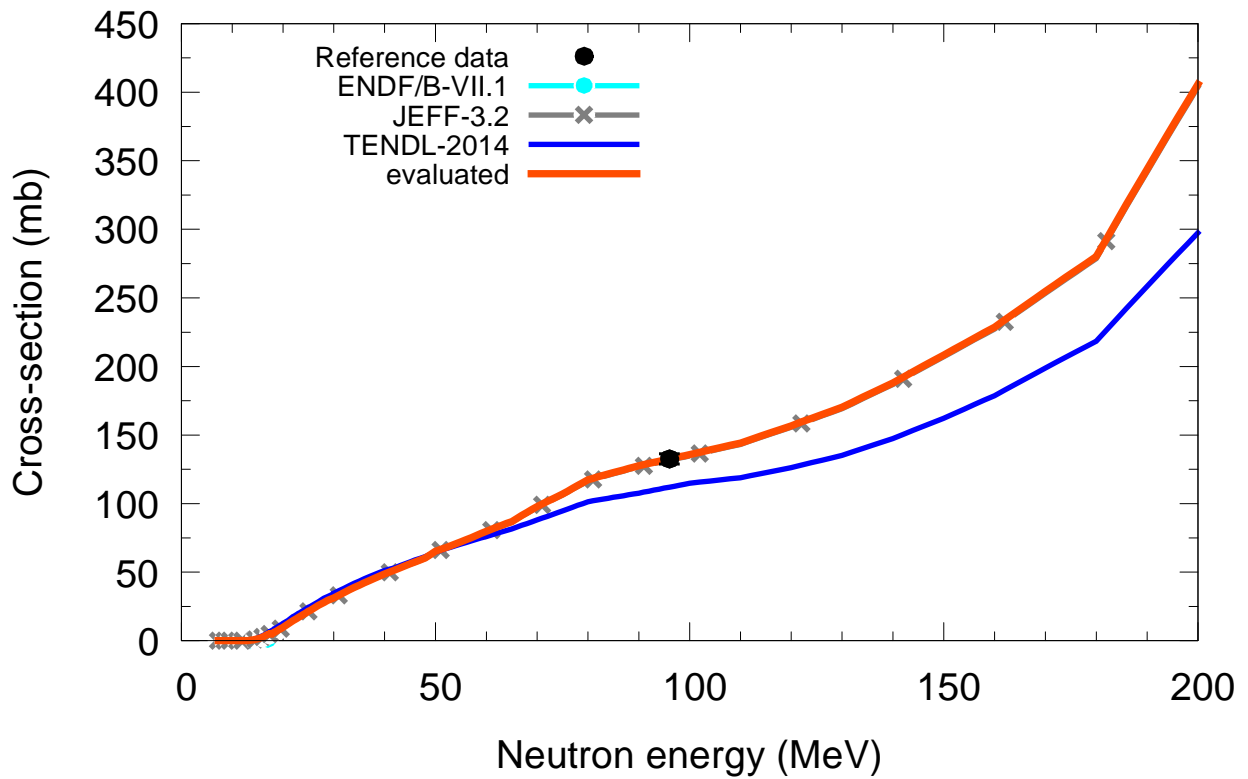
$^{90}\text{Zr}(n,x)d$



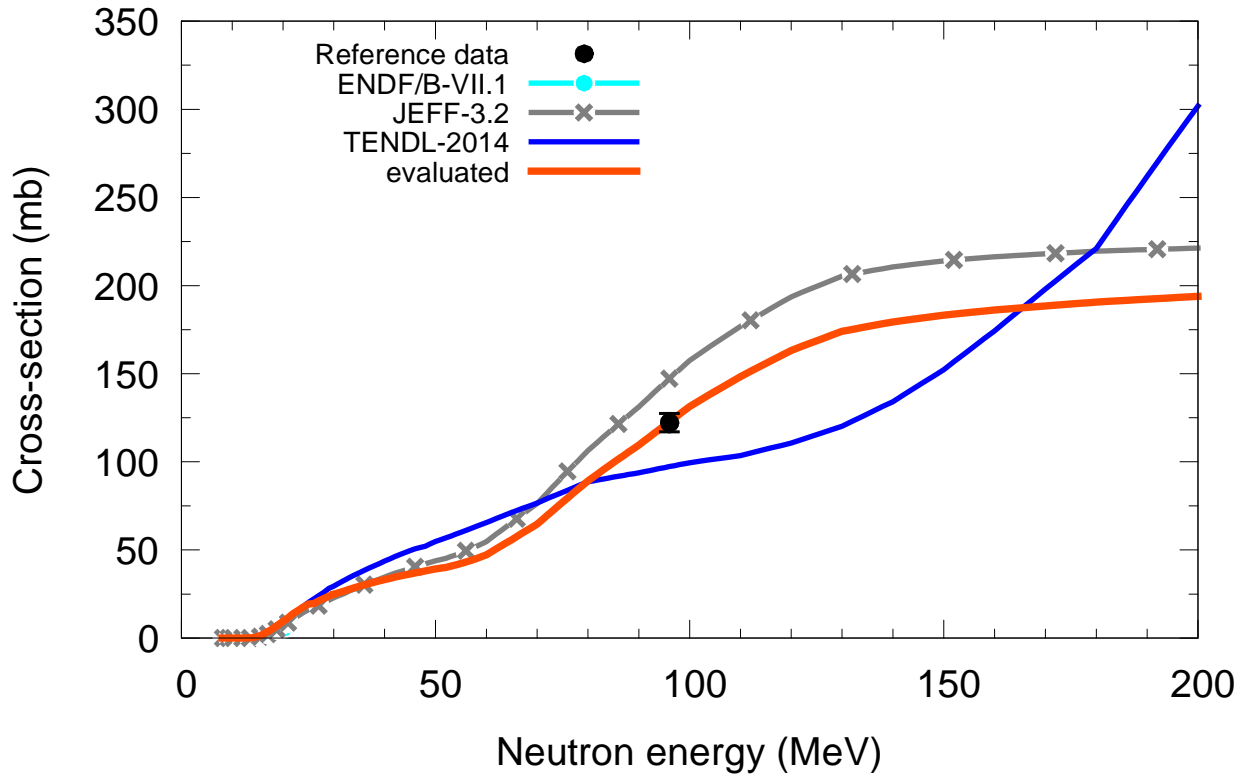
$^{91}\text{Zr}(n,x)d$



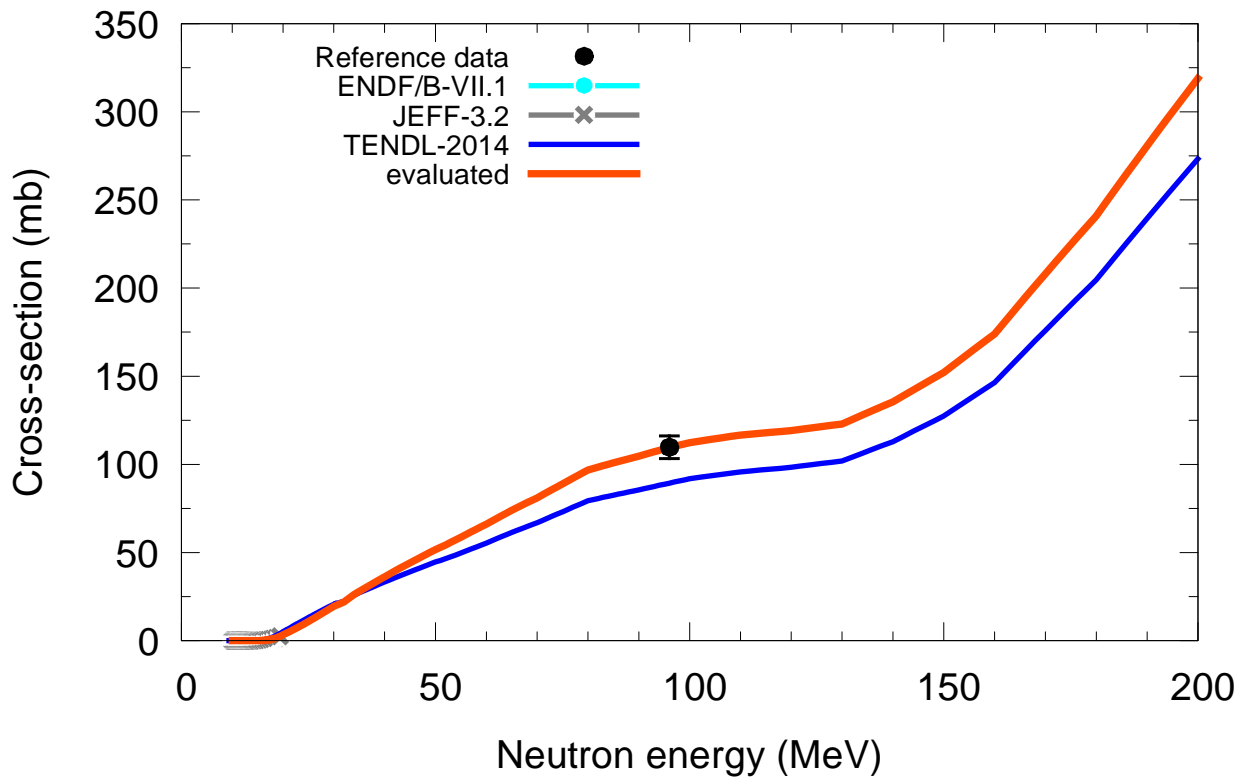
$^{92}\text{Zr}(n,x)d$



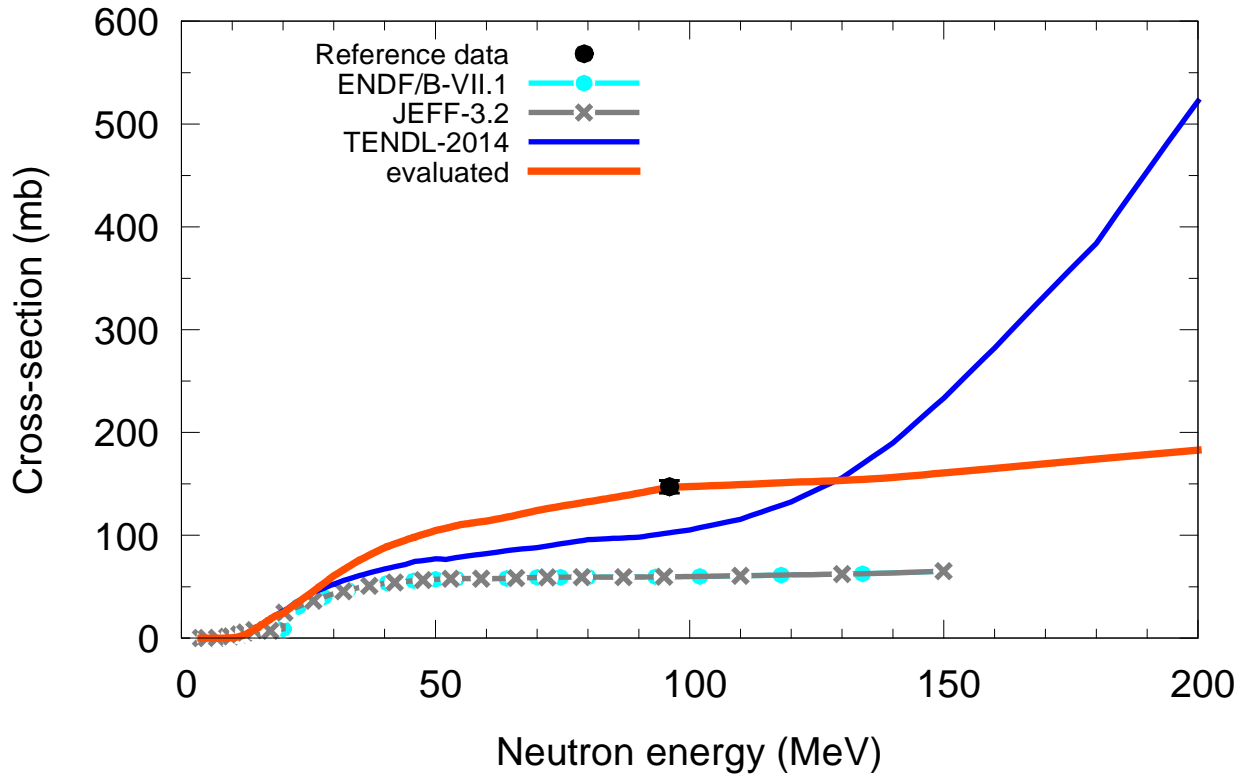
$^{94}\text{Zr}(n,x)d$



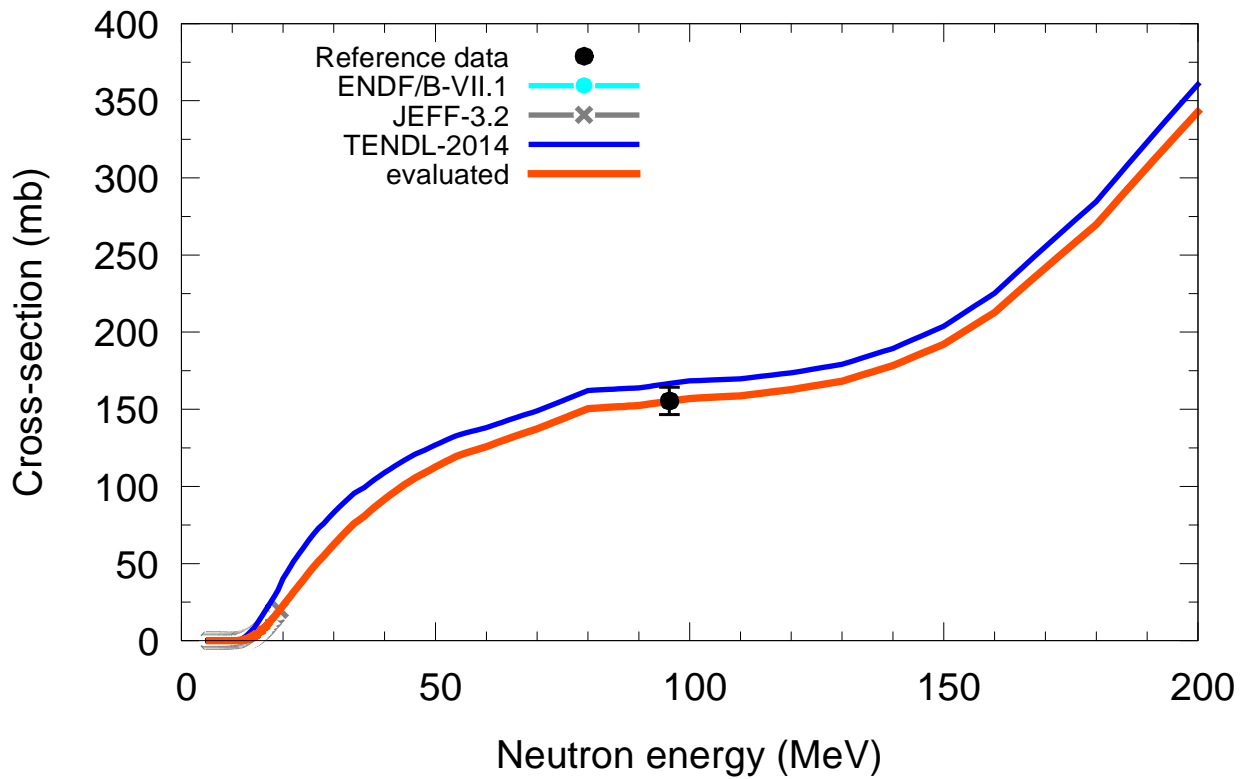
$^{96}\text{Zr}(n,x)d$



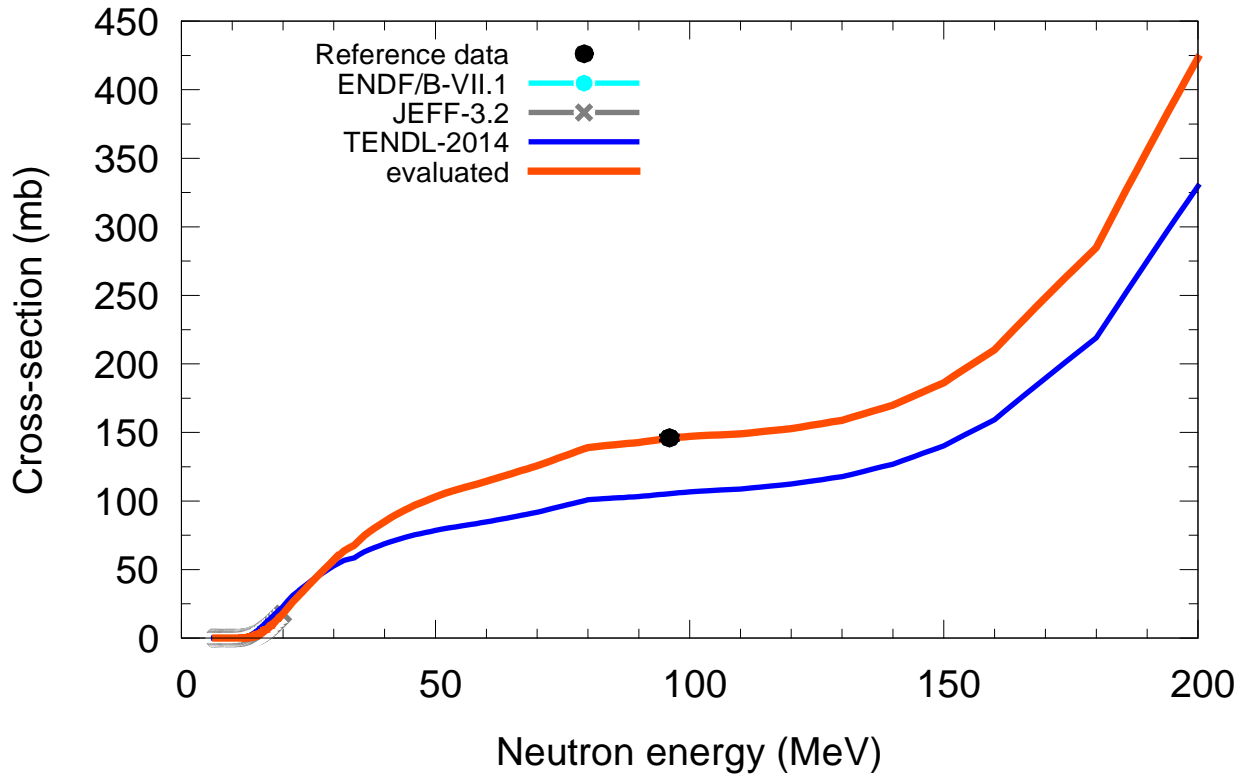
$^{93}\text{Nb}(n,x)d$



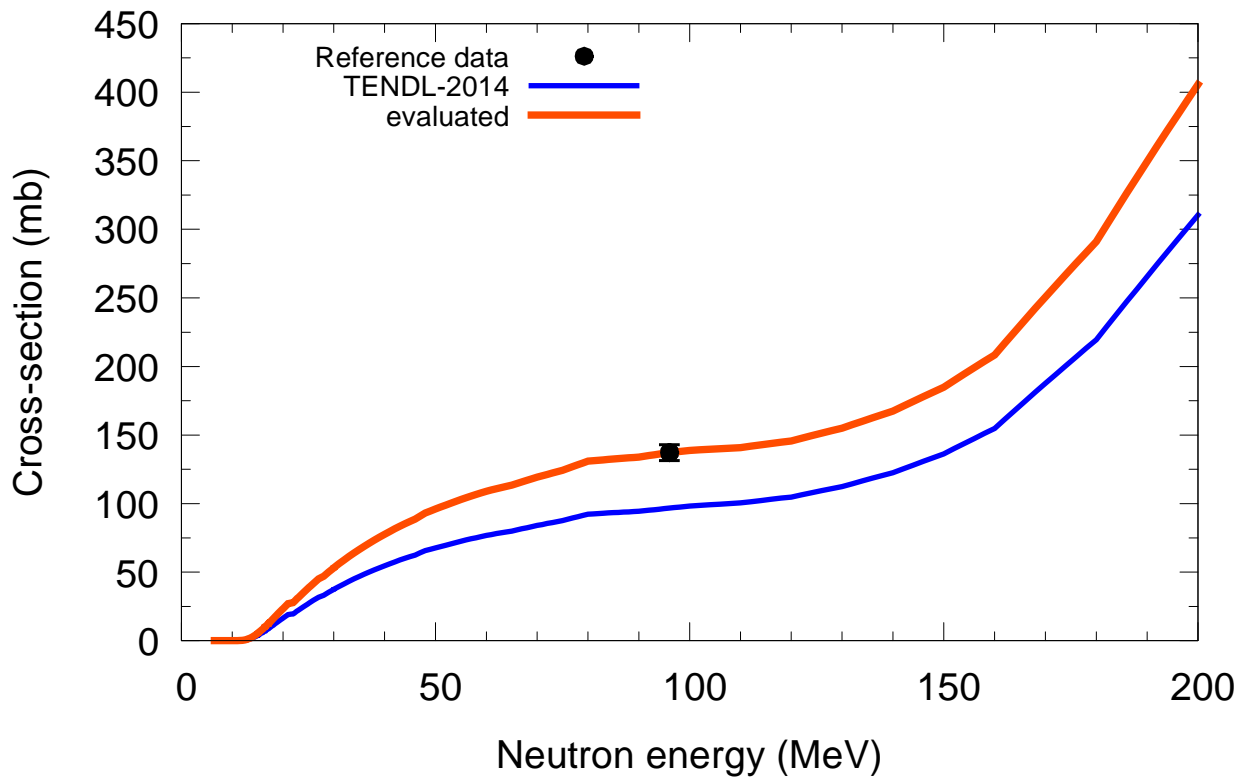
$^{92}\text{Mo}(n,x)d$



### $^{94}\text{Mo}(n,x)d$

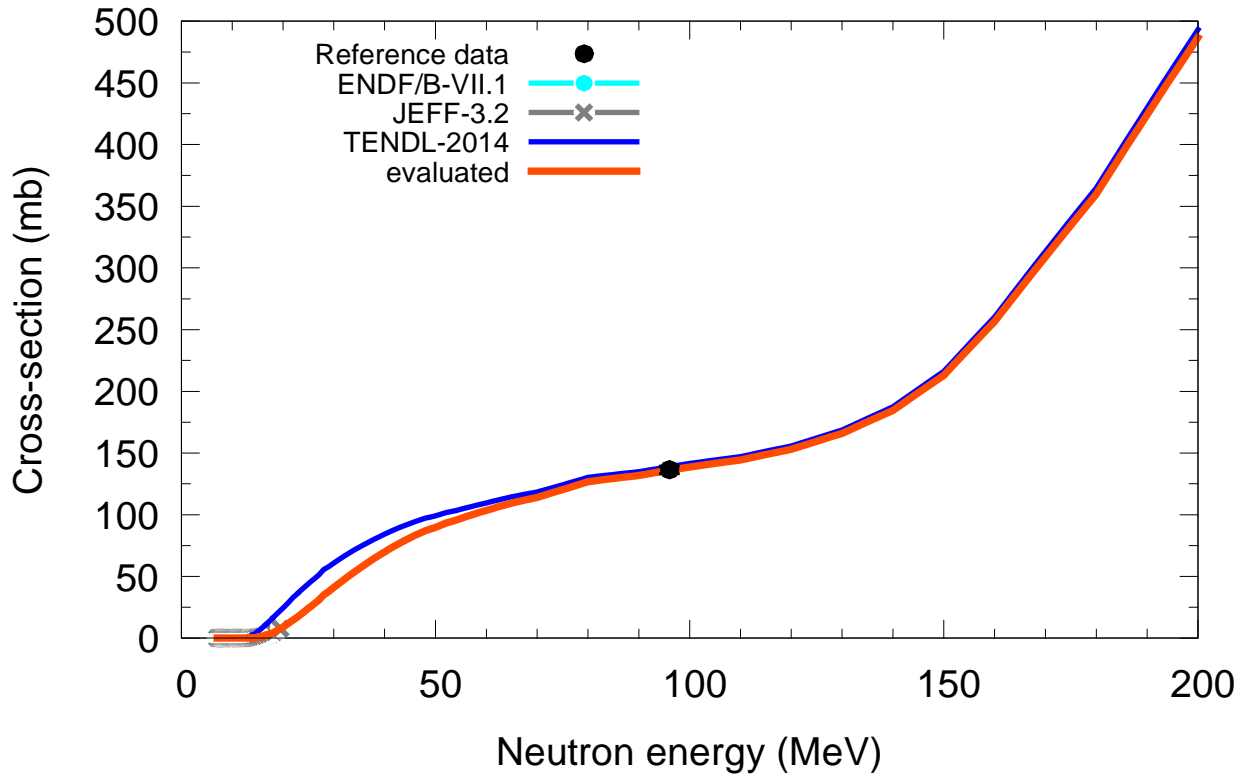


### $^{95}\text{Mo}(n,x)d$

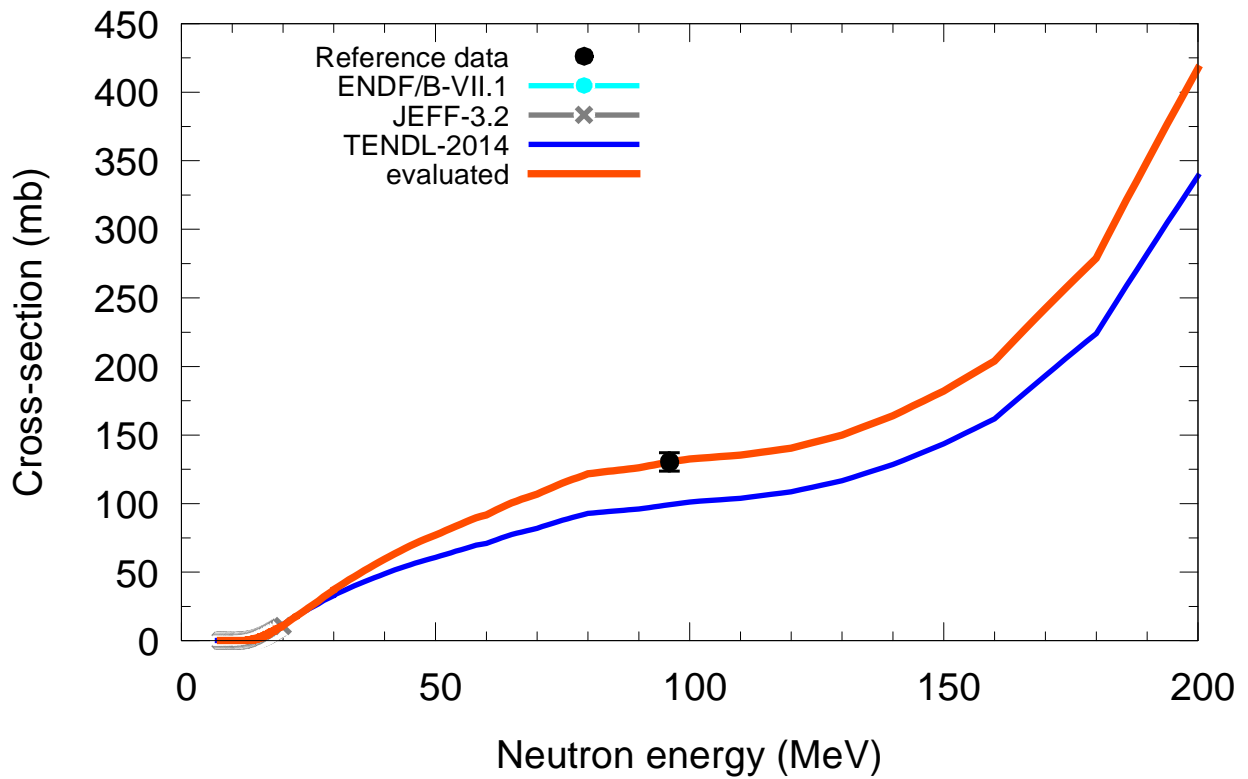




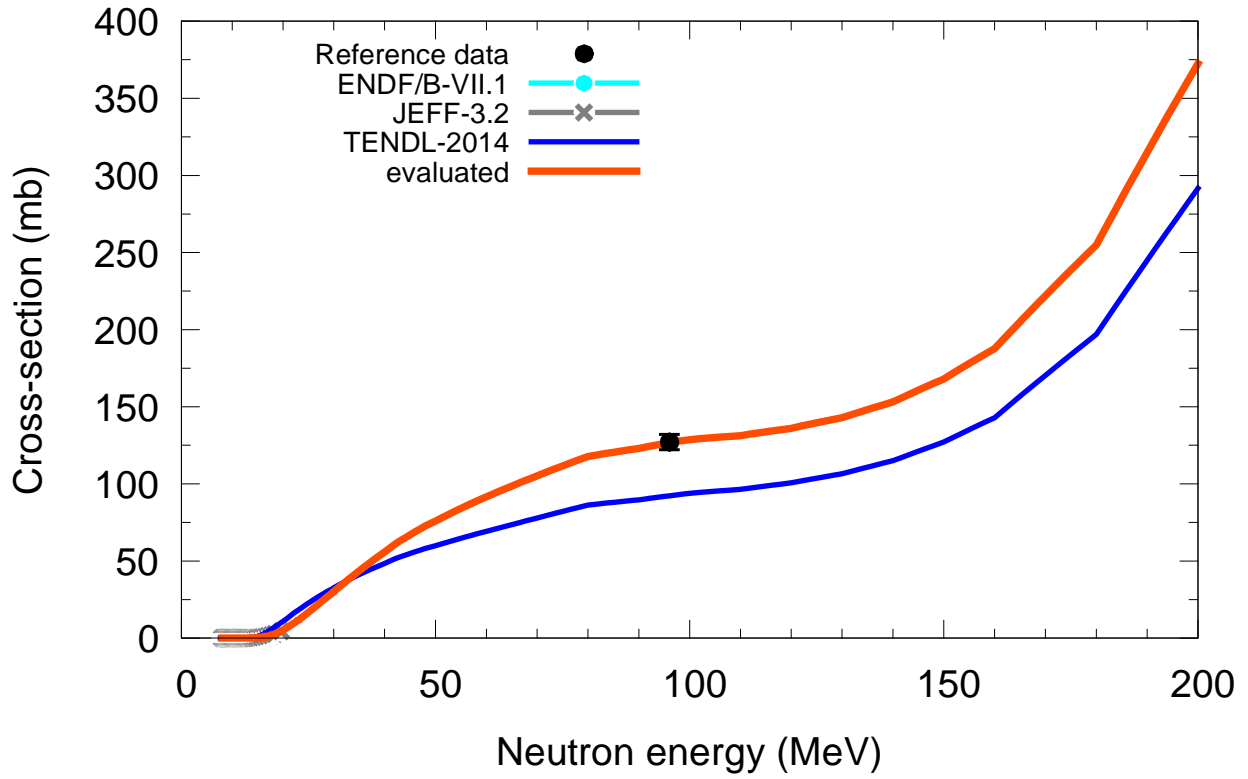
### $^{96}\text{Mo}(n,x)d$



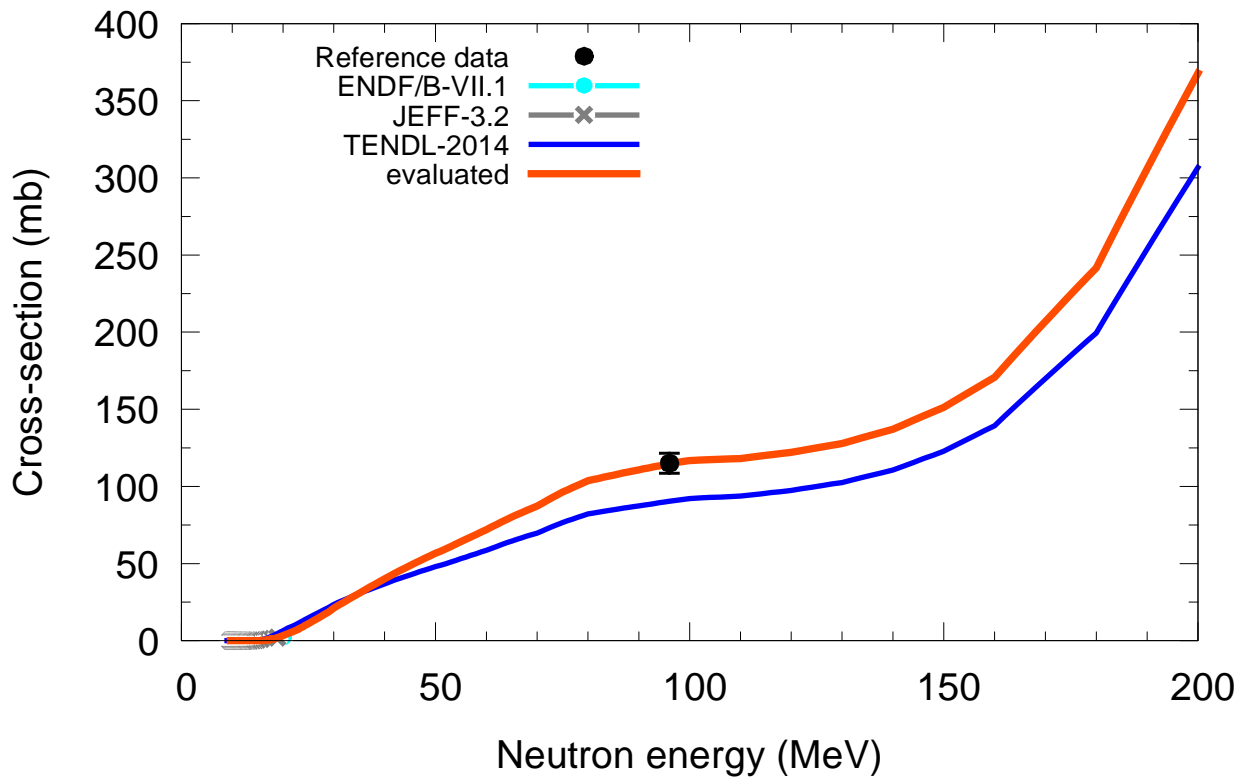
### $^{97}\text{Mo}(n,x)d$



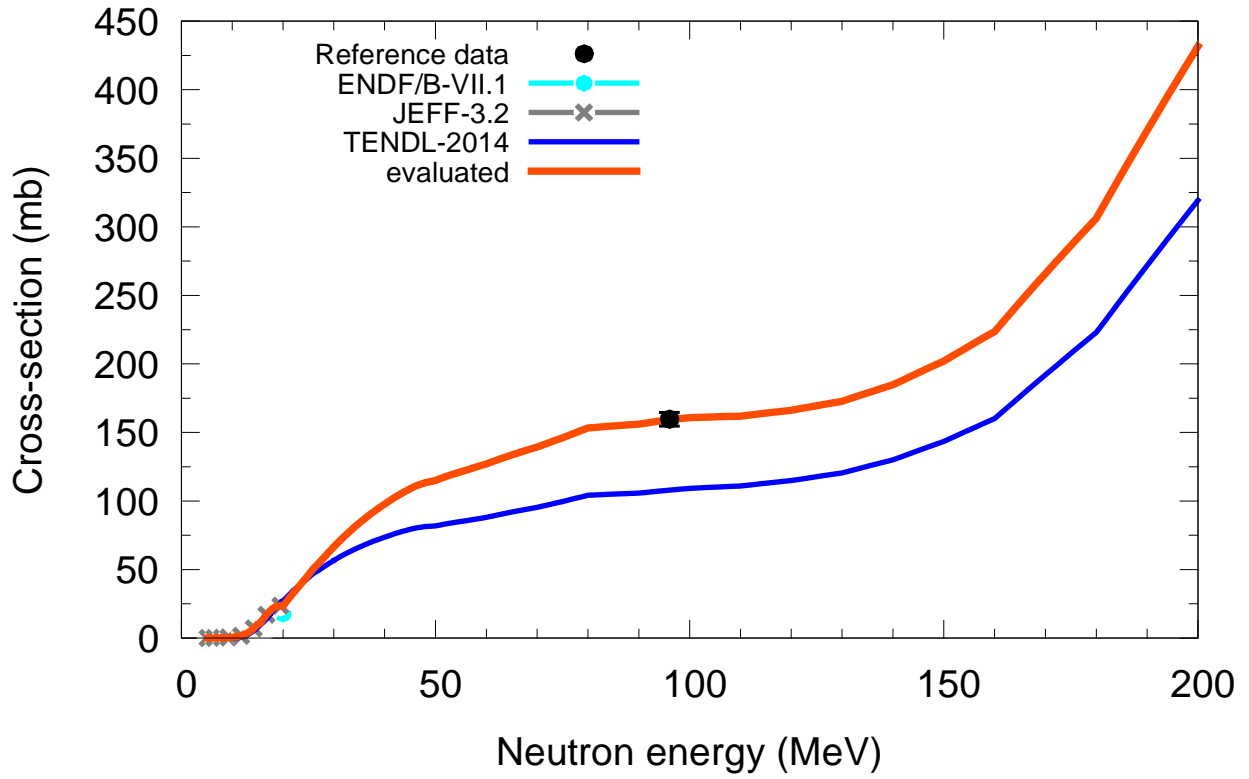
$^{98}\text{Mo}(n,x)d$



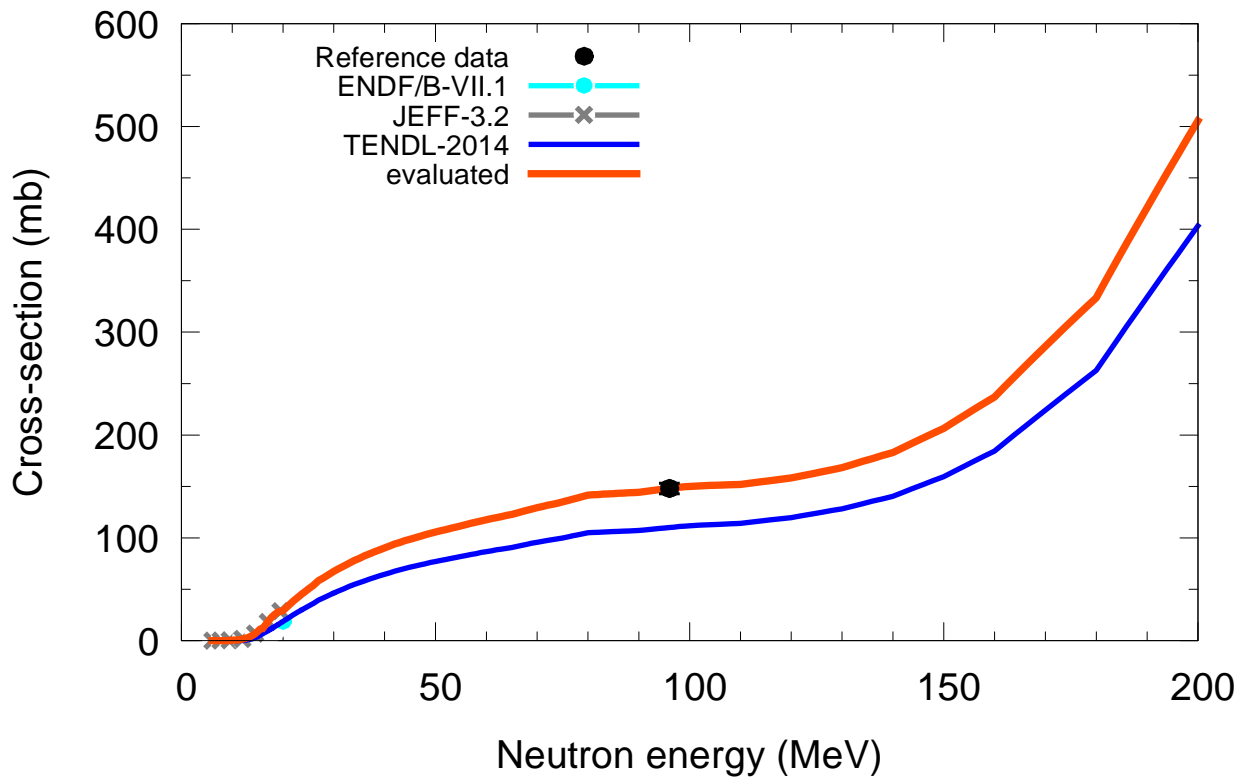
$^{100}\text{Mo}(n,x)d$



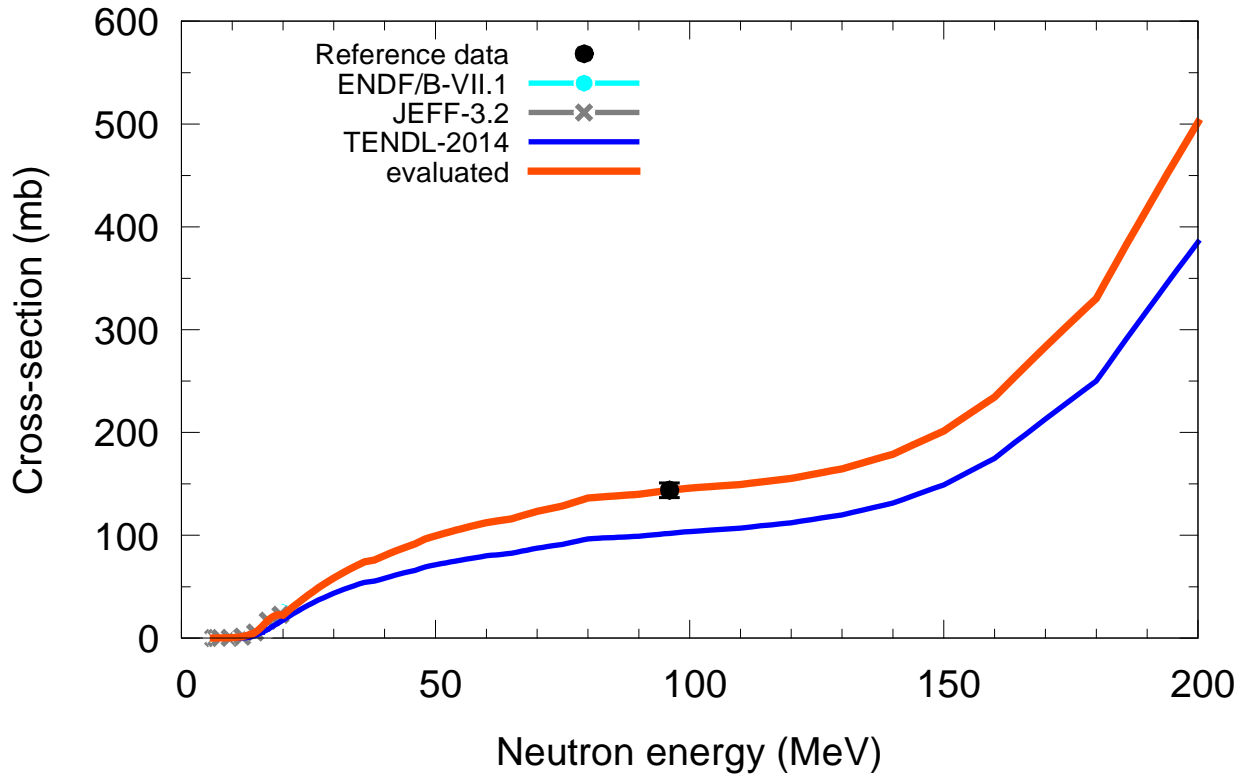
$^{96}\text{Ru}(n,x)d$



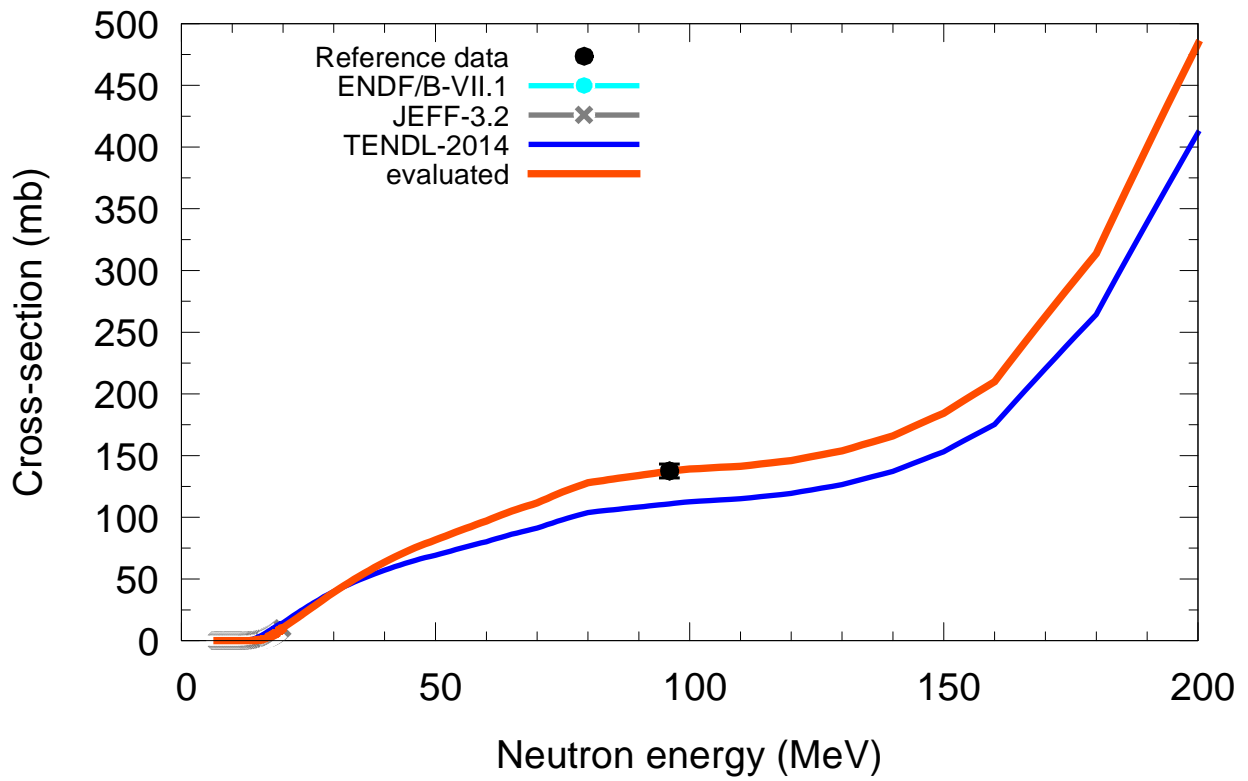
$^{98}\text{Ru}(n,x)d$



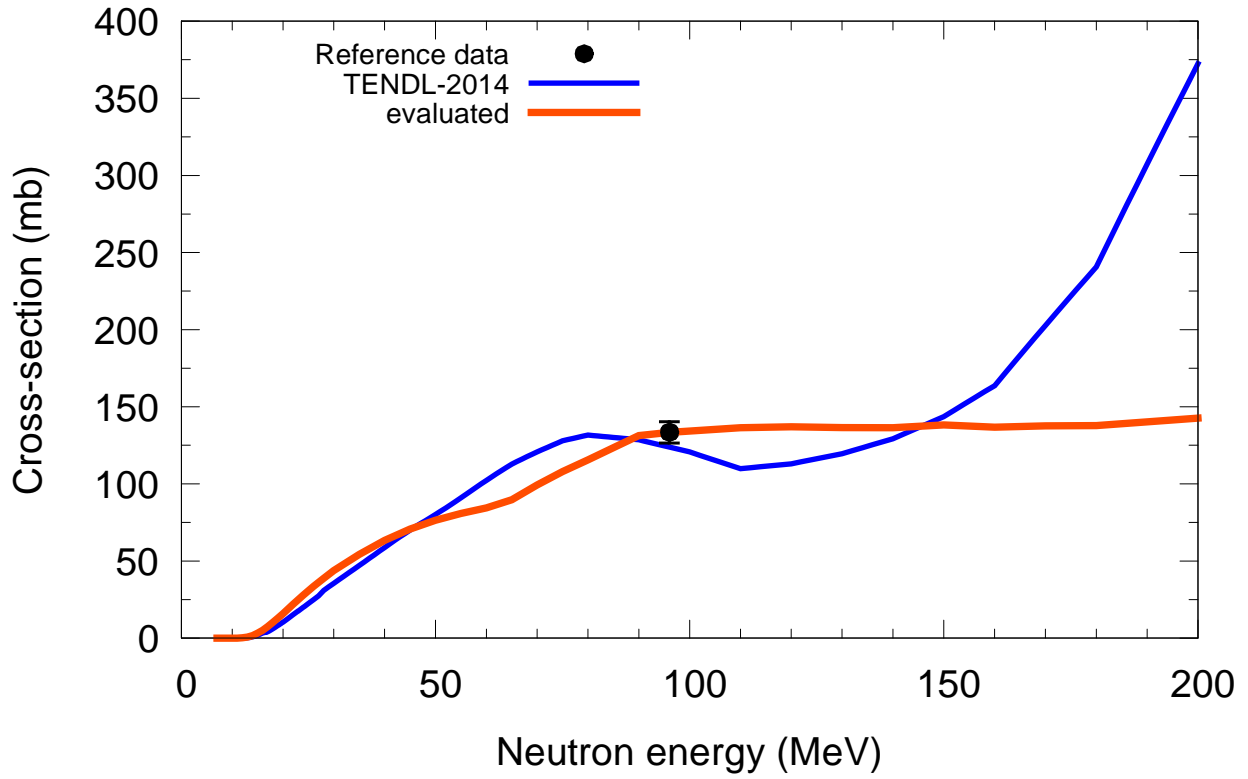
$^{99}\text{Ru}(n,x)d$



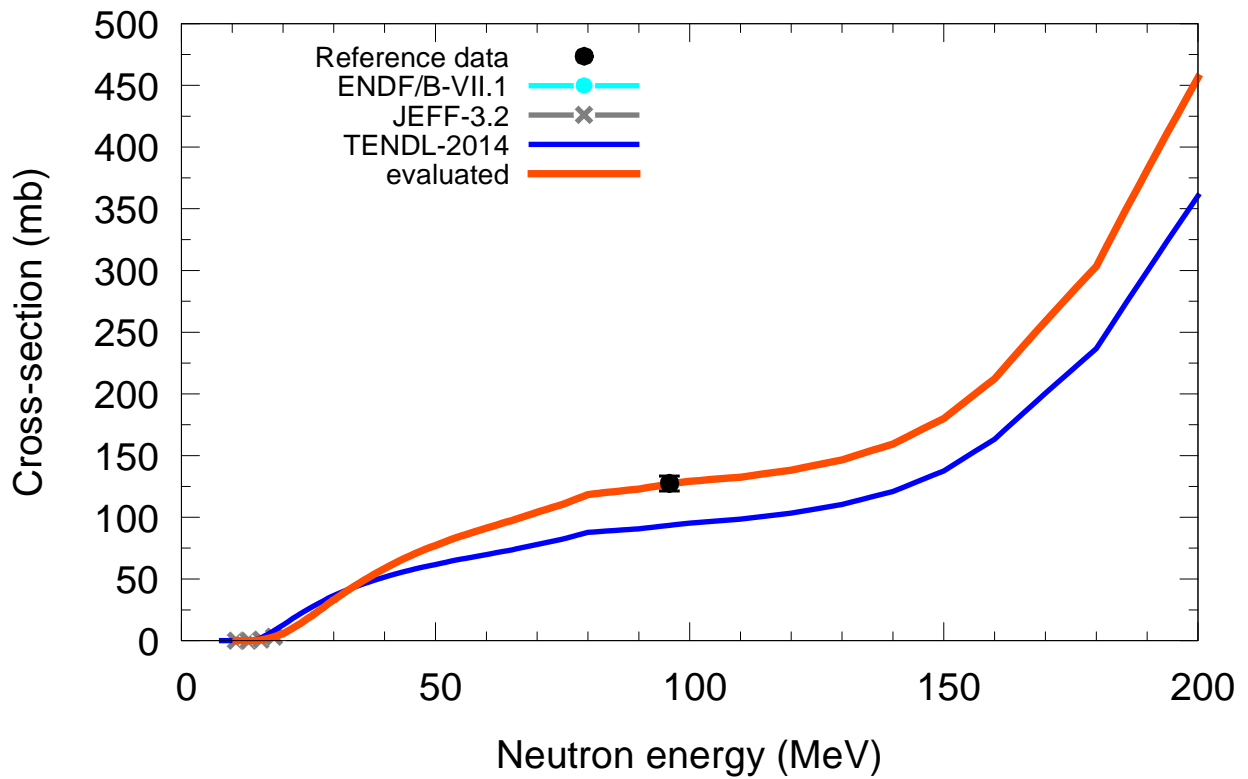
$^{100}\text{Ru}(n,x)d$

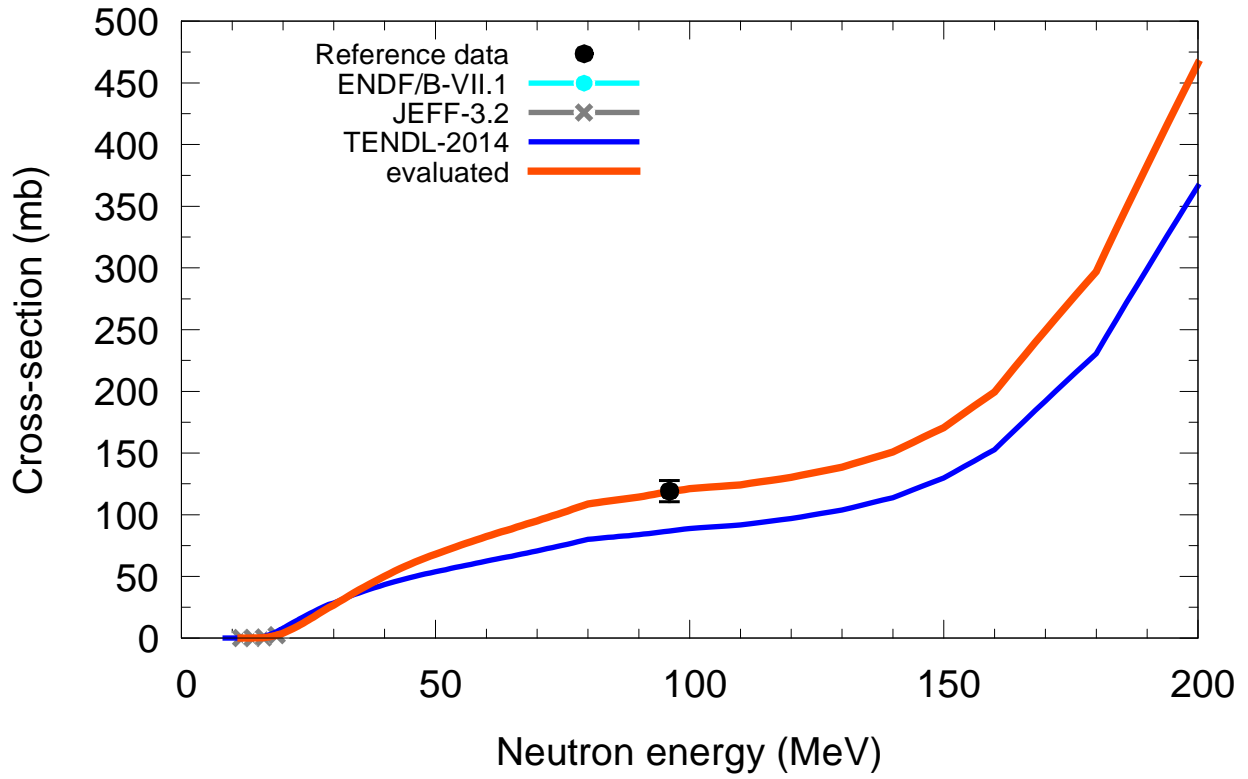
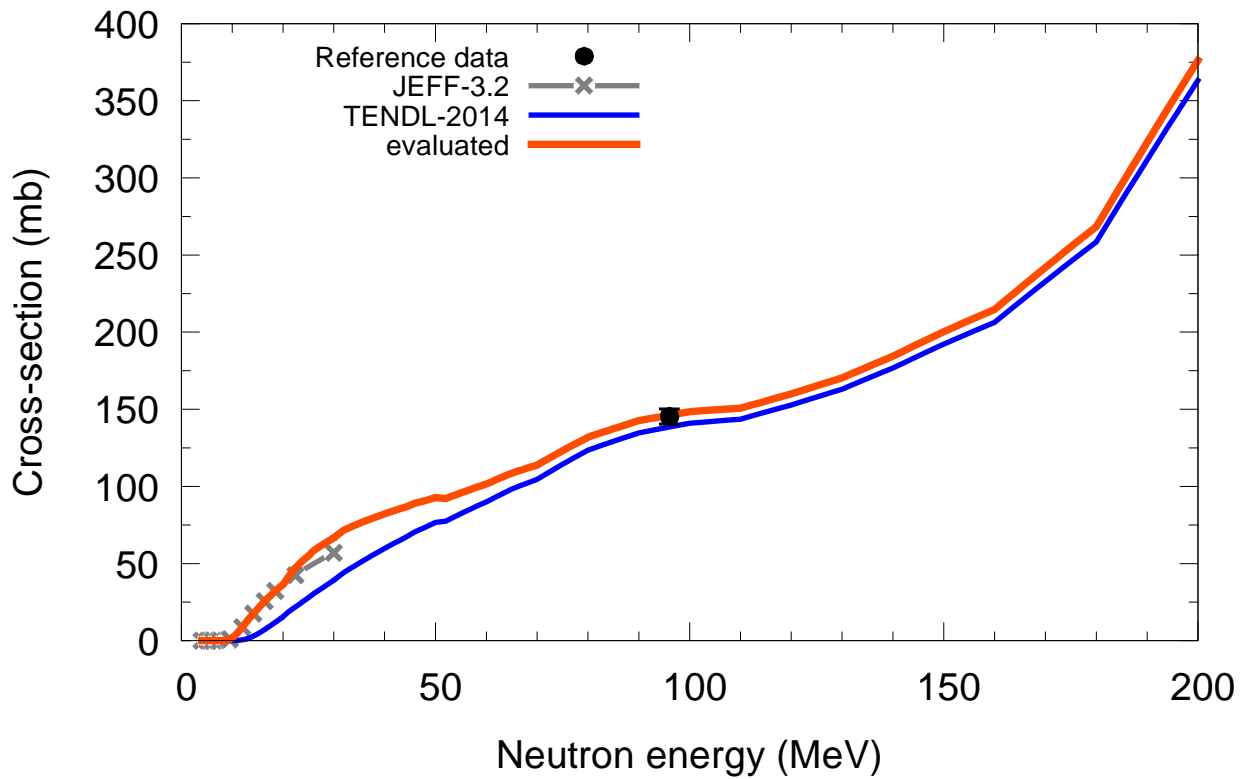


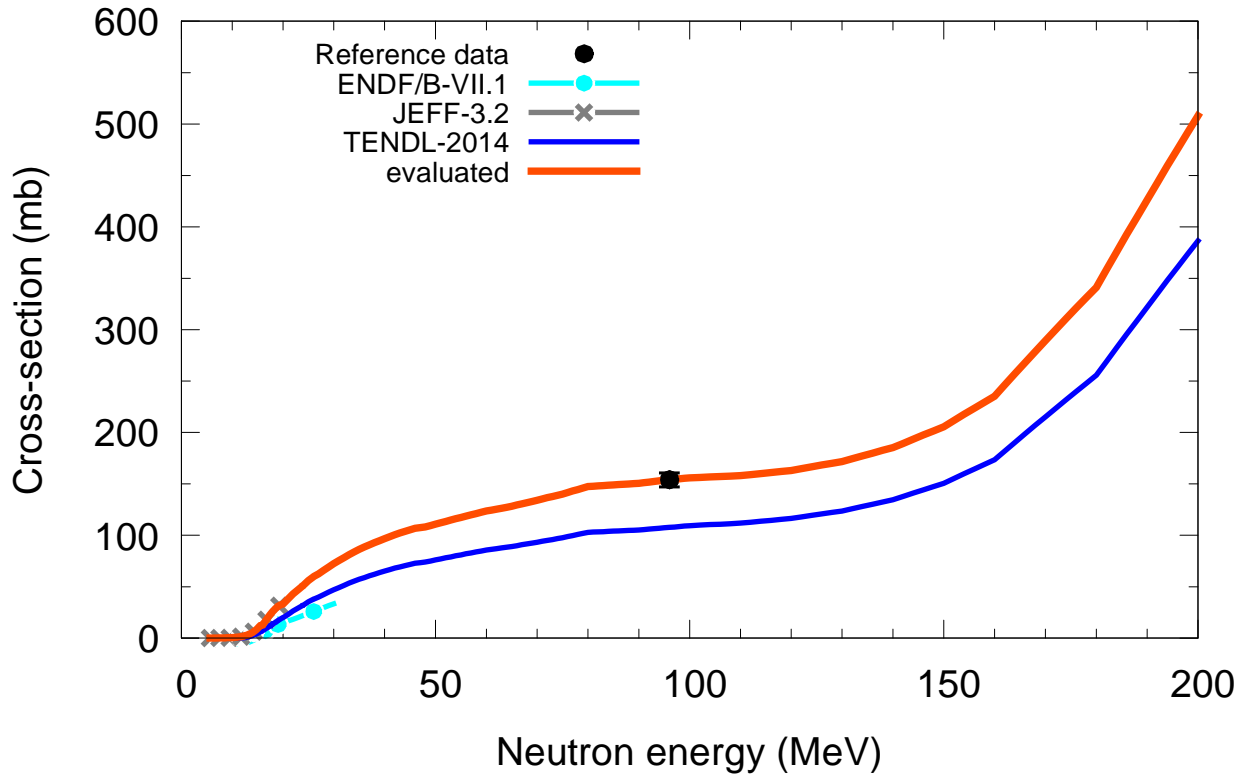
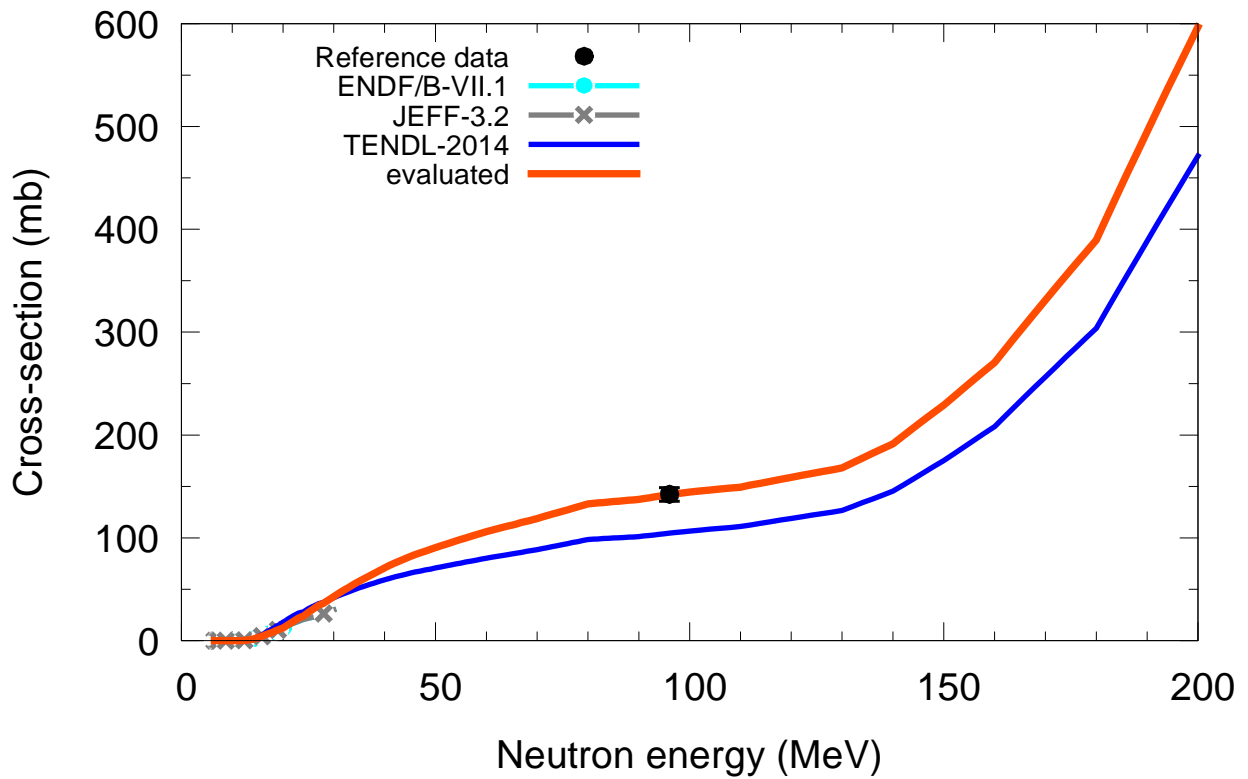
$^{101}\text{Ru}(n,x)d$

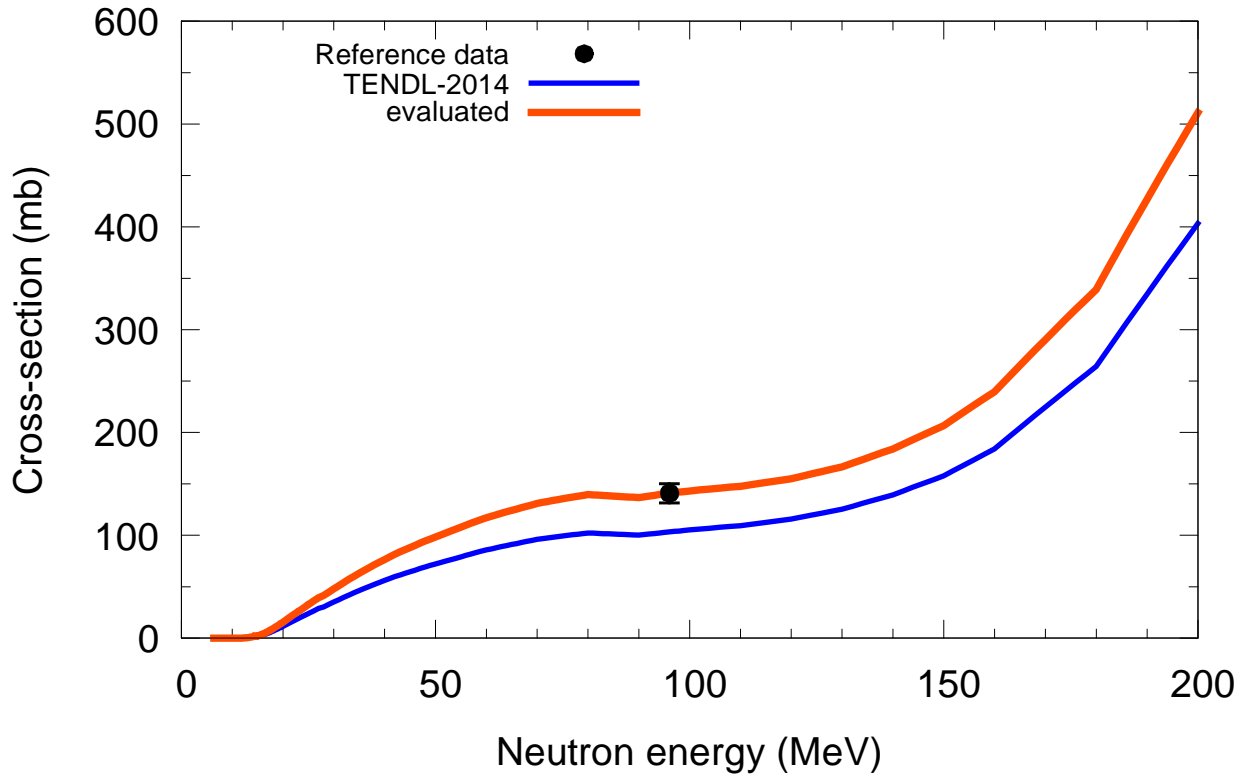
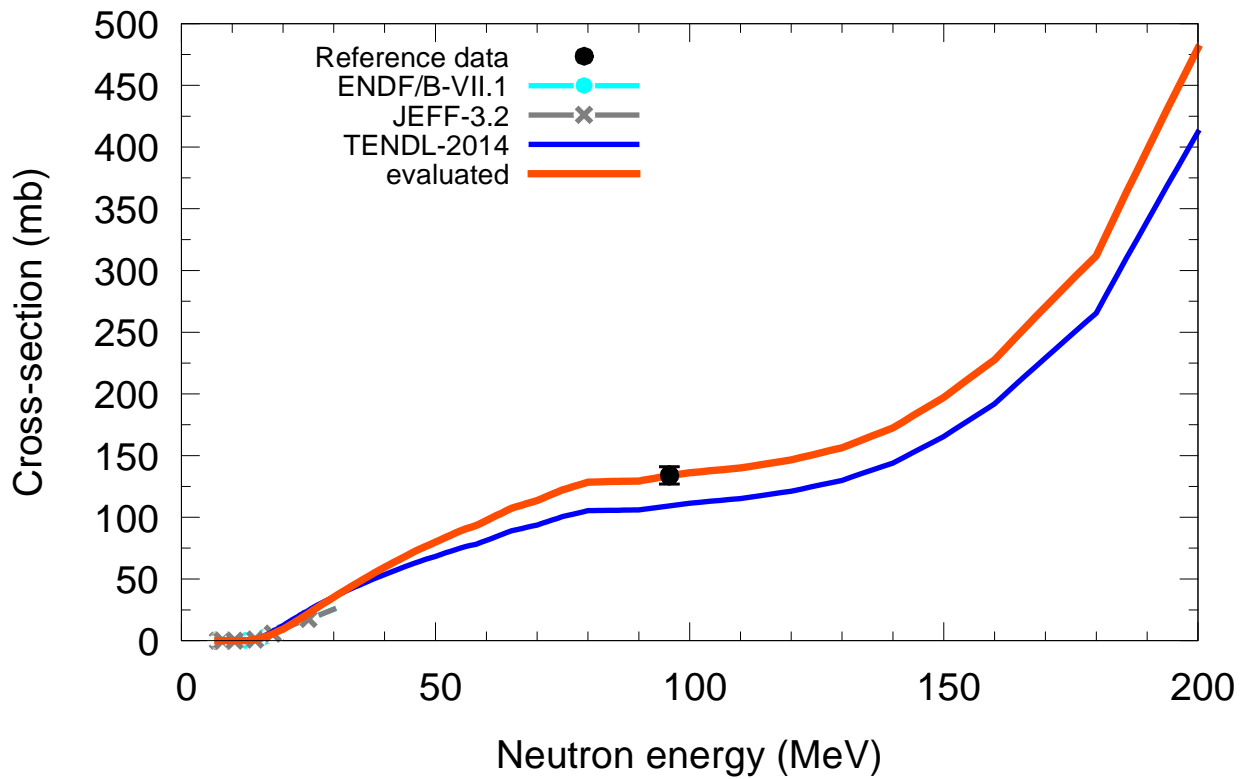


$^{102}\text{Ru}(n,x)d$

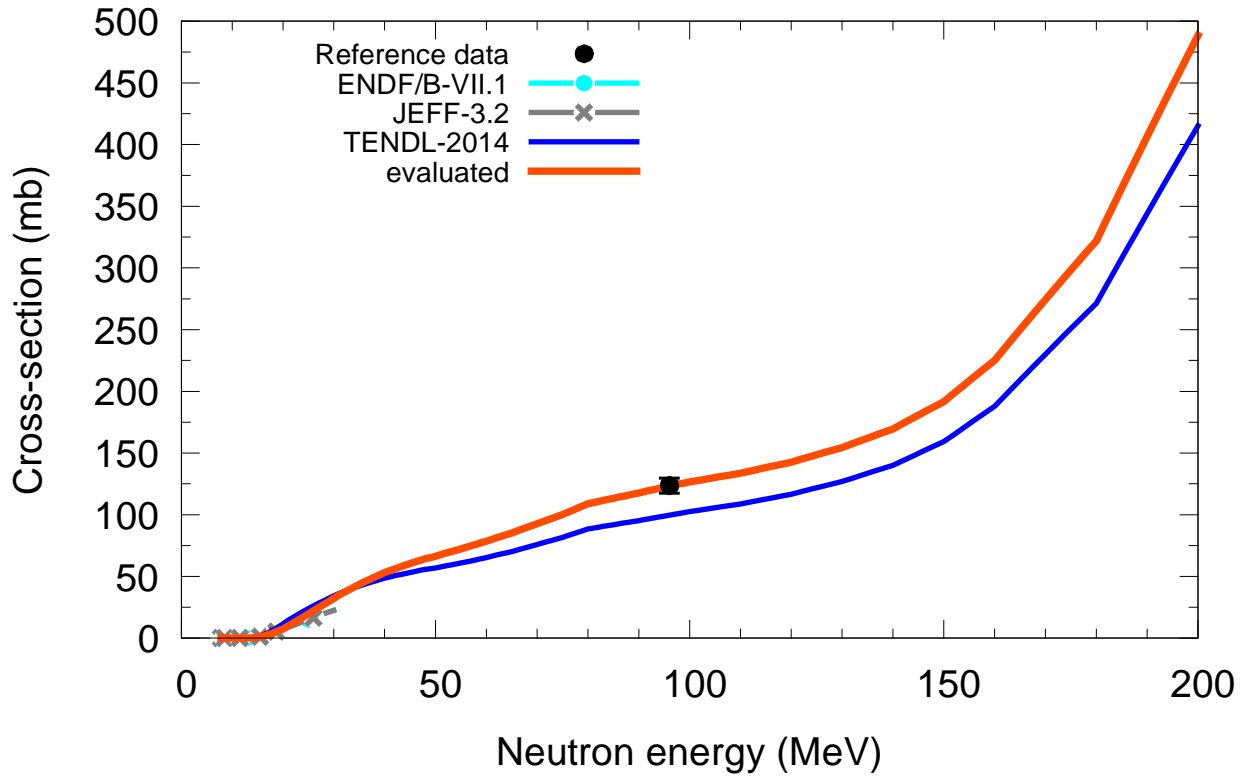
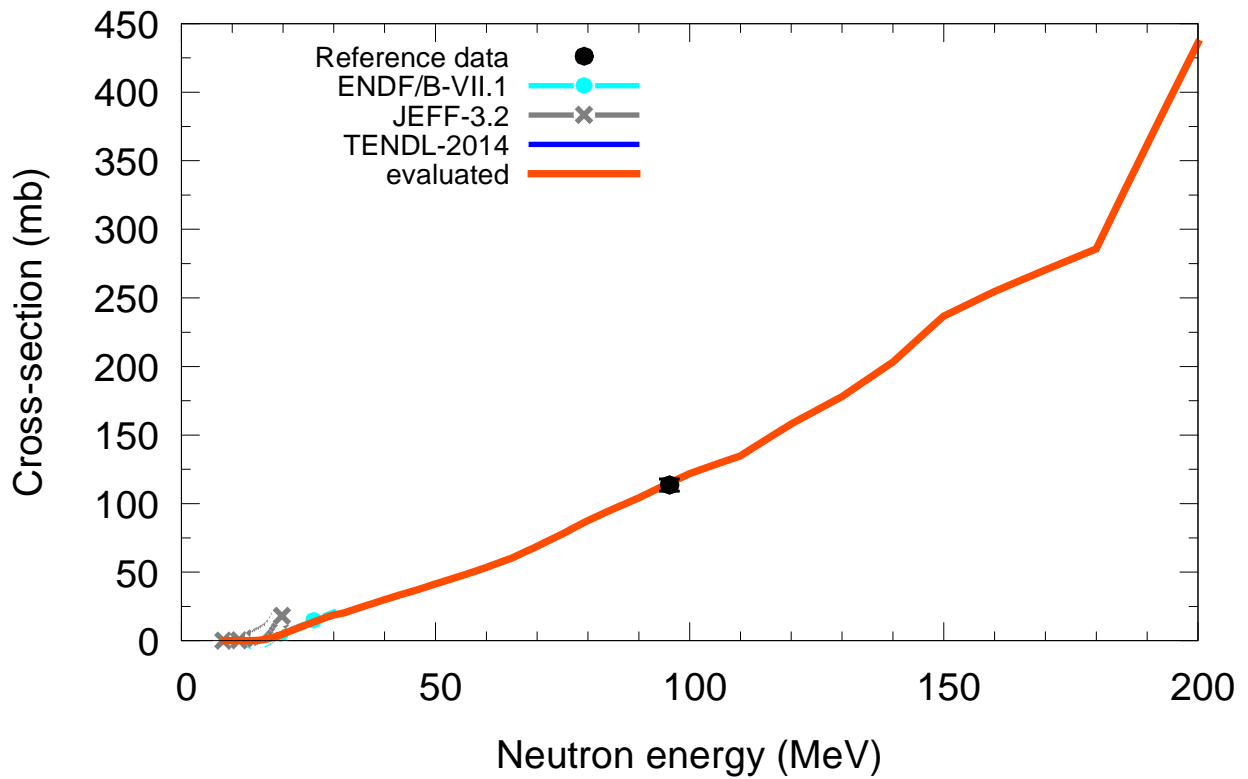


$^{104}\text{Ru}(n,x)d$  $^{103}\text{Rh}(n,x)d$ 

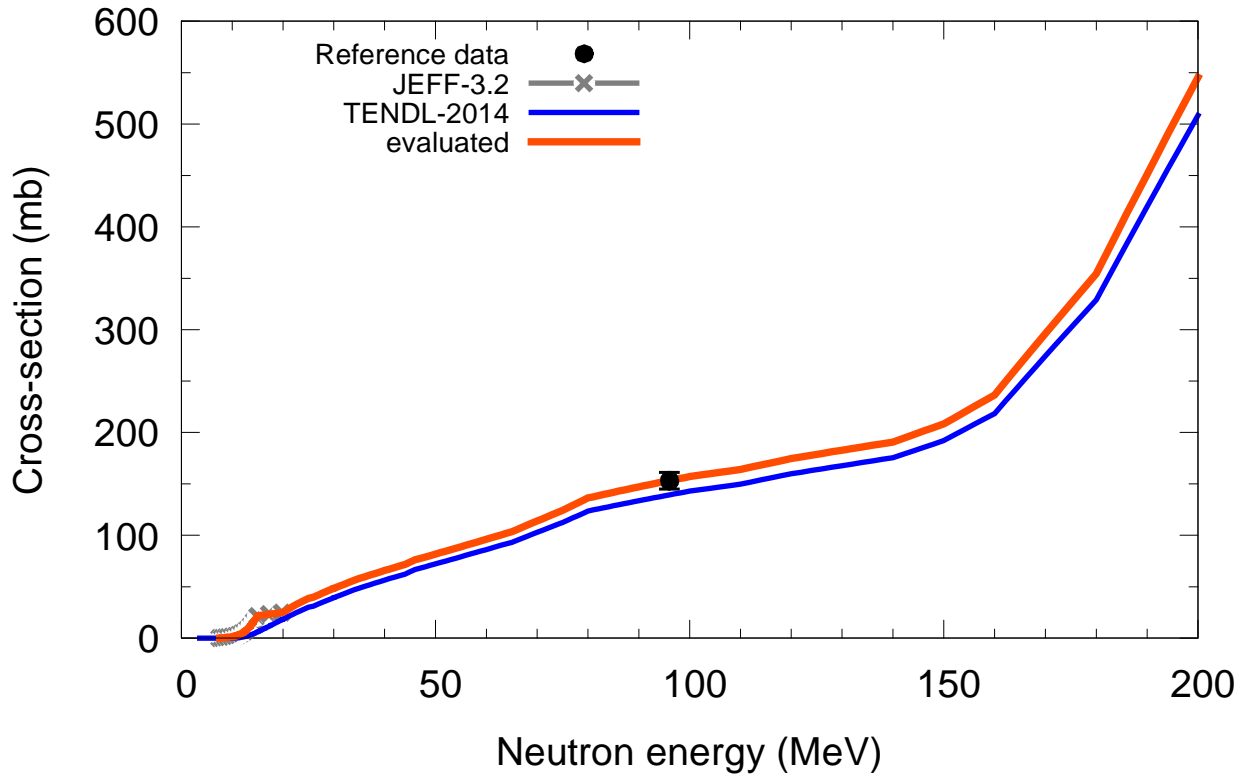
$^{102}\text{Pd}(n,x)d$  $^{104}\text{Pd}(n,x)d$ 

$^{105}\text{Pd}(n,x)d$  $^{106}\text{Pd}(n,x)d$ 

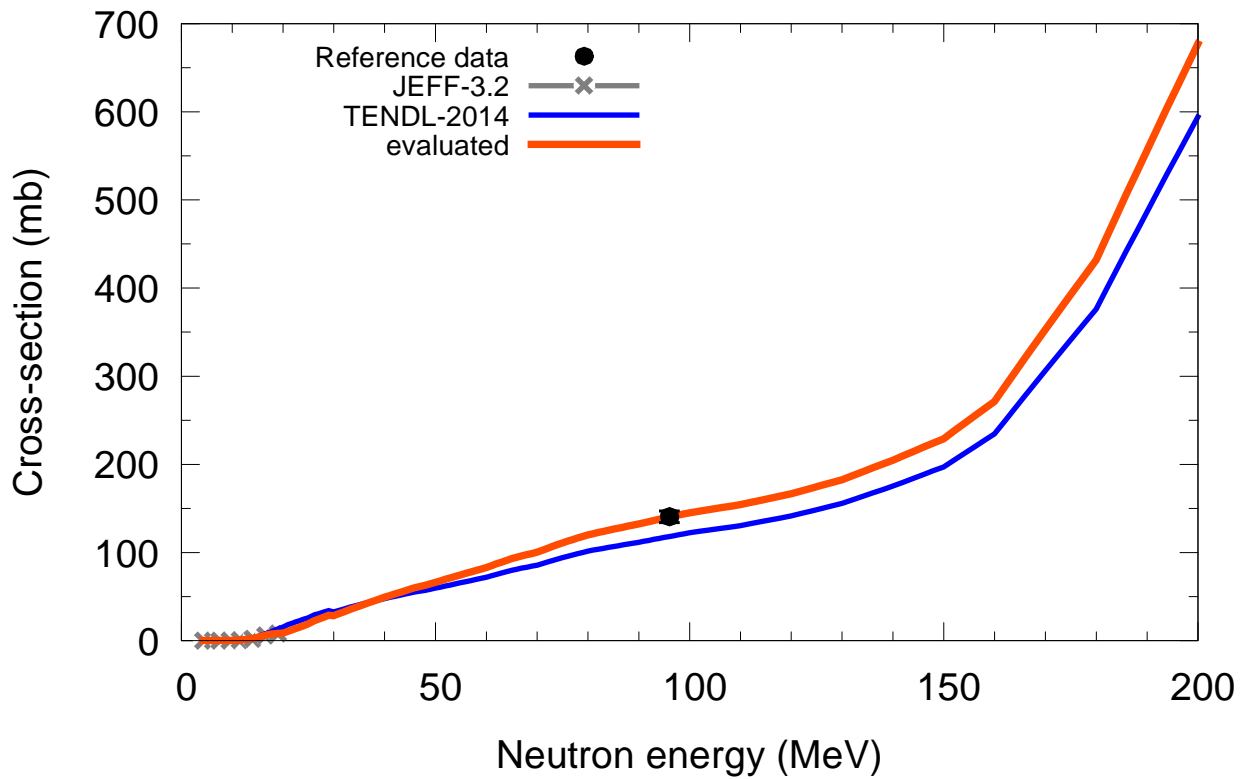


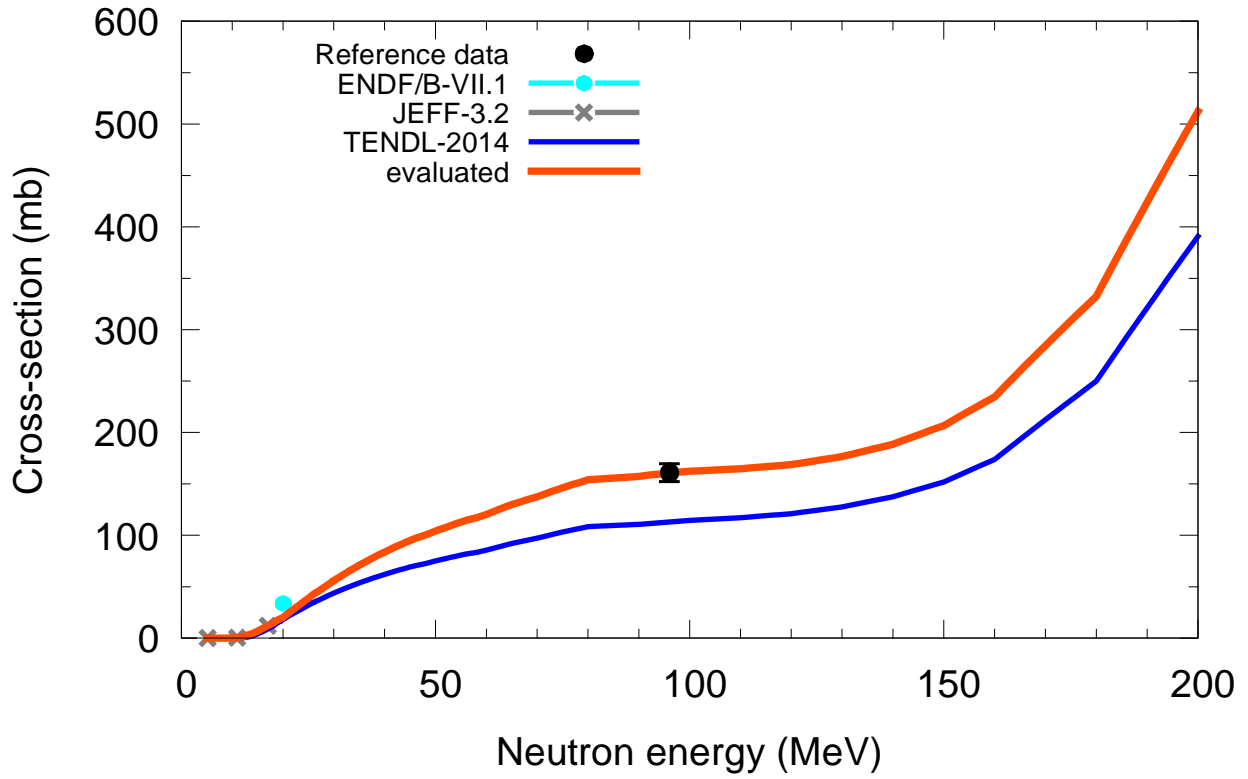
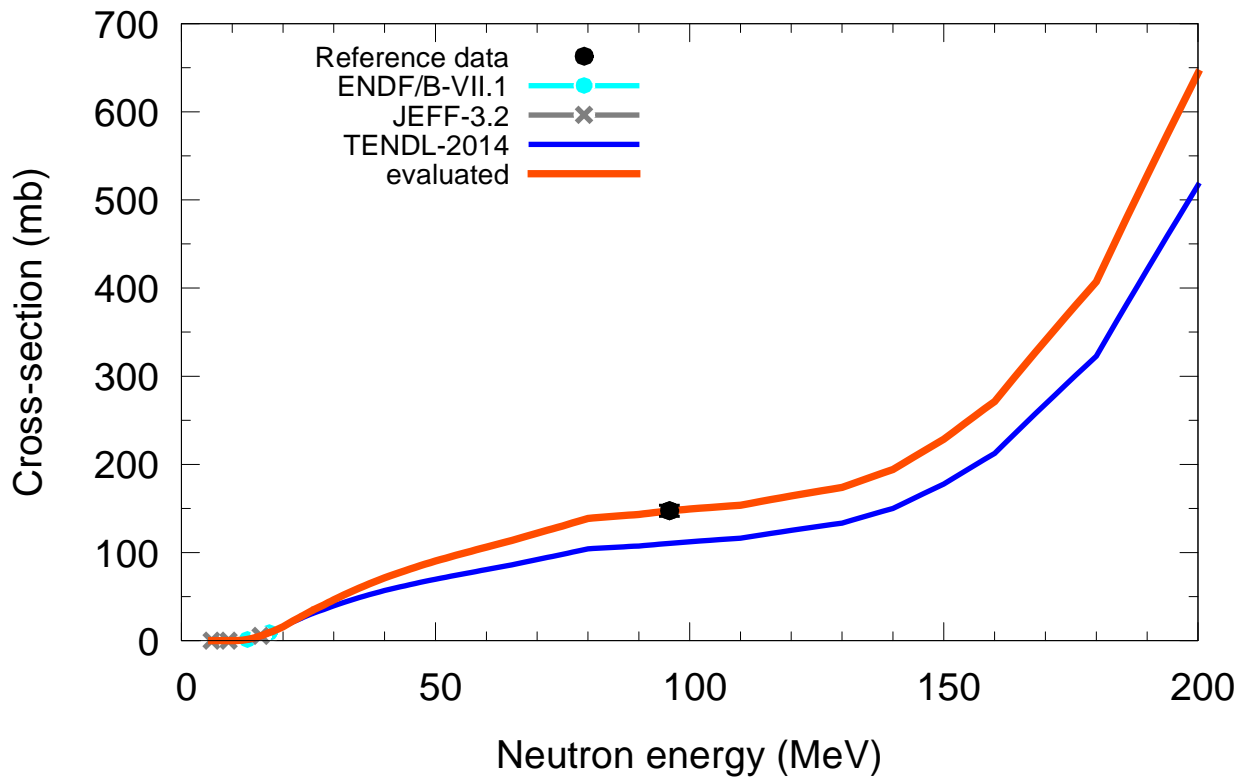
$^{108}\text{Pd}(n,x)d$  $^{110}\text{Pd}(n,x)d$ 

$^{107}\text{Ag}(n,x)d$

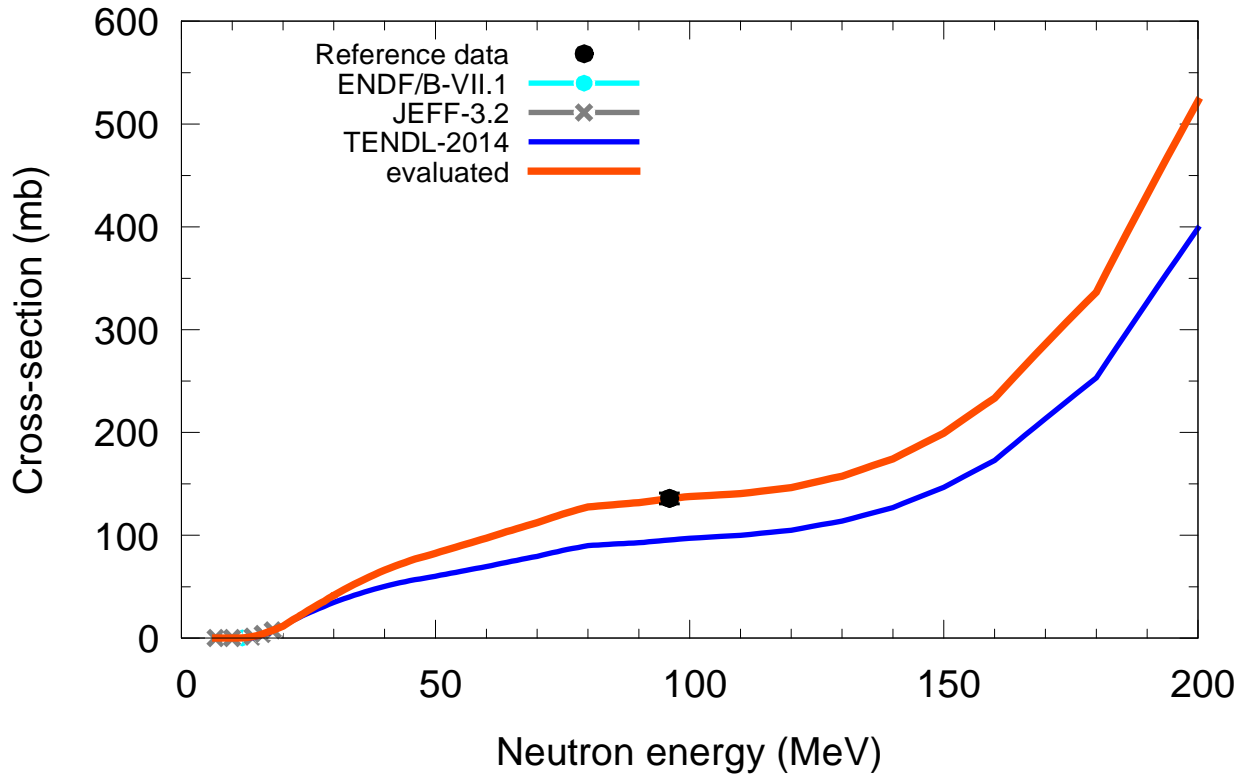


$^{109}\text{Ag}(n,x)d$

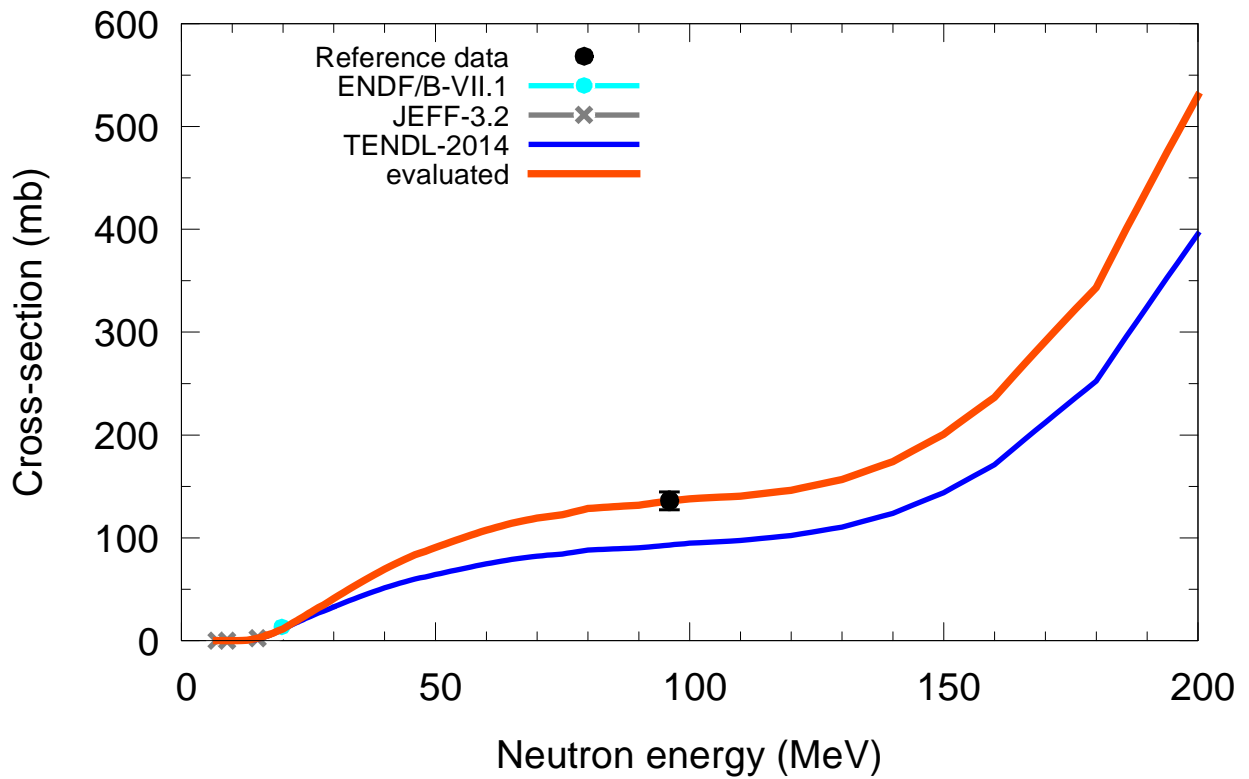


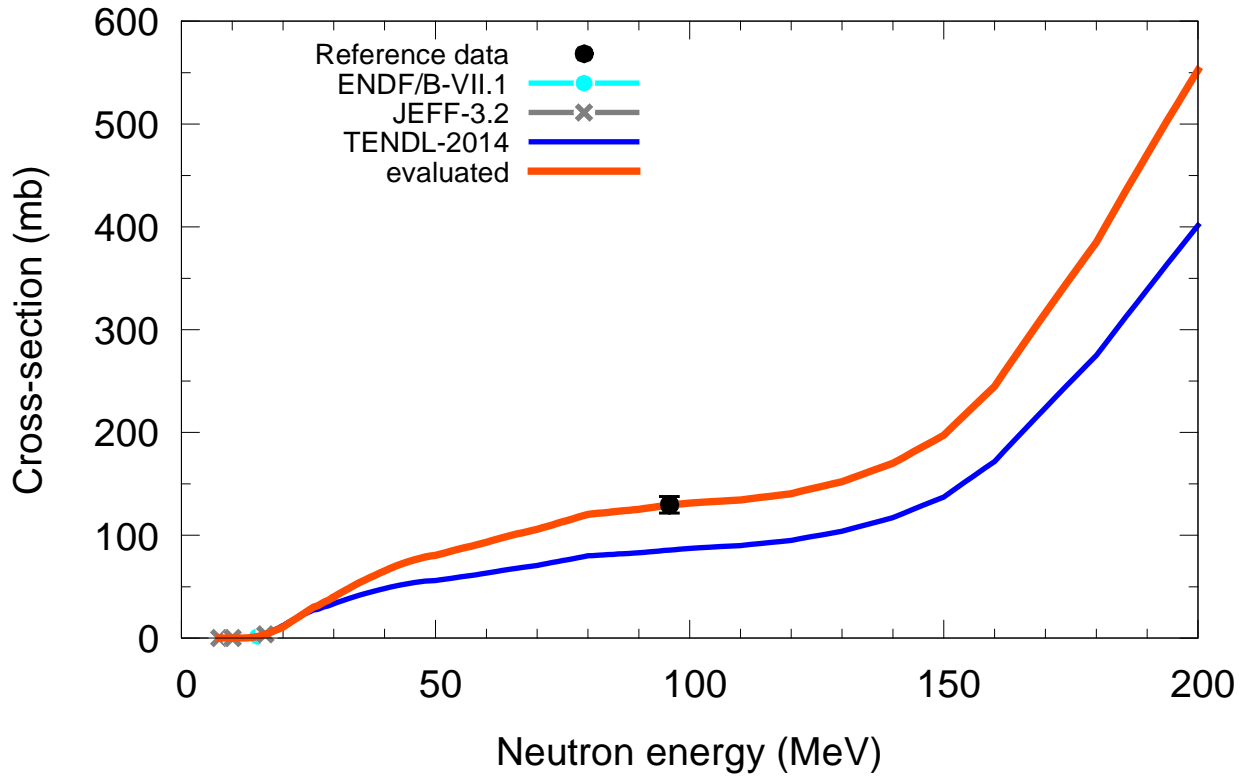
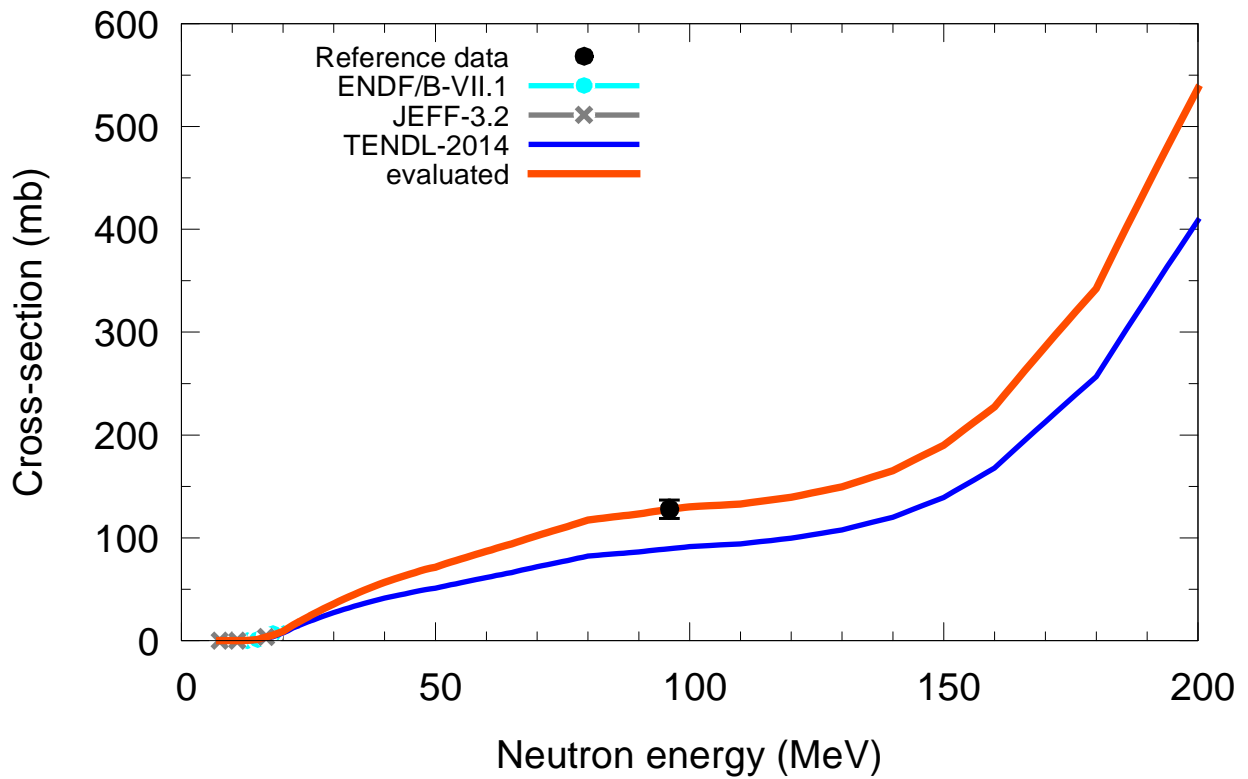
$^{106}\text{Cd}(n,x)d$  $^{108}\text{Cd}(n,x)d$ 

### $^{110}\text{Cd}(n,x)d$

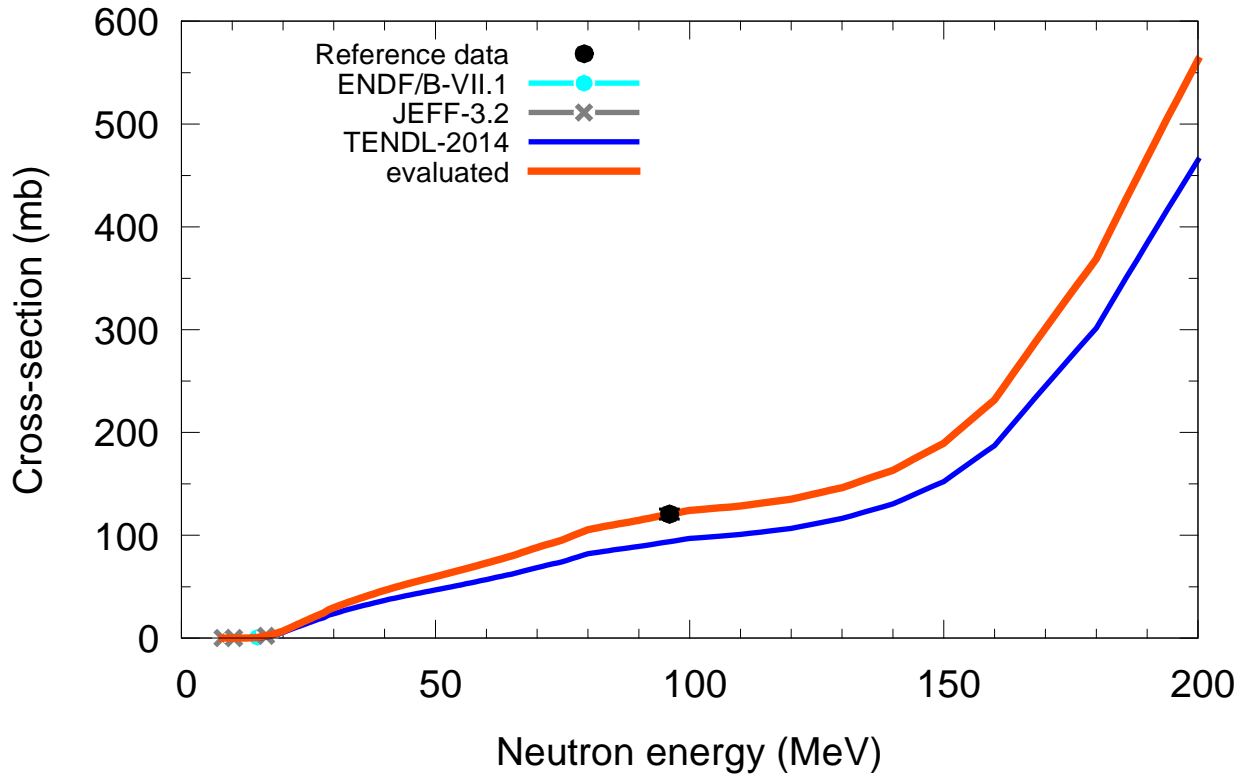


### $^{111}\text{Cd}(n,x)d$

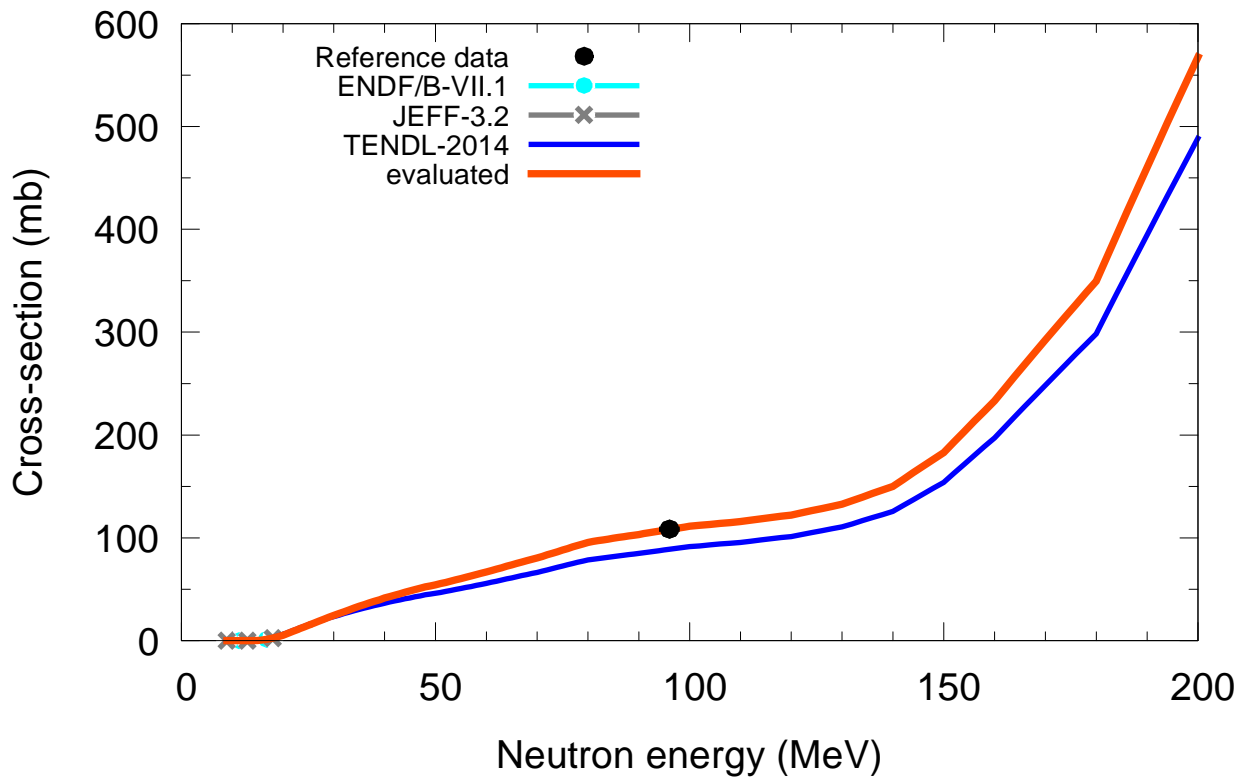


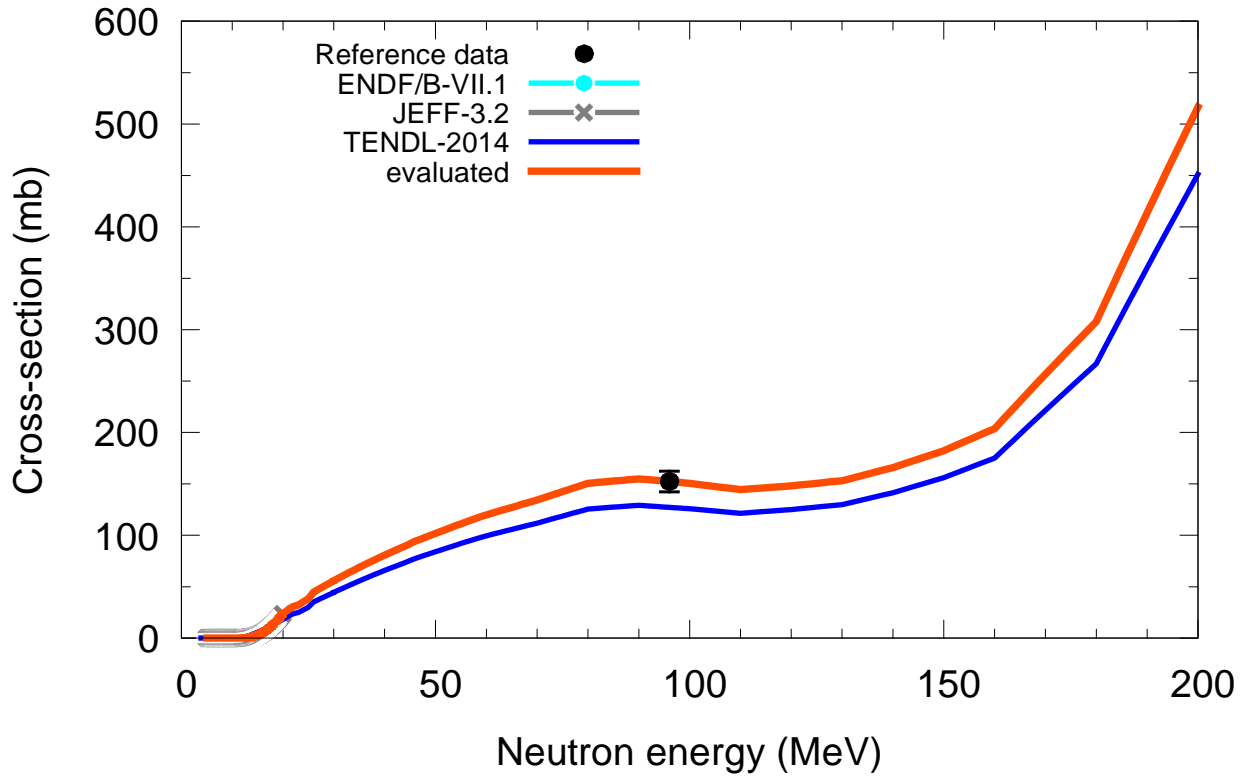
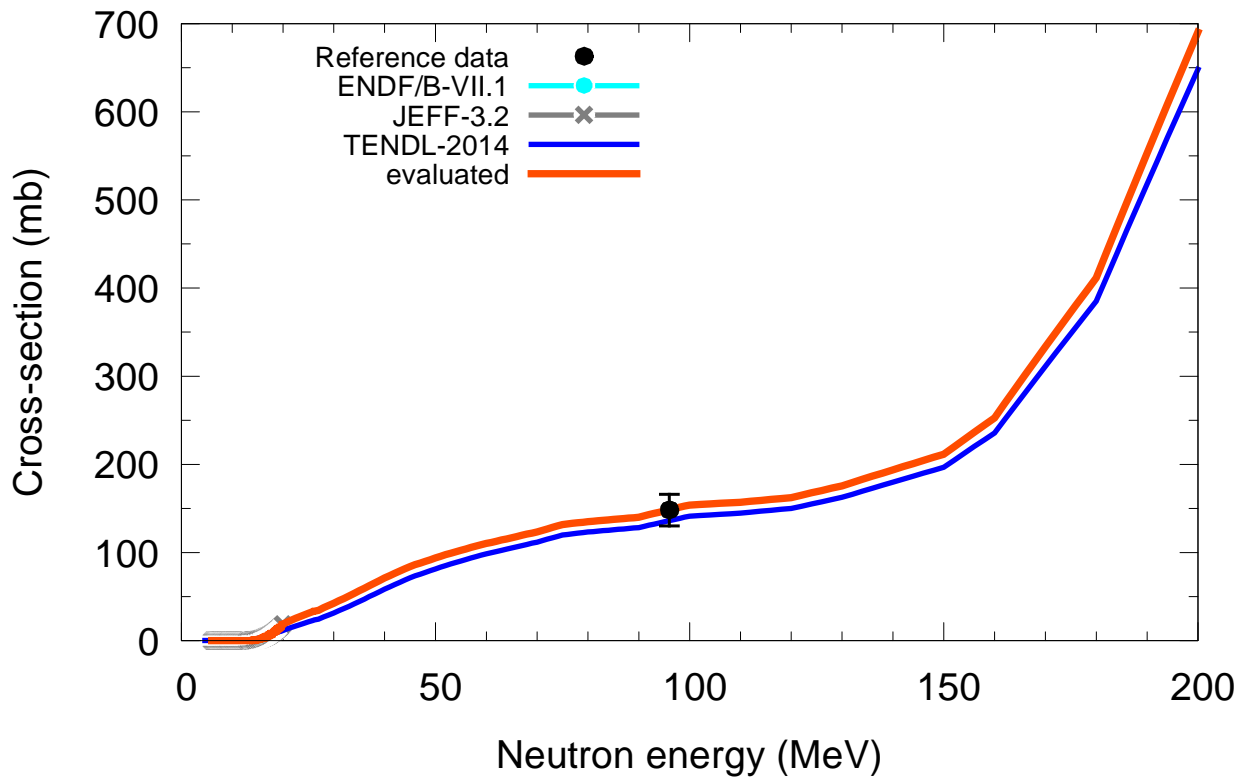
$^{112}\text{Cd}(n,x)d$  $^{113}\text{Cd}(n,x)d$ 

### $^{114}\text{Cd}(n,x)d$

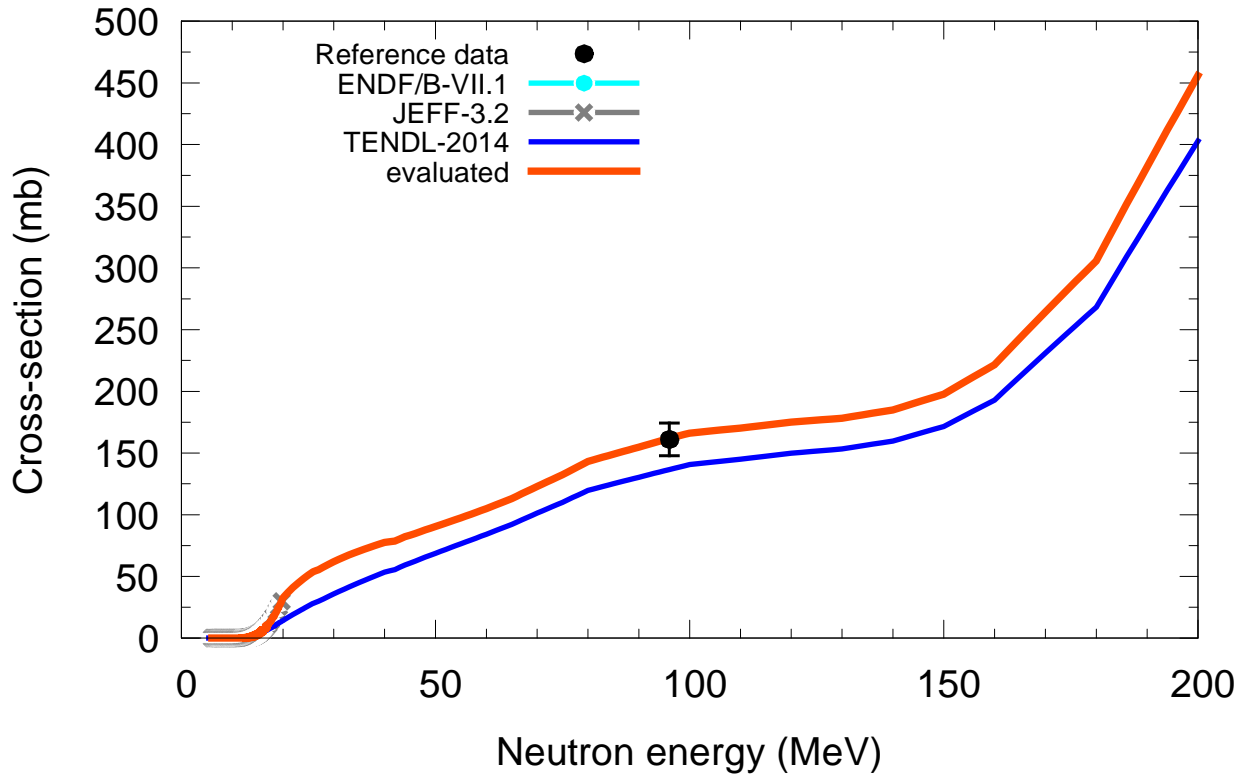


### $^{116}\text{Cd}(n,x)d$

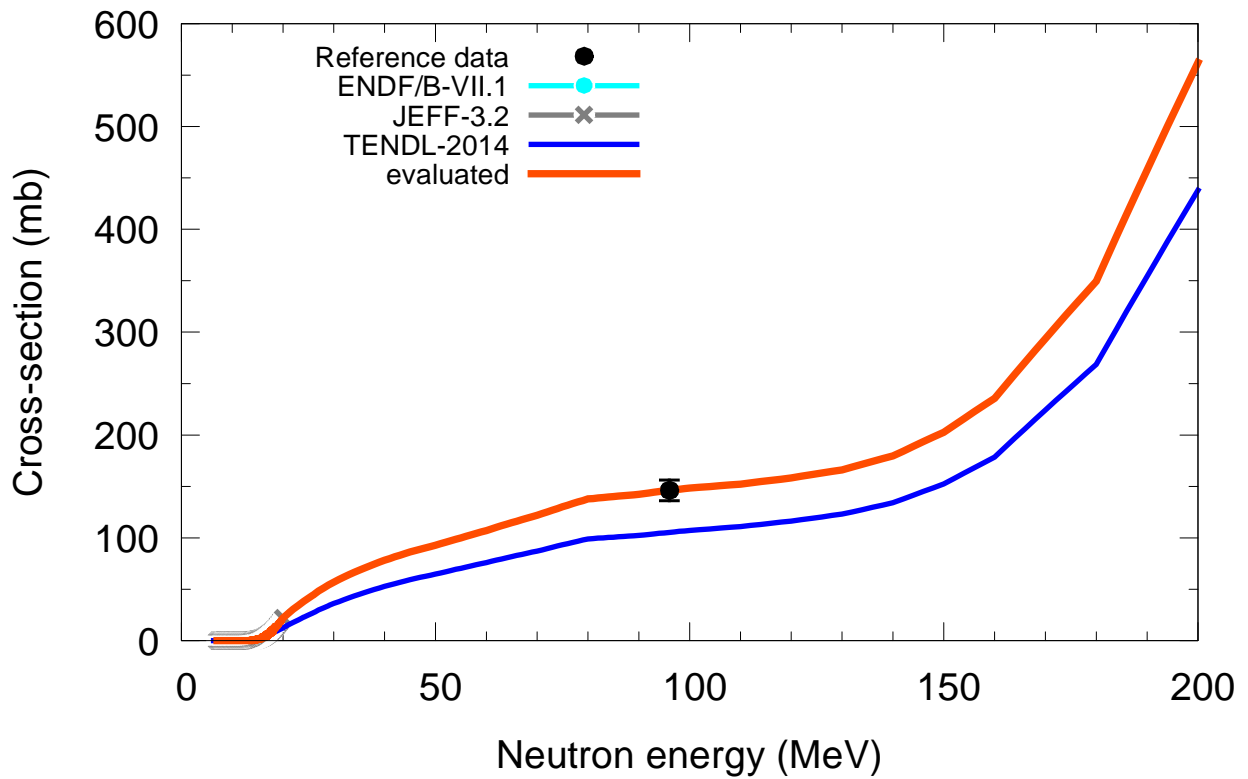


$^{113}\text{In}(n,x)d$  $^{115}\text{In}(n,x)d$ 

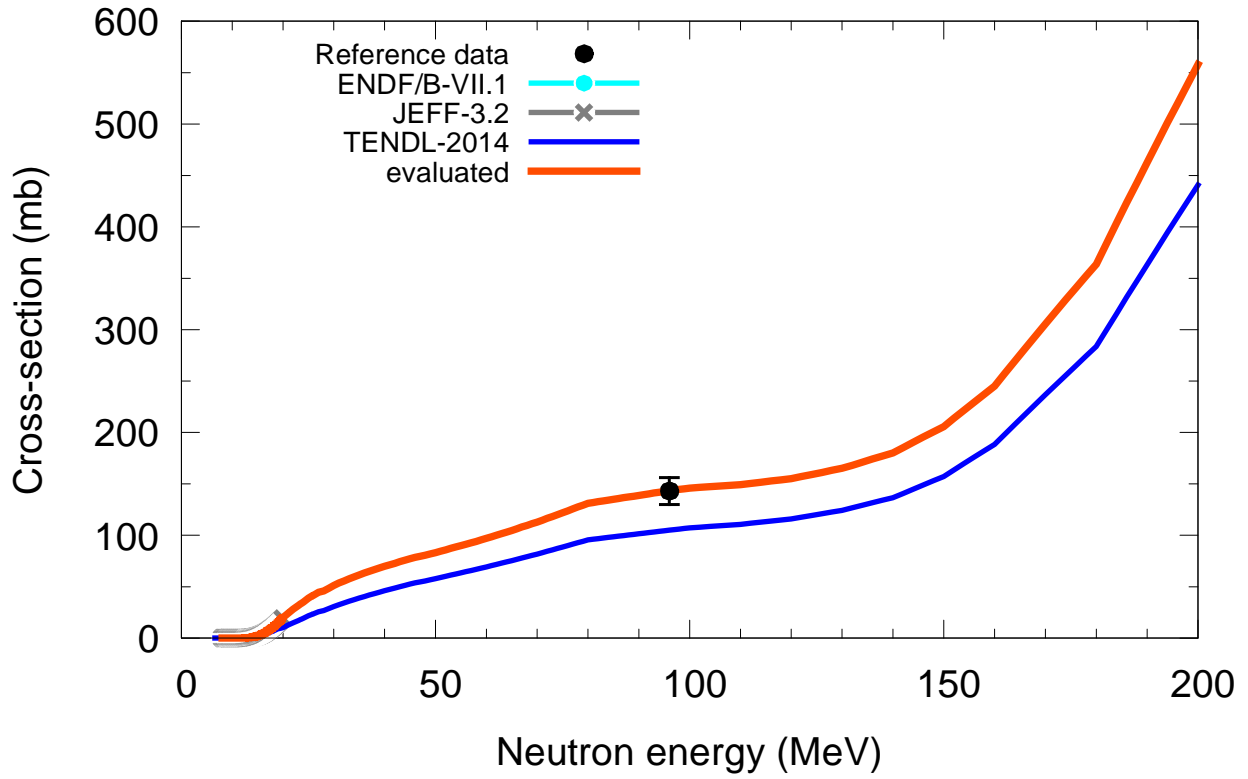
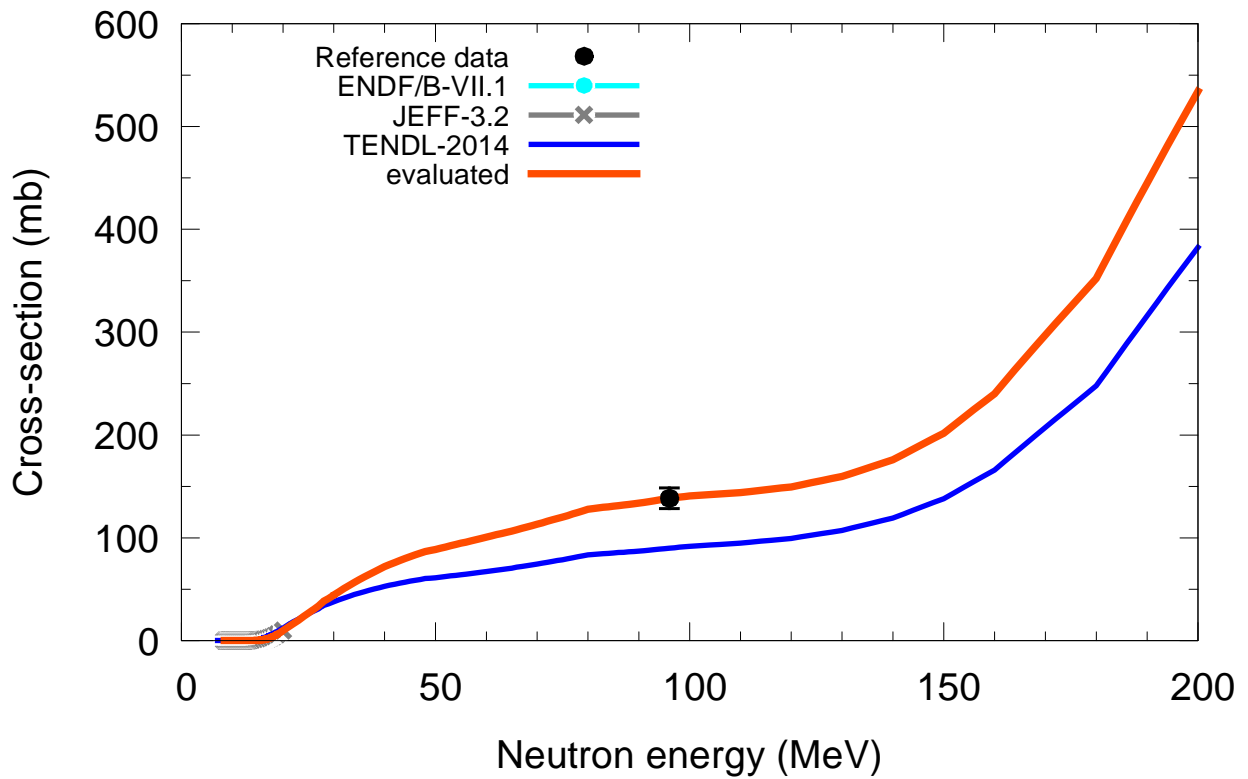
### $^{112}\text{Sn}(n,x)d$



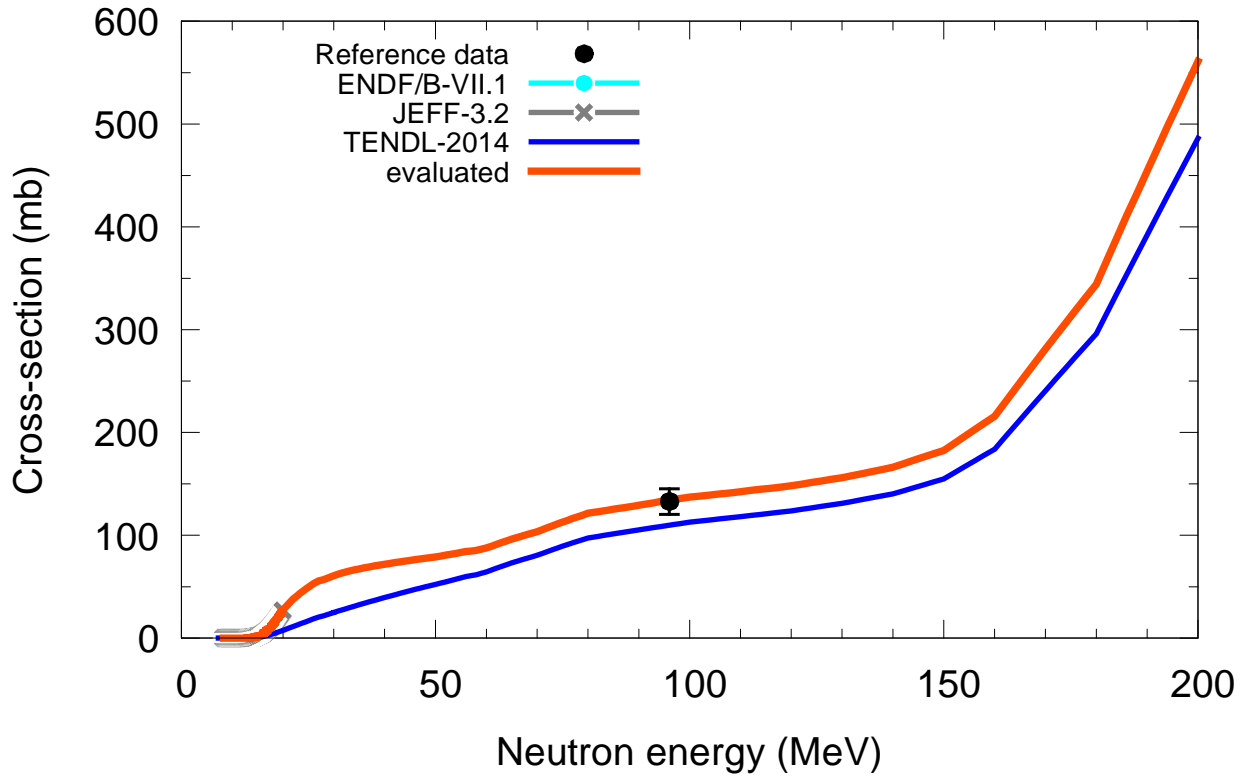
### $^{114}\text{Sn}(n,x)d$



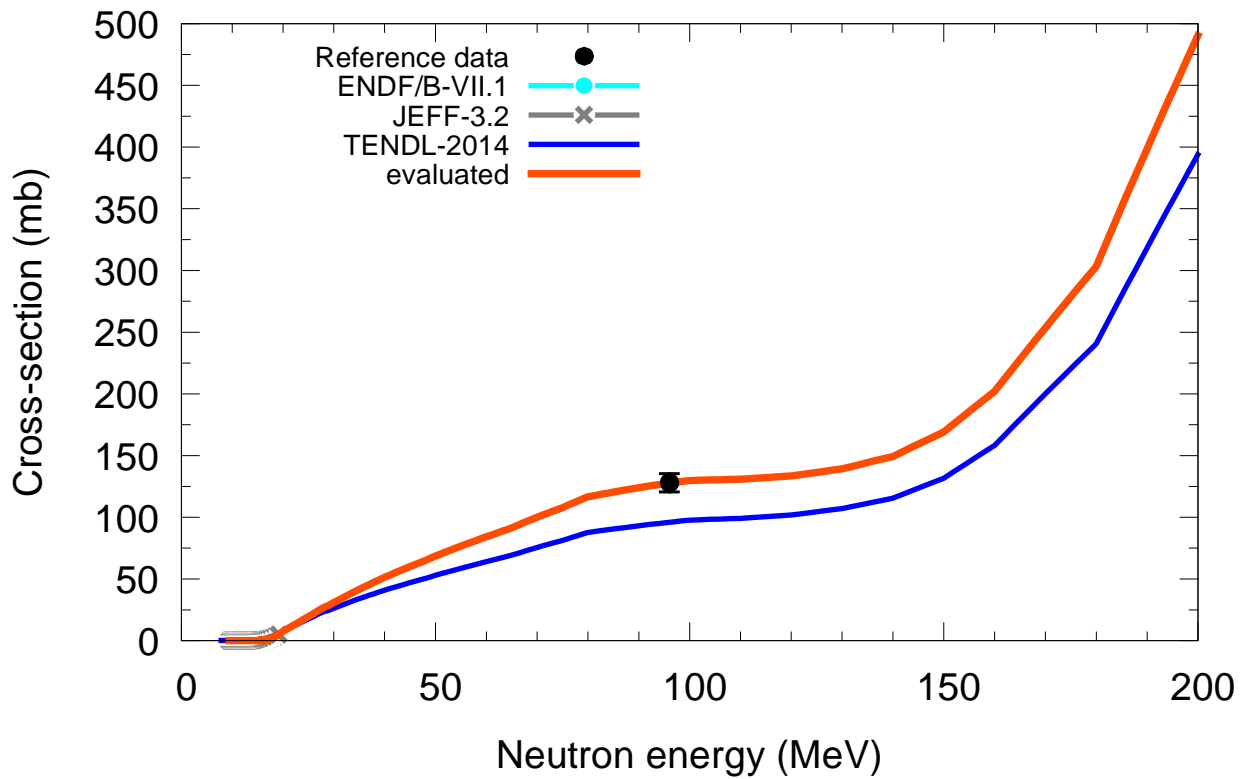


$^{115}\text{Sn}(n,x)d$  $^{116}\text{Sn}(n,x)d$ 

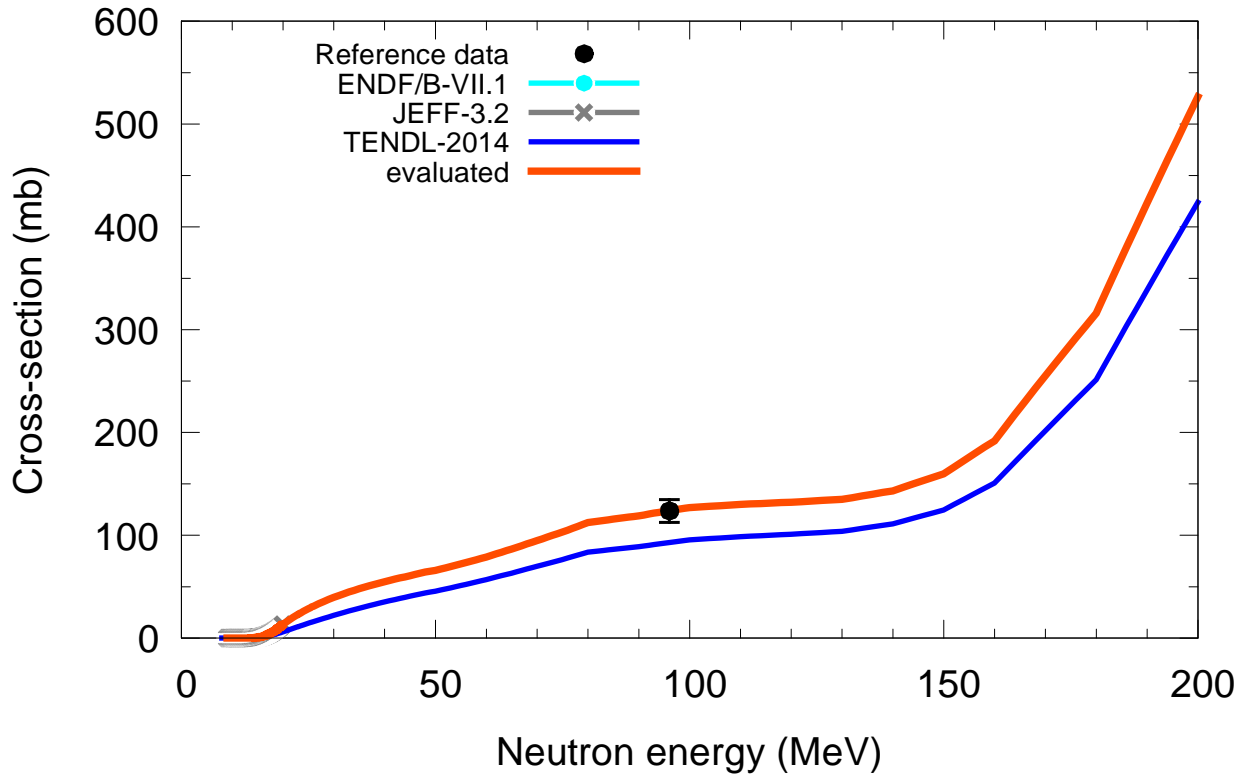
### $^{117}\text{Sn}(n,x)d$



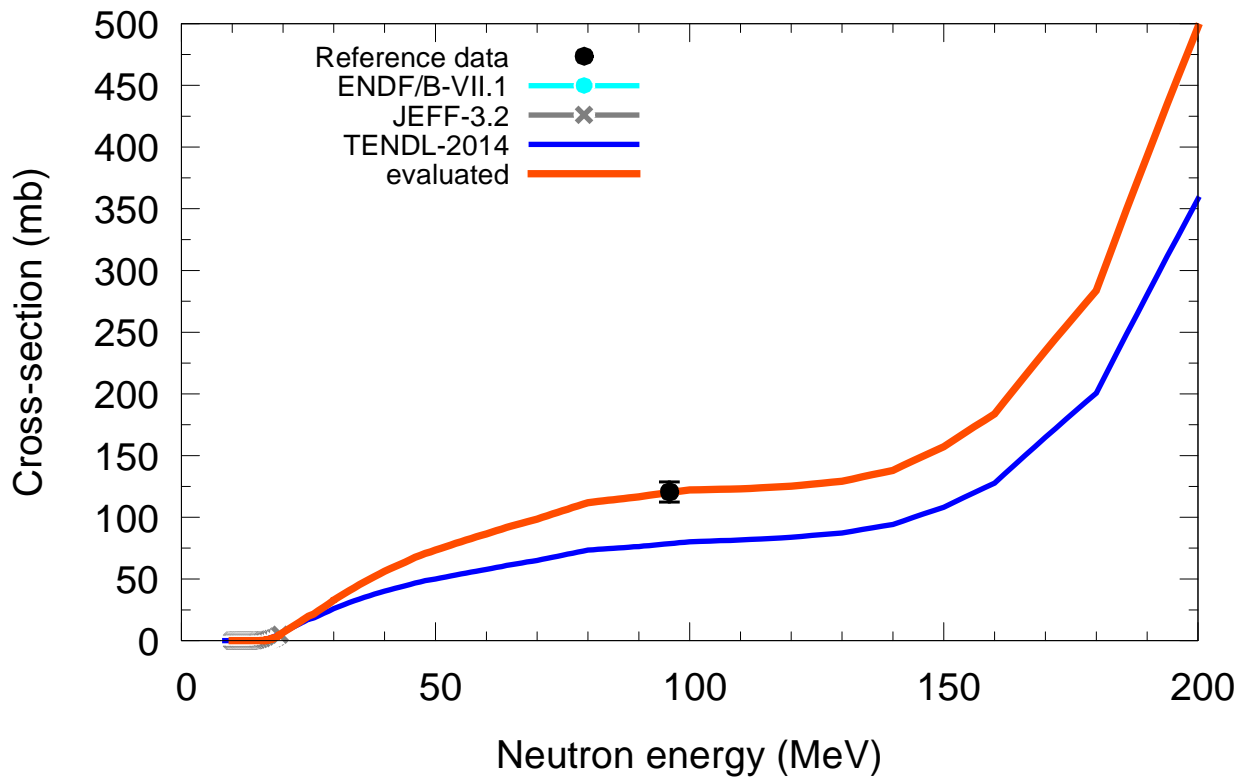
### $^{118}\text{Sn}(n,x)d$

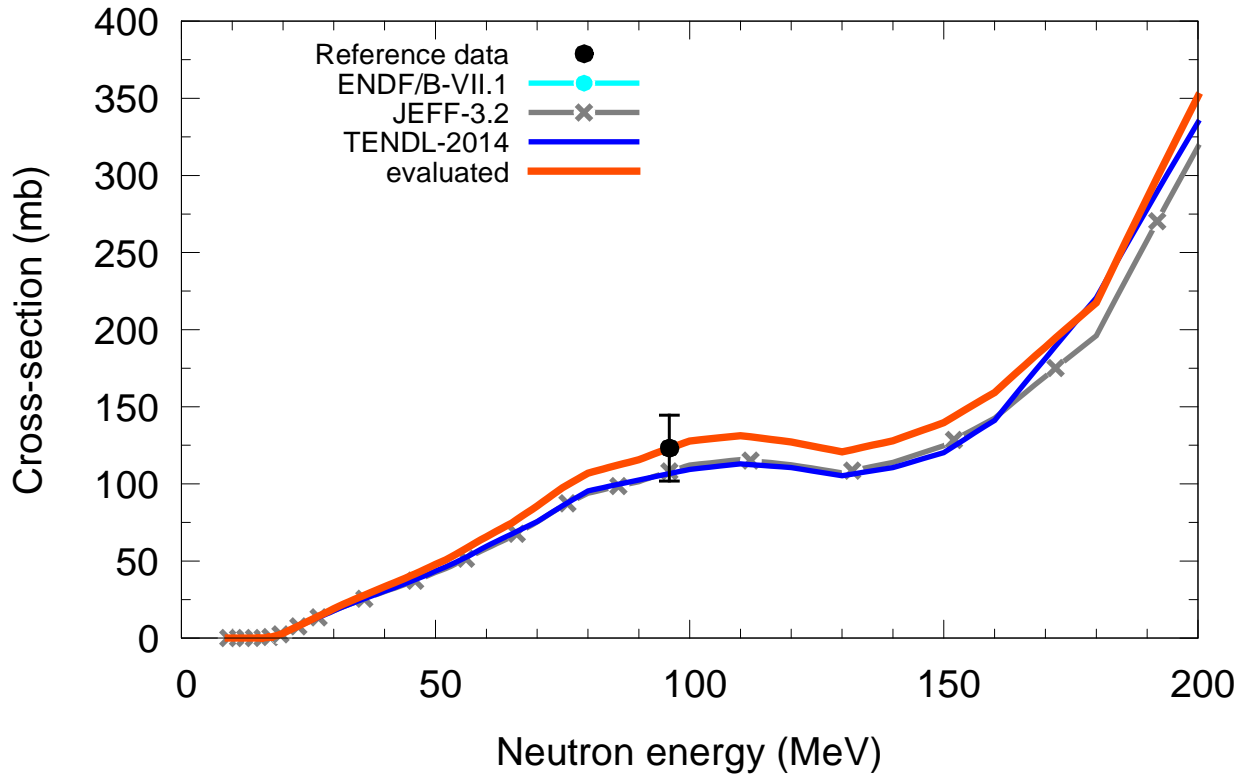
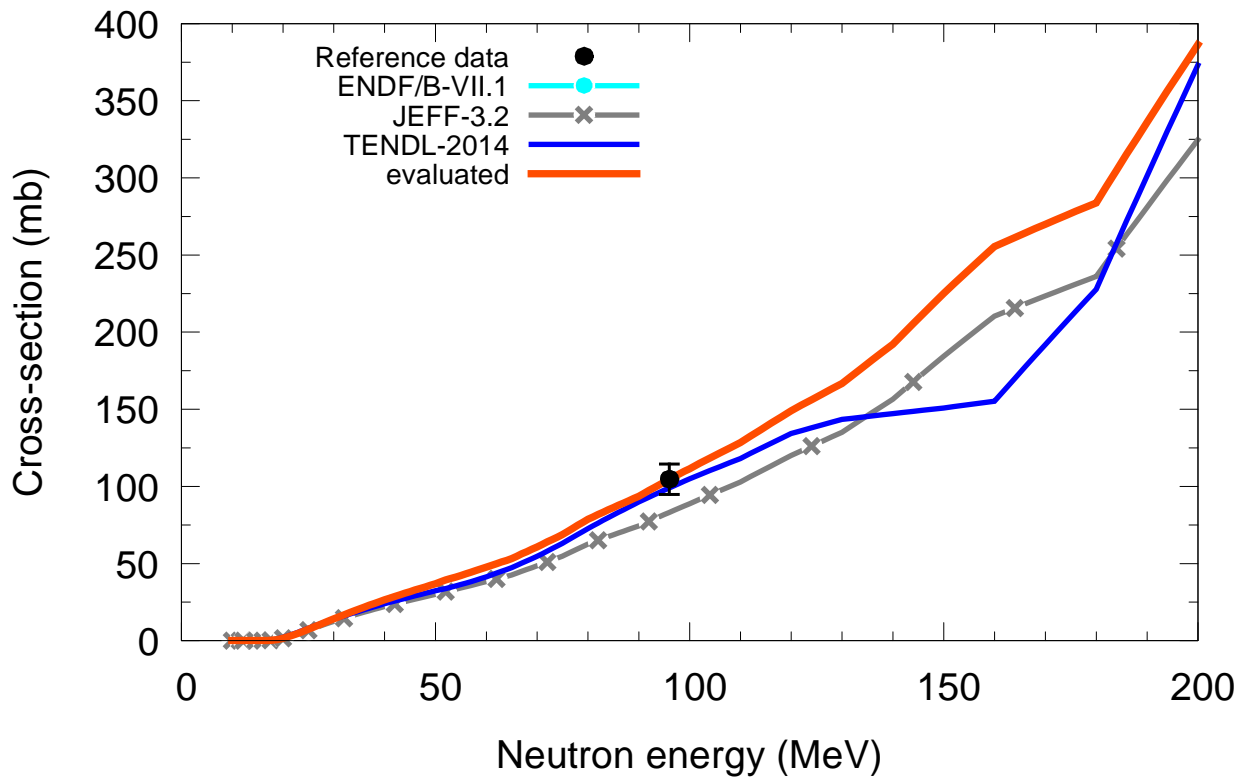


### $^{119}\text{Sn}(n,x)d$

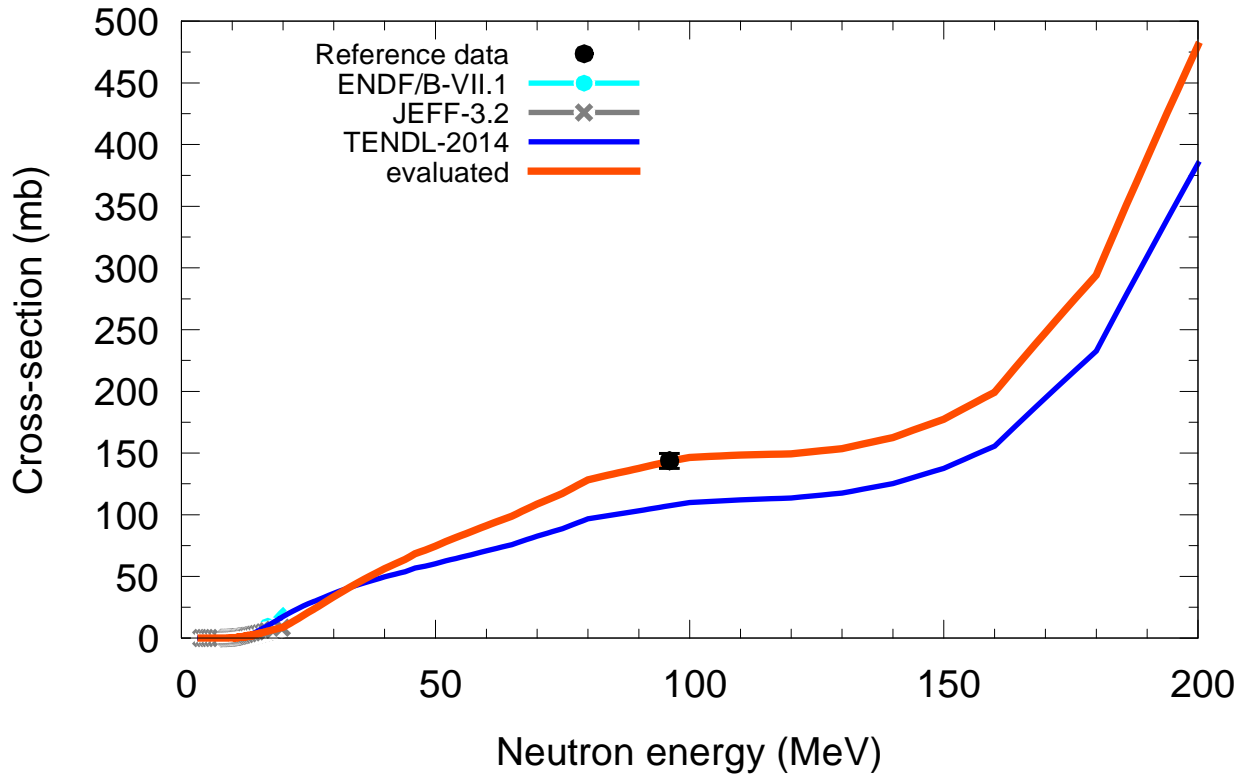


### $^{120}\text{Sn}(n,x)d$

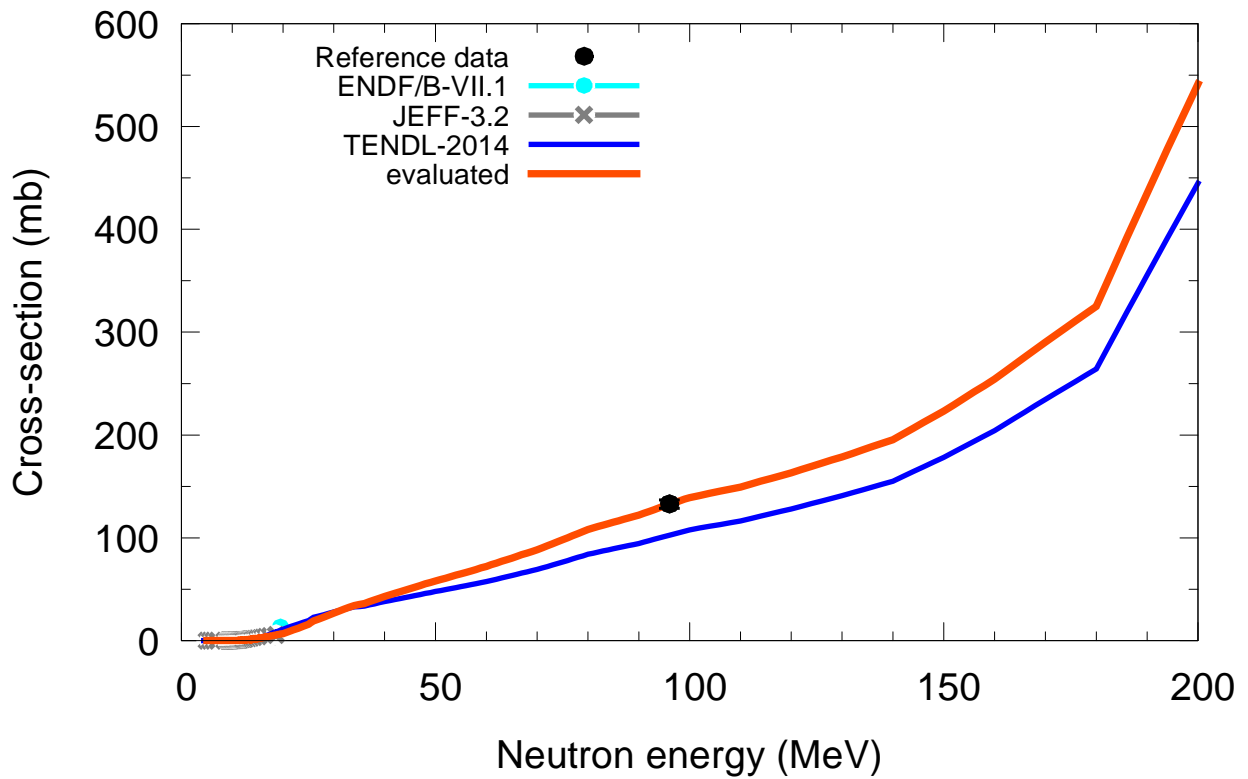


$^{122}\text{Sn}(n,x)d$  $^{124}\text{Sn}(n,x)d$ 

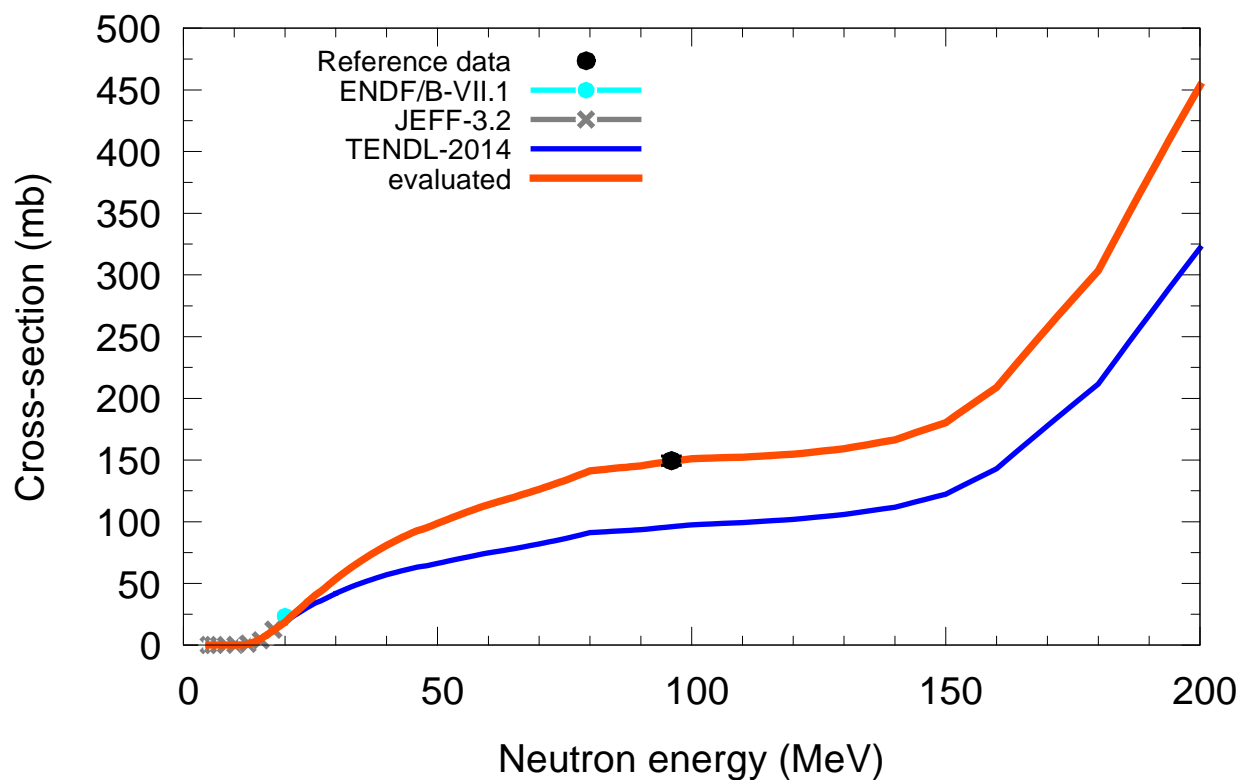
### $^{121}\text{Sb}(n,x)d$



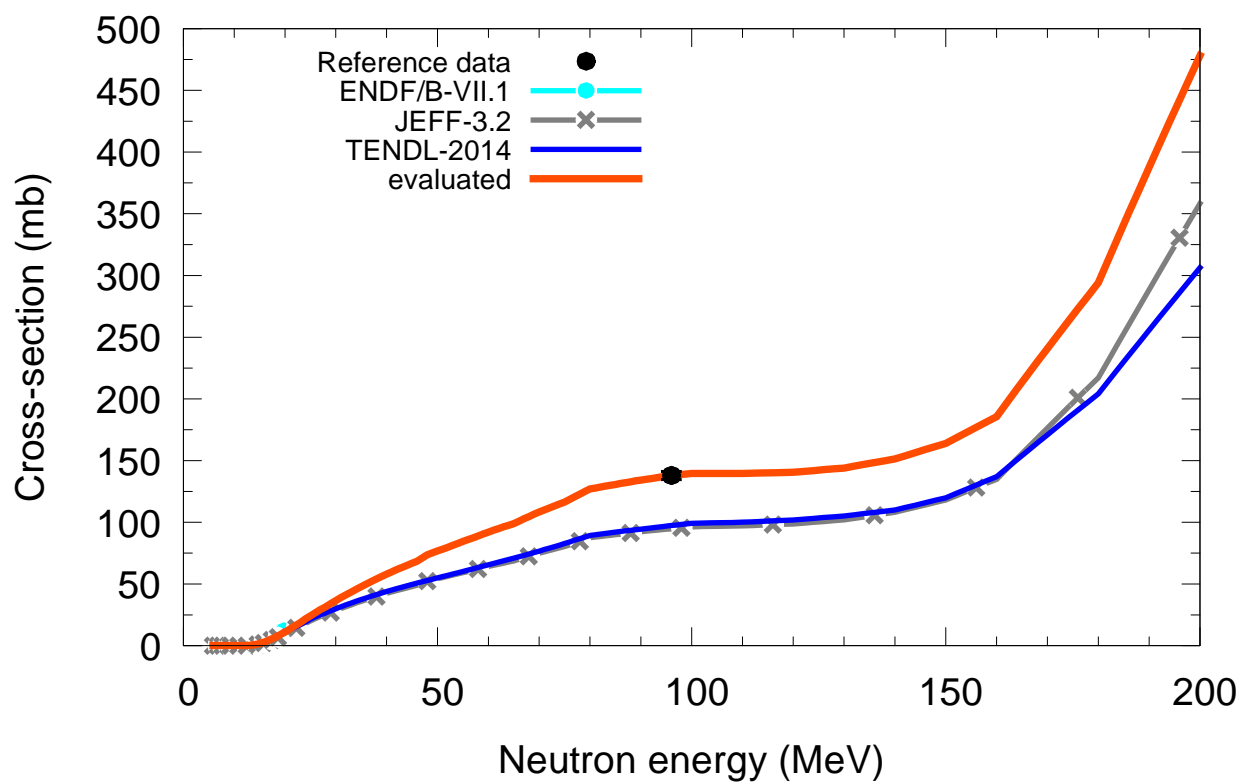
### $^{123}\text{Sb}(n,x)d$

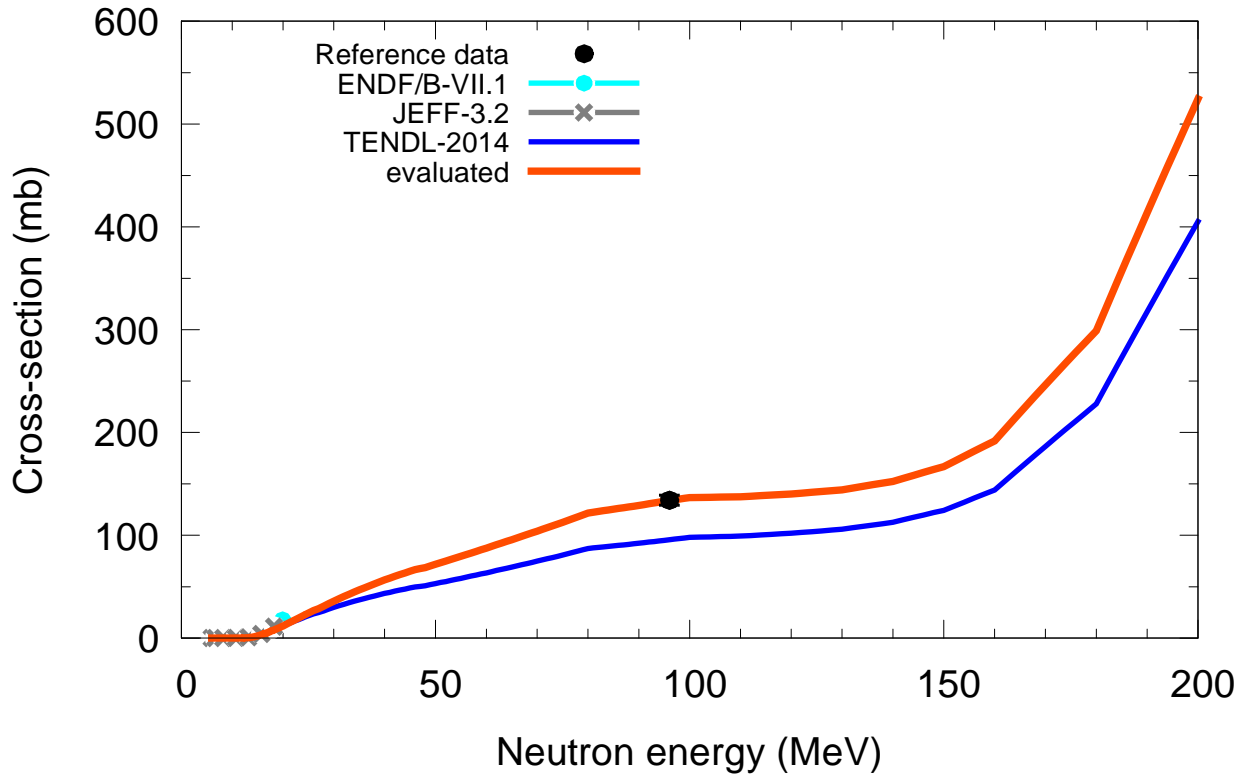
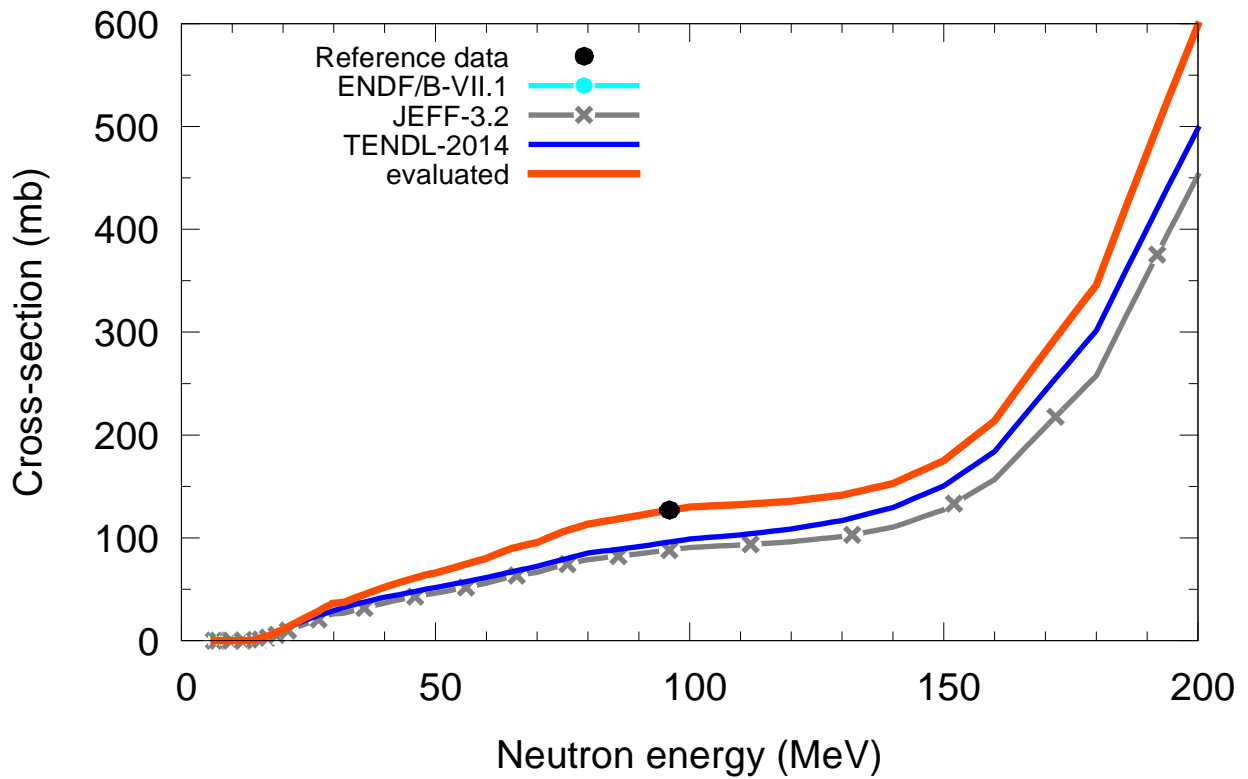


### $^{120}\text{Te}(n,x)d$

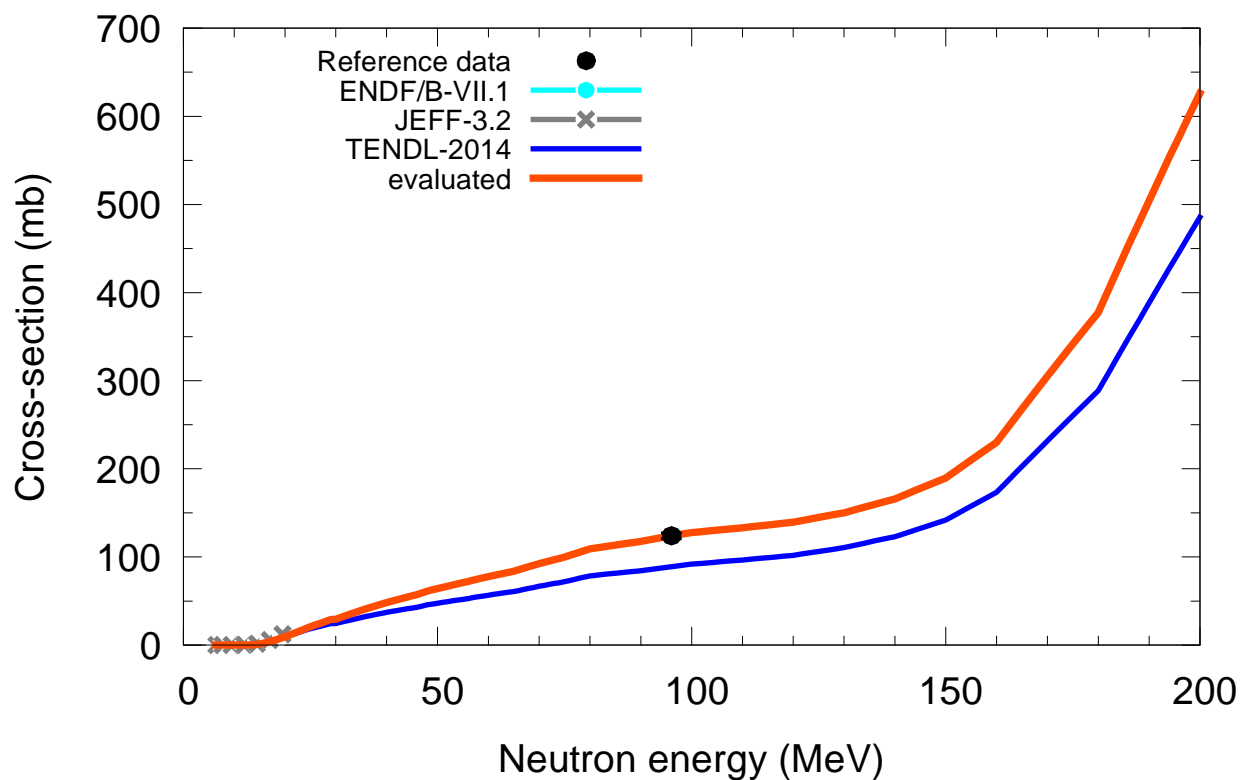


### $^{122}\text{Te}(n,x)d$

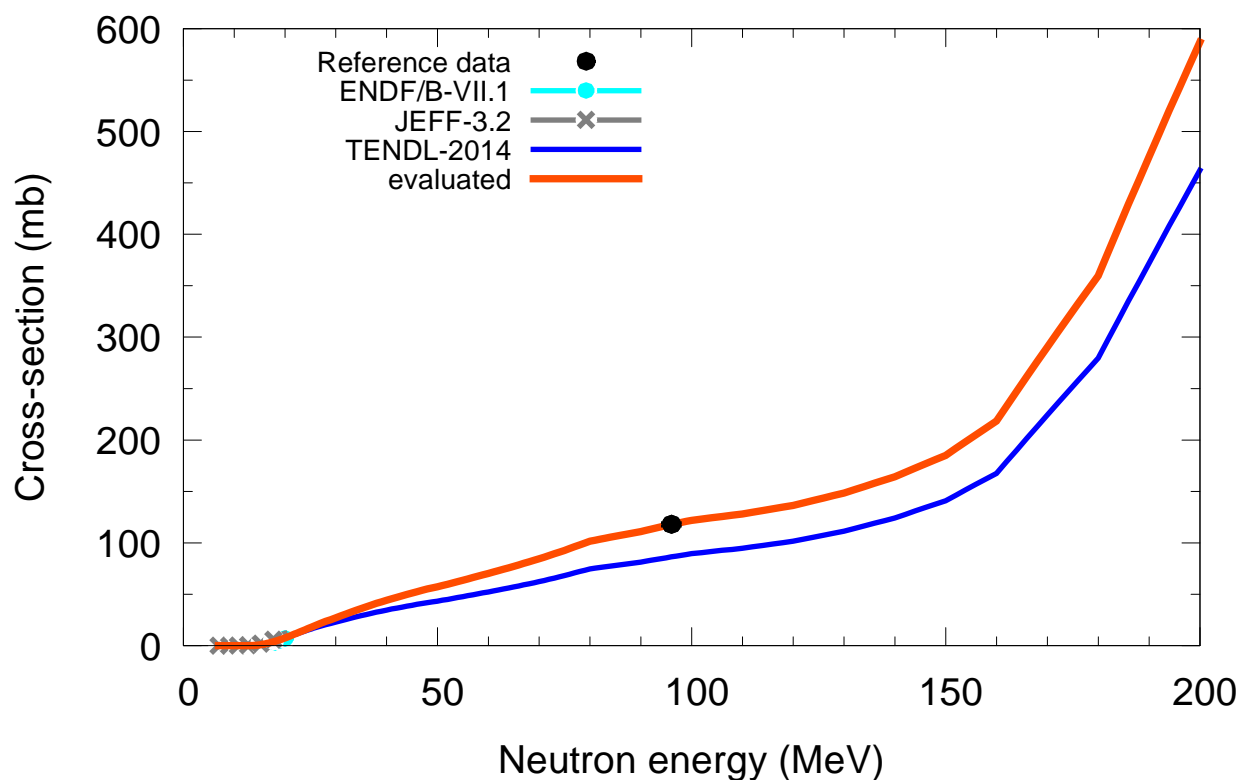


$^{123}\text{Te}(n,x)d$  $^{124}\text{Te}(n,x)d$ 

### $^{125}\text{Te}(n,x)d$

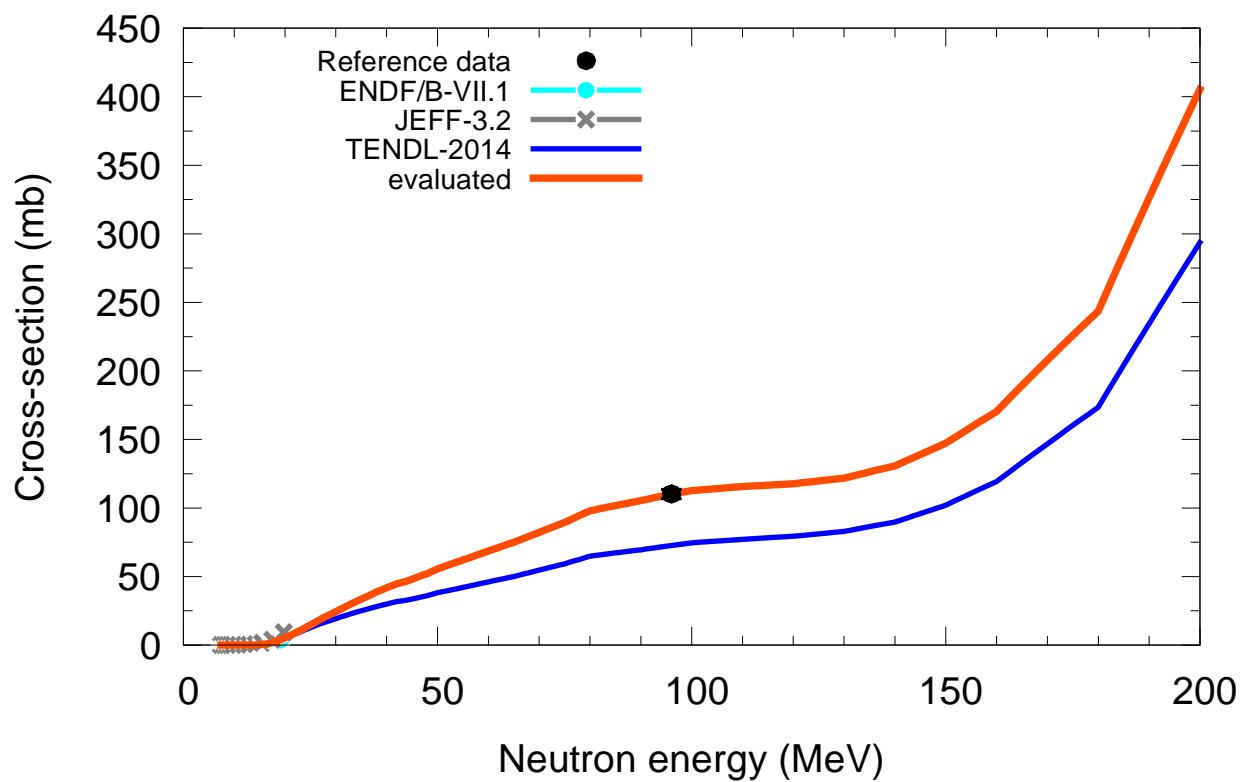


### $^{126}\text{Te}(n,x)d$

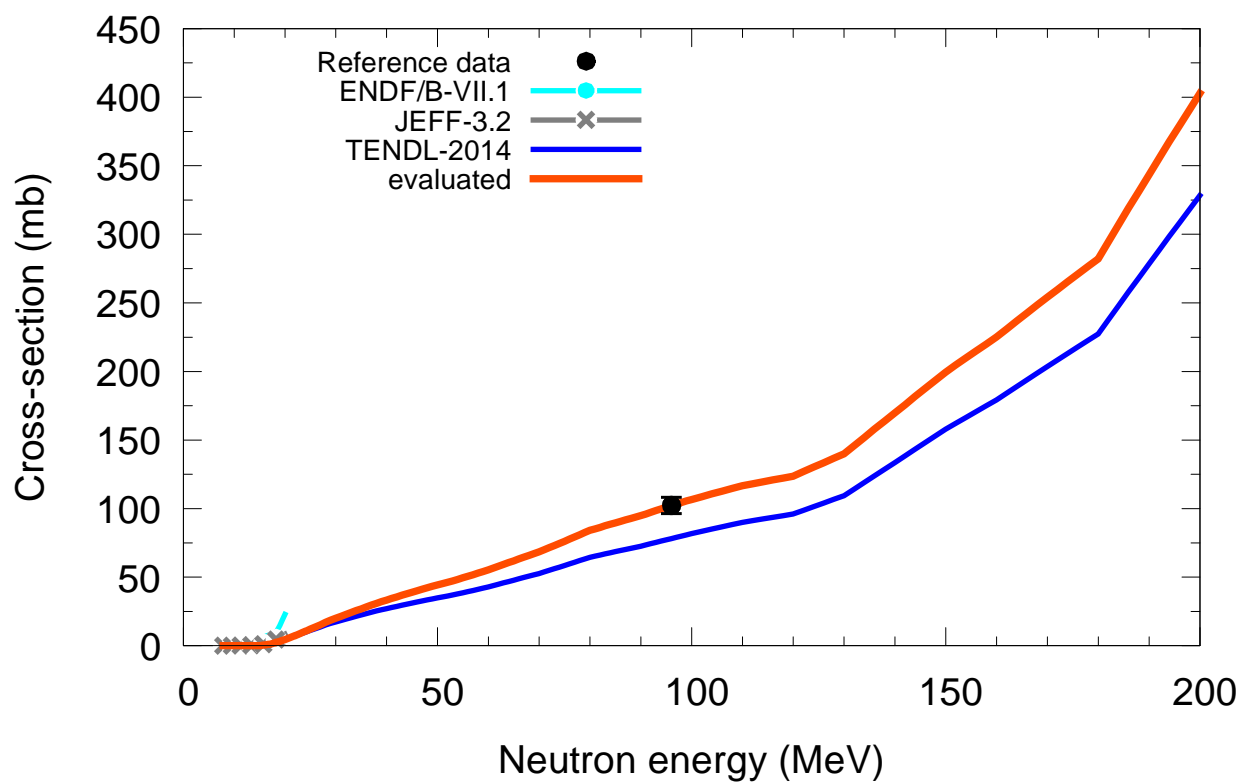


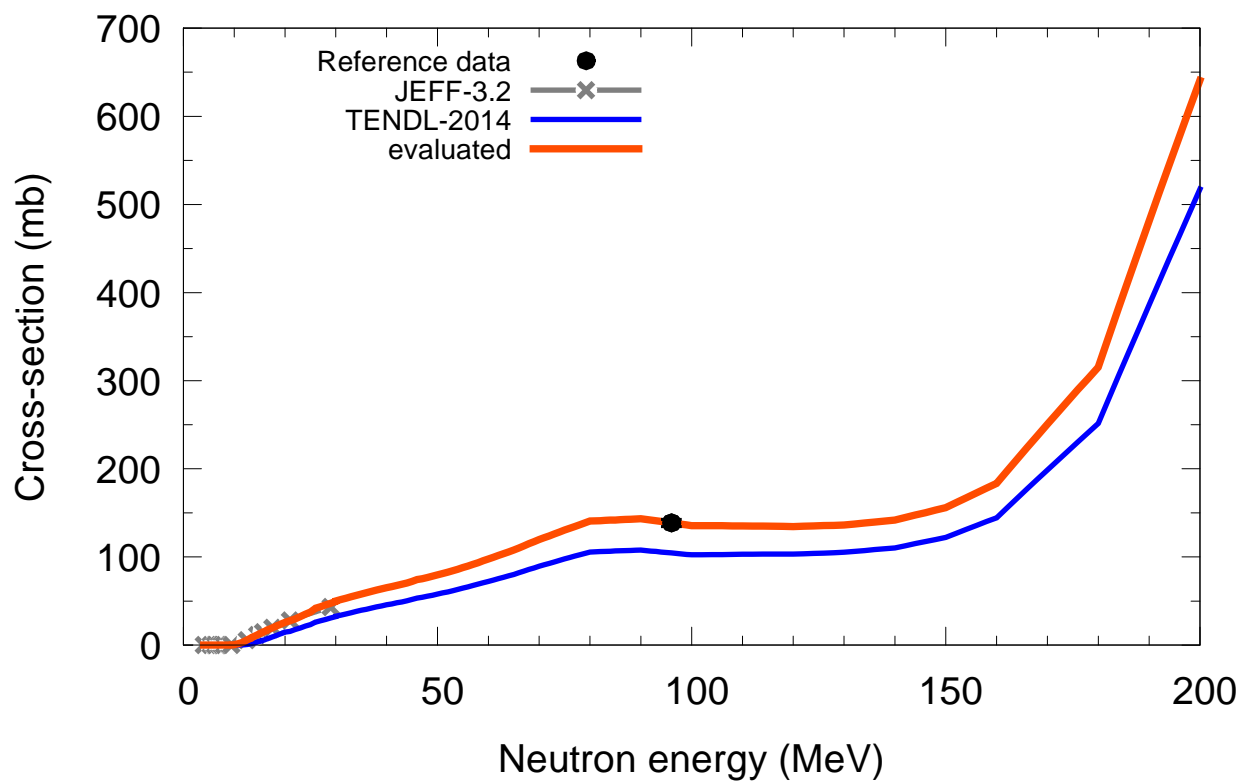
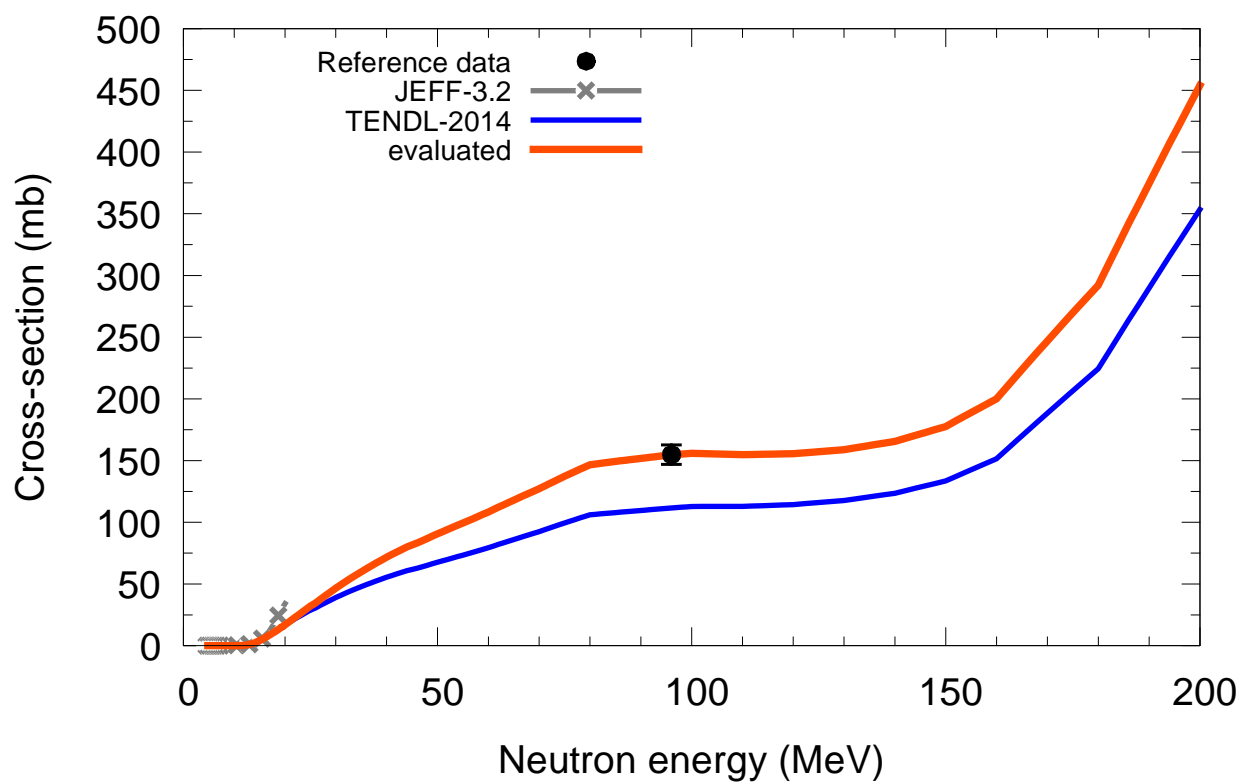


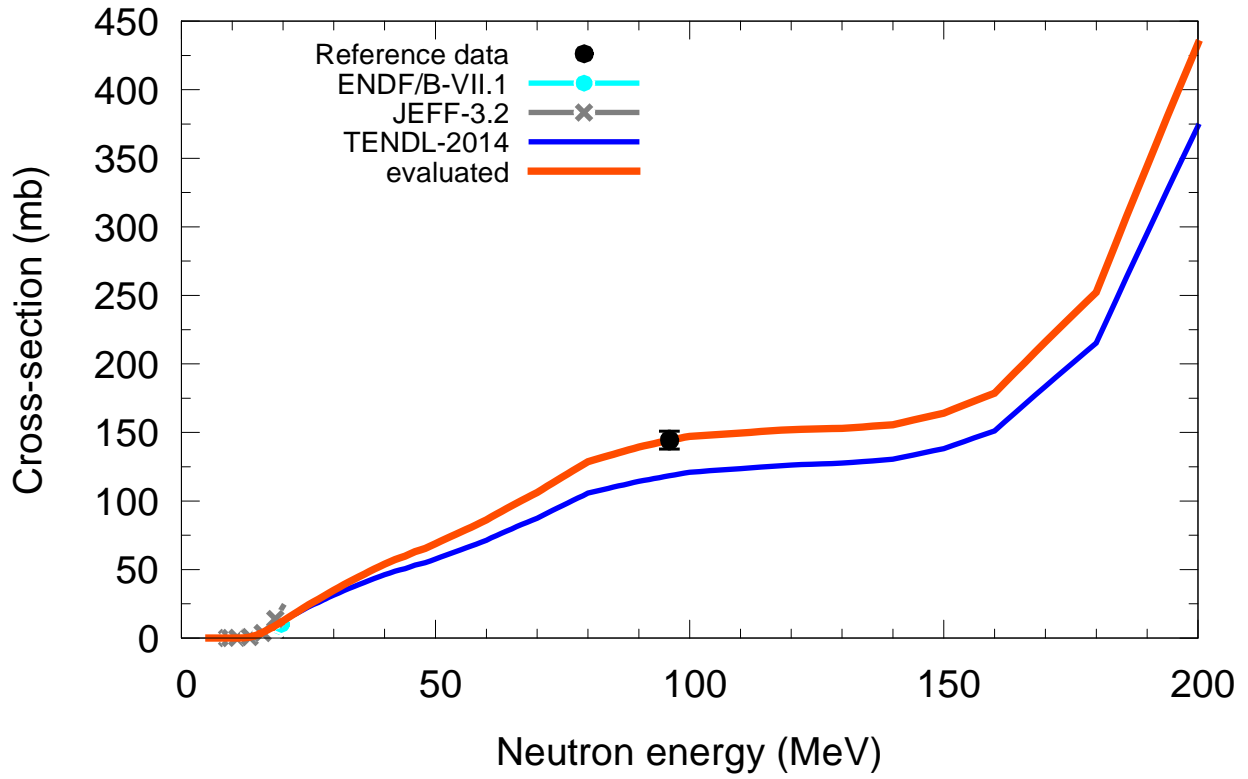
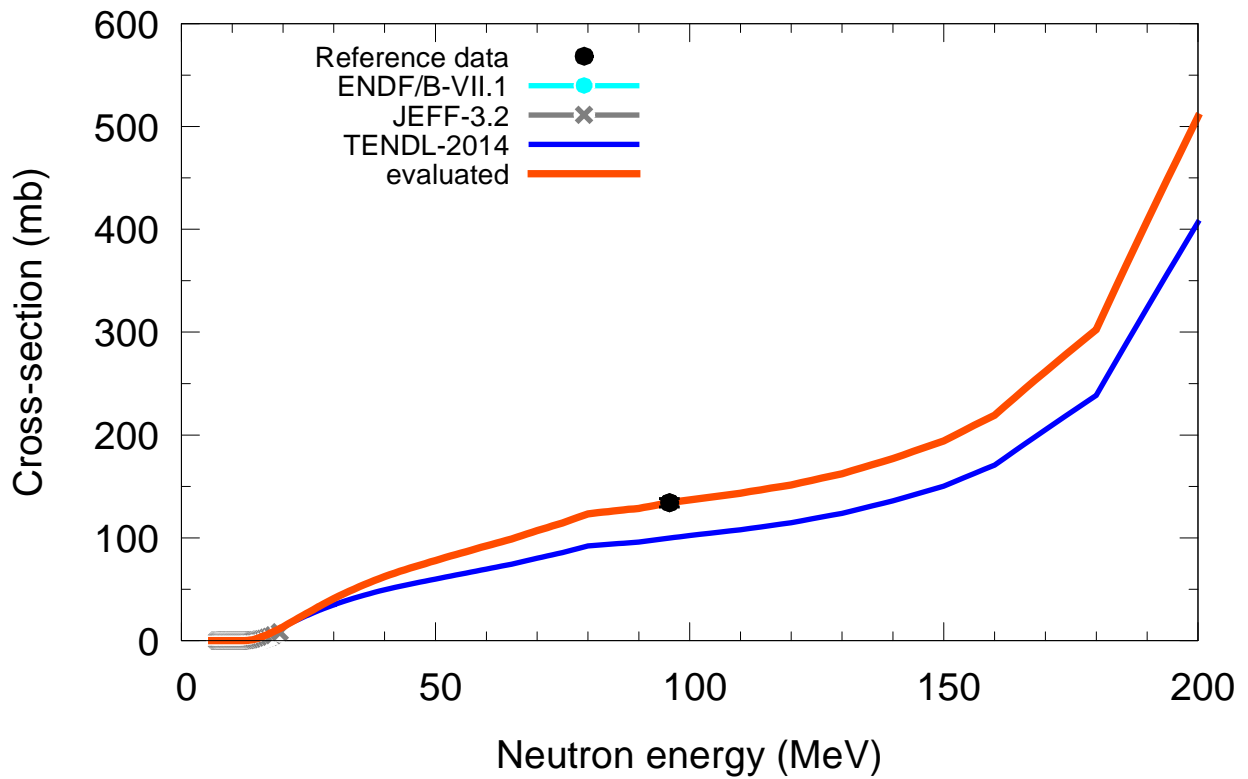
### $^{128}\text{Te}(n,x)d$

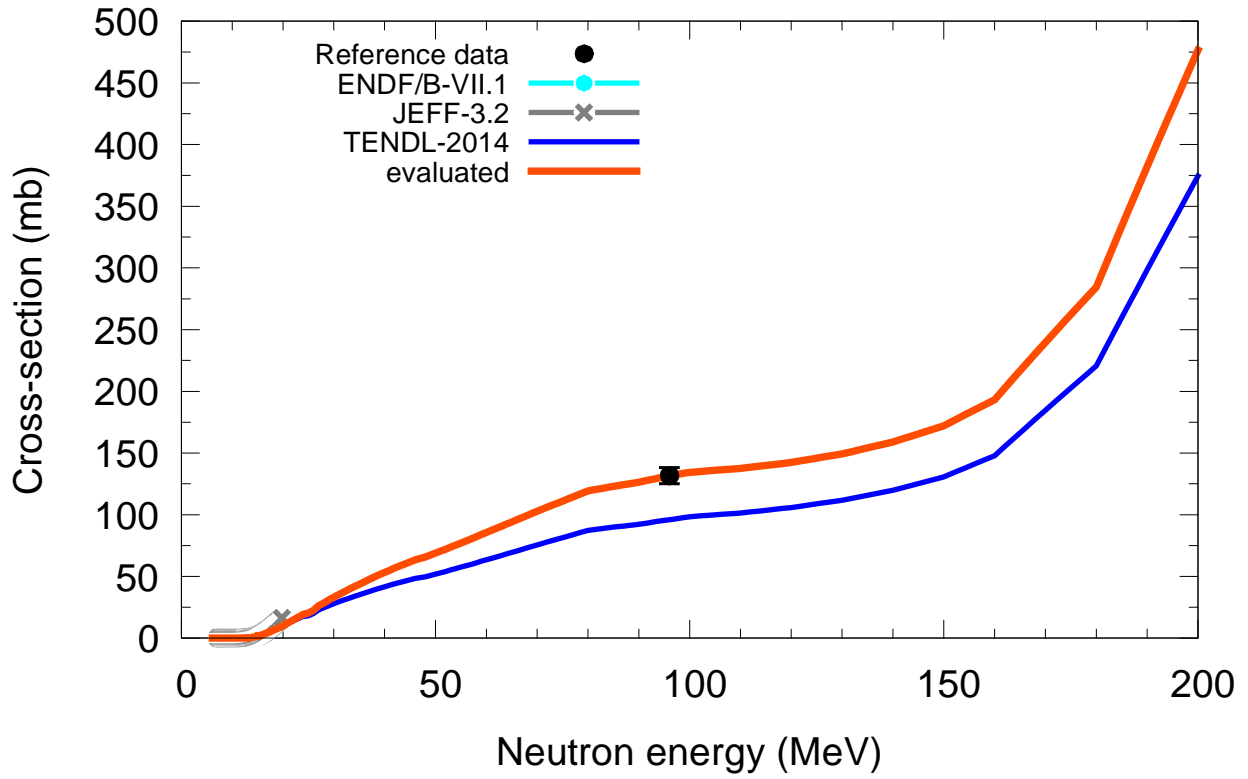
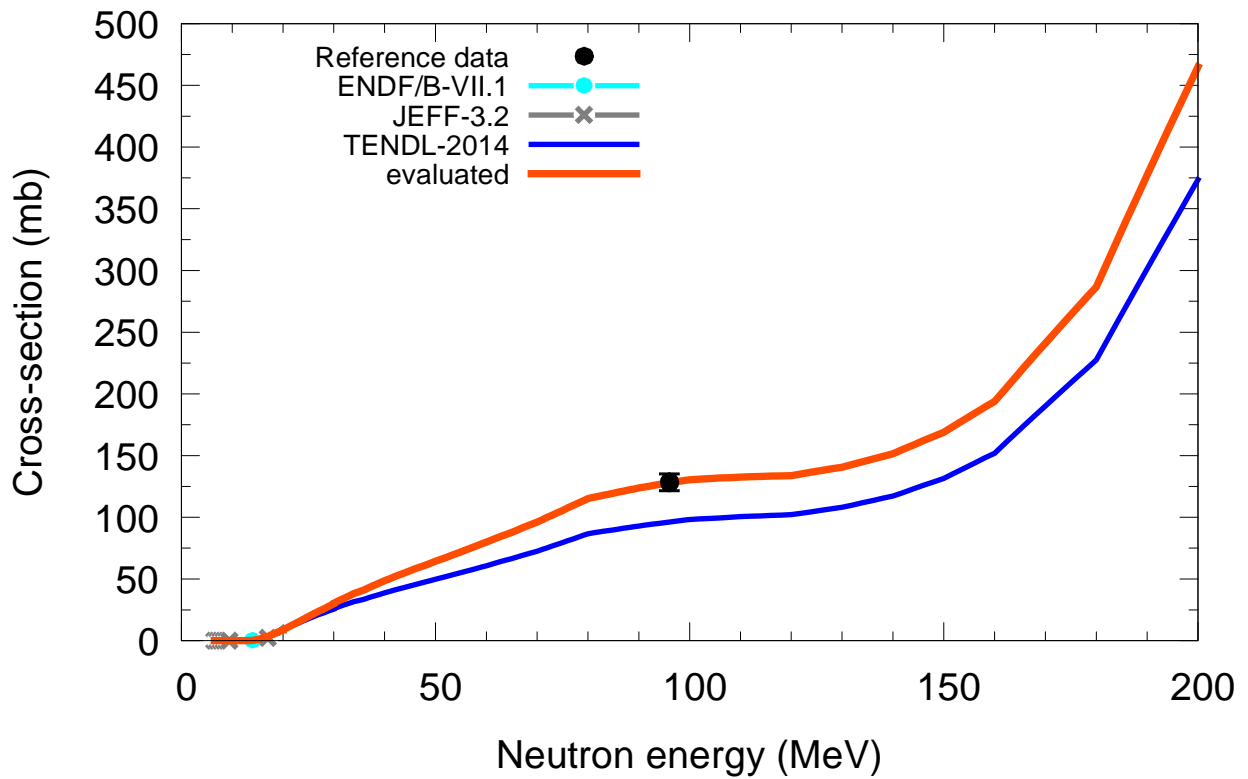


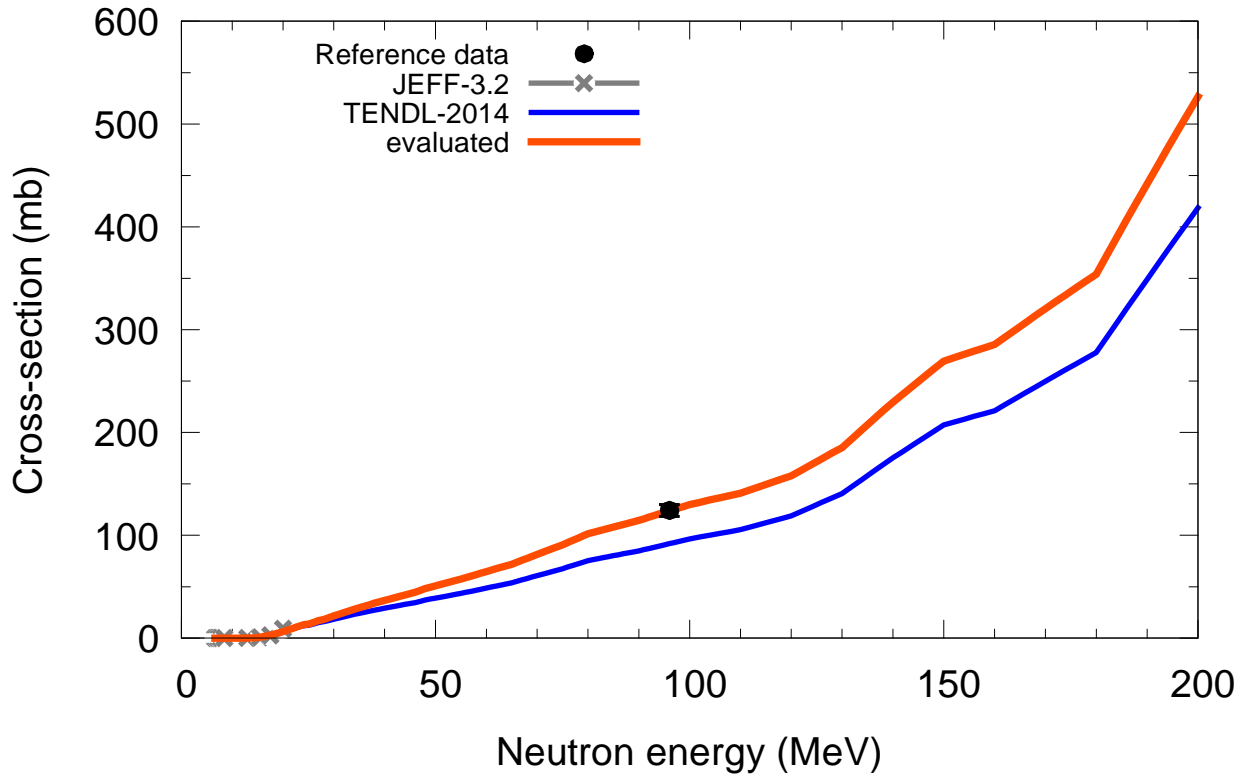
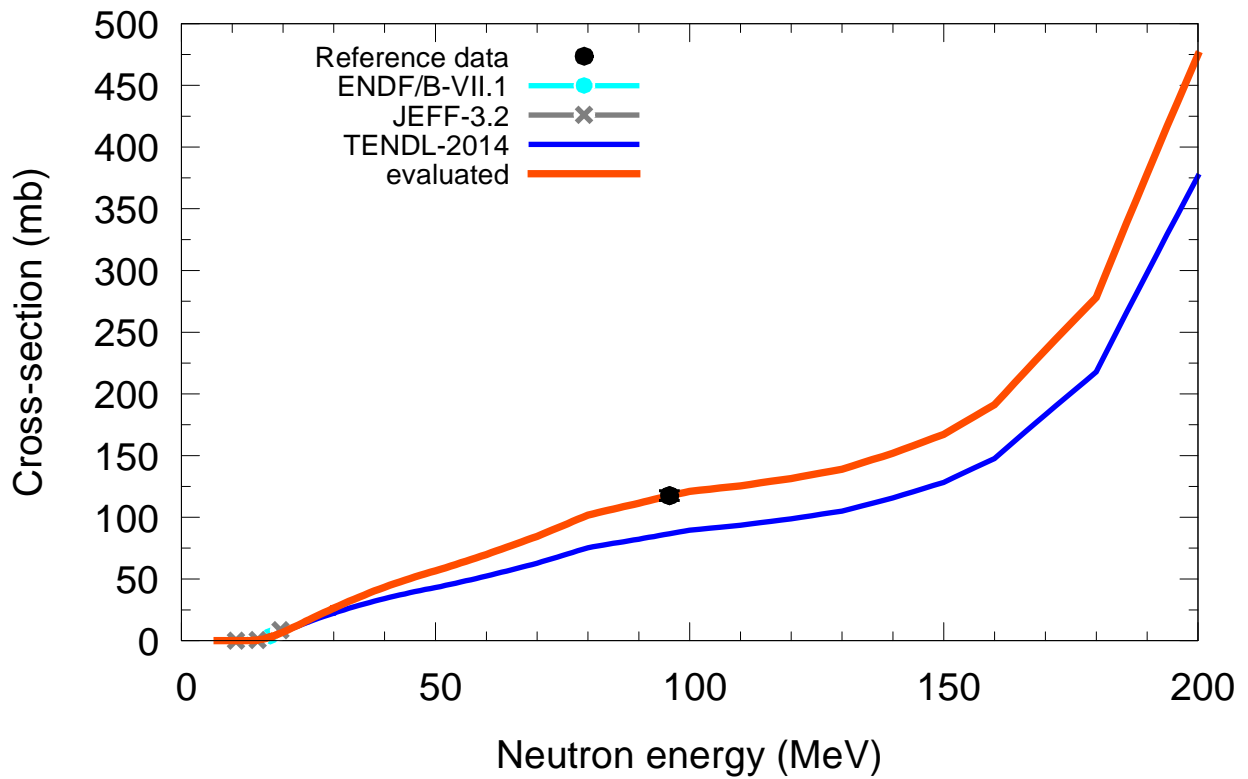
### $^{130}\text{Te}(n,x)d$

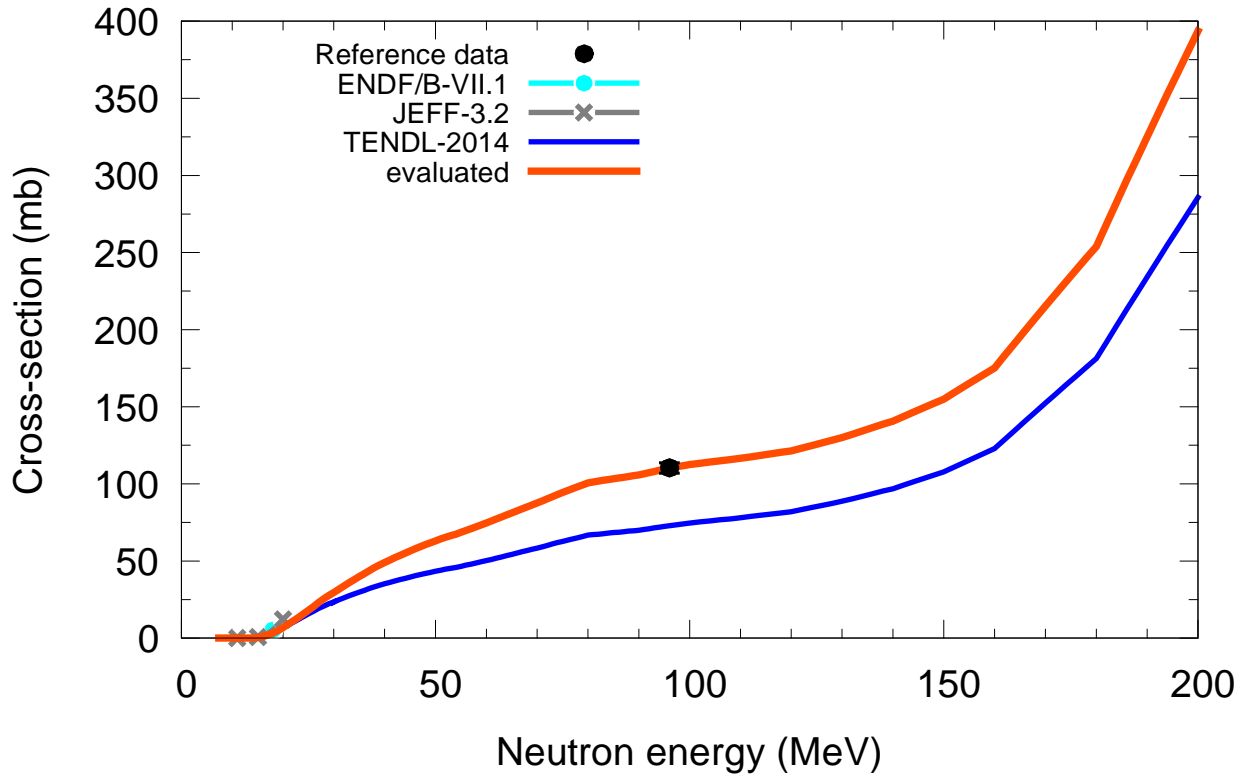
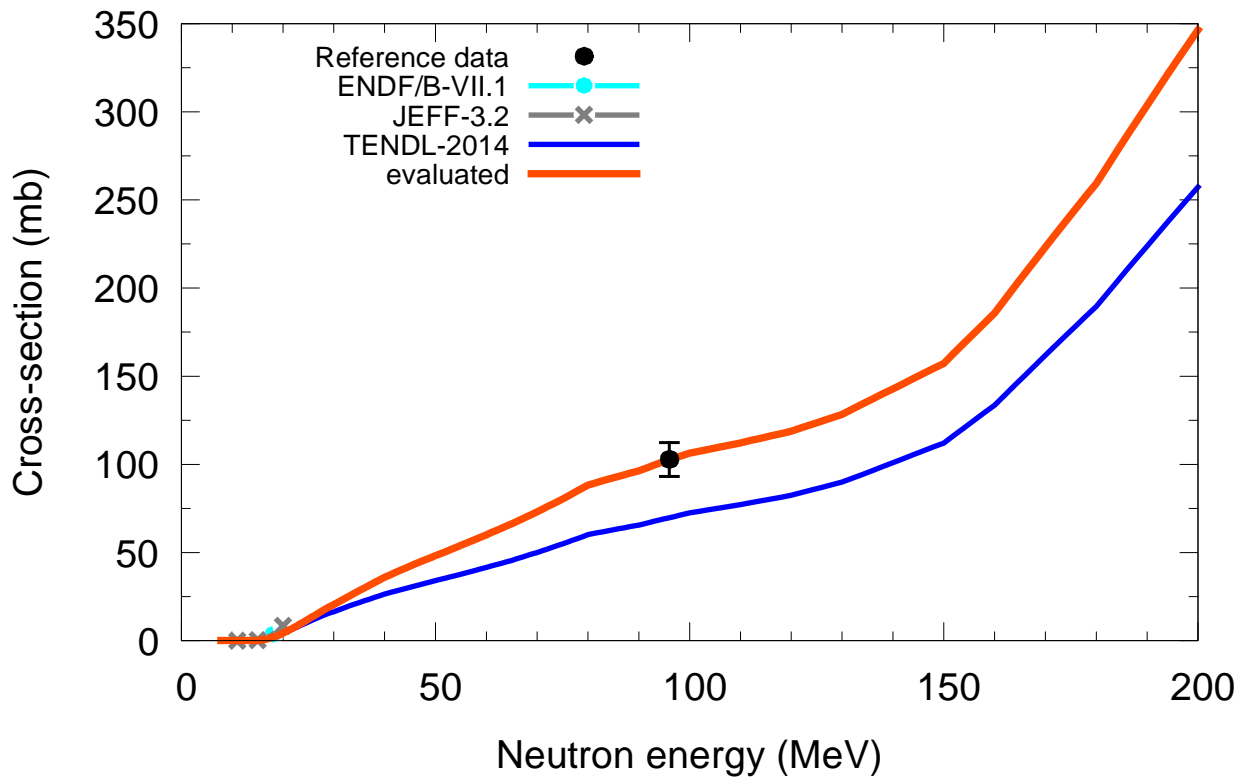


$^{127}\text{I}(n,x)d$  $^{124}\text{Xe}(n,x)d$ 

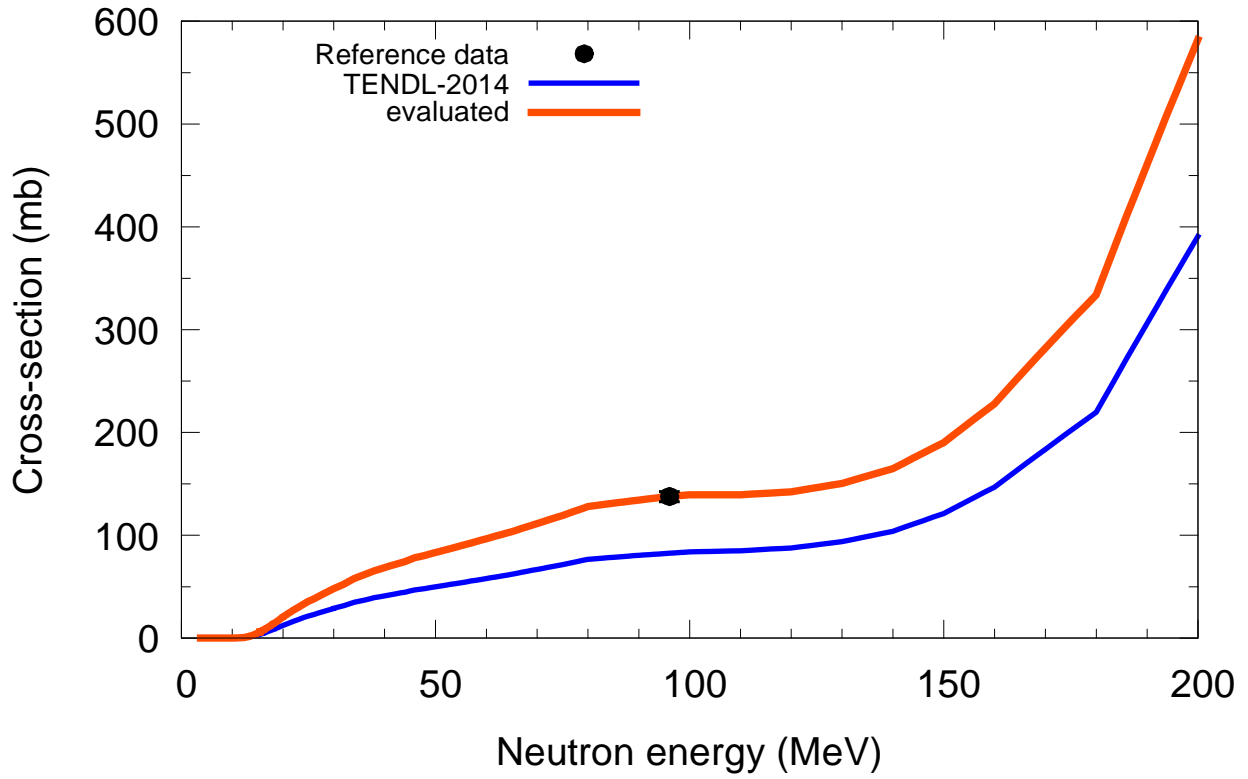
$^{126}\text{Xe}(n,x)d$  $^{128}\text{Xe}(n,x)d$ 

$^{129}\text{Xe}(n,x)d$  $^{130}\text{Xe}(n,x)d$ 

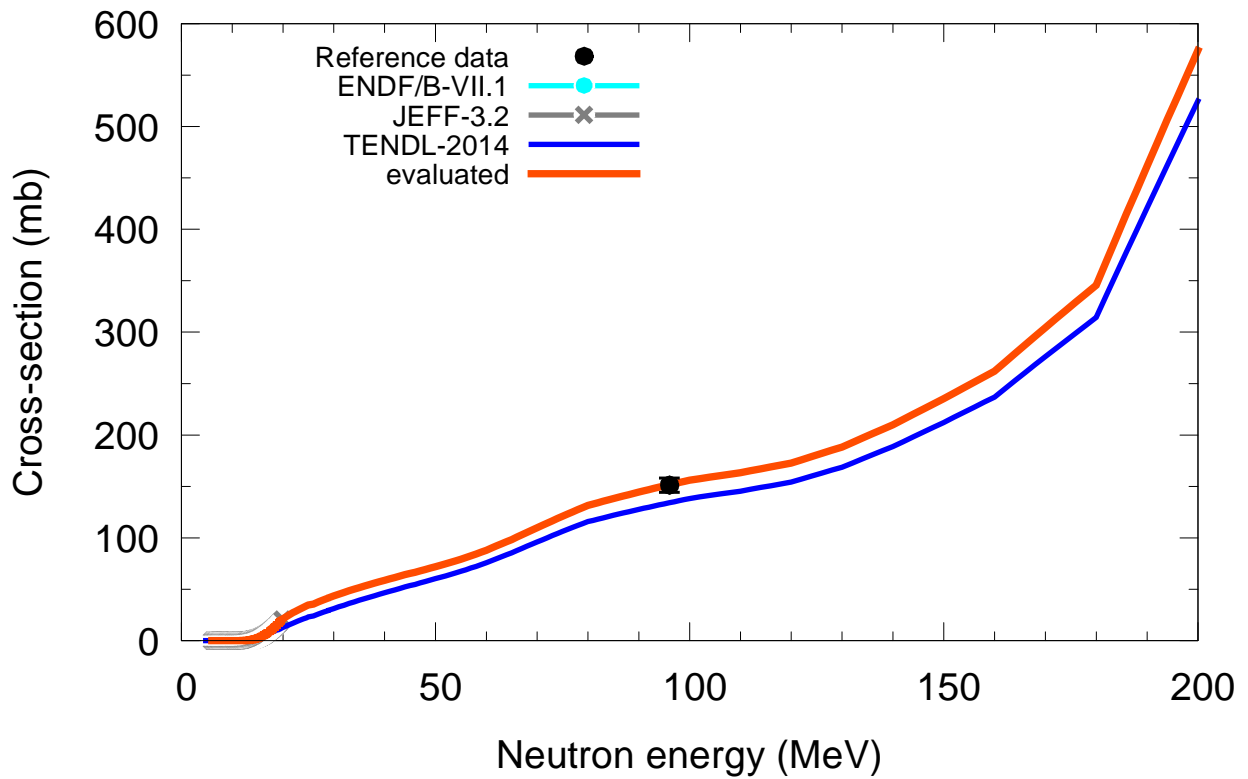
$^{131}\text{Xe}(n,x)d$  $^{132}\text{Xe}(n,x)d$ 

$^{134}\text{Xe}(n,x)d$  $^{136}\text{Xe}(n,x)d$ 

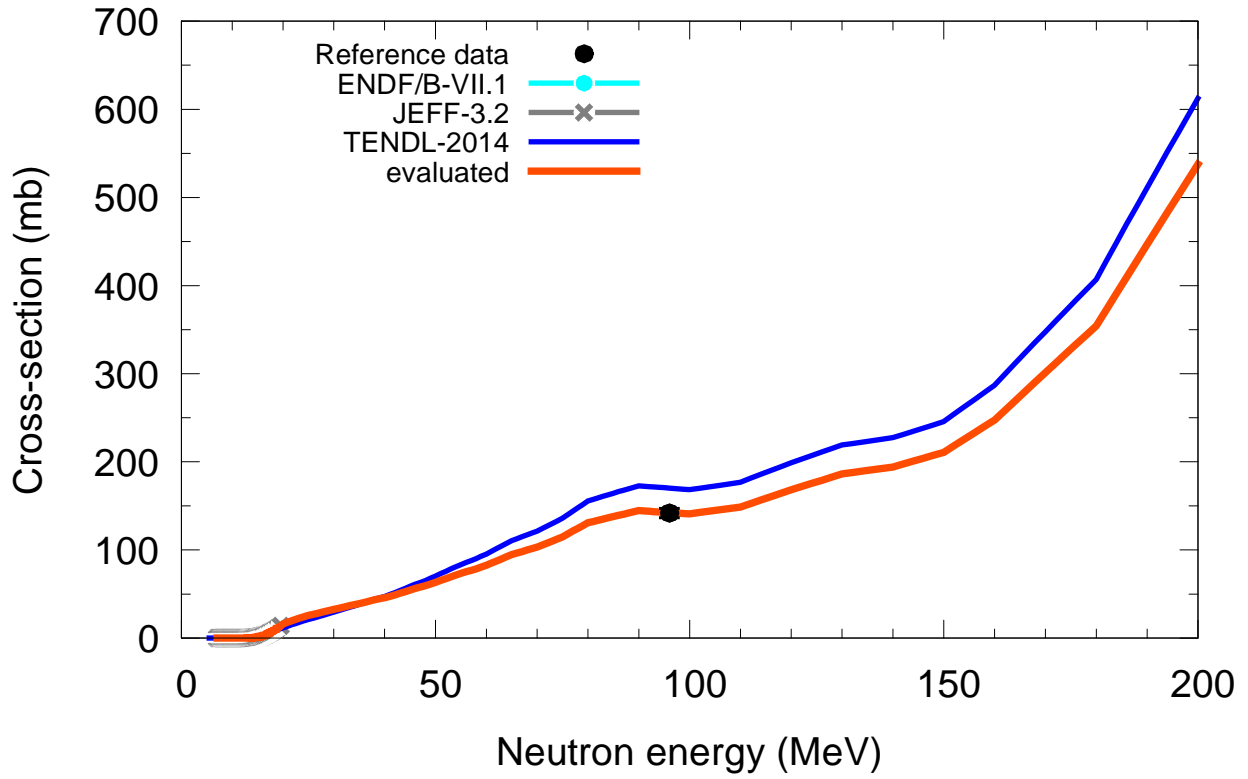
$^{133}\text{Cs}(n,x)d$



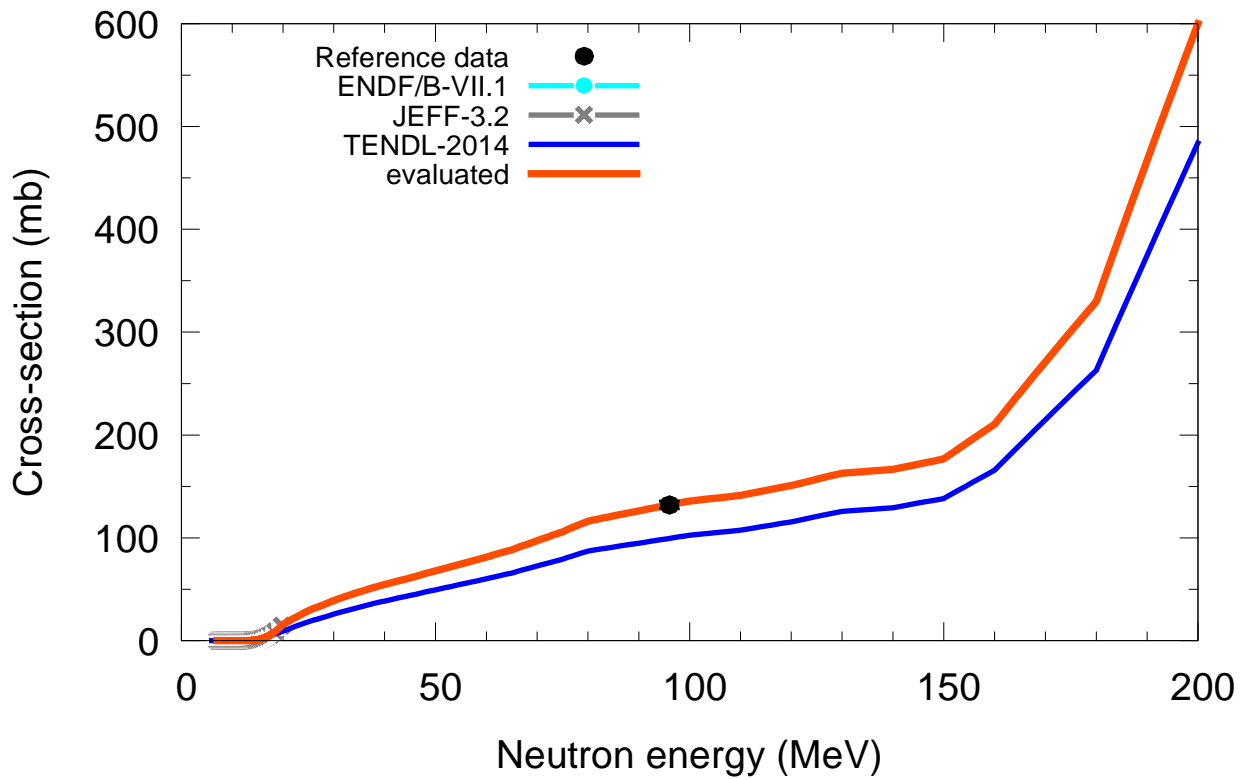
$^{130}\text{Ba}(n,x)d$



$^{132}\text{Ba}(n,x)d$

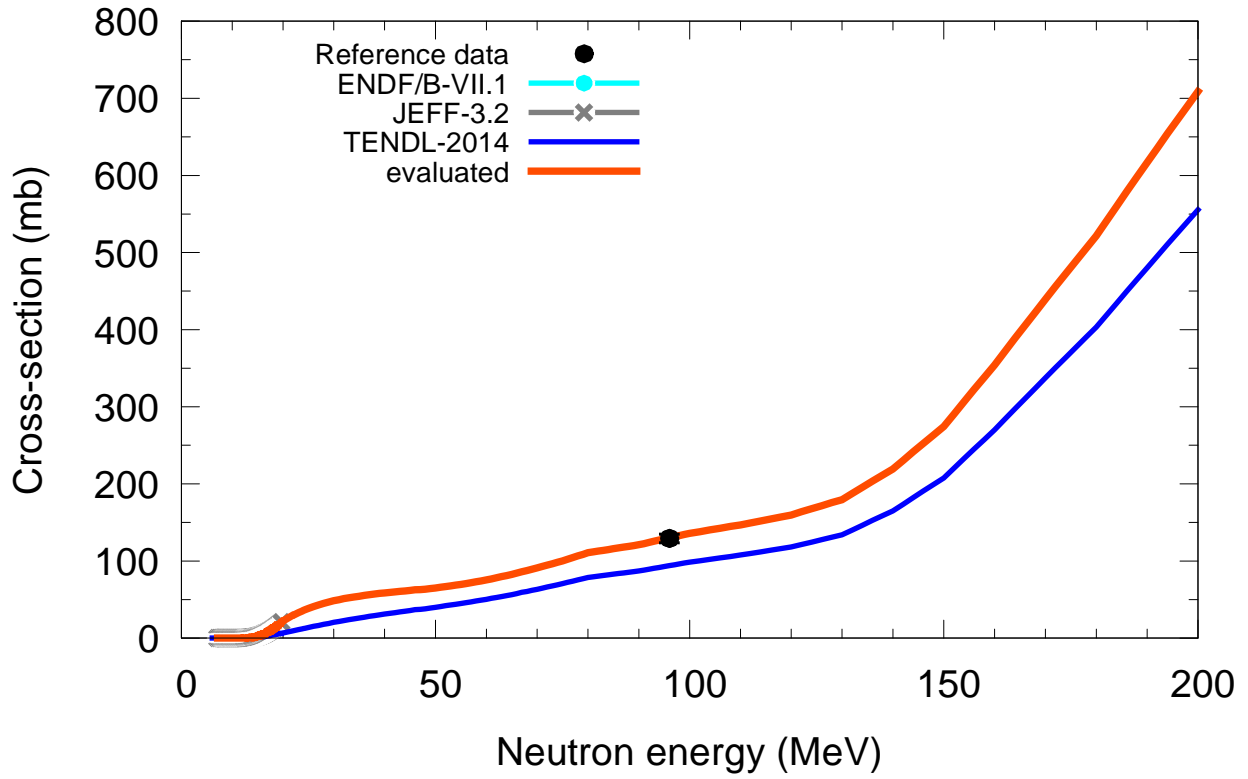


$^{134}\text{Ba}(n,x)d$

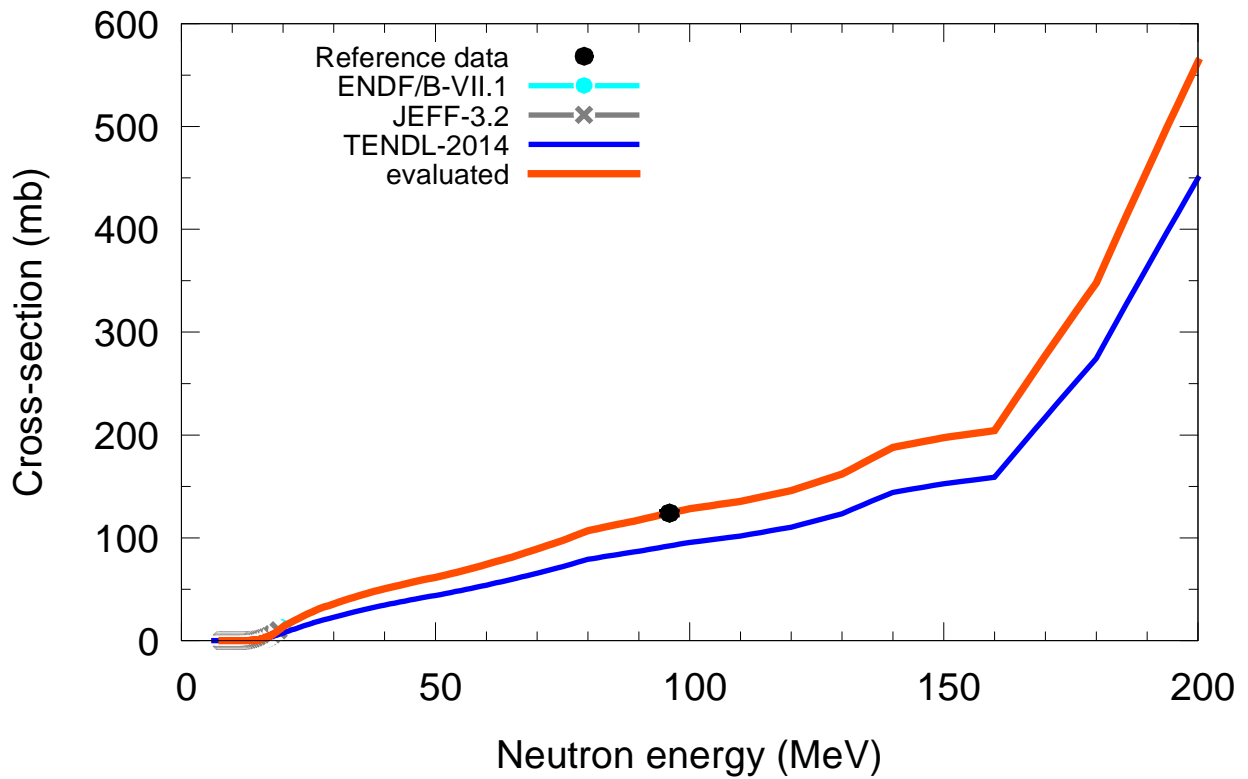




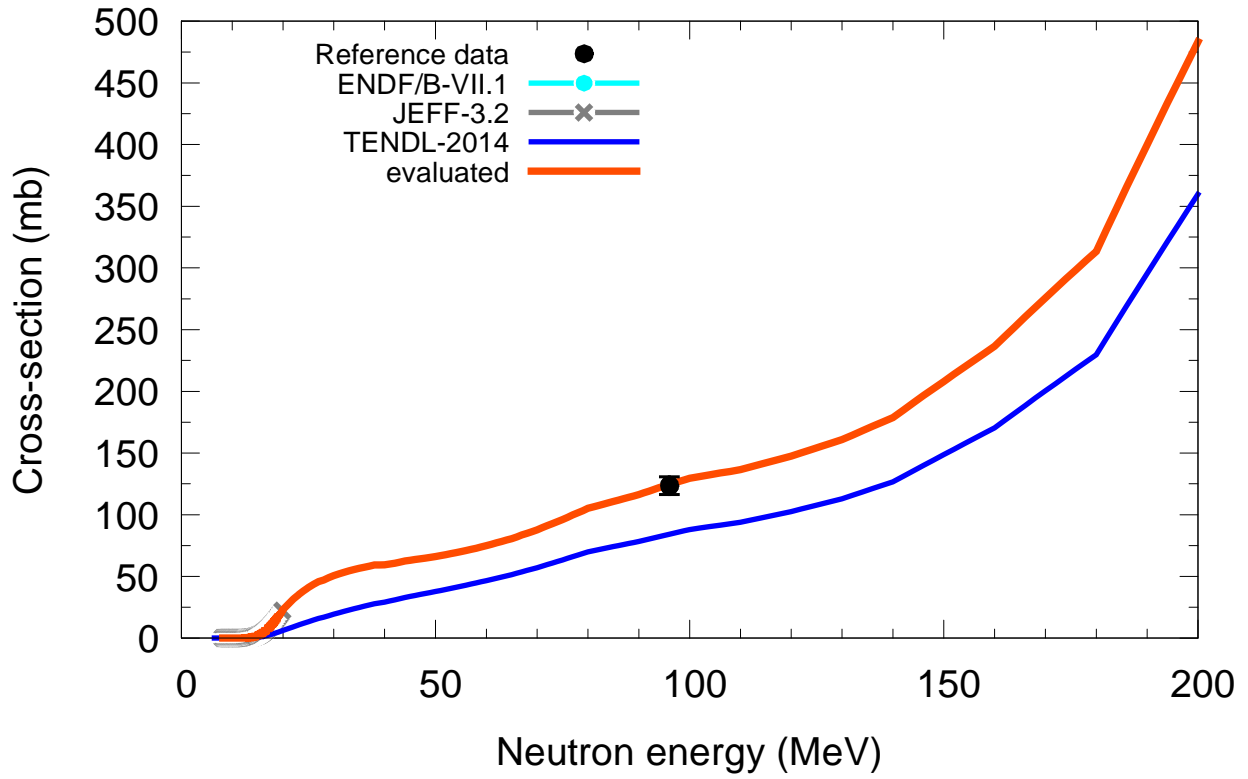
$^{135}\text{Ba}(n,x)d$



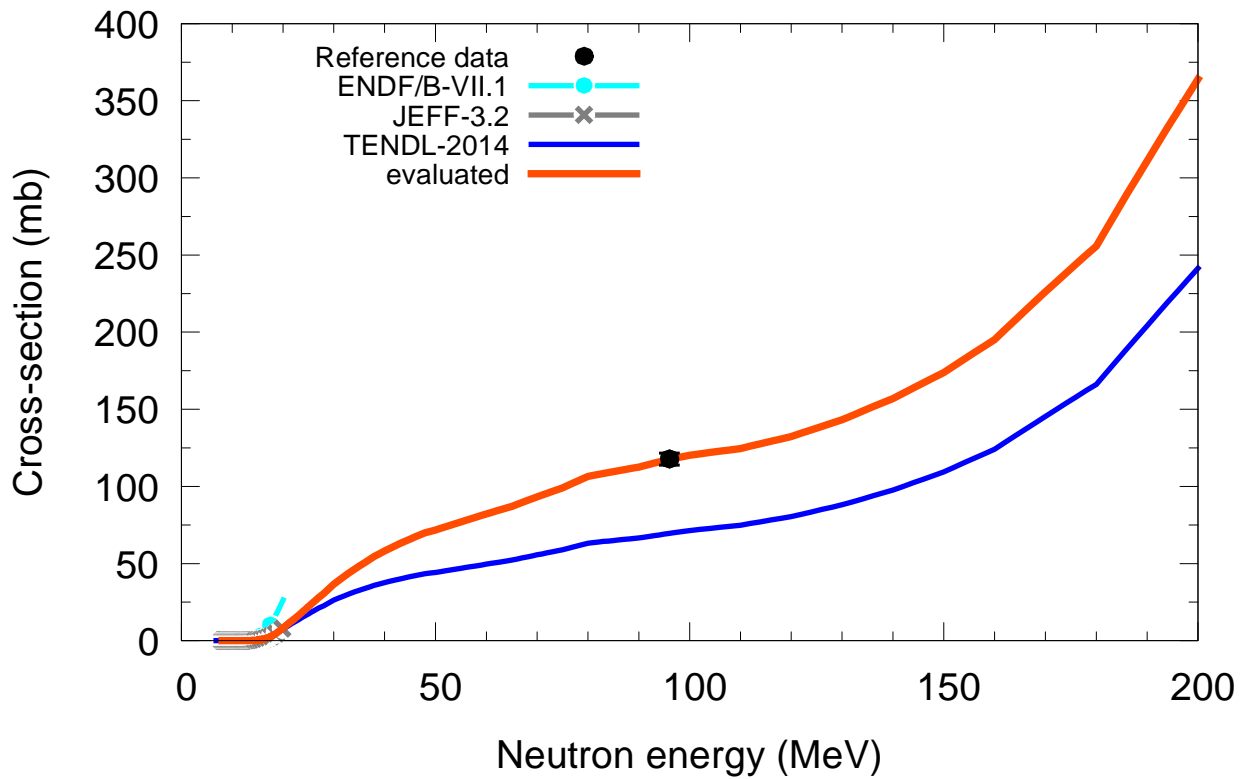
$^{136}\text{Ba}(n,x)d$



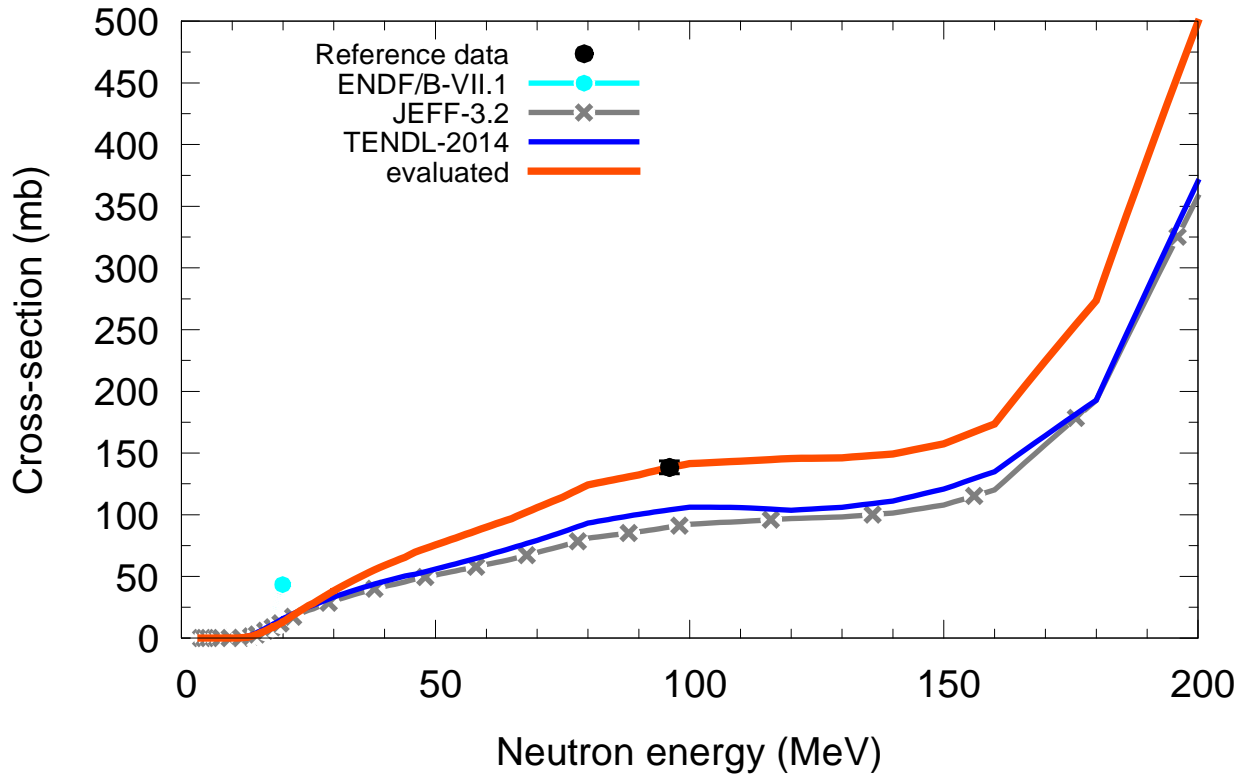
### $^{137}\text{Ba}(n,x)d$



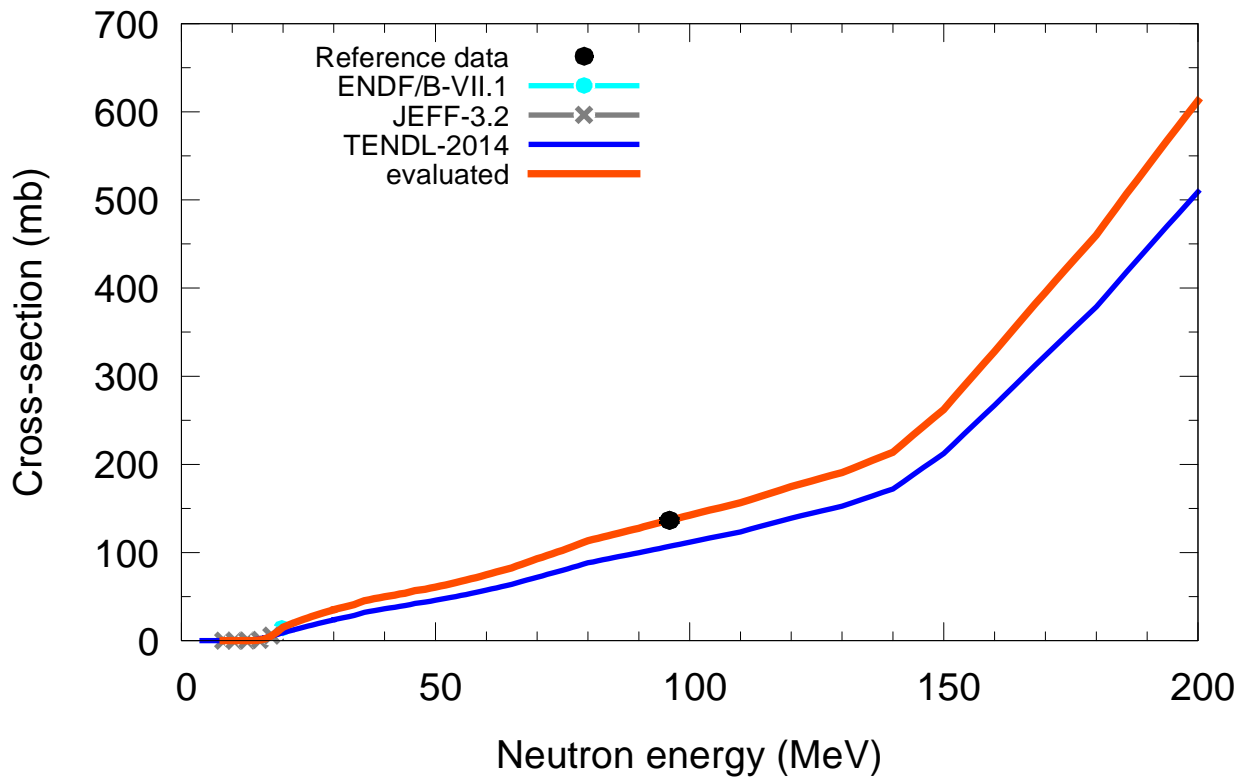
### $^{138}\text{Ba}(n,x)d$



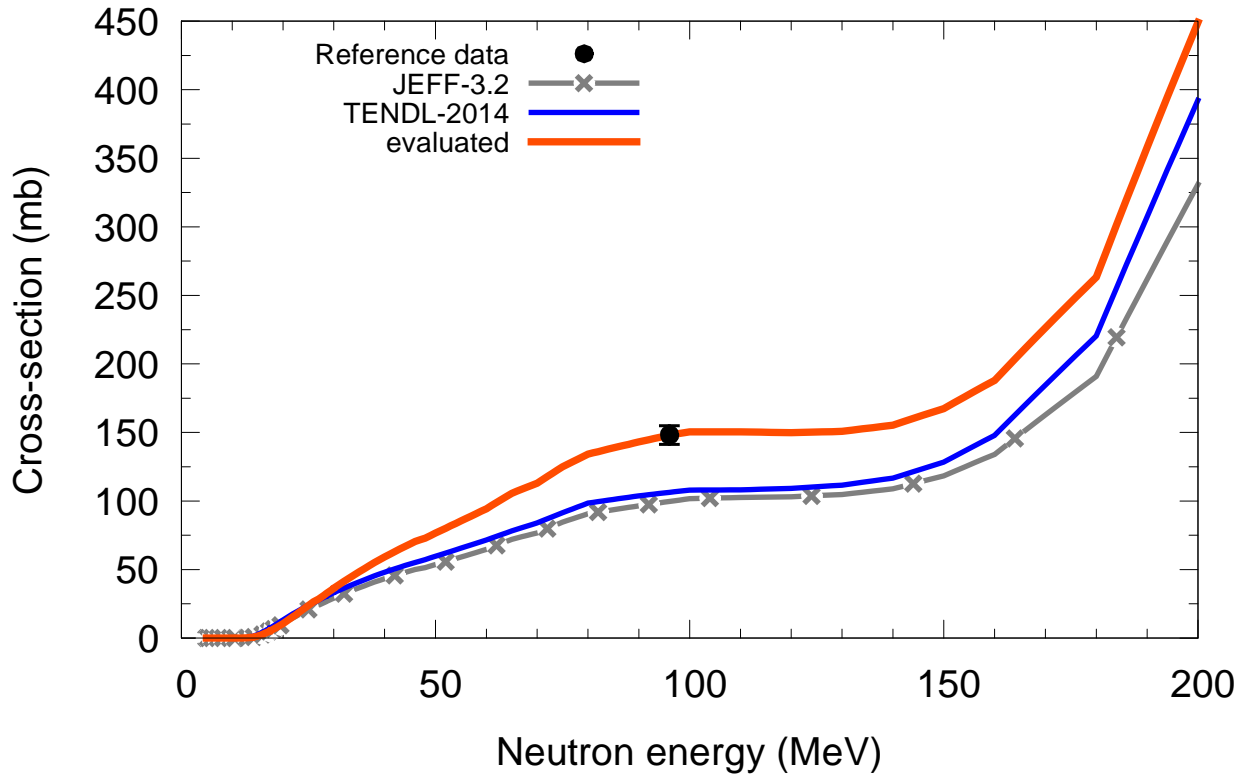
$^{138}\text{La}(n,x)d$



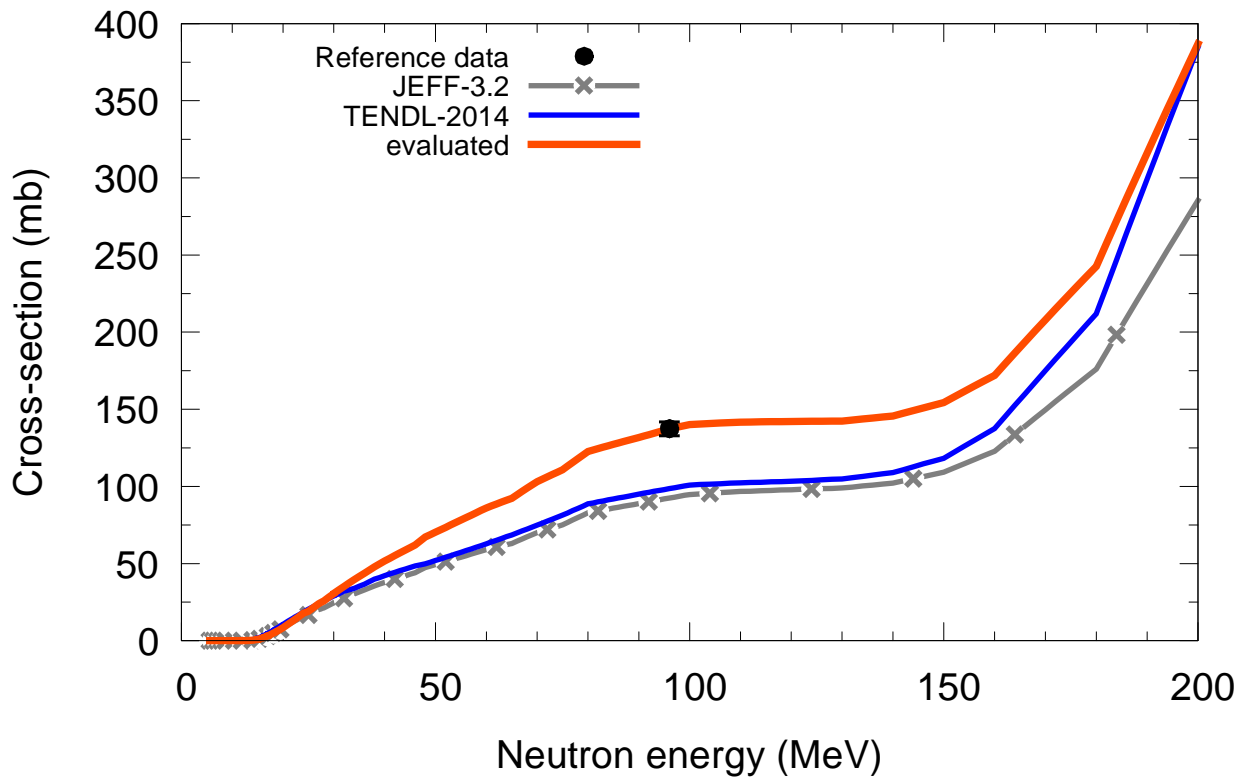
$^{139}\text{La}(n,x)d$

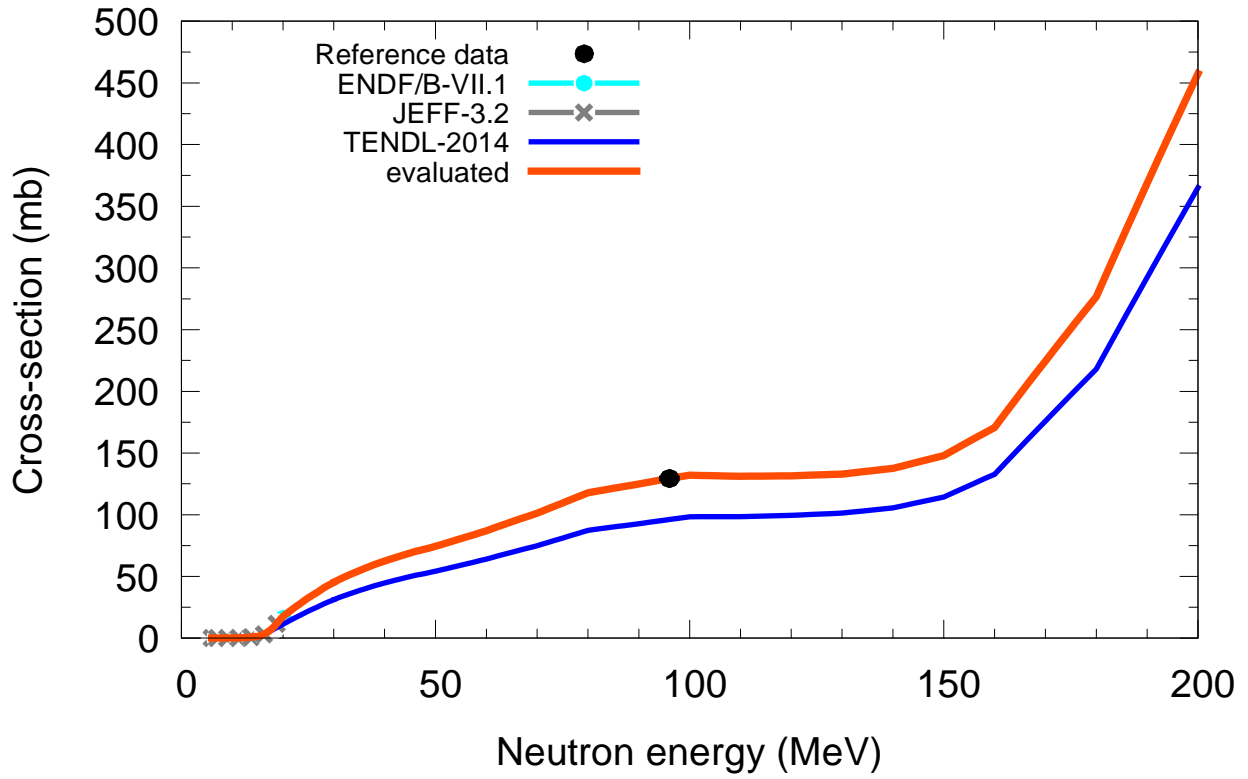
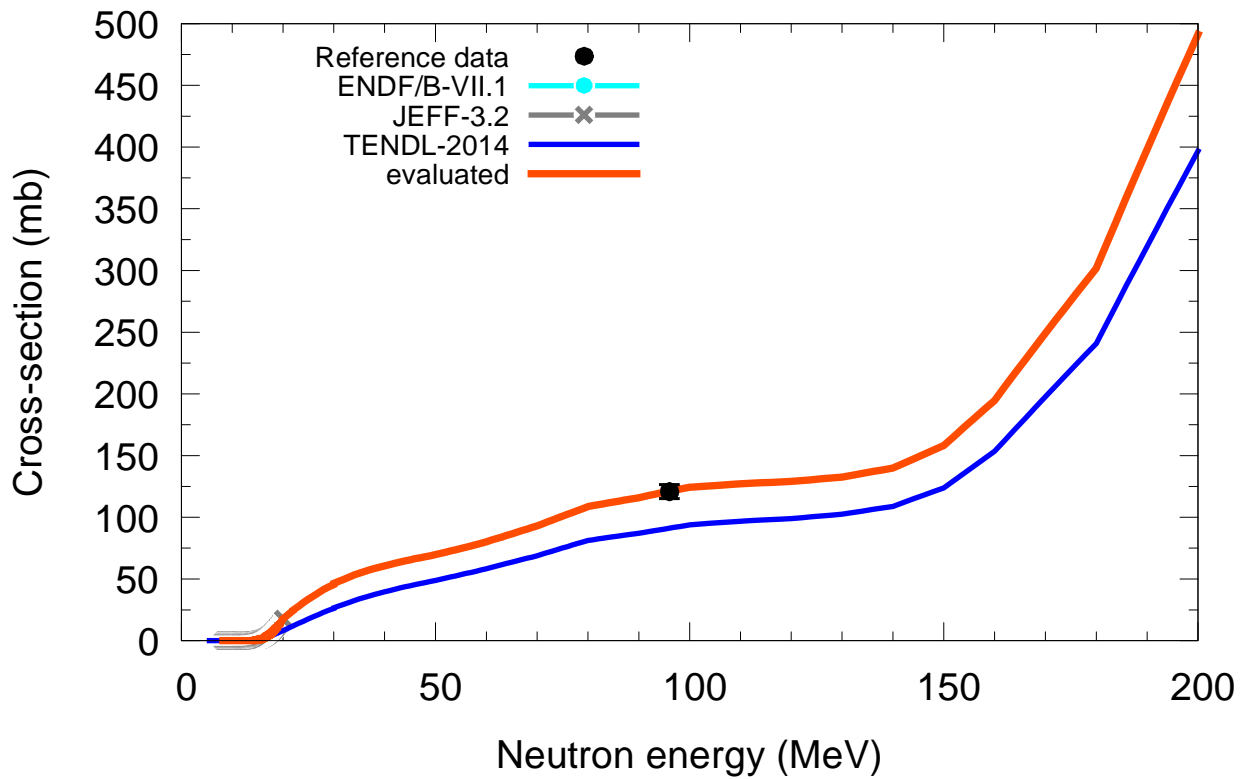


$^{136}\text{Ce}(n,x)d$

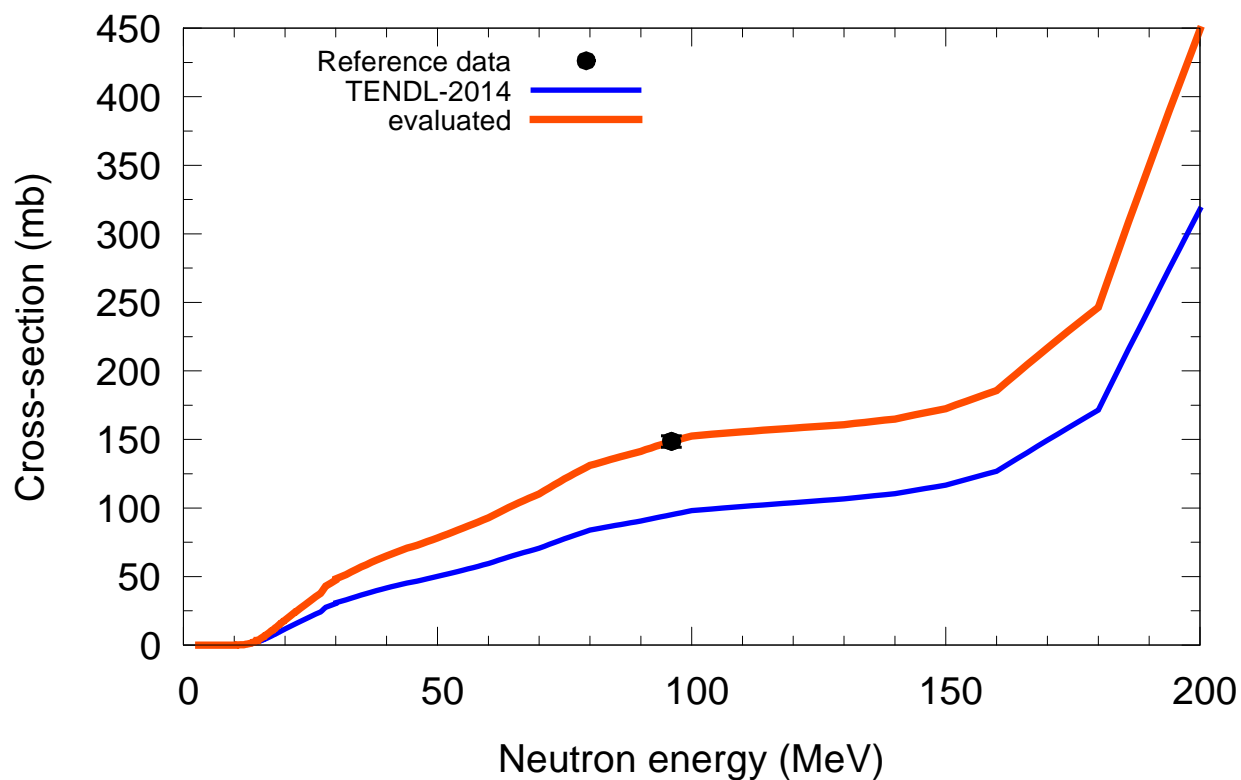


$^{138}\text{Ce}(n,x)d$

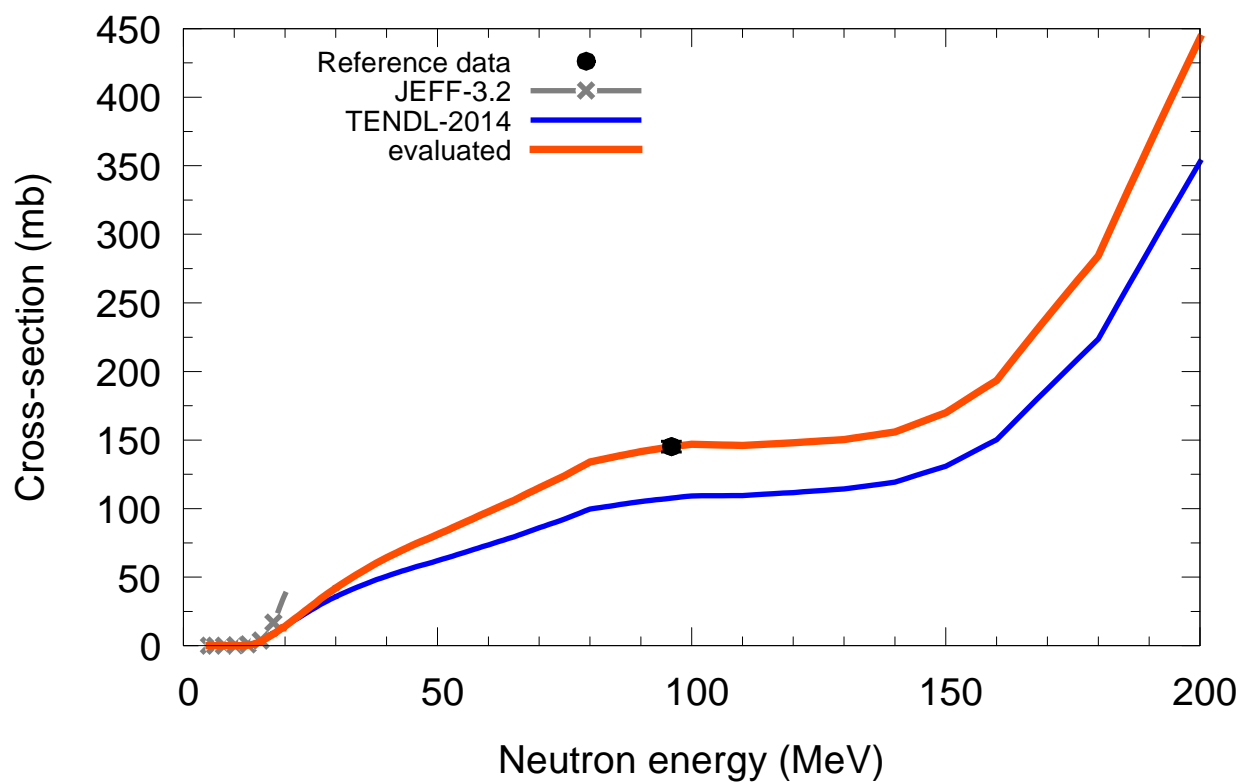


$^{140}\text{Ce}(n,x)d$  $^{142}\text{Ce}(n,x)d$ 

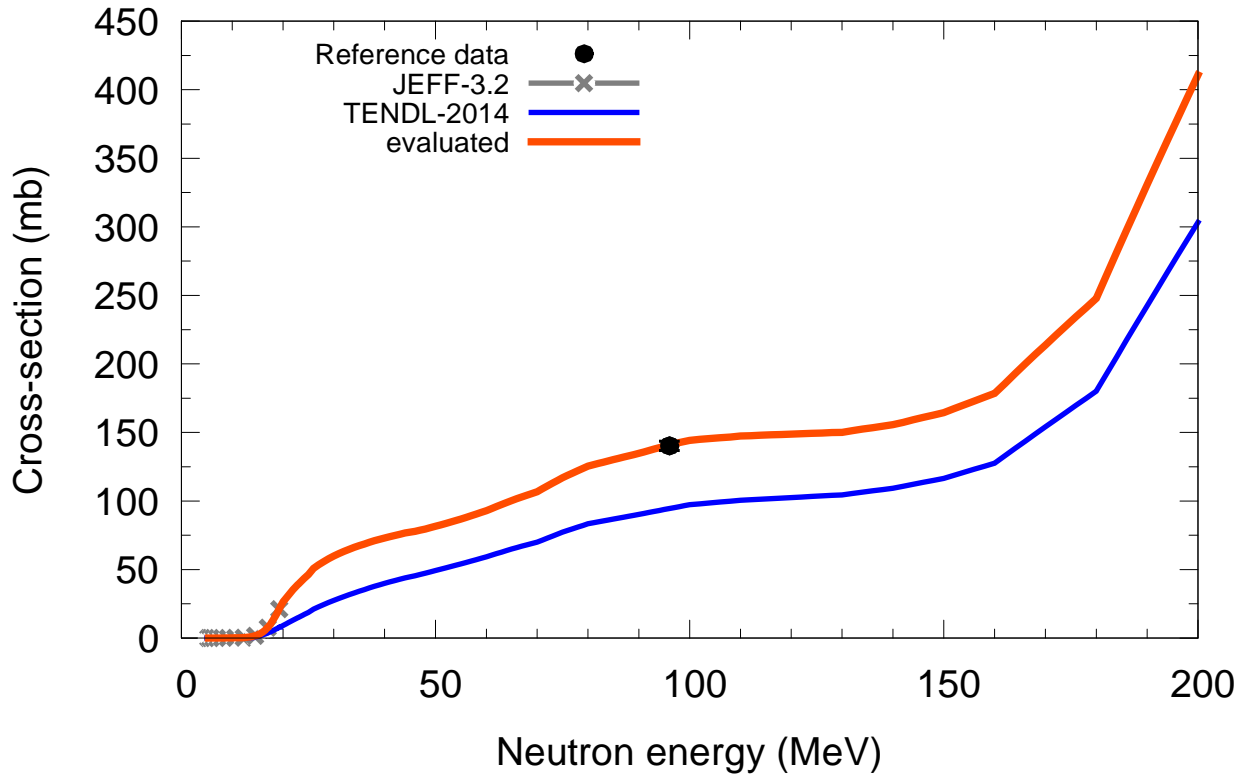
### $^{141}\text{Pr}(n,x)d$



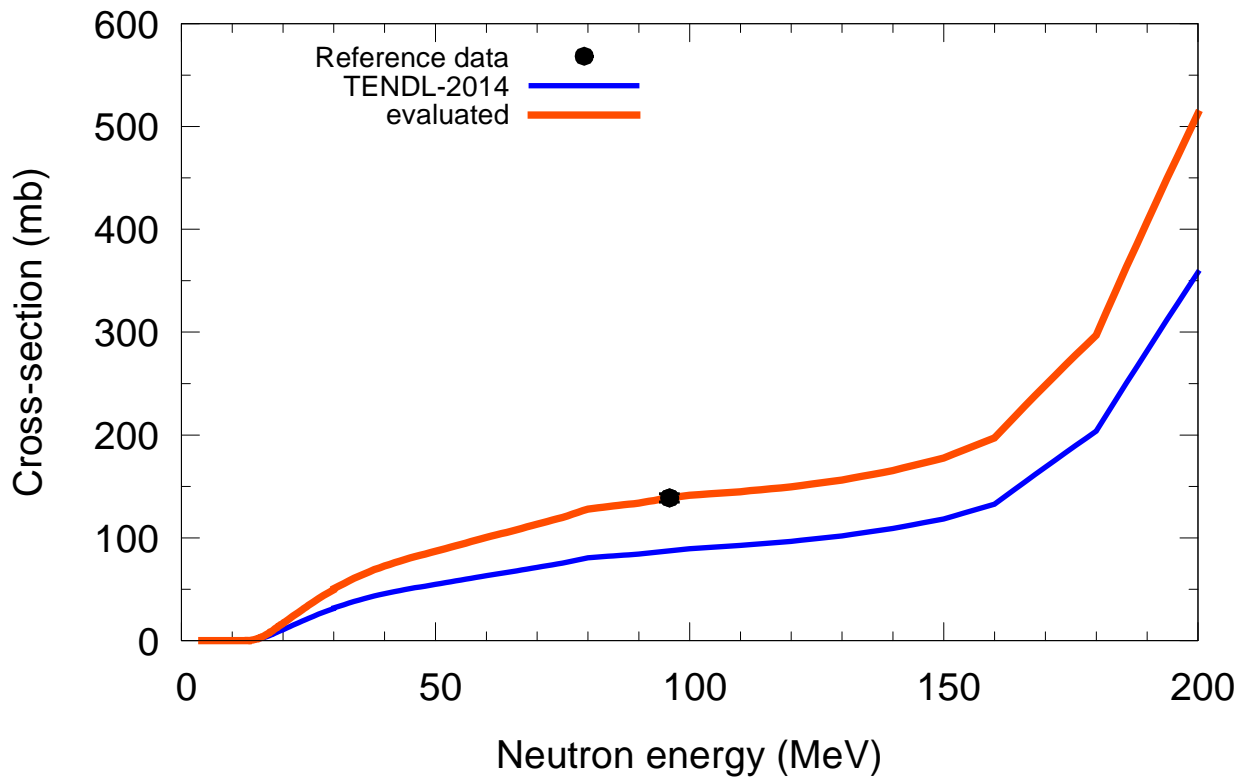
### $^{142}\text{Nd}(n,x)d$



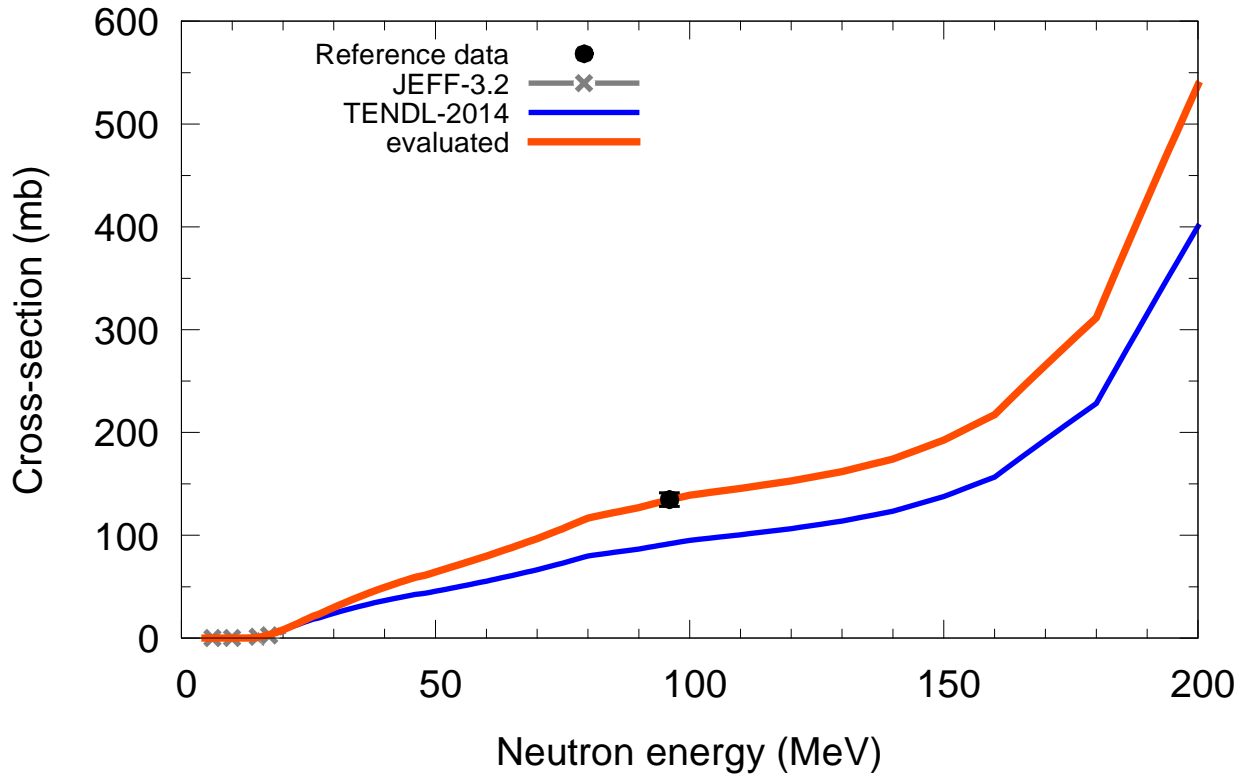
### $^{143}\text{Nd}(n,x)d$



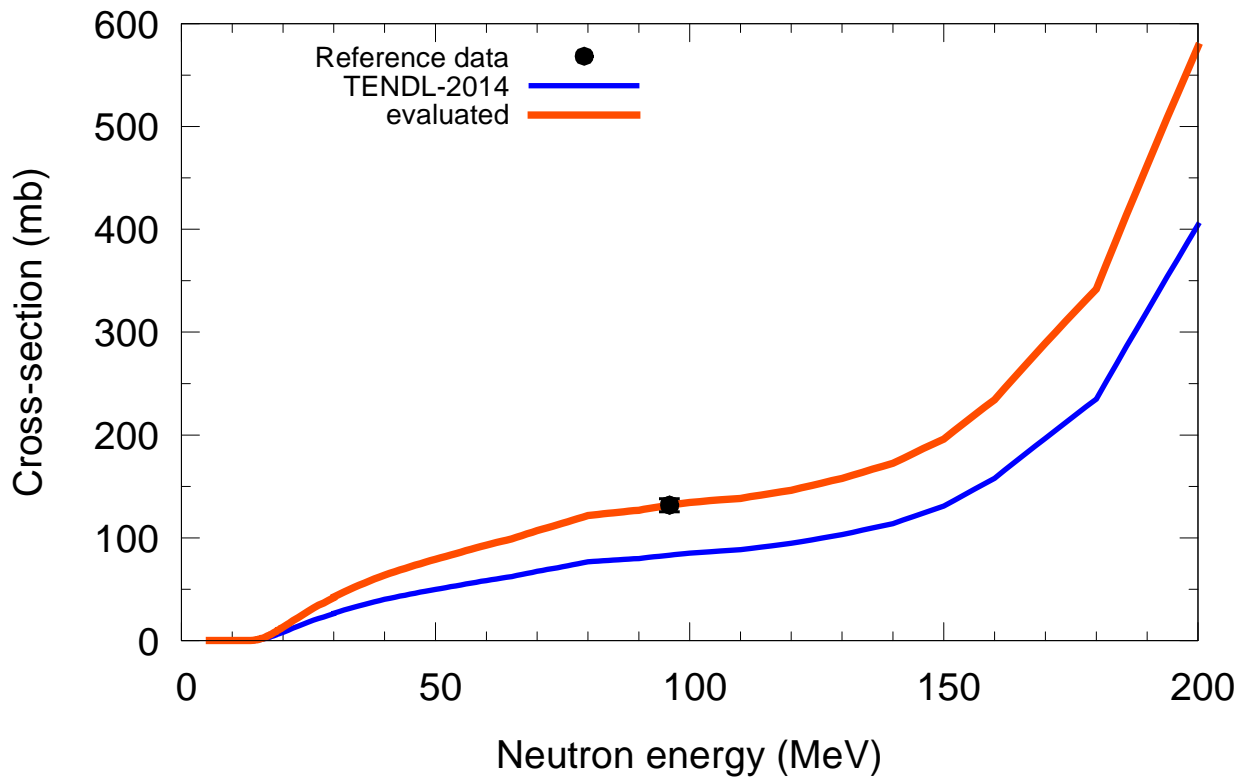
### $^{144}\text{Nd}(n,x)d$



$^{145}\text{Nd}(n,x)d$

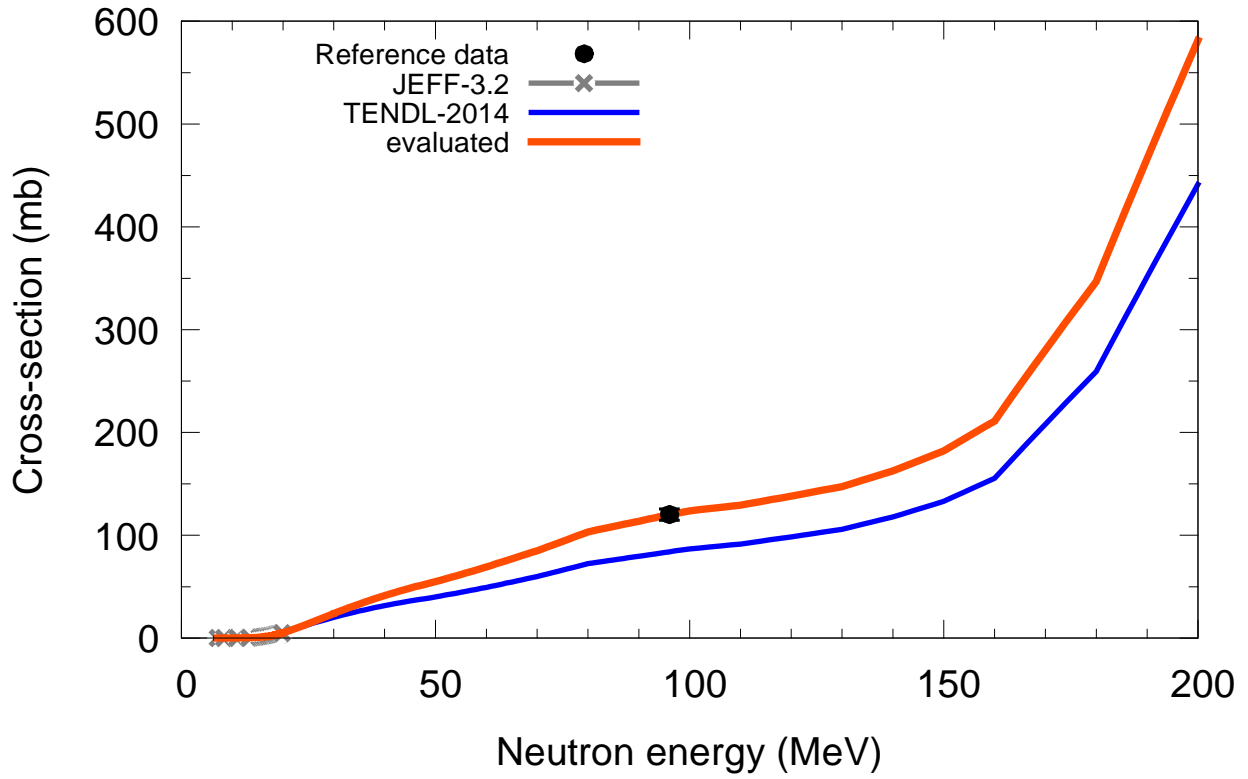


$^{146}\text{Nd}(n,x)d$

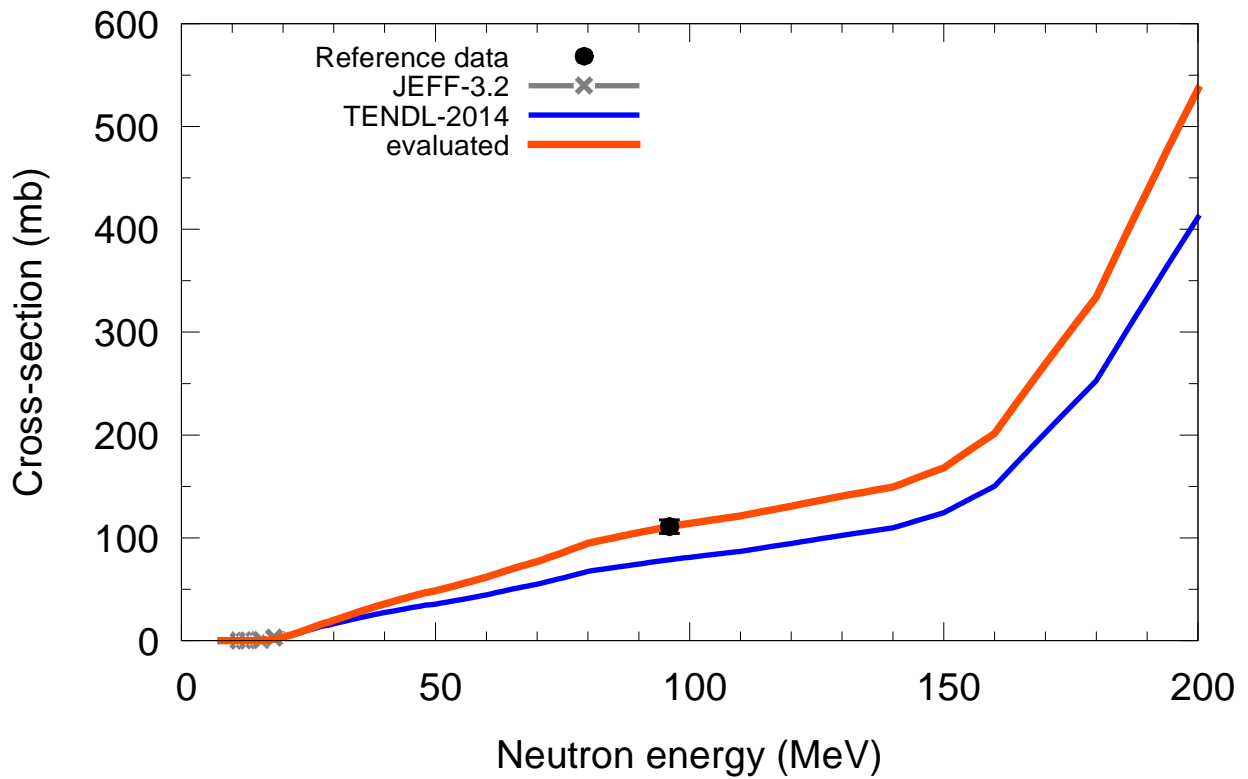




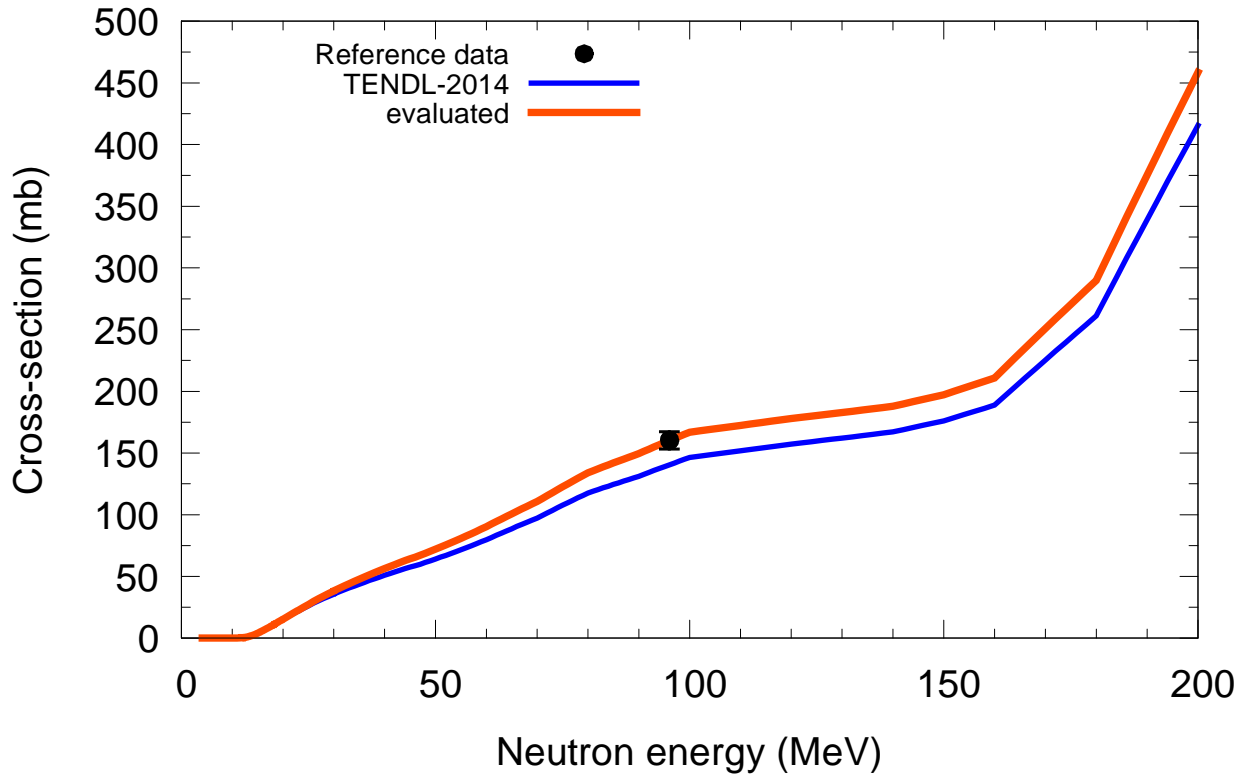
$^{148}\text{Nd}(n,x)d$



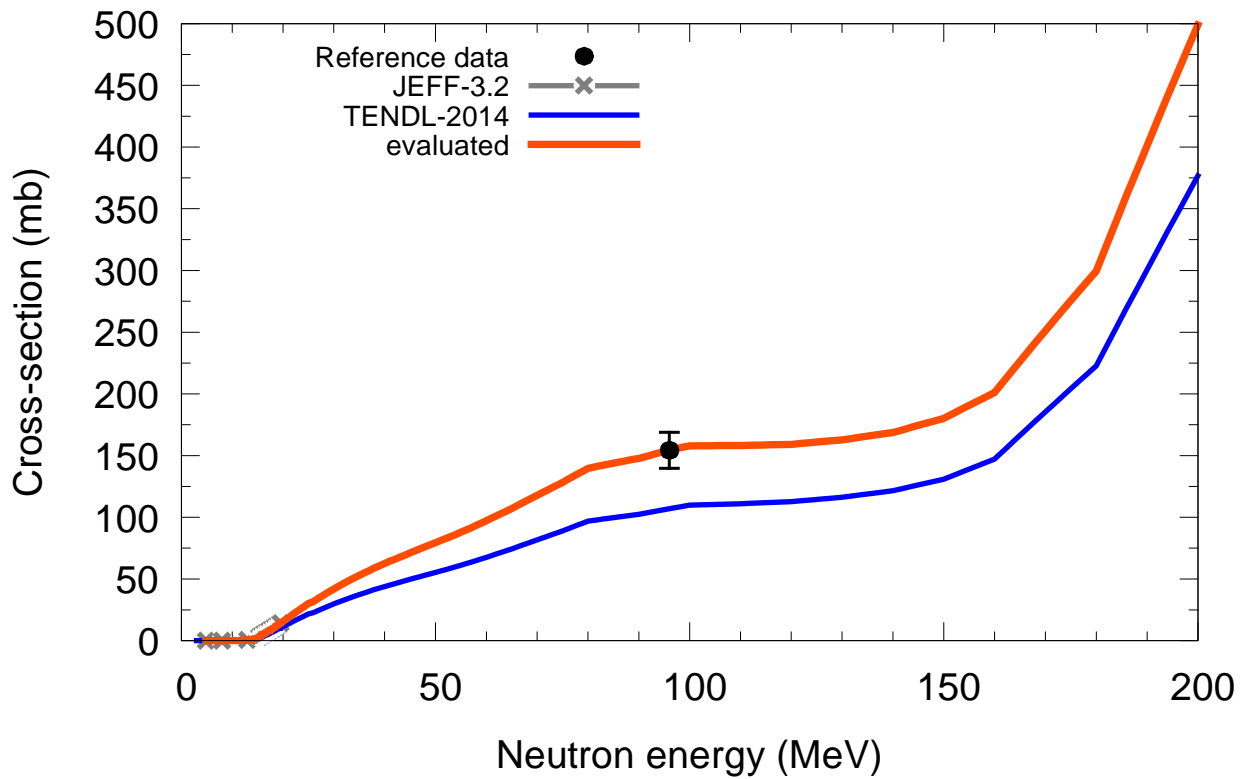
$^{150}\text{Nd}(n,x)d$



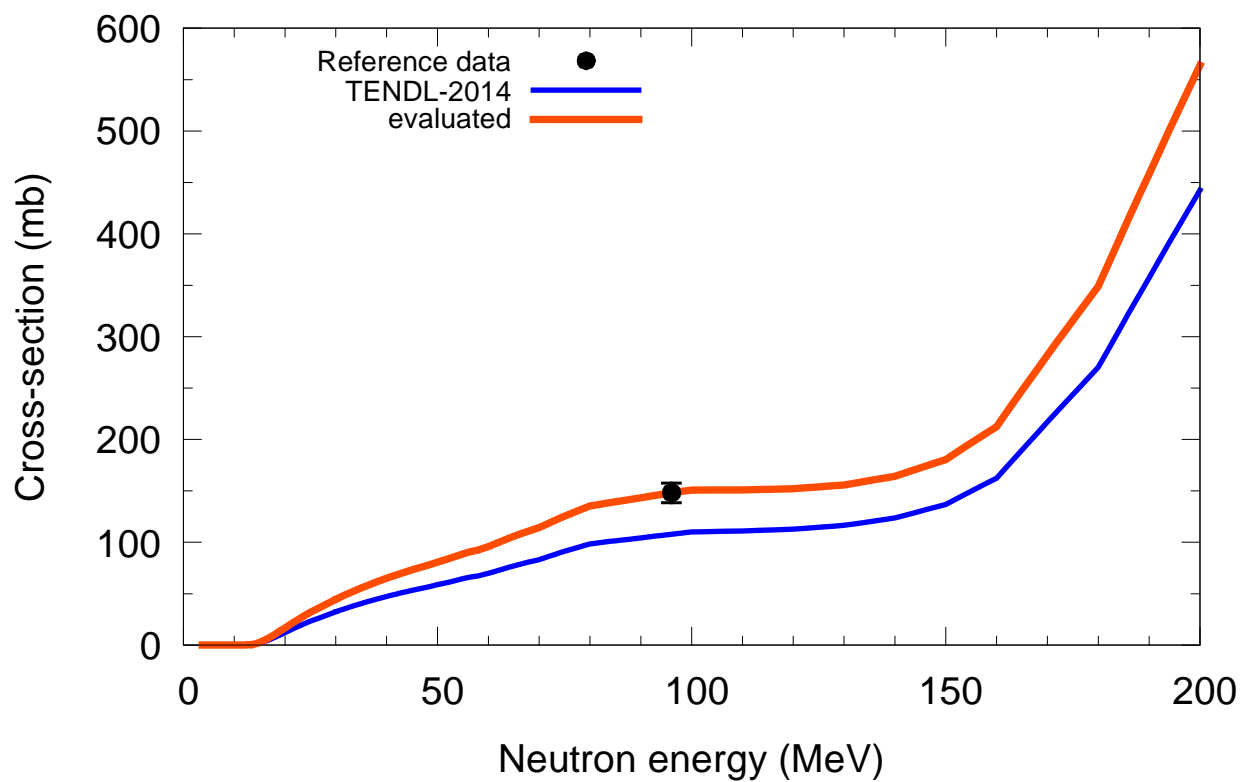
### $^{144}\text{Sm}(n,x)d$



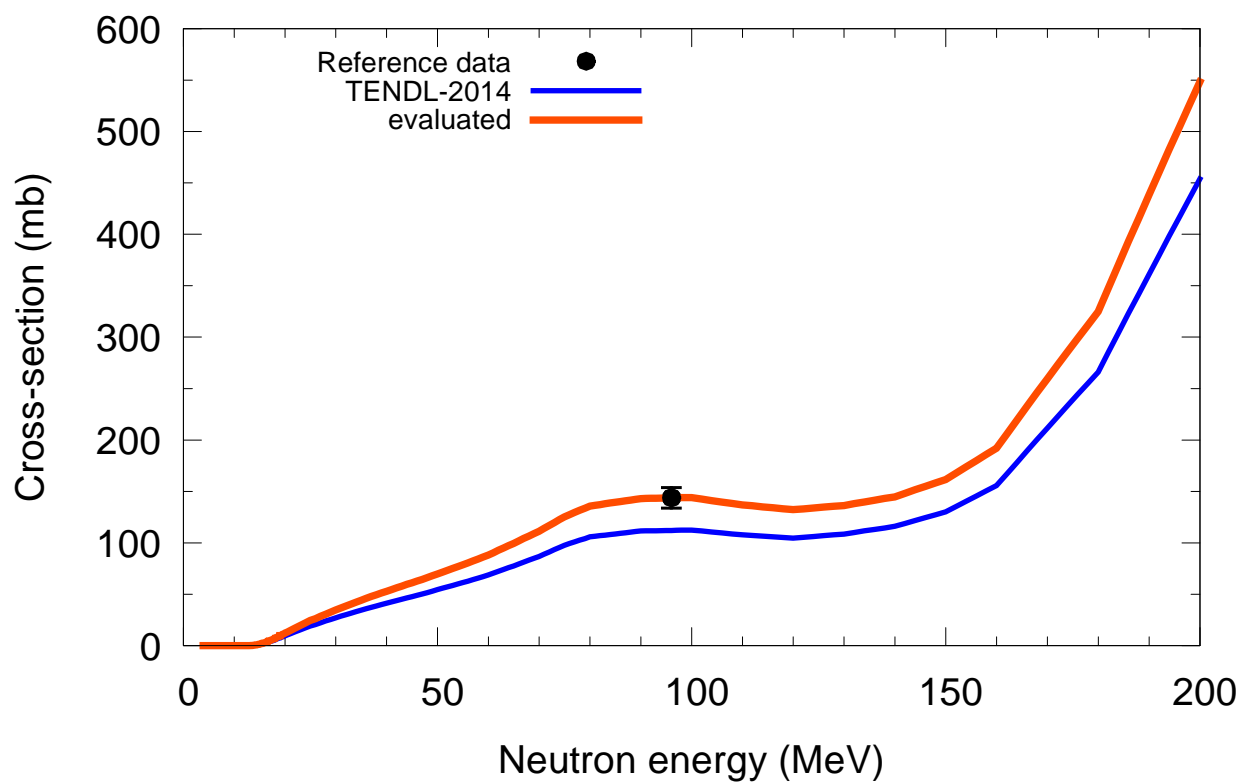
### $^{147}\text{Sm}(n,x)d$



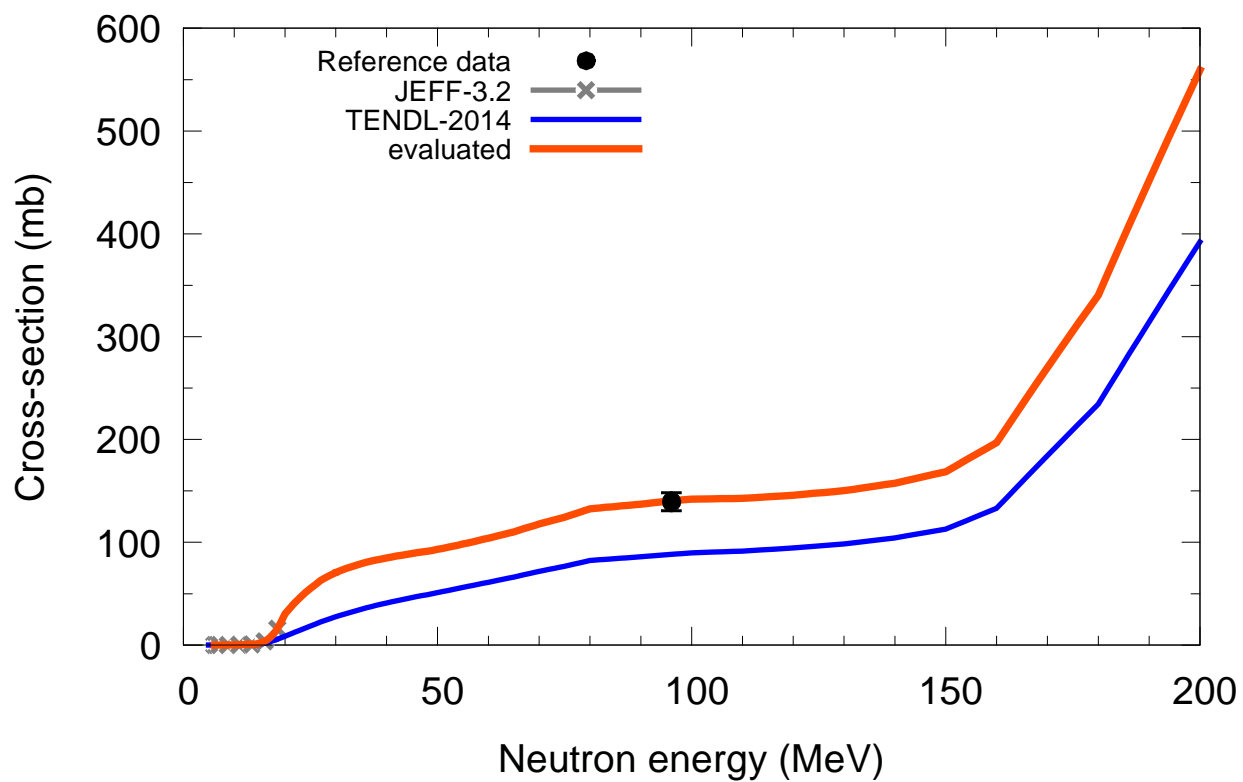
$^{148}\text{Sm}(n,x)d$



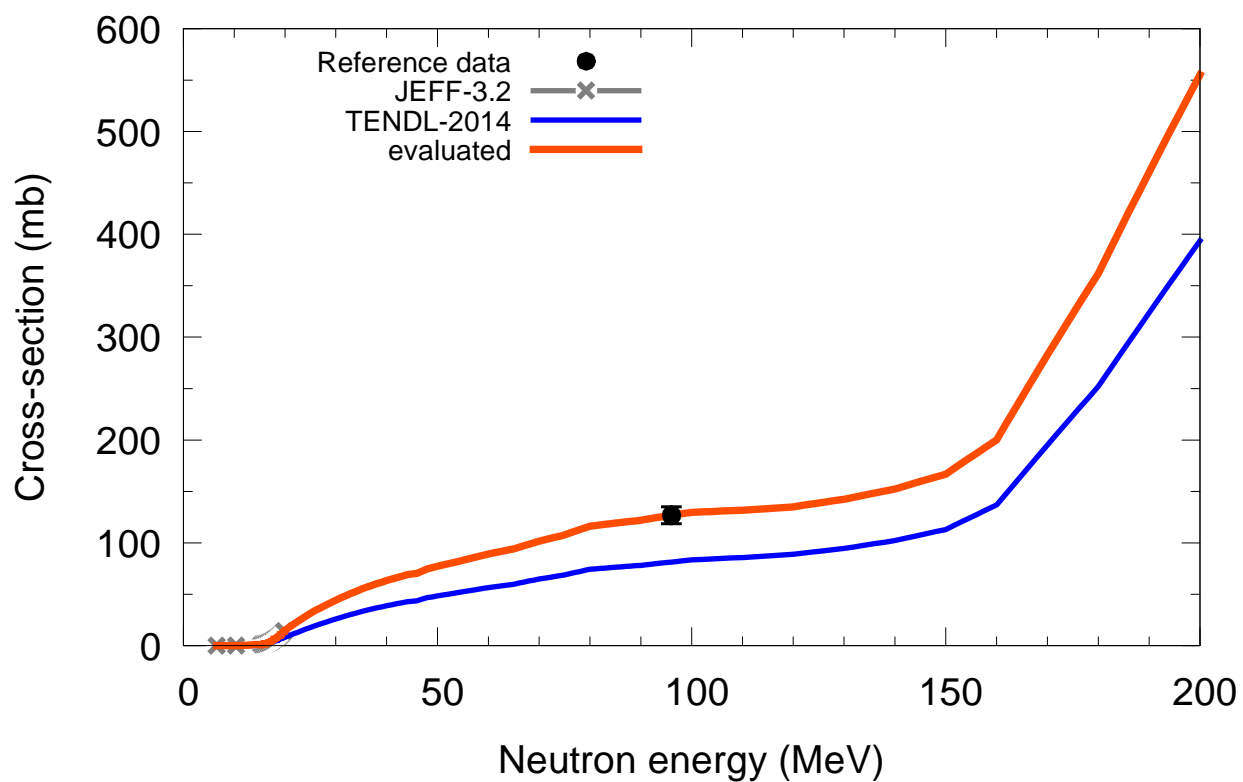
$^{149}\text{Sm}(n,x)d$



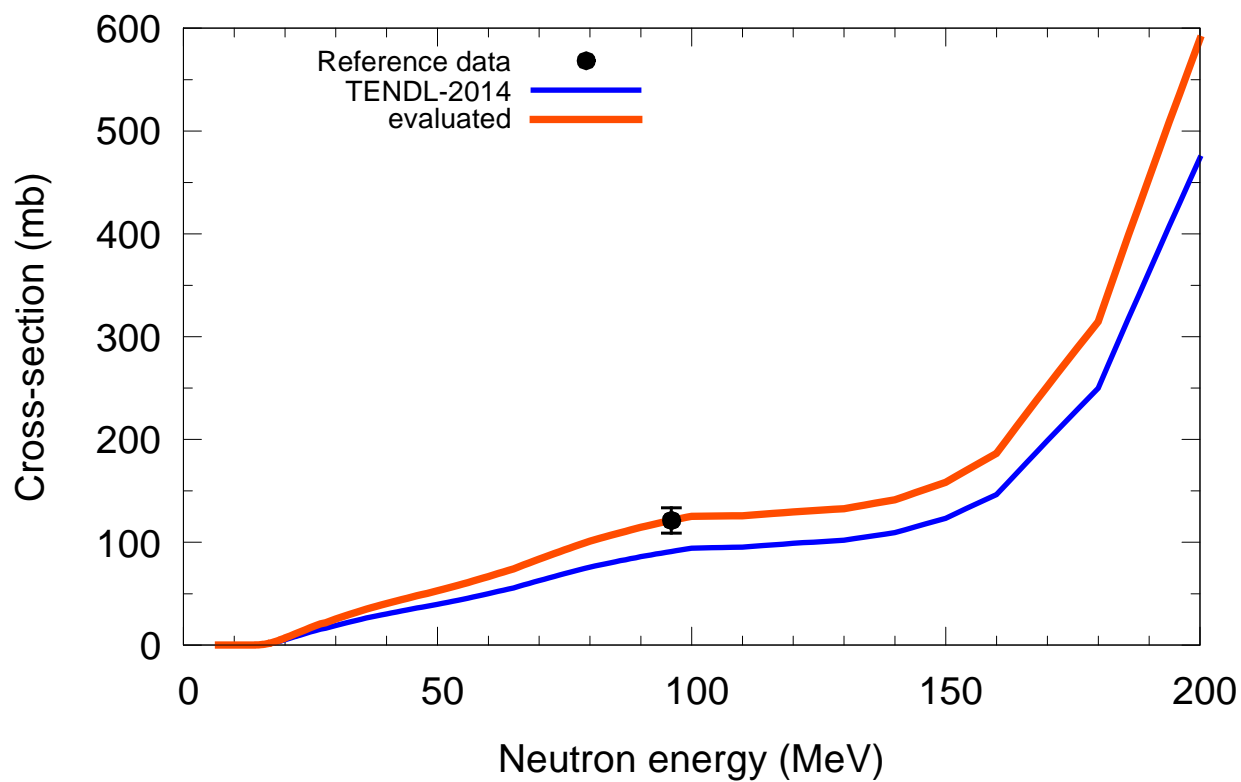
$^{150}\text{Sm}(n,x)d$



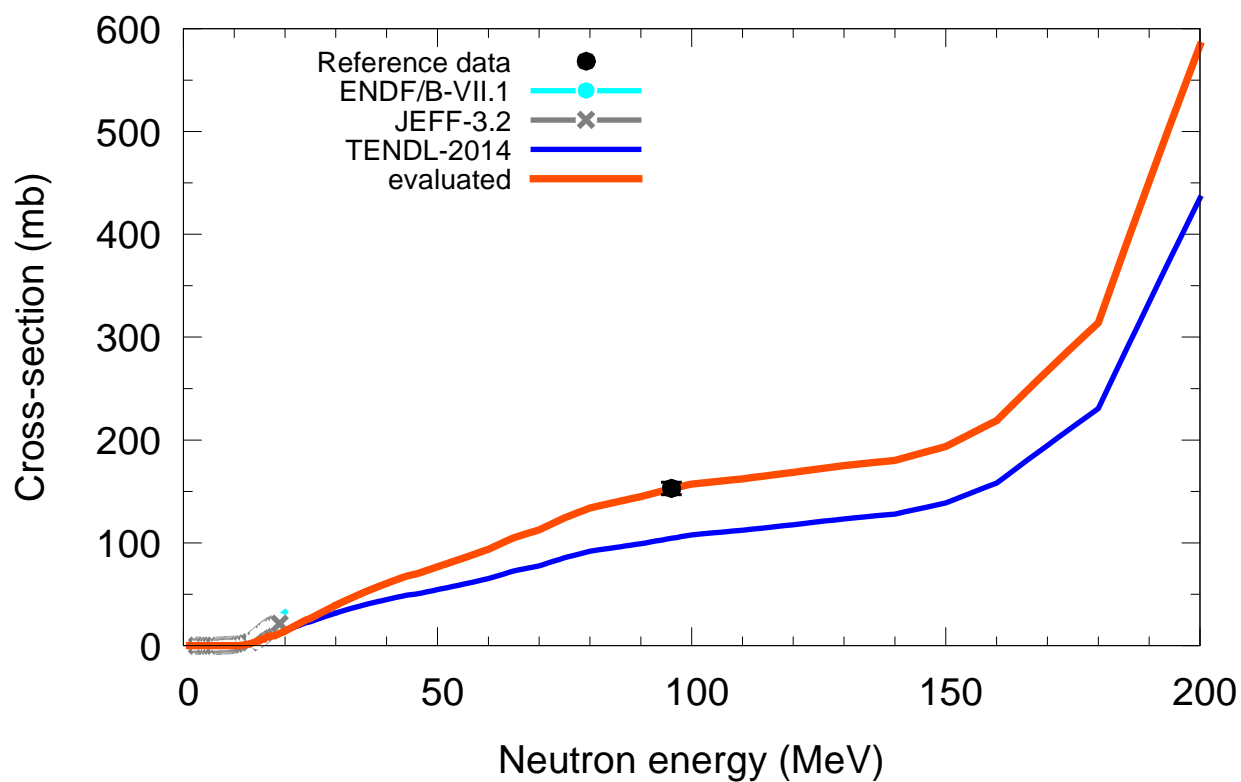
$^{152}\text{Sm}(n,x)d$



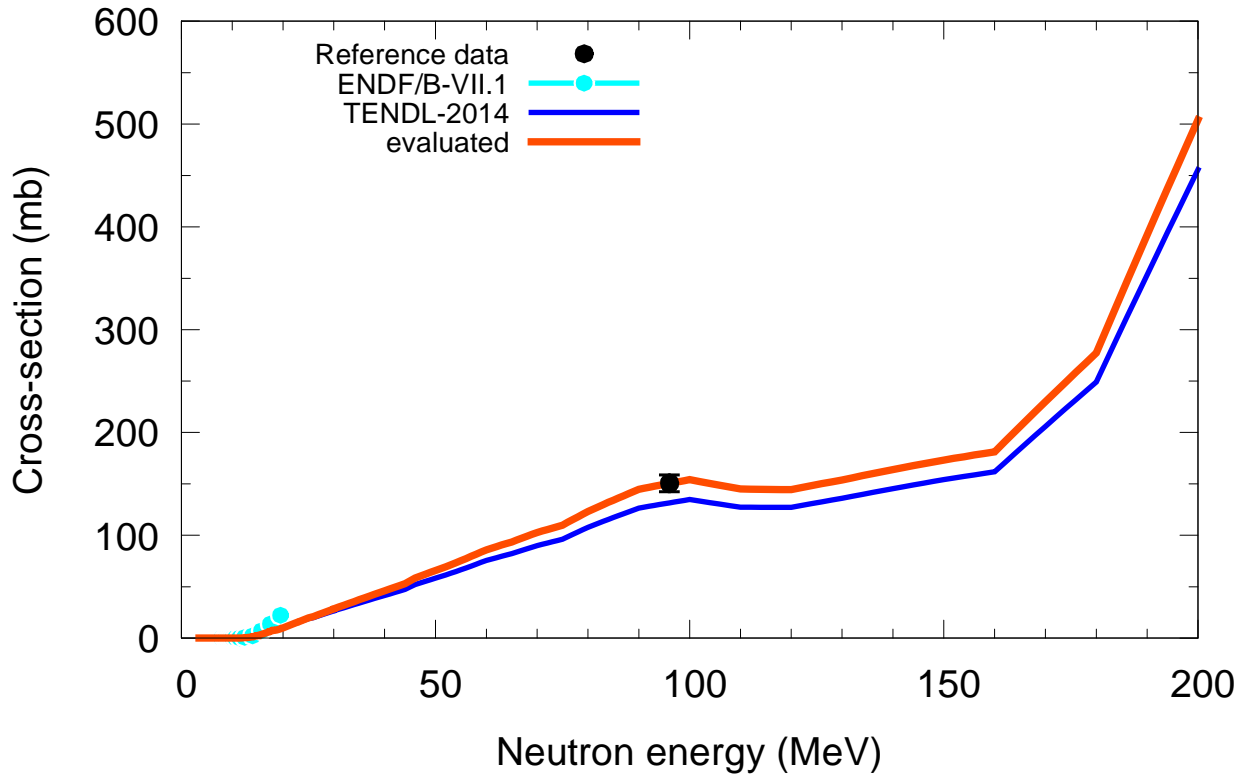
$^{154}\text{Sm}(n,x)d$



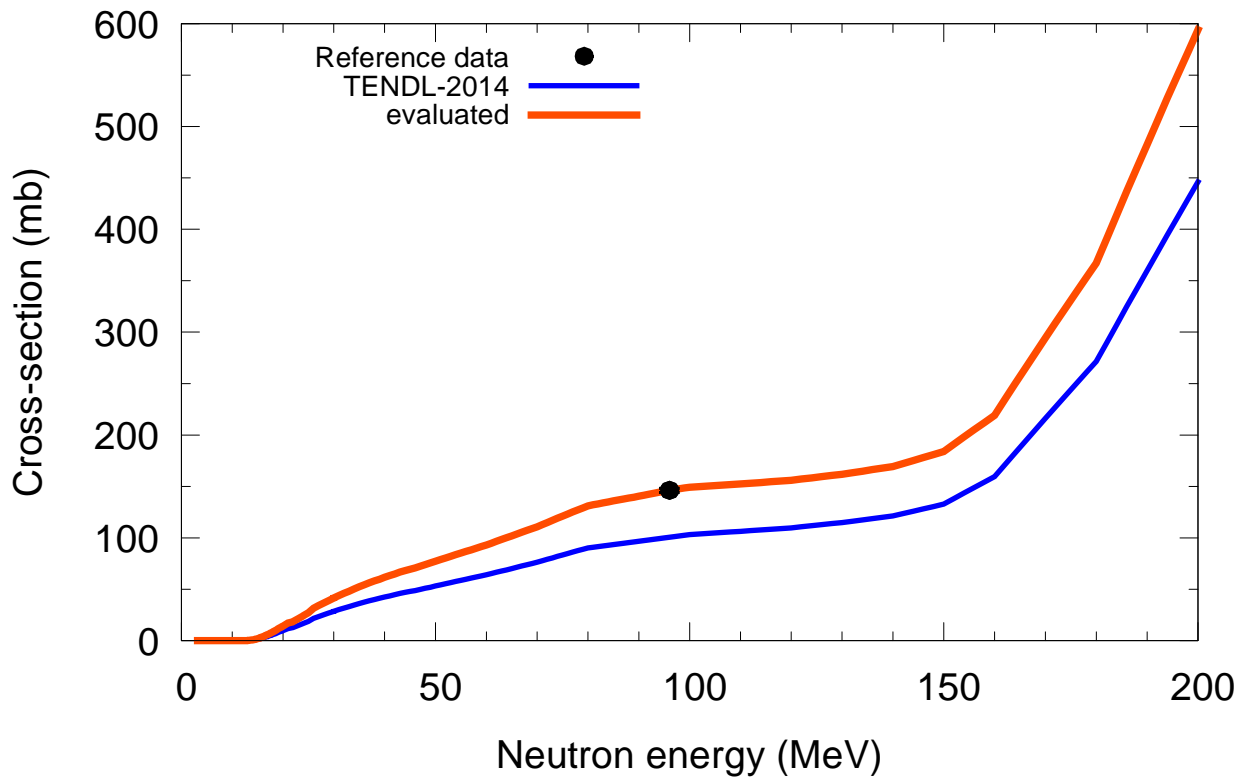
$^{151}\text{Eu}(n,x)d$



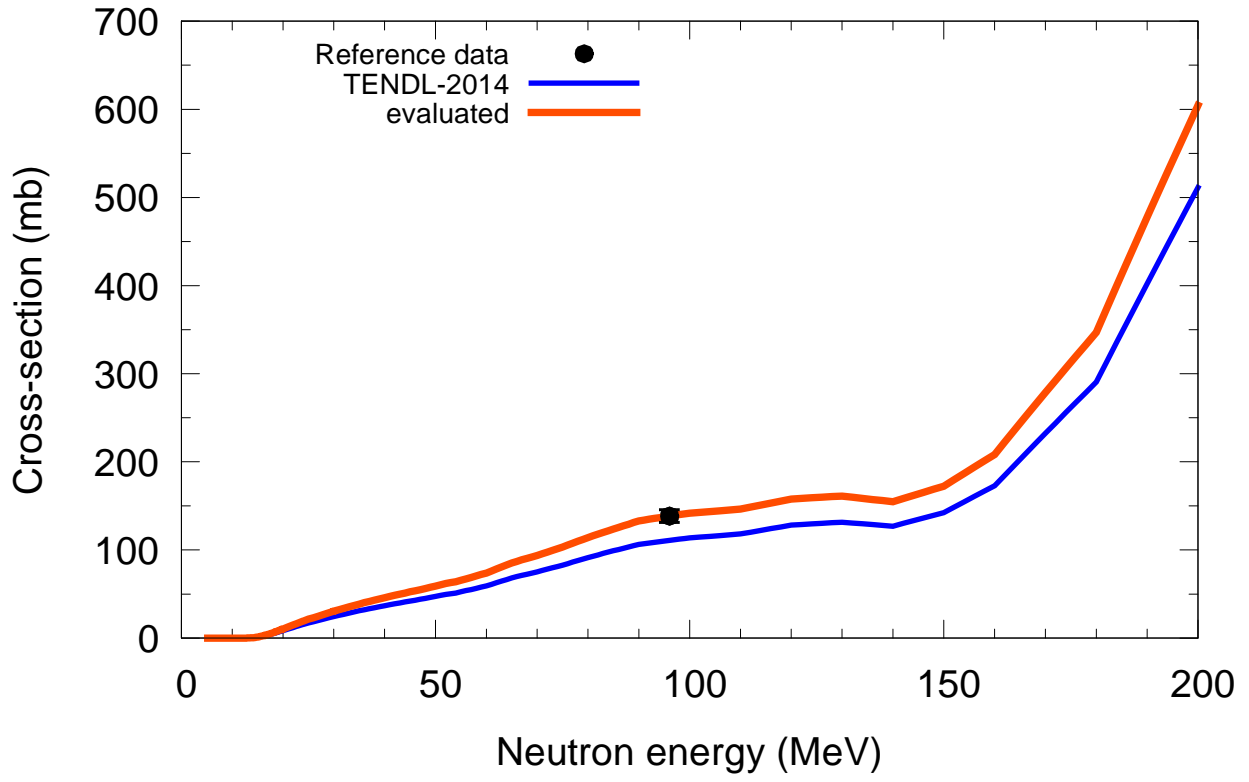
$^{153}\text{Eu}(n,x)d$



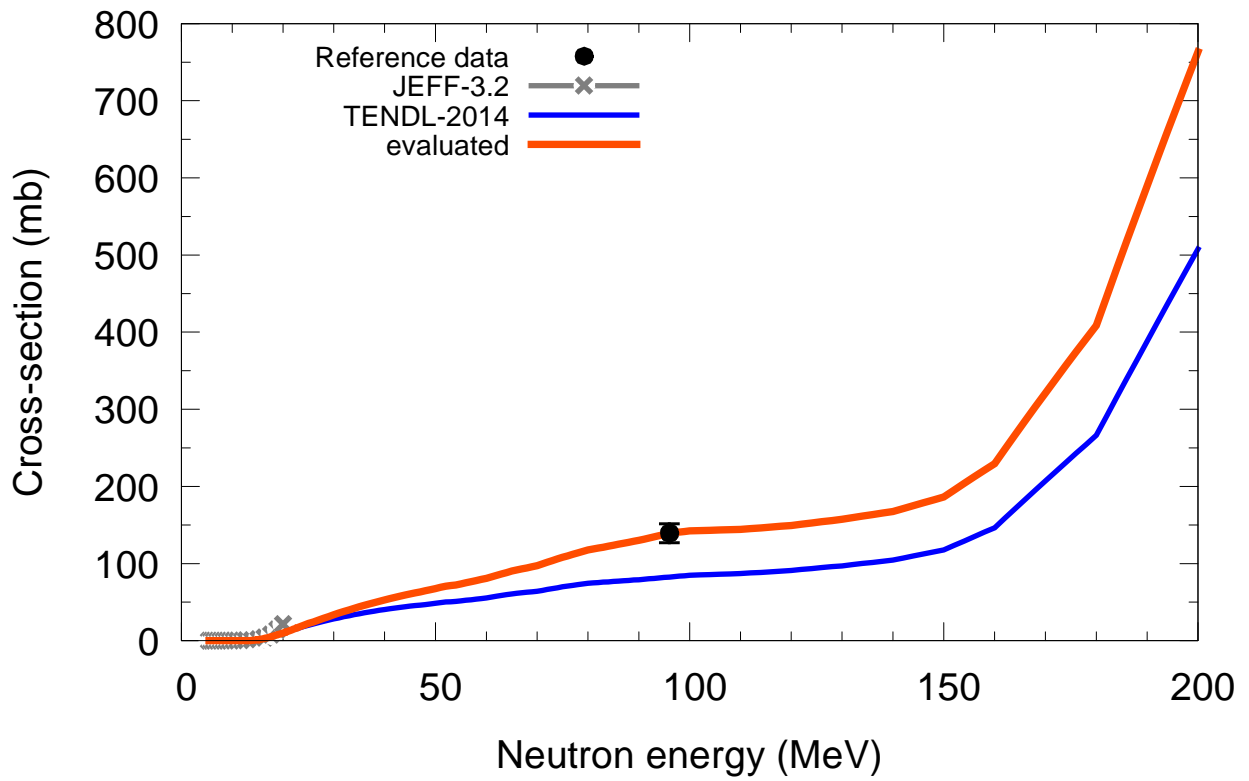
$^{152}\text{Gd}(n,x)d$



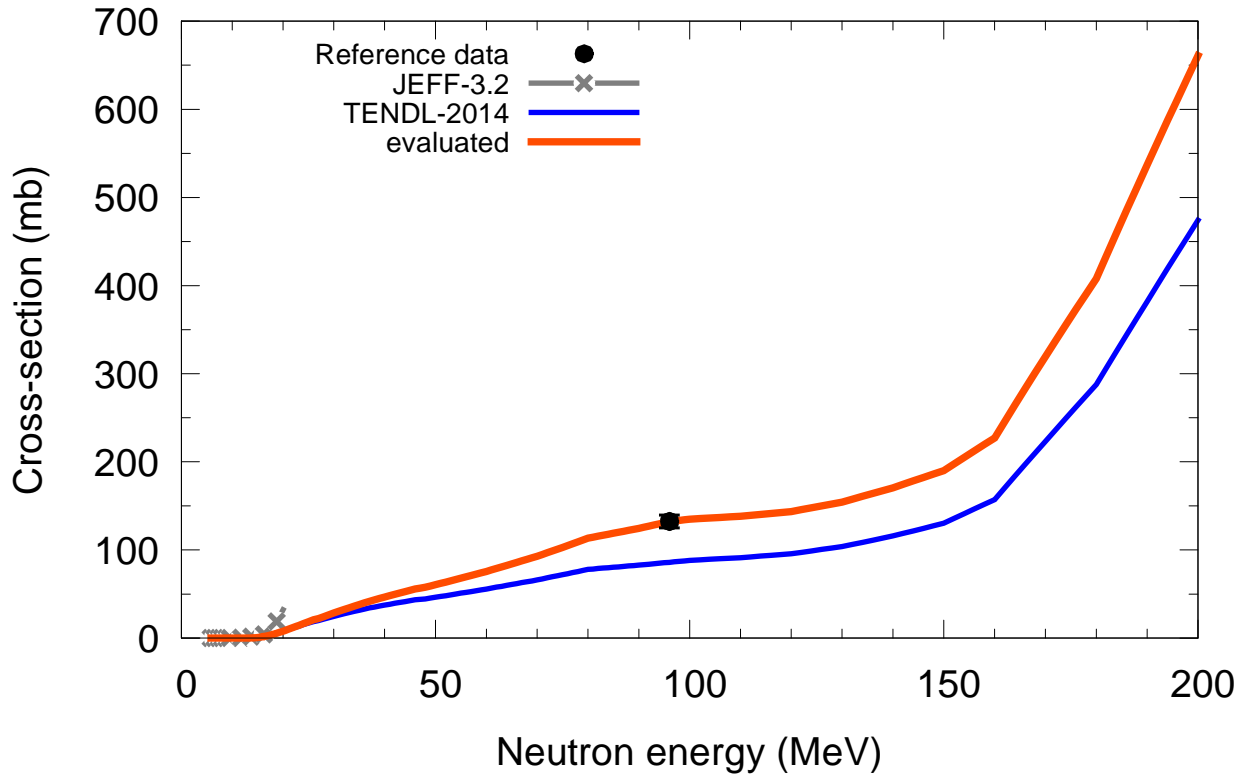
$^{154}\text{Gd}(n,x)d$



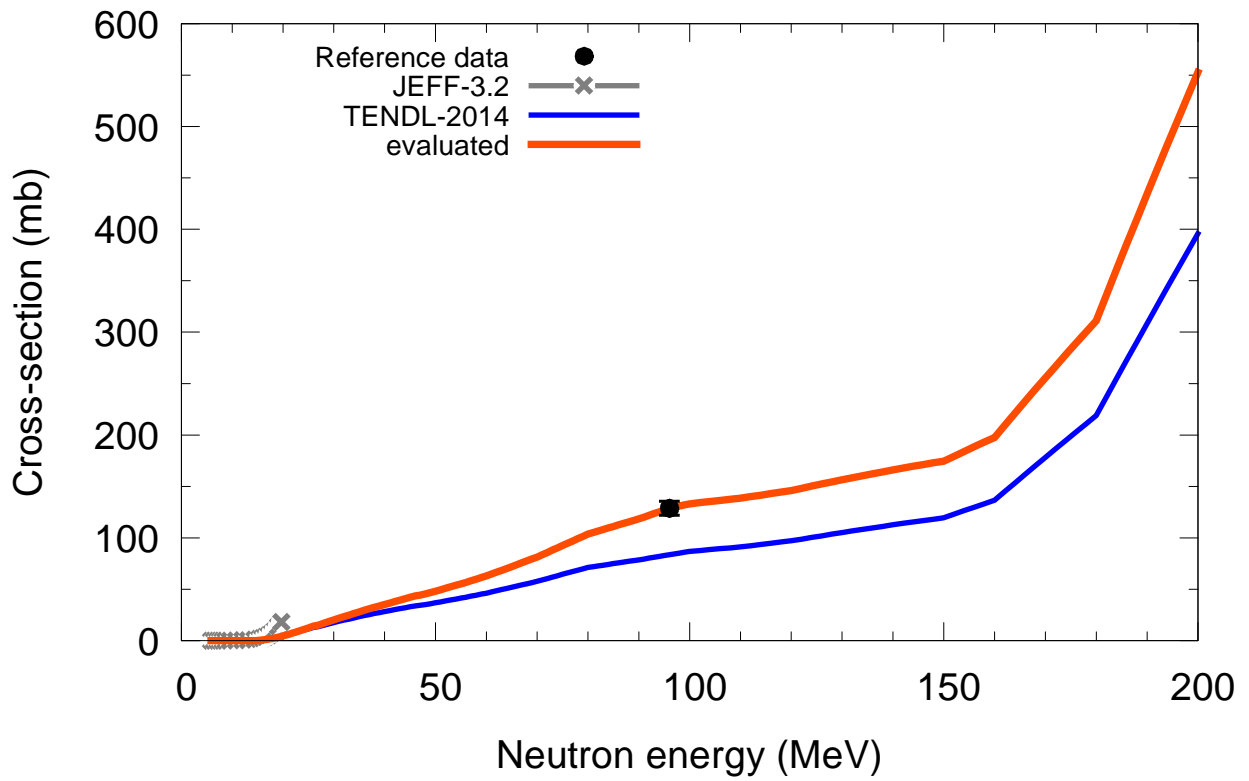
$^{155}\text{Gd}(n,x)d$



$^{156}\text{Gd}(n,x)d$

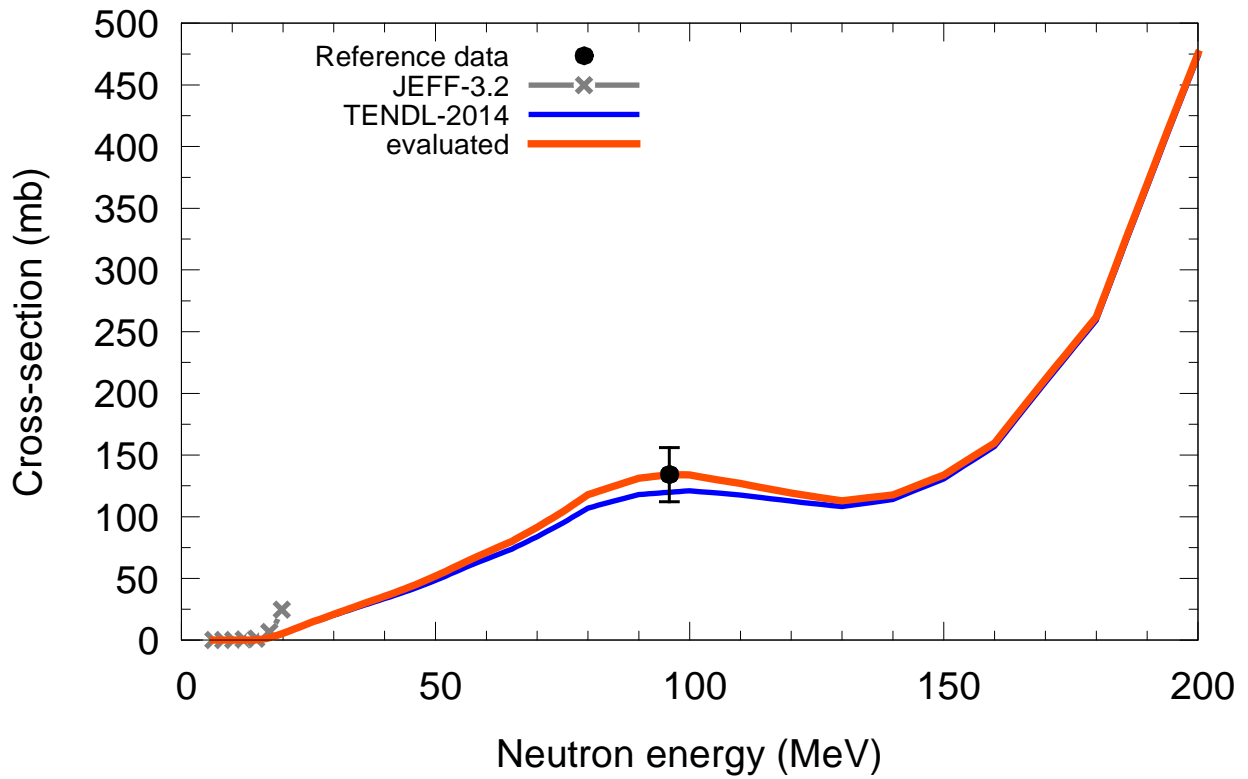


$^{157}\text{Gd}(n,x)d$

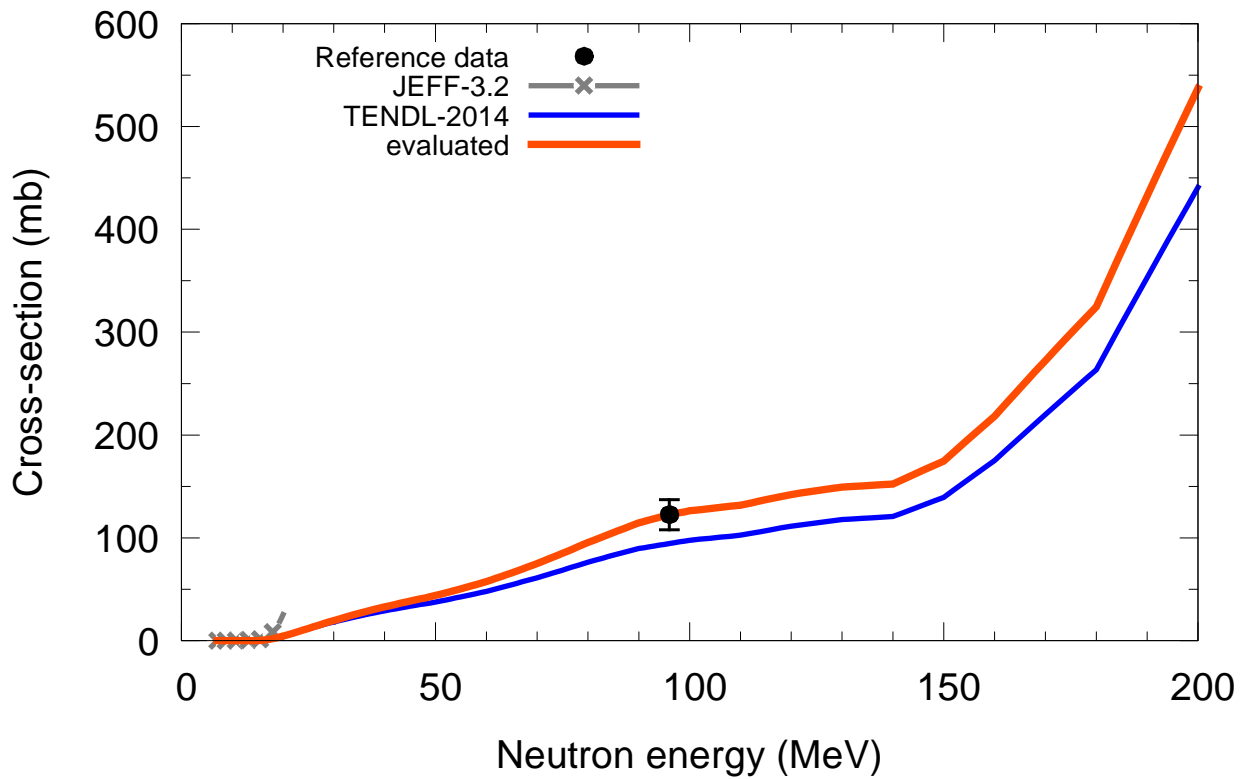




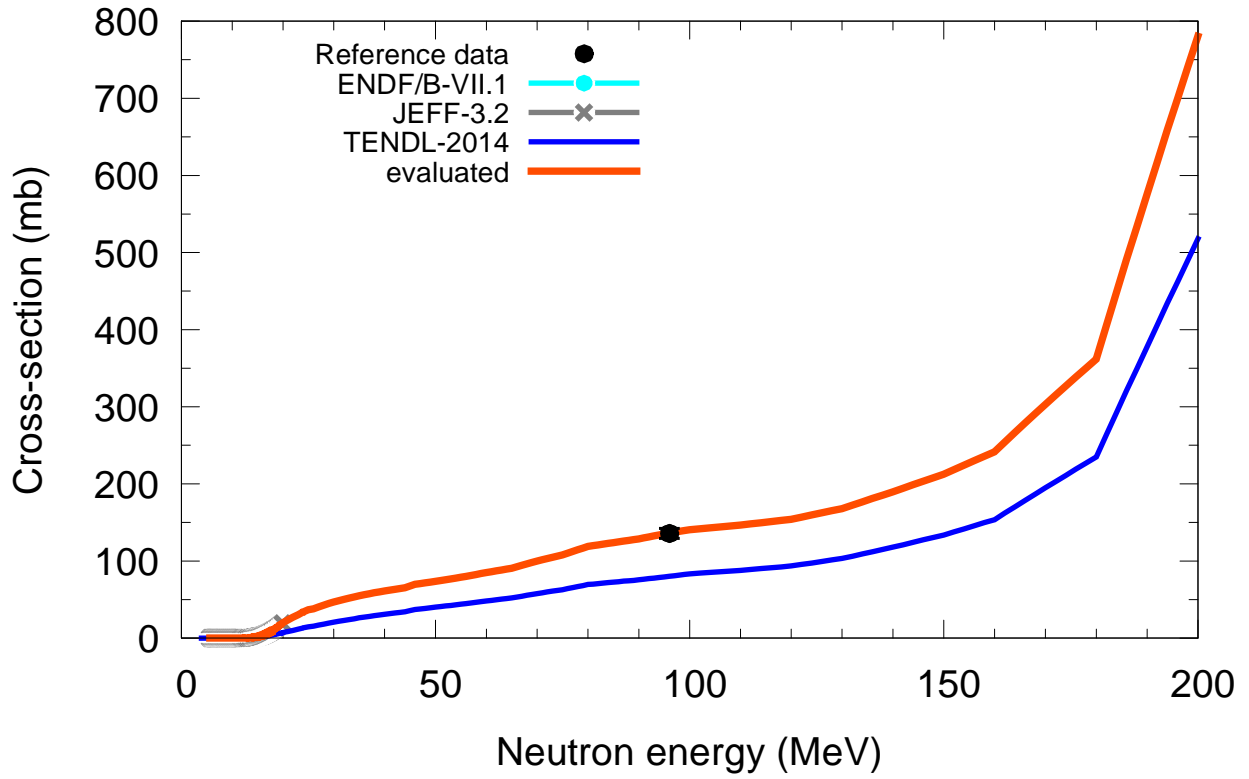
$^{158}\text{Gd}(n,x)d$



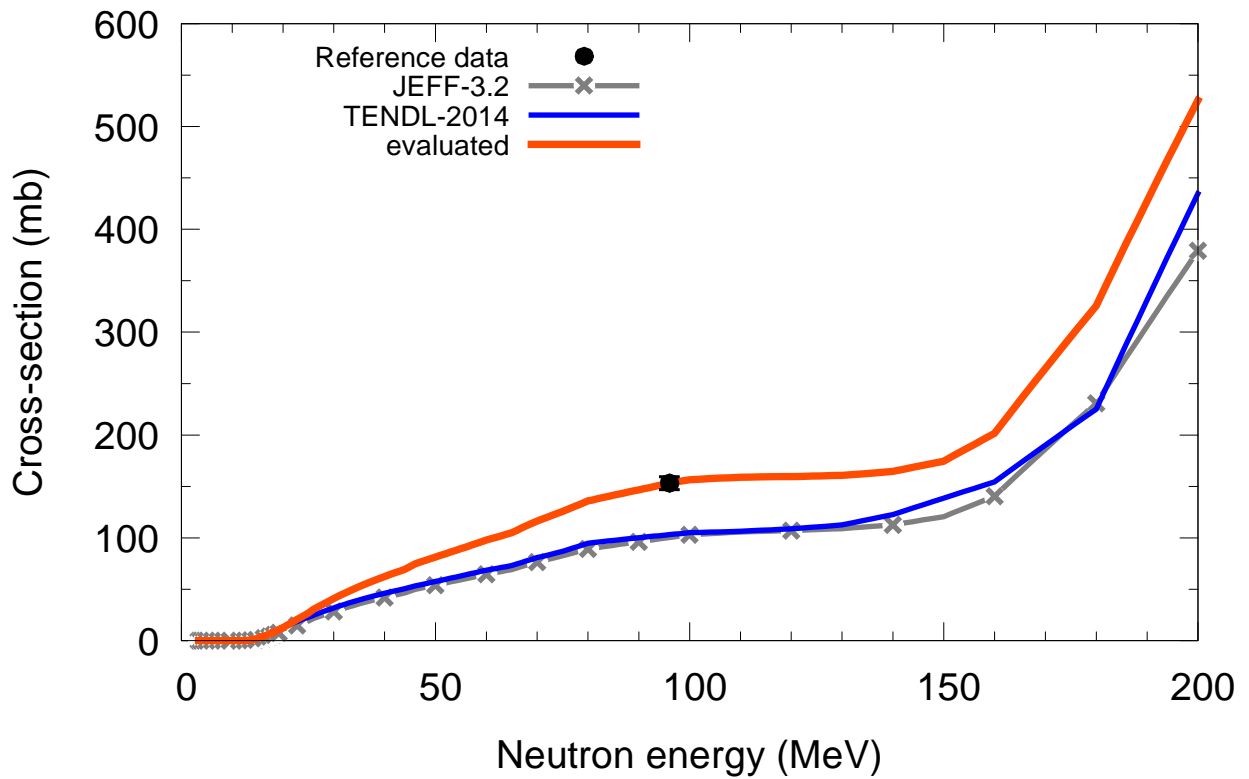
$^{160}\text{Gd}(n,x)d$



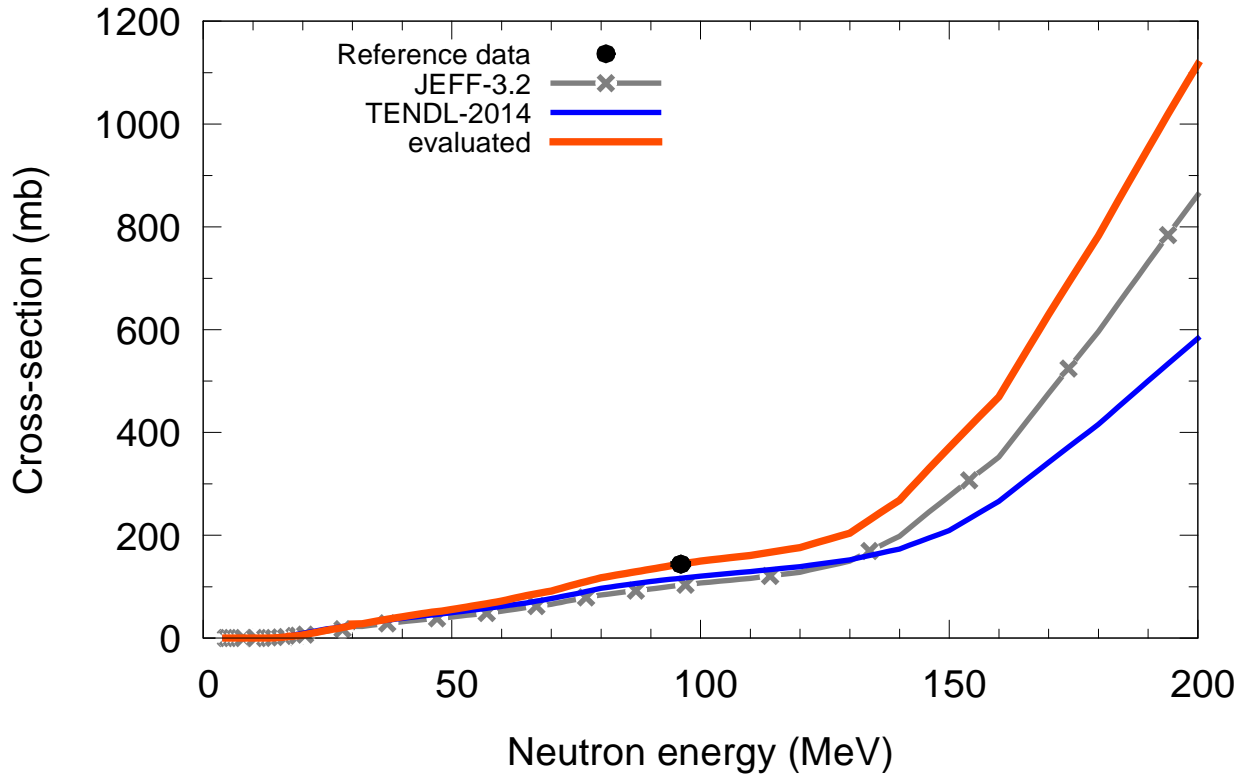
$^{159}\text{Tb}(n,x)d$



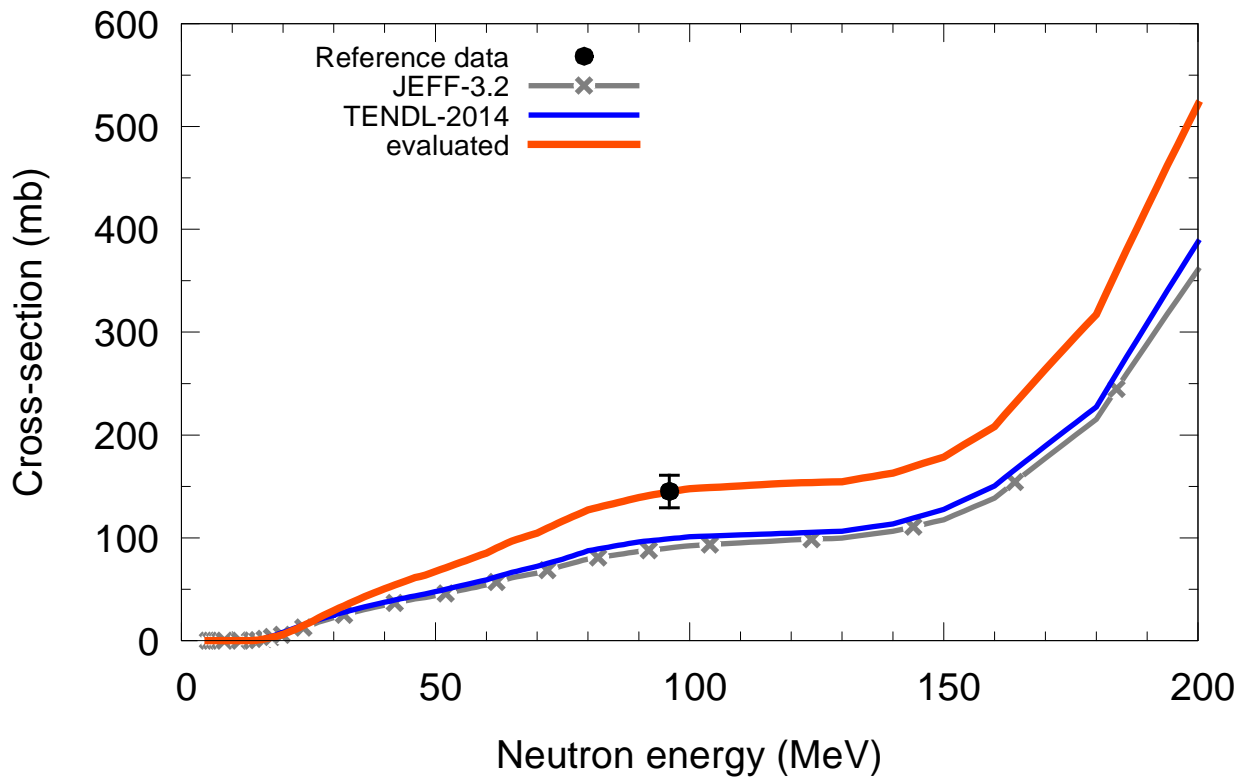
$^{156}\text{Dy}(n,x)d$



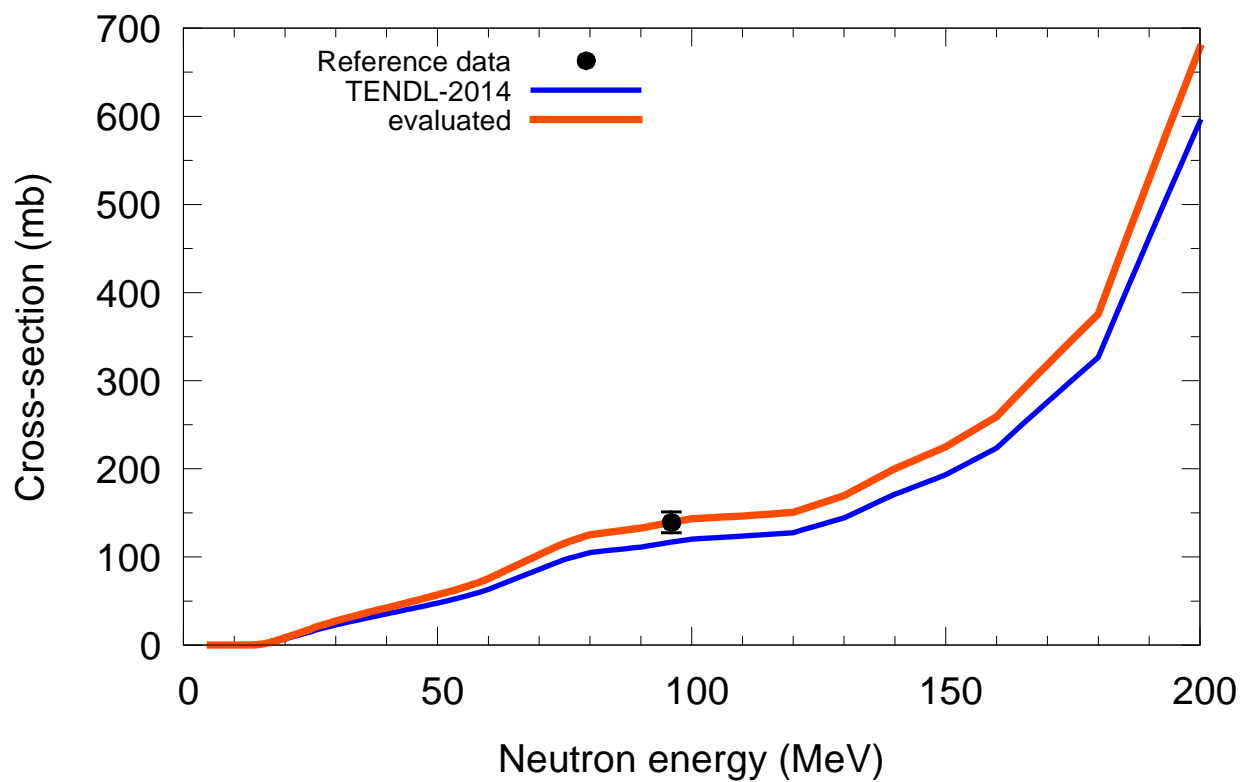
$^{158}\text{Dy}(n,x)d$



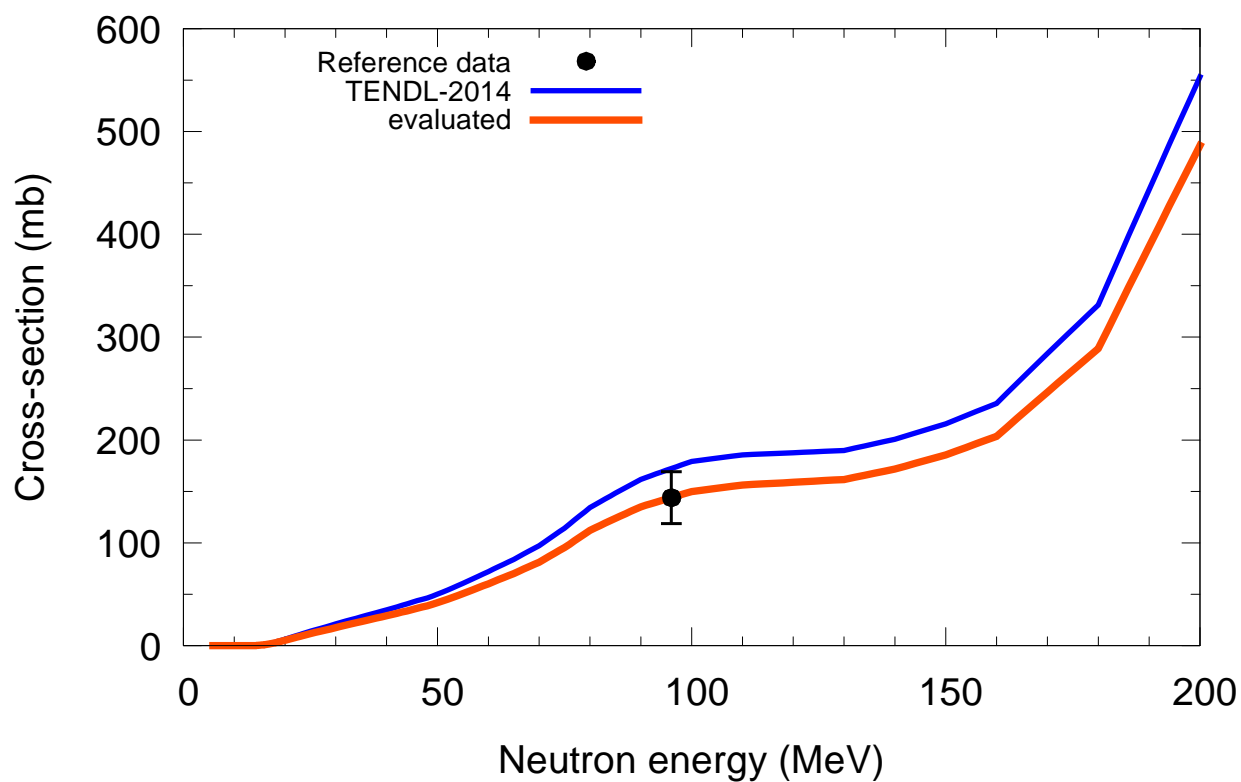
$^{160}\text{Dy}(n,x)d$



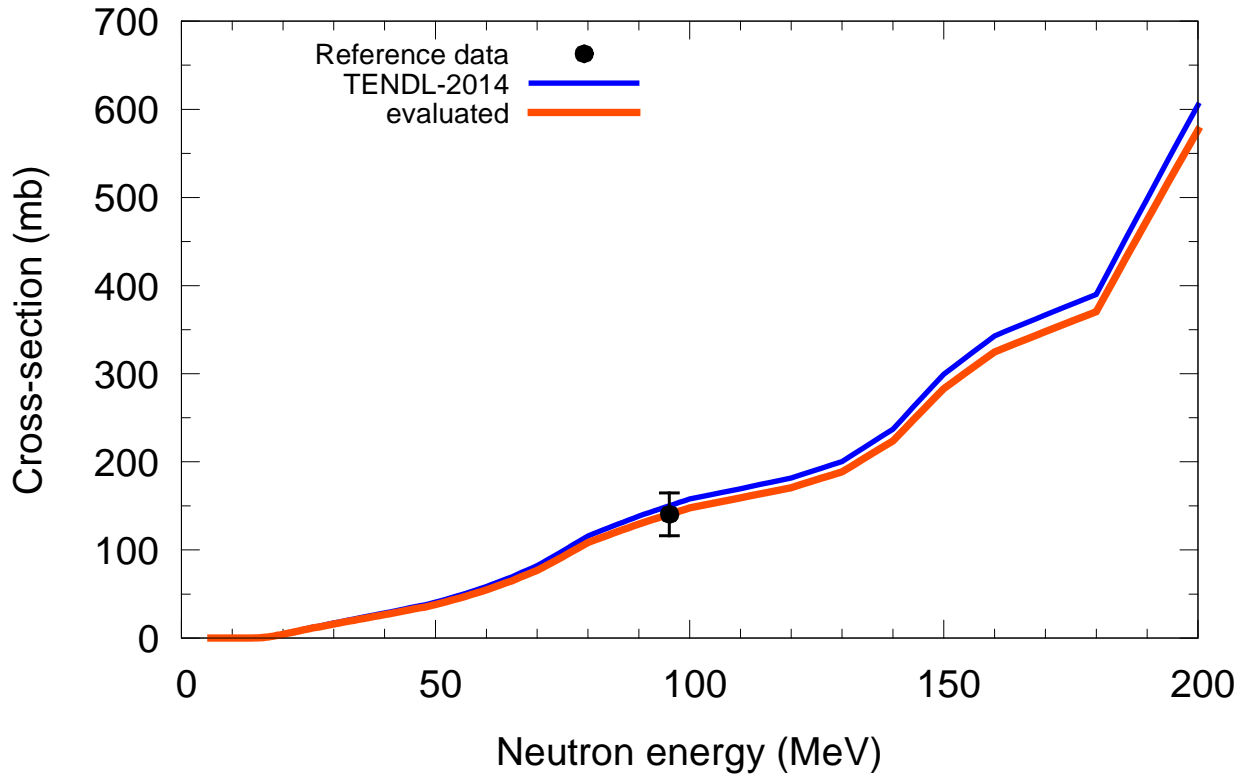
$^{161}\text{Dy}(n,x)d$



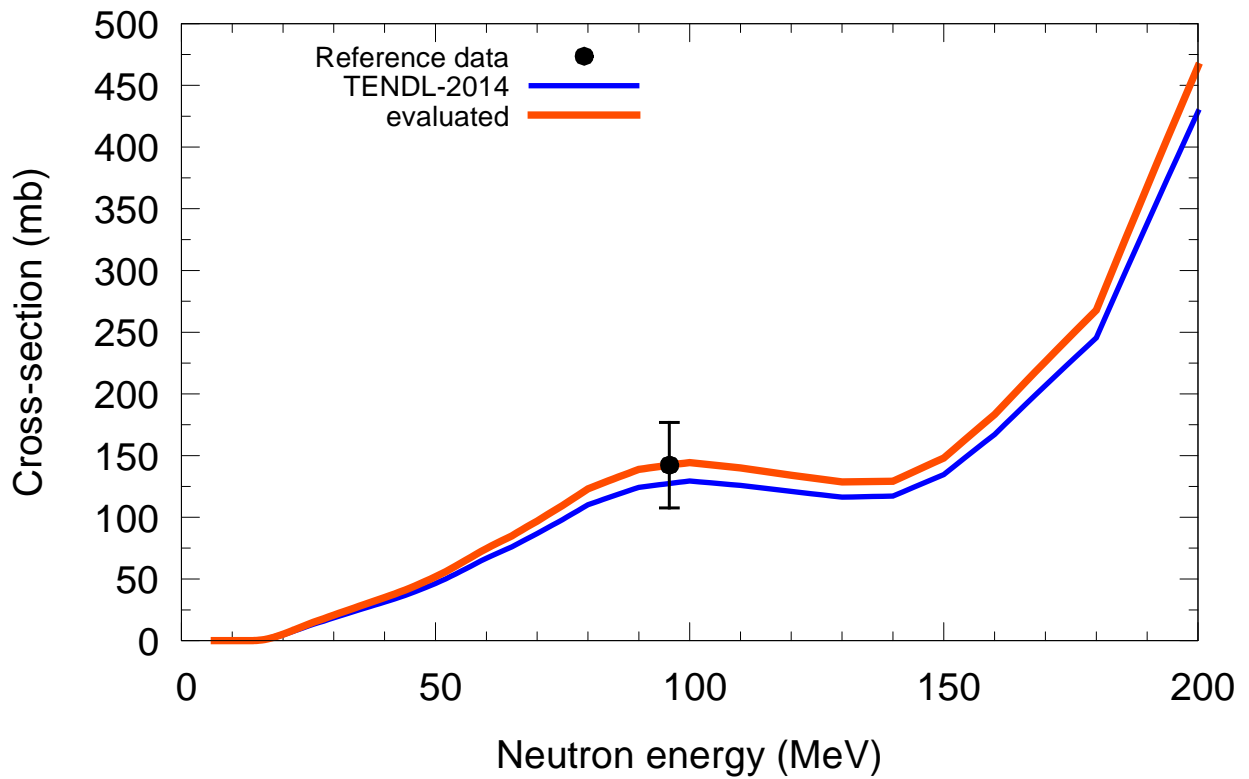
$^{162}\text{Dy}(n,x)d$

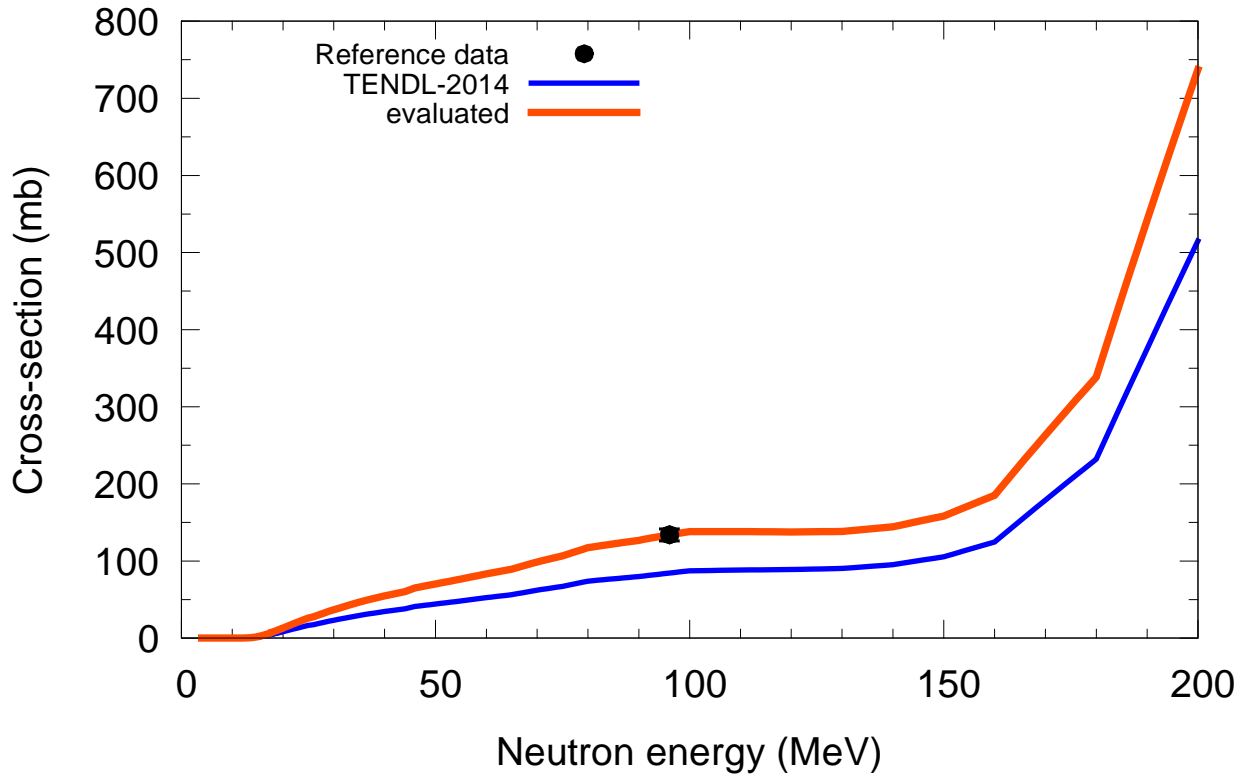
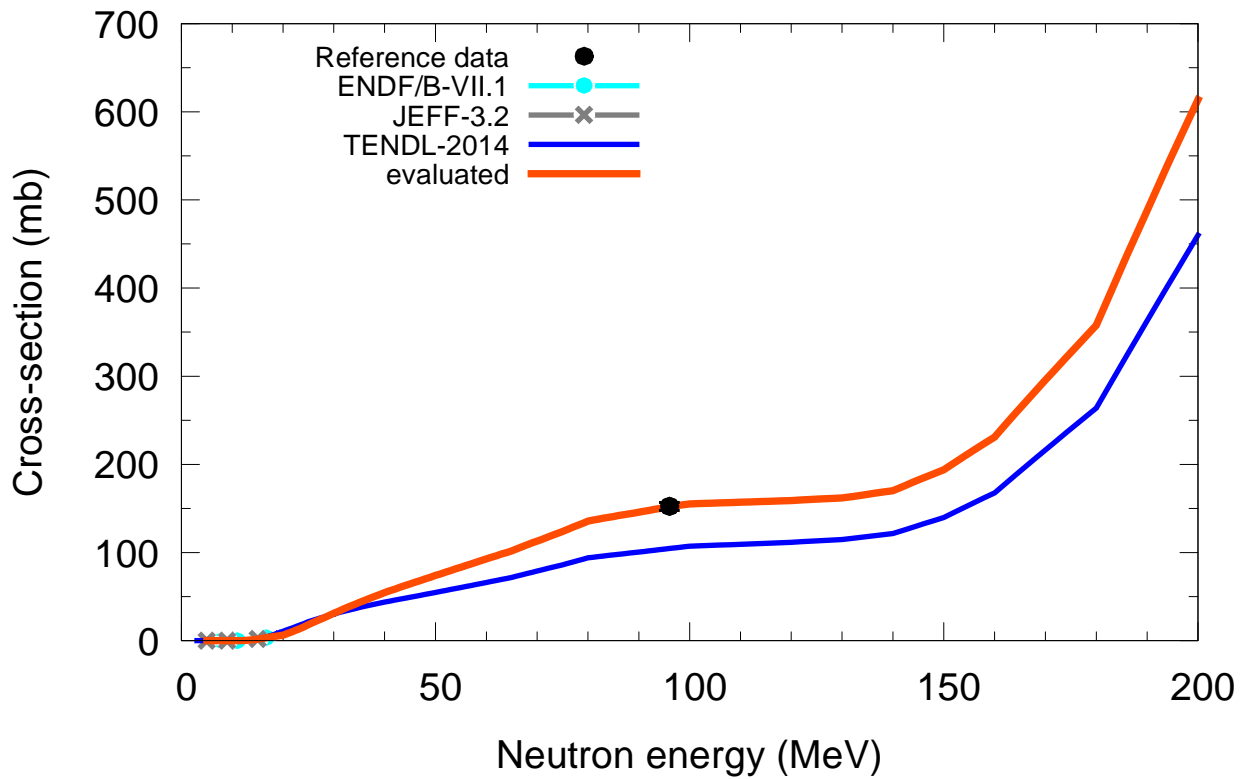


$^{163}\text{Dy}(n,x)d$

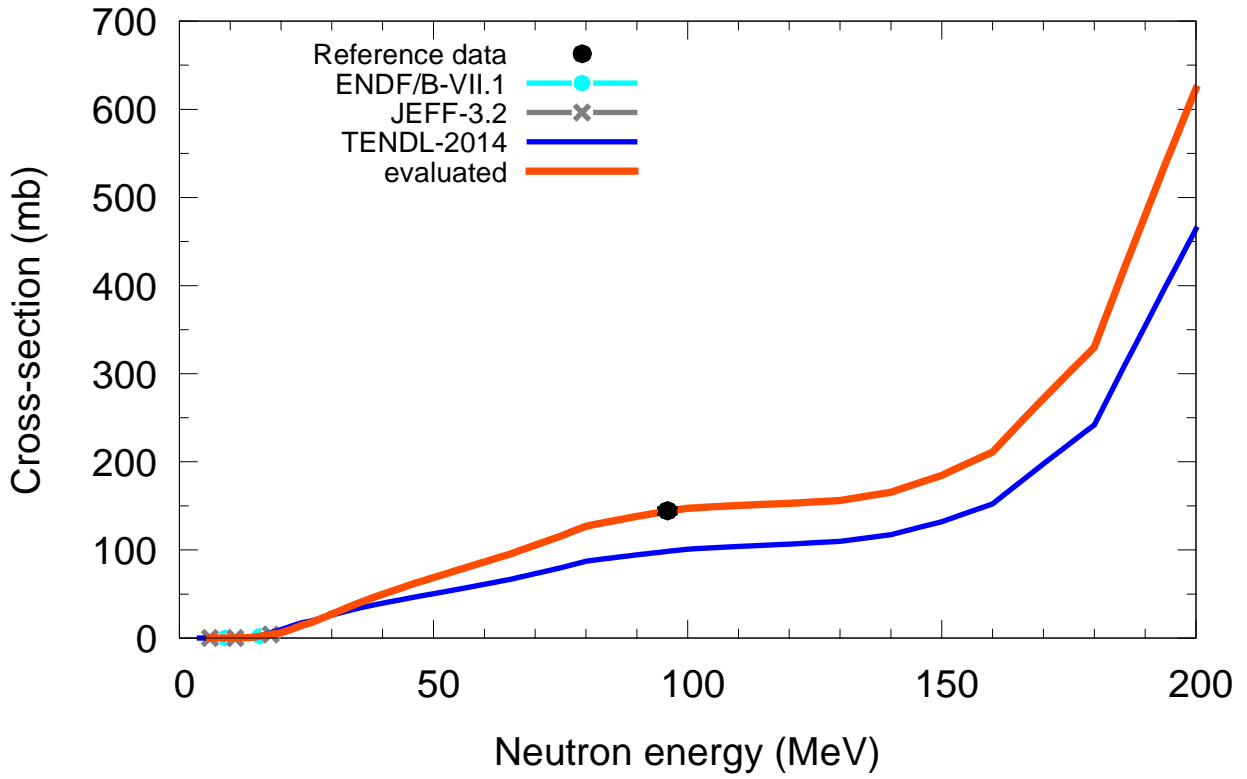


$^{164}\text{Dy}(n,x)d$

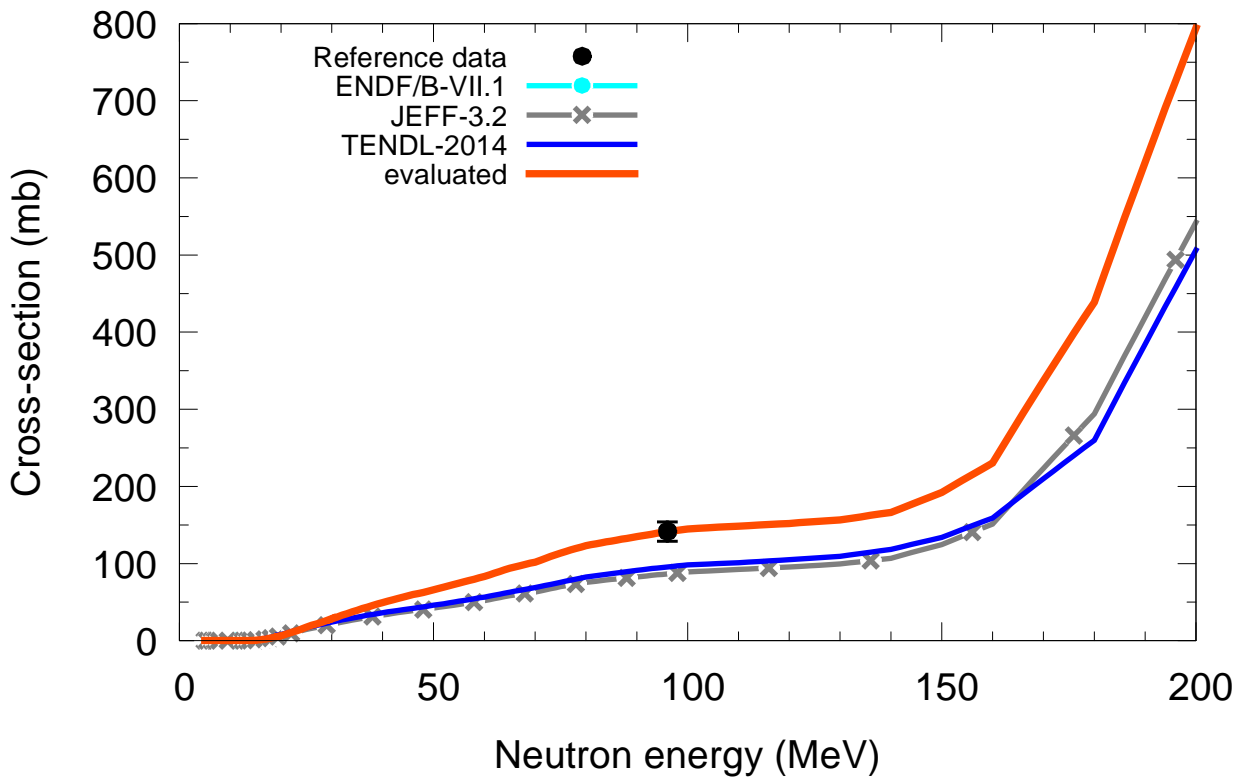


$^{165}\text{Ho}(n,x)d$  $^{162}\text{Er}(n,x)d$ 

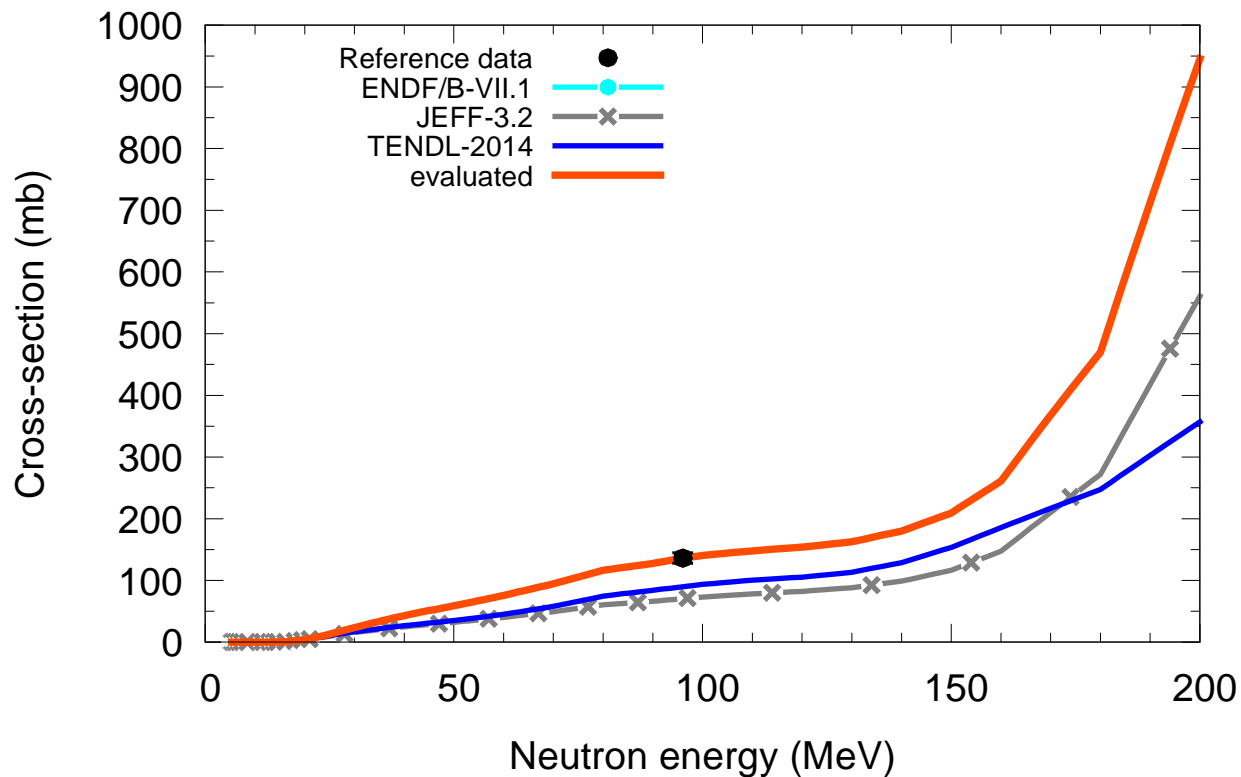
$^{164}\text{Er}(n,x)d$



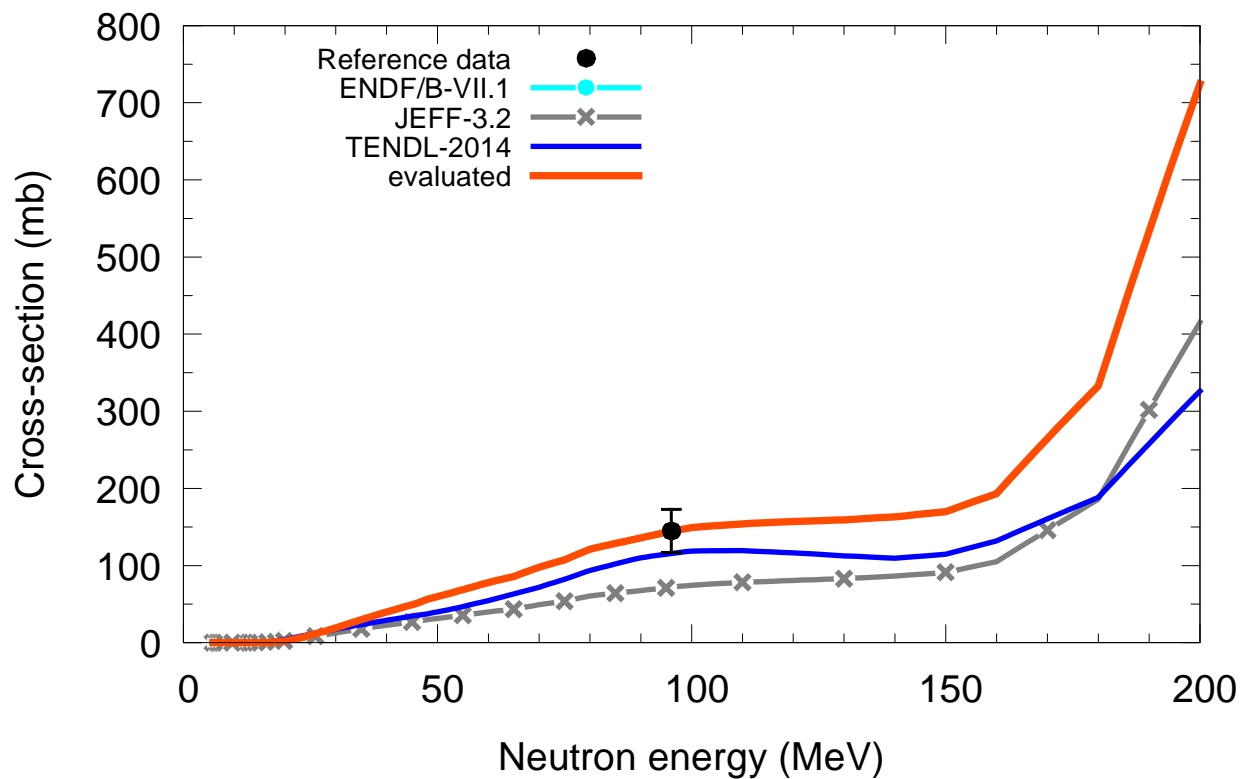
$^{166}\text{Er}(n,x)d$



### $^{167}\text{Er}(n,x)d$

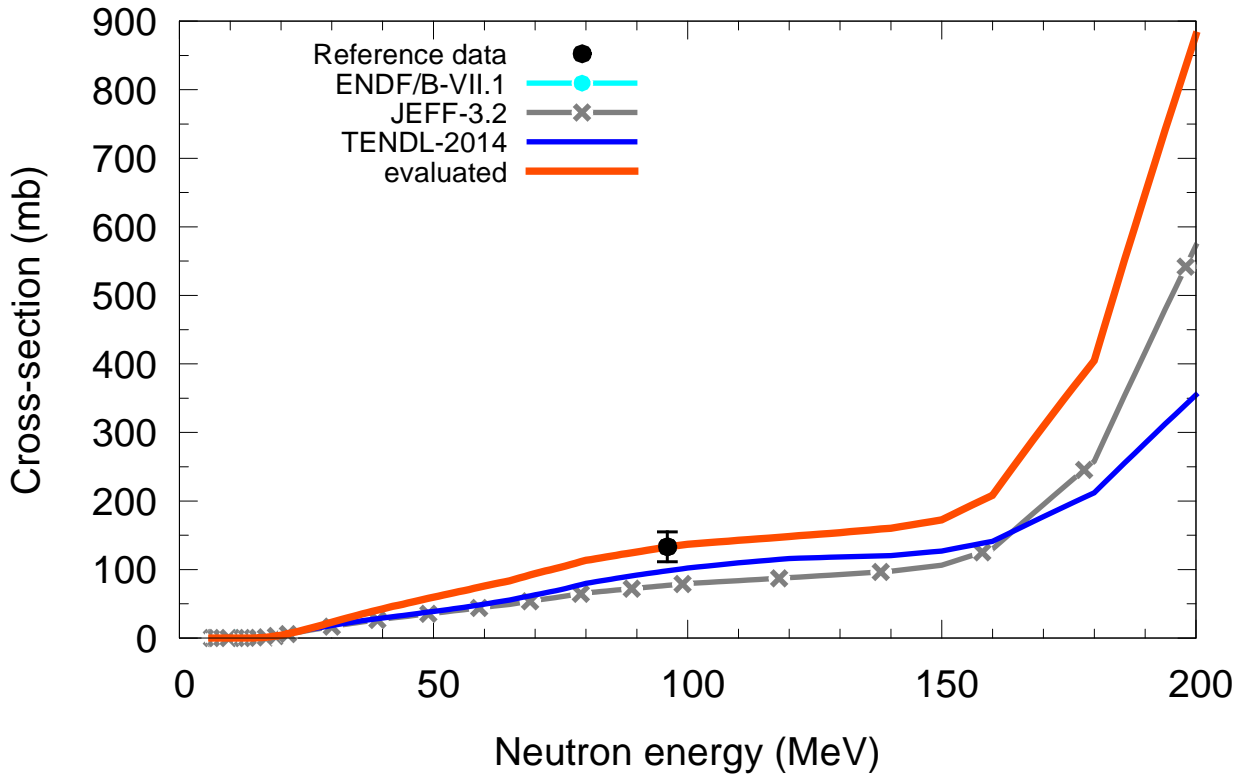


### $^{168}\text{Er}(n,x)d$

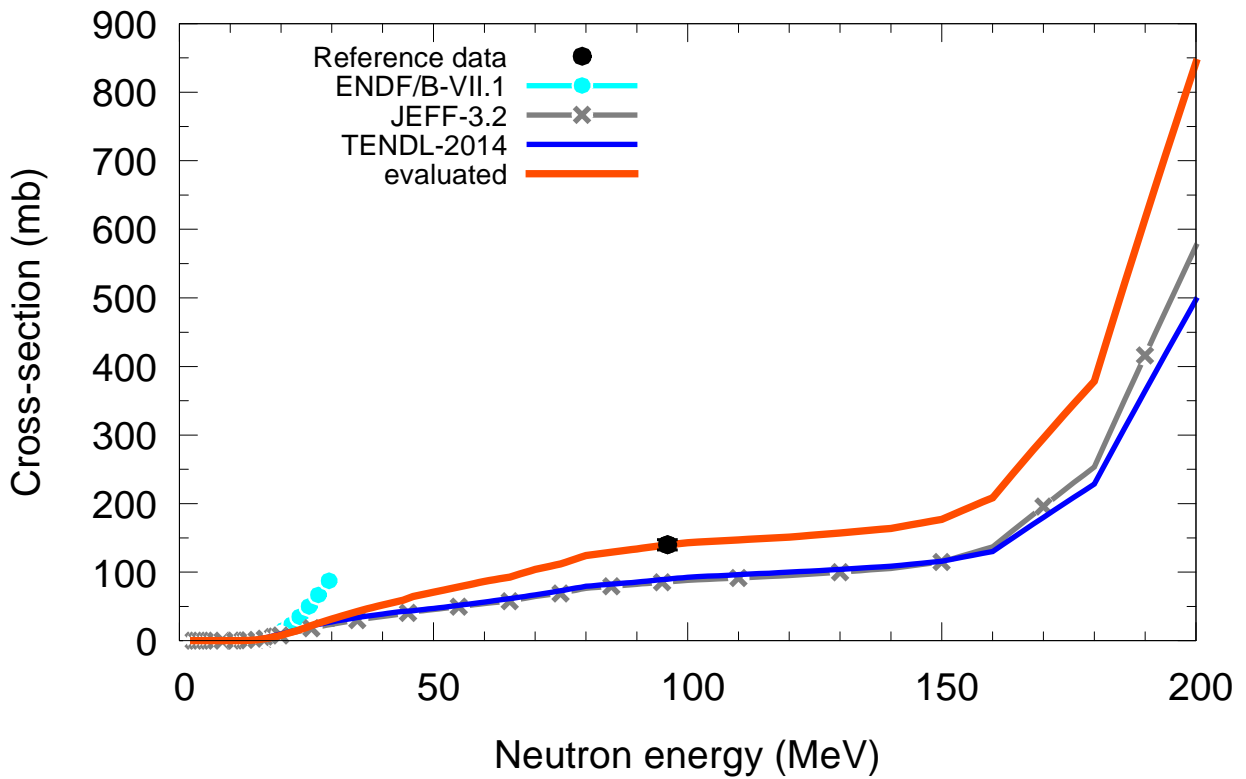




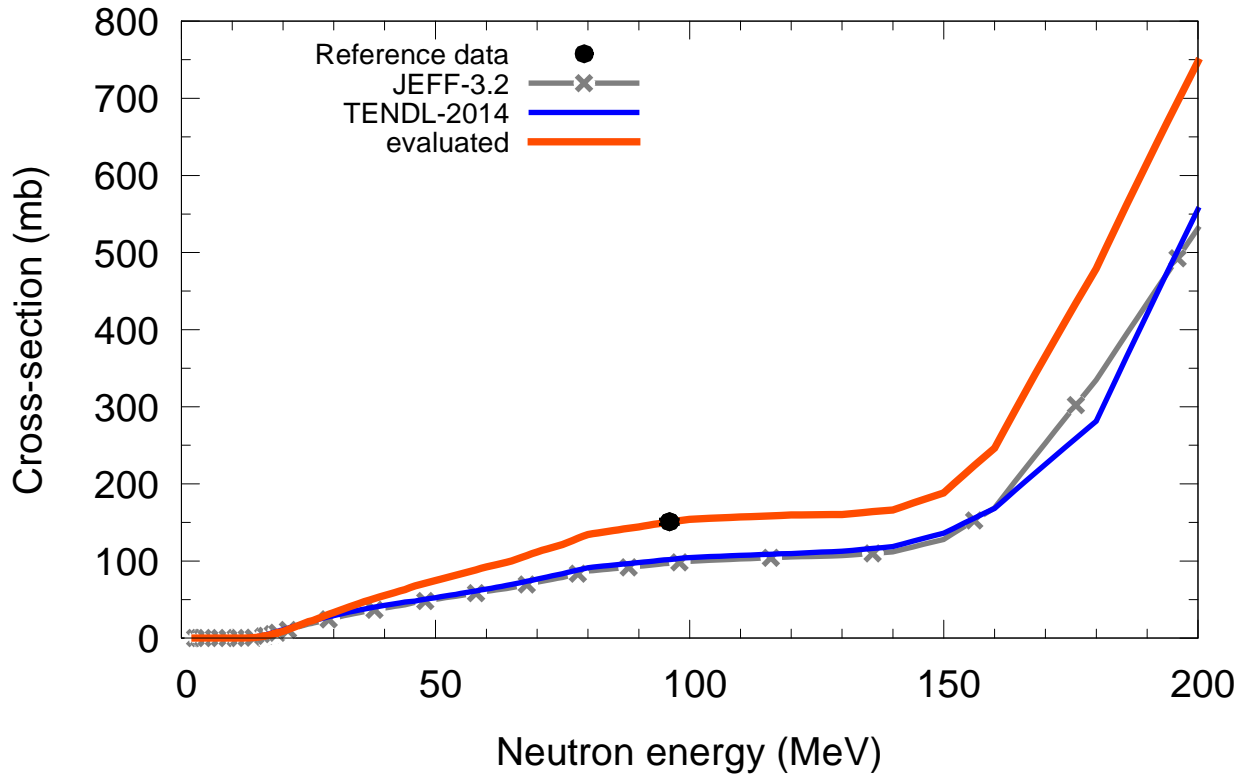
$^{170}\text{Er}(n,x)d$



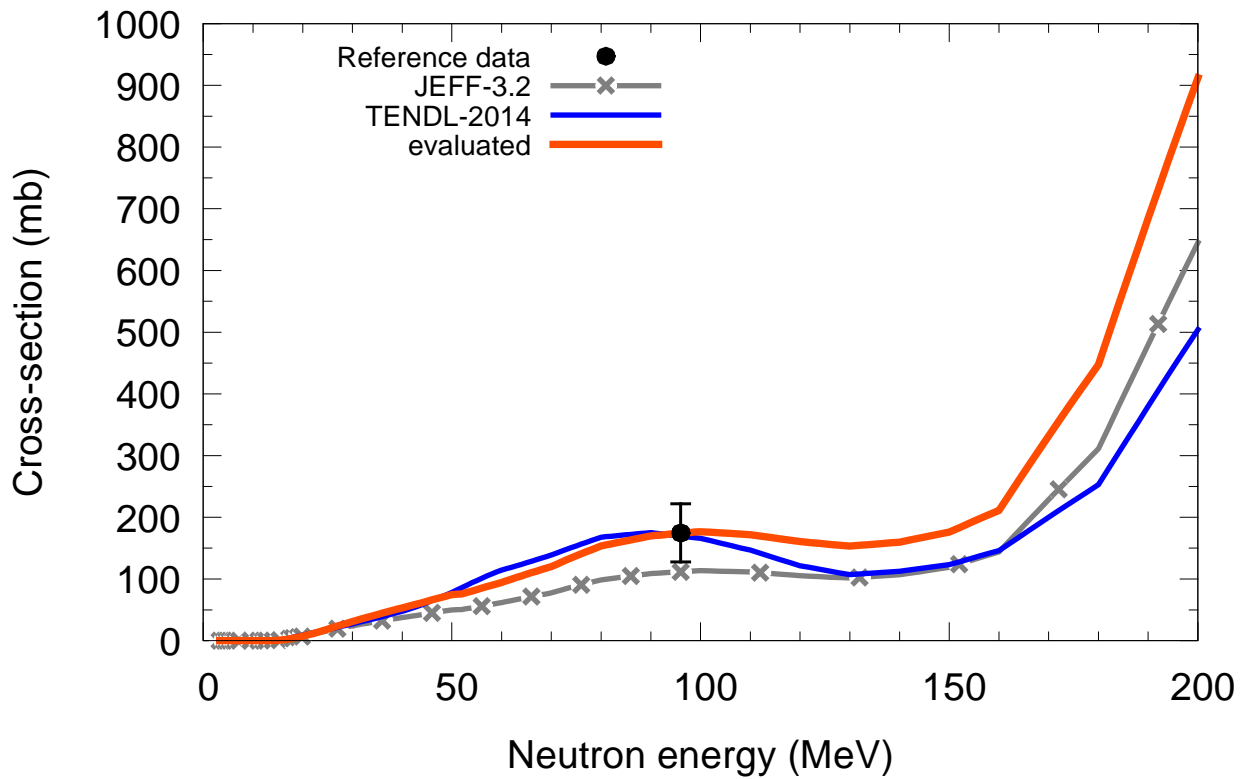
$^{169}\text{Tm}(n,x)d$



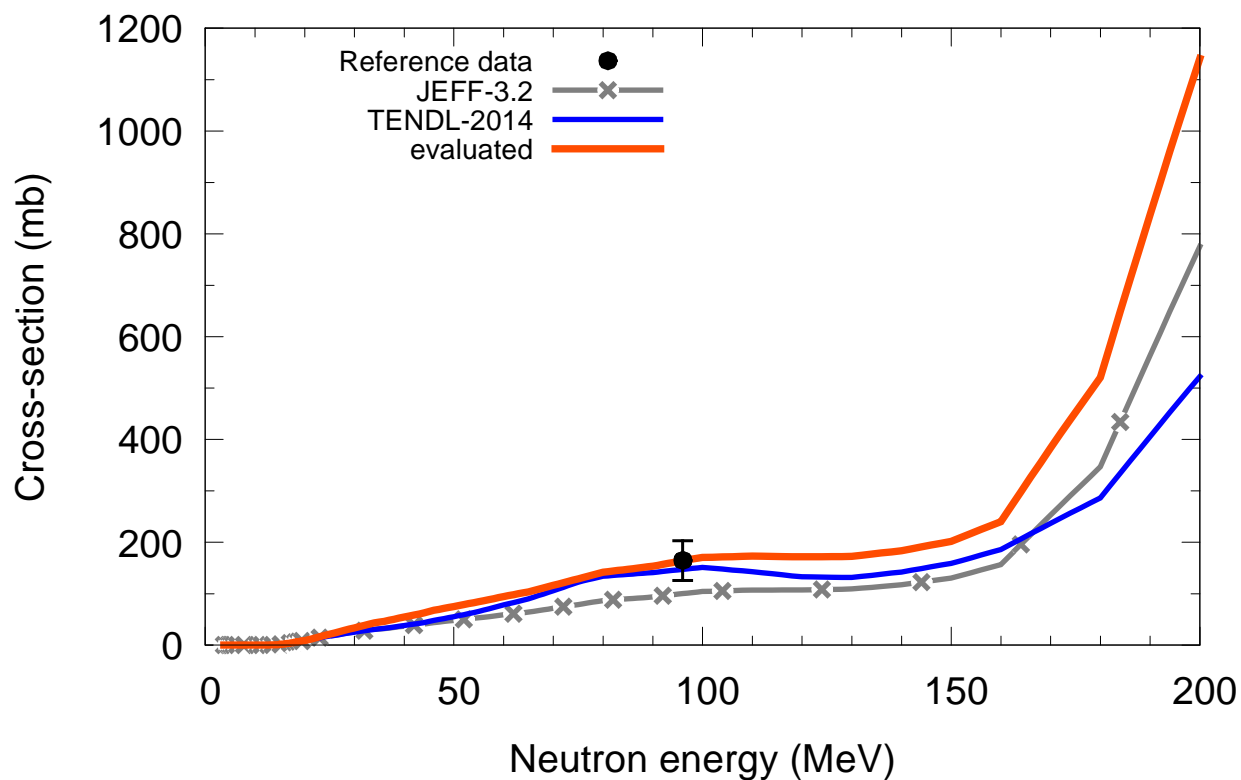
$^{168}\text{Yb}(n,x)d$



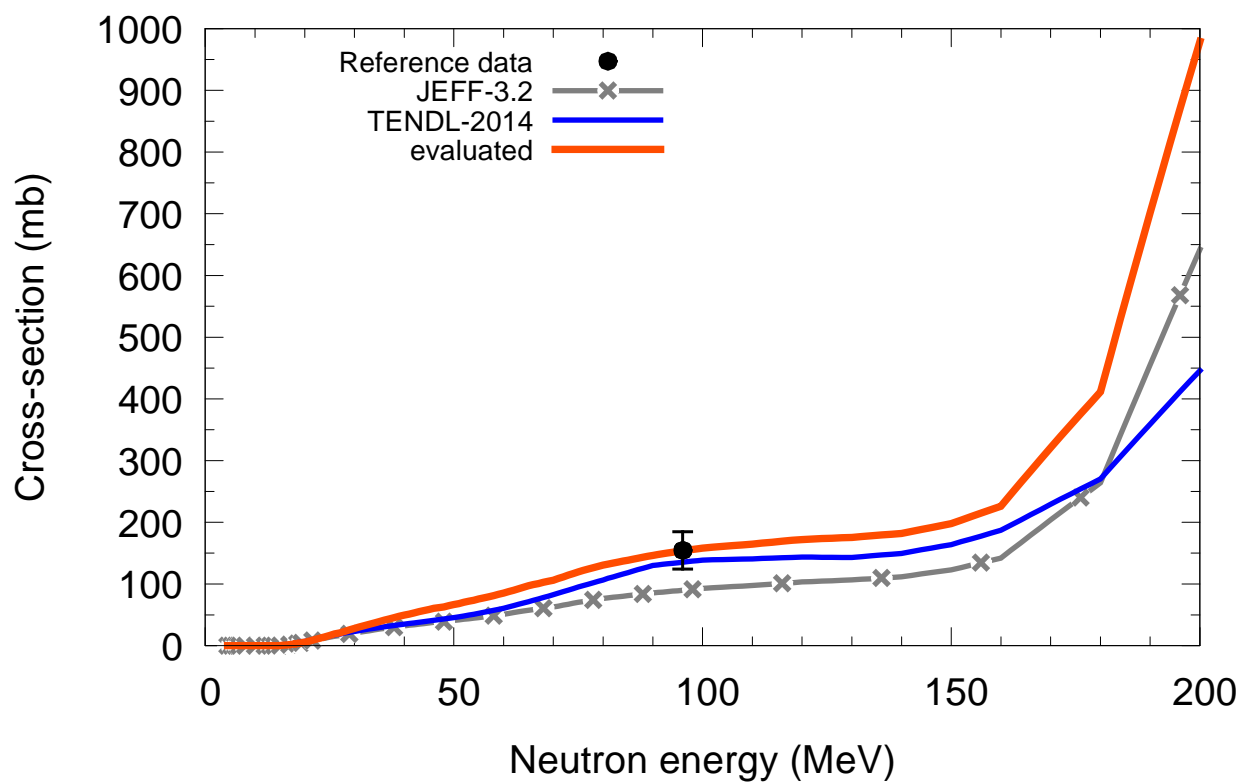
$^{170}\text{Yb}(n,x)d$



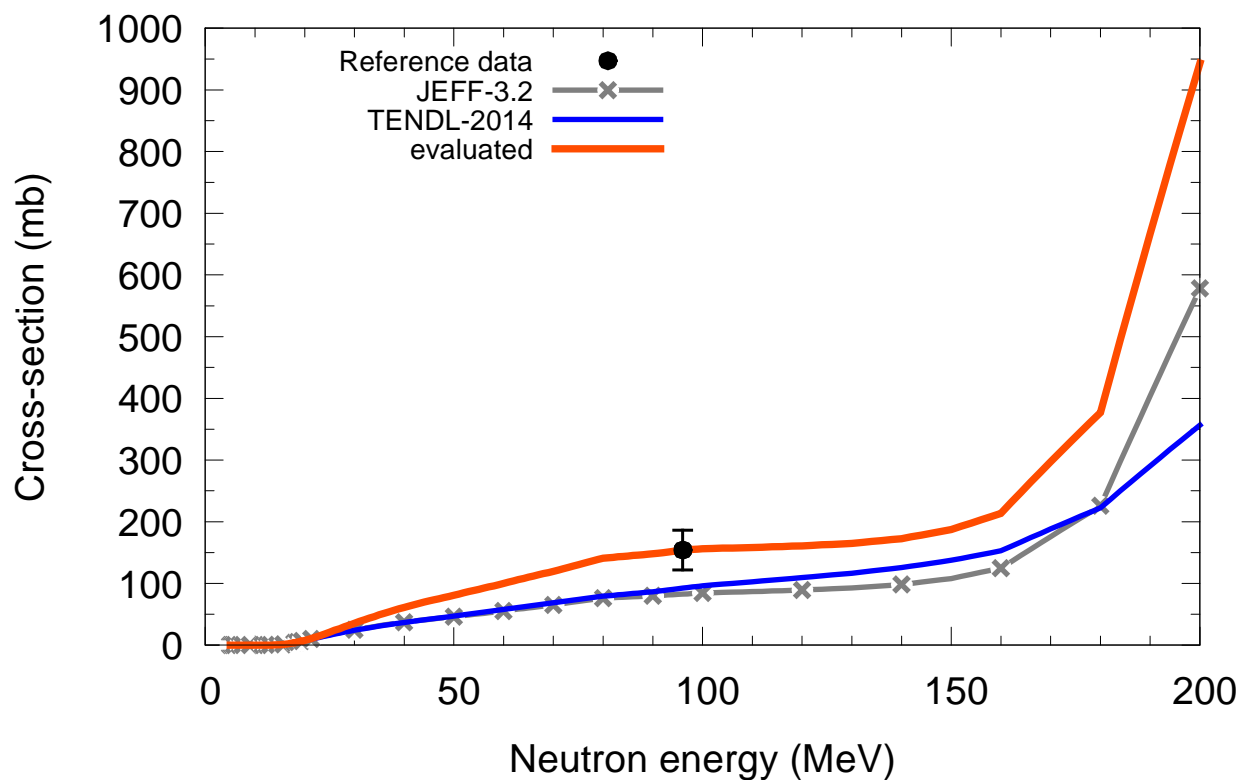
### $^{171}\text{Yb}(n,x)d$



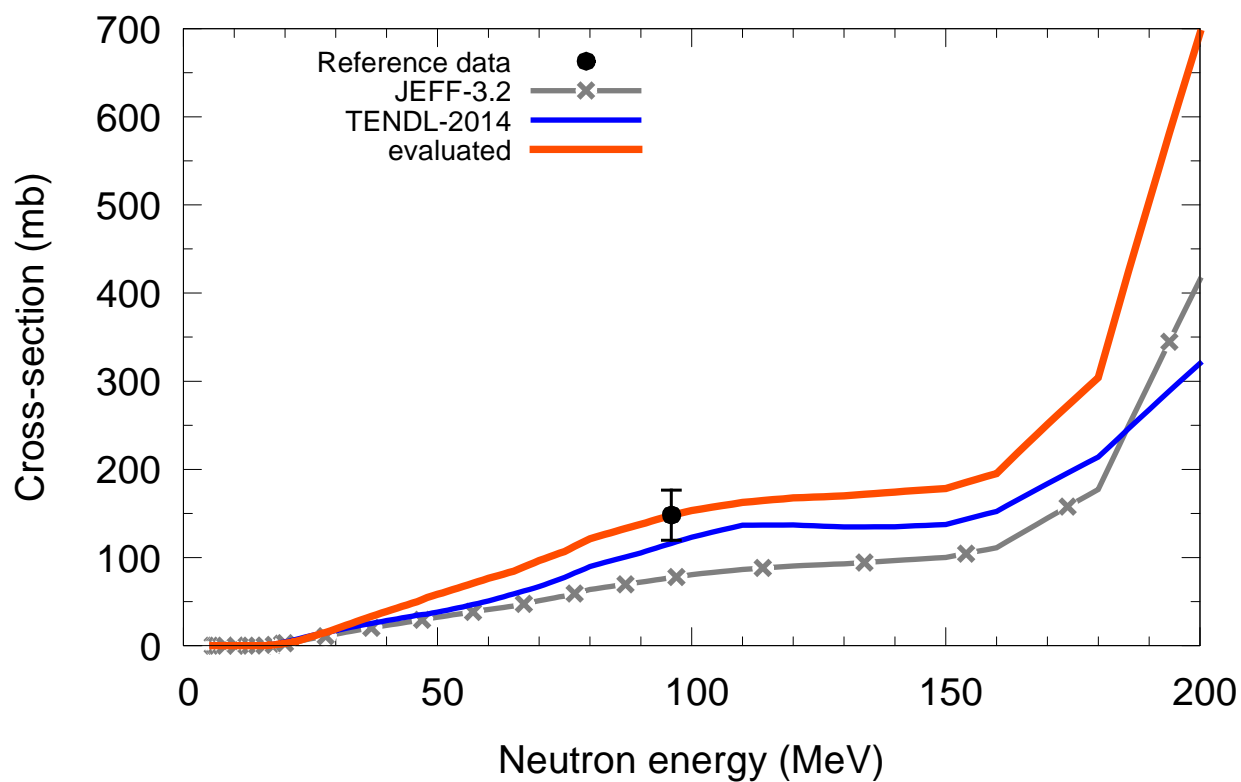
### $^{172}\text{Yb}(n,x)d$



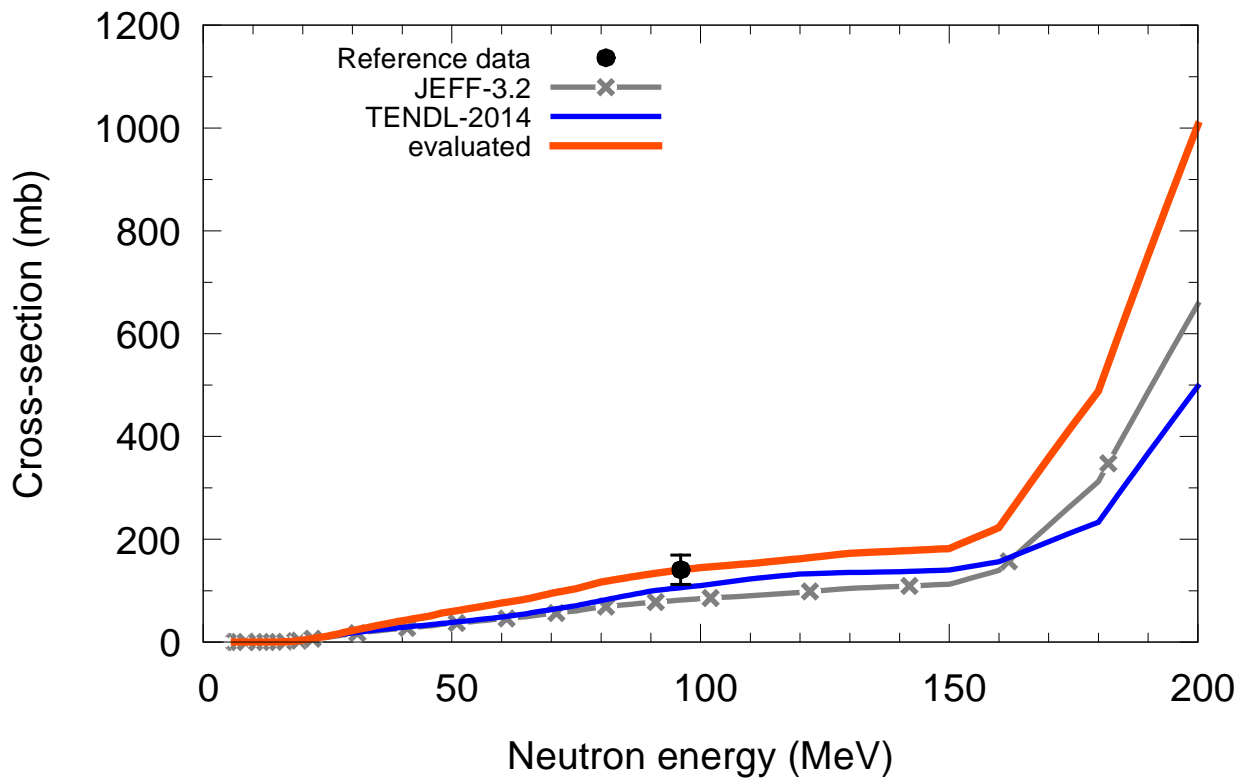
$^{173}\text{Yb}(n,x)d$



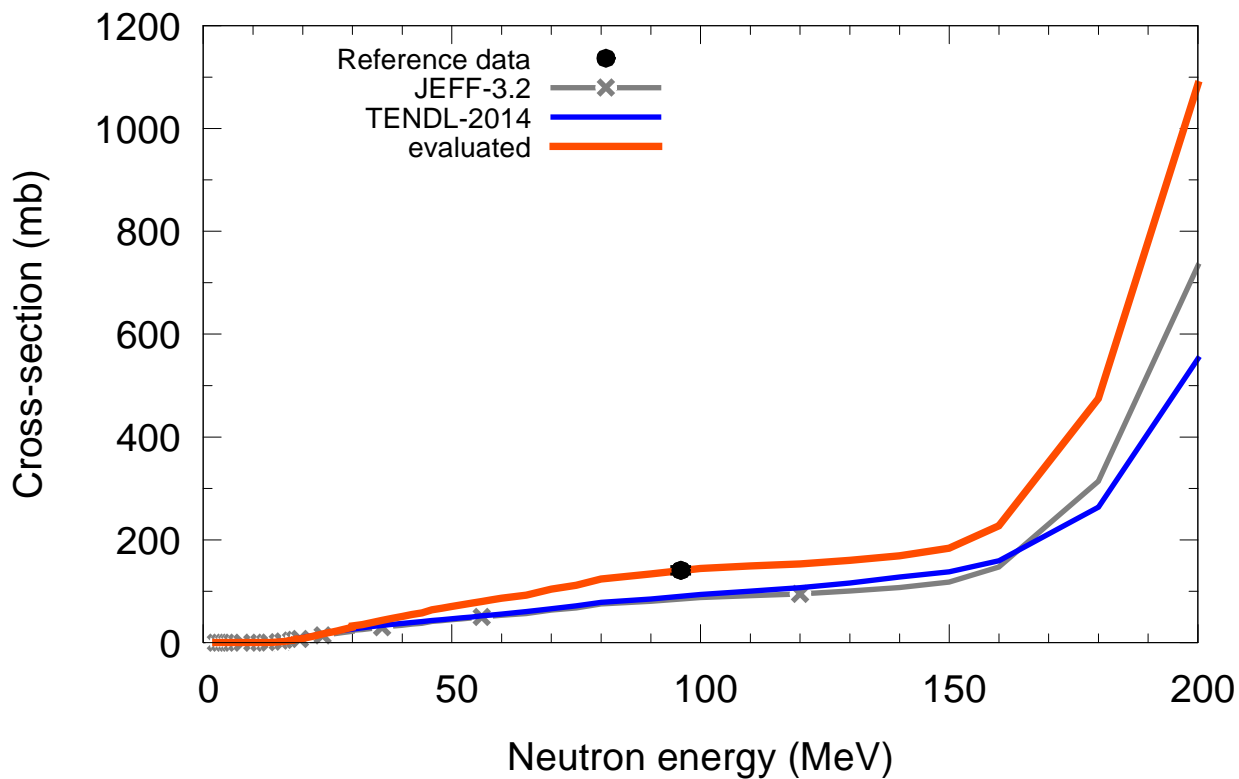
$^{174}\text{Yb}(n,x)d$



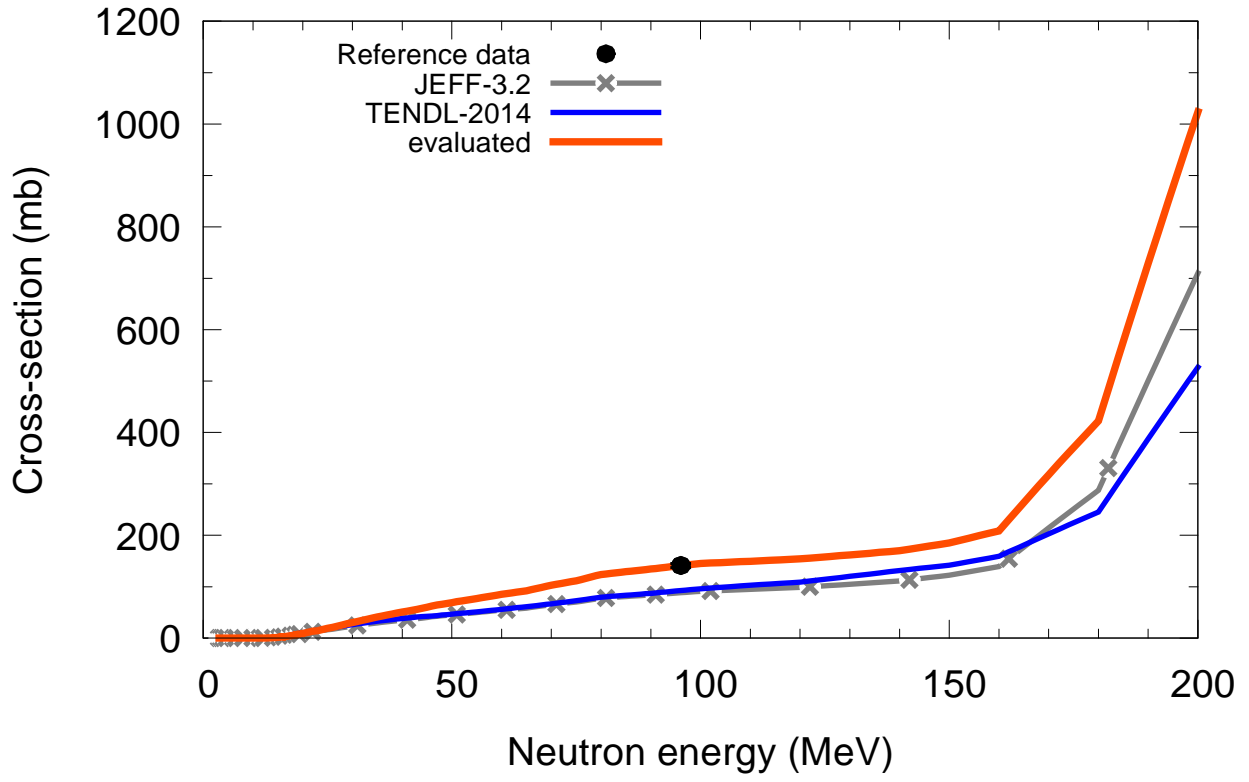
$^{176}\text{Yb}(n,x)d$



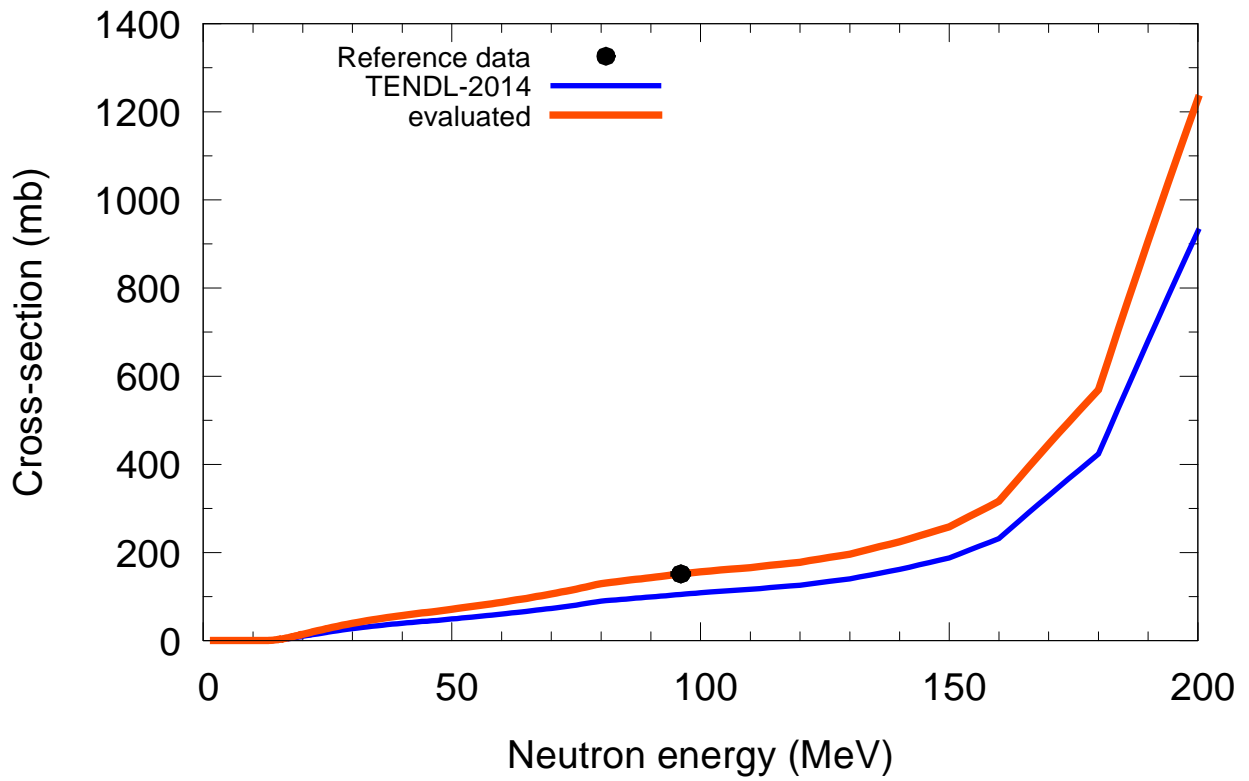
$^{175}\text{Lu}(n,x)d$



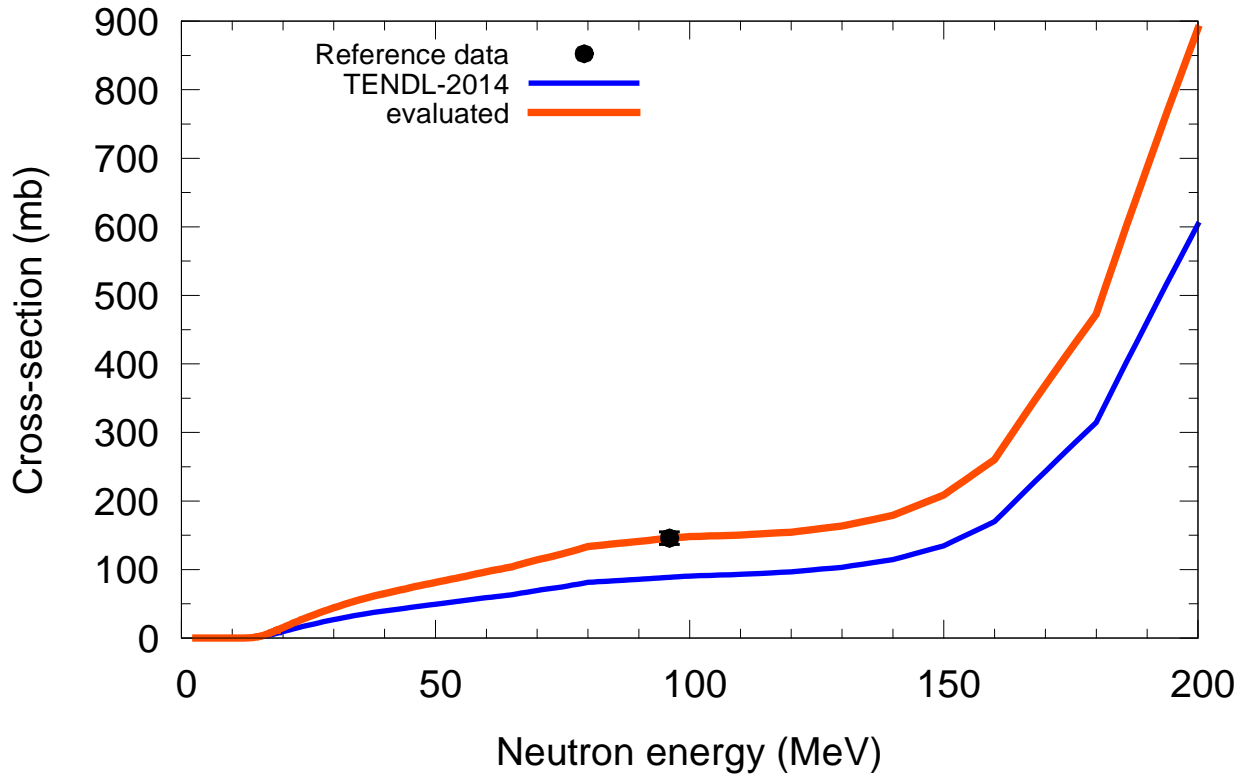
$^{176}\text{Lu}(n,x)d$



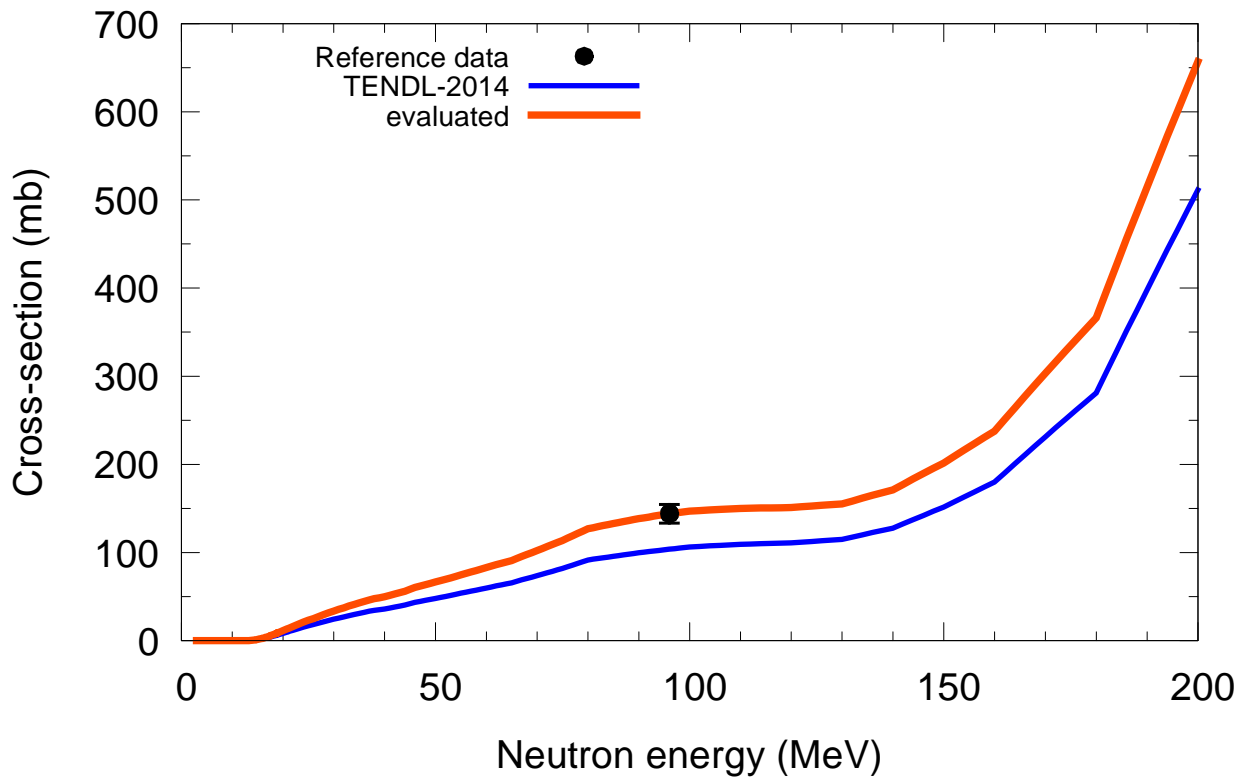
$^{174}\text{Hf}(n,x)d$



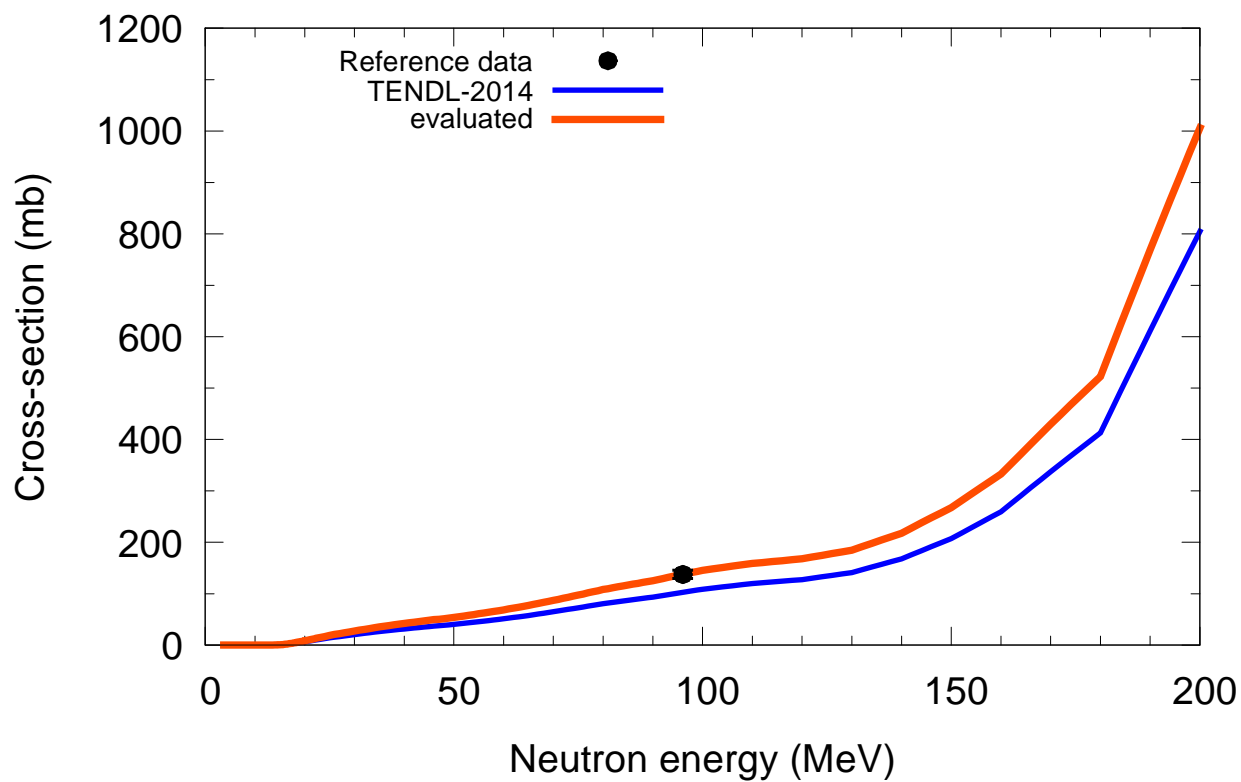
$^{176}\text{Hf}(n,x)d$



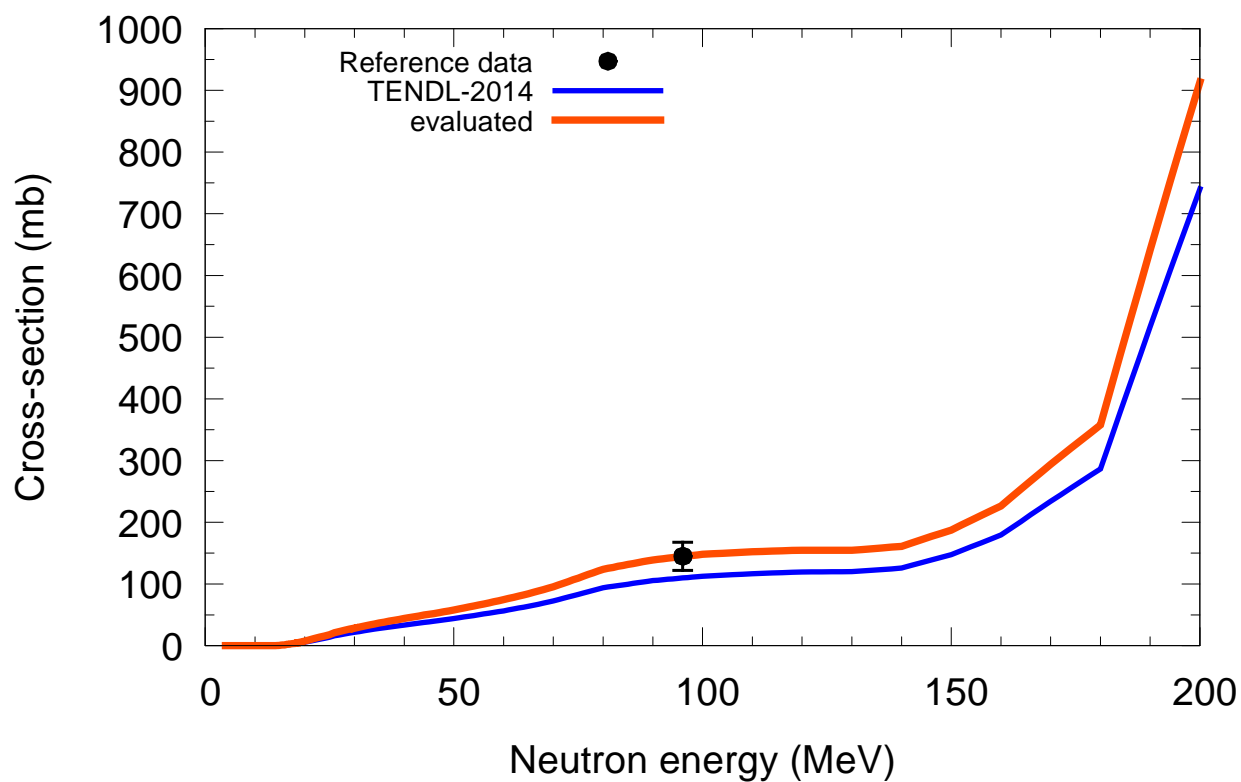
$^{177}\text{Hf}(n,x)d$



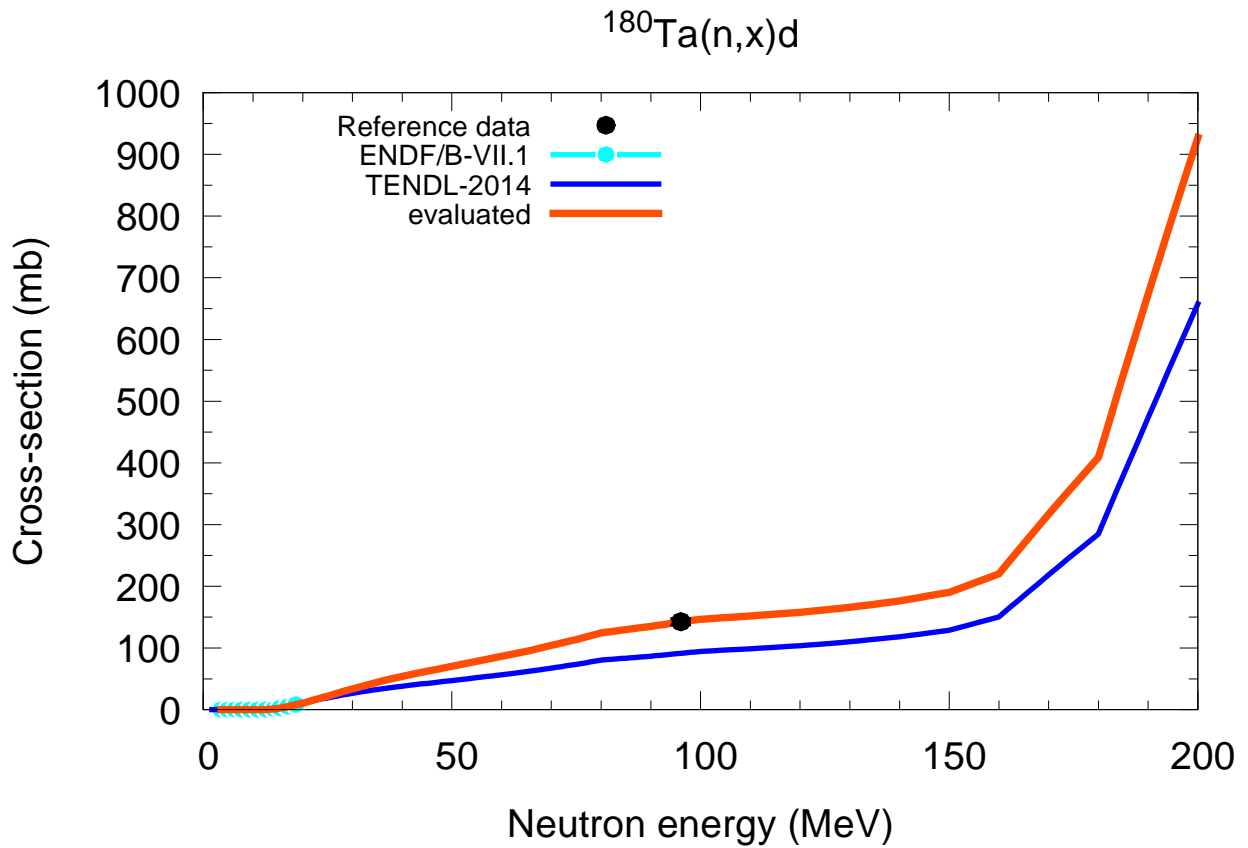
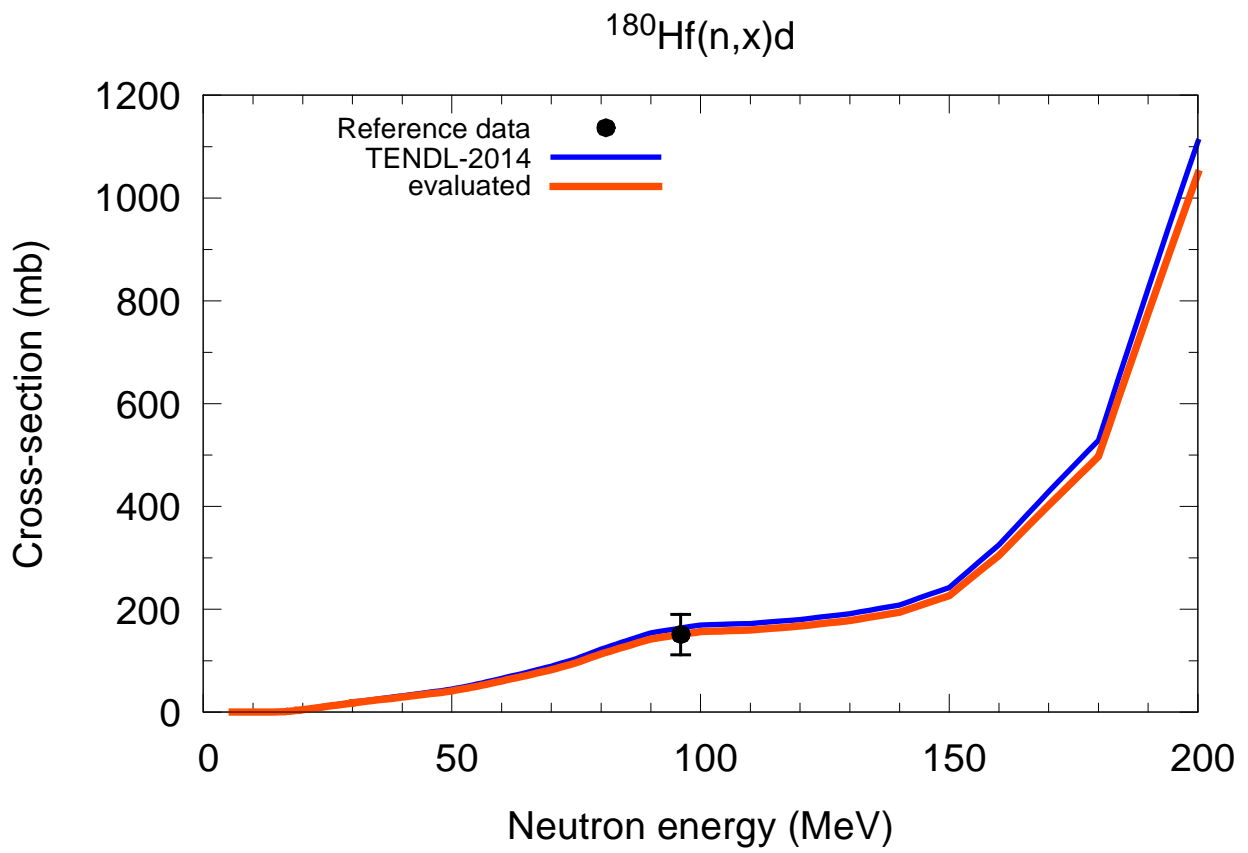
$^{178}\text{Hf}(n,x)d$



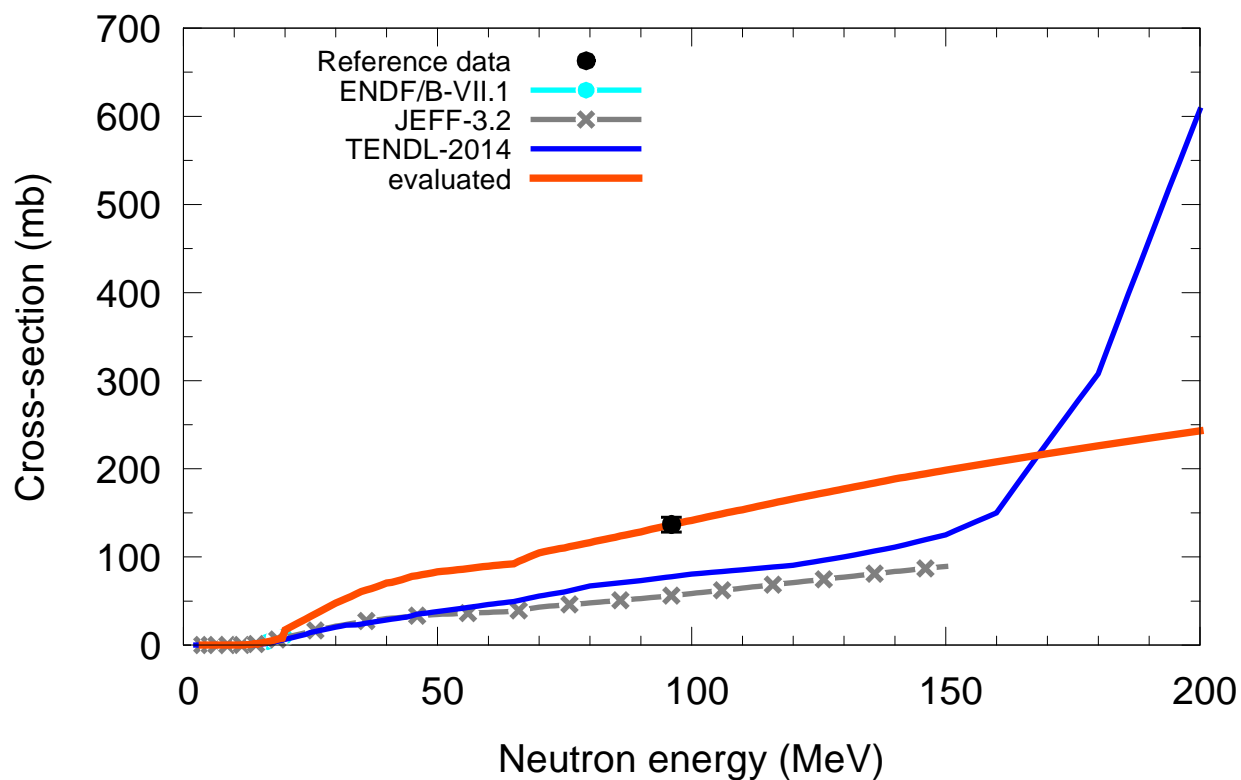
$^{179}\text{Hf}(n,x)d$



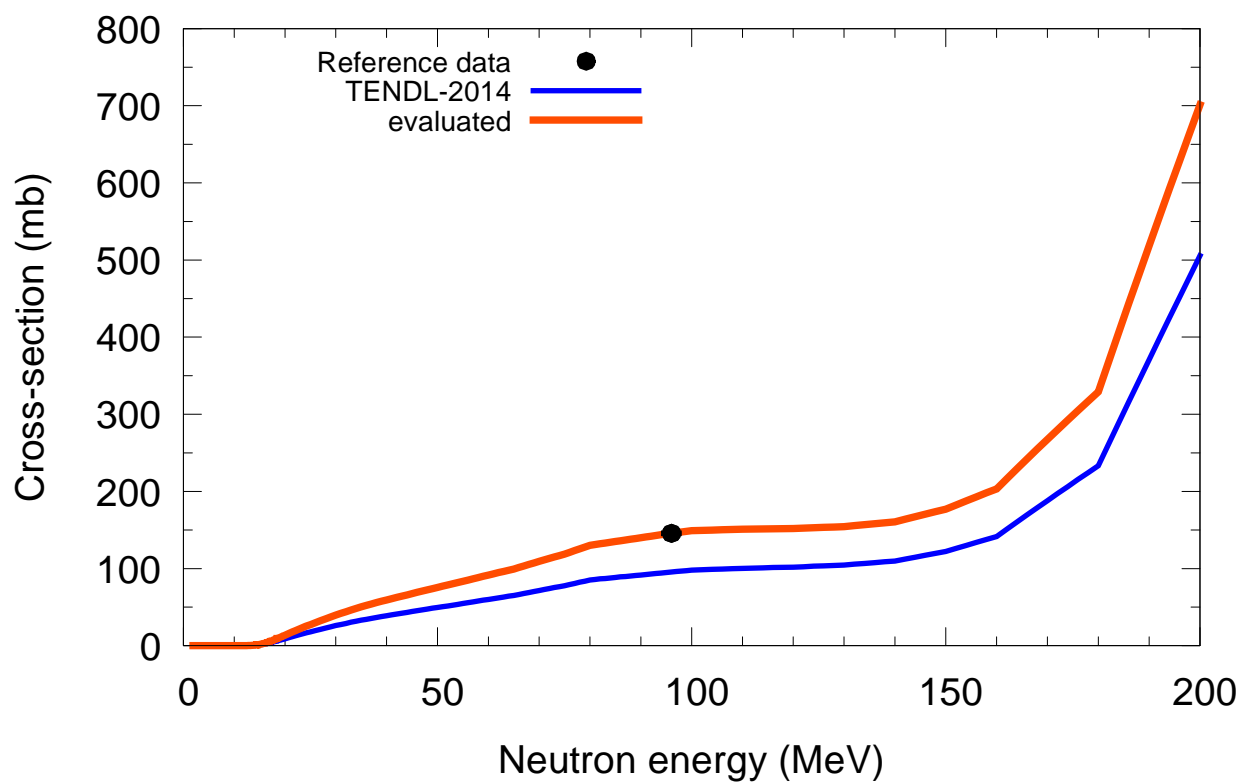




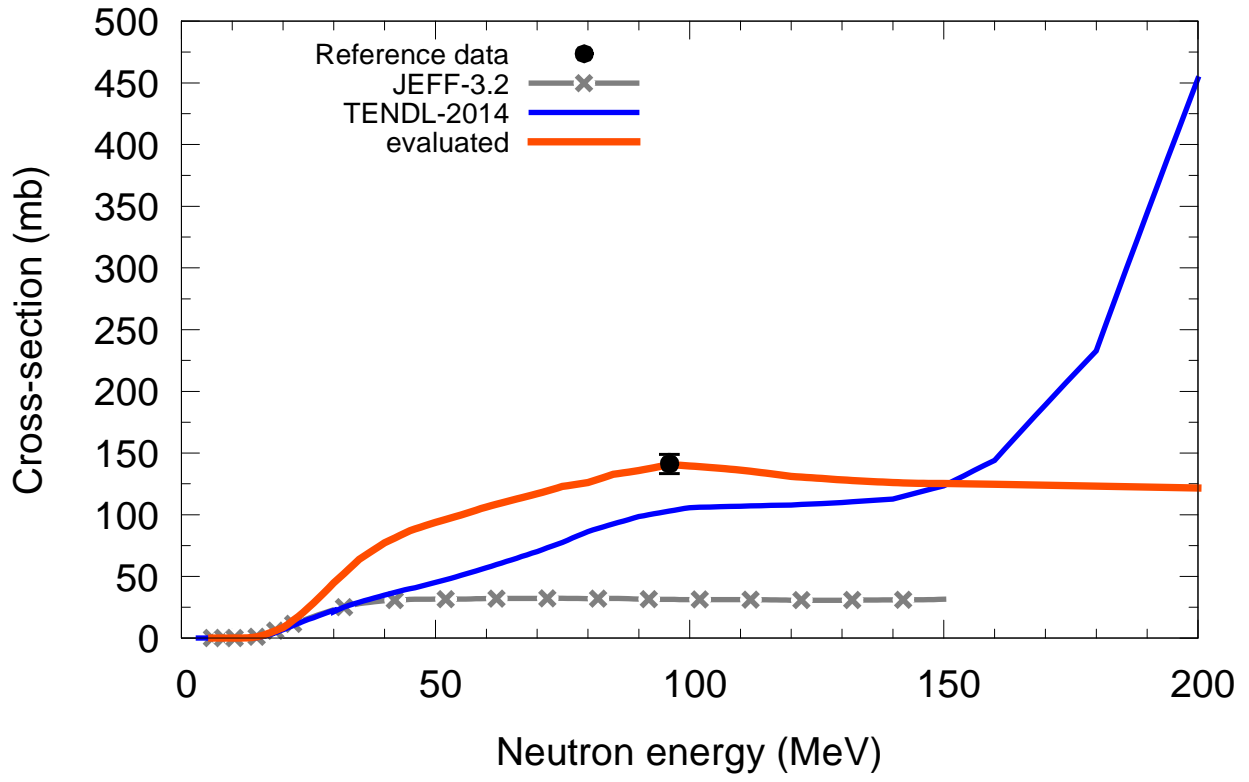
$^{181}\text{Ta}(n,x)d$



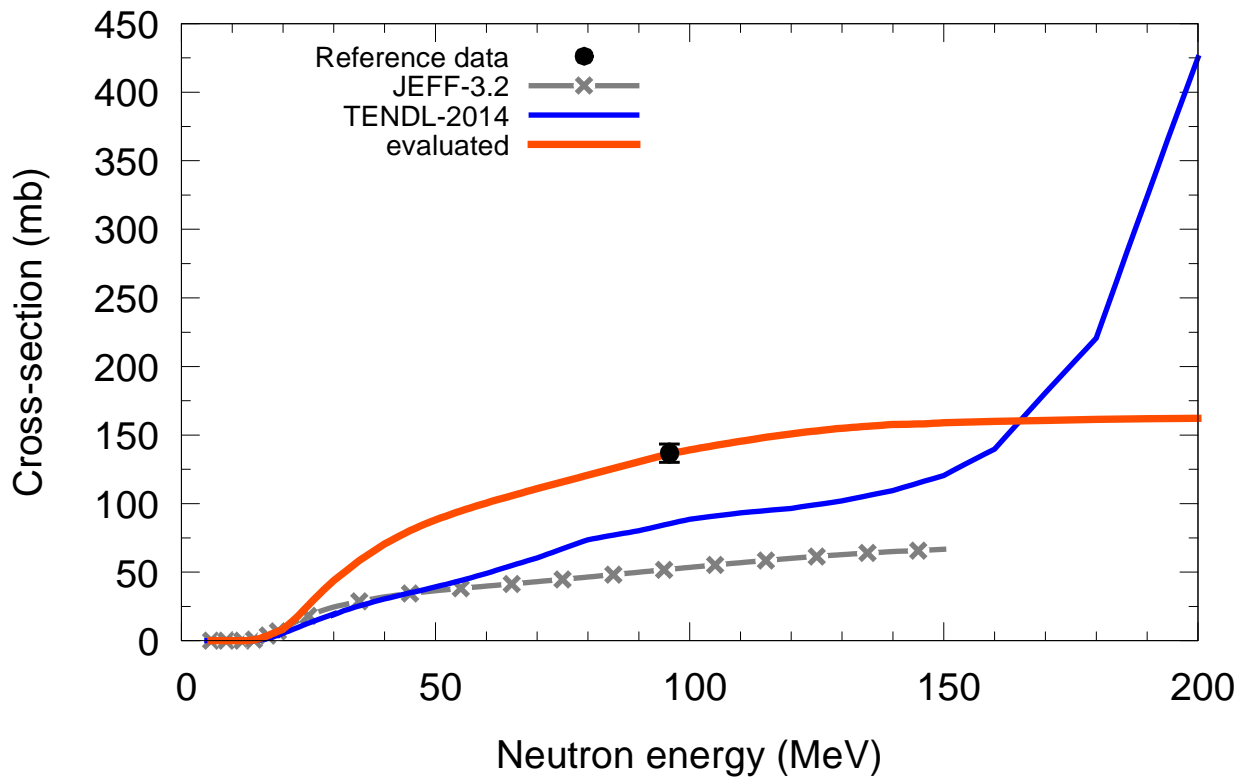
$^{180}\text{W}(n,x)d$



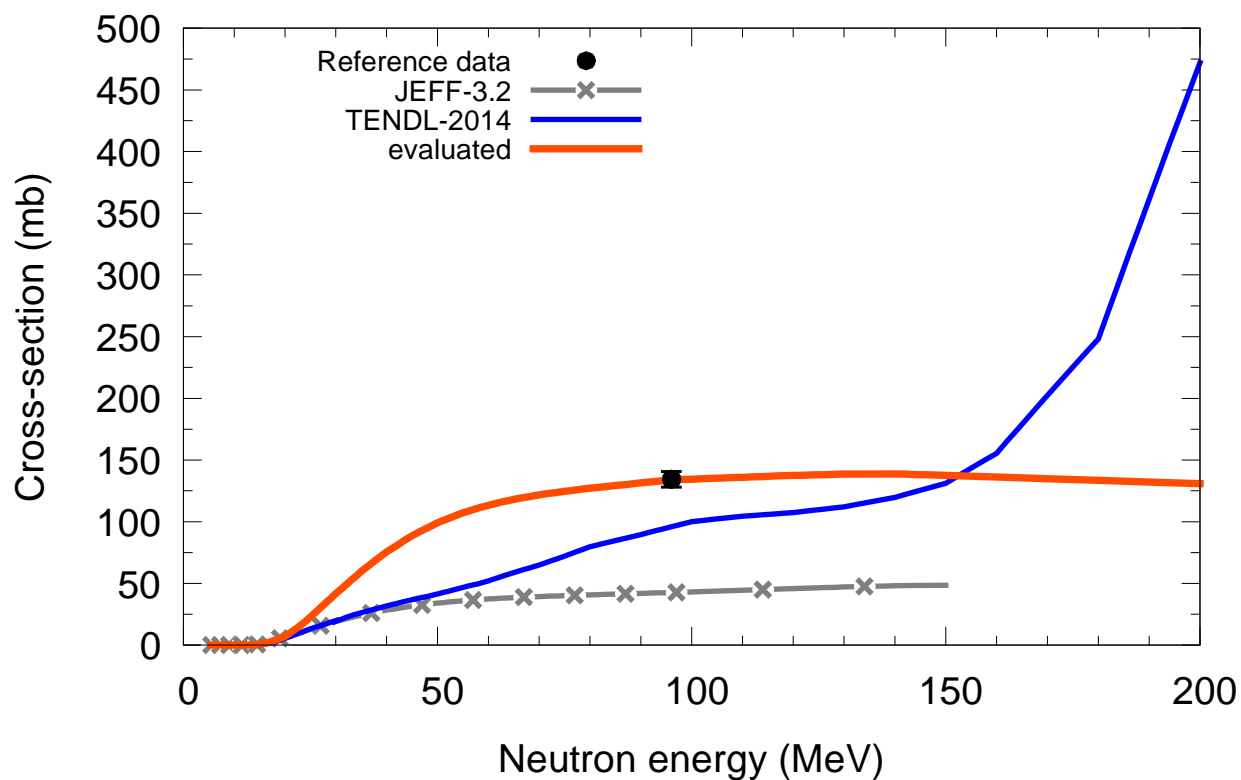
$^{182}\text{W}(n,x)d$



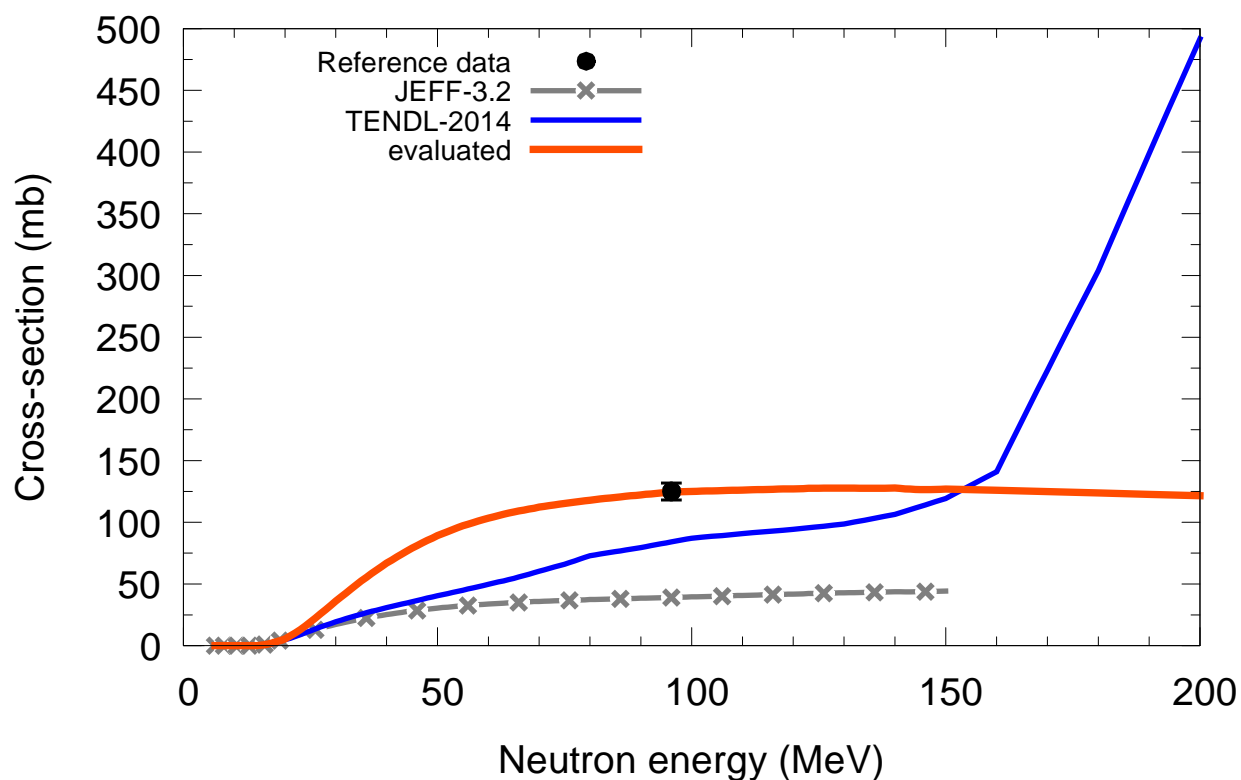
$^{183}\text{W}(n,x)d$



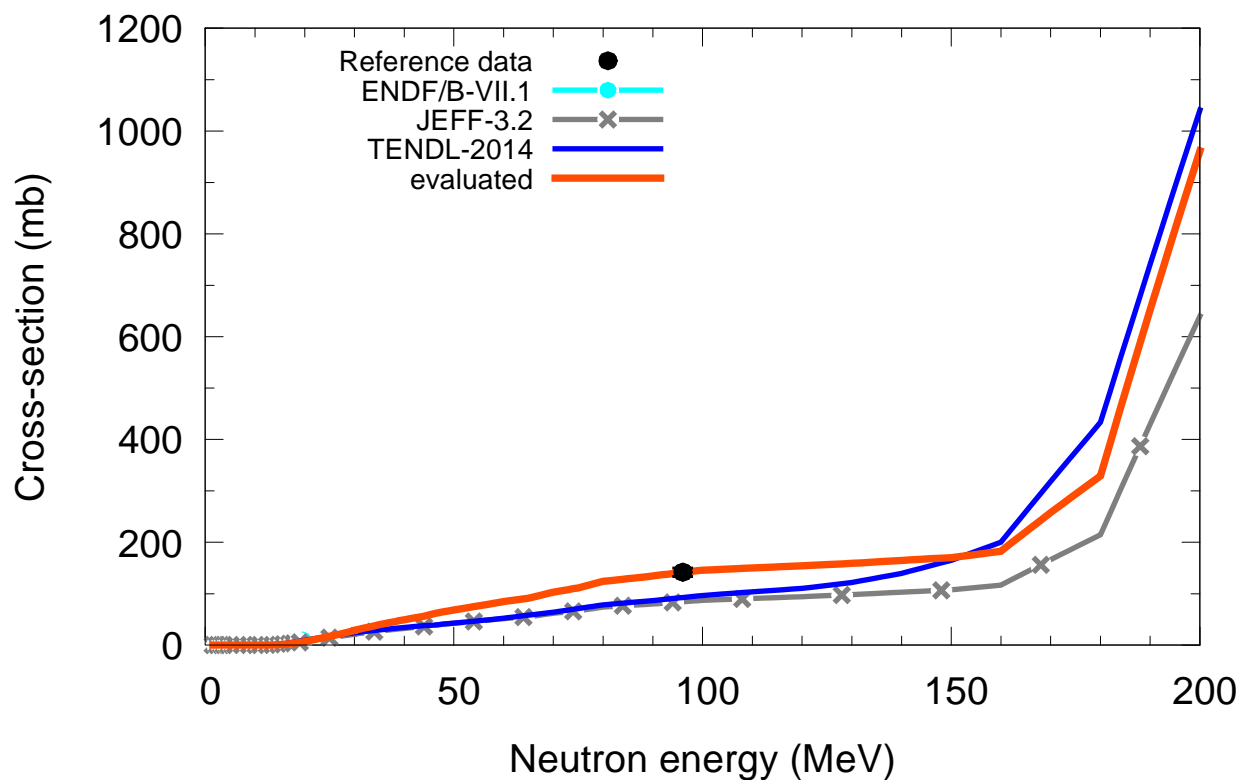
$^{184}\text{W}(n,x)d$



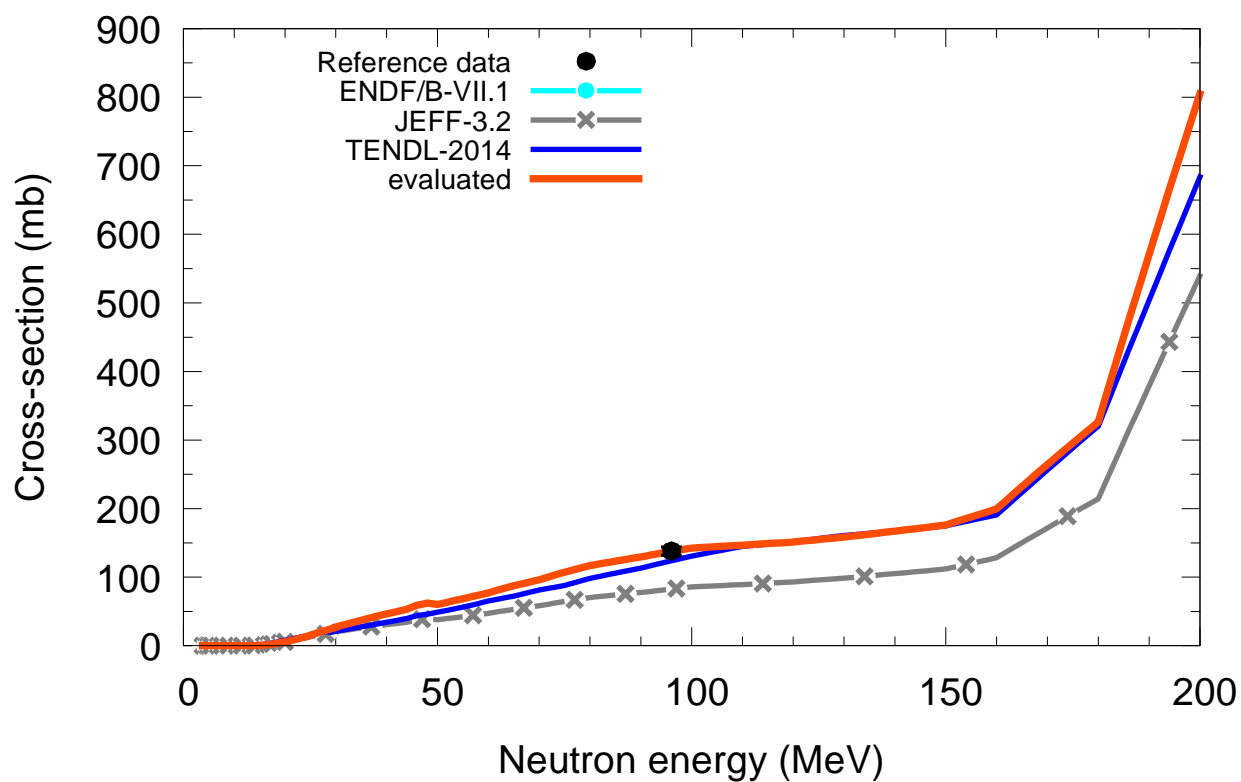
$^{186}\text{W}(n,x)d$



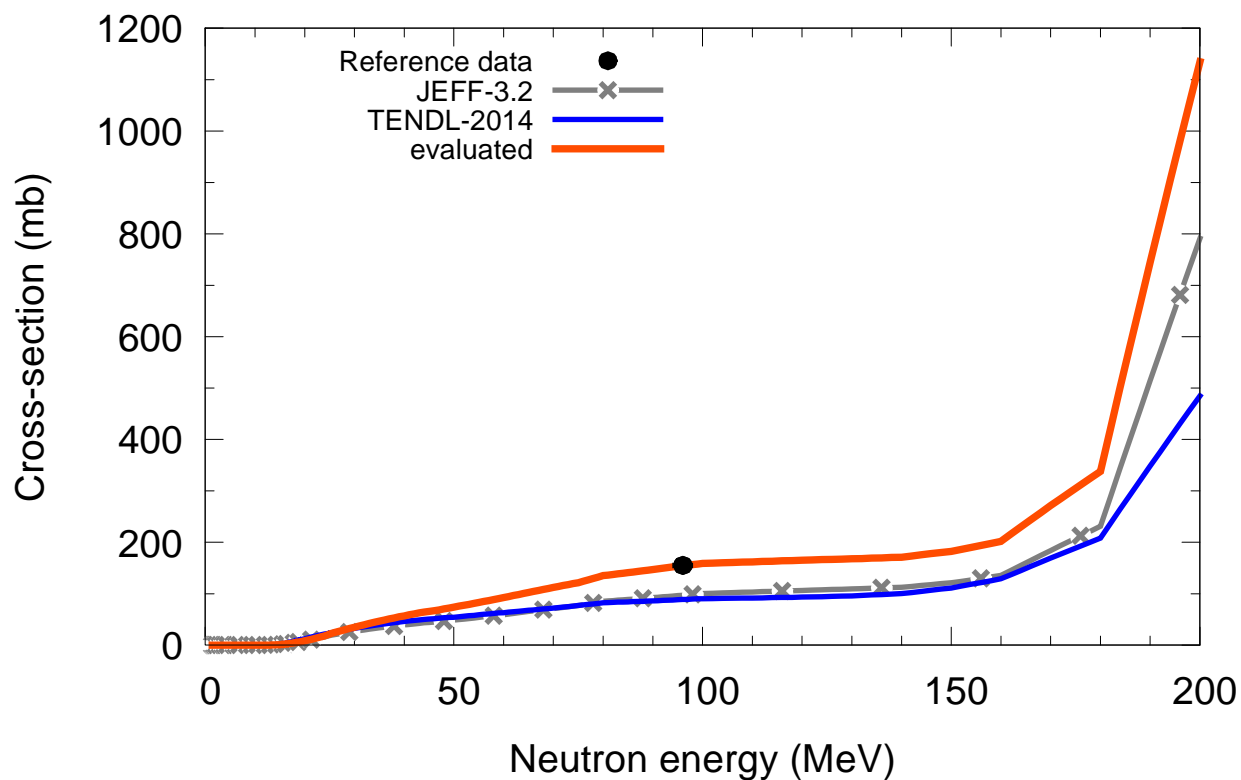
$^{185}\text{Re}(n,x)d$



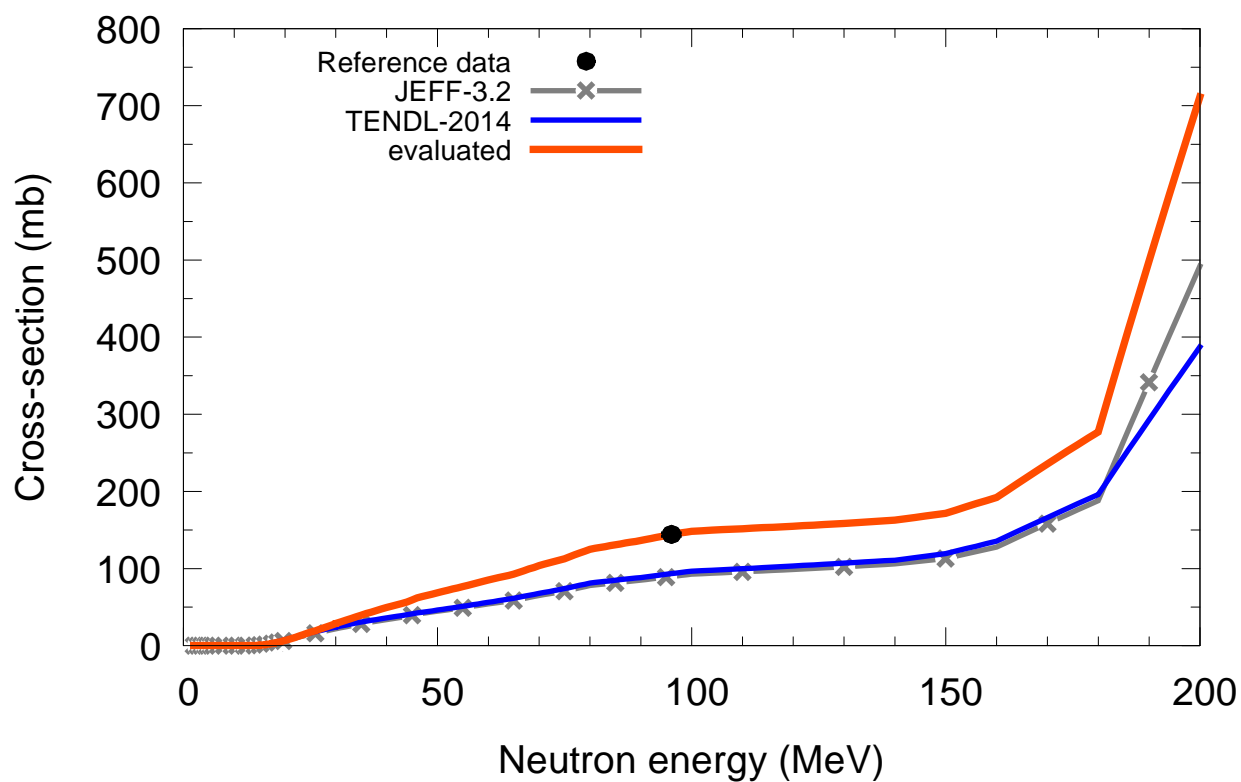
$^{187}\text{Re}(n,x)d$

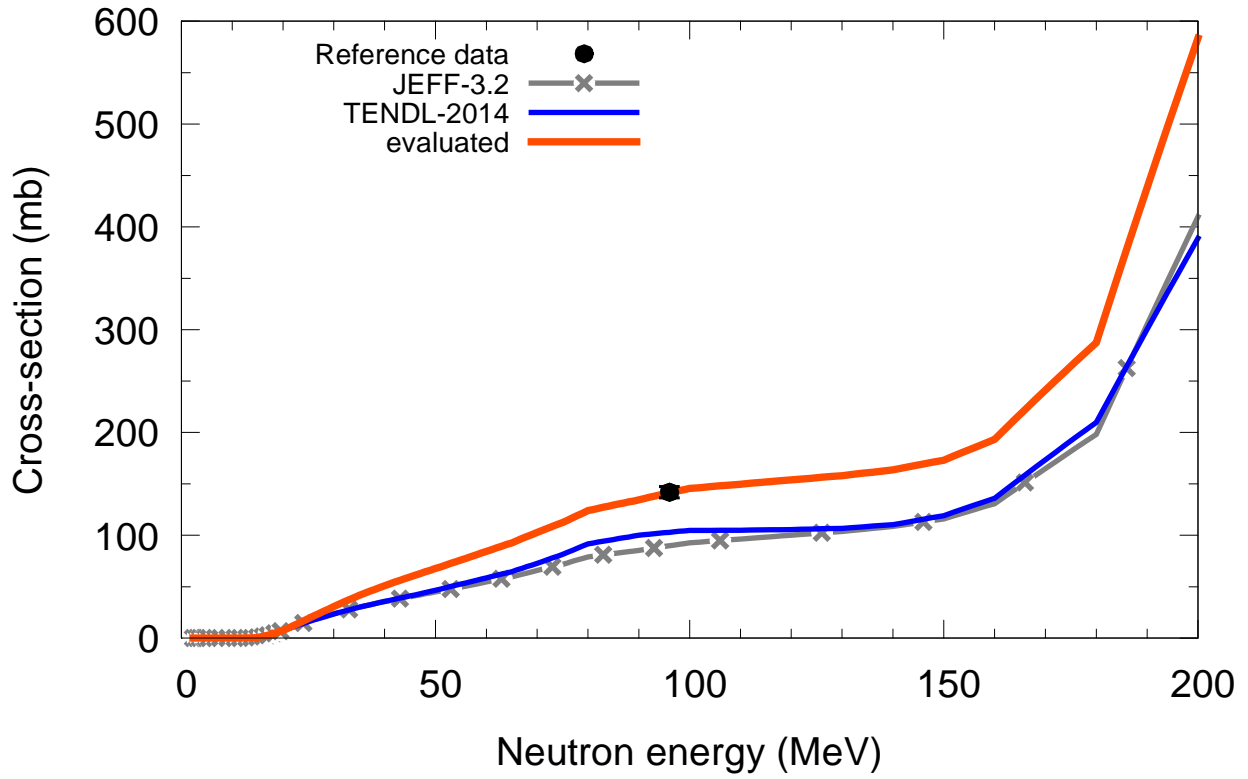
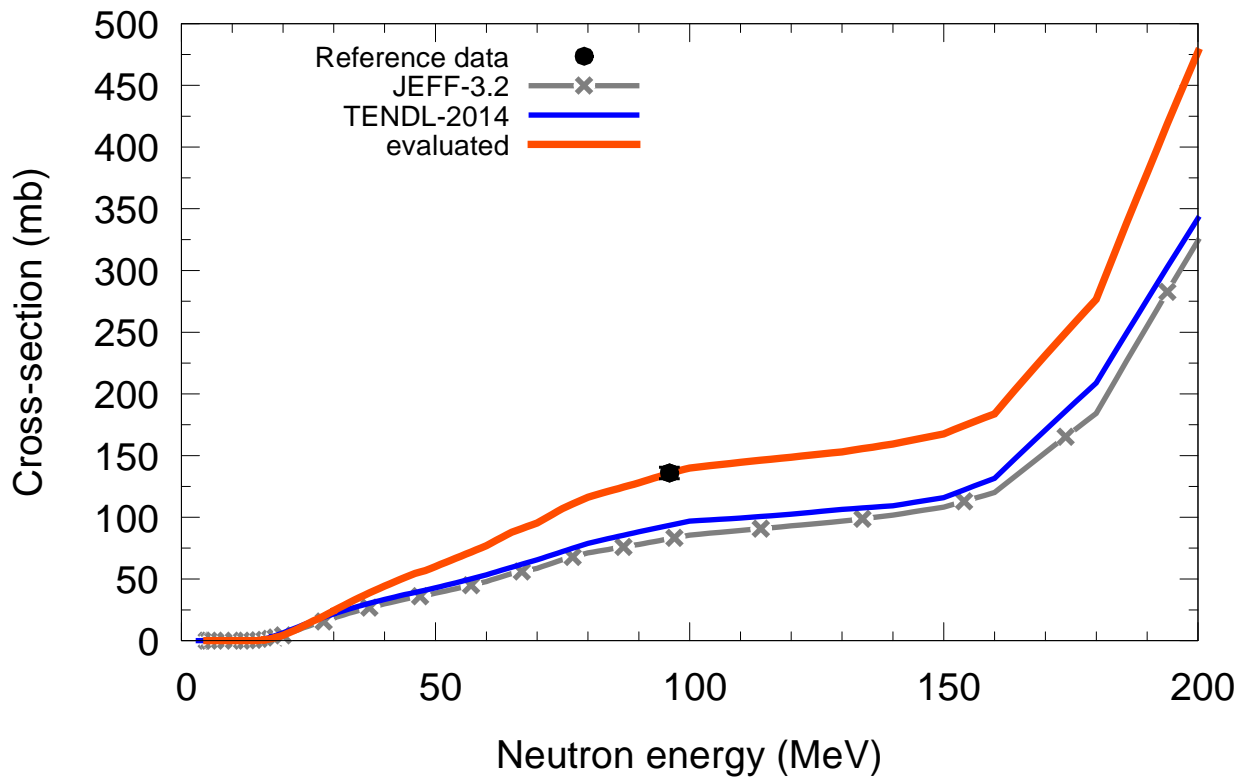


$^{184}\text{Os}(n,x)d$

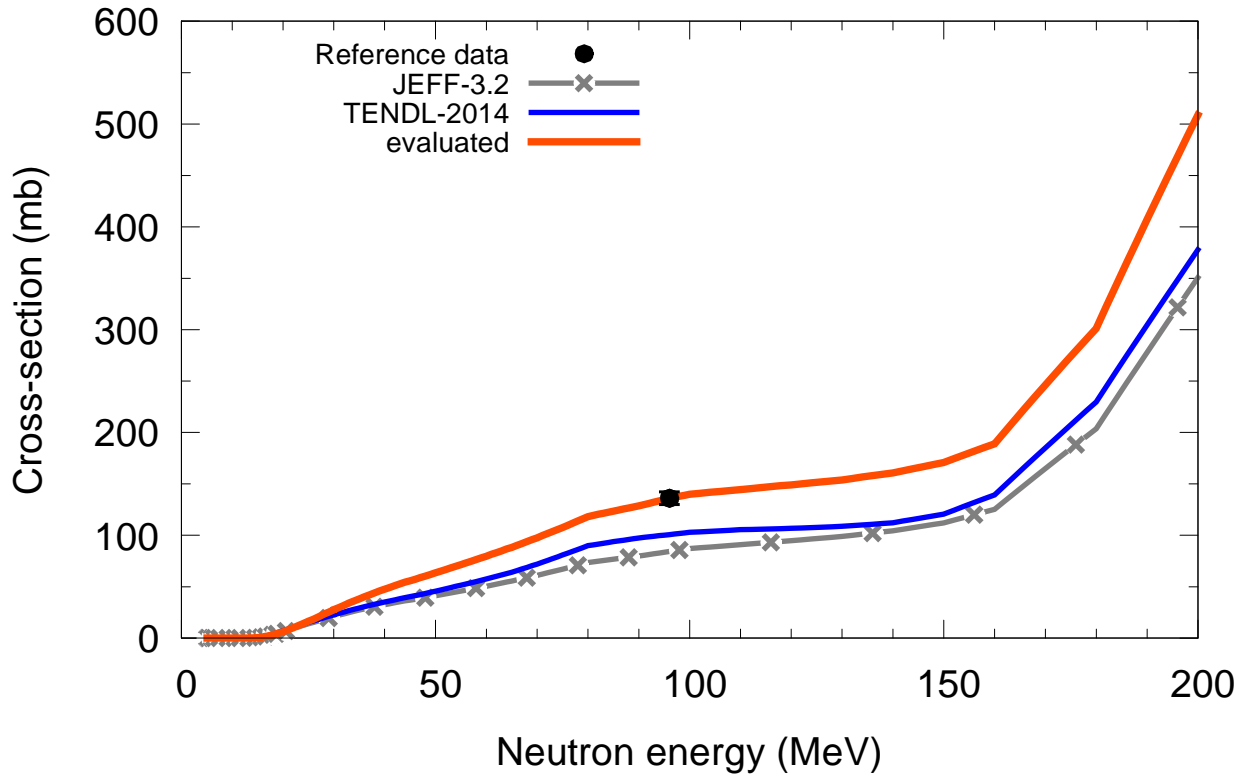


$^{186}\text{Os}(n,x)d$

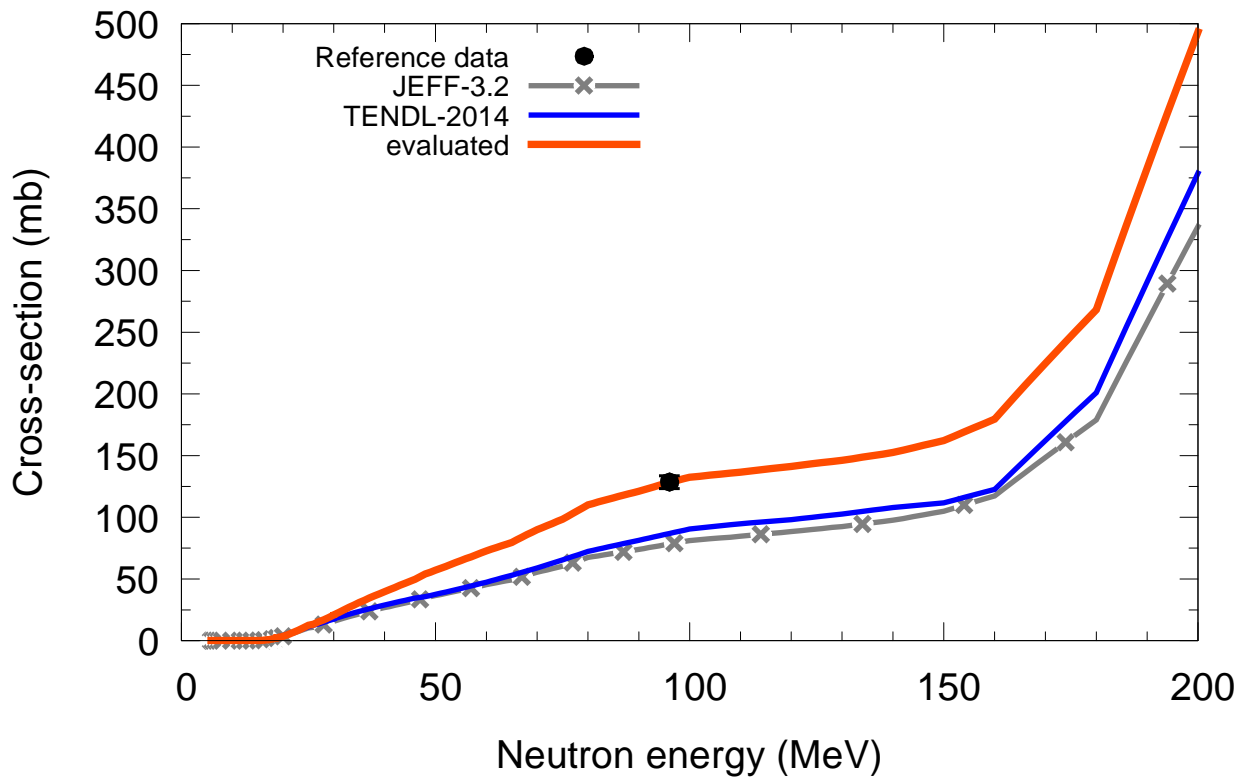


$^{187}\text{Os}(n,x)d$  $^{188}\text{Os}(n,x)d$ 

$^{189}\text{Os}(n,x)d$

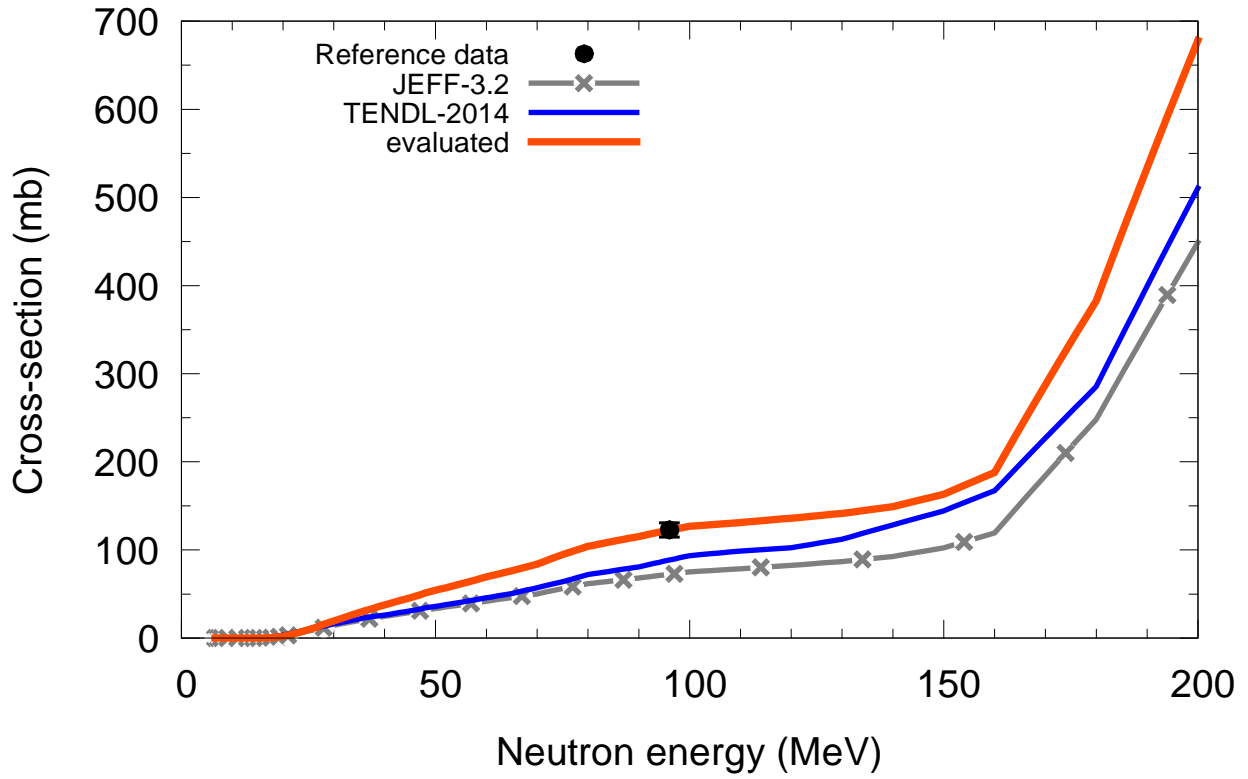


$^{190}\text{Os}(n,x)d$

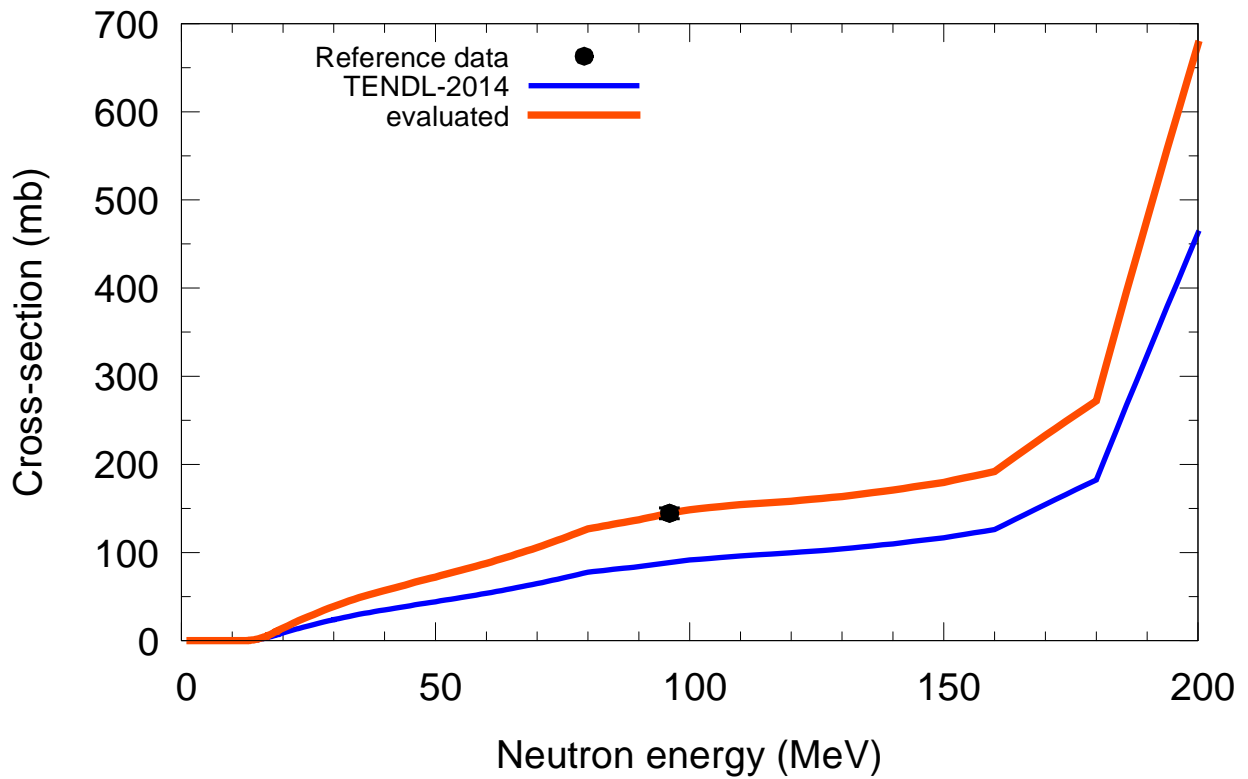




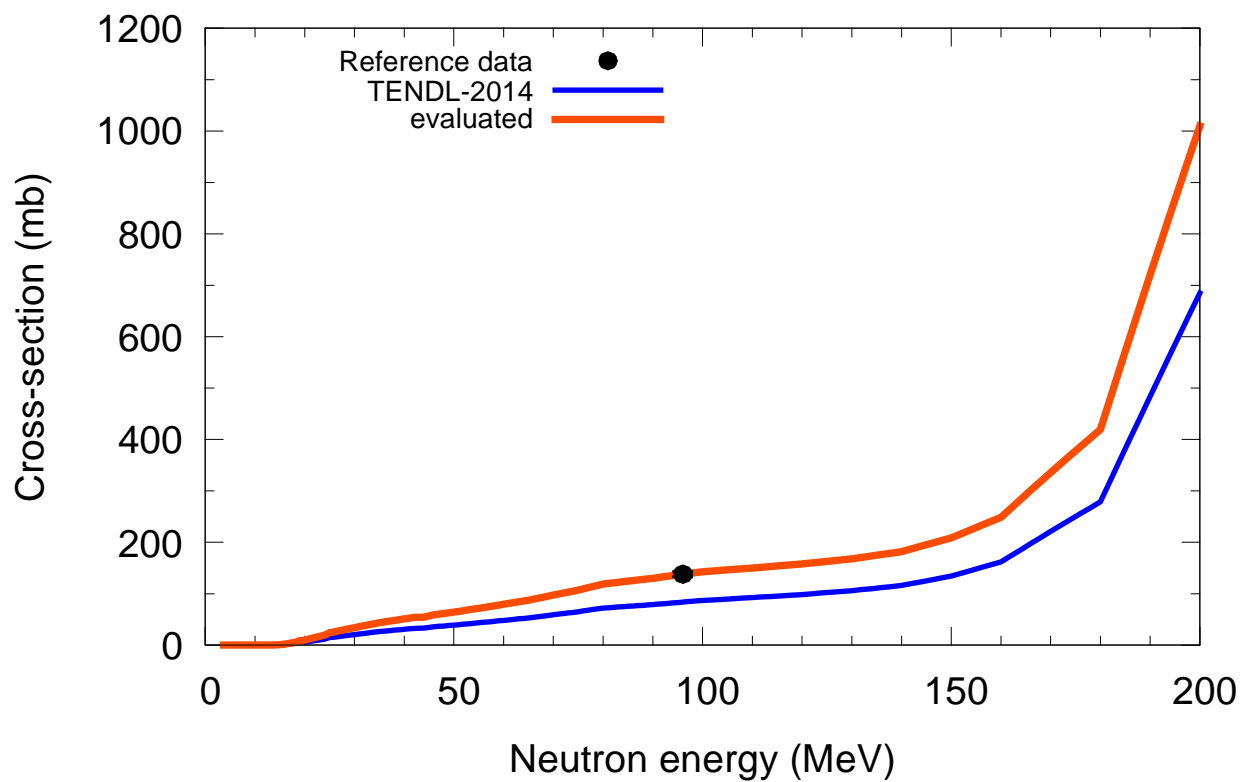
$^{192}\text{Os}(n,x)d$



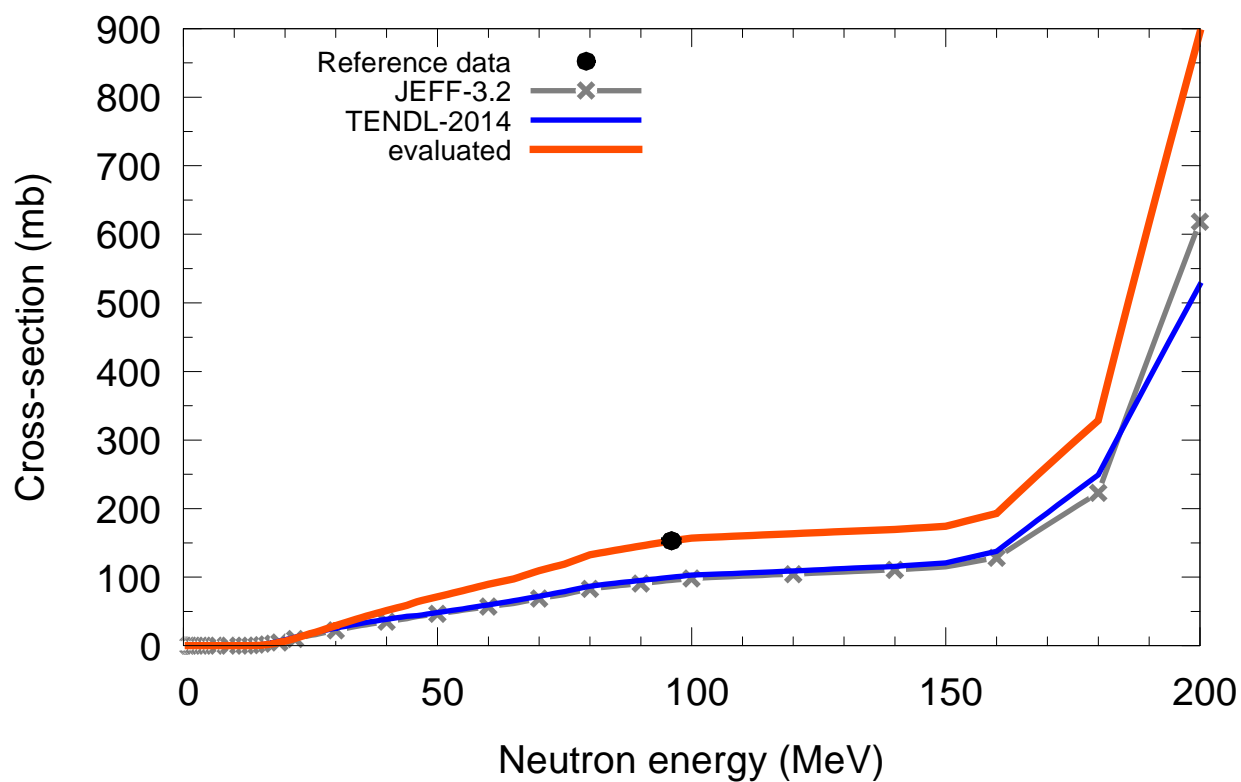
$^{191}\text{Ir}(n,x)d$



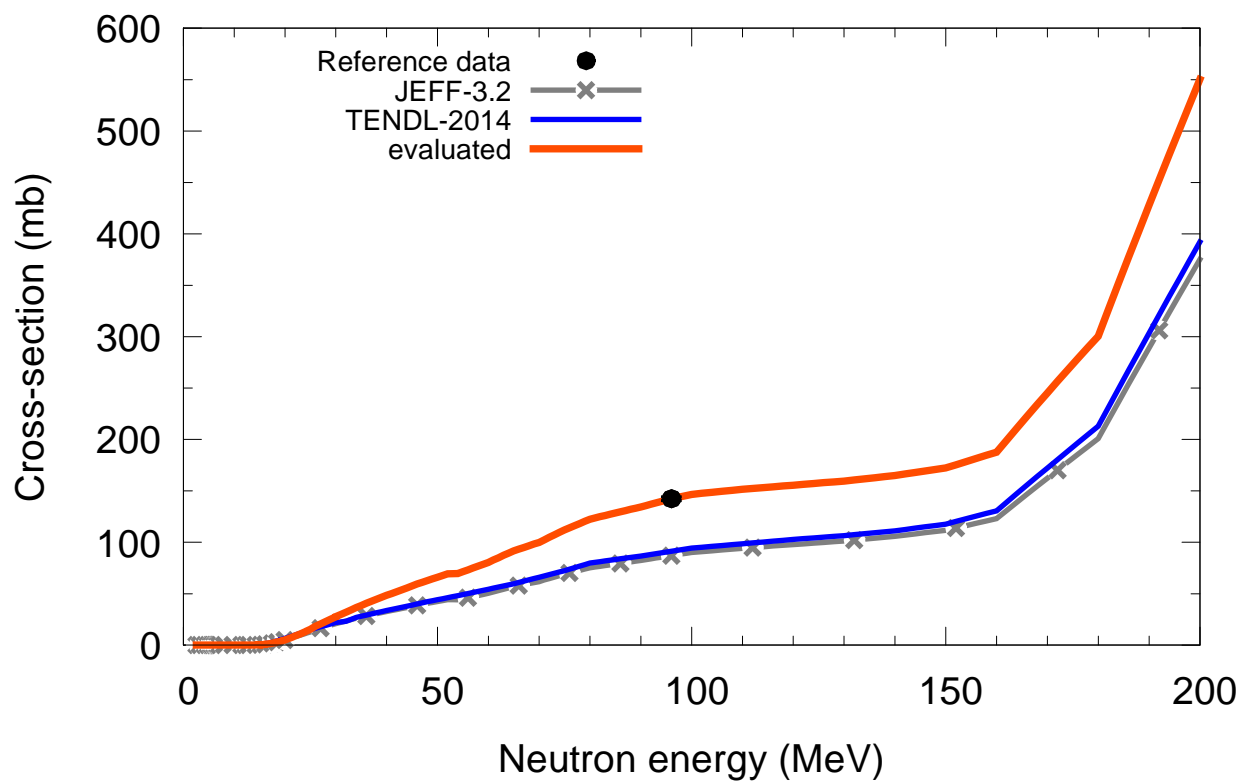
$^{193}\text{Ir}(n,x)d$



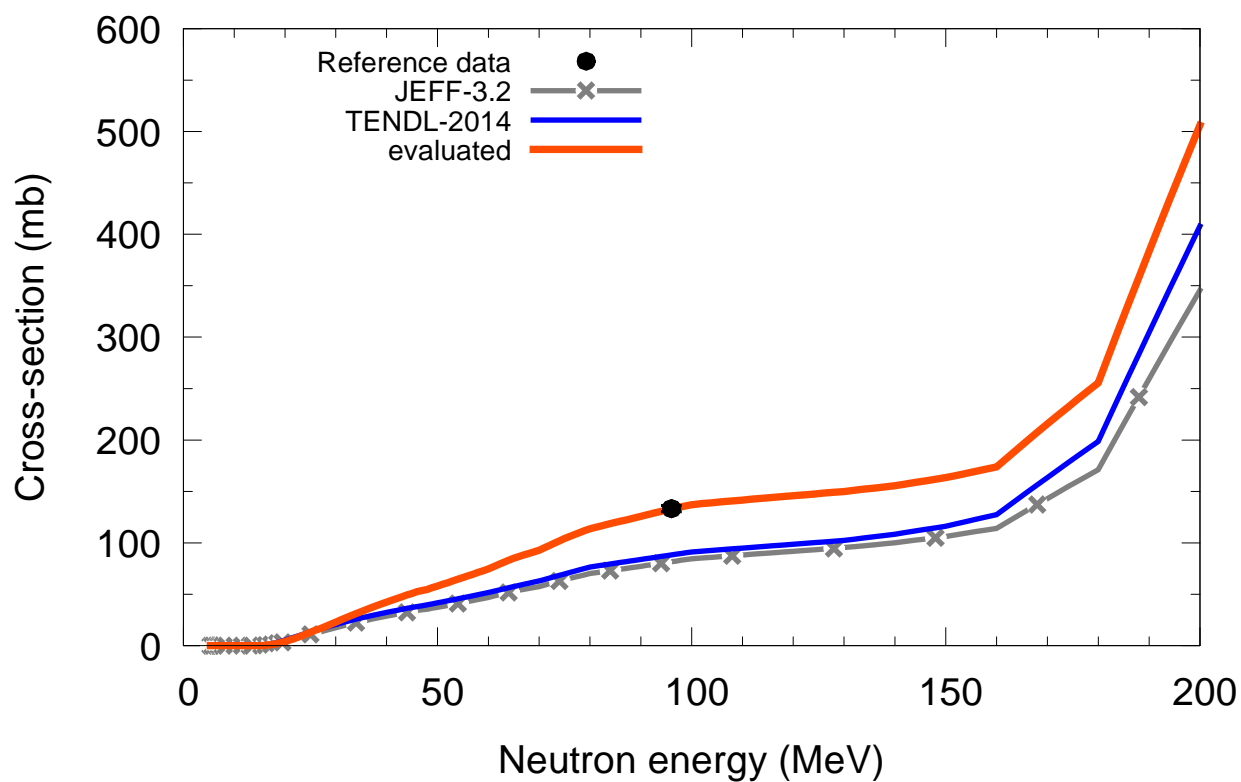
$^{190}\text{Pt}(n,x)d$



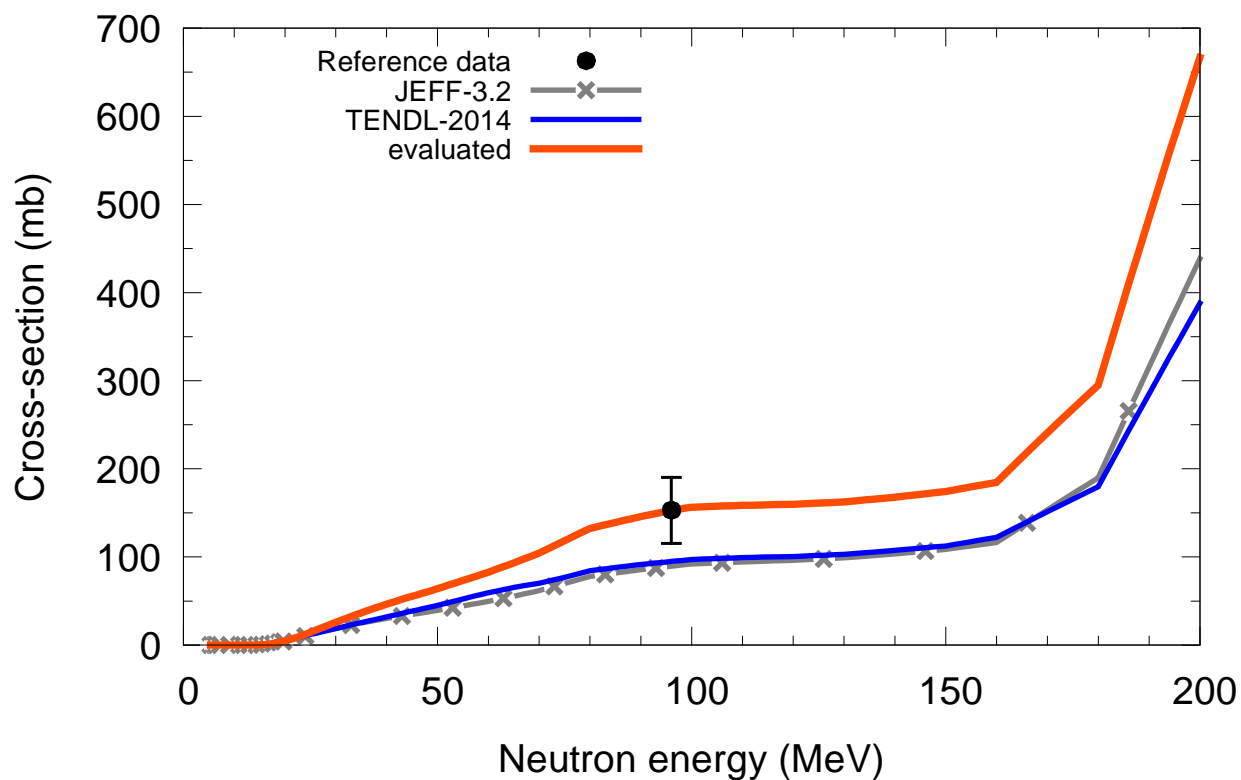
$^{192}\text{Pt}(n,x)d$



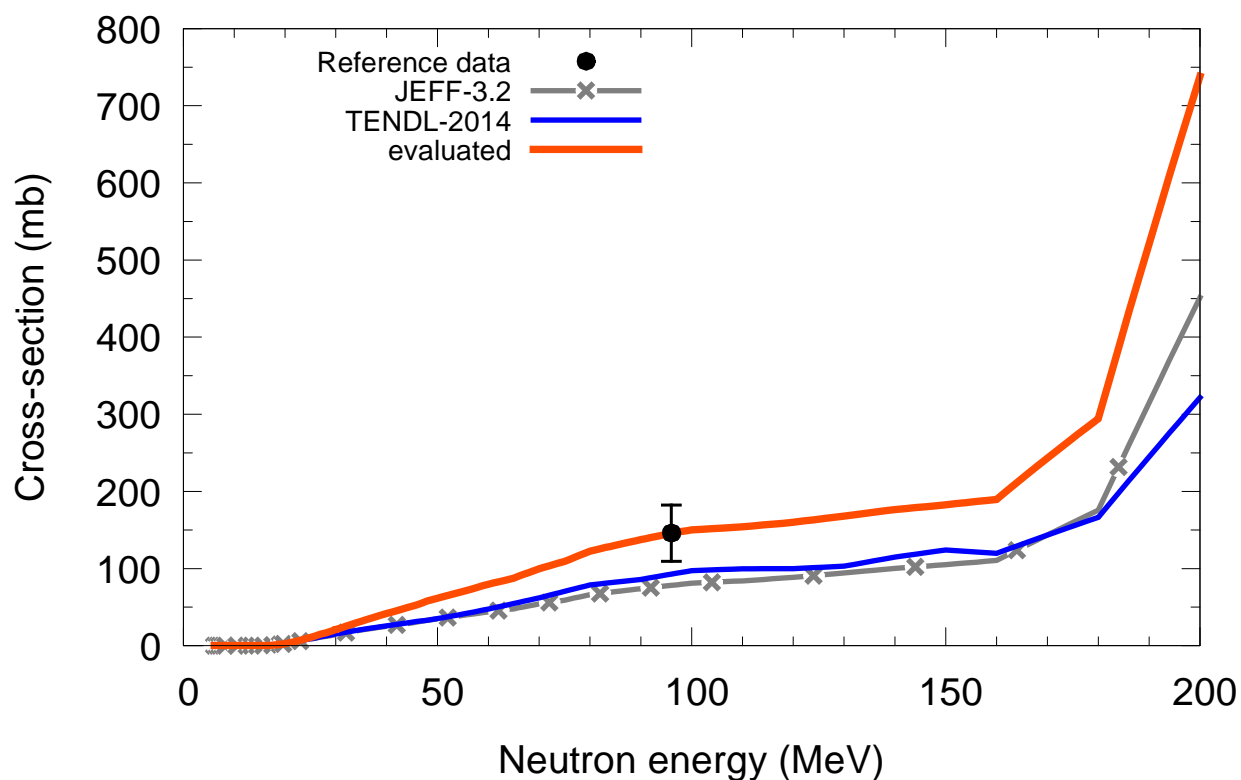
$^{194}\text{Pt}(n,x)d$



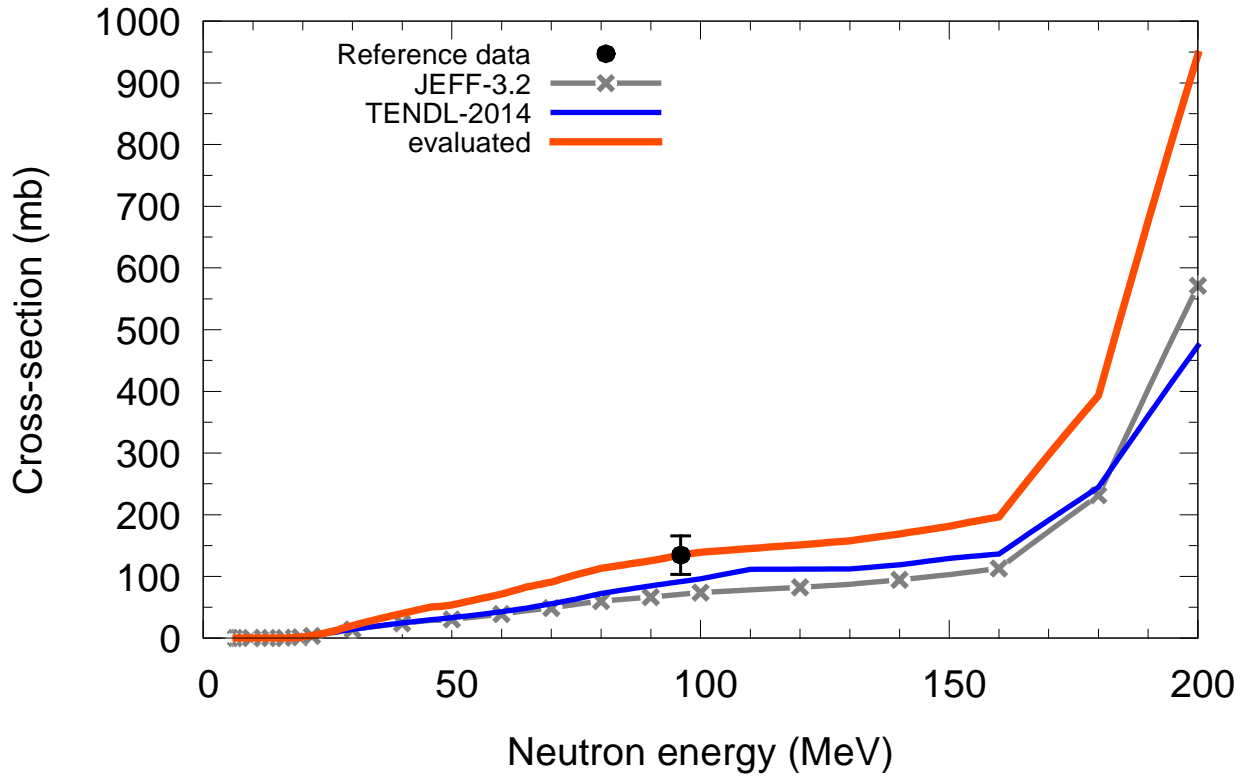
### $^{195}\text{Pt}(n,x)d$



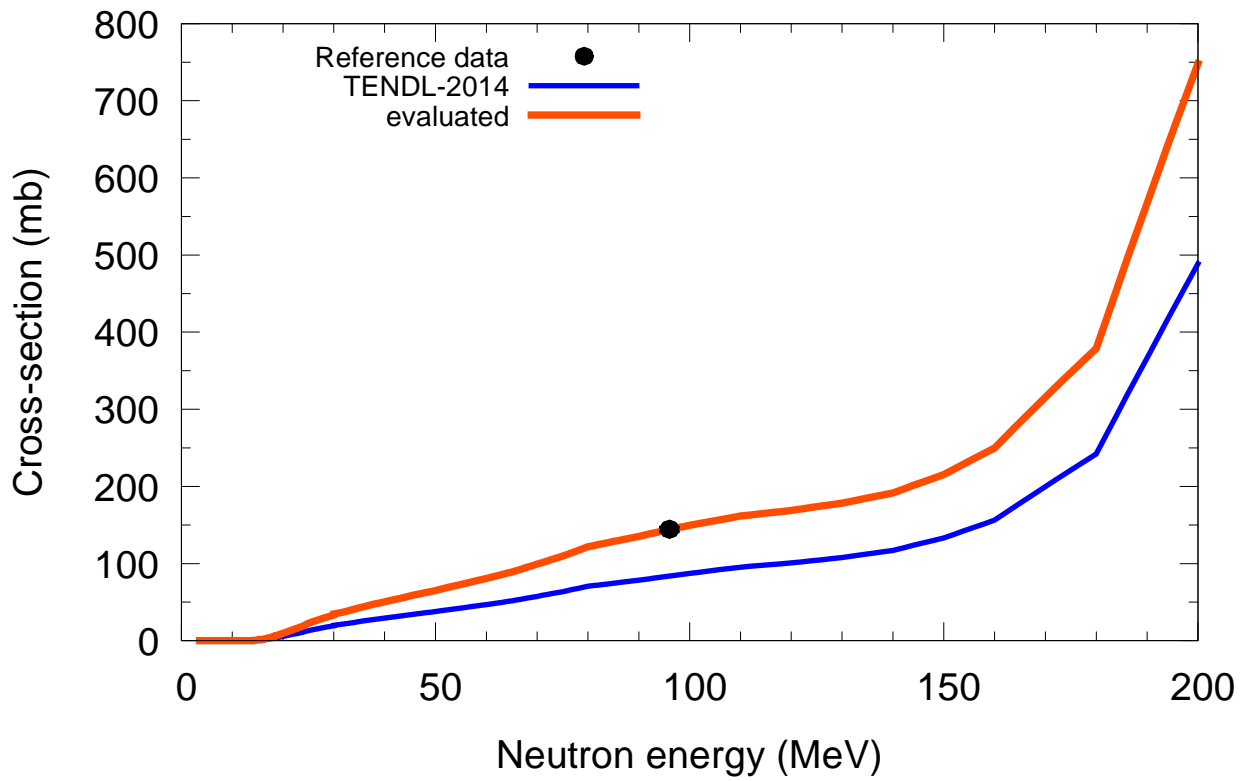
### $^{196}\text{Pt}(n,x)d$



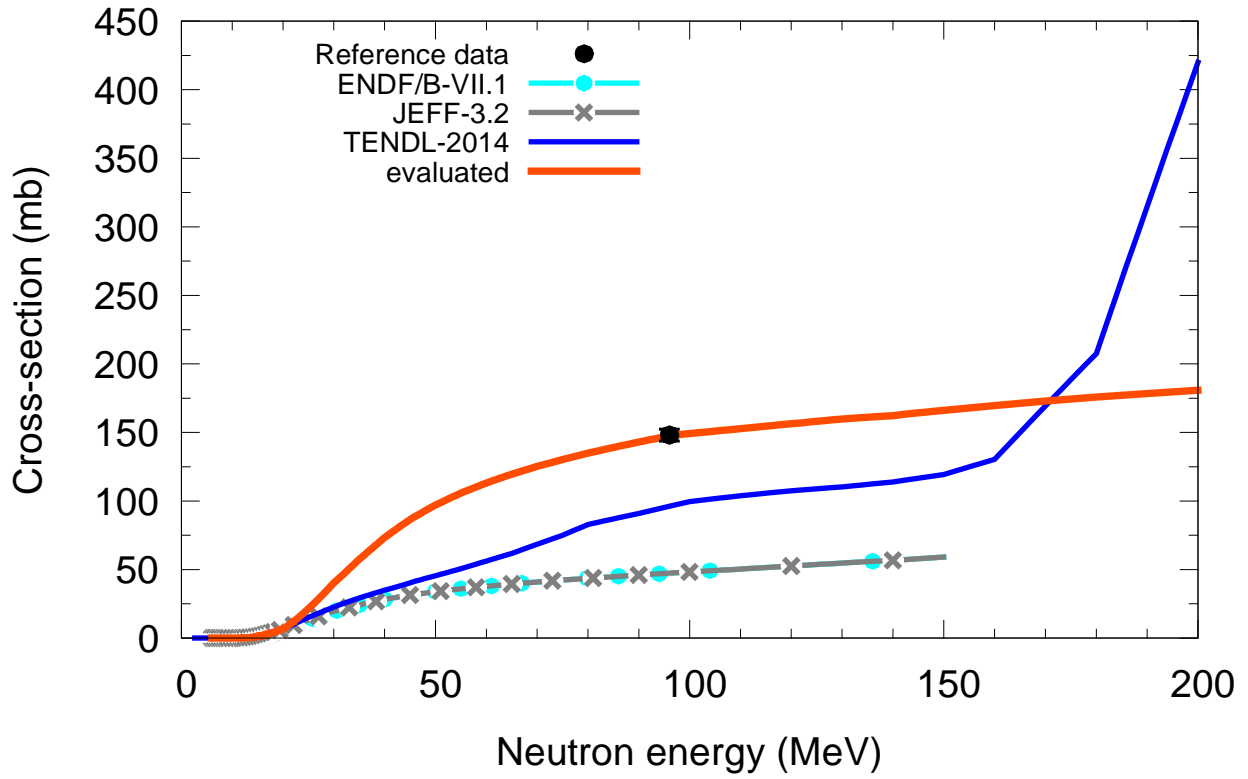
$^{198}\text{Pt}(n,x)d$



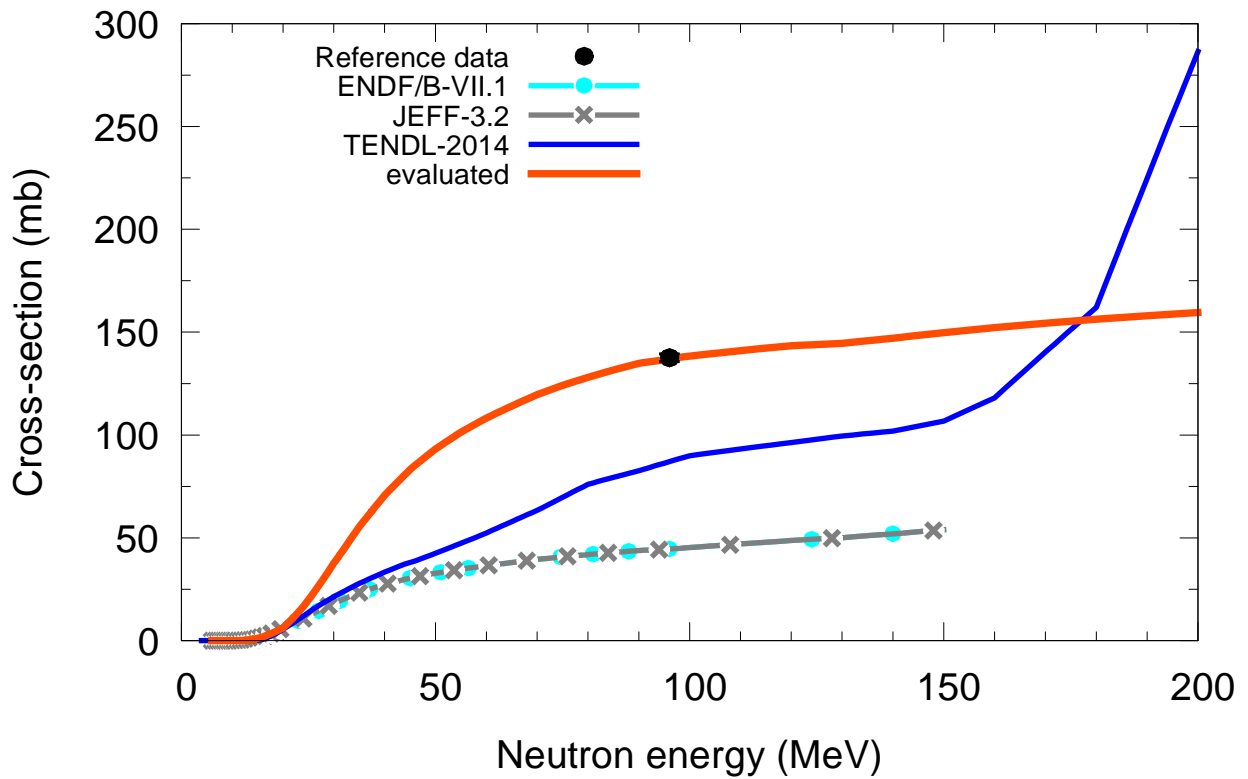
$^{197}\text{Au}(n,x)d$



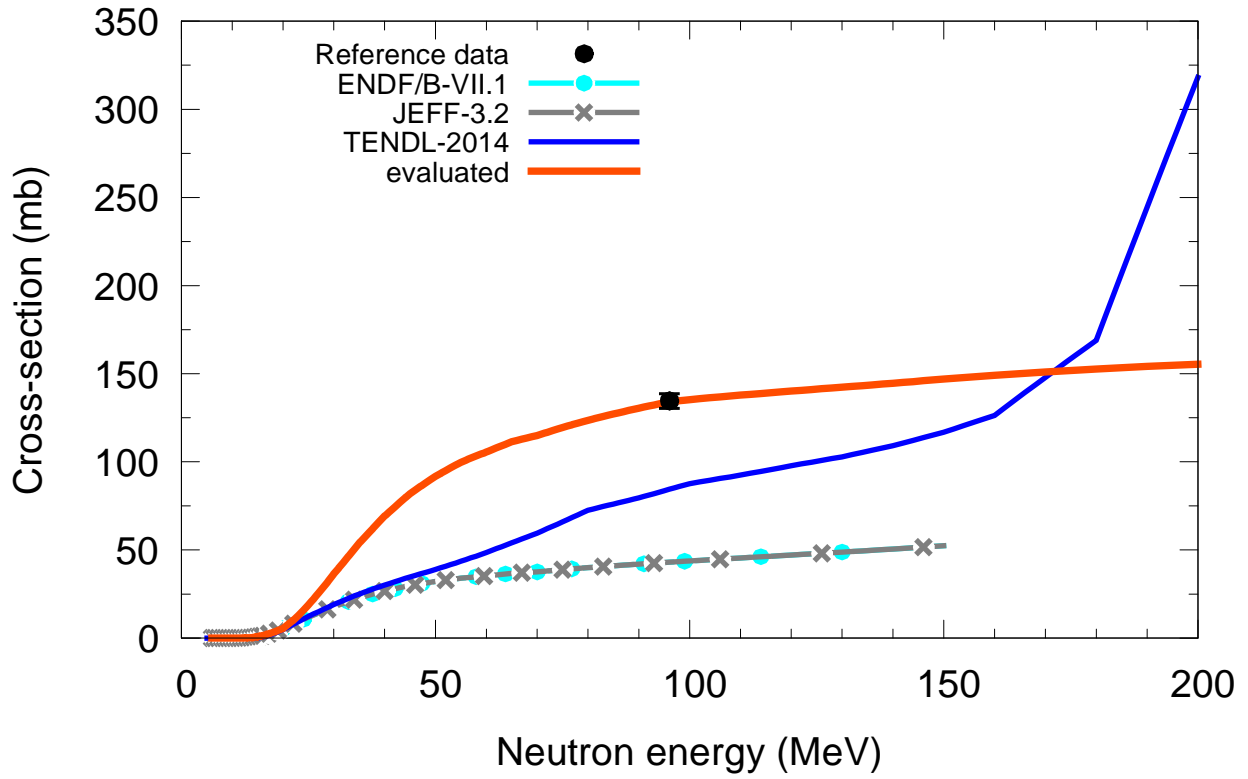
$^{196}\text{Hg}(n,x)d$



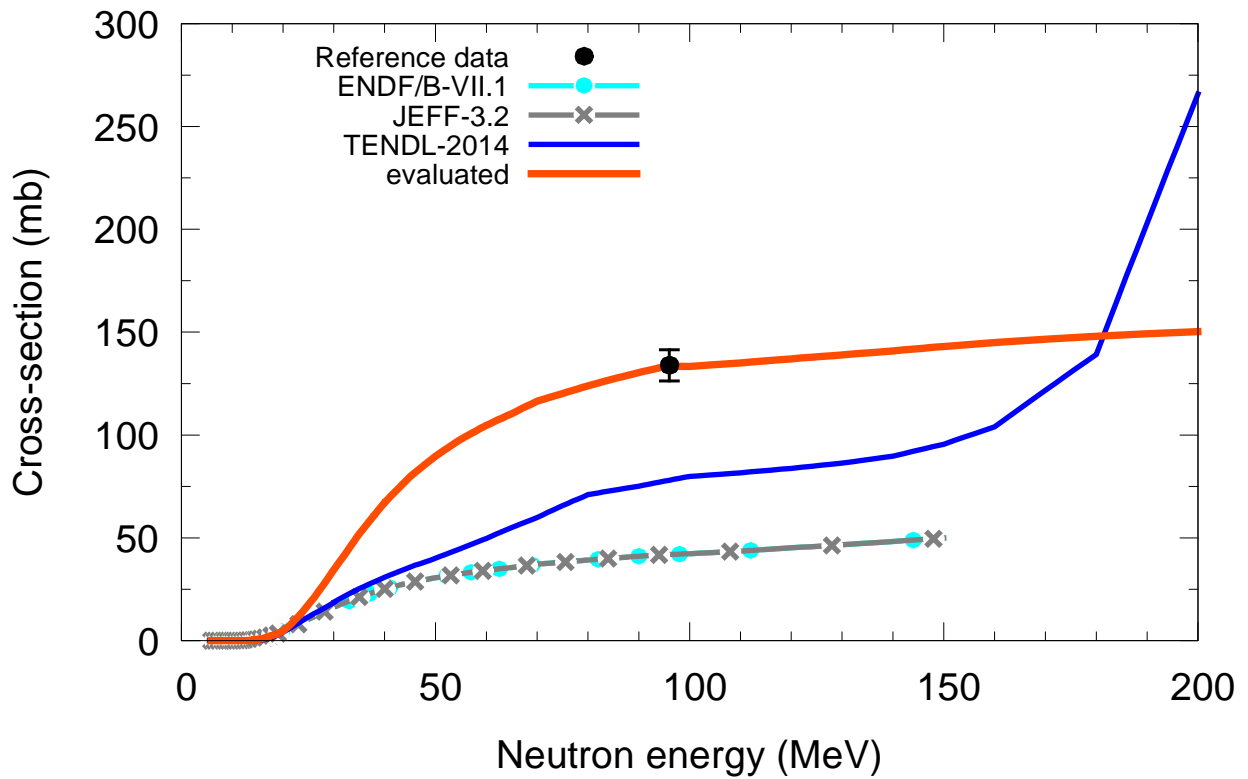
$^{198}\text{Hg}(n,x)d$



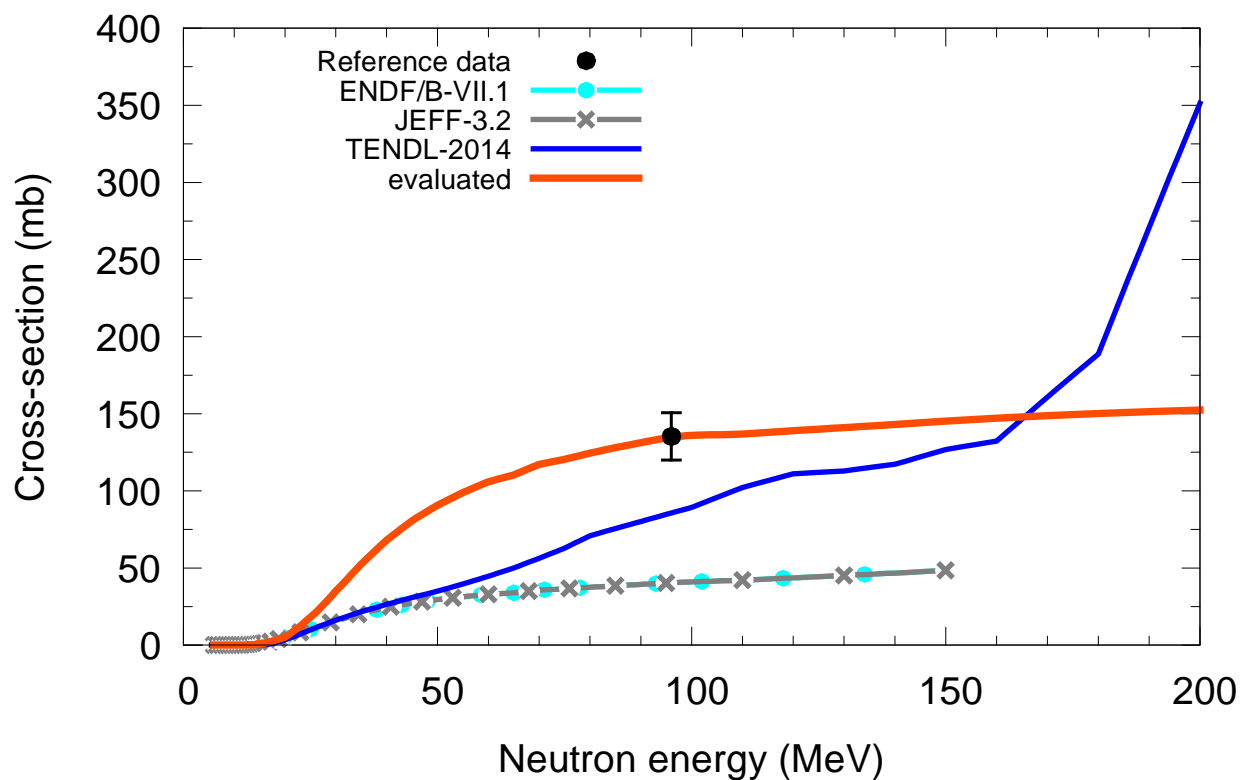
$^{199}\text{Hg}(n,x)d$



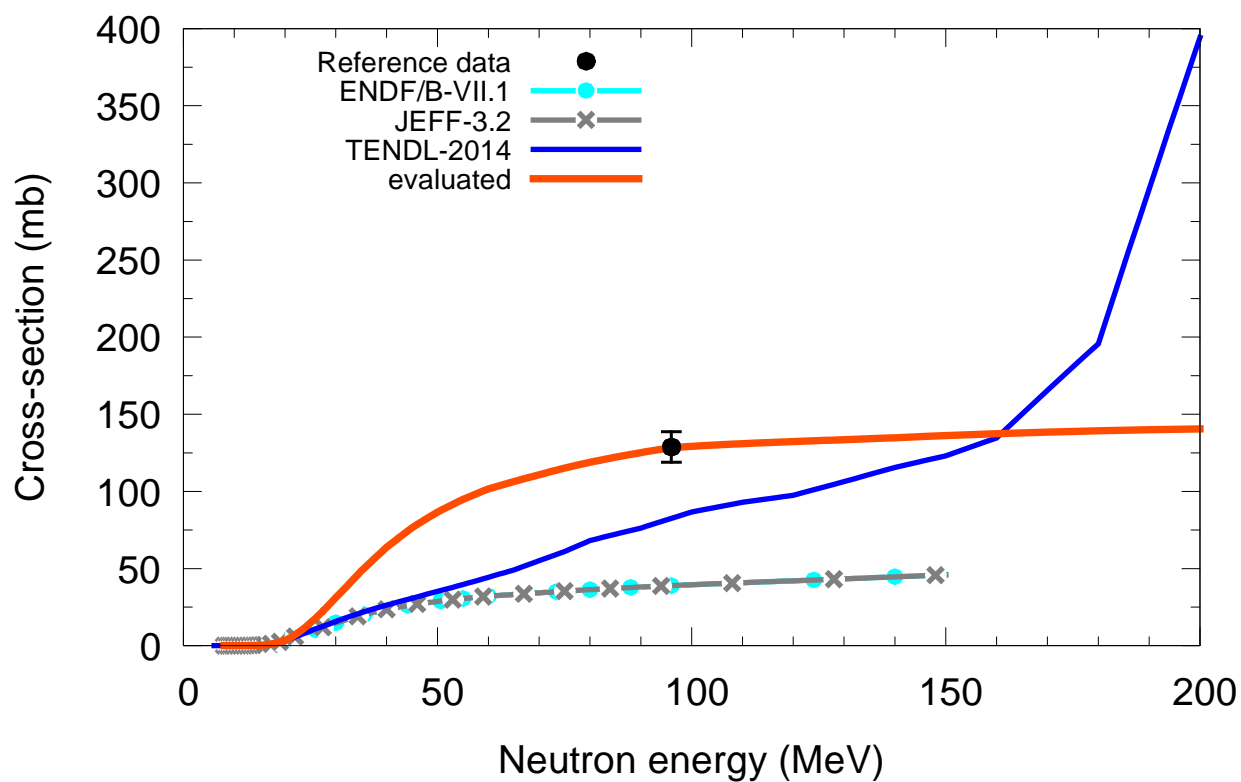
$^{200}\text{Hg}(n,x)d$



$^{201}\text{Hg}(n,x)d$

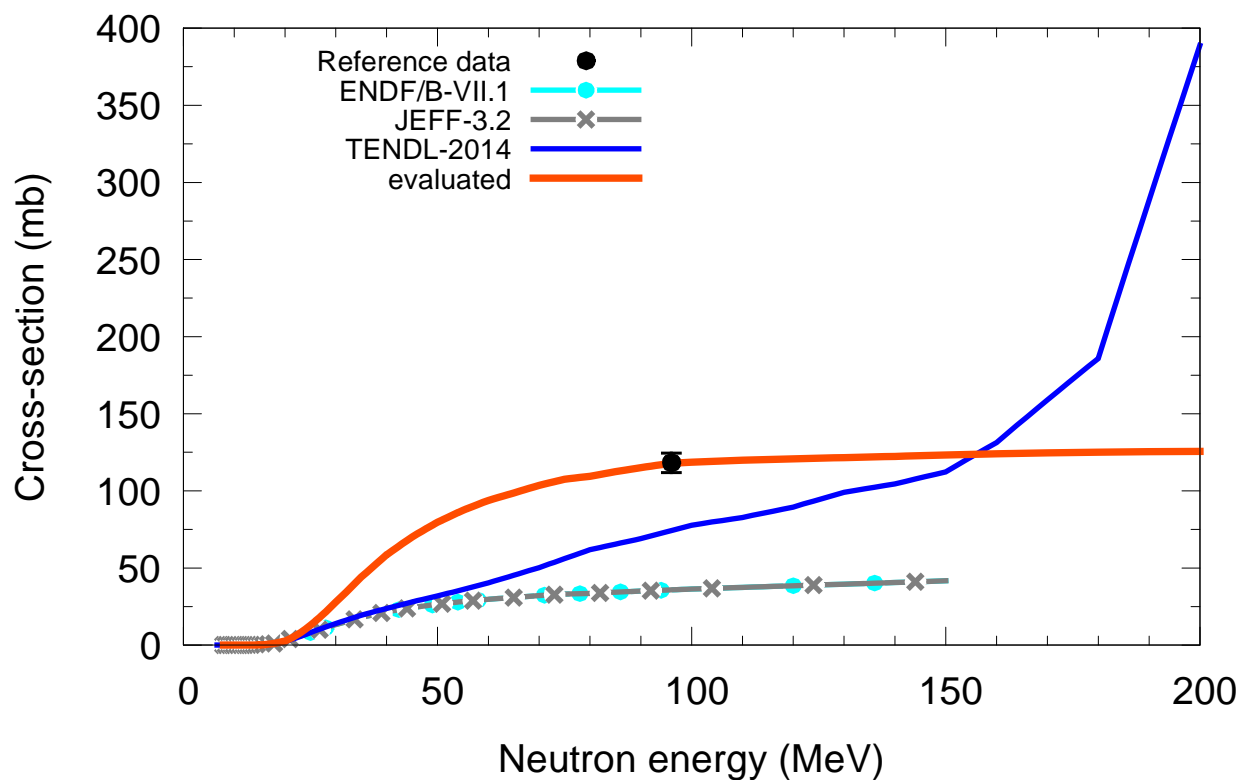


$^{202}\text{Hg}(n,x)d$

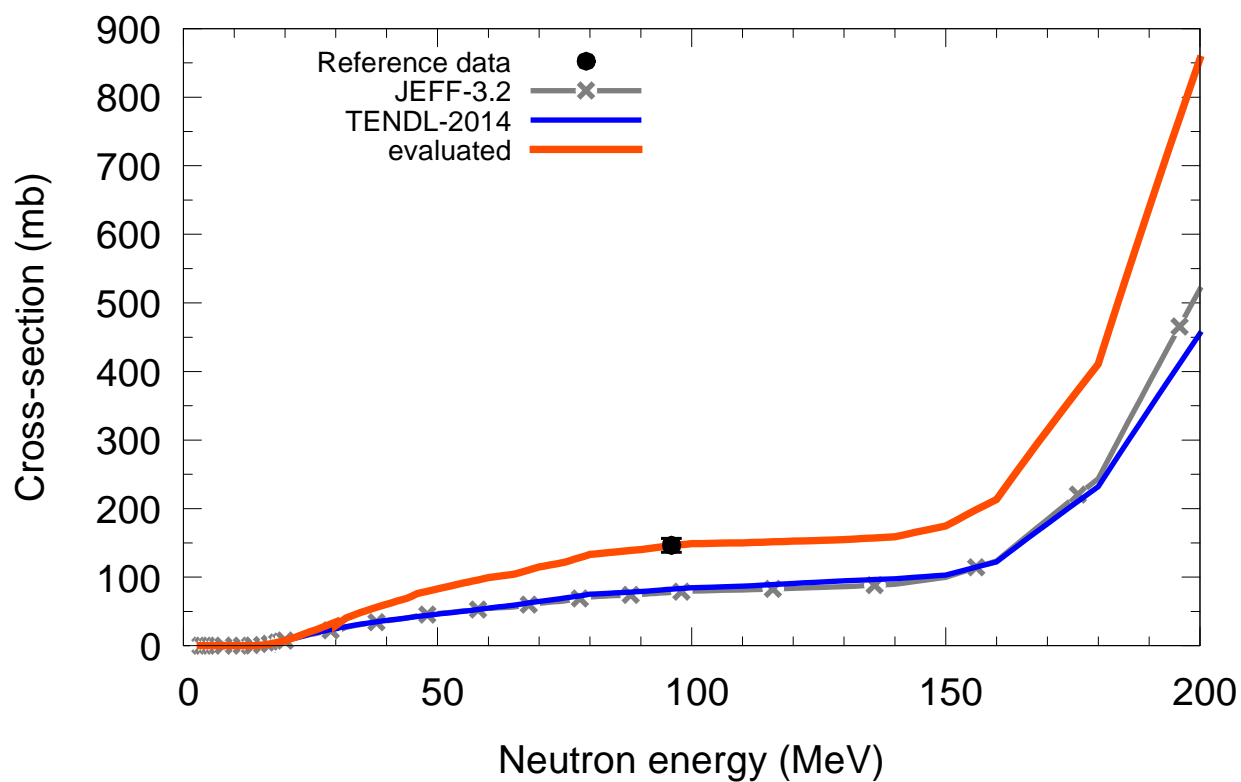




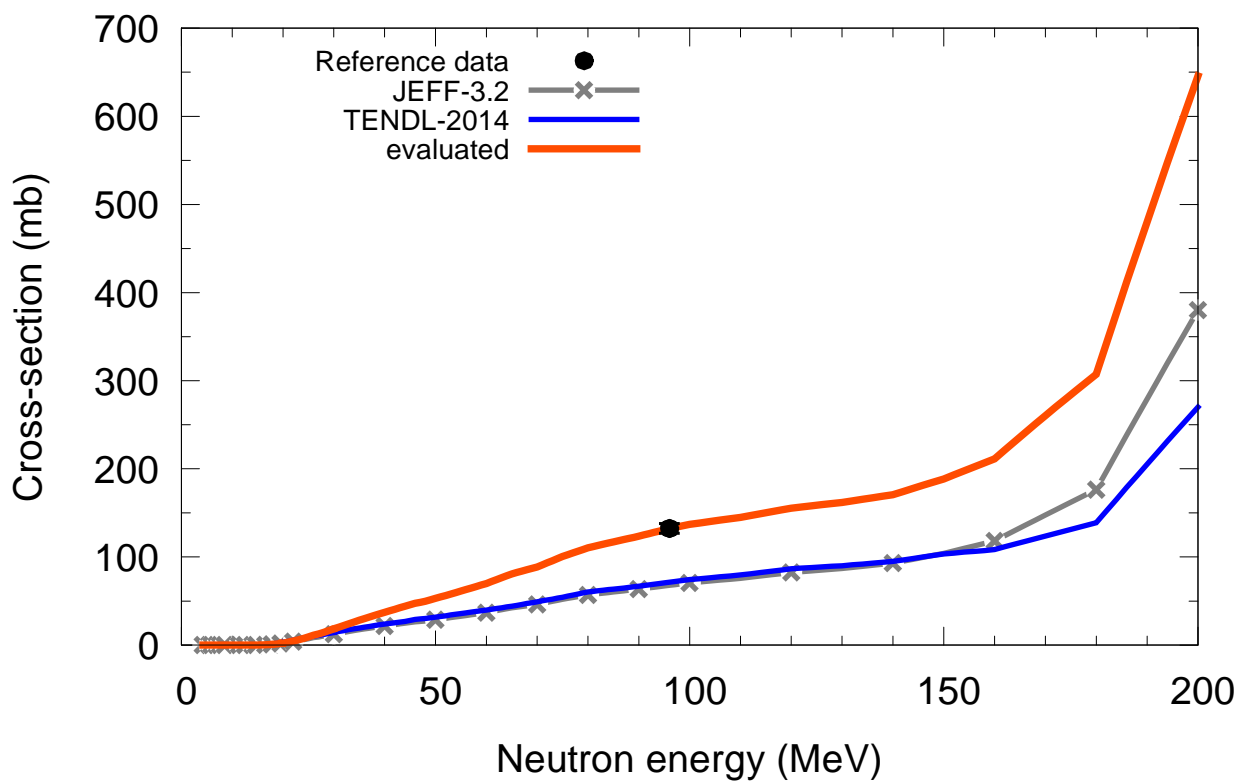
### $^{204}\text{Hg}(n,x)d$



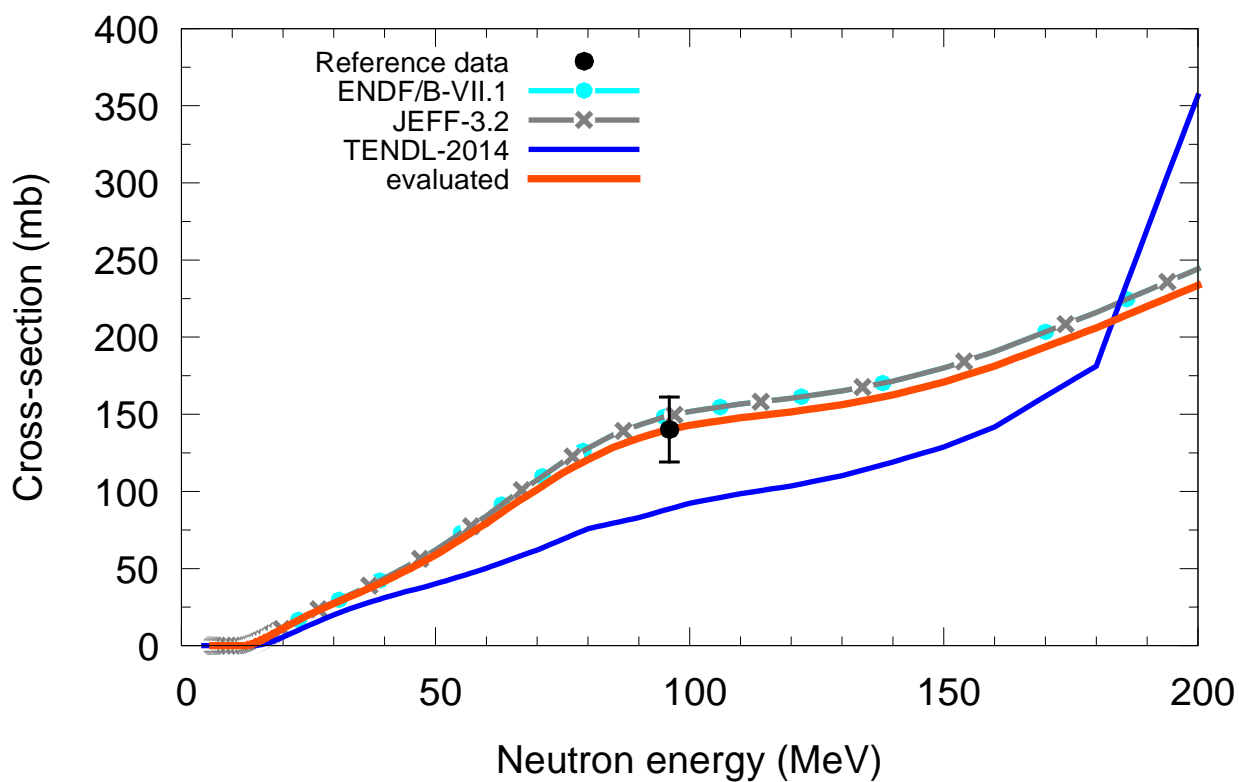
### $^{203}\text{Tl}(n,x)d$

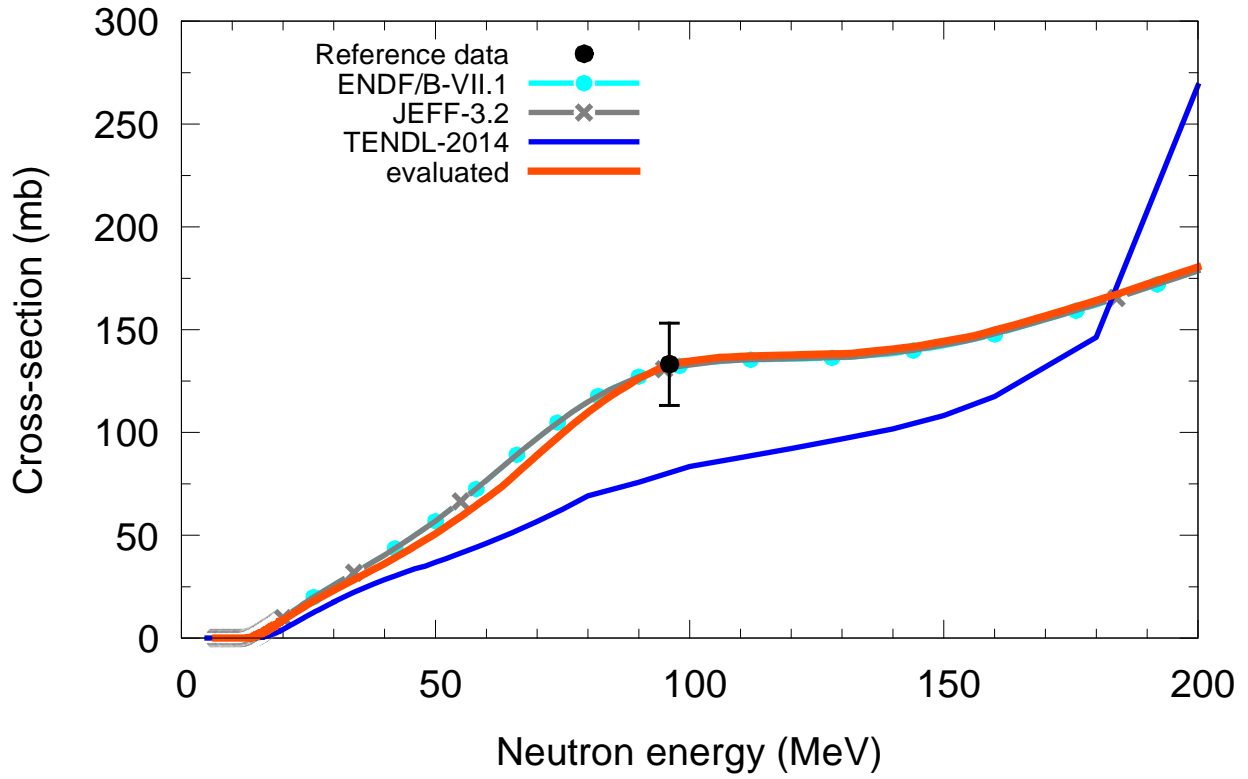
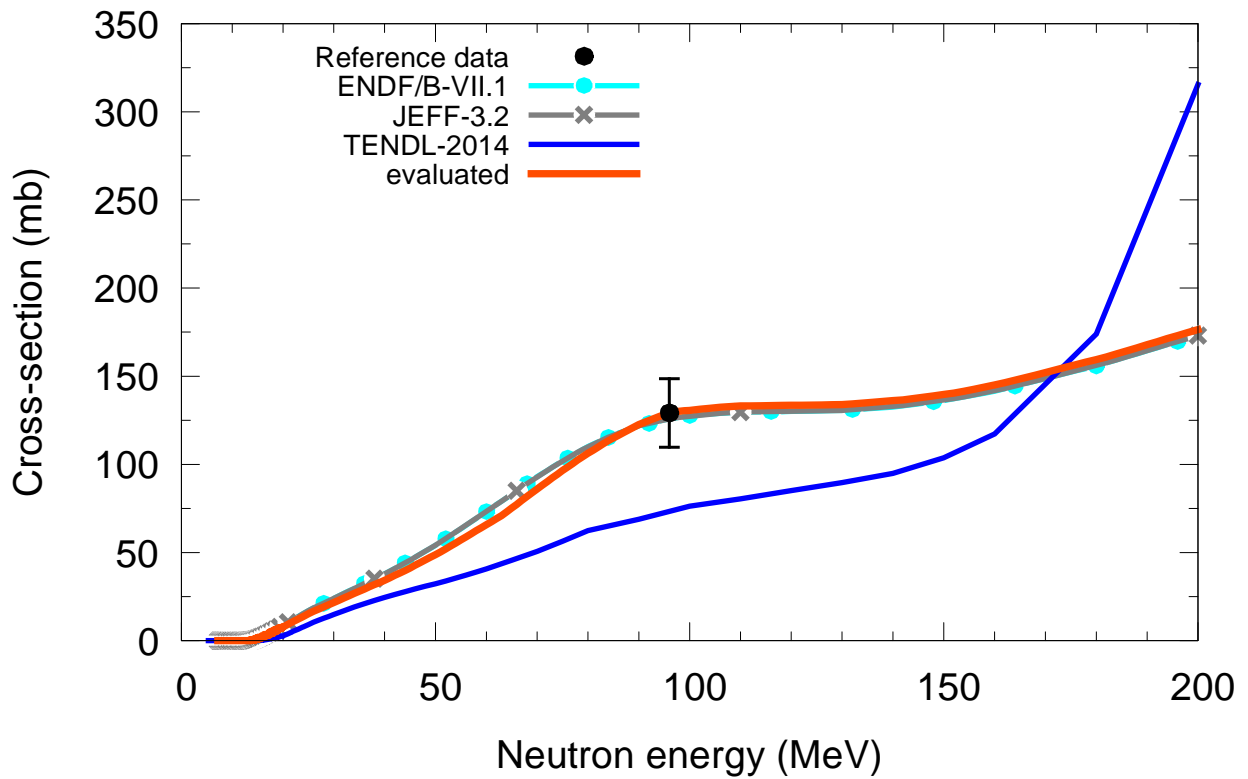


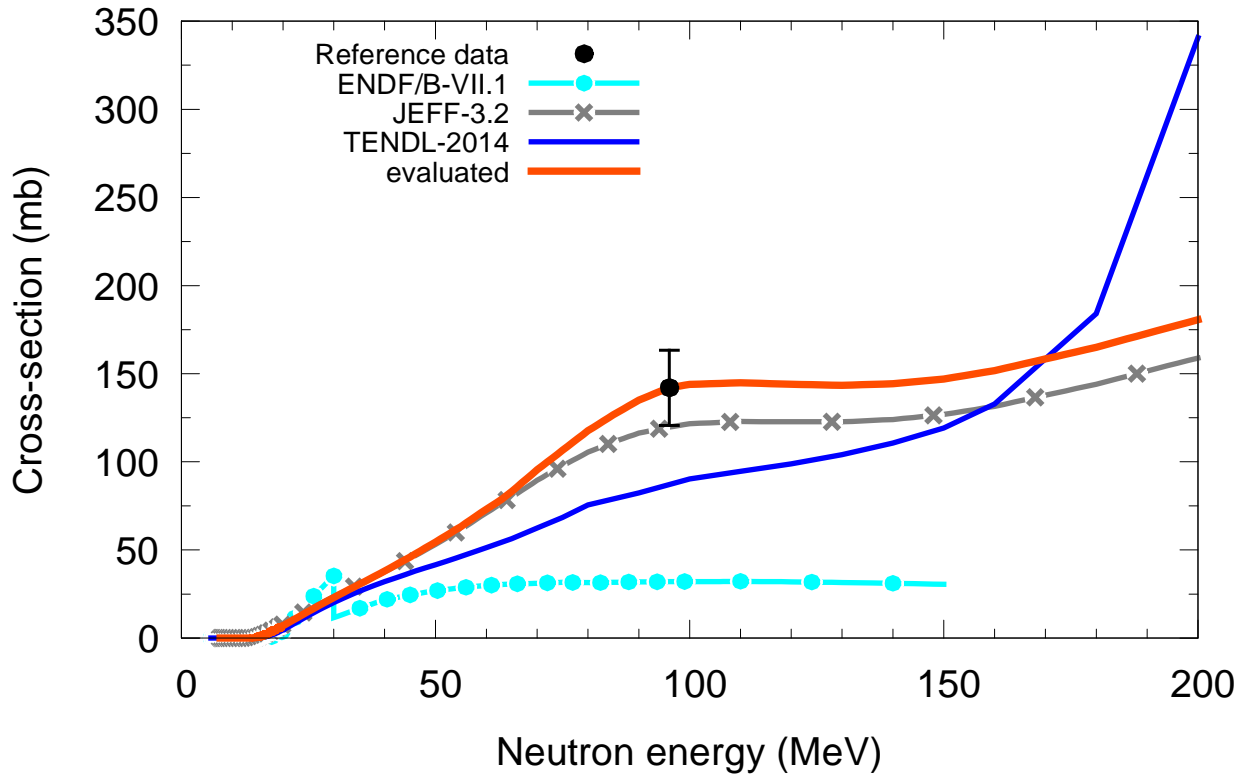
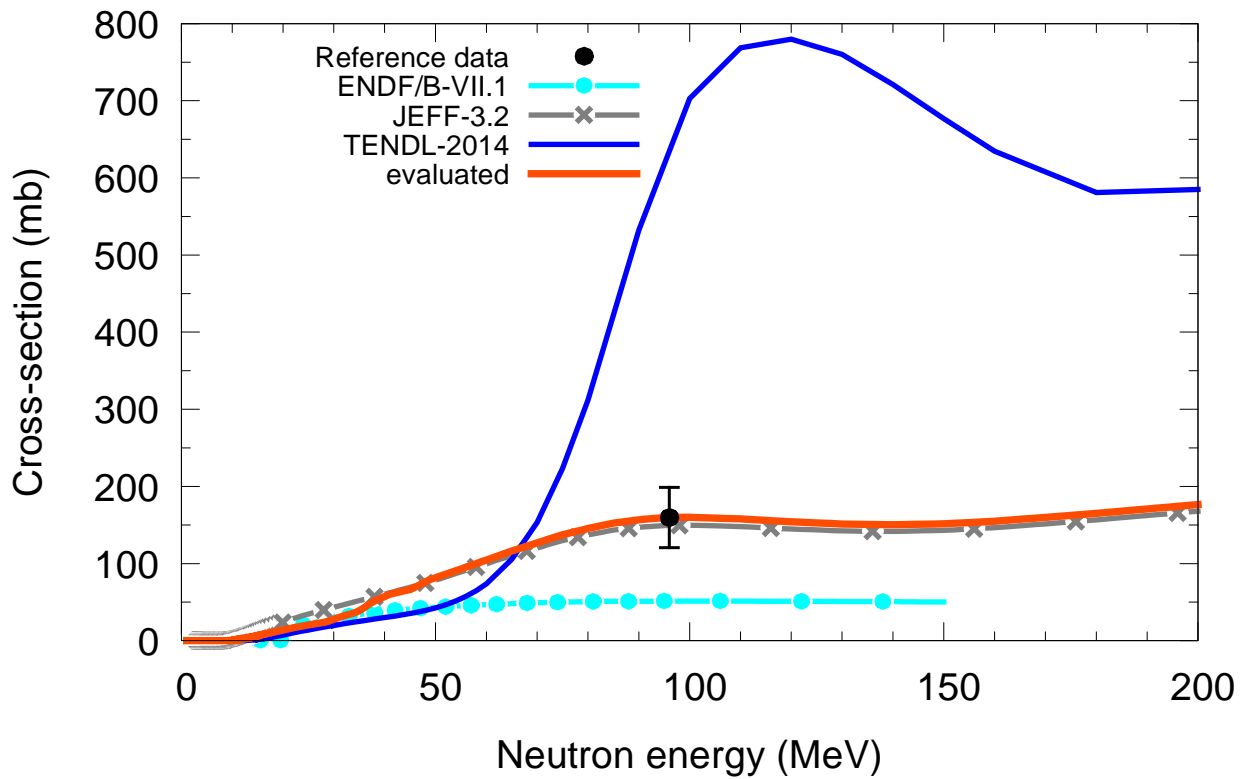
$^{205}\text{Tl}(n,x)d$



$^{204}\text{Pb}(n,x)d$



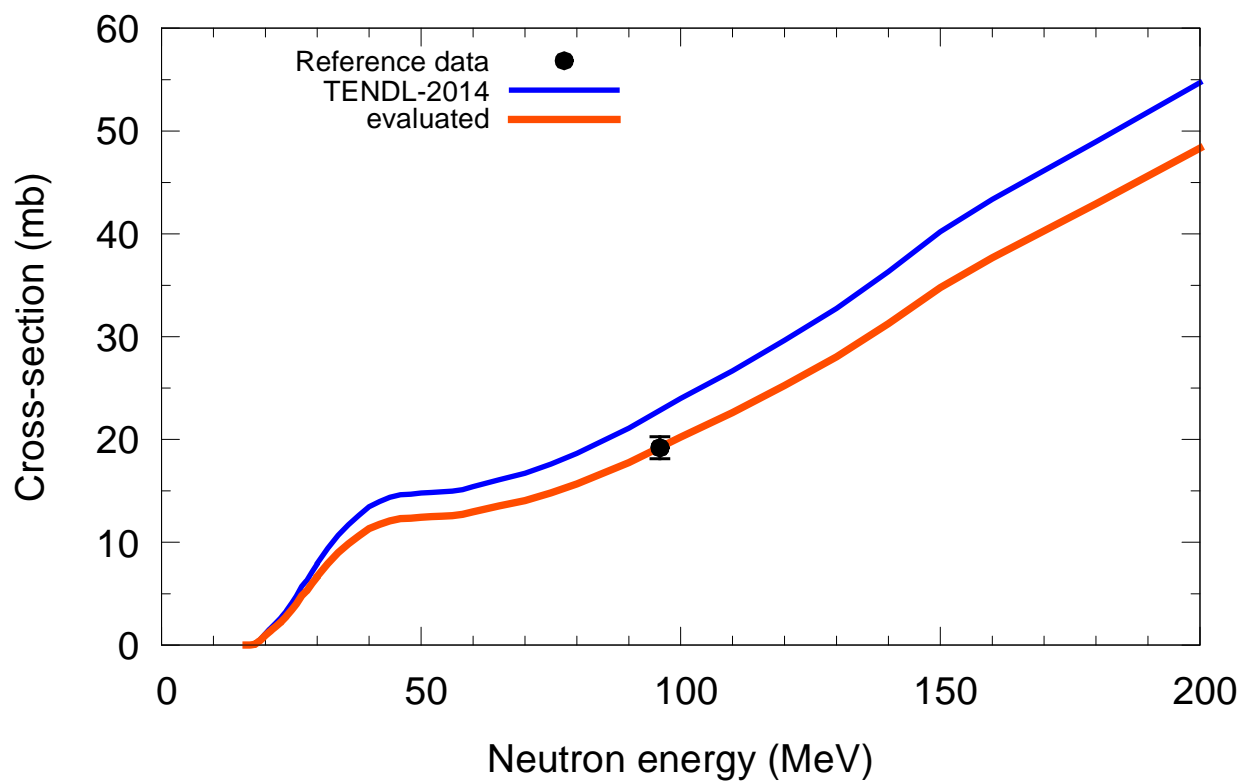
$^{206}\text{Pb}(n,x)d$  $^{207}\text{Pb}(n,x)d$ 

$^{208}\text{Pb}(n,x)d$  $^{209}\text{Bi}(n,x)d$ 

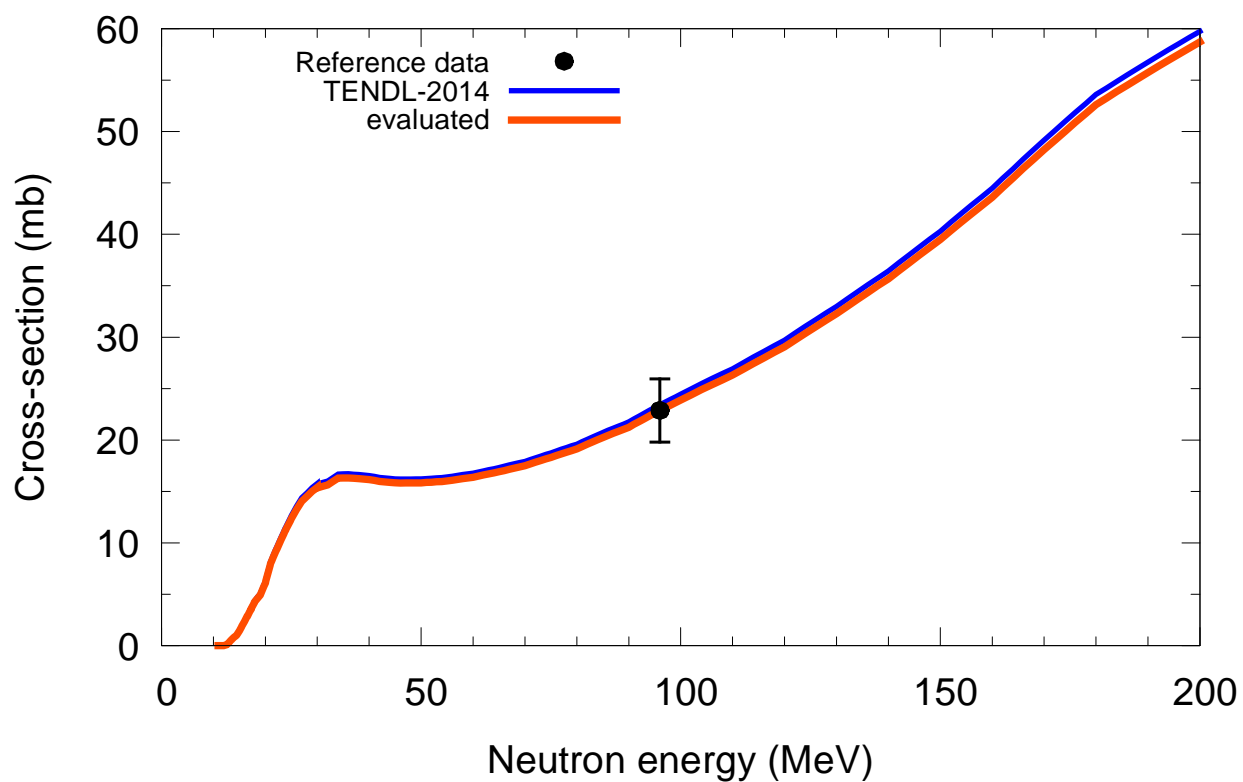
## Appendix C

Evaluated triton production cross-sections, data from ENDF/B-VII.1, JEFF-3.2, and TENDL-2014, and cross-sections at 96 MeV estimated using the  $\sigma(A)$ -dependence

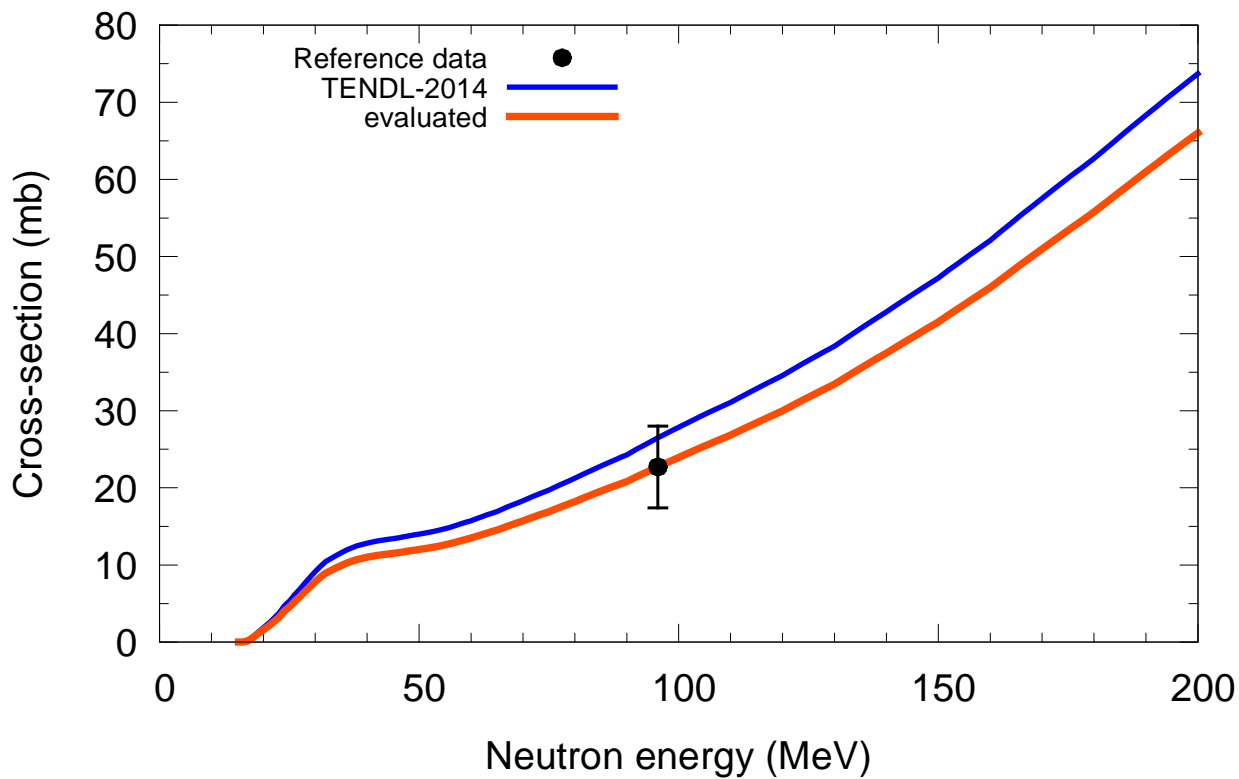
### $^{24}\text{Mg}(n,x)t$



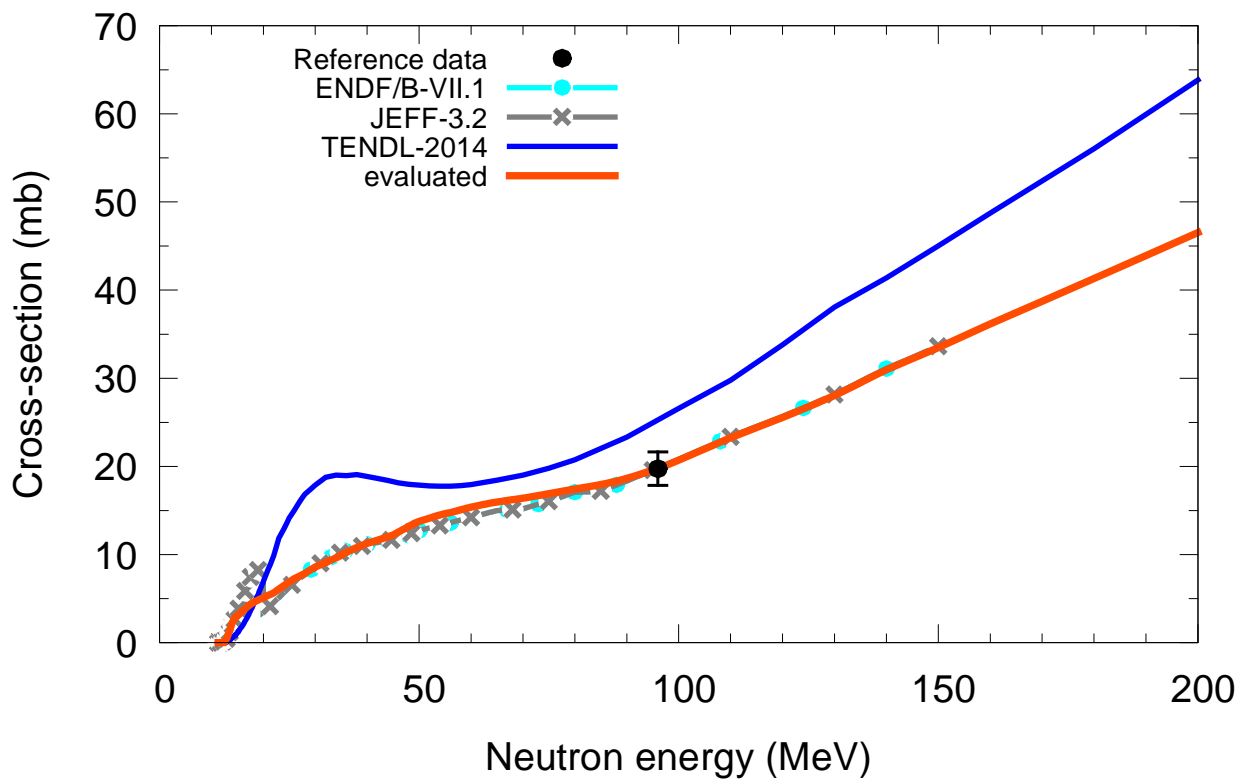
### $^{25}\text{Mg}(n,x)t$

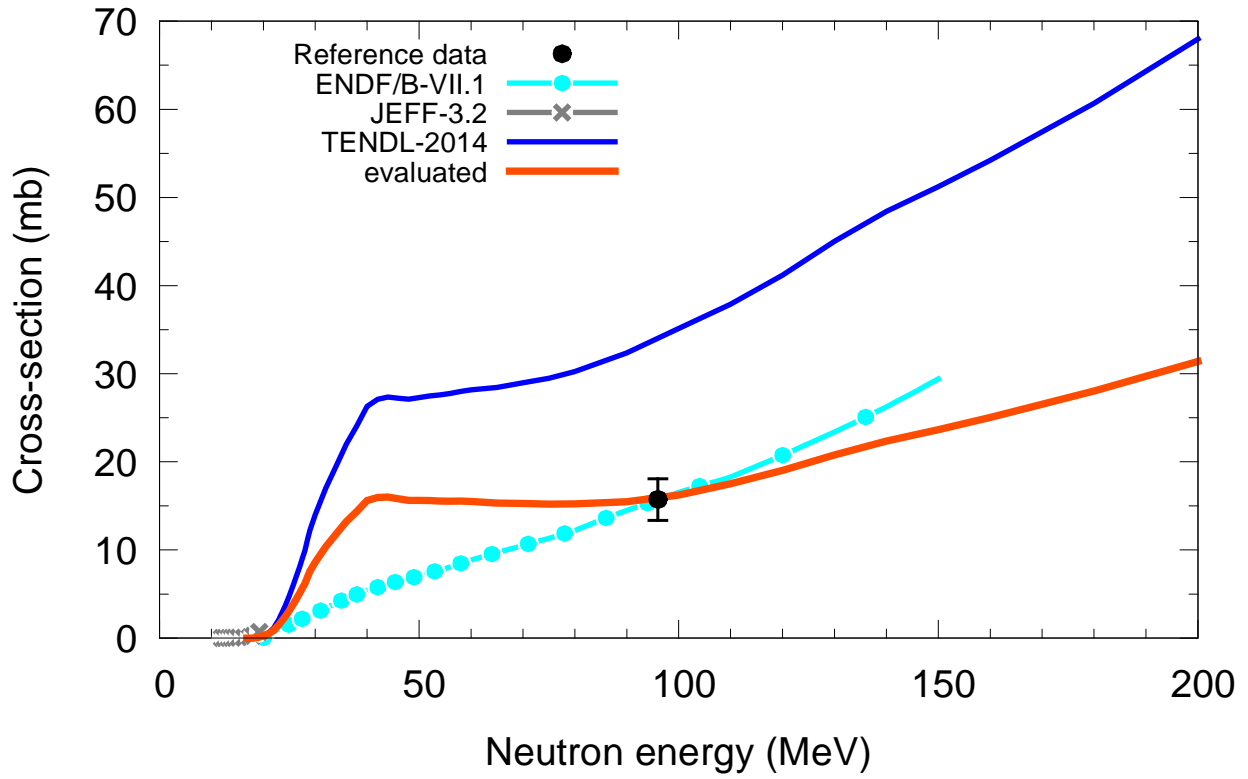
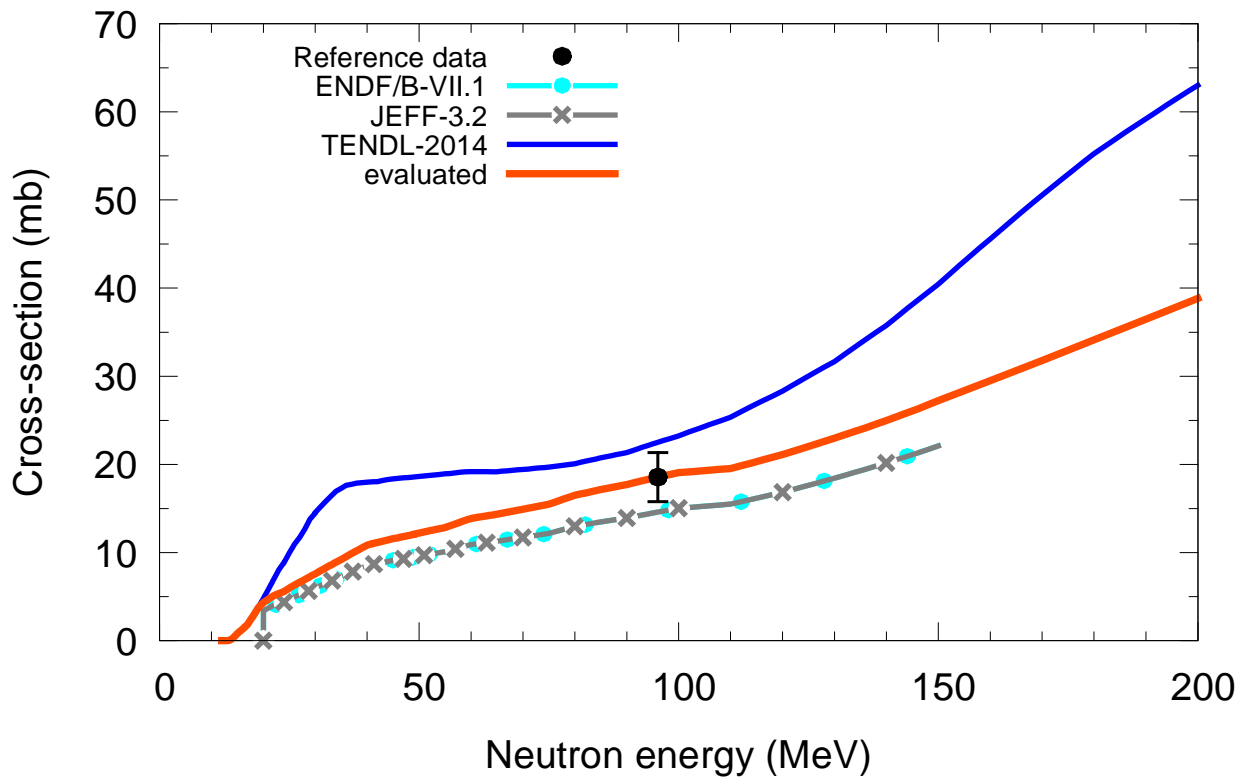


### $^{26}\text{Mg}(n,x)t$



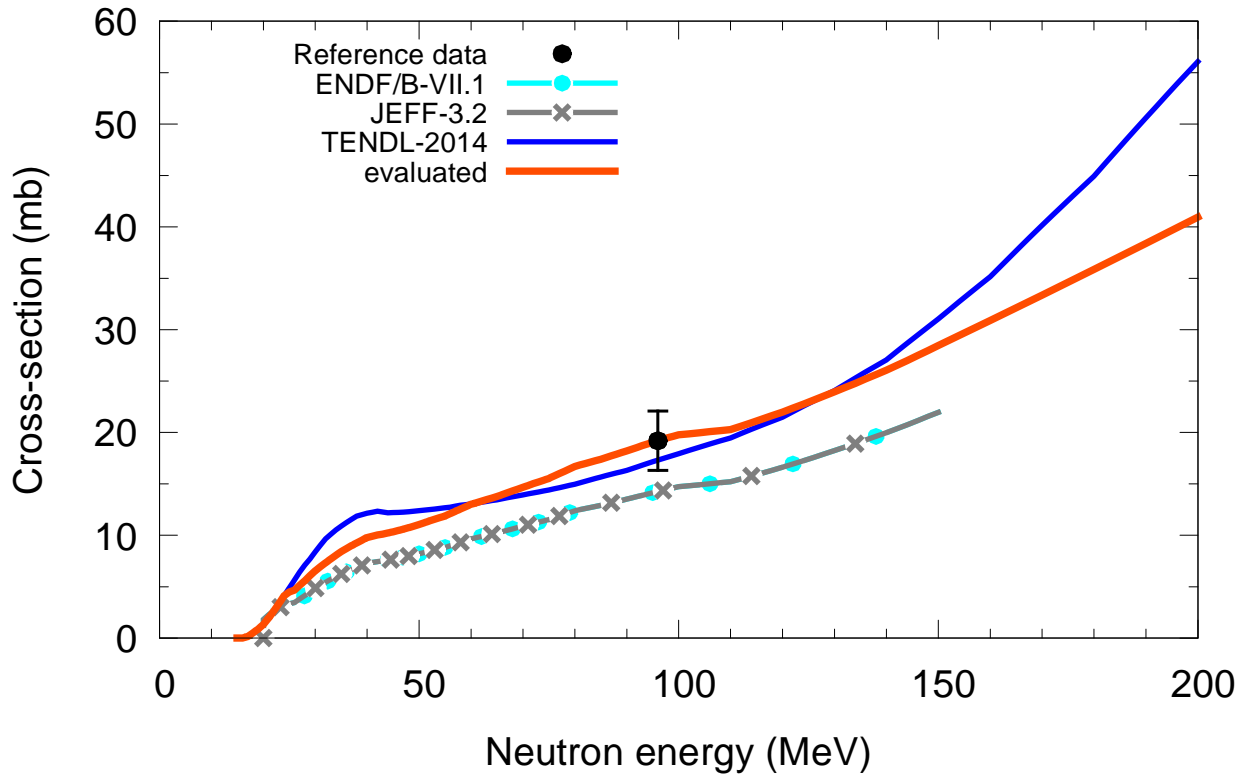
### $^{27}\text{Al}(n,x)t$



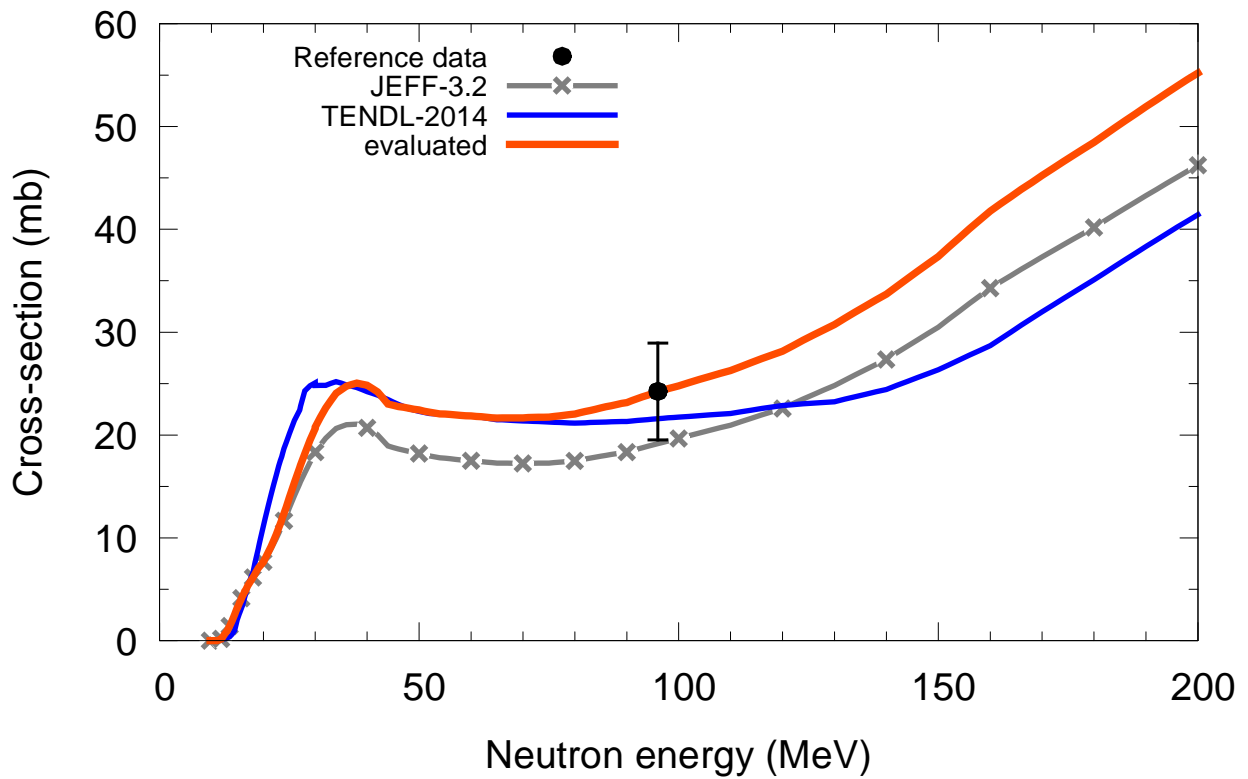
$^{28}\text{Si}(n,x)t$  $^{29}\text{Si}(n,x)t$ 

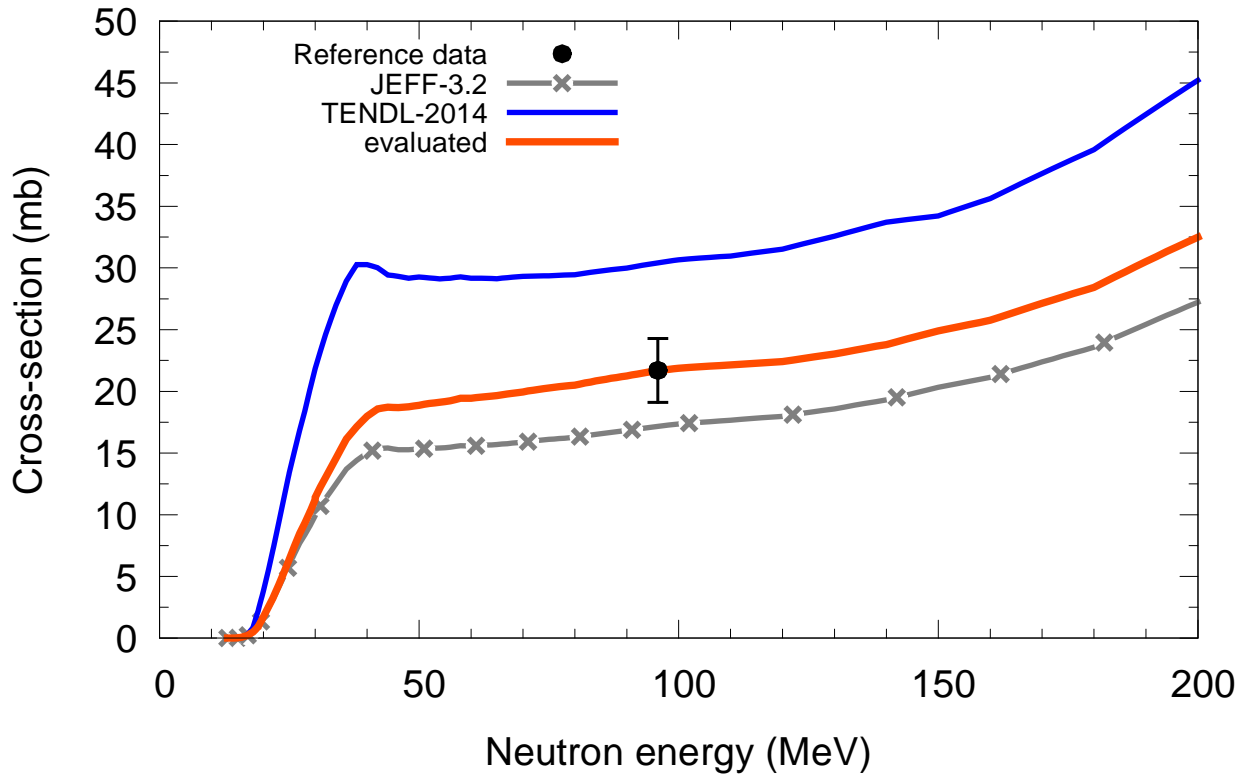
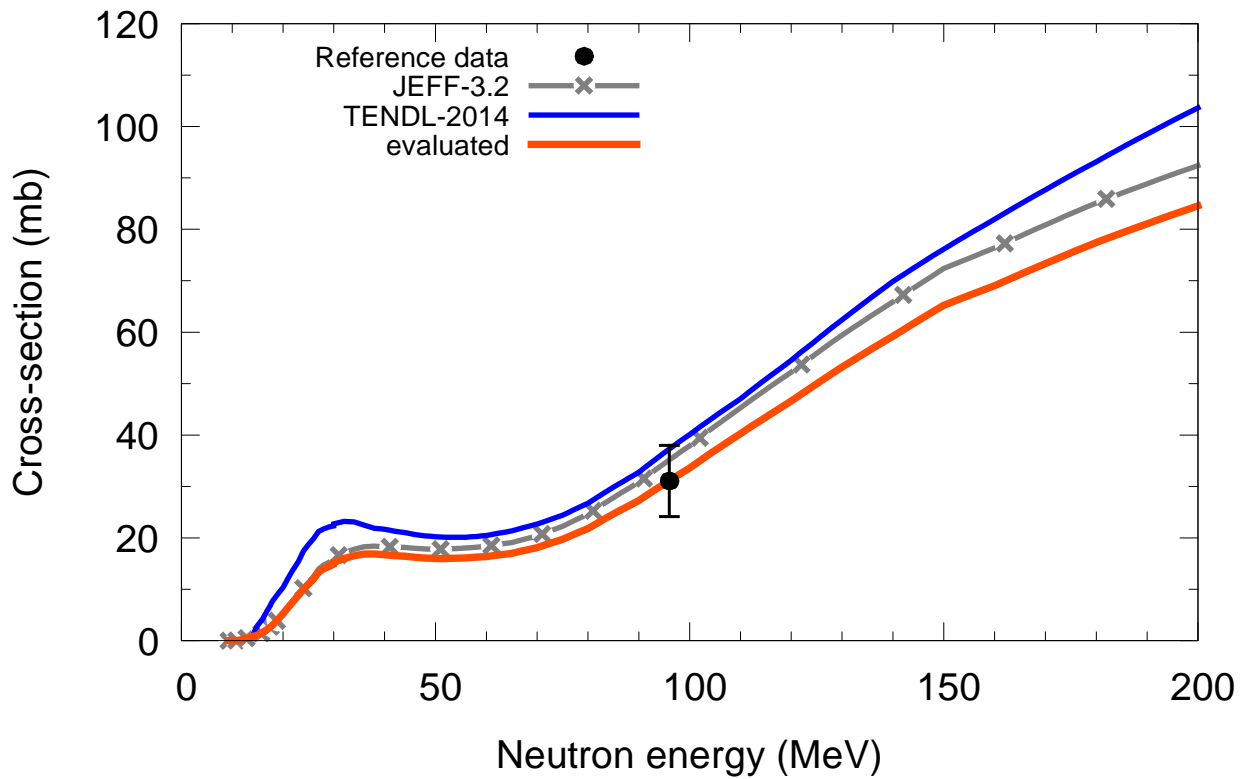


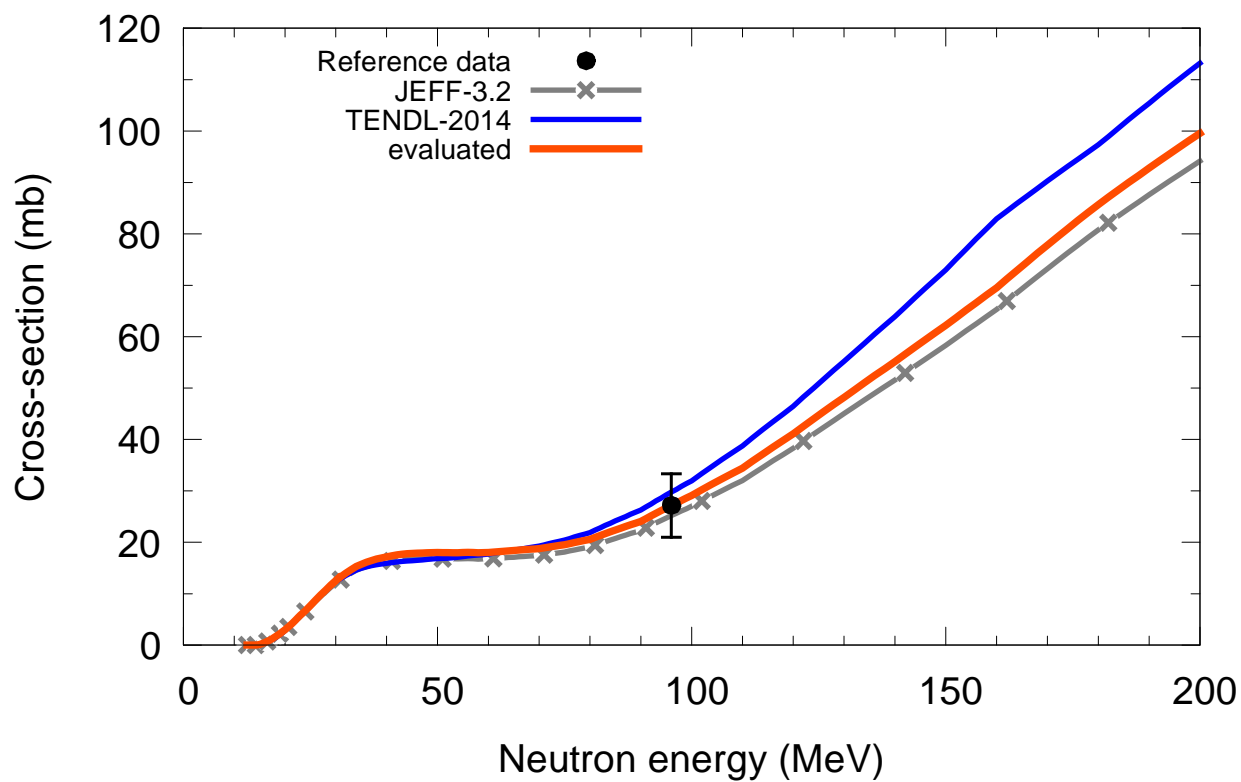
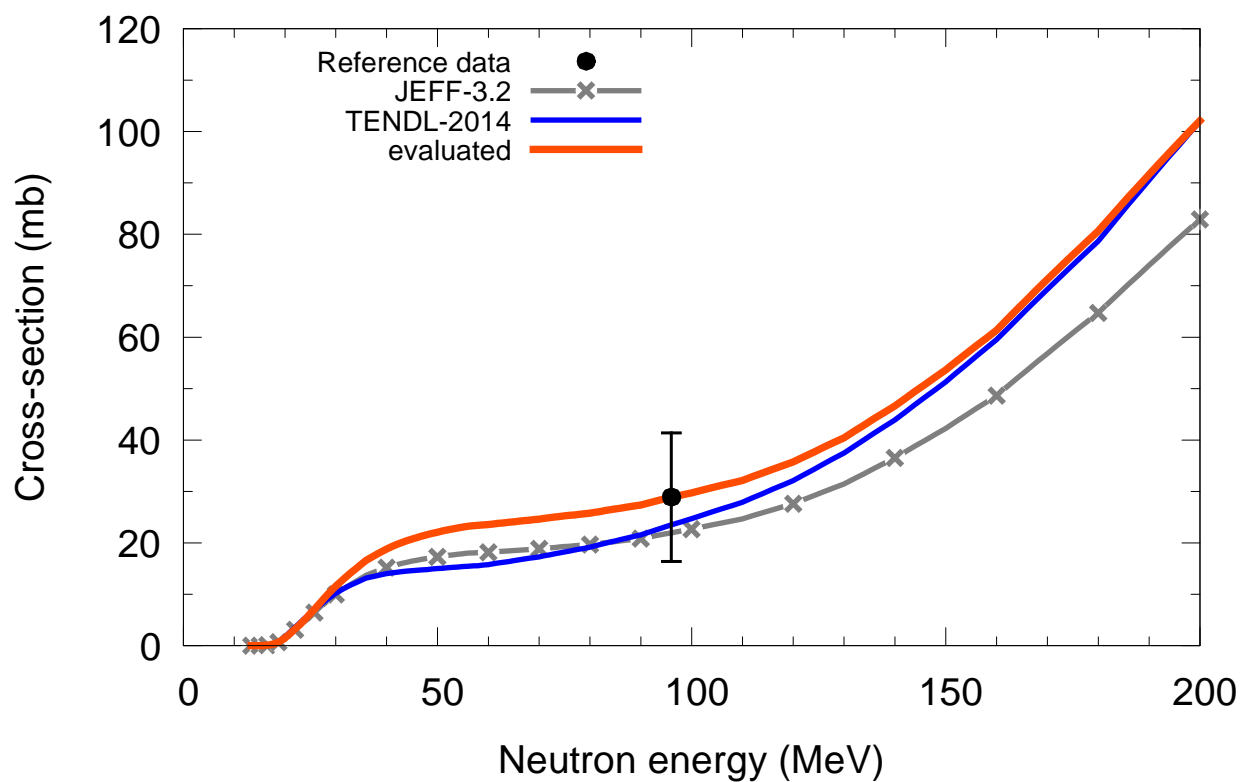
### $^{30}\text{Si}(n,x)t$

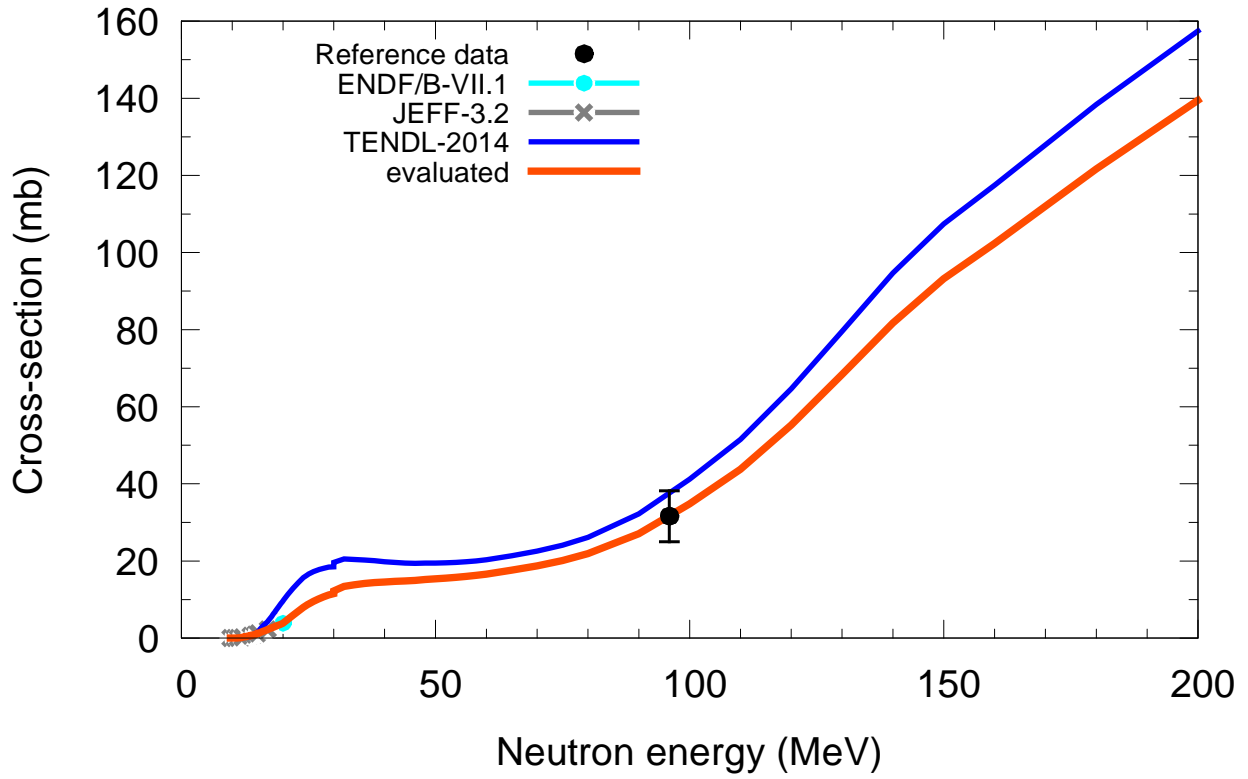
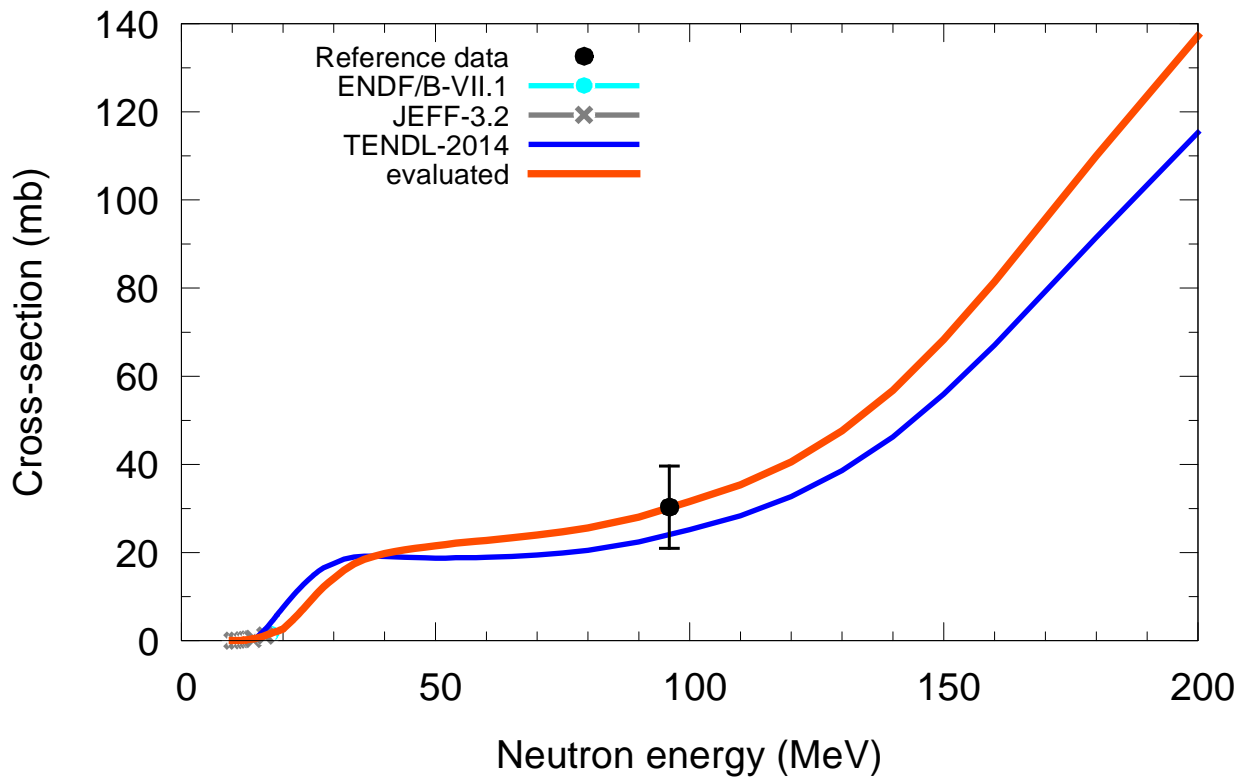


### $^{31}\text{P}(n,x)t$

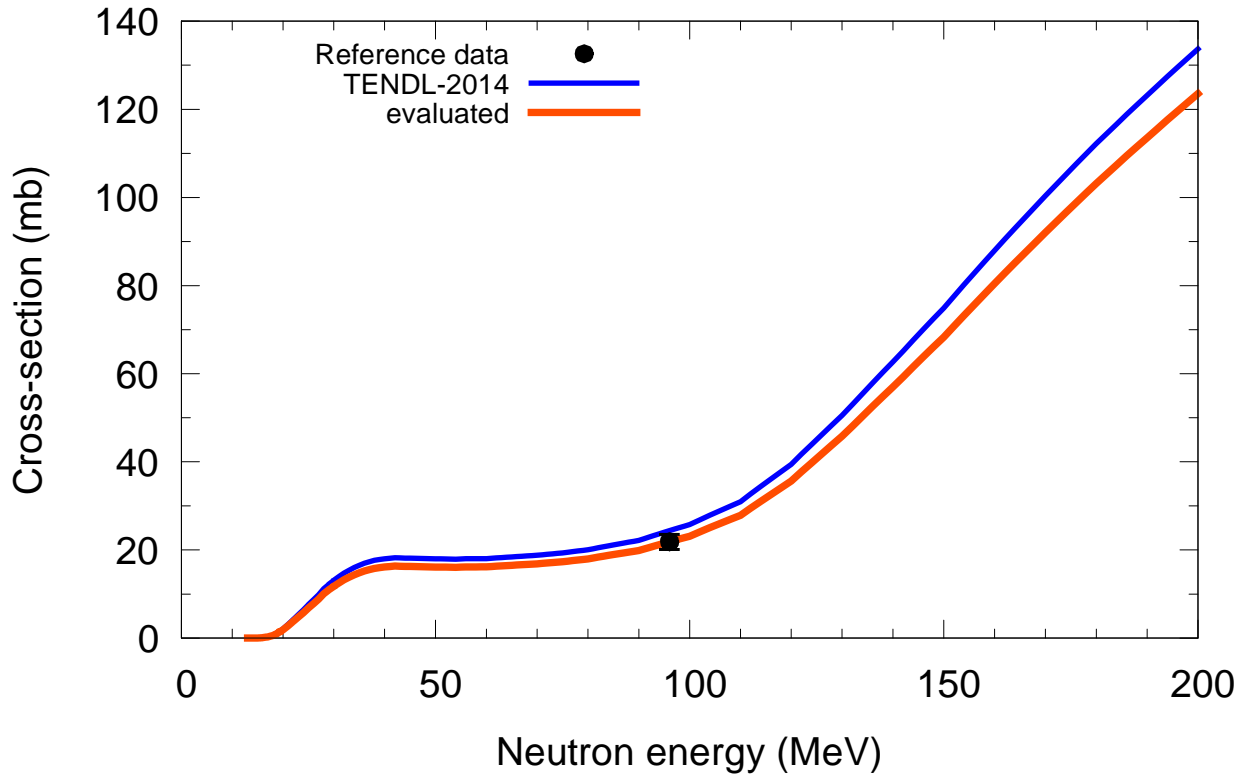


$^{32}\text{S}(n,x)t$  $^{33}\text{S}(n,x)t$ 

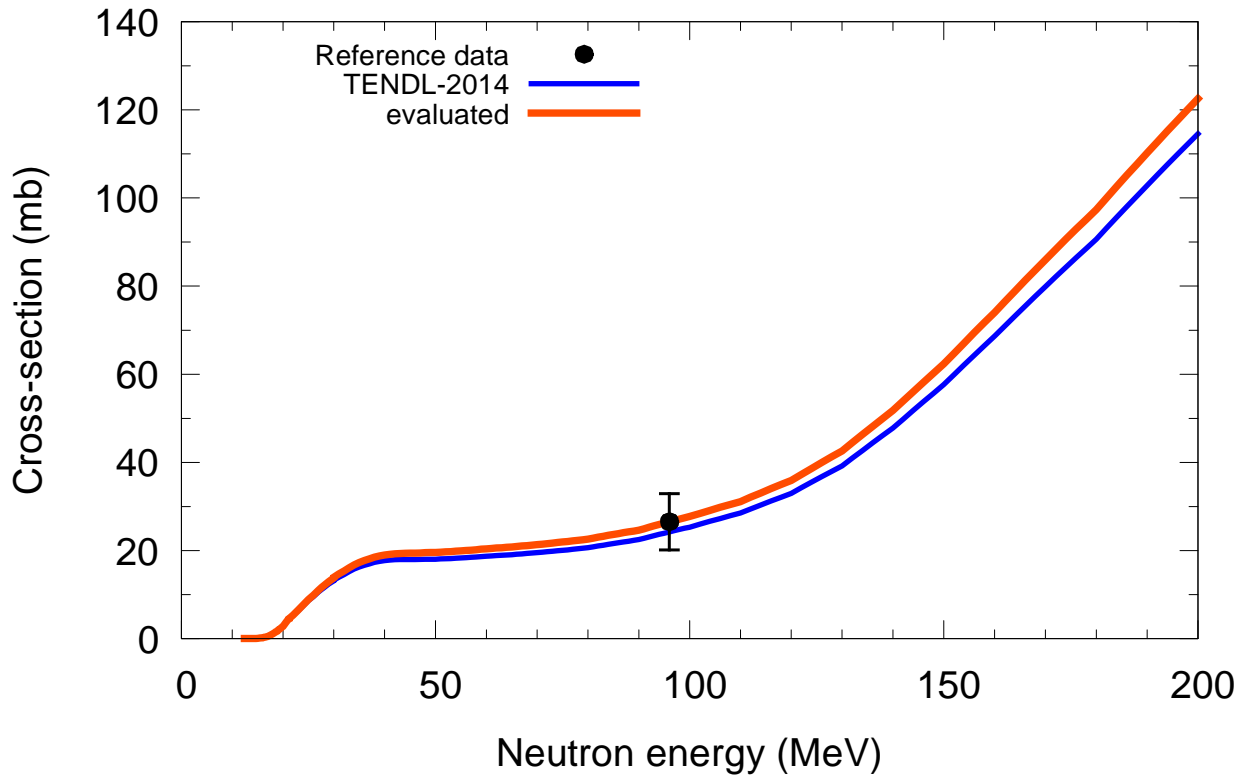
$^{34}\text{S}(n,x)t$  $^{36}\text{S}(n,x)t$ 

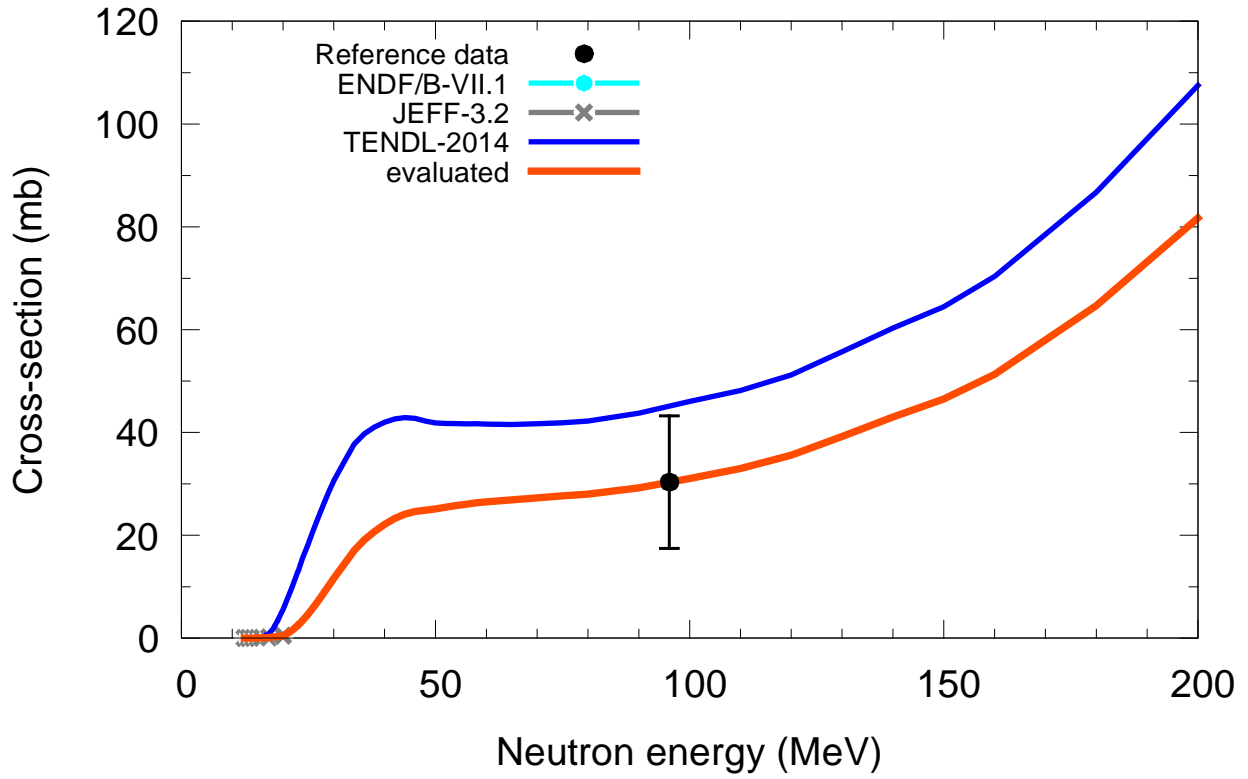
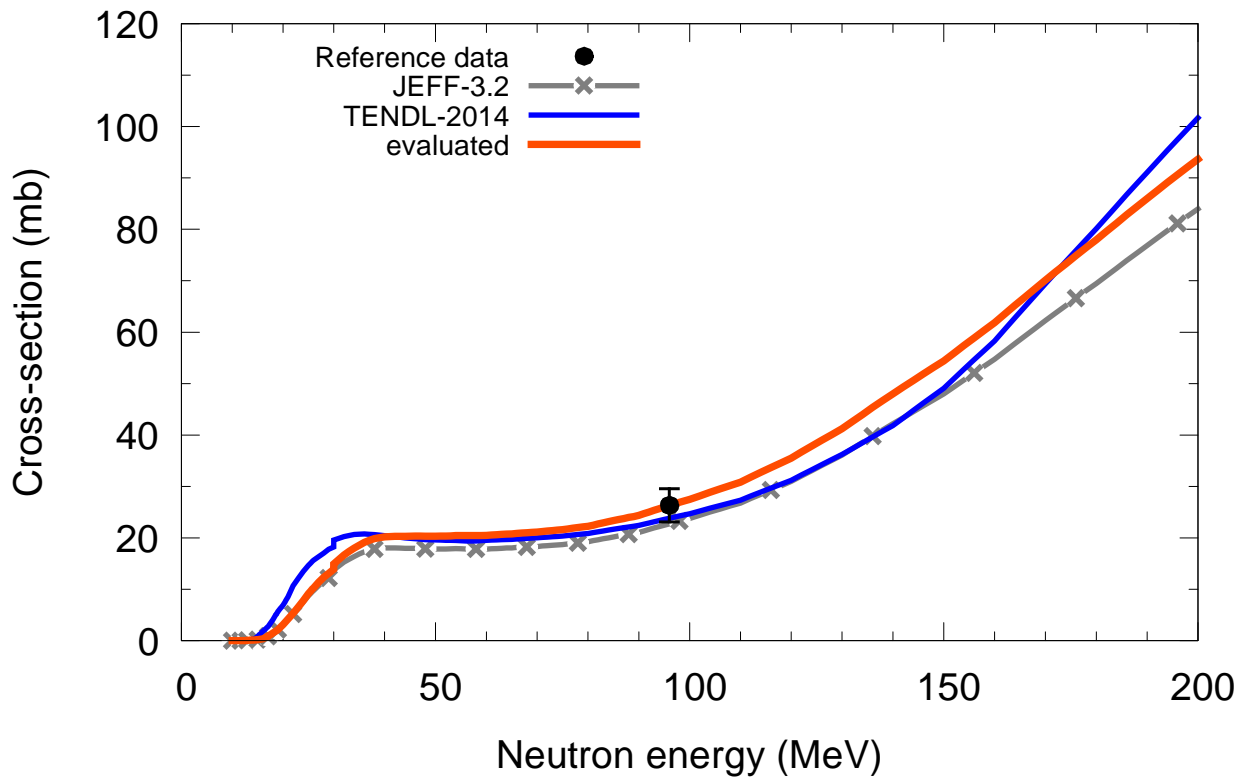
$^{35}\text{Cl}(n,x)t$  $^{37}\text{Cl}(n,x)t$ 

$^{36}\text{Ar}(n,x)t$

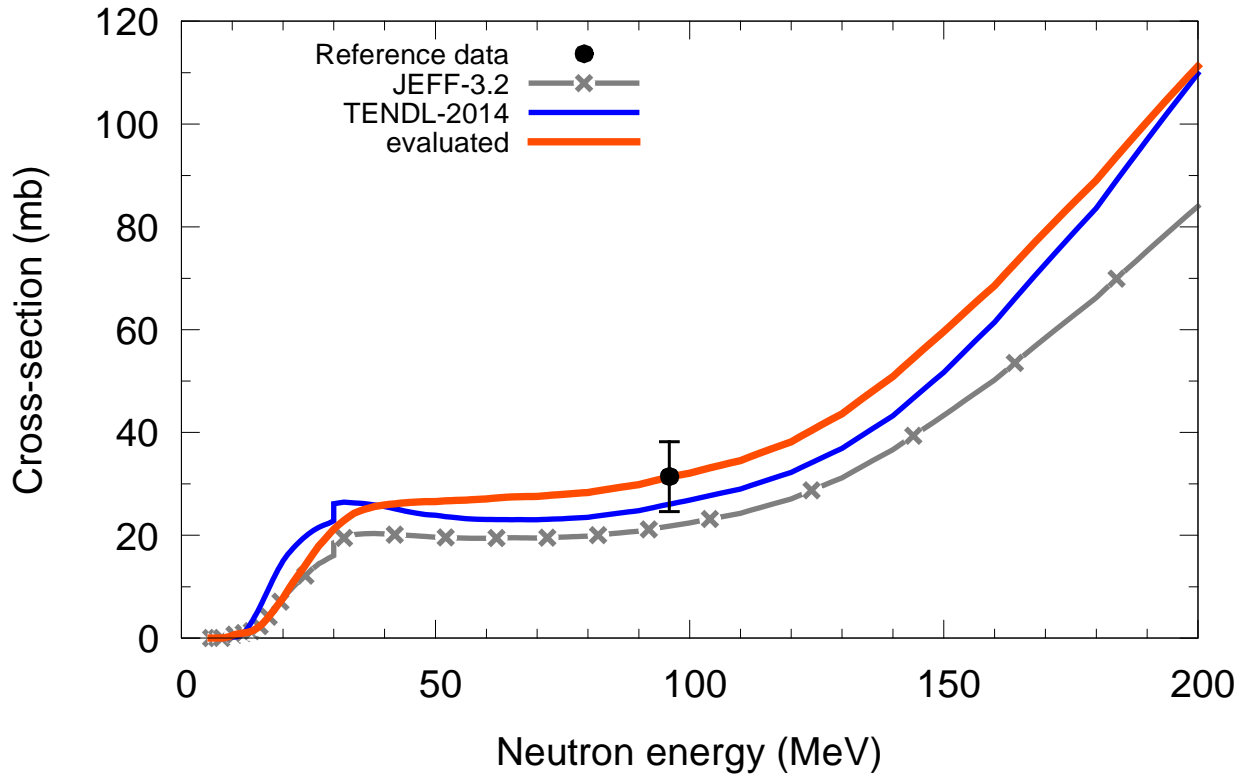


$^{38}\text{Ar}(n,x)t$

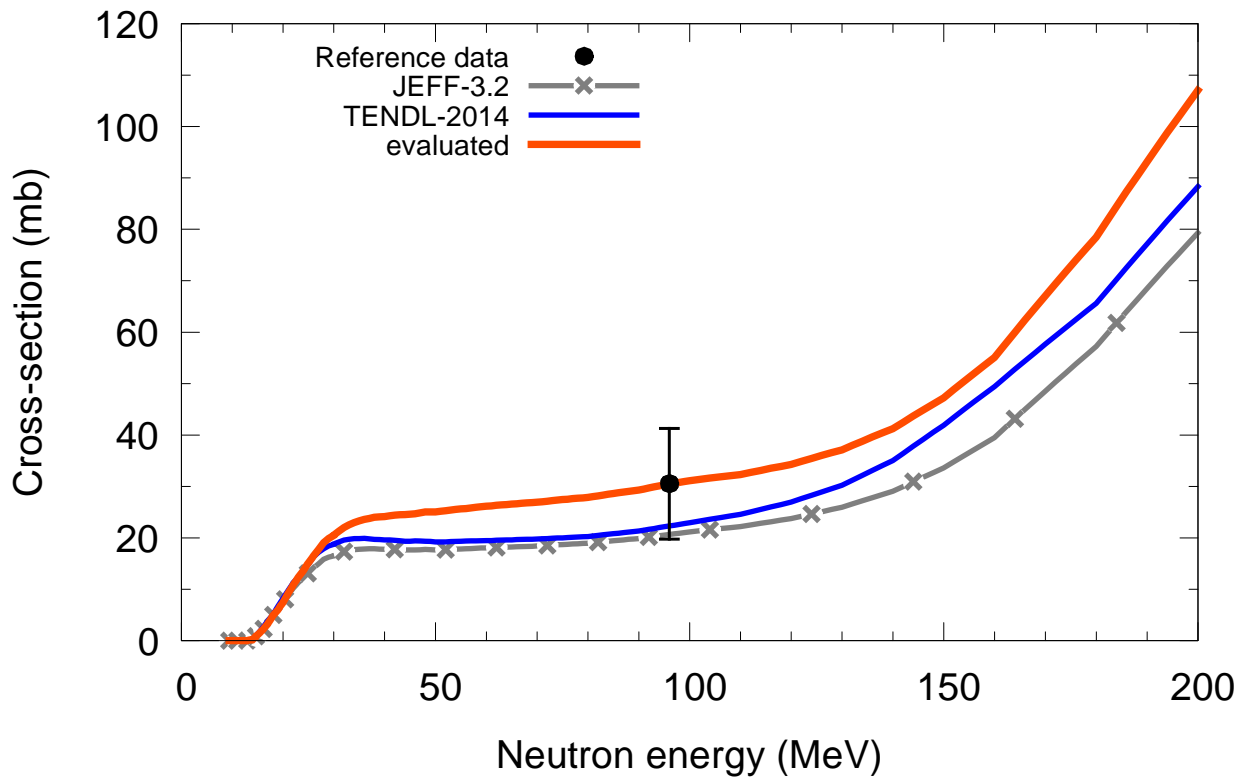


$^{40}\text{Ar}(n,x)t$  $^{39}\text{K}(n,x)t$ 

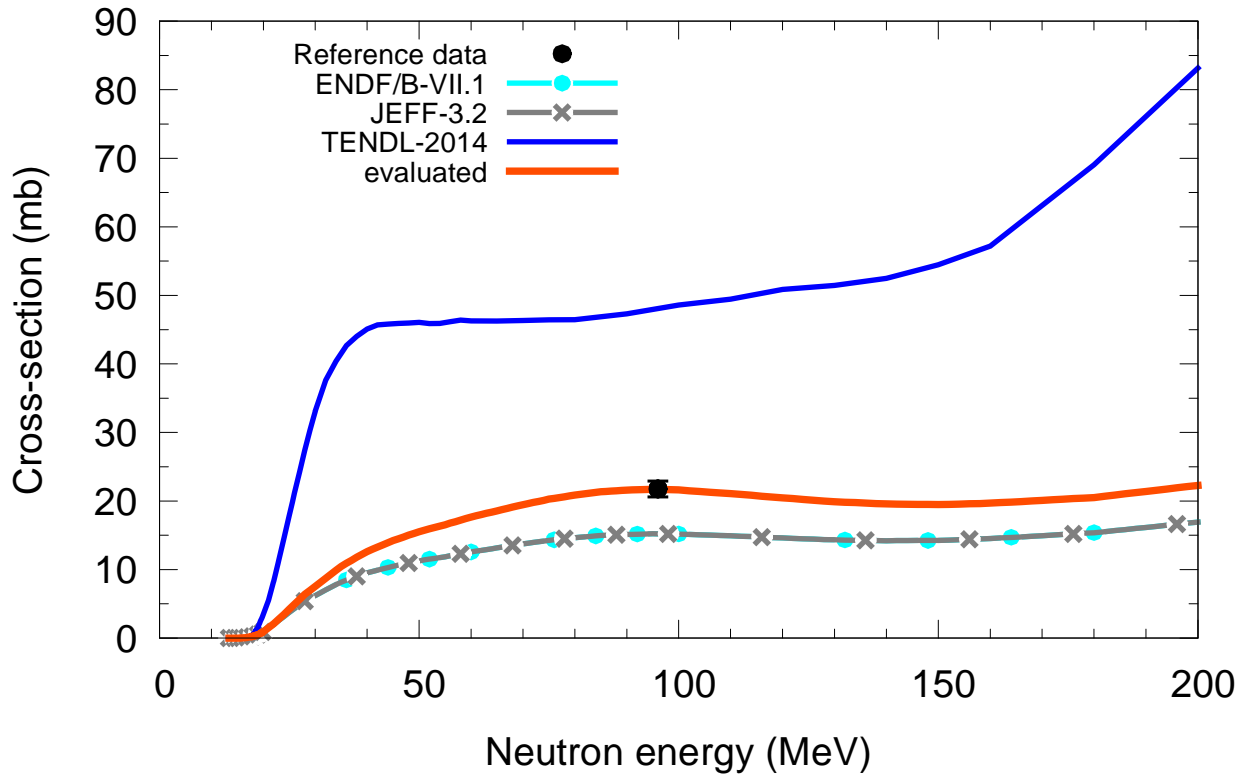
$^{40}\text{K}(n,x)t$



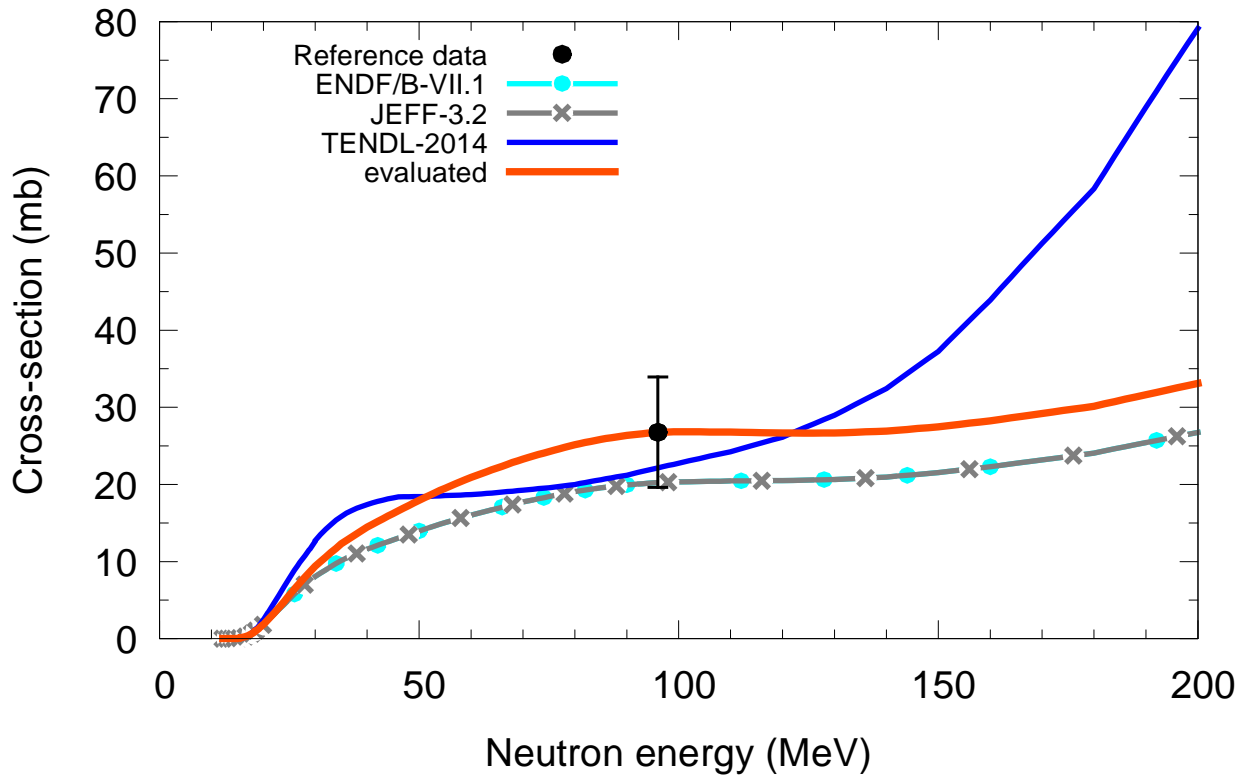
$^{41}\text{K}(n,x)t$



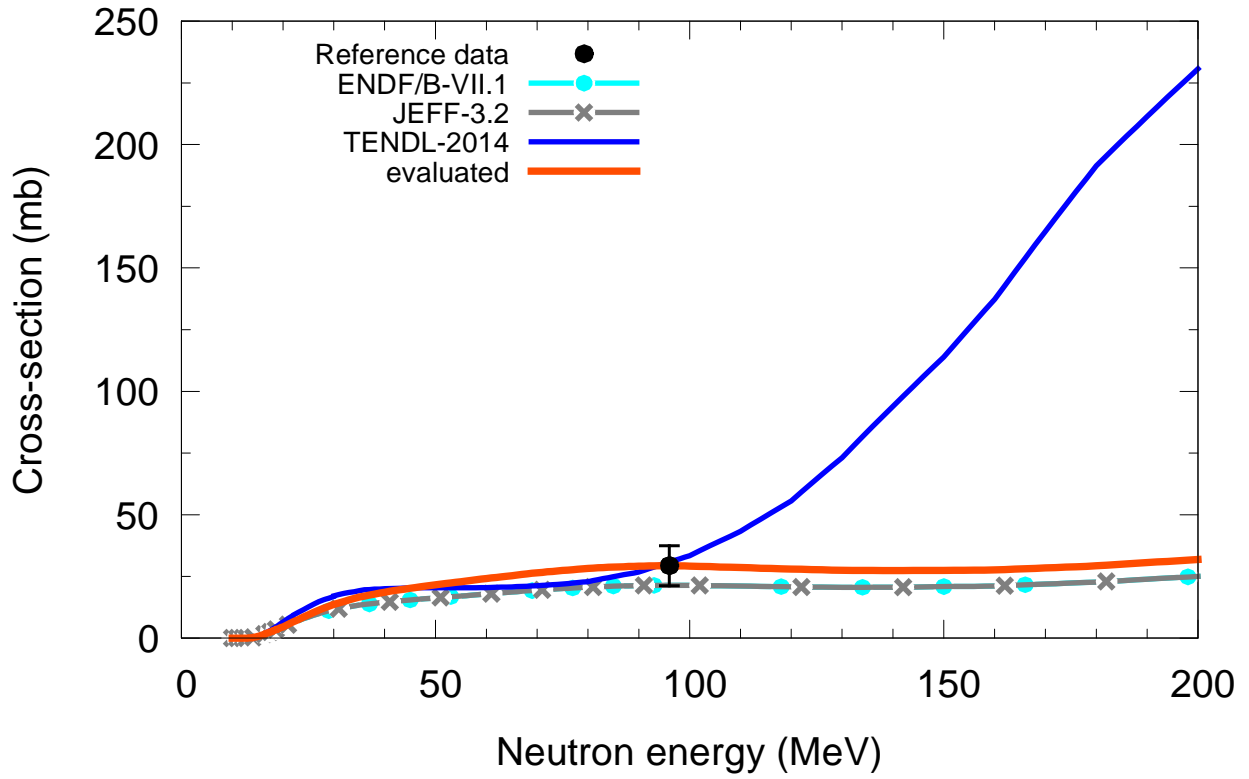
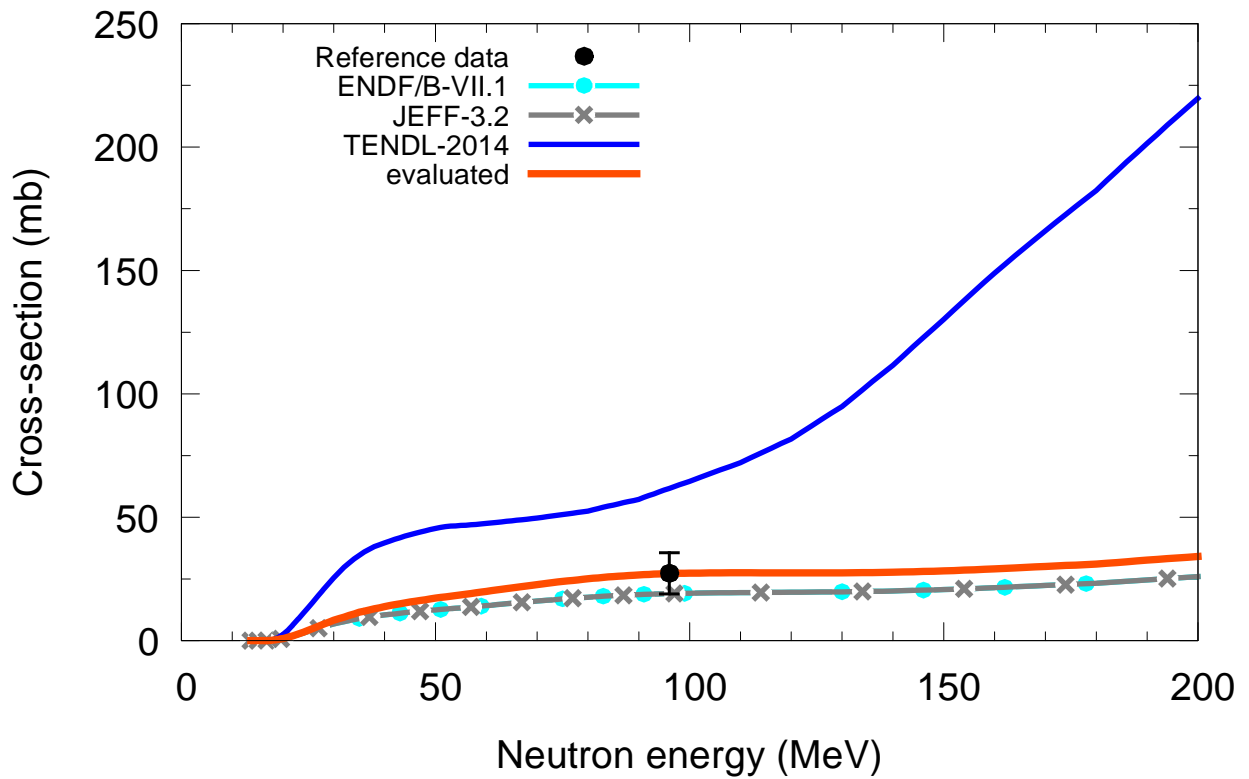
### $^{40}\text{Ca}(n,x)t$



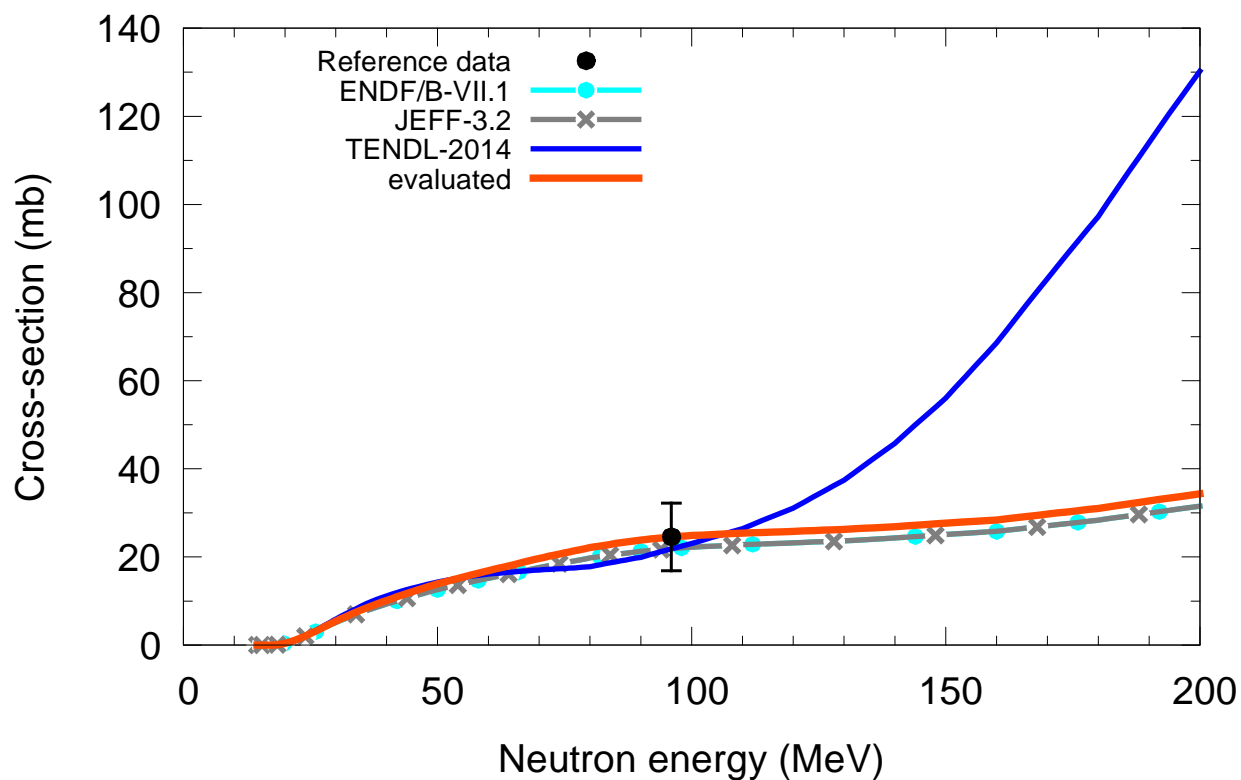
### $^{42}\text{Ca}(n,x)t$



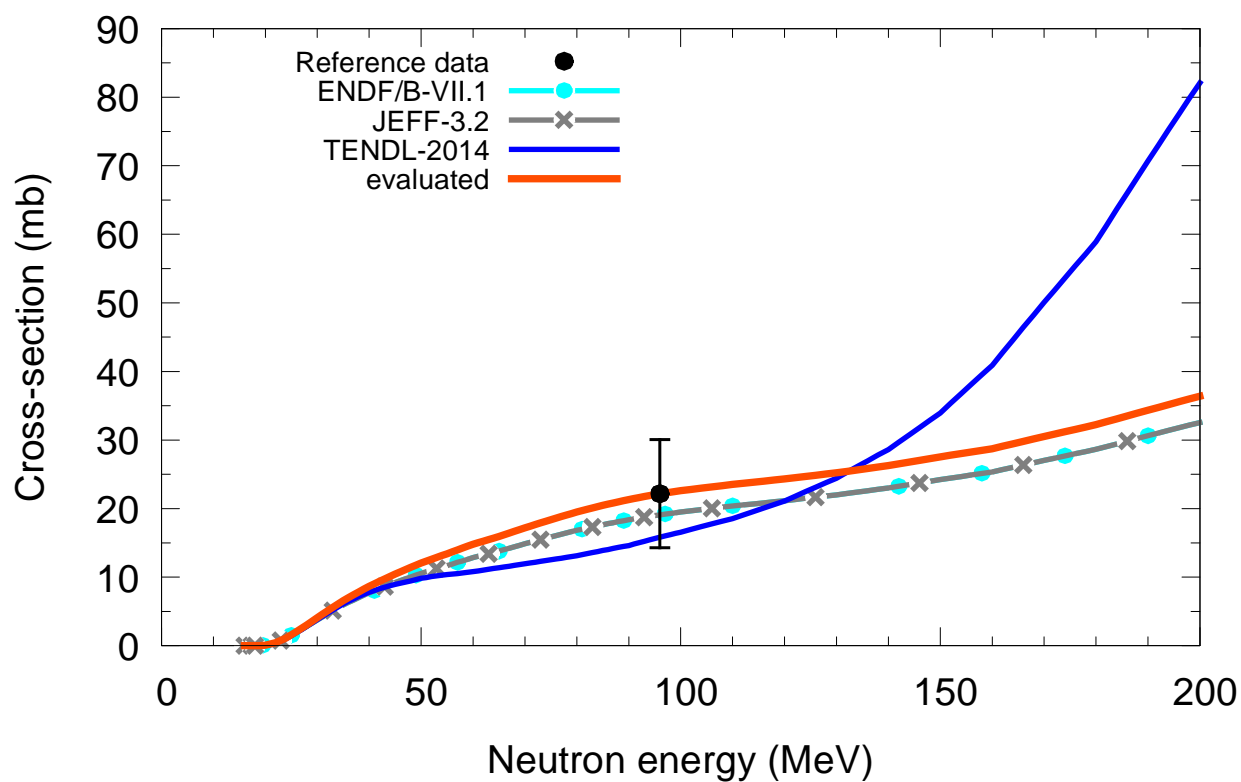


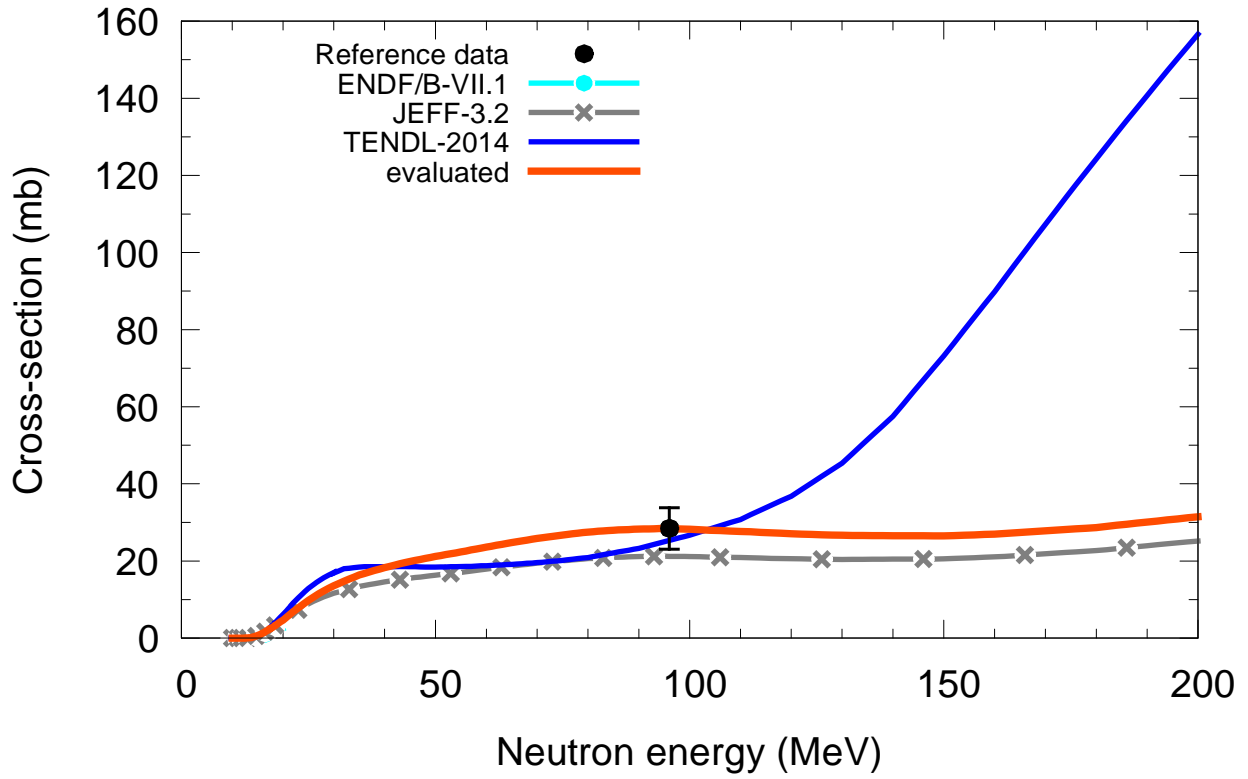
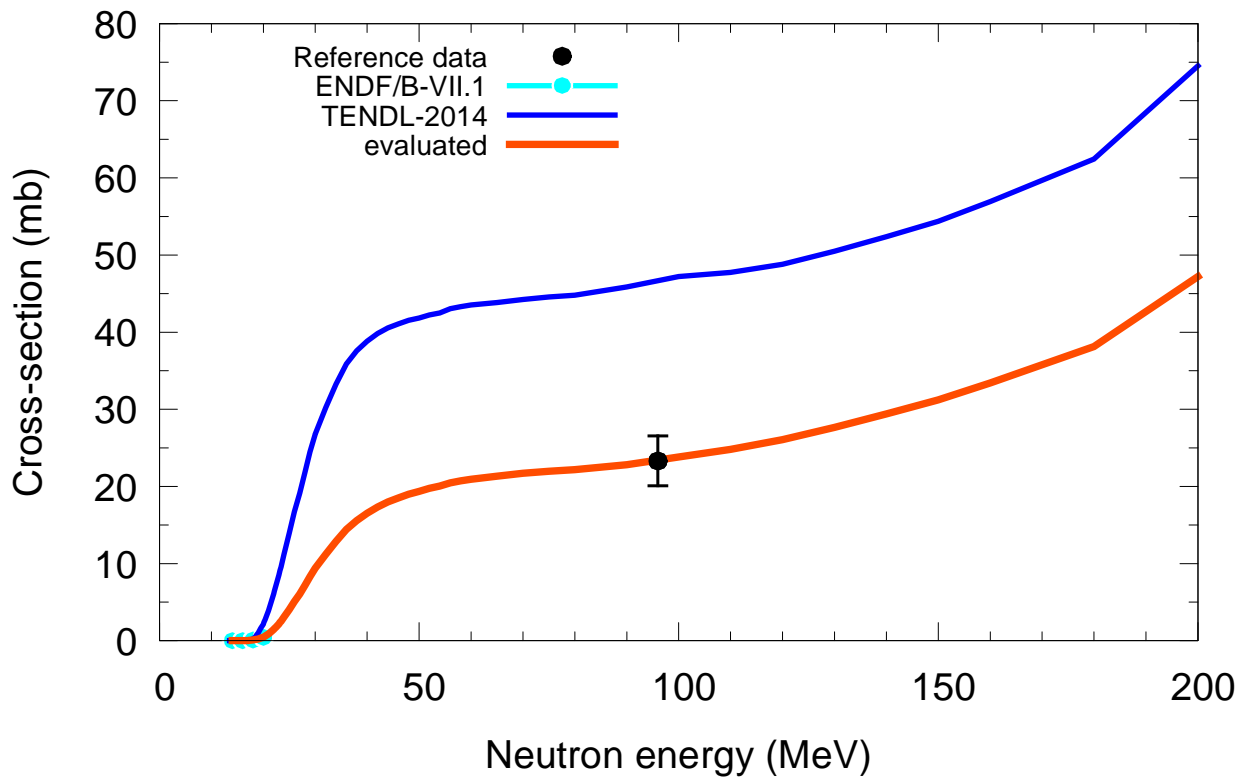
$^{43}\text{Ca}(n,x)t$  $^{44}\text{Ca}(n,x)t$ 

### $^{46}\text{Ca}(n,x)t$

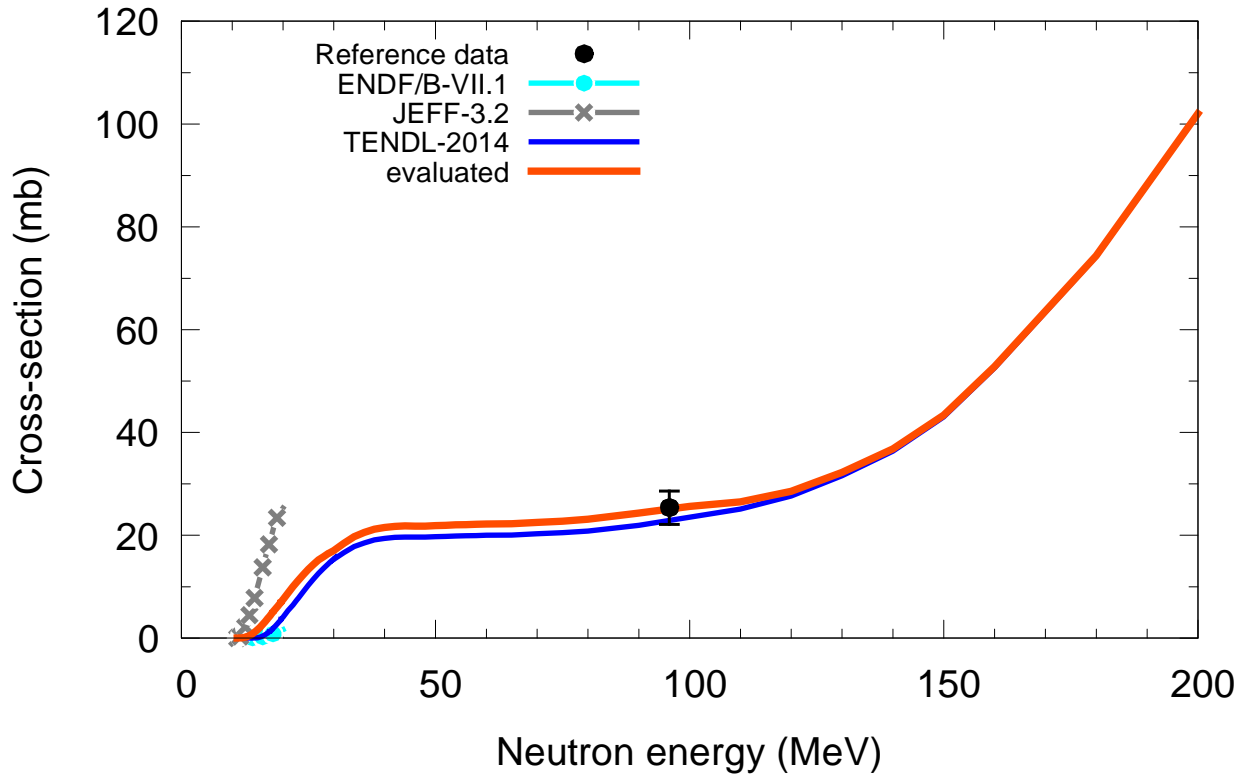


### $^{48}\text{Ca}(n,x)t$

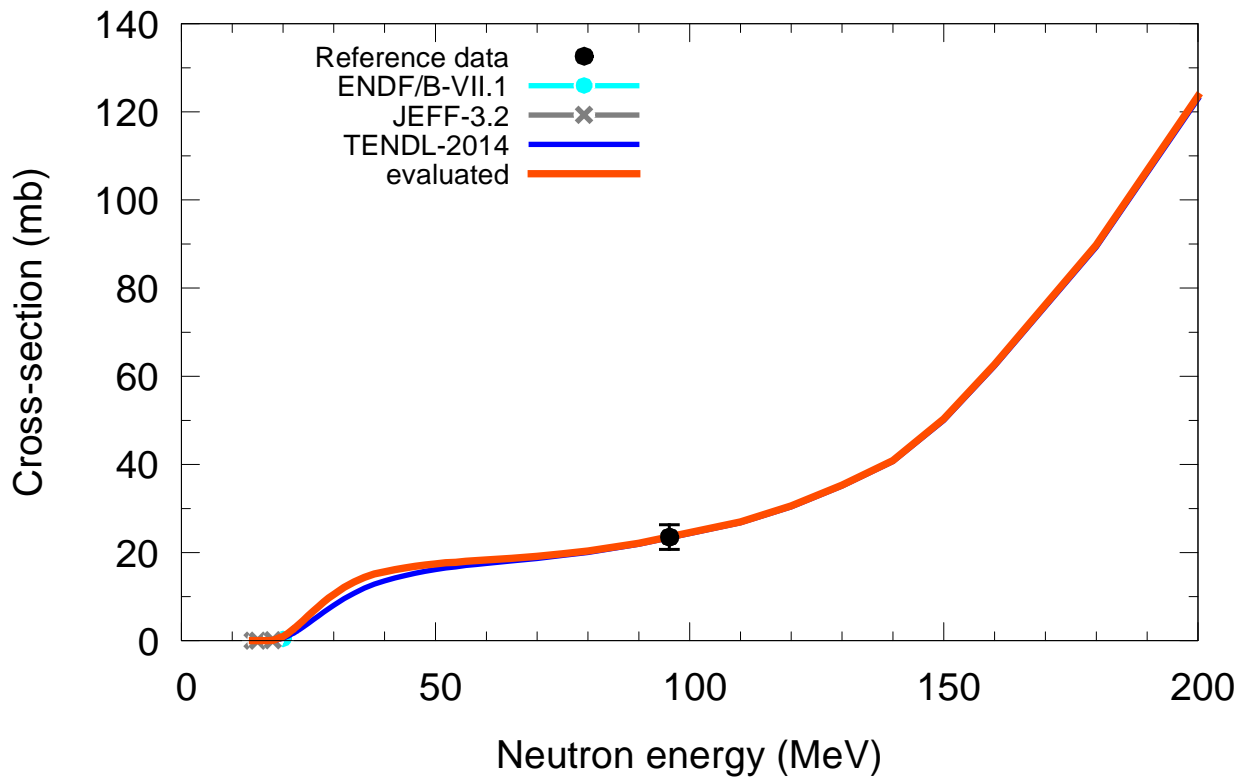


$^{45}\text{Sc}(n,x)t$  $^{46}\text{Ti}(n,x)t$ 

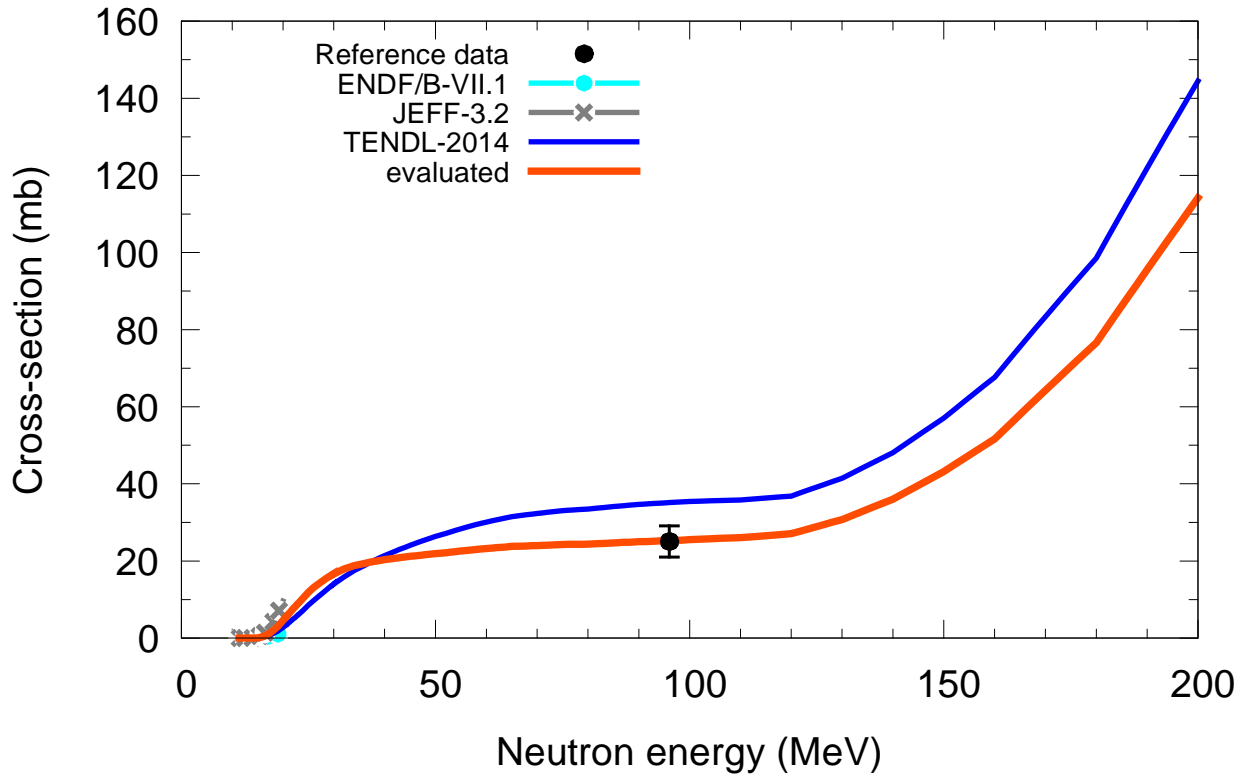
### $^{47}\text{Ti}(n,x)t$



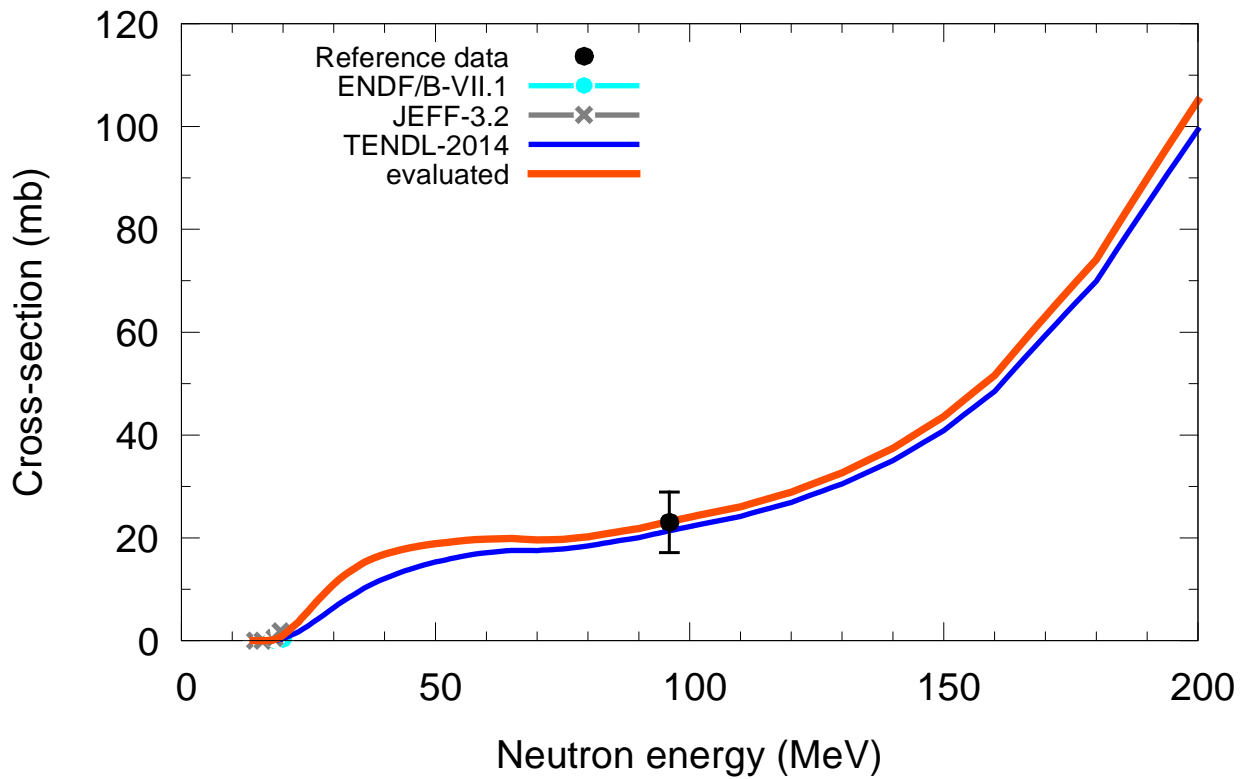
### $^{48}\text{Ti}(n,x)t$

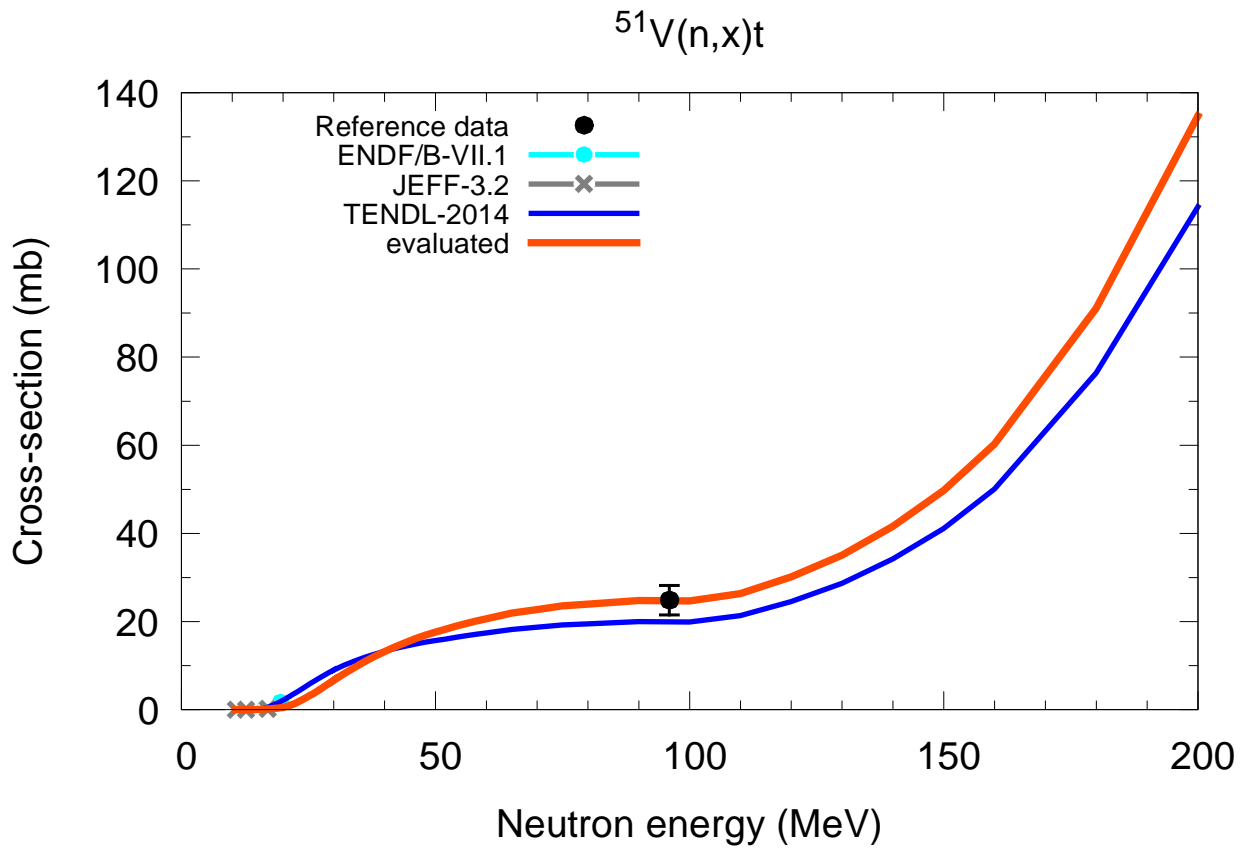
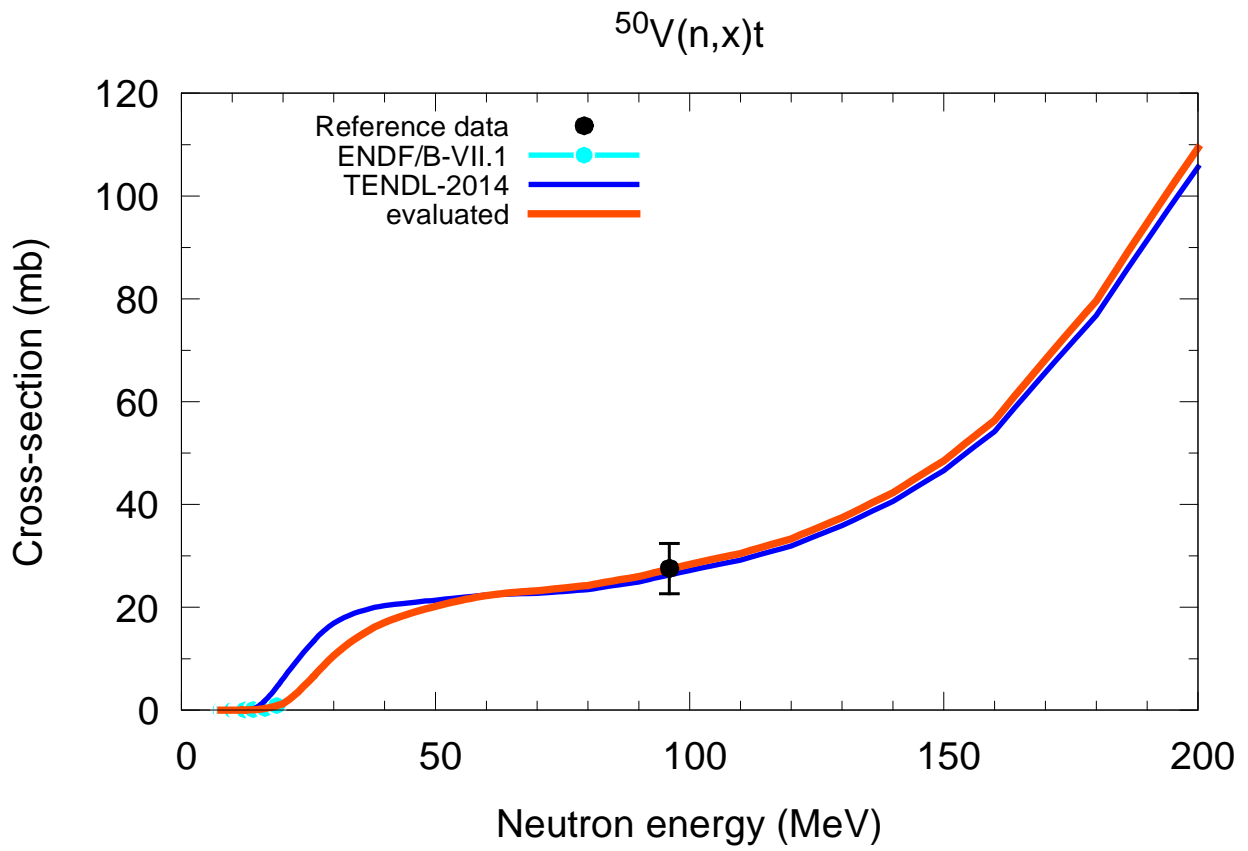


### $^{49}\text{Ti}(n,x)t$

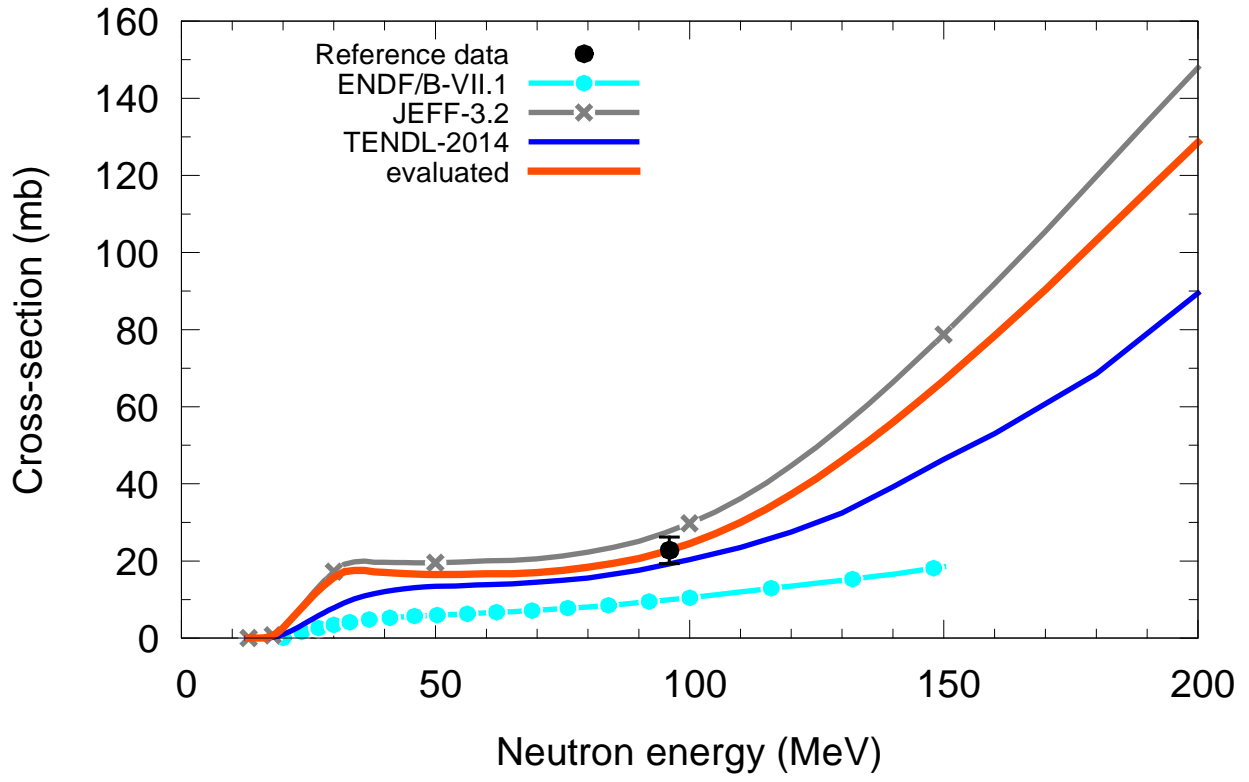


### $^{50}\text{Ti}(n,x)t$

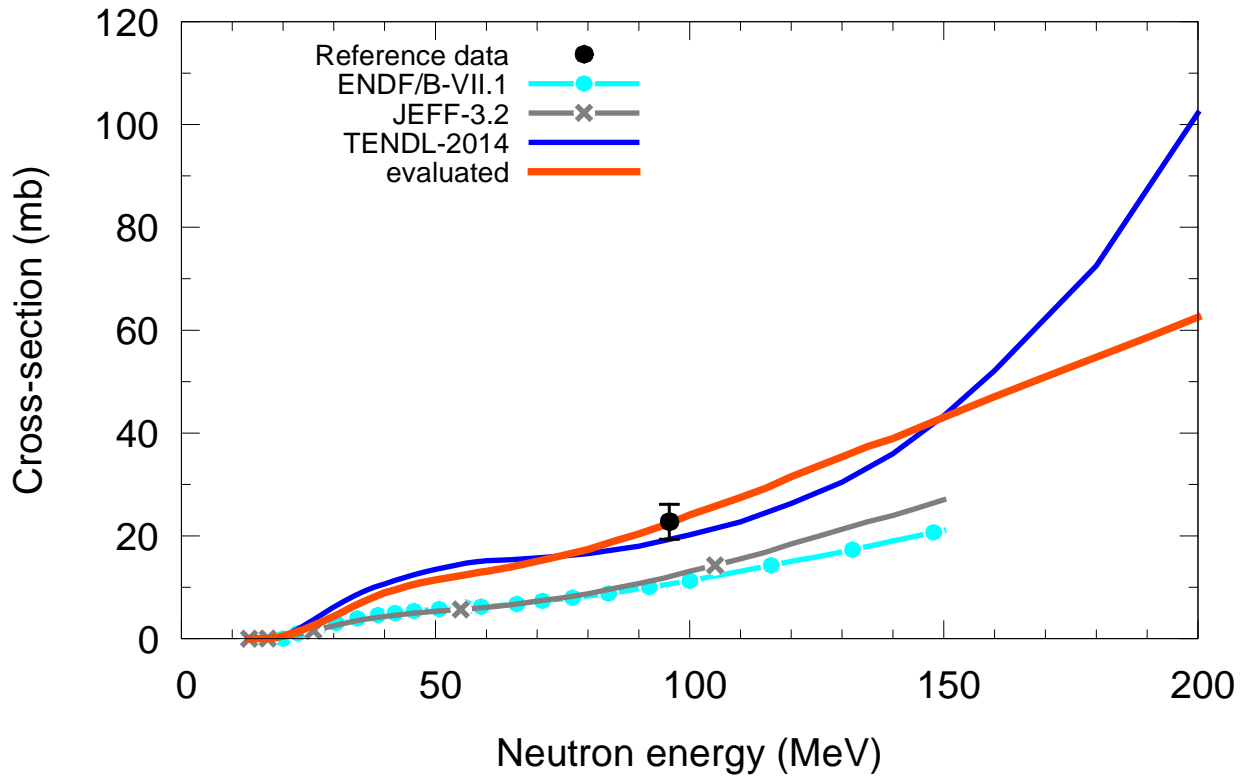


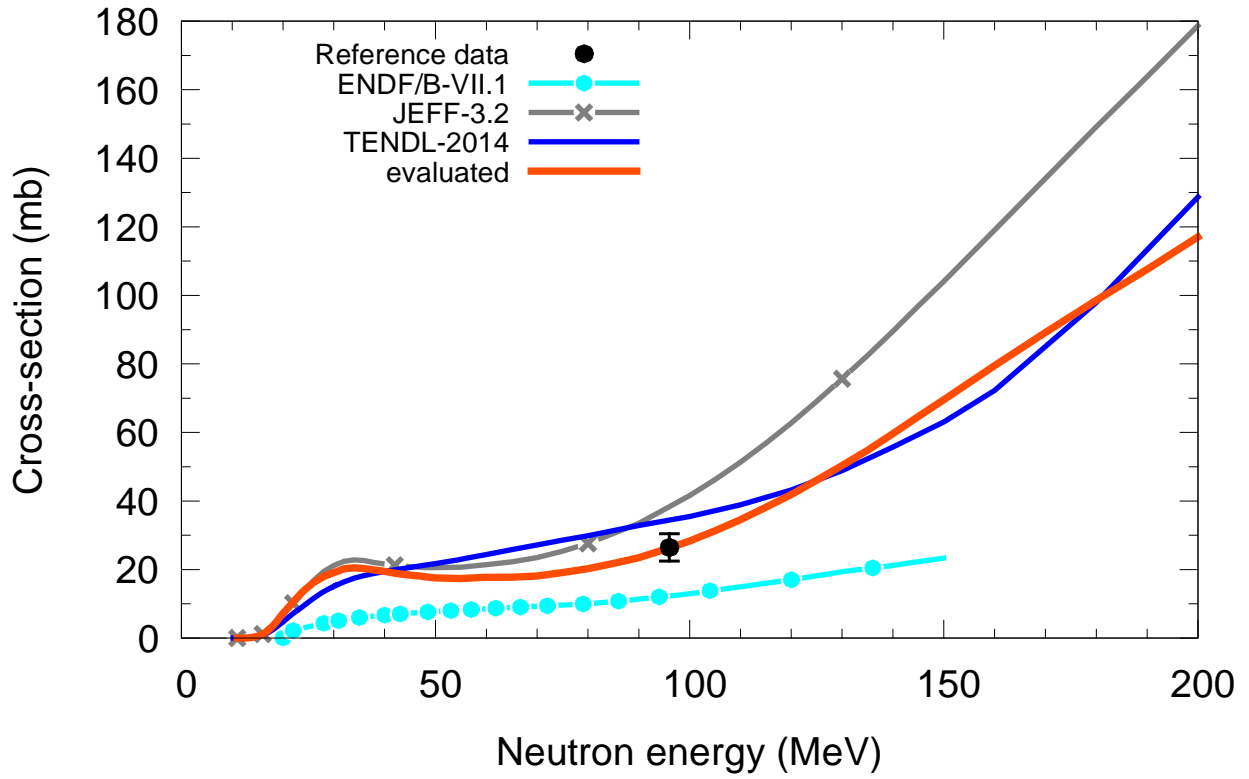
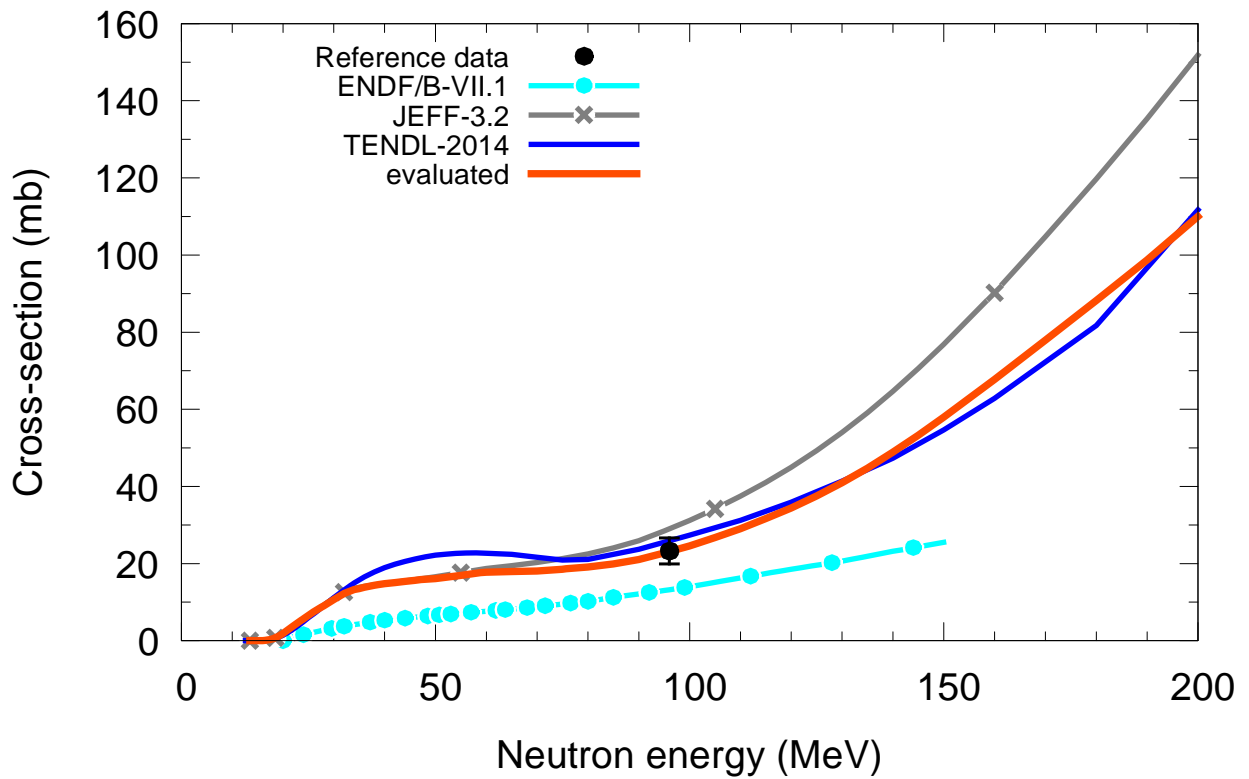


$^{50}\text{Cr}(n,x)t$

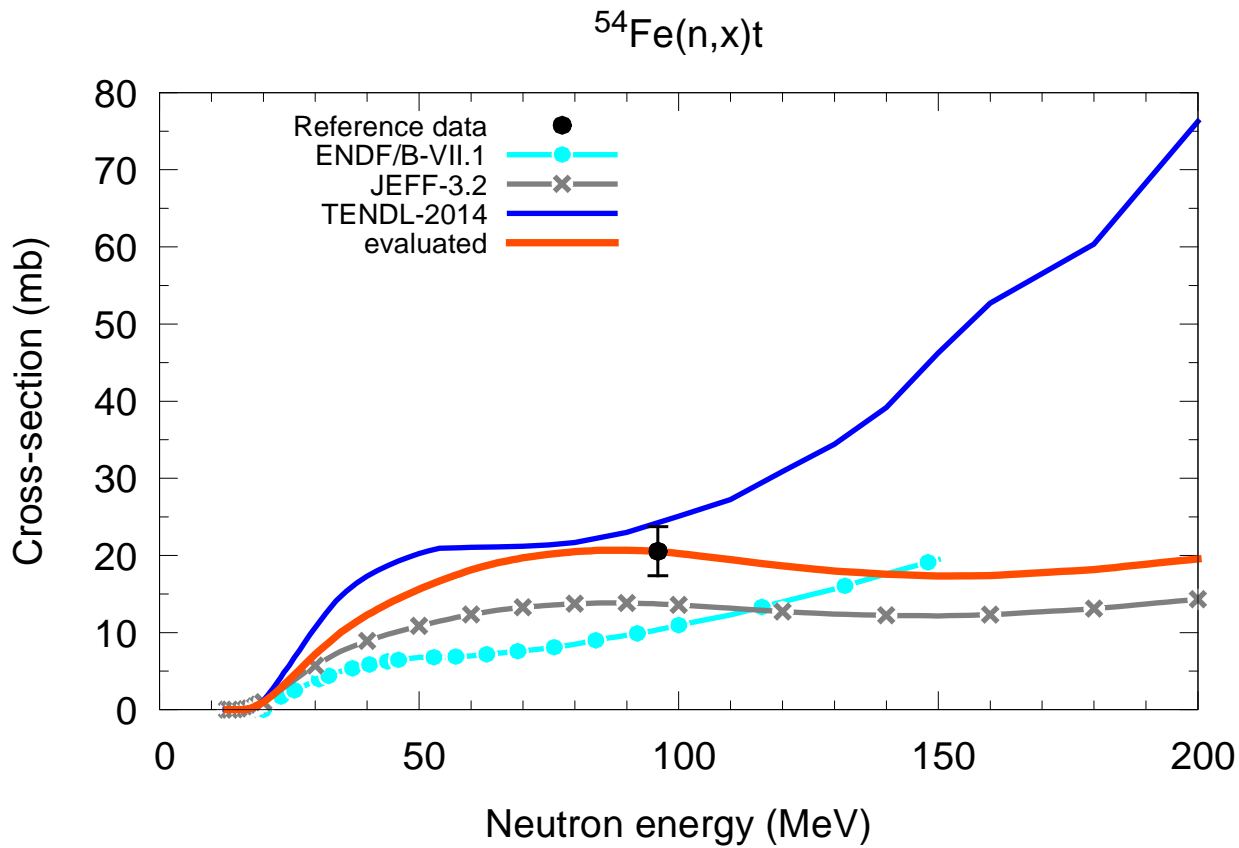
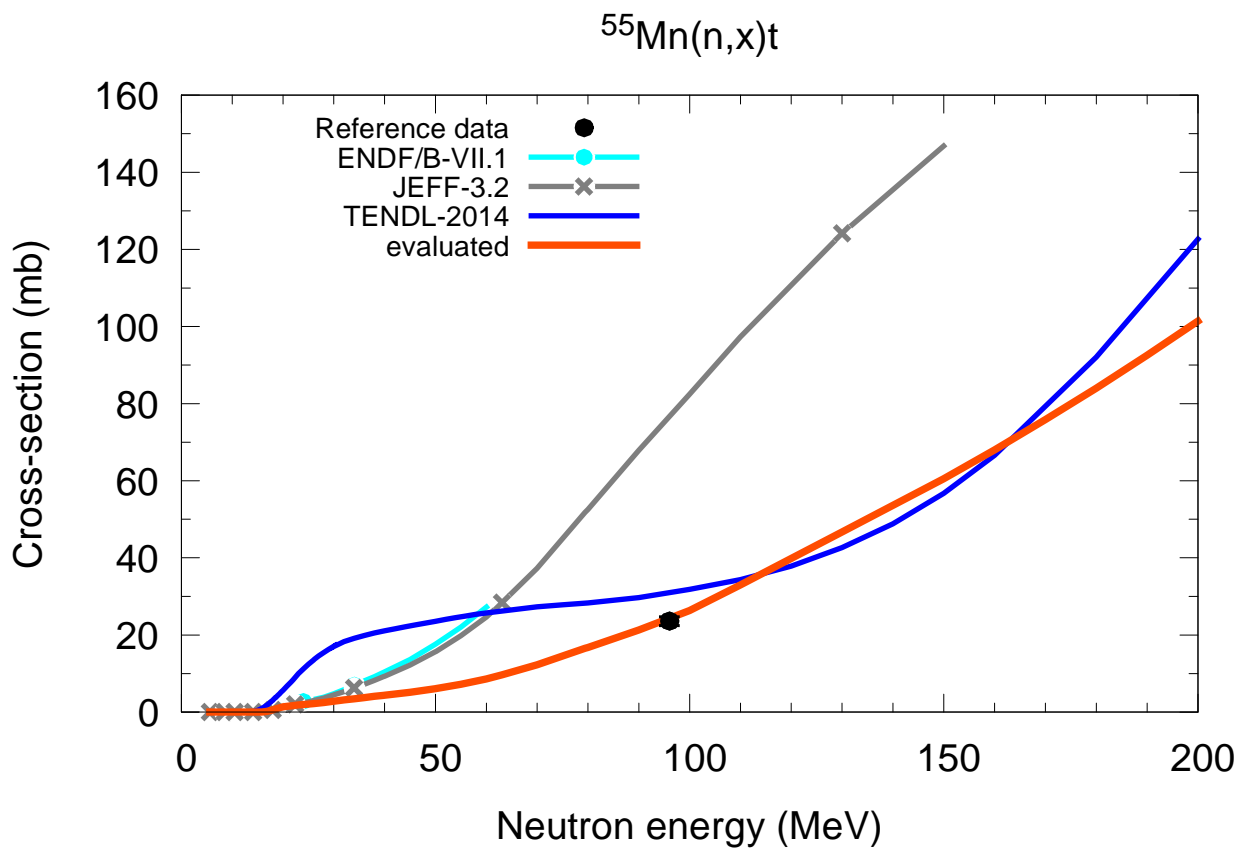


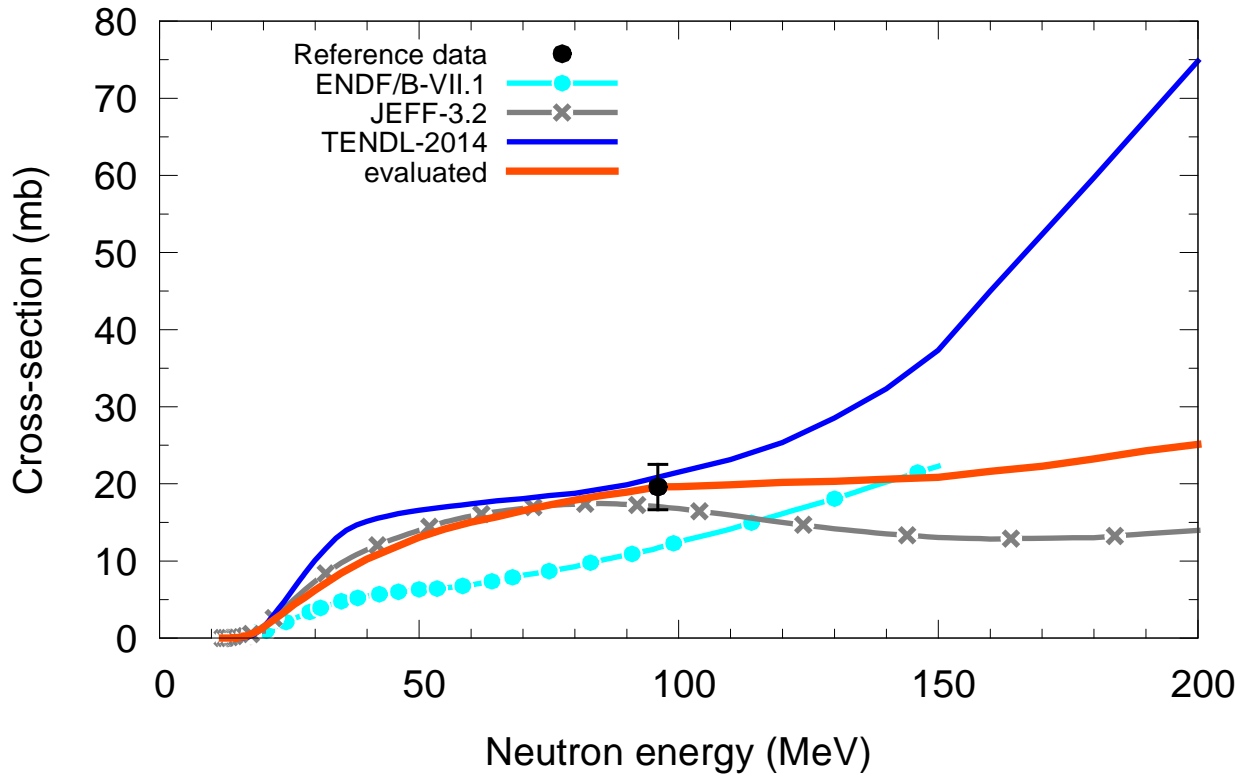
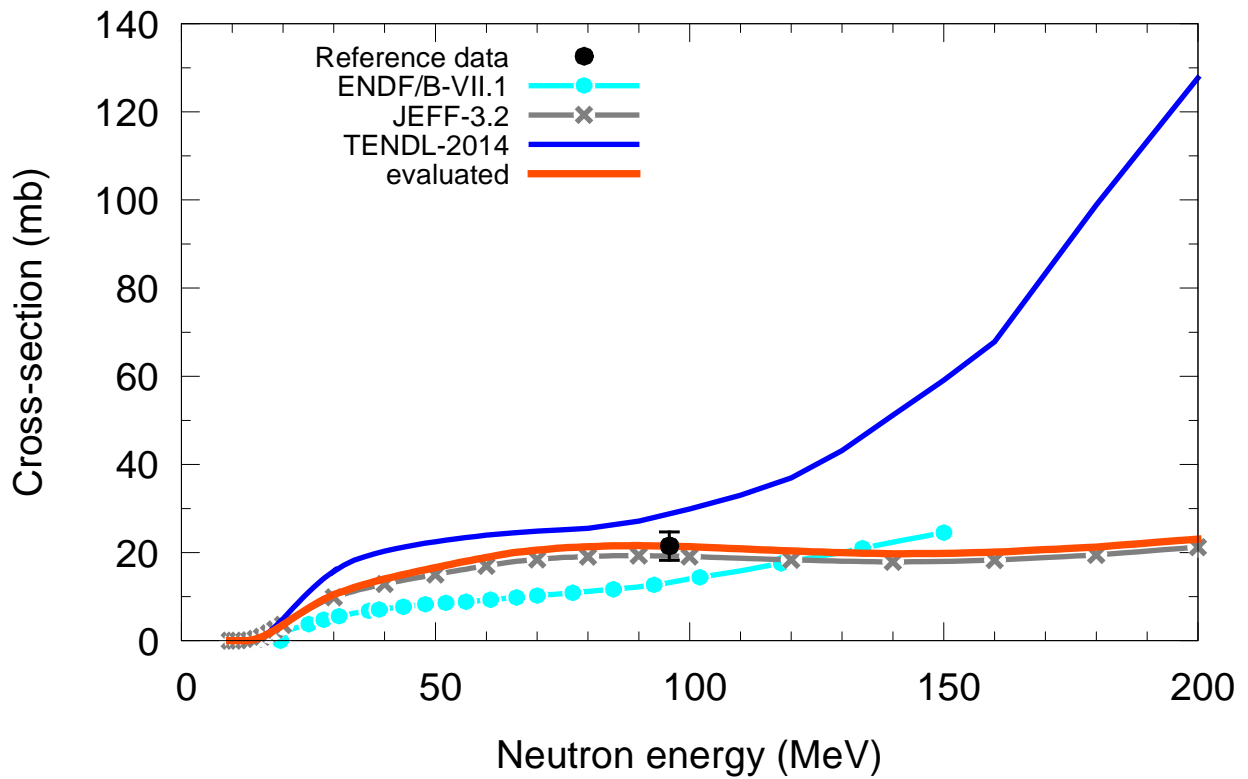
$^{52}\text{Cr}(n,x)t$

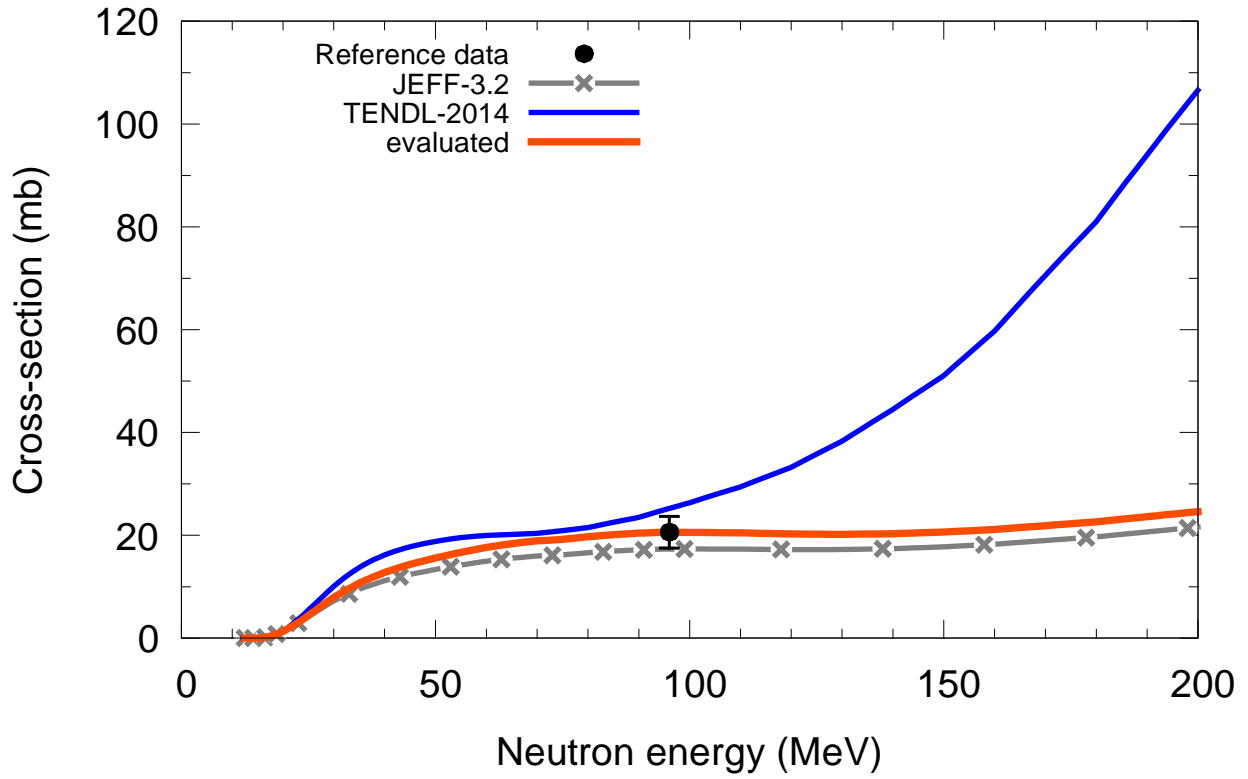
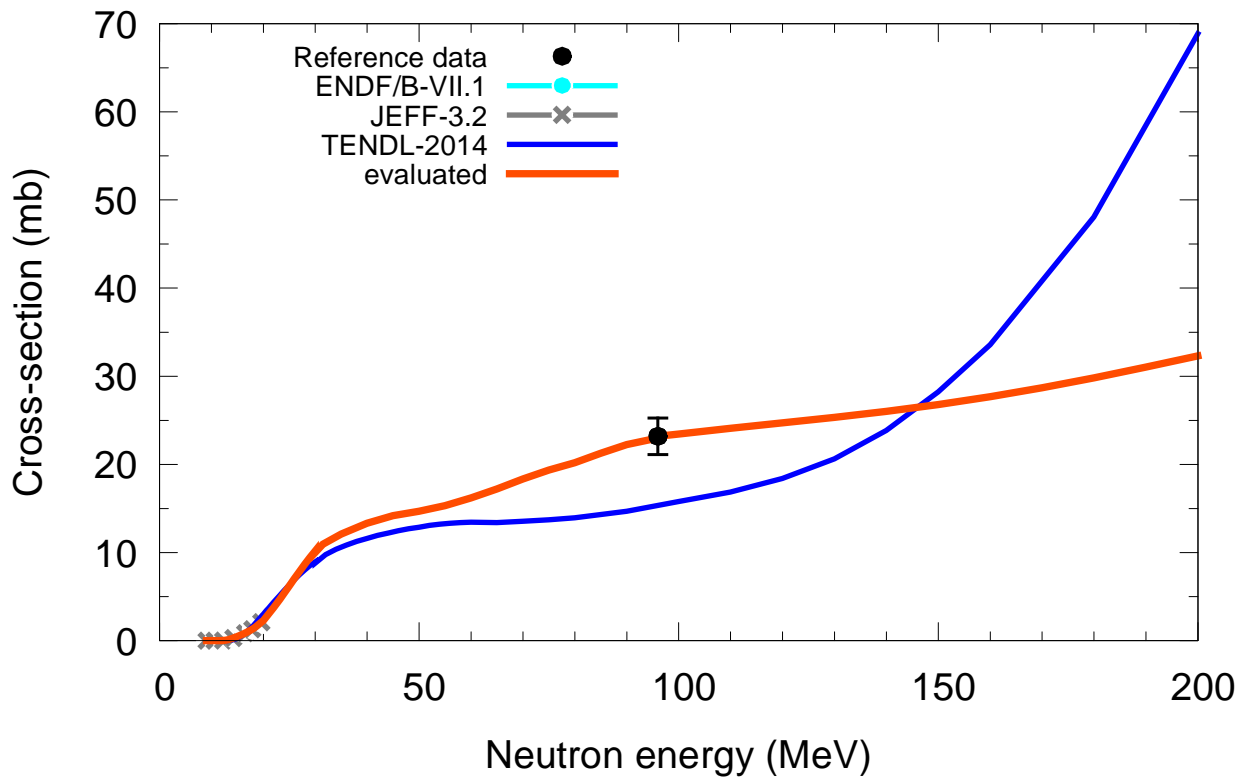


$^{53}\text{Cr}(n,x)t$  $^{54}\text{Cr}(n,x)t$ 

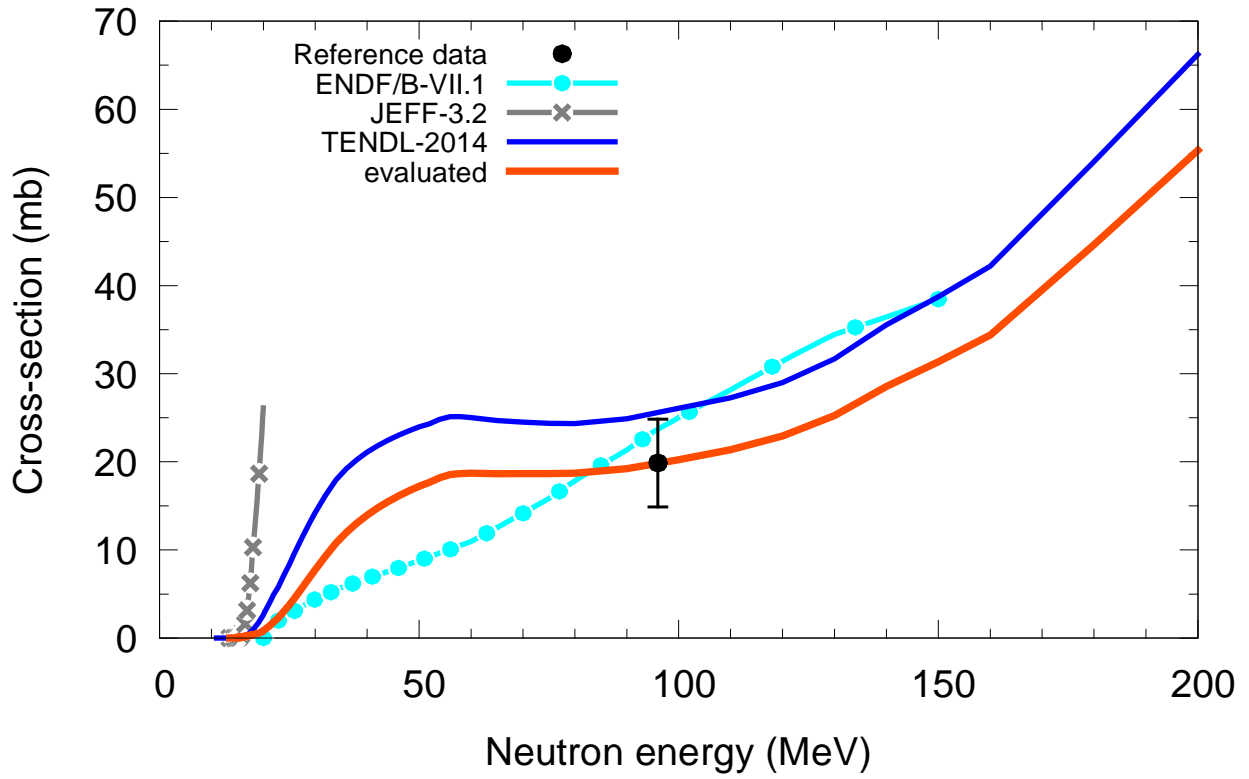




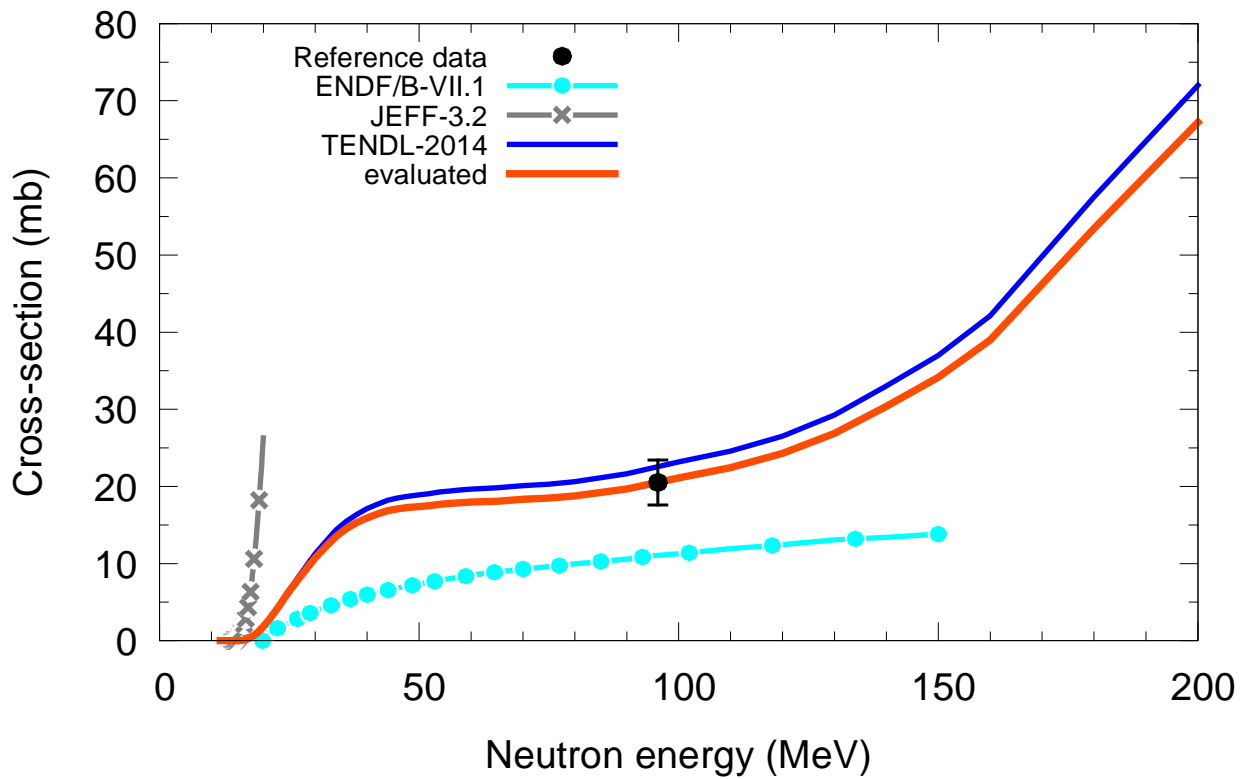
$^{56}\text{Fe}(n,x)t$  $^{57}\text{Fe}(n,x)t$ 

$^{58}\text{Fe}(n,x)t$  $^{59}\text{Co}(n,x)t$ 

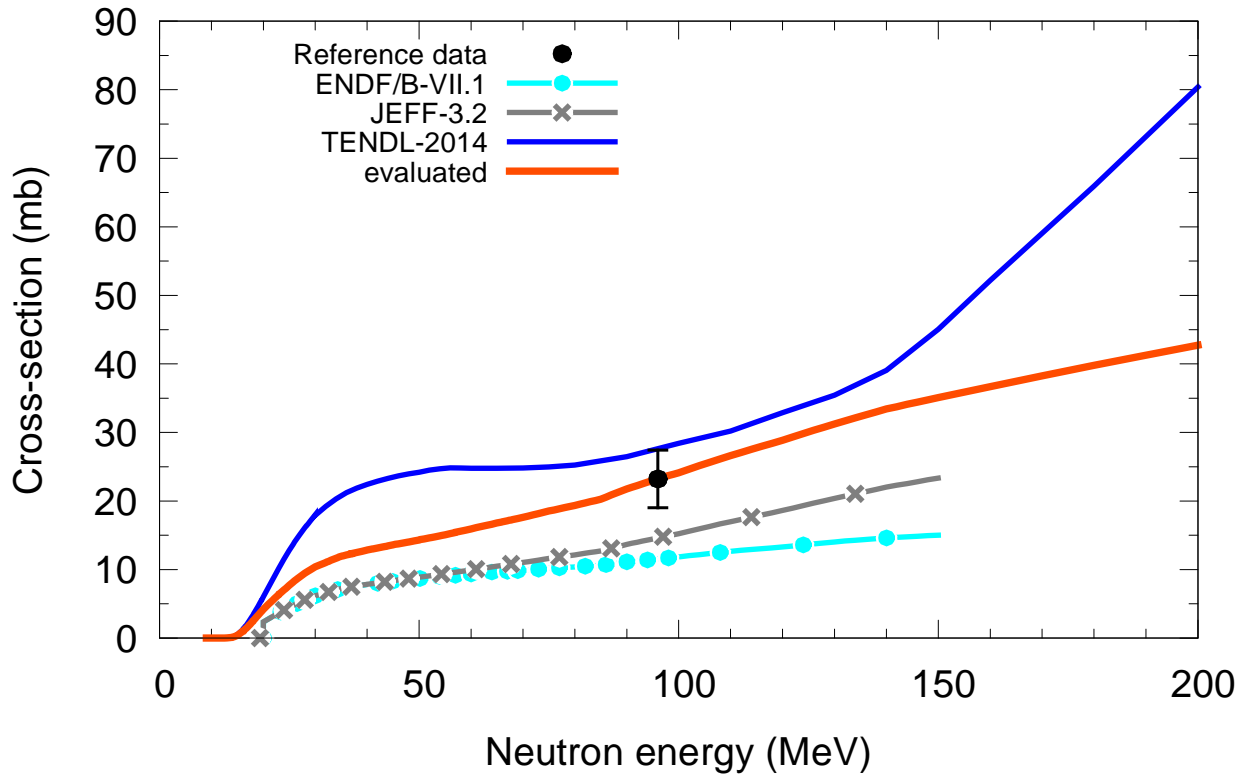
$^{58}\text{Ni}(n,x)t$



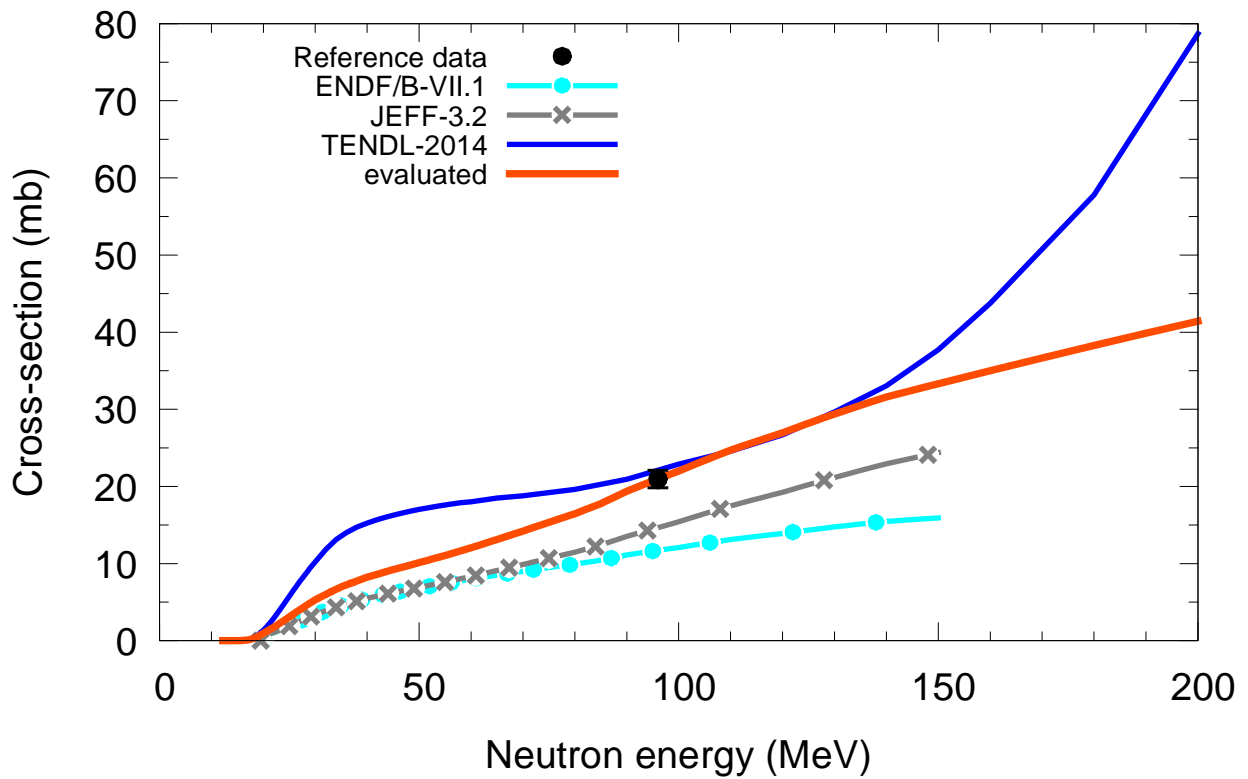
$^{60}\text{Ni}(n,x)t$

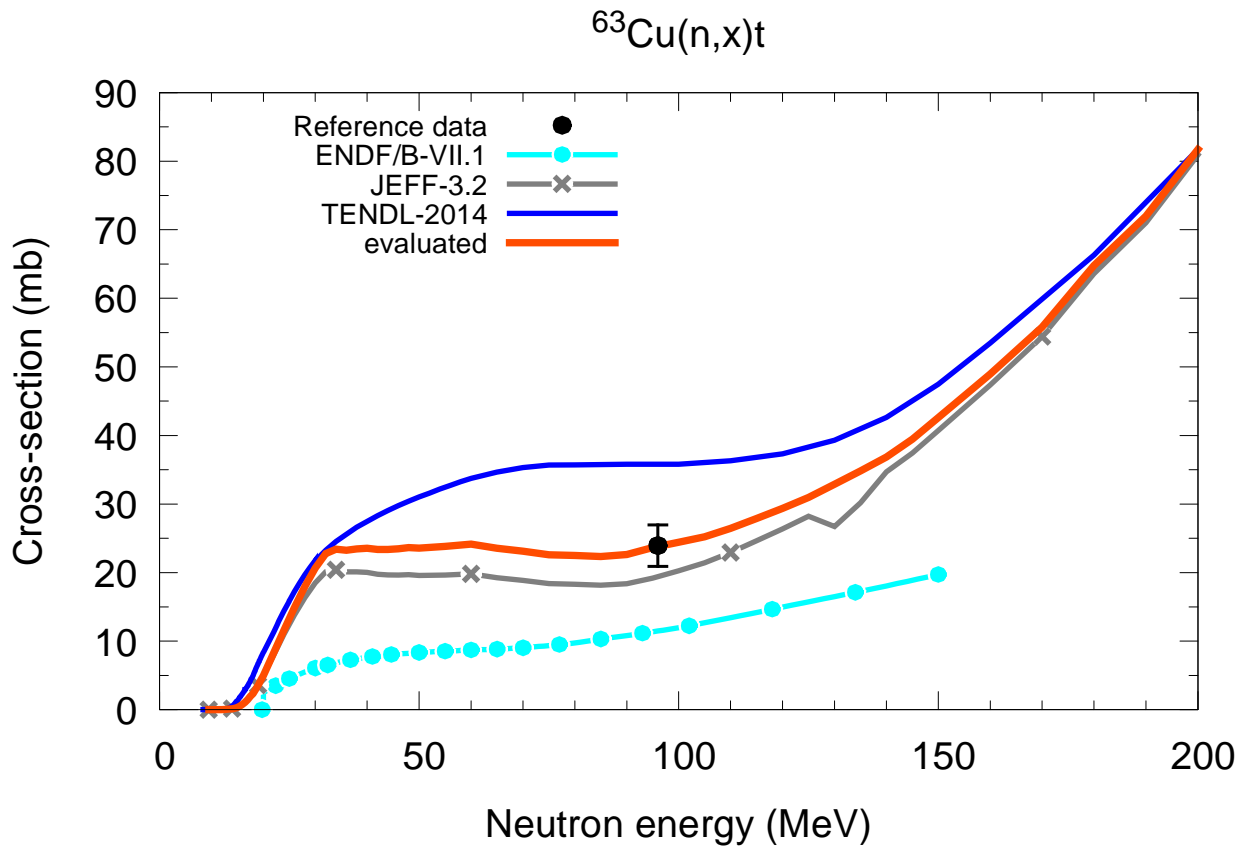
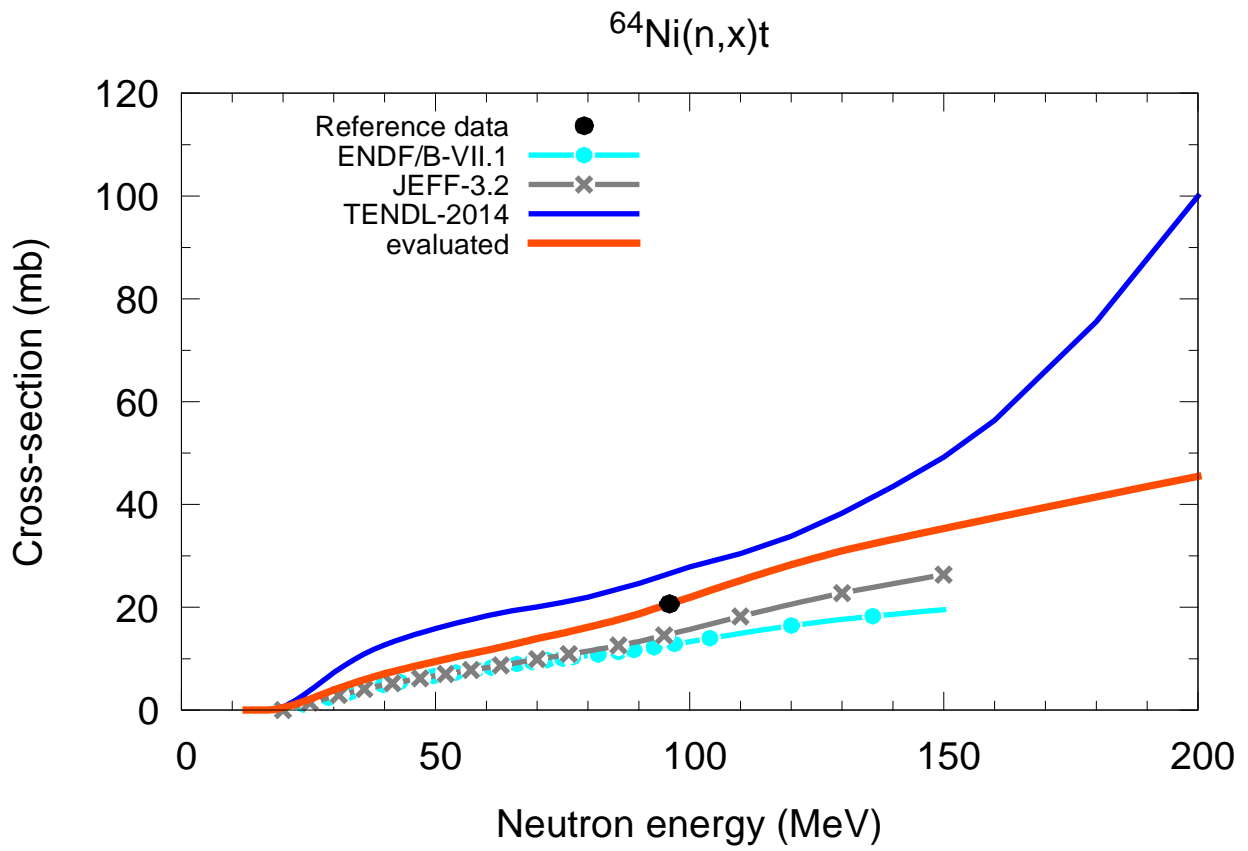


### $^{61}\text{Ni}(n,x)t$

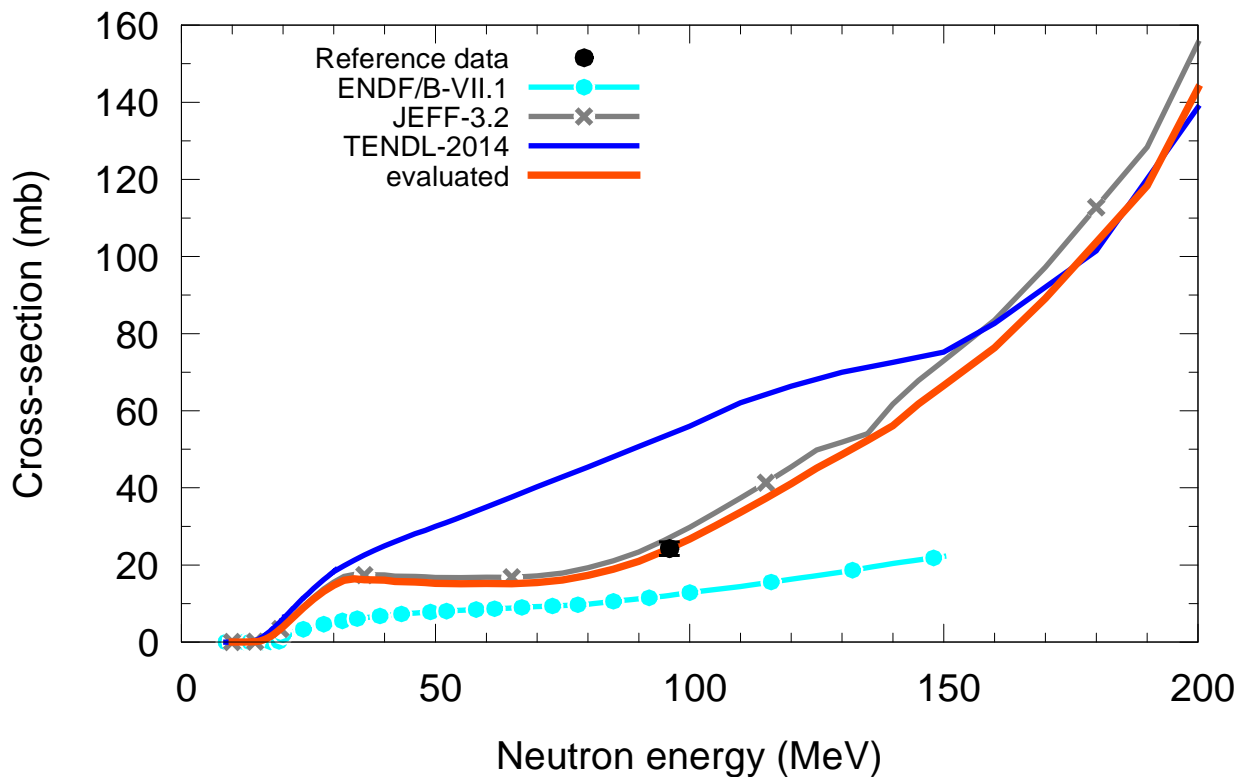


### $^{62}\text{Ni}(n,x)t$

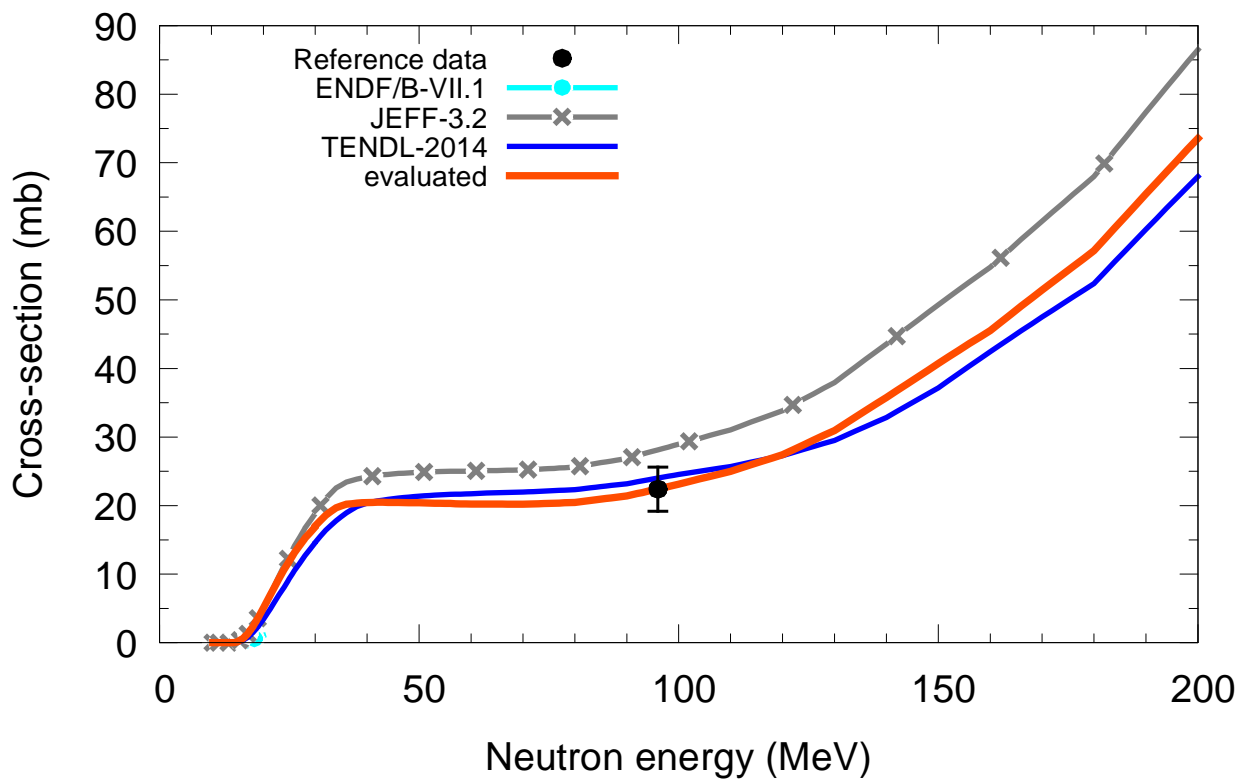


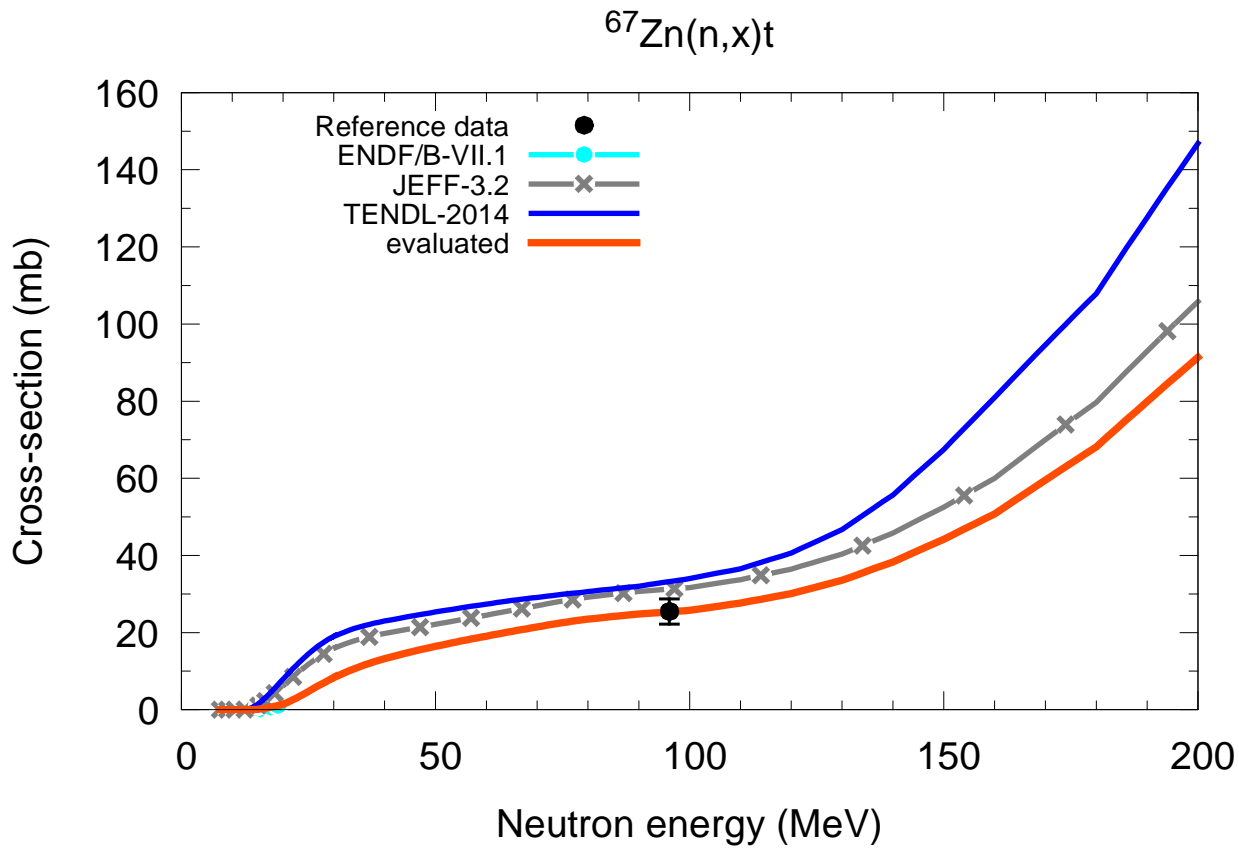
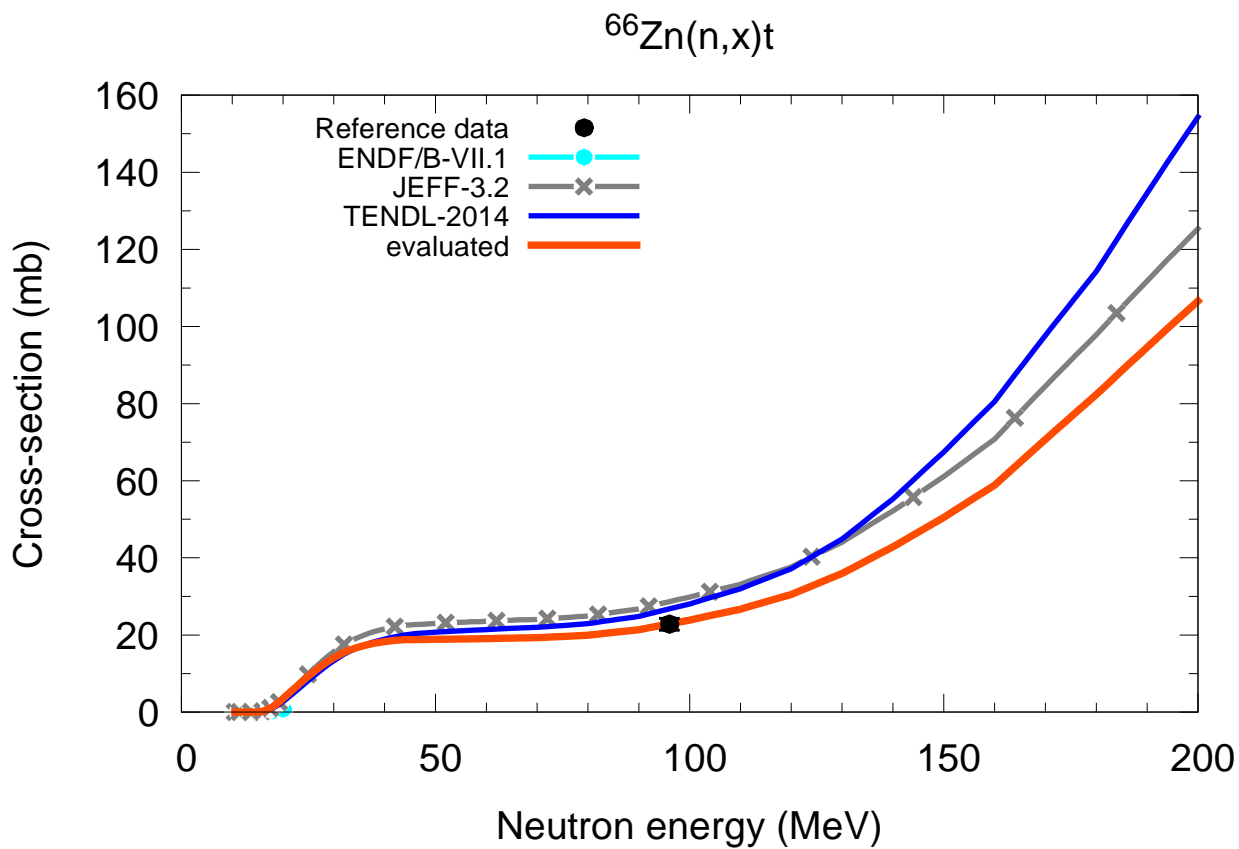


### $^{65}\text{Cu}(n,x)t$

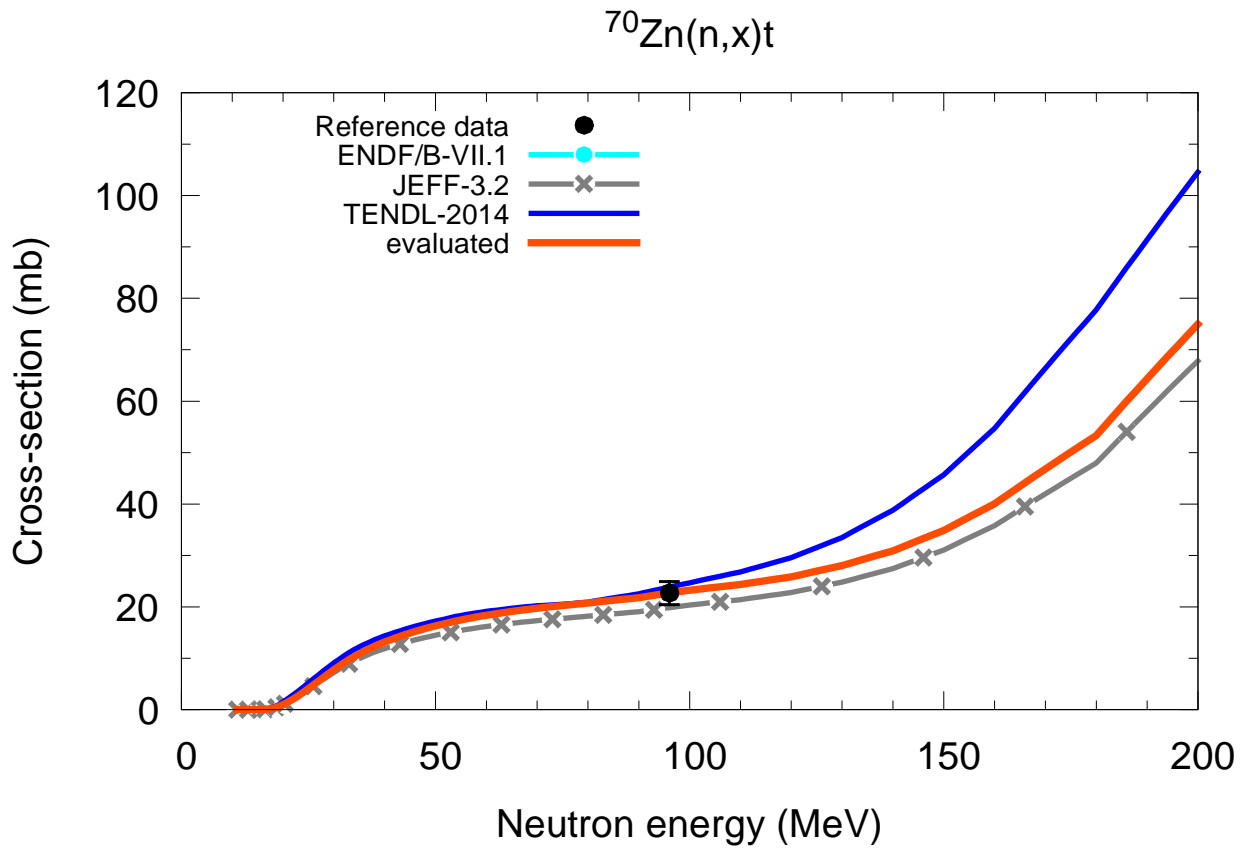
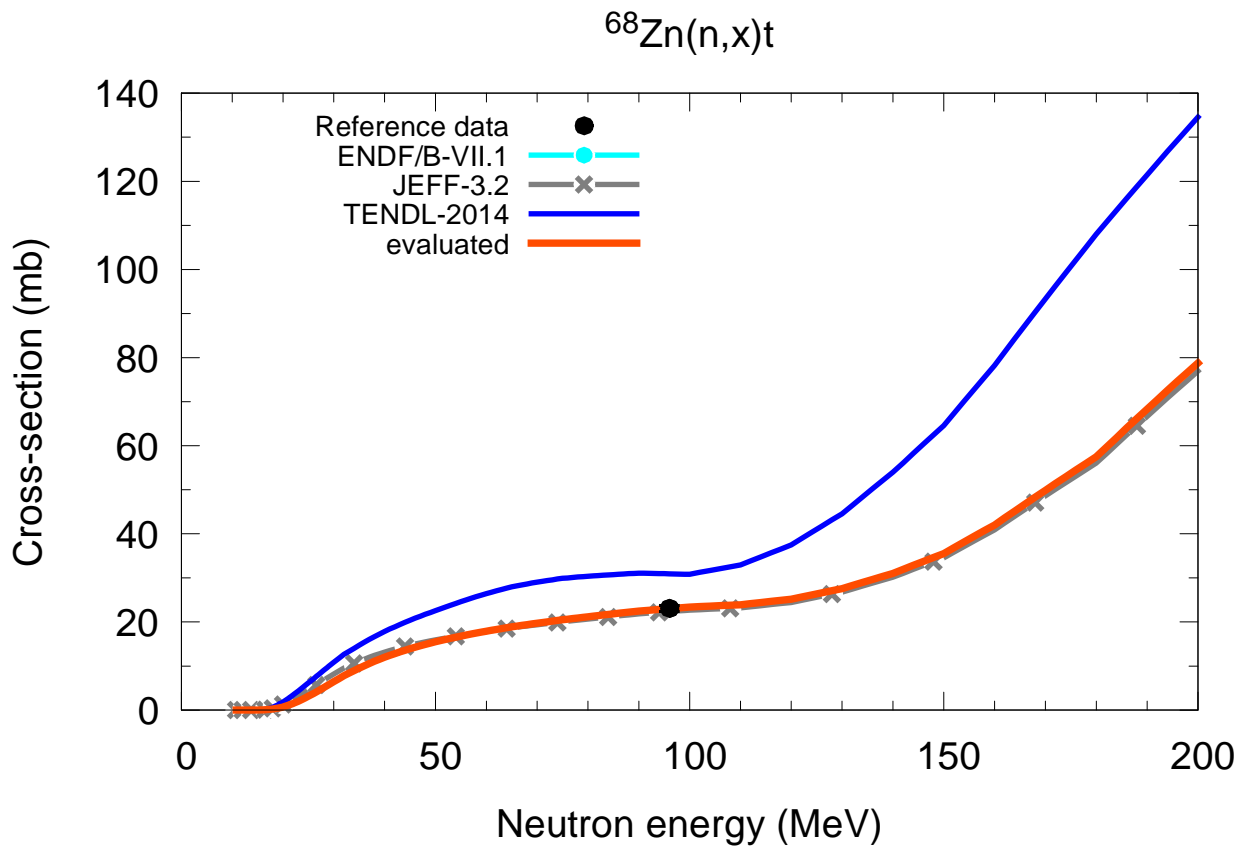


### $^{64}\text{Zn}(n,x)t$

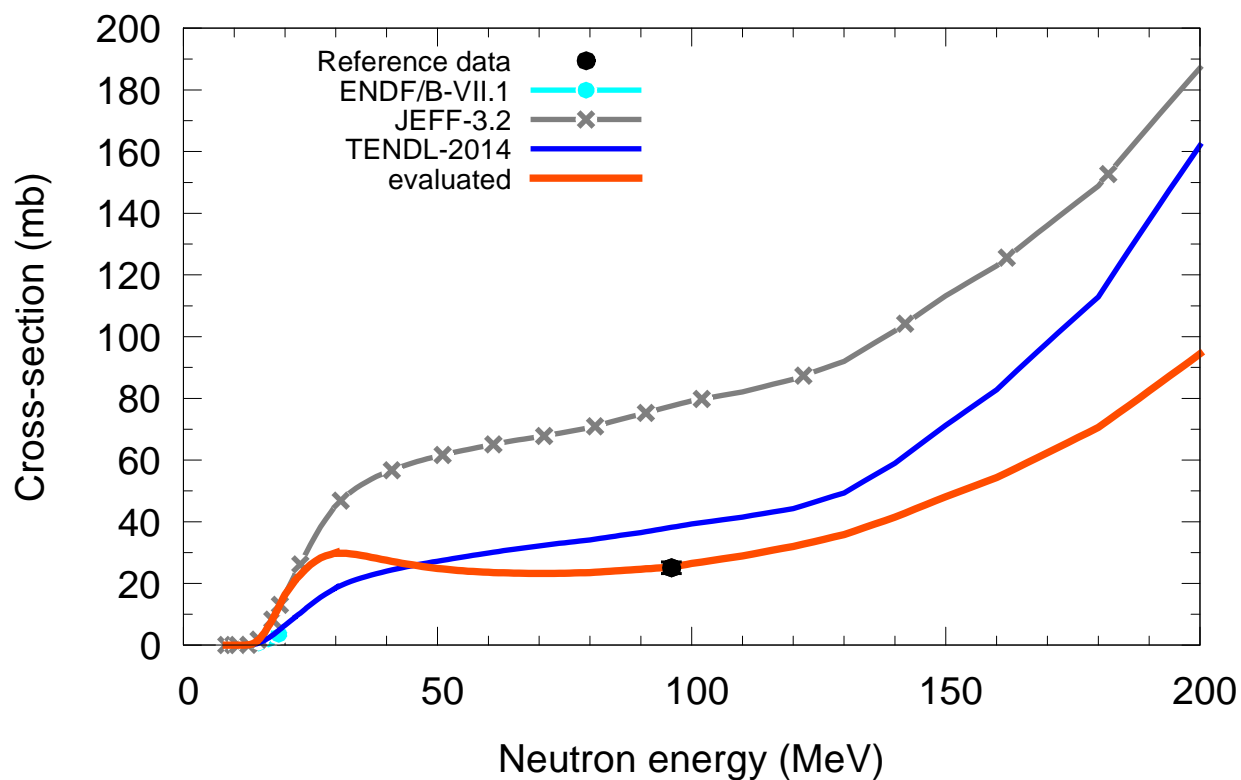




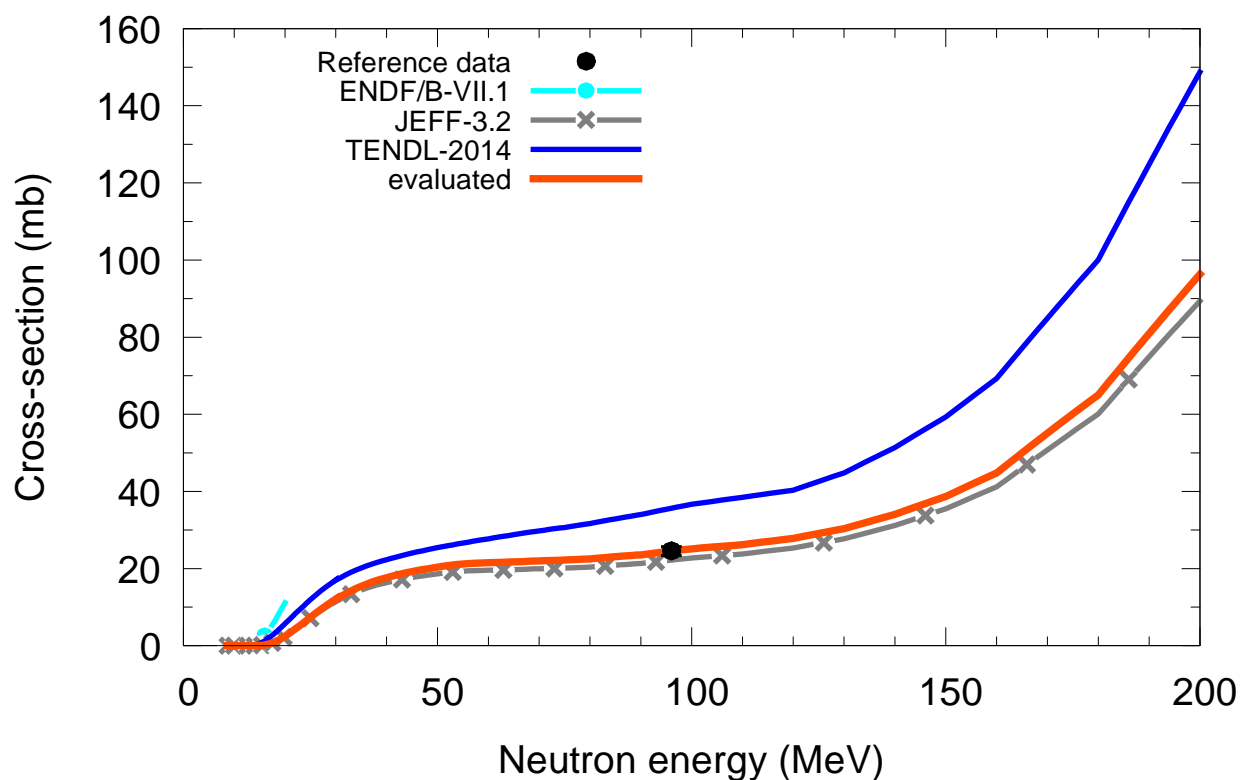




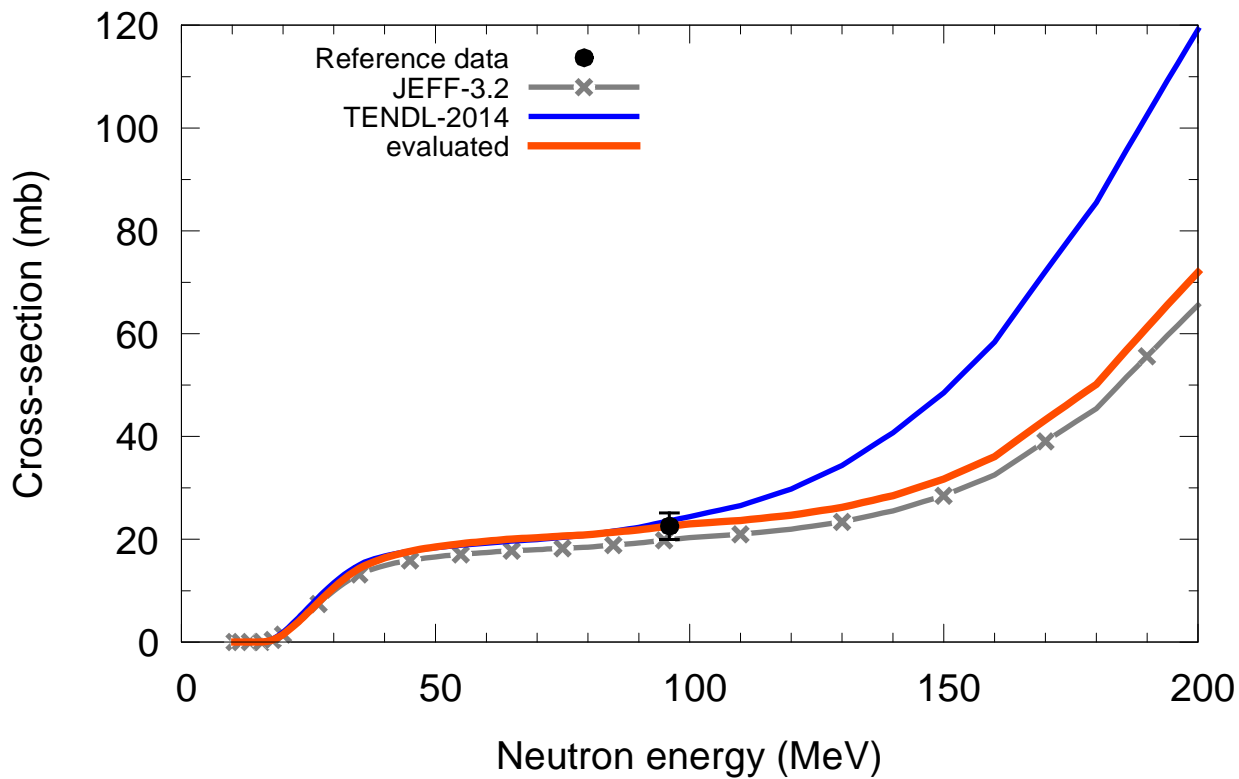
### $^{69}\text{Ga}(n,x)t$



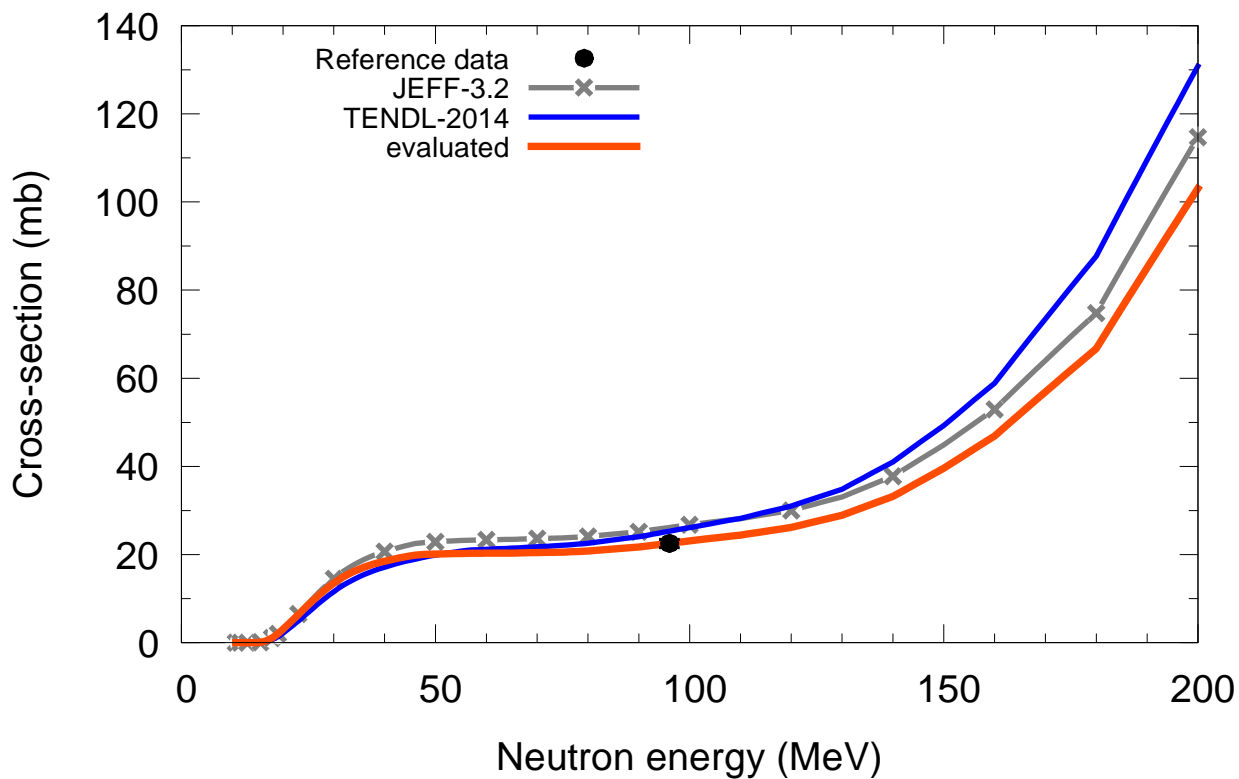
### $^{71}\text{Ga}(n,x)t$



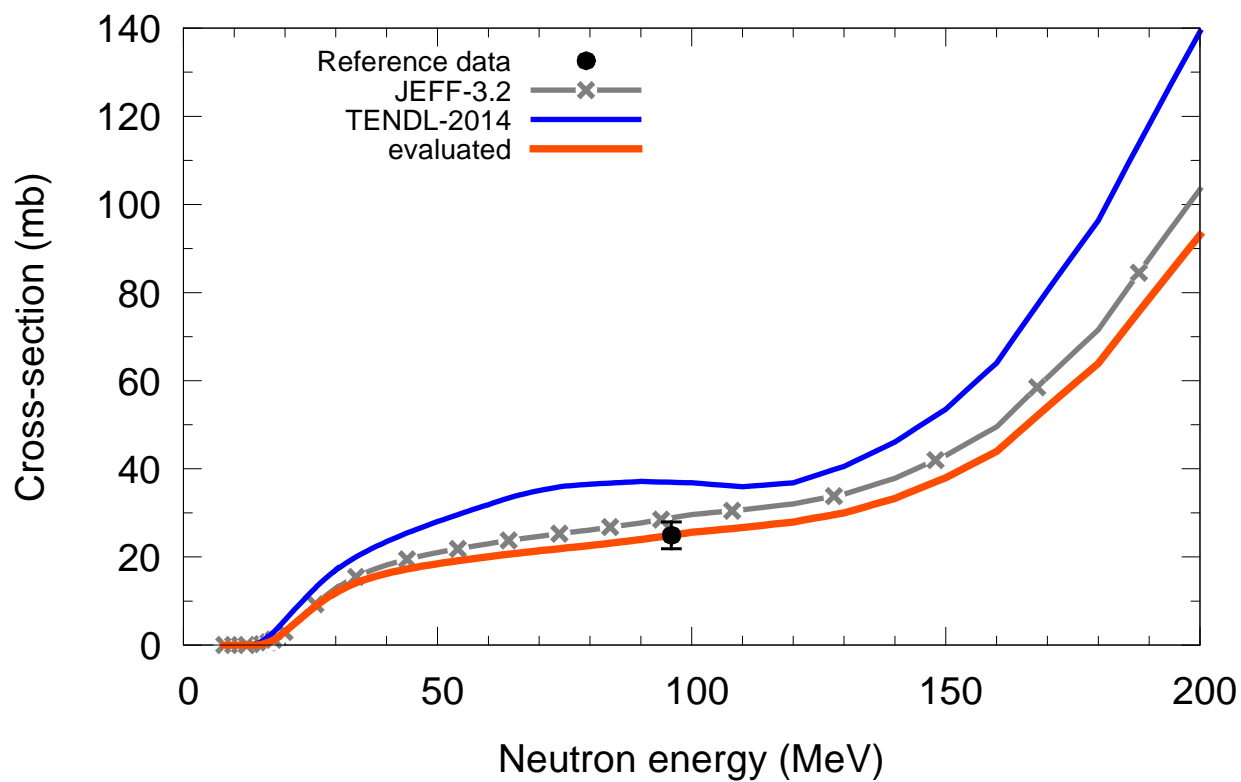
$^{70}\text{Ge}(n,x)t$



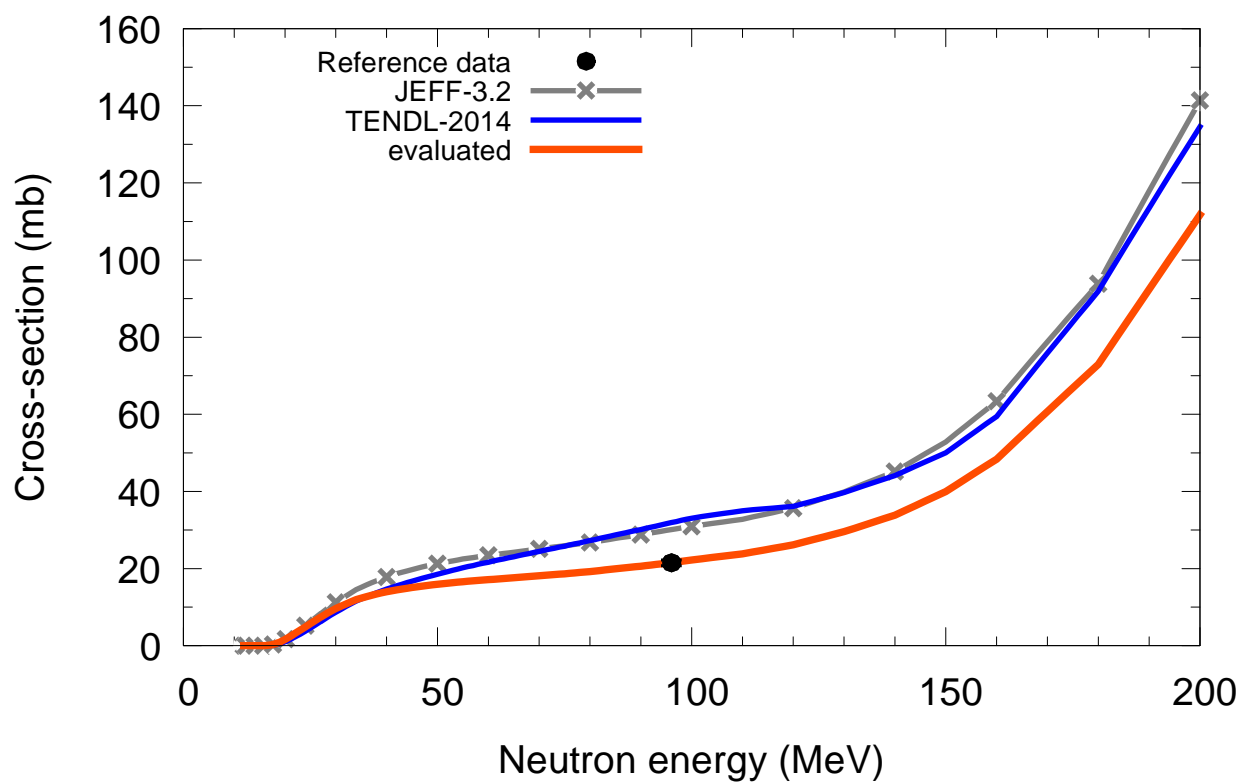
$^{72}\text{Ge}(n,x)t$



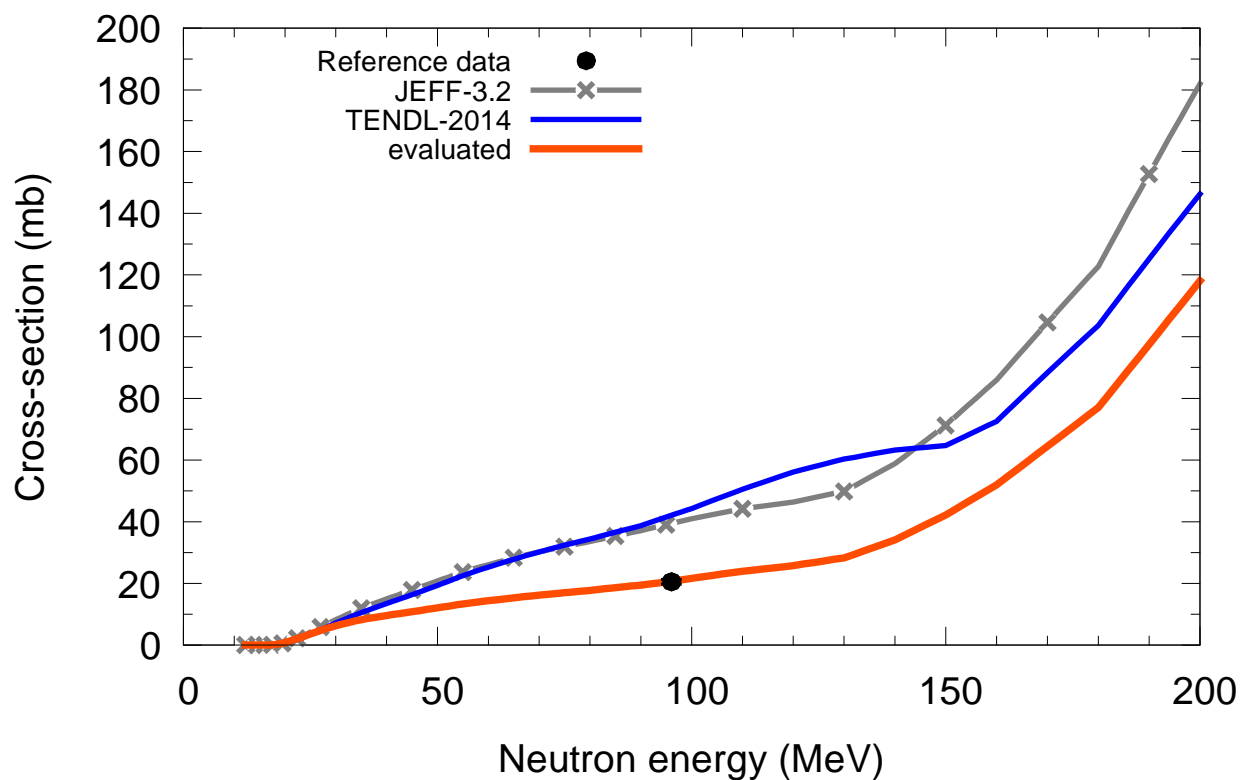
### $^{73}\text{Ge}(n,x)t$



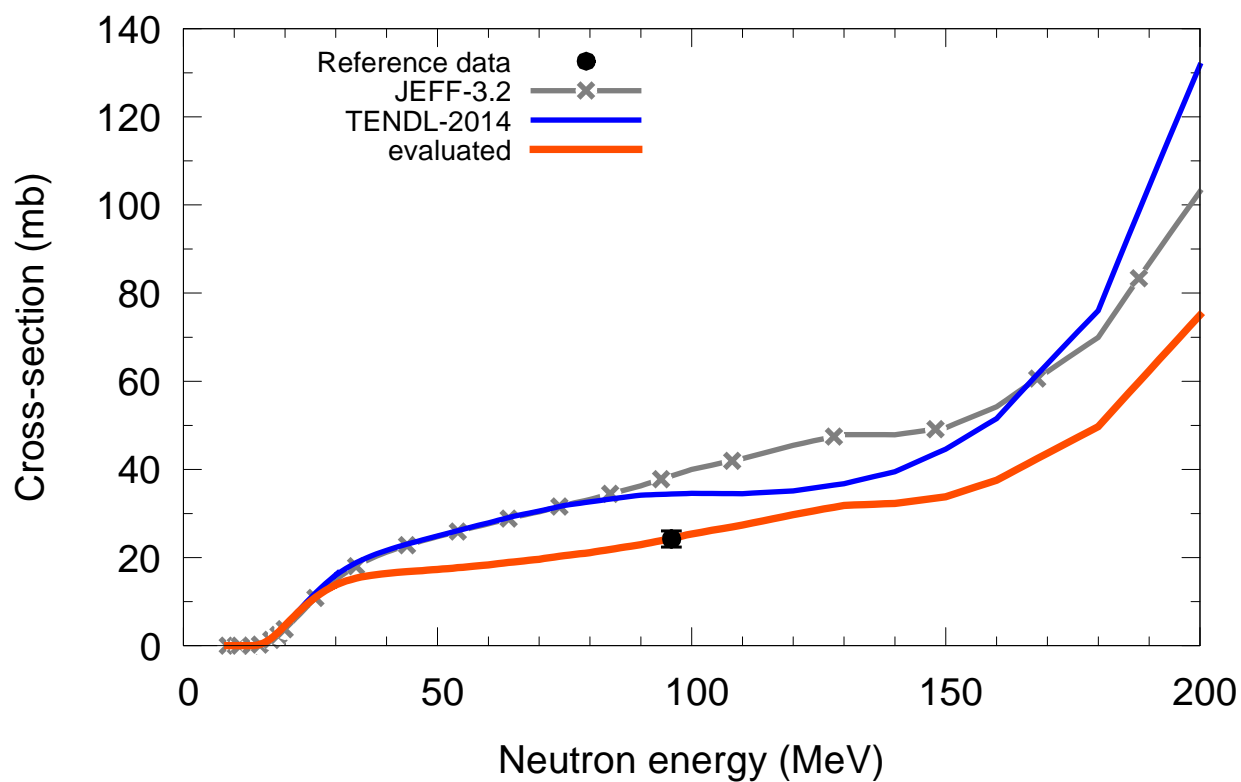
### $^{74}\text{Ge}(n,x)t$



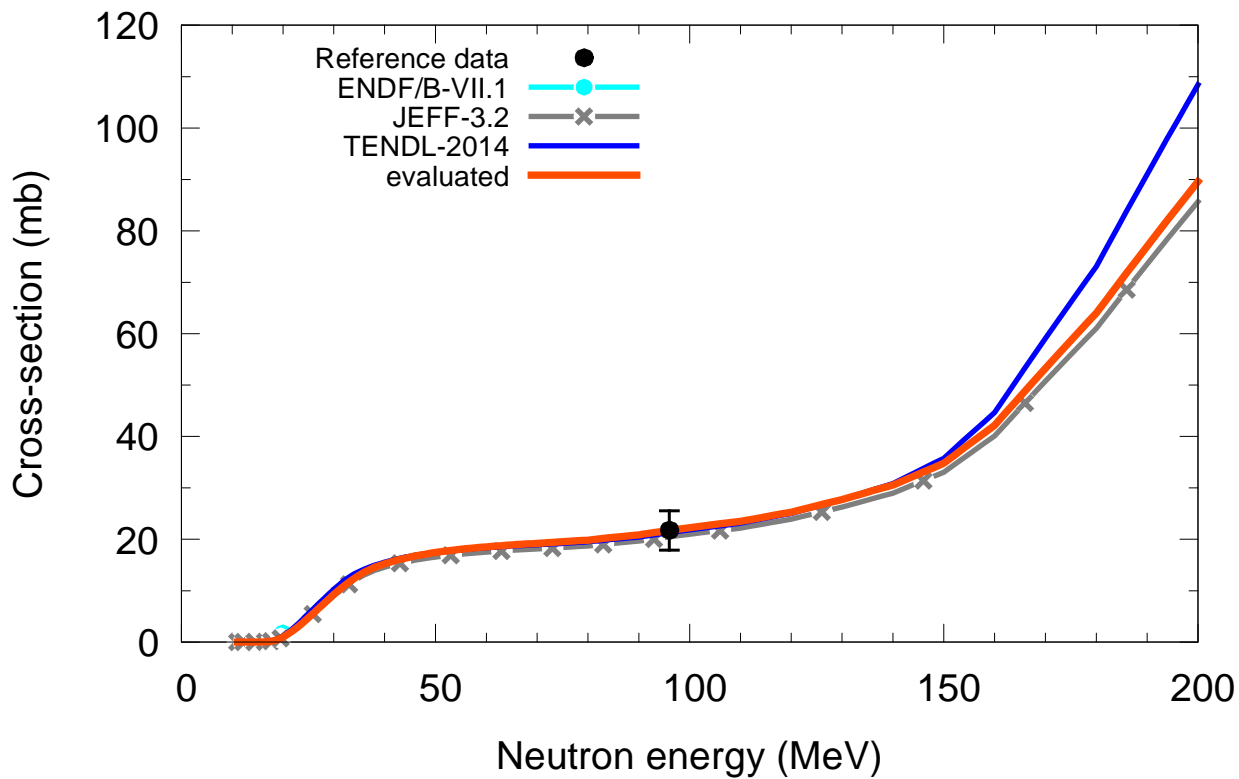
$^{76}\text{Ge}(n,x)t$



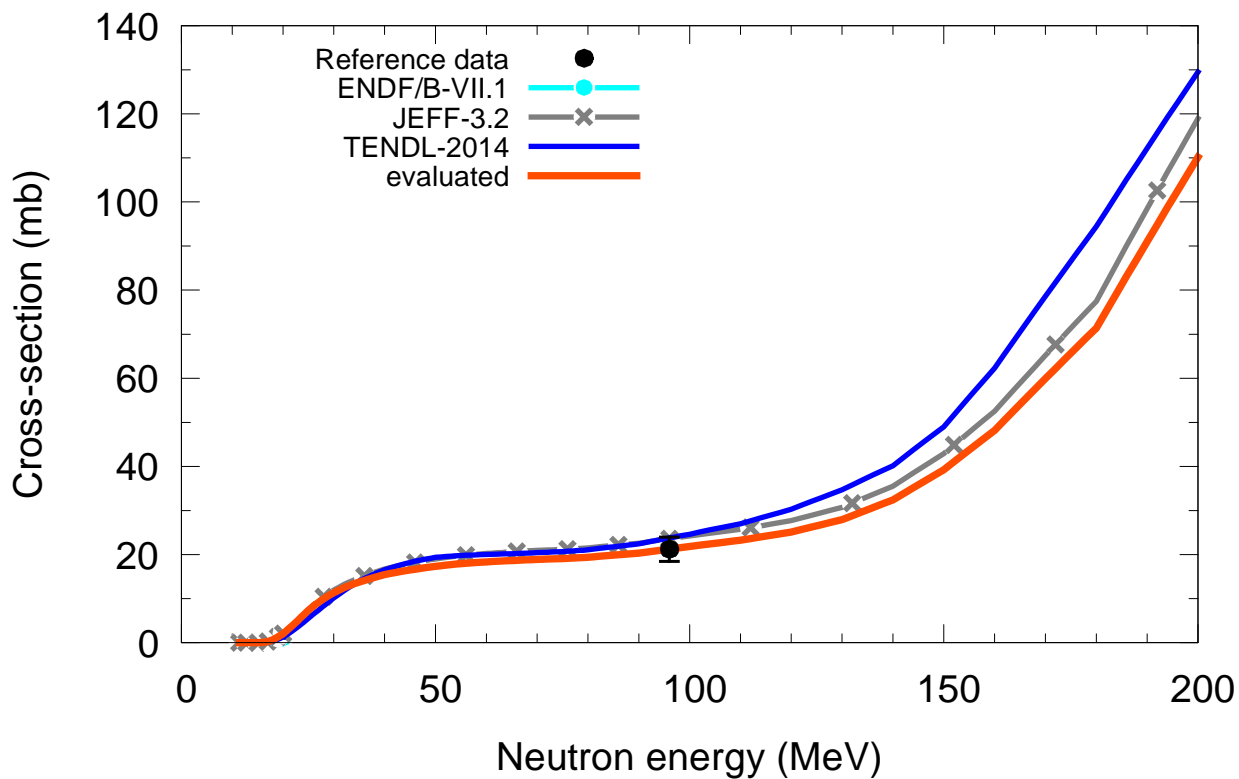
$^{75}\text{As}(n,x)t$



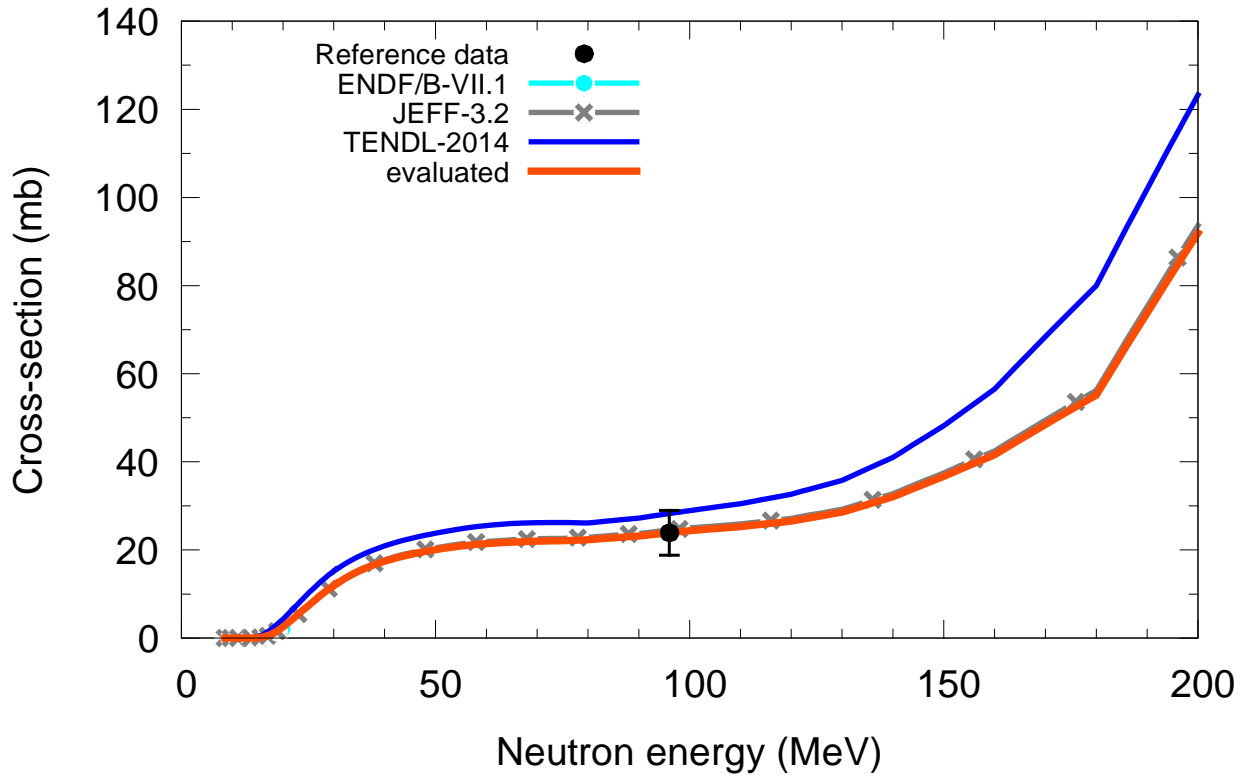
### $^{74}\text{Se}(n,x)t$



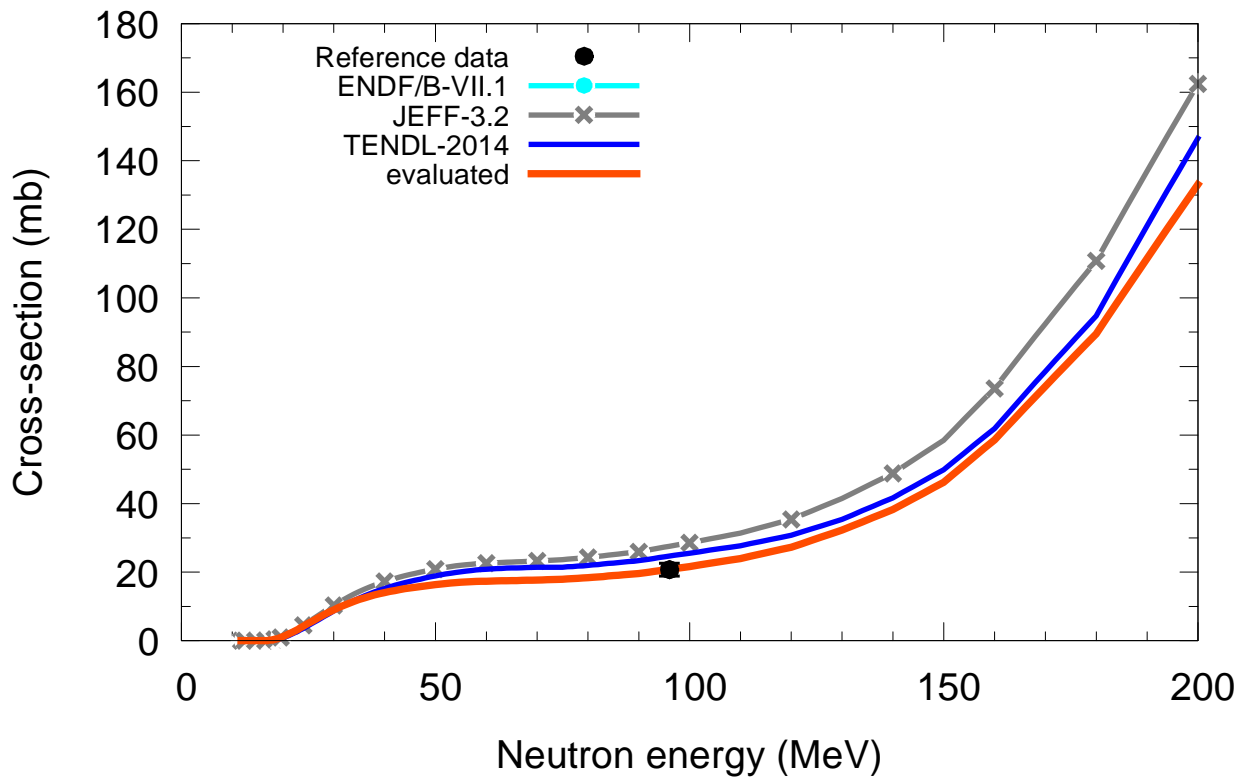
### $^{76}\text{Se}(n,x)t$

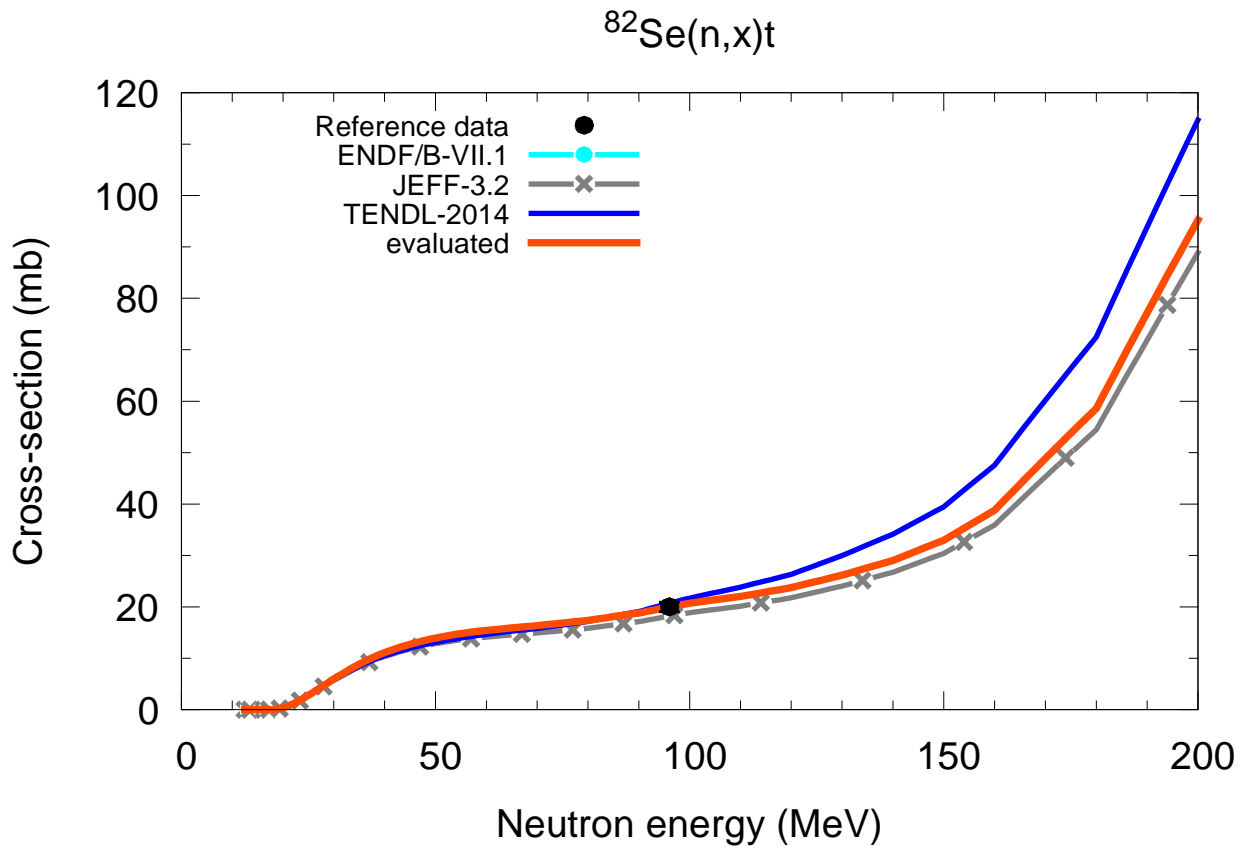
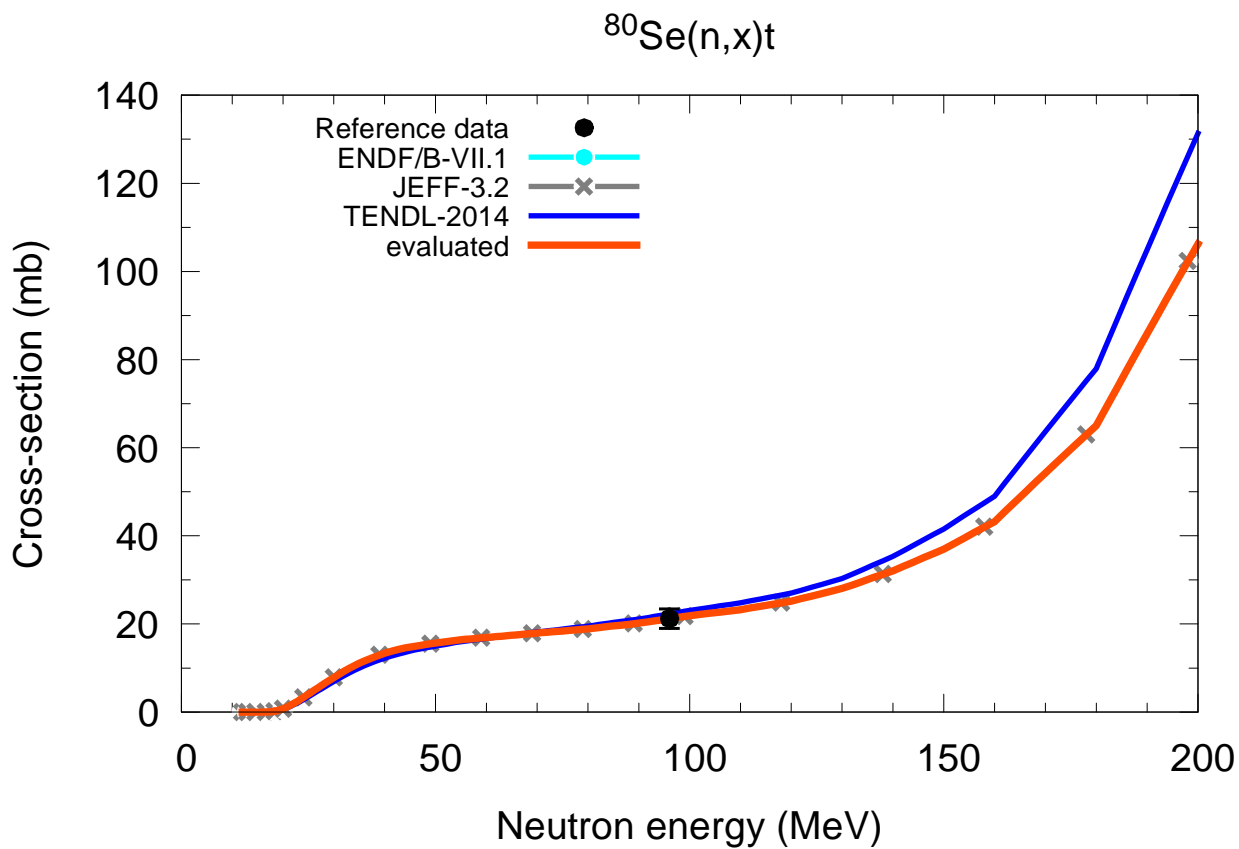


### $^{77}\text{Se}(n,x)t$



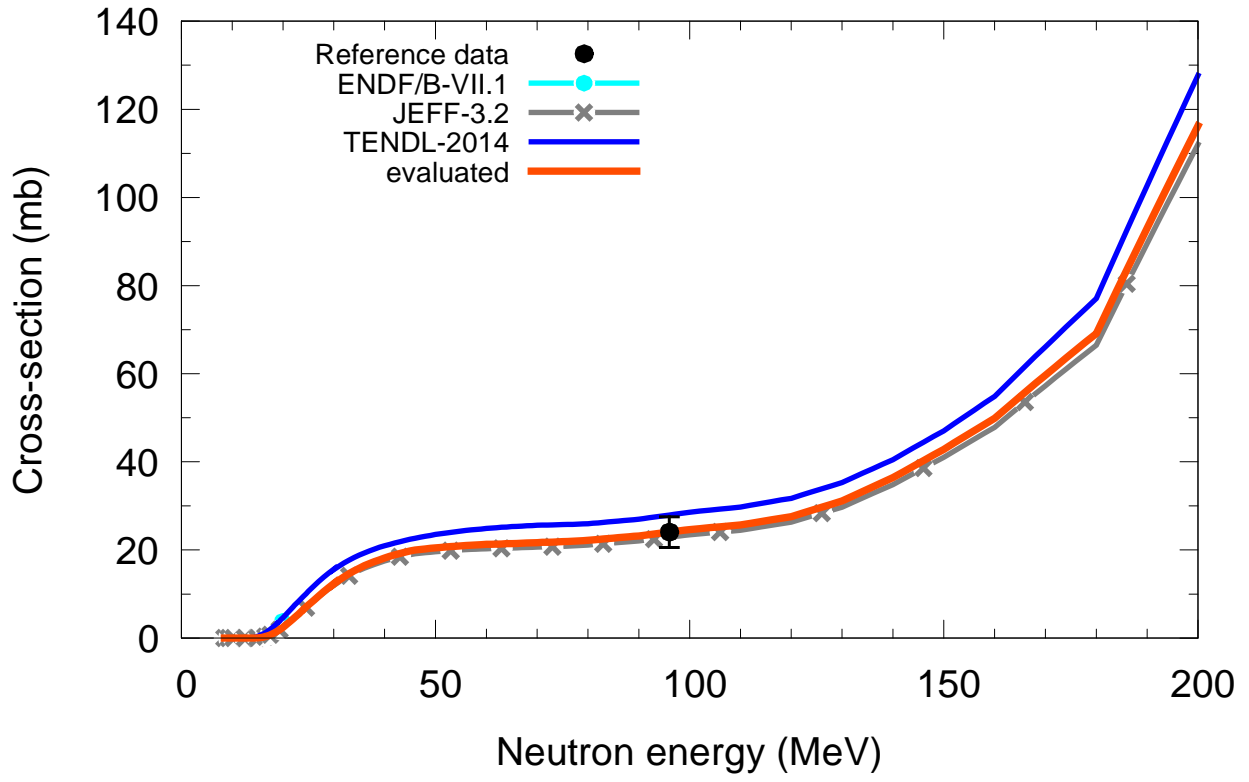
### $^{78}\text{Se}(n,x)t$



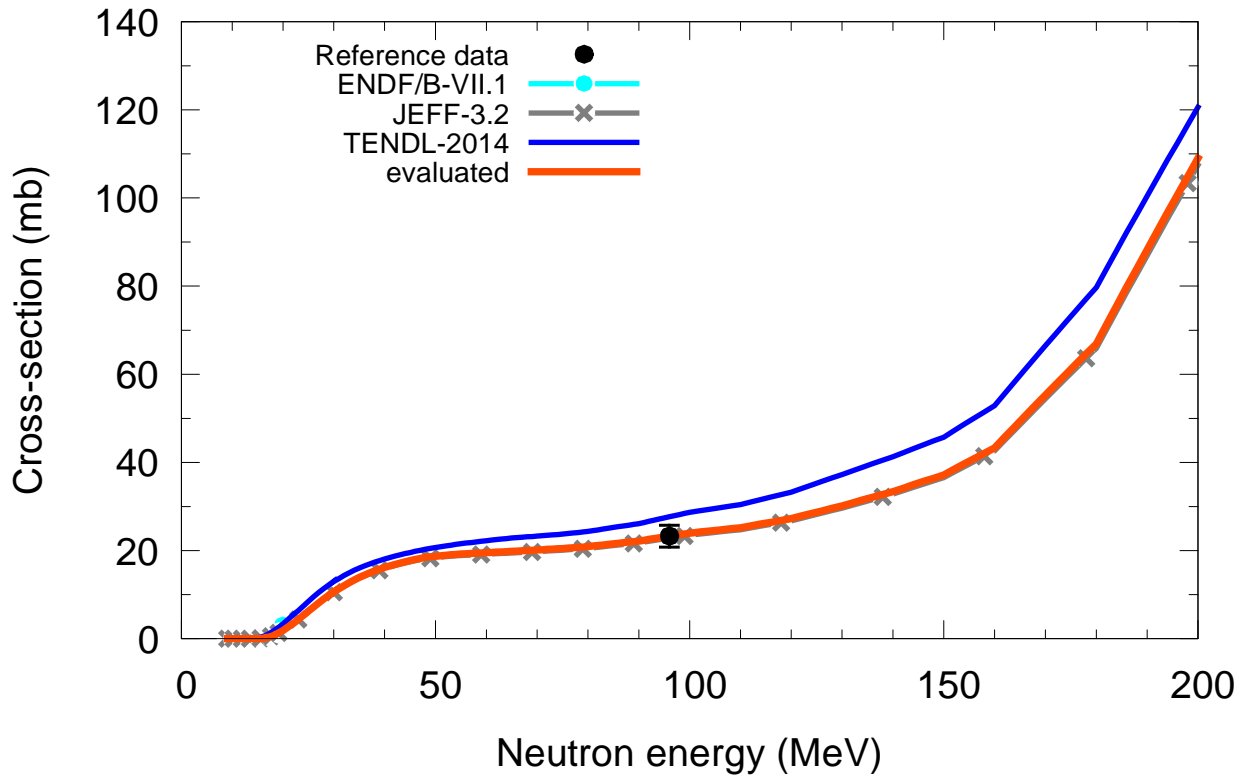


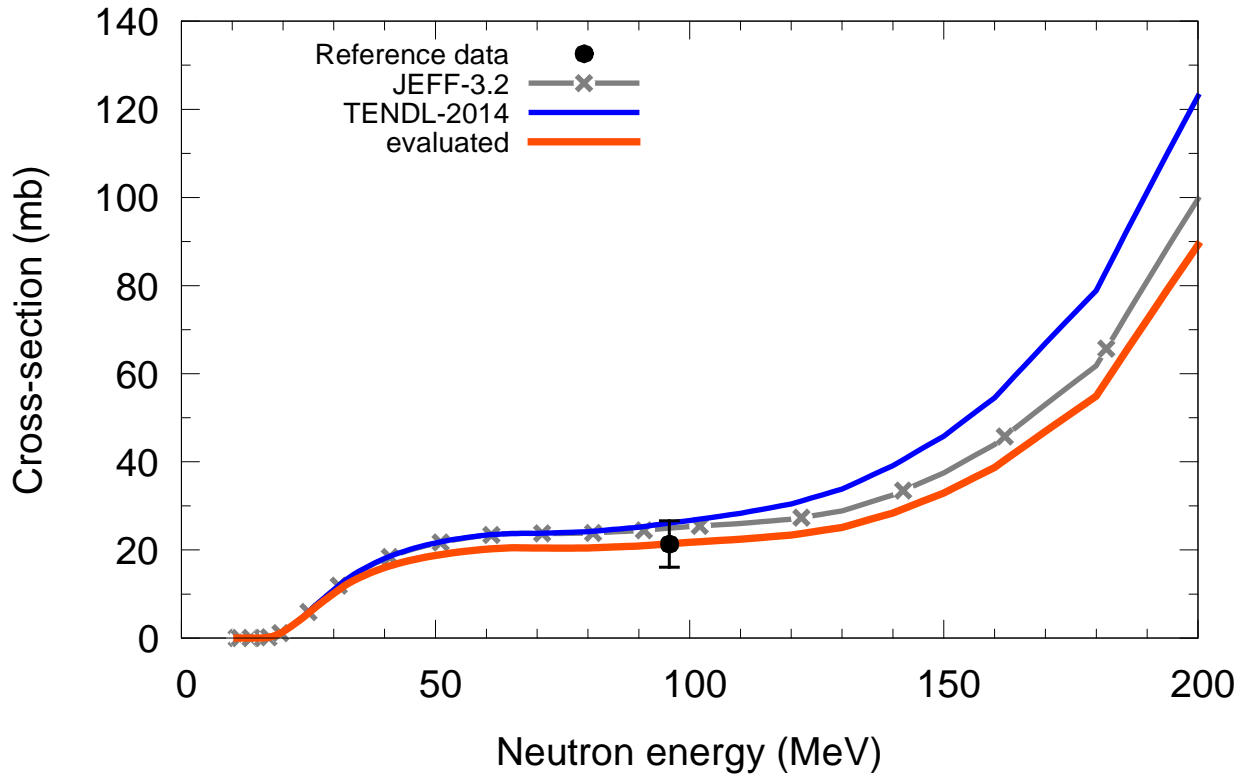
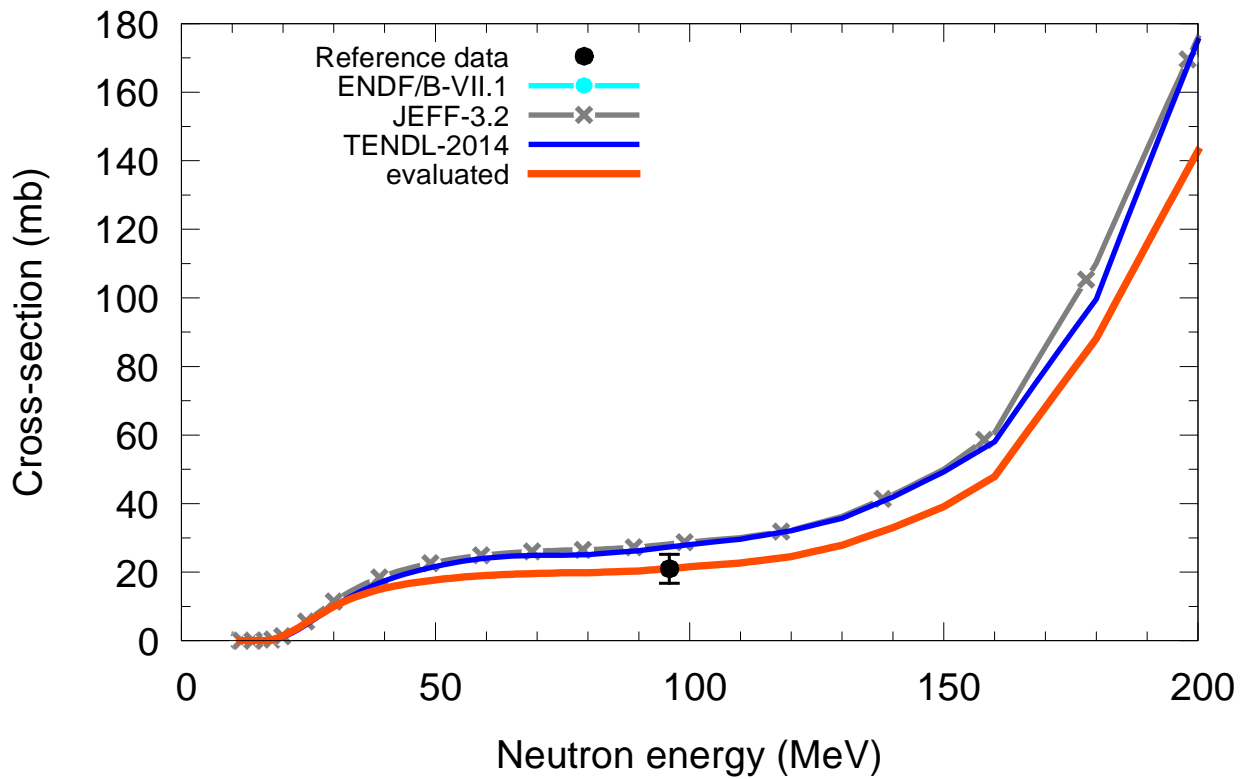


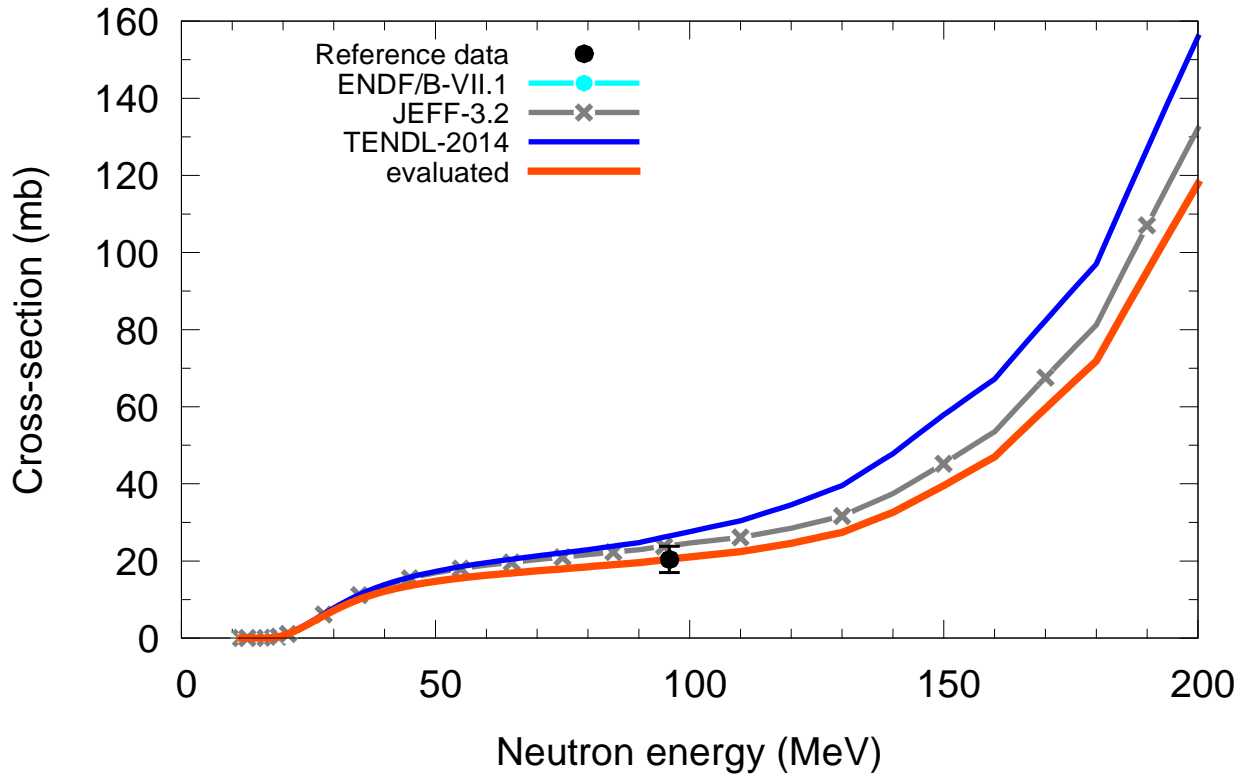
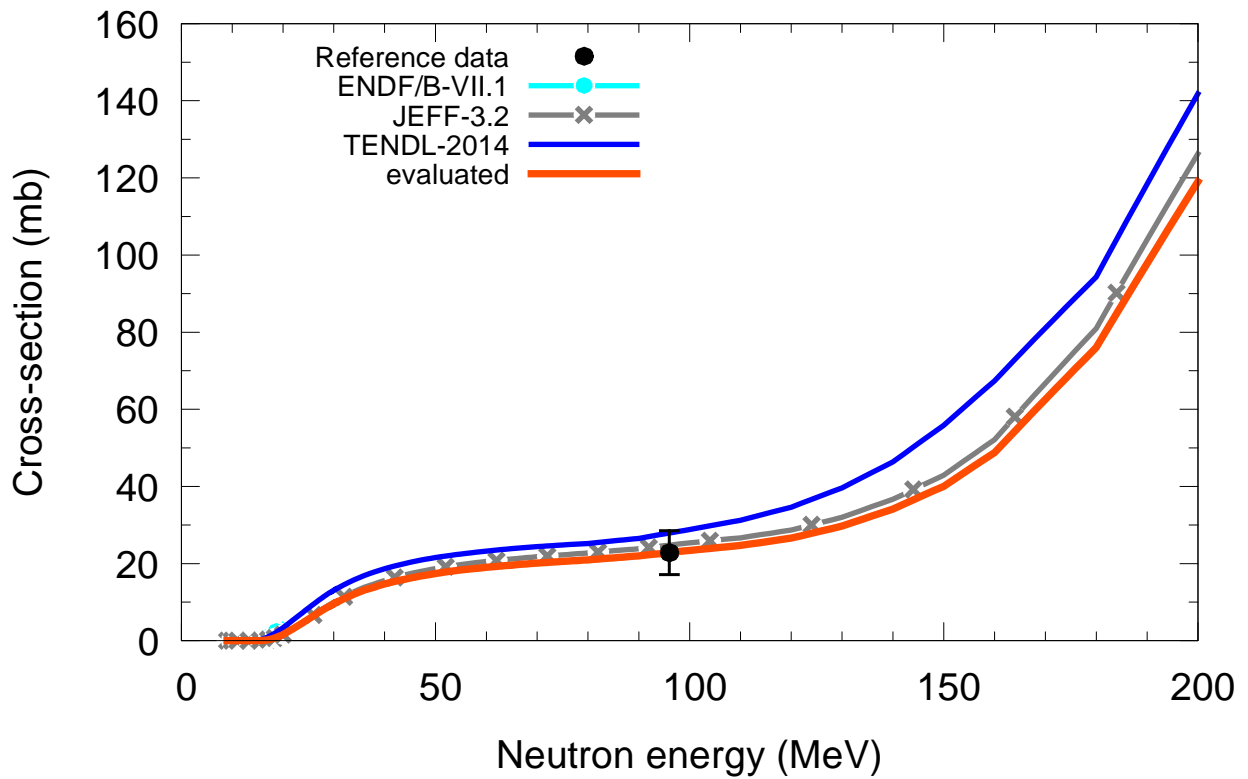
### $^{79}\text{Br}(n,x)t$

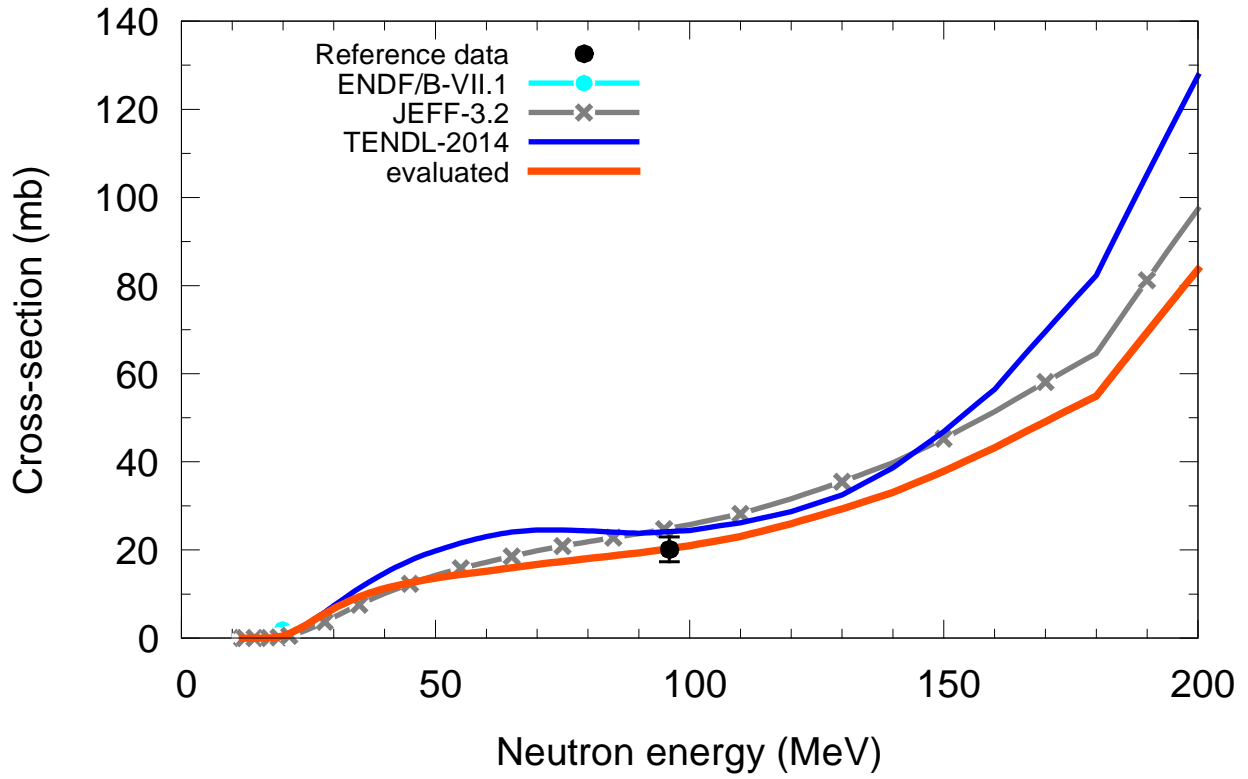
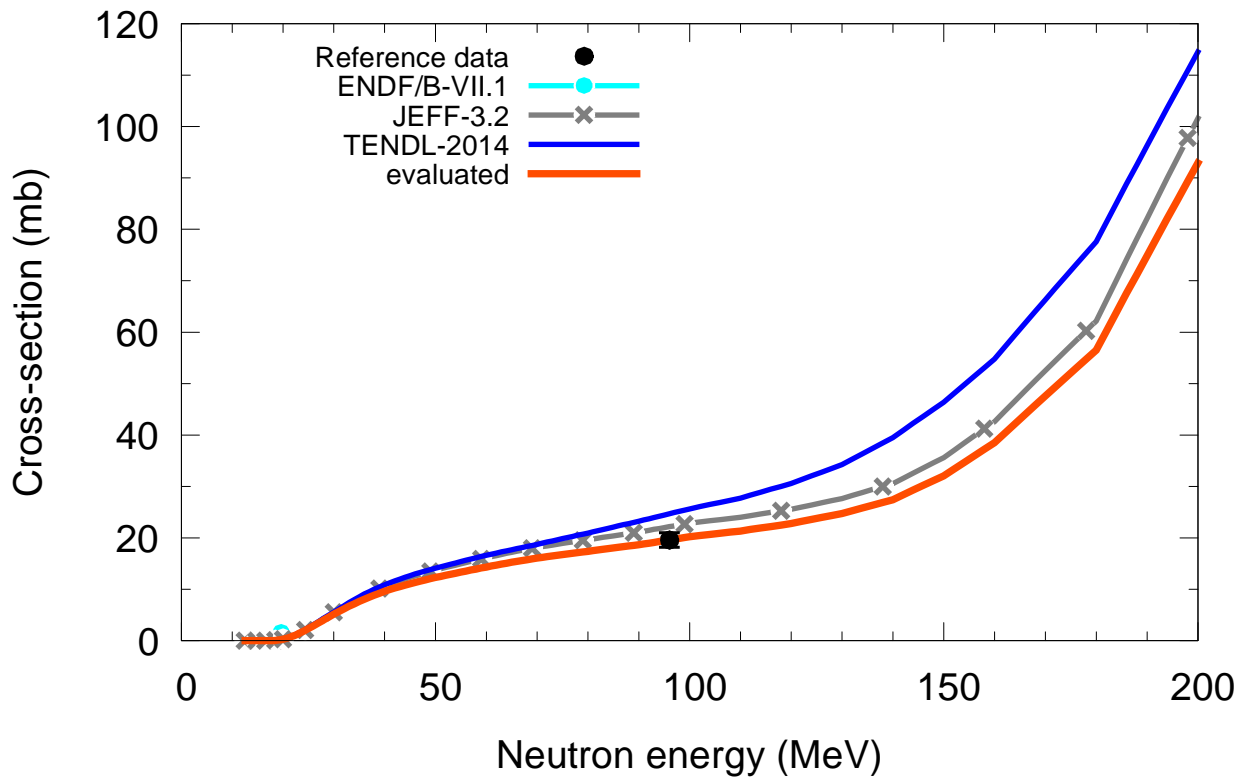


### $^{81}\text{Br}(n,x)t$

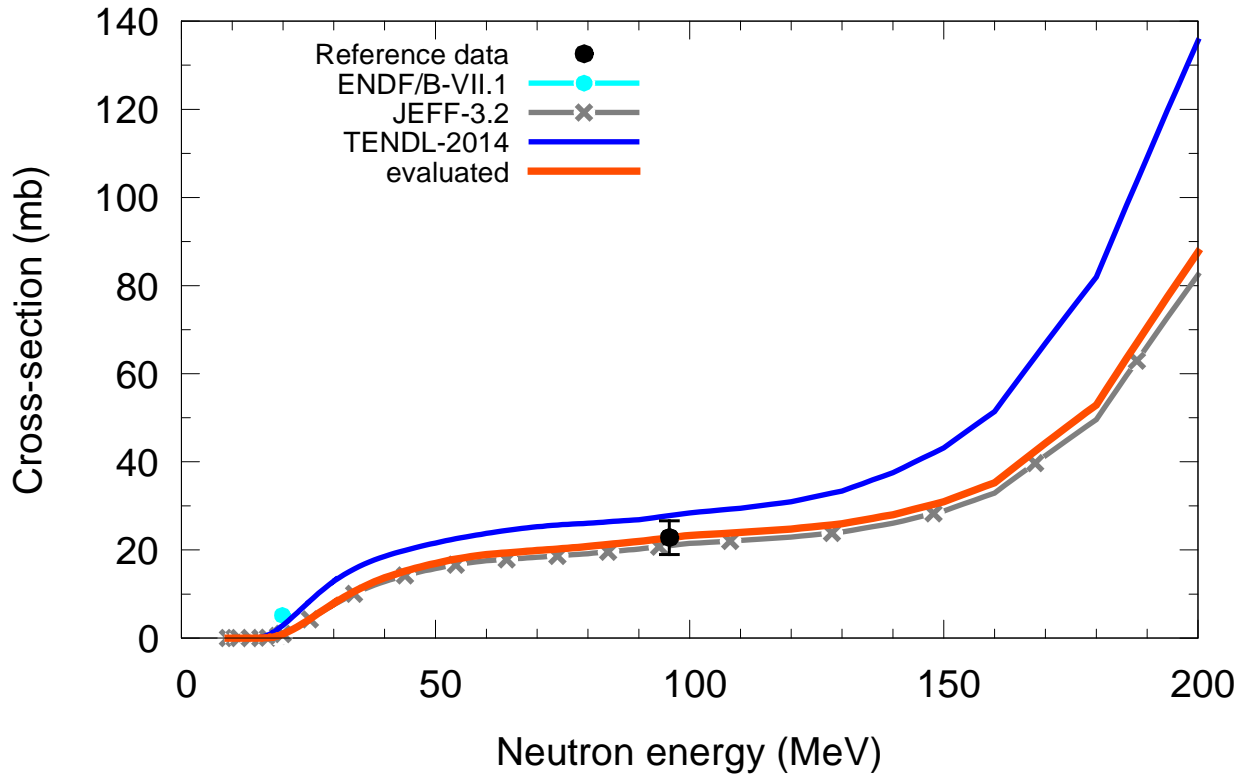


$^{78}\text{Kr}(n,x)t$  $^{80}\text{Kr}(n,x)t$ 

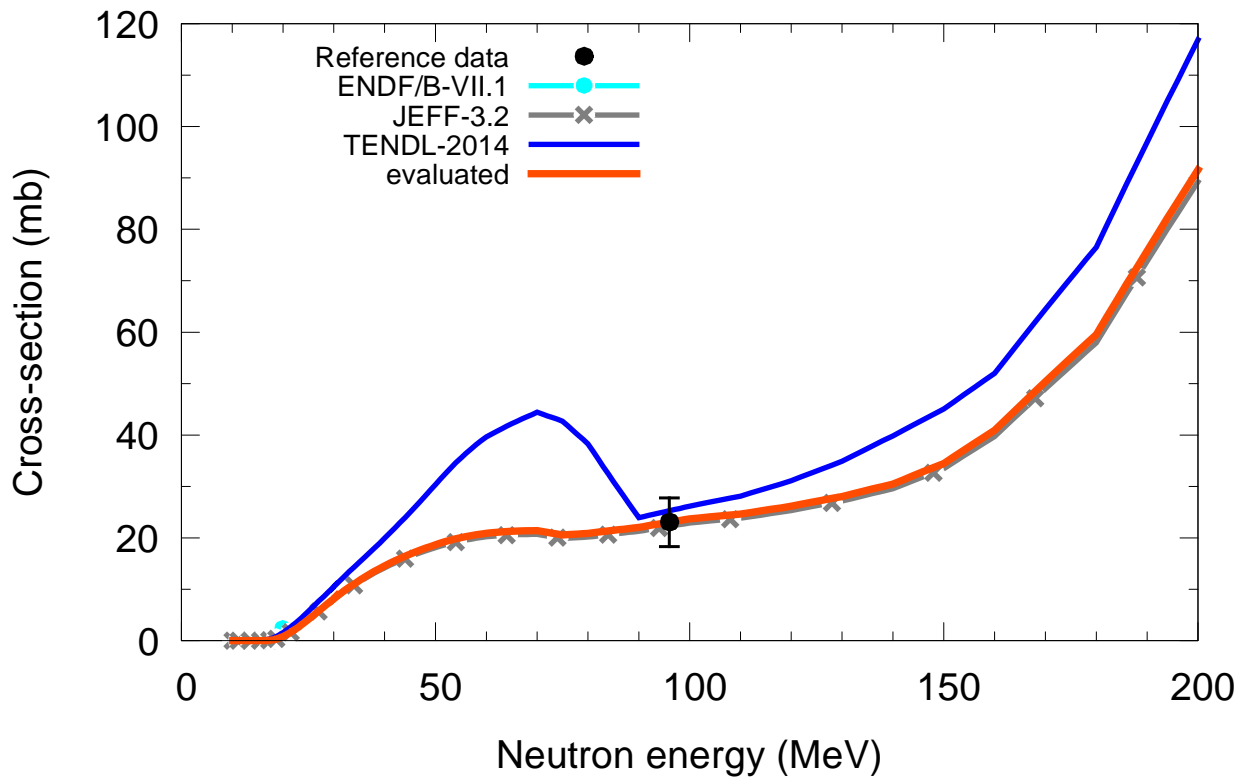
$^{82}\text{Kr}(n,x)t$  $^{83}\text{Kr}(n,x)t$ 

$^{84}\text{Kr}(n,x)t$  $^{86}\text{Kr}(n,x)t$ 

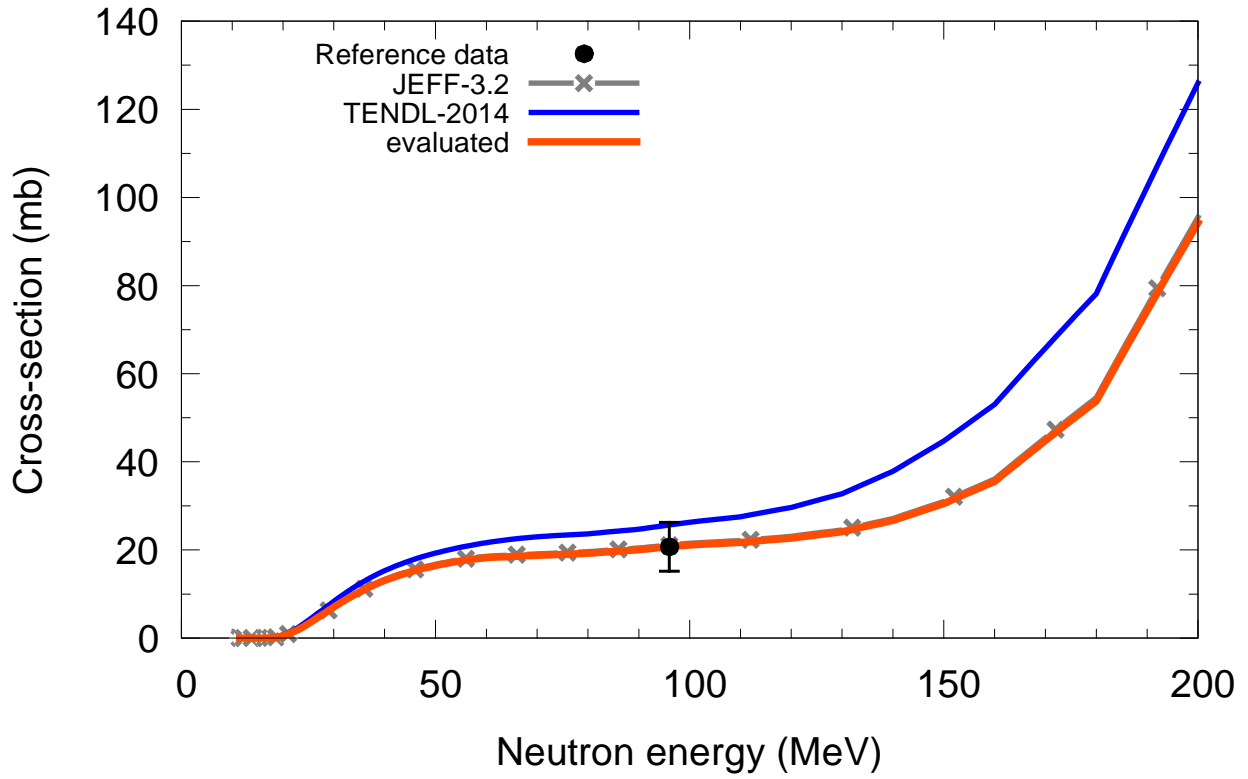
### $^{85}\text{Rb}(n,x)t$



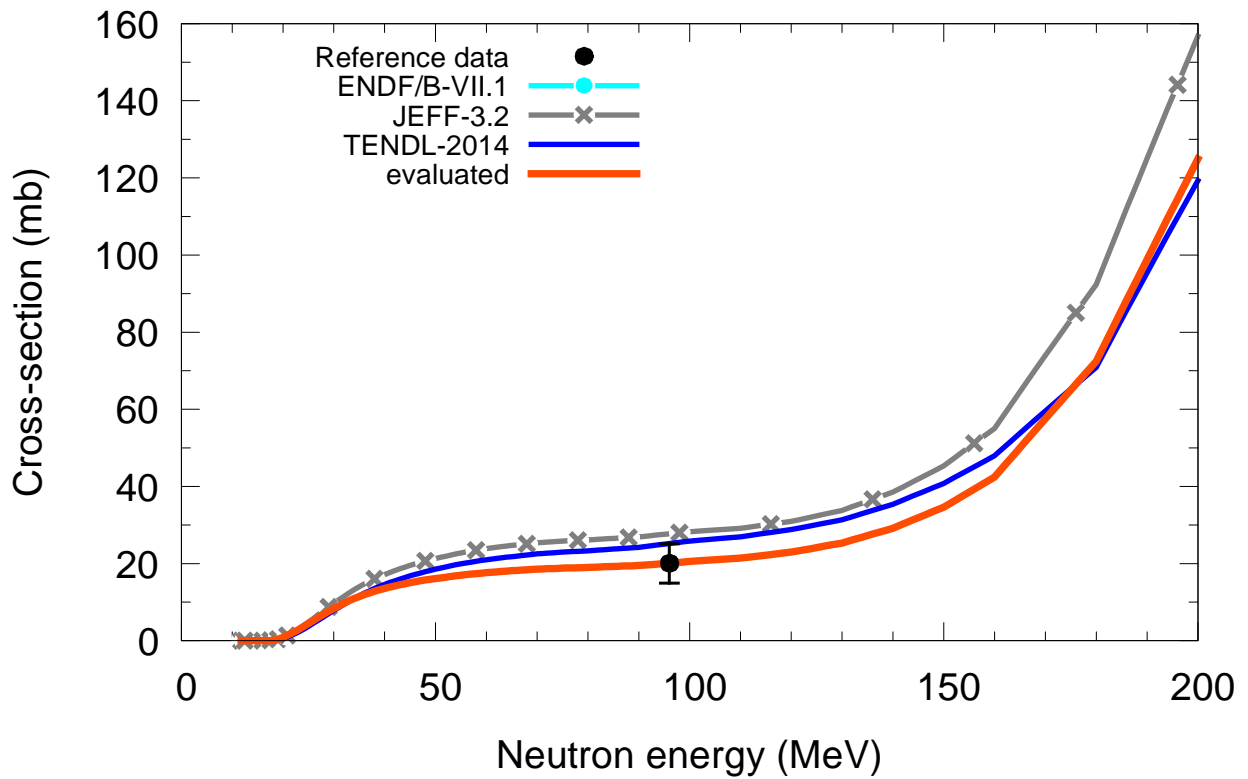
### $^{87}\text{Rb}(n,x)t$

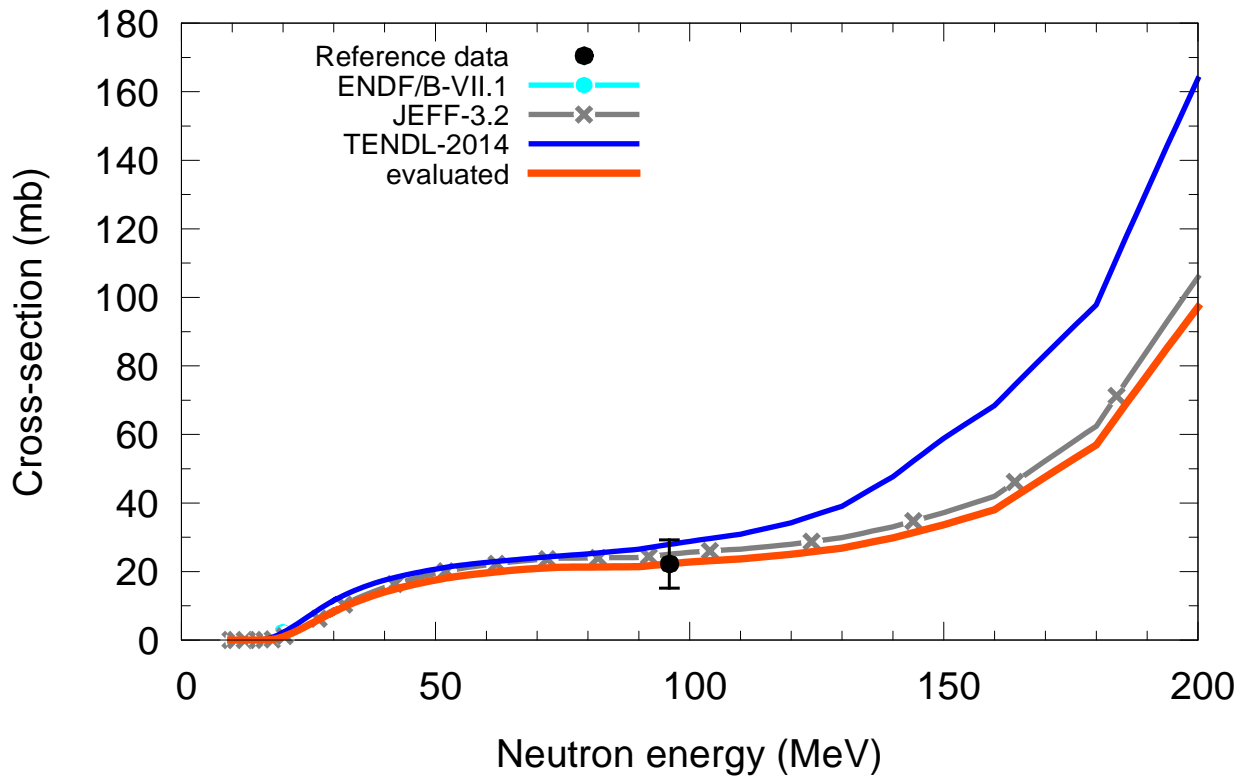
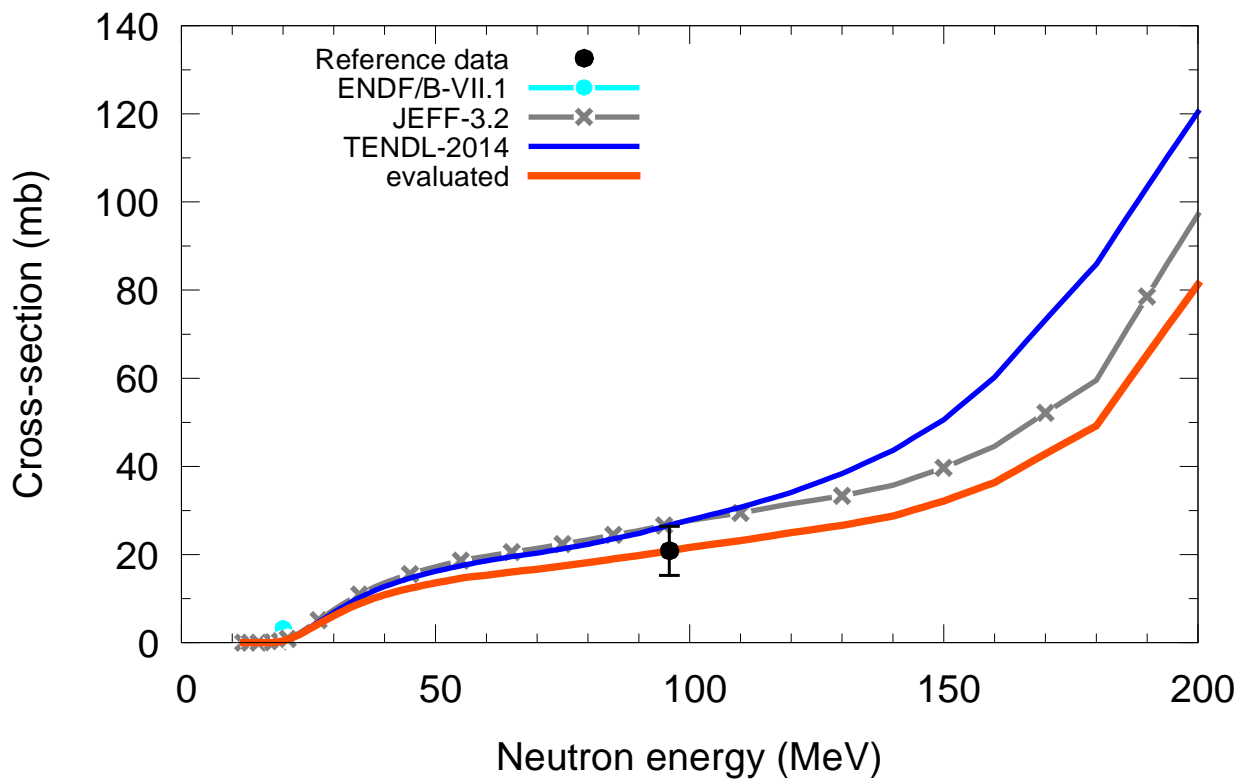


### $^{84}\text{Sr}(n,x)t$

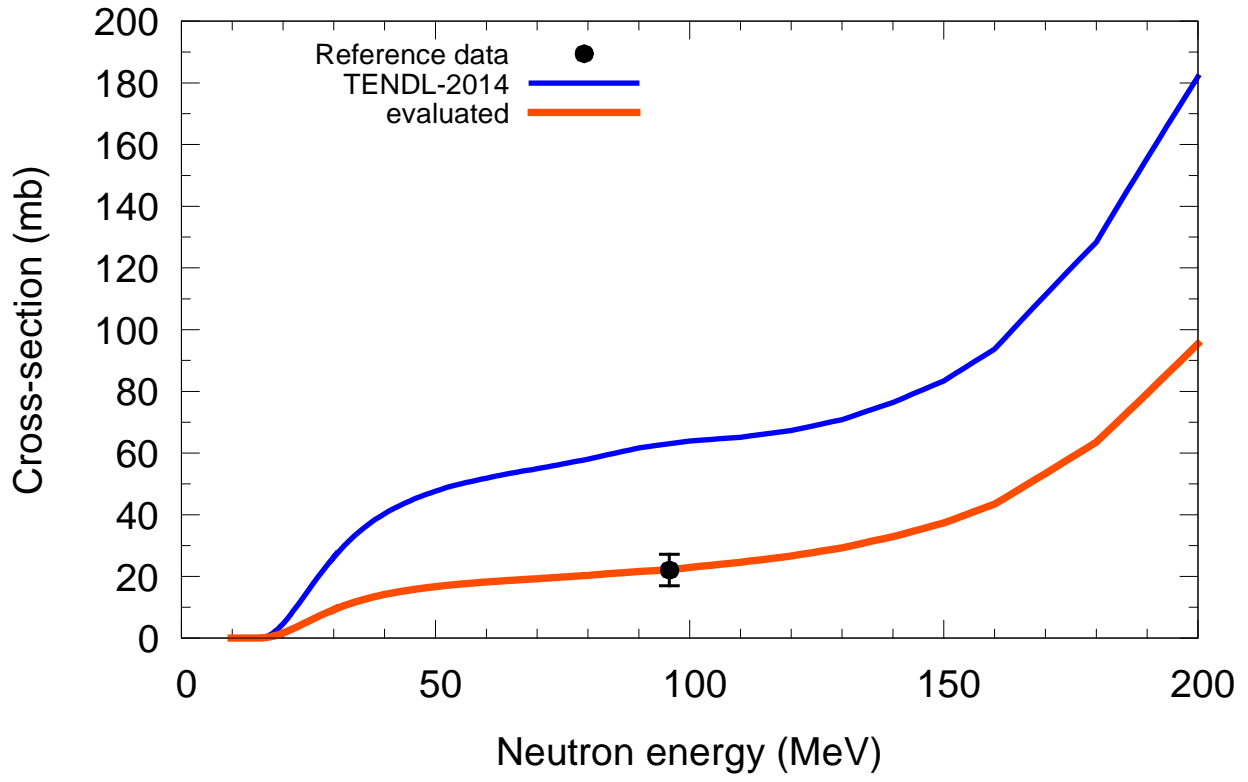


### $^{86}\text{Sr}(n,x)t$

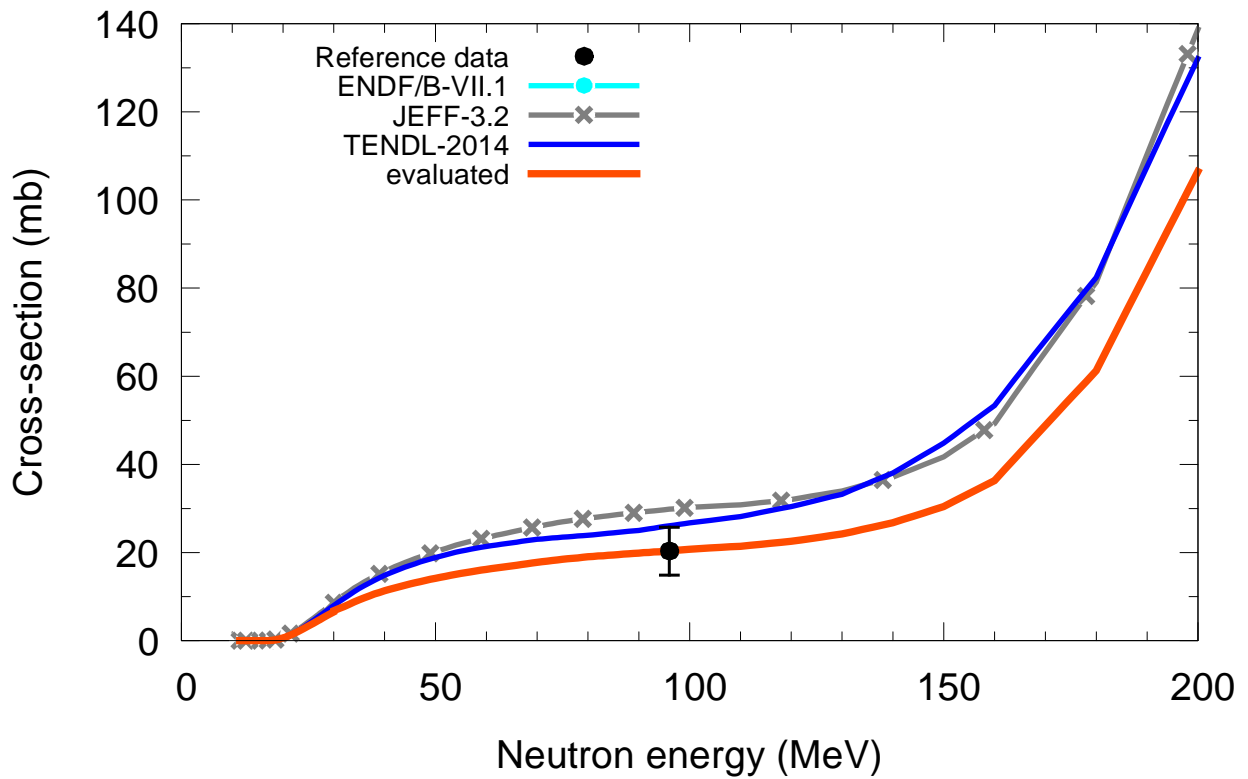


$^{87}\text{Sr}(n,x)t$  $^{88}\text{Sr}(n,x)t$ 

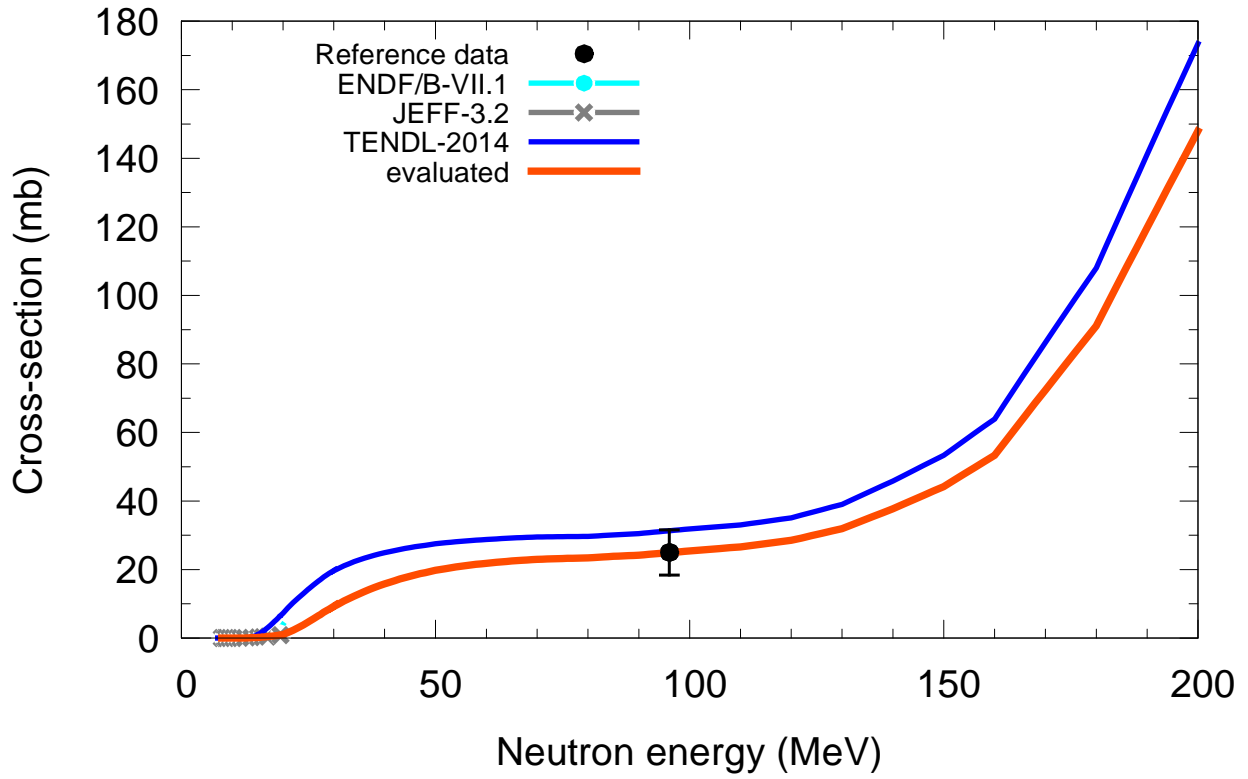
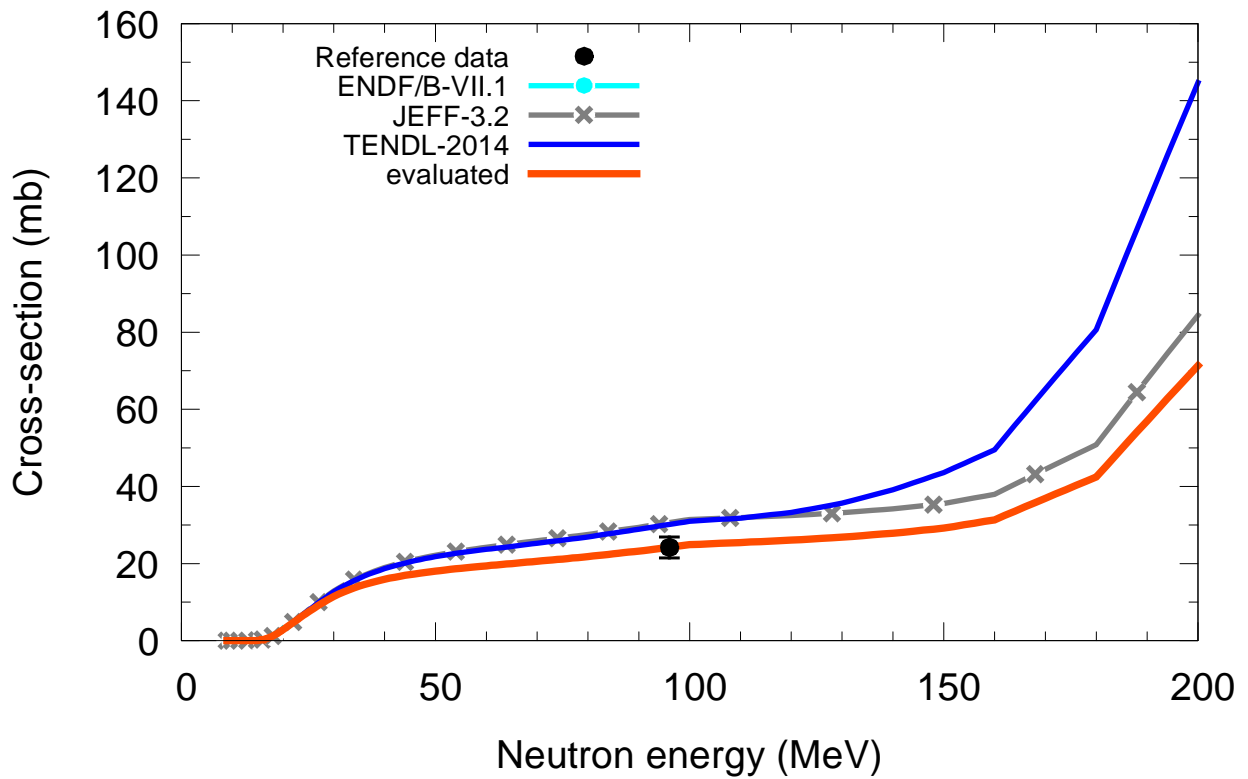
$^{89}\text{Y}(n,x)t$

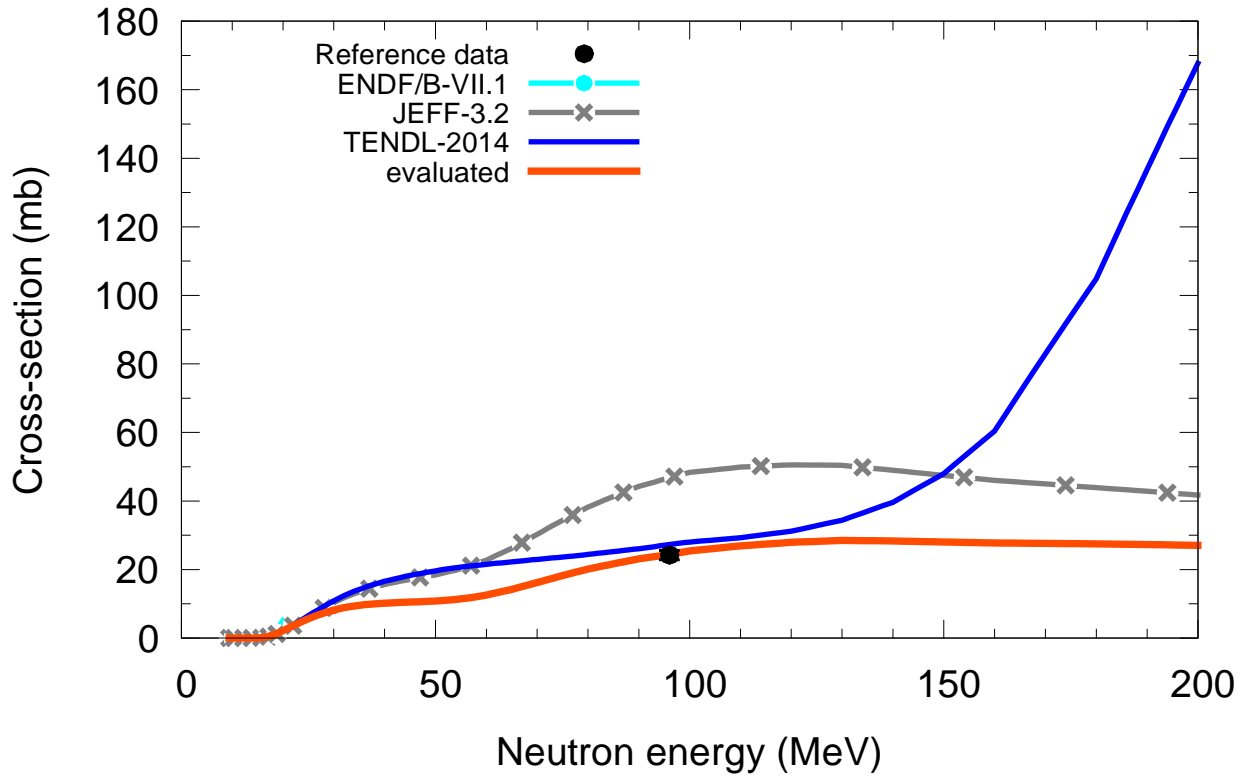
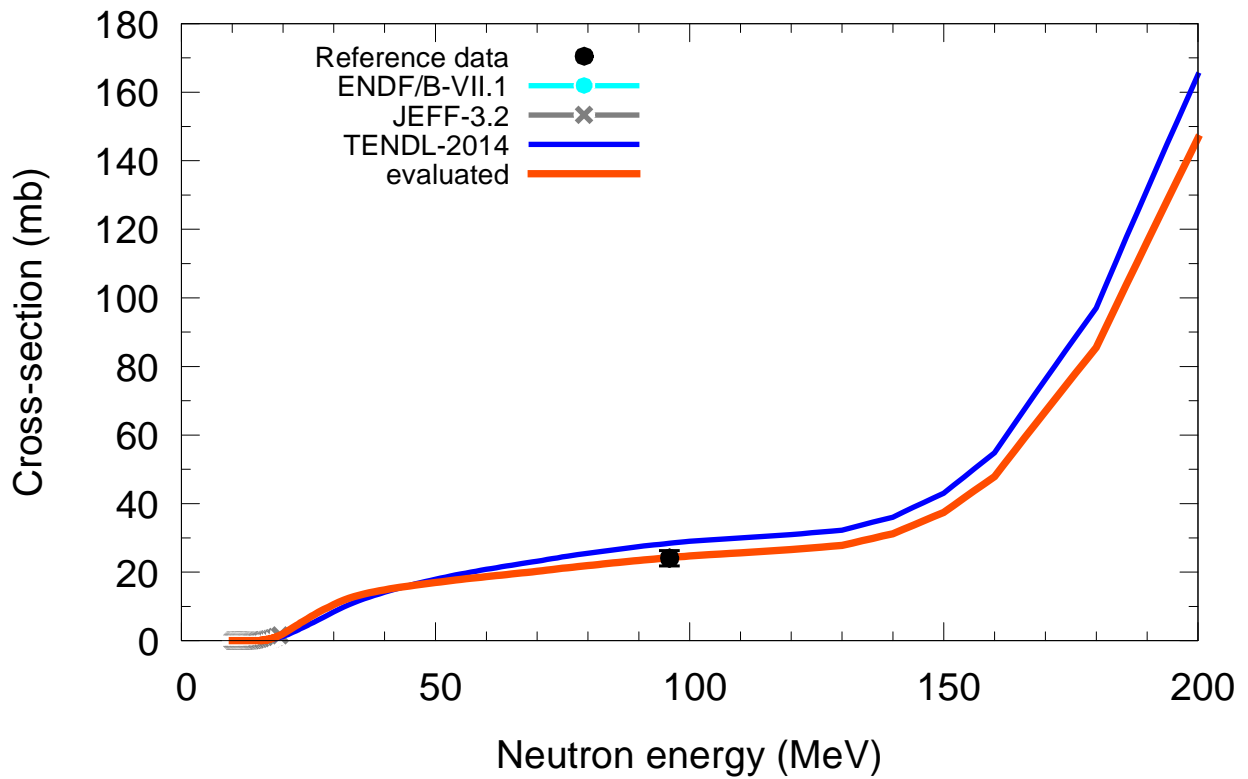


$^{90}\text{Zr}(n,x)t$

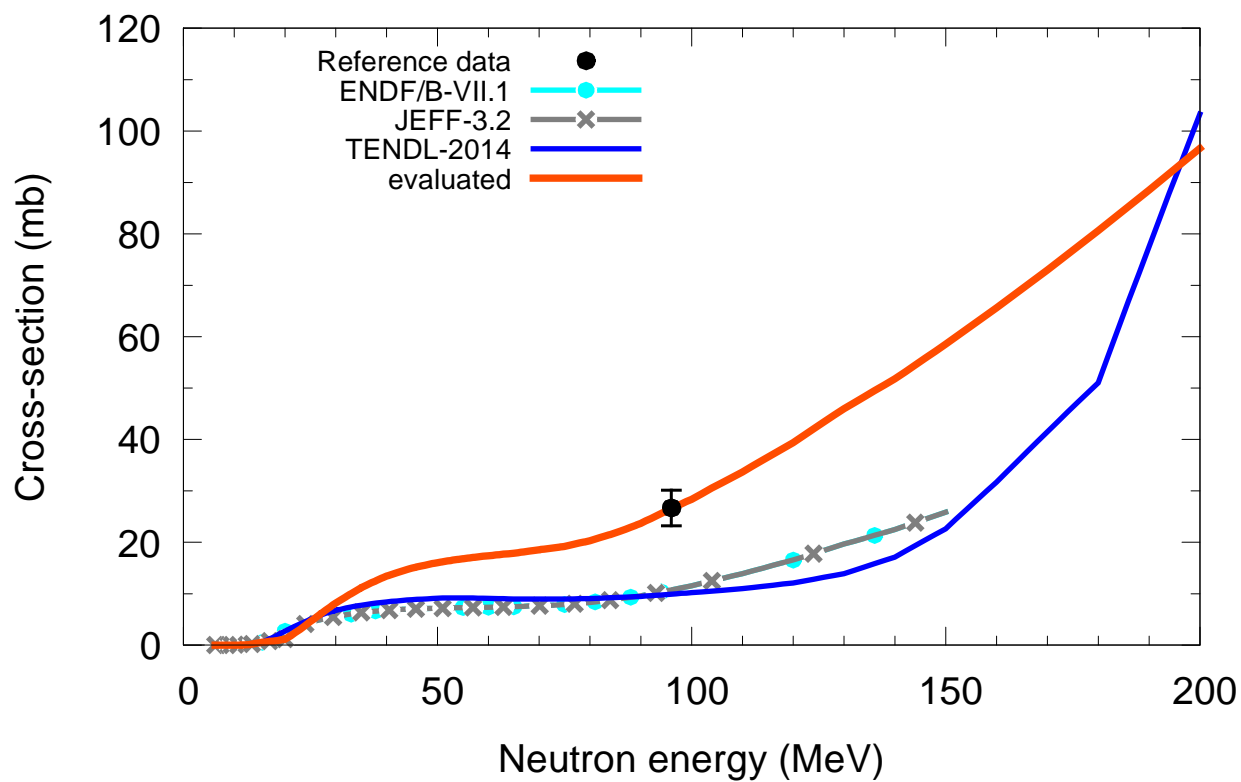




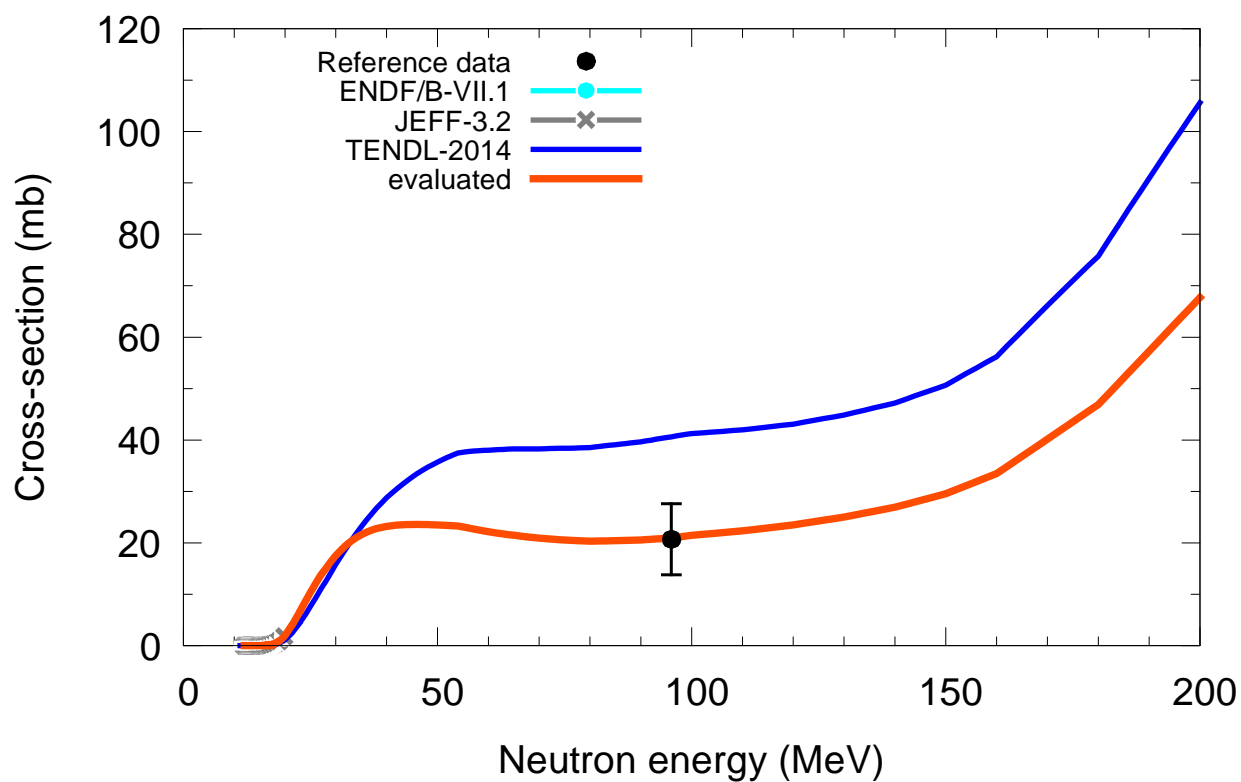
$^{91}\text{Zr}(n,x)t$  $^{92}\text{Zr}(n,x)t$ 

$^{94}\text{Zr}(n,x)t$  $^{96}\text{Zr}(n,x)t$ 

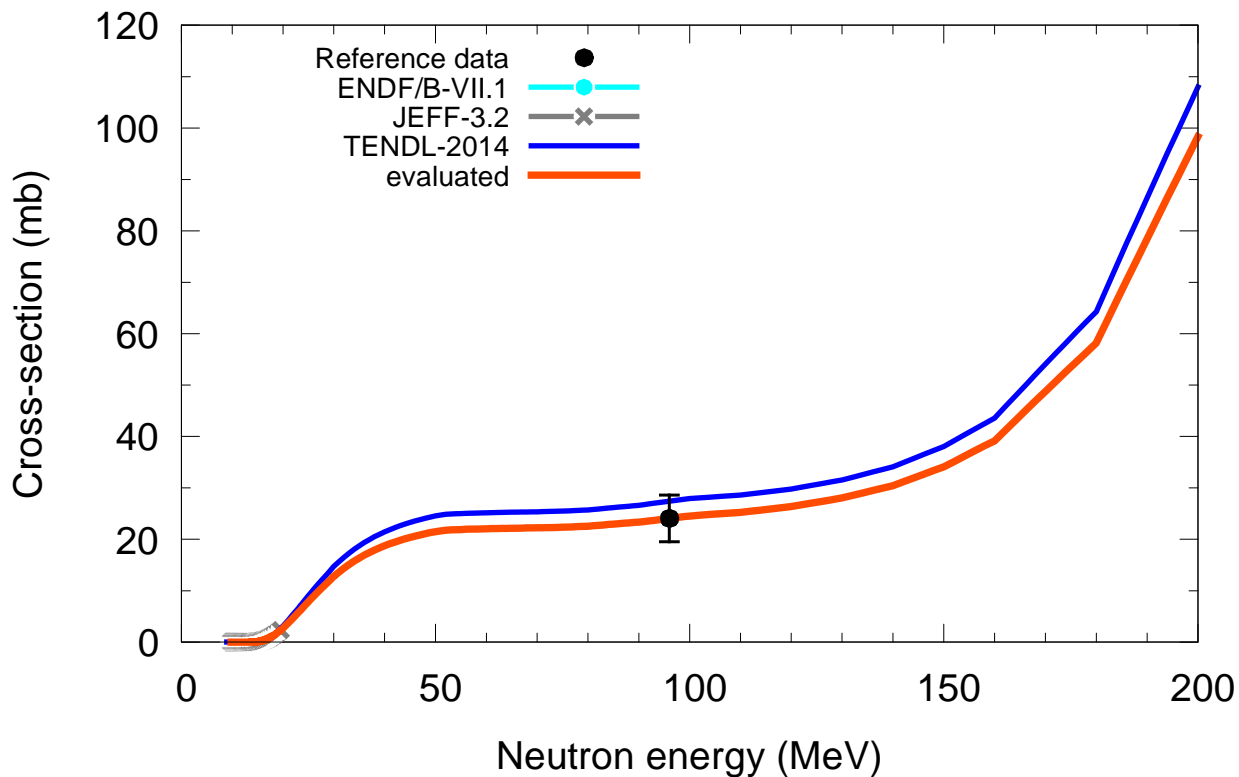
$^{93}\text{Nb}(n,x)t$



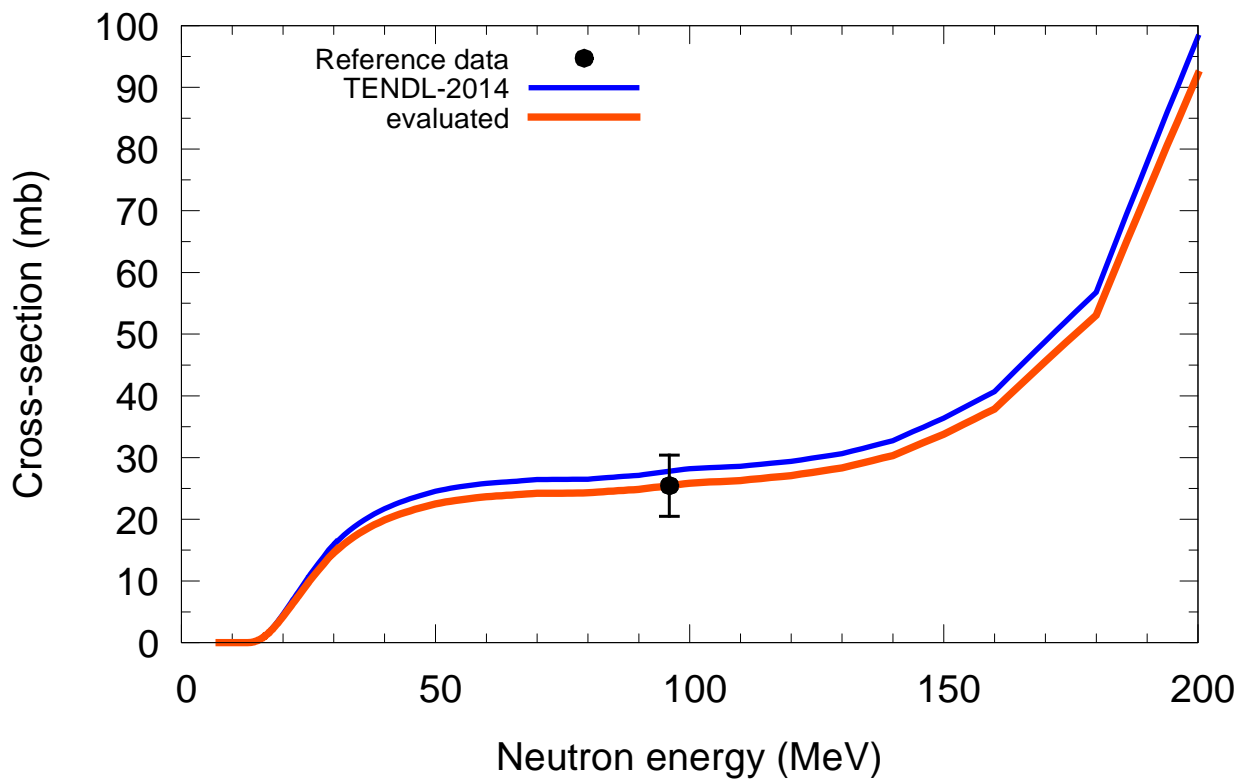
$^{92}\text{Mo}(n,x)t$



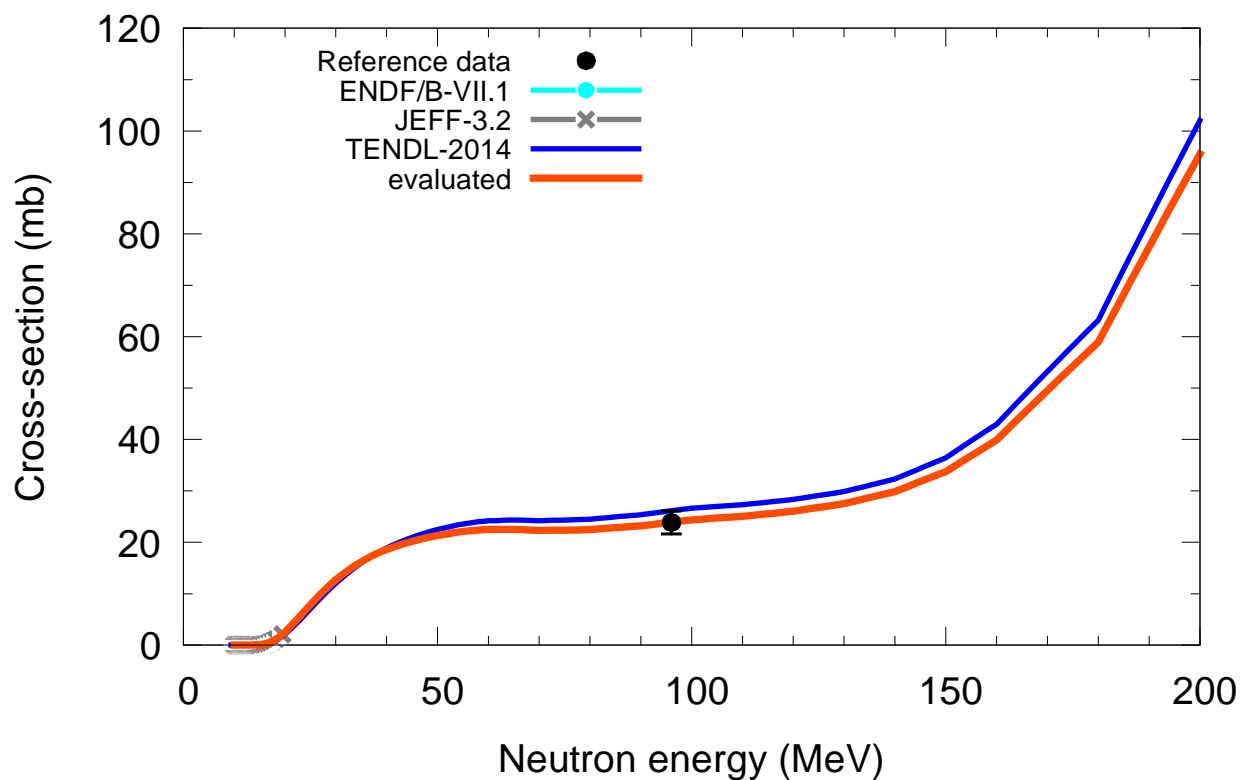
$^{94}\text{Mo}(n,x)t$



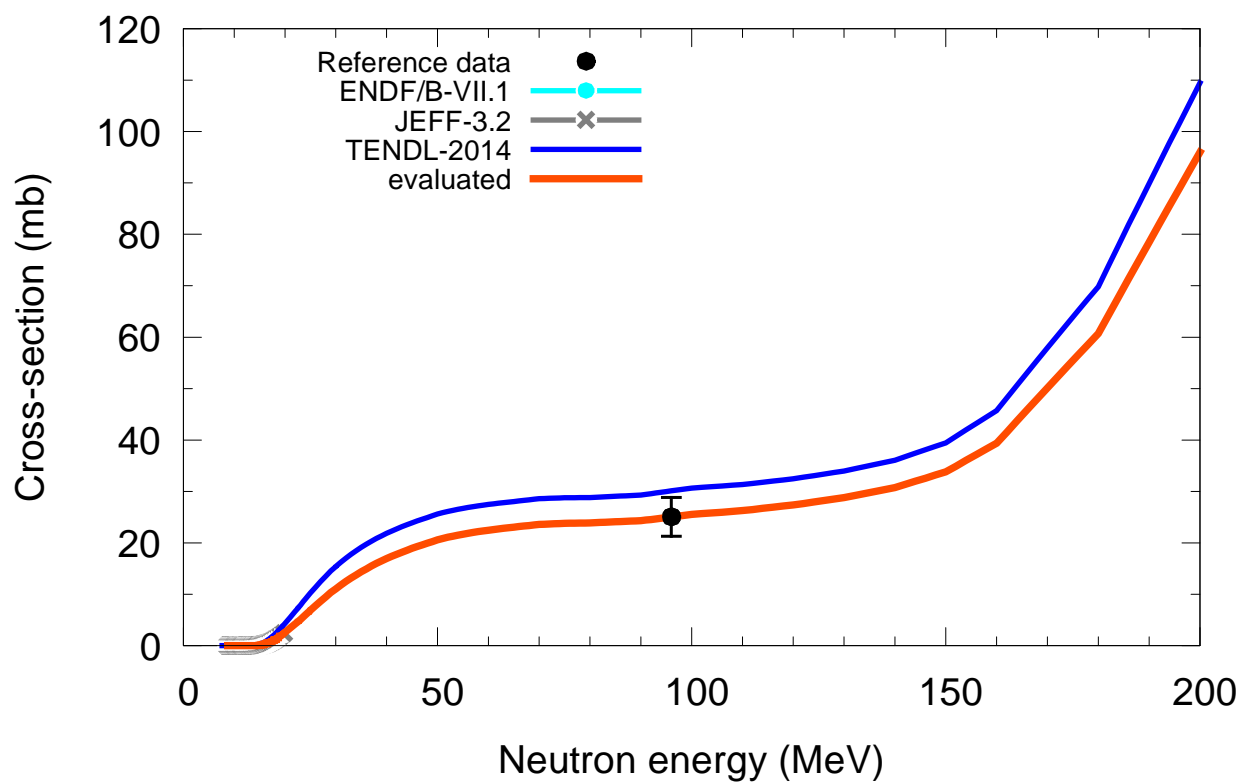
$^{95}\text{Mo}(n,x)t$



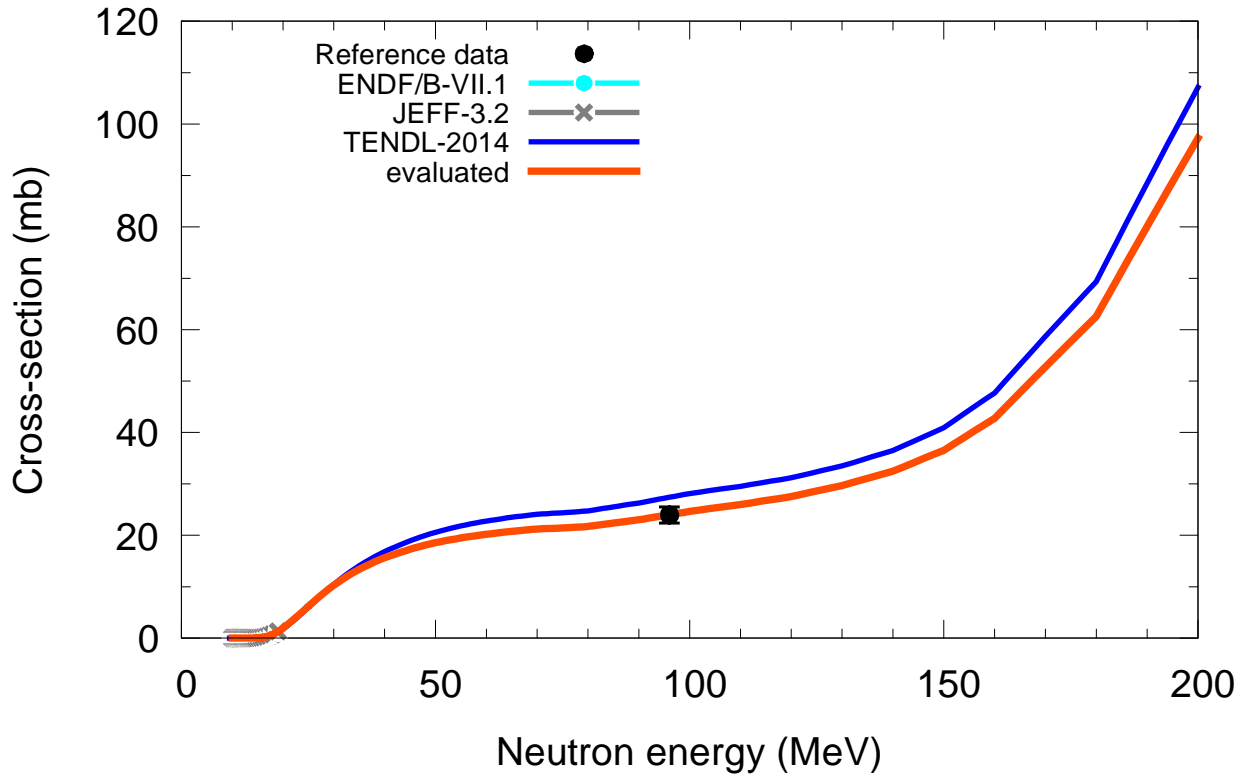
$^{96}\text{Mo}(n,x)t$



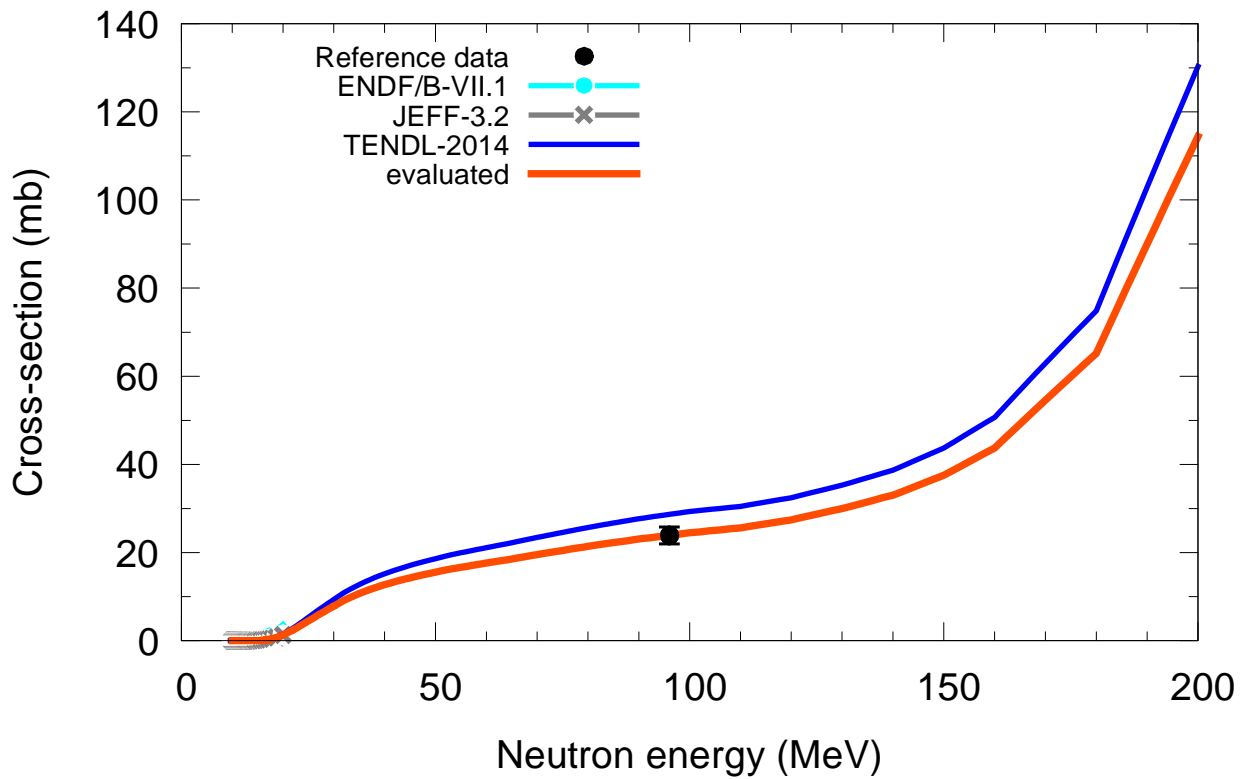
$^{97}\text{Mo}(n,x)t$



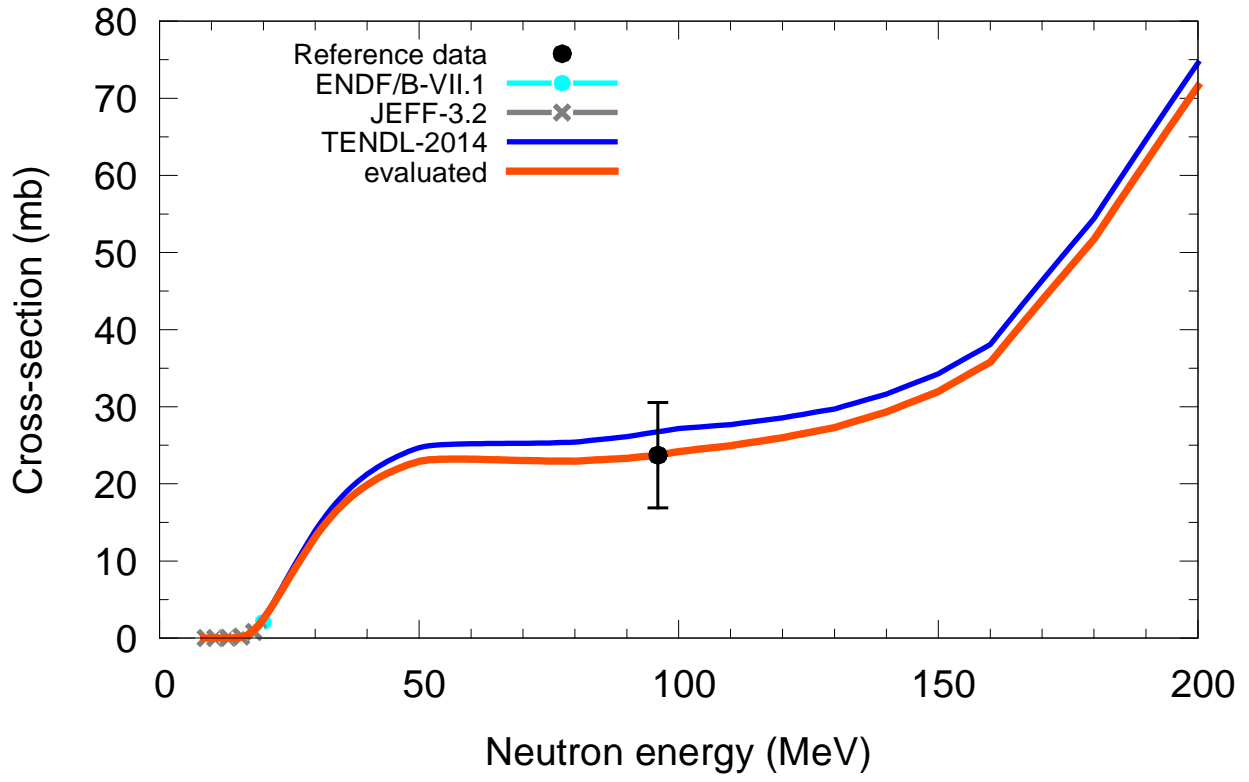
$^{98}\text{Mo}(n,x)t$



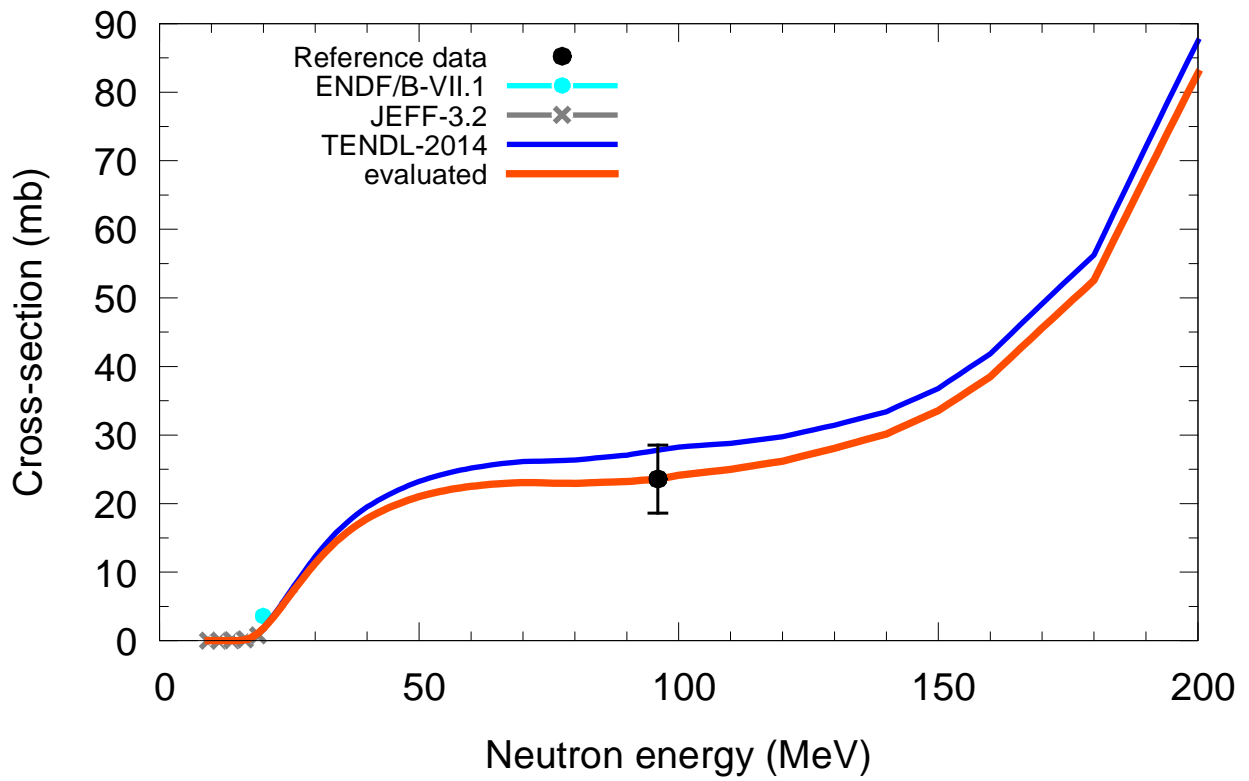
$^{100}\text{Mo}(n,x)t$



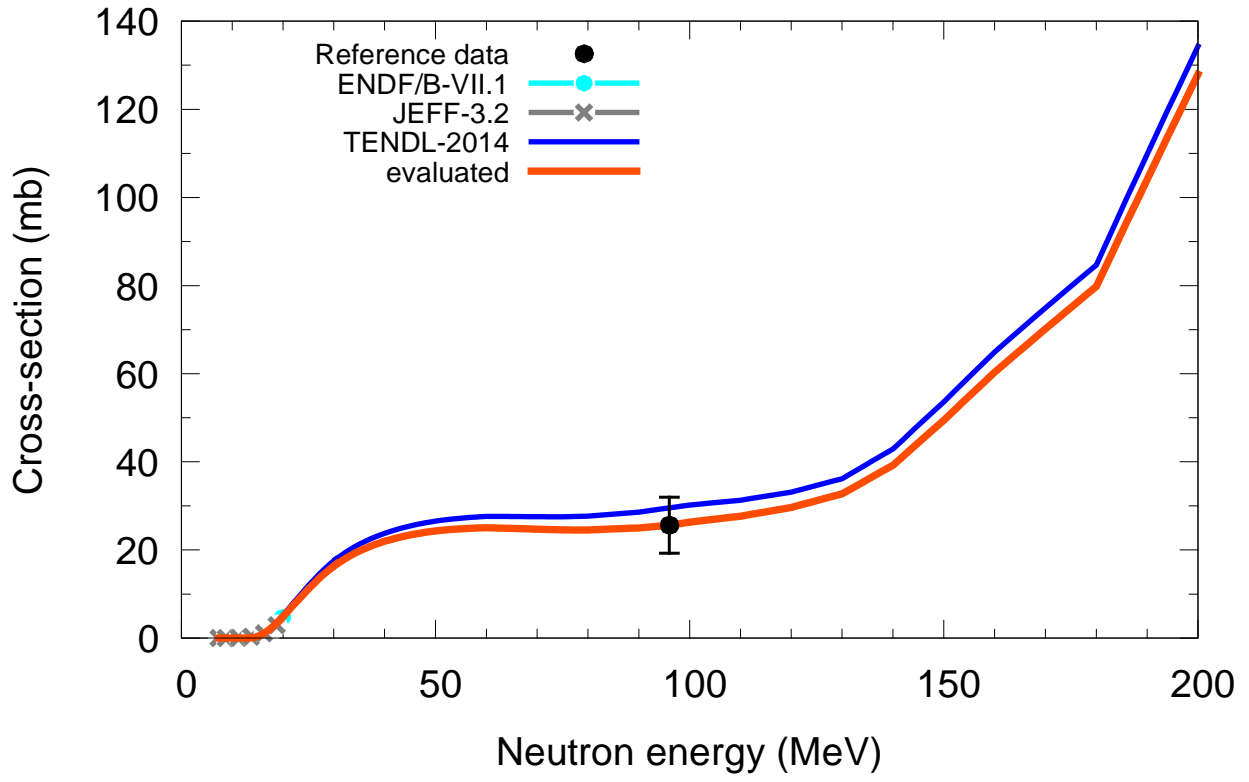
### $^{96}\text{Ru}(n,x)t$



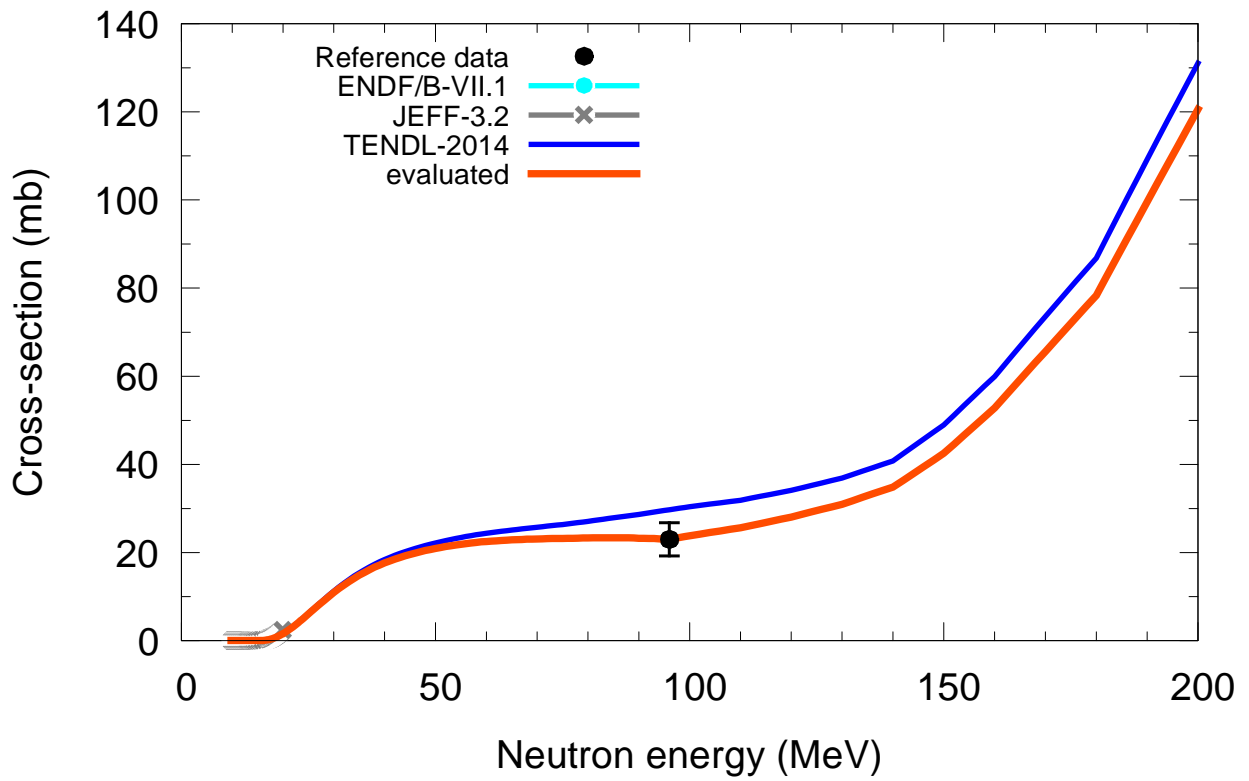
### $^{98}\text{Ru}(n,x)t$



$^{99}\text{Ru}(n,x)t$

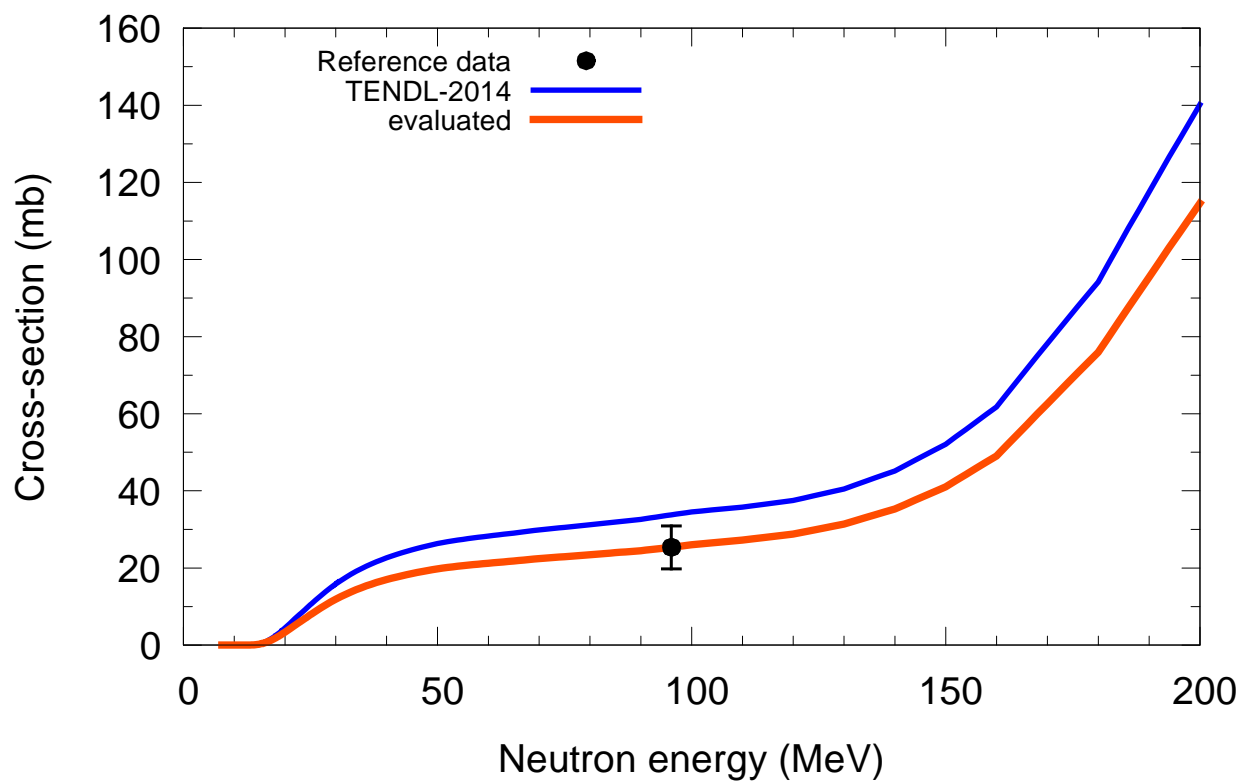


$^{100}\text{Ru}(n,x)t$

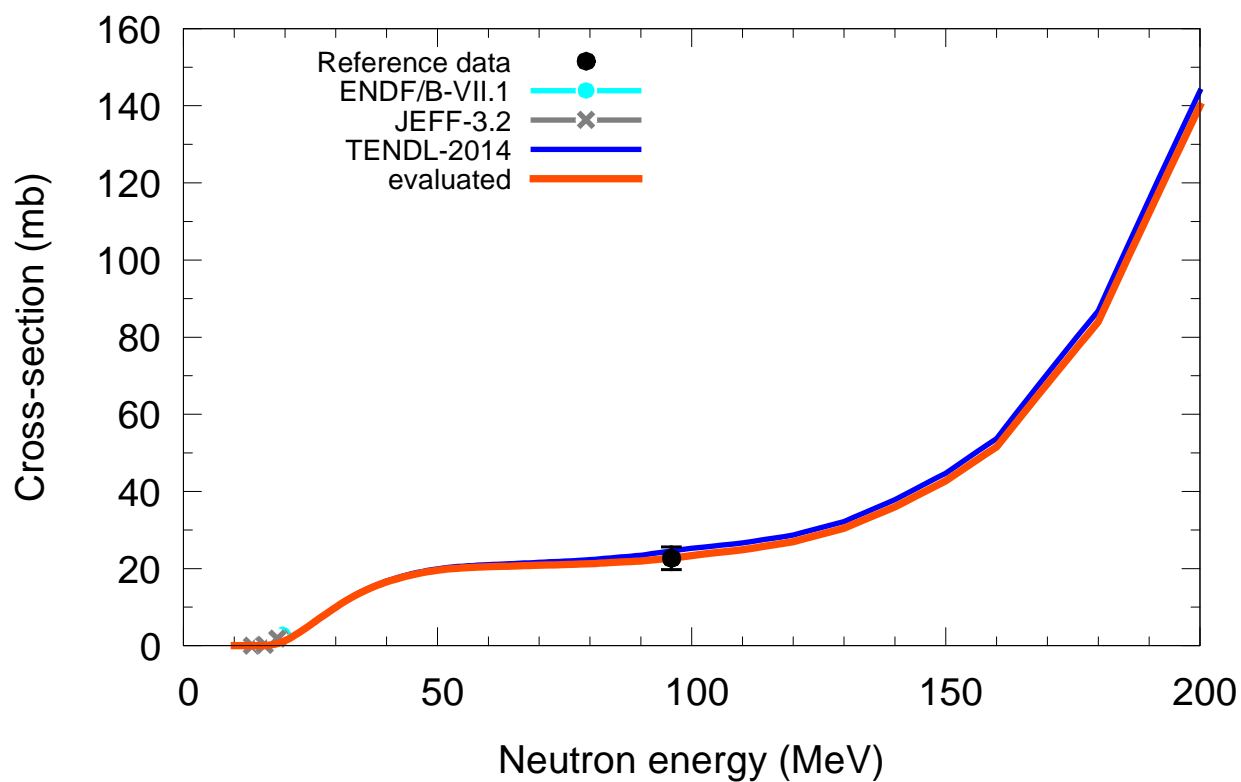


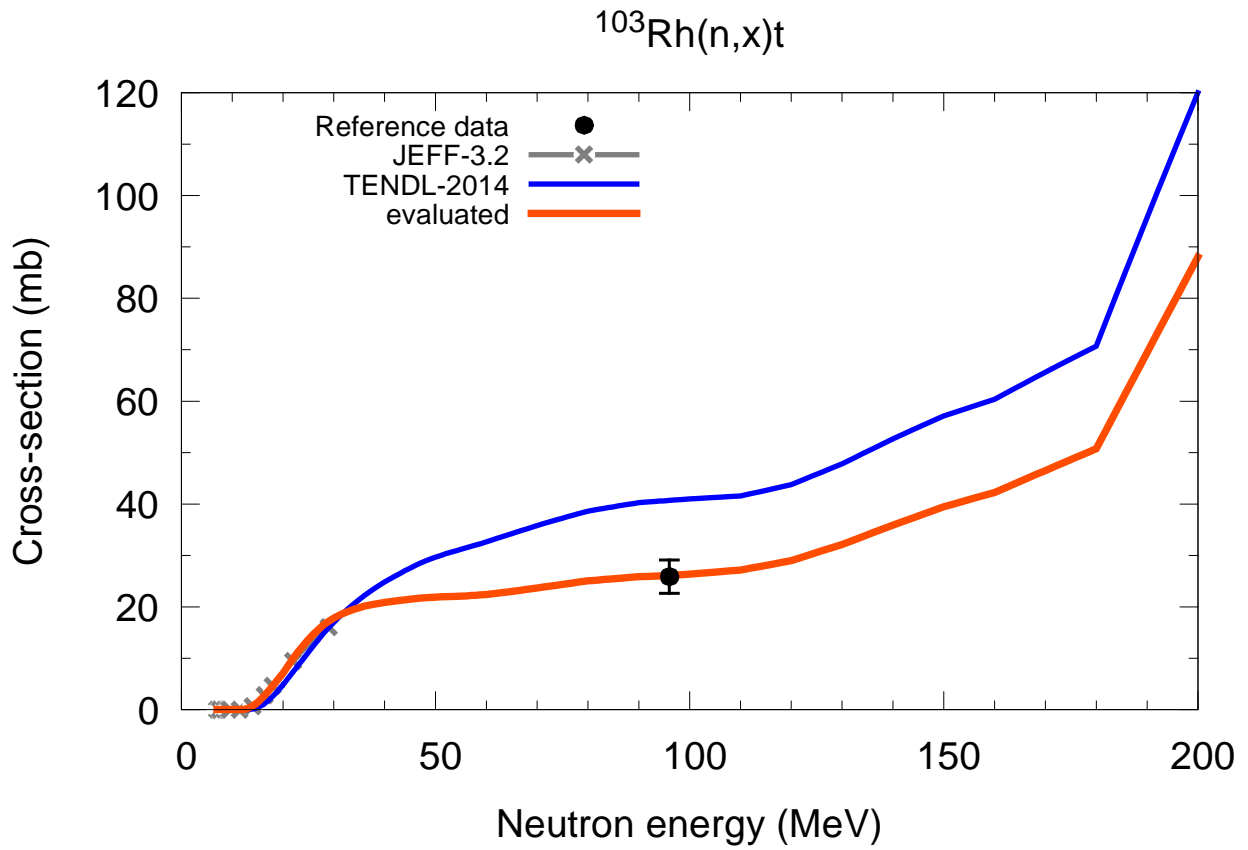
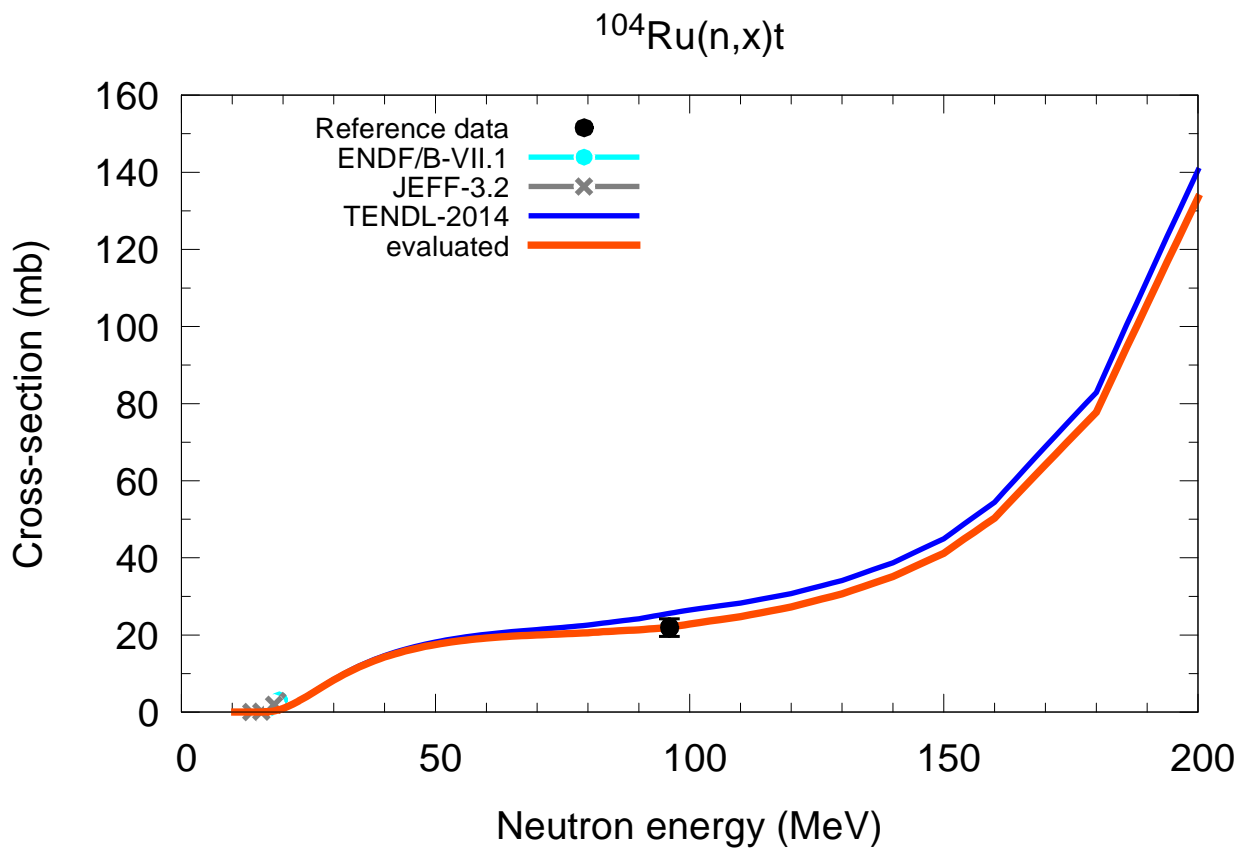


### $^{101}\text{Ru}(n,x)t$

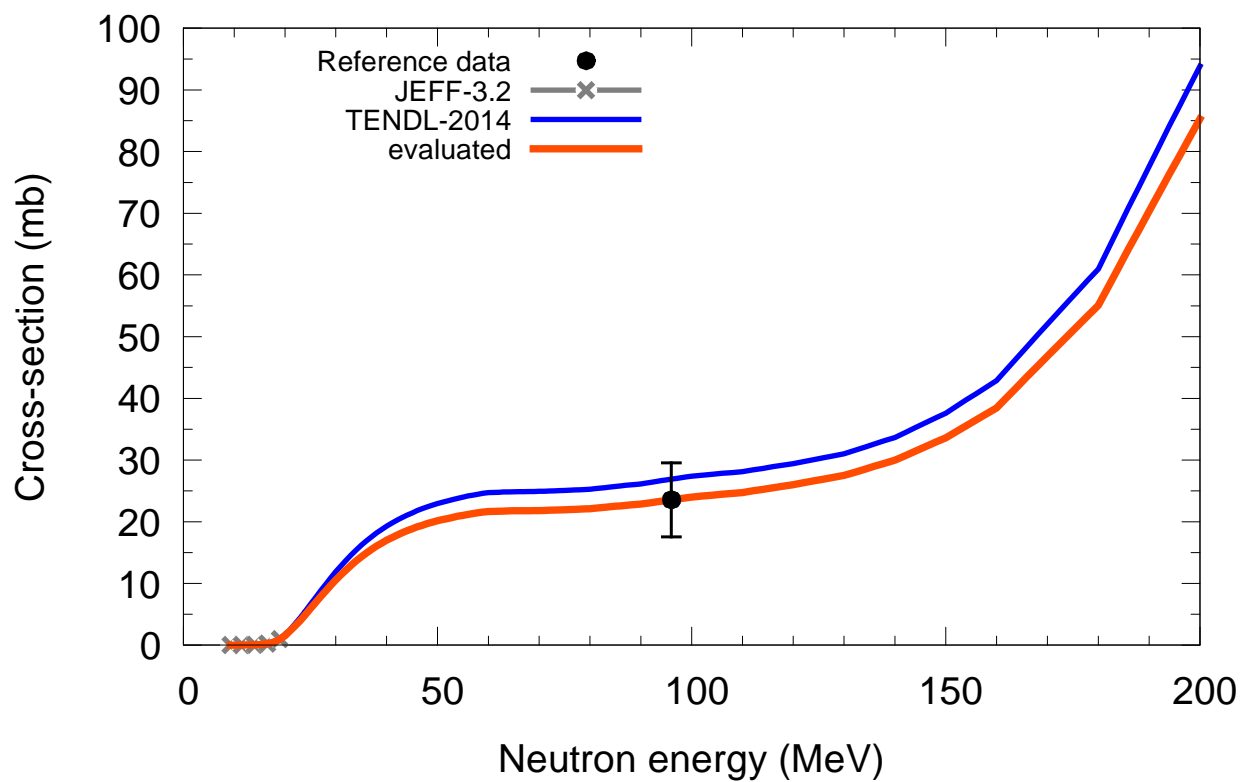


### $^{102}\text{Ru}(n,x)t$

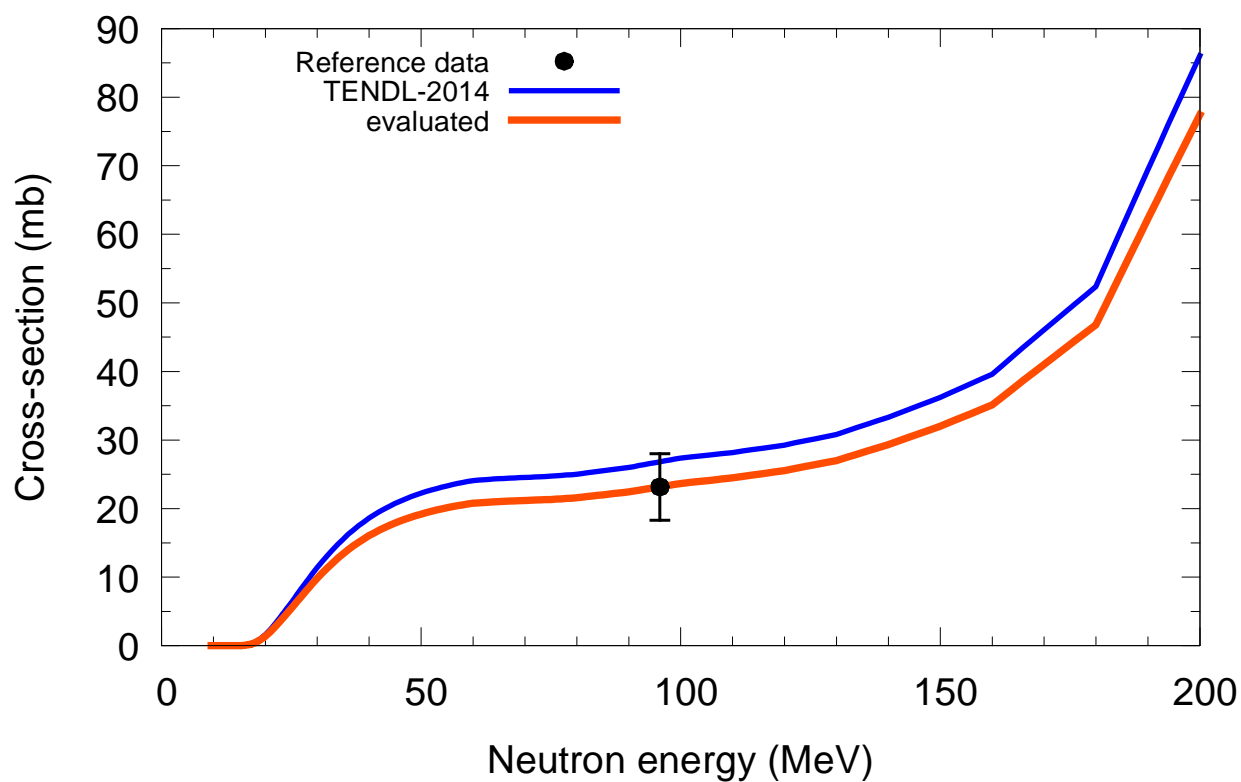




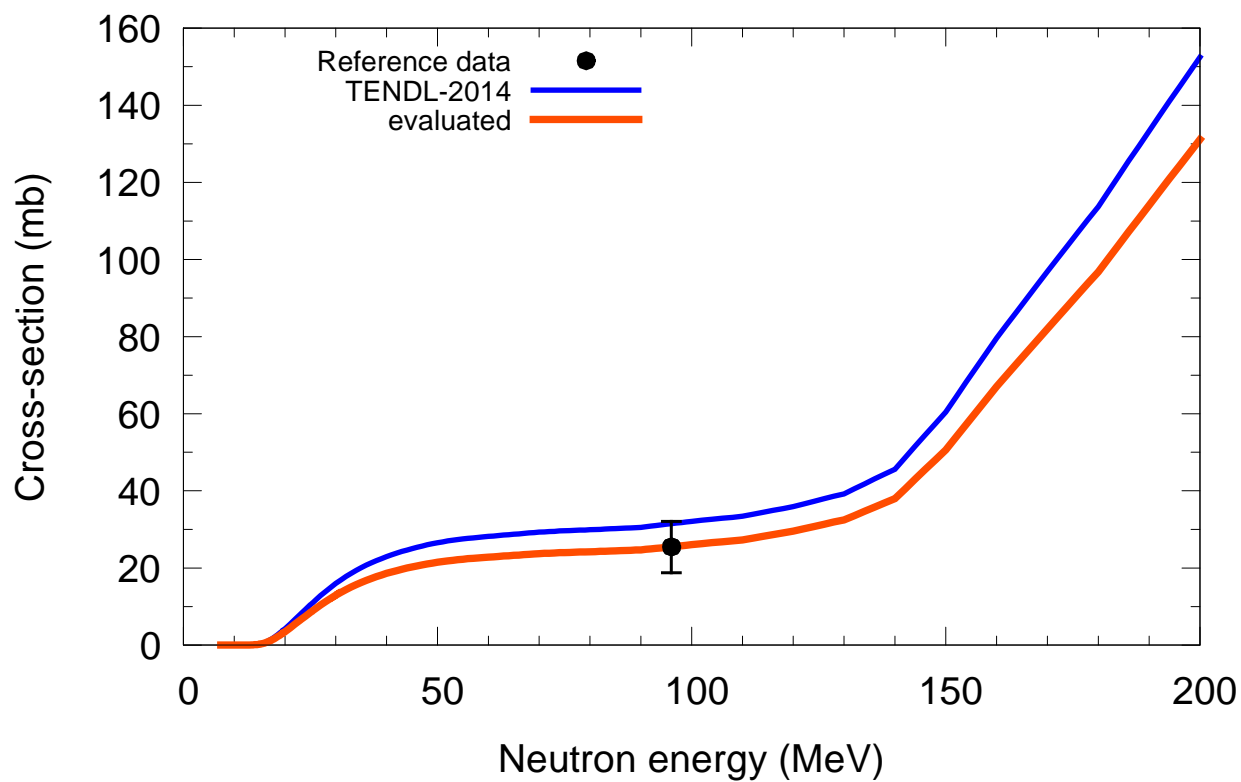
$^{102}\text{Pd}(n,x)t$



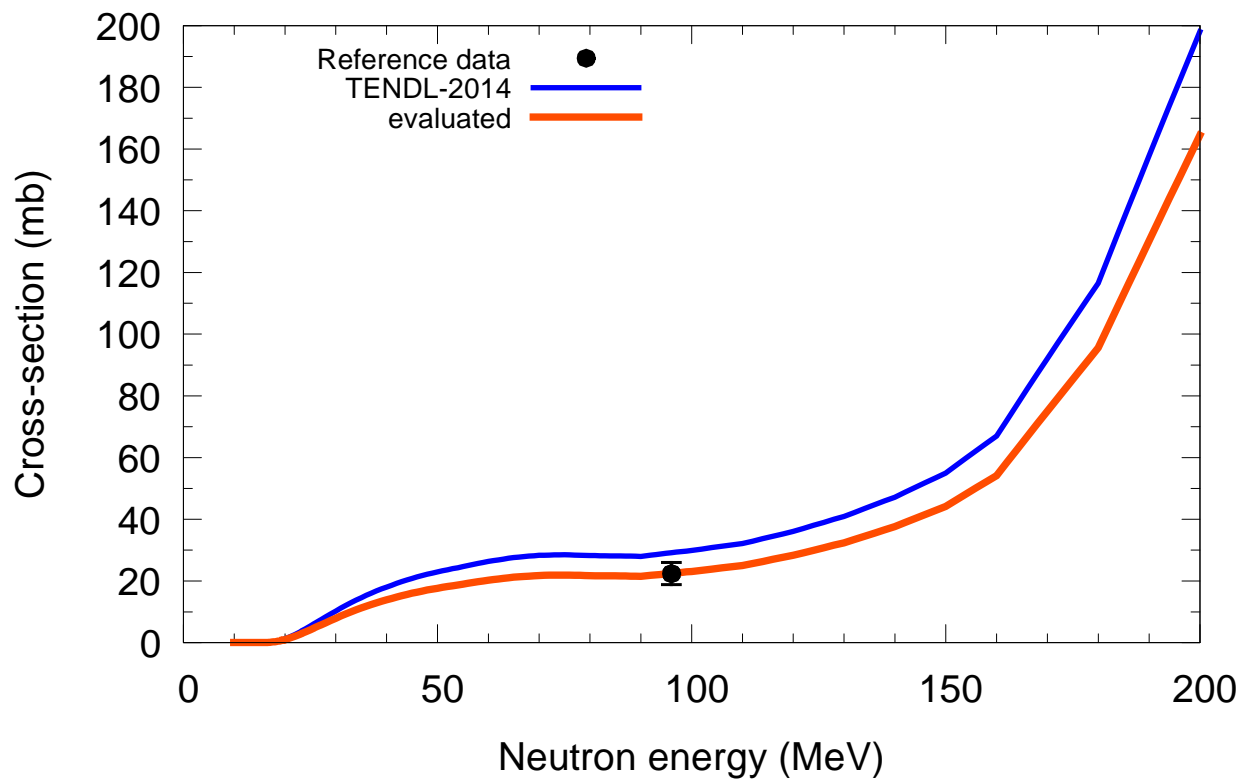
$^{104}\text{Pd}(n,x)t$



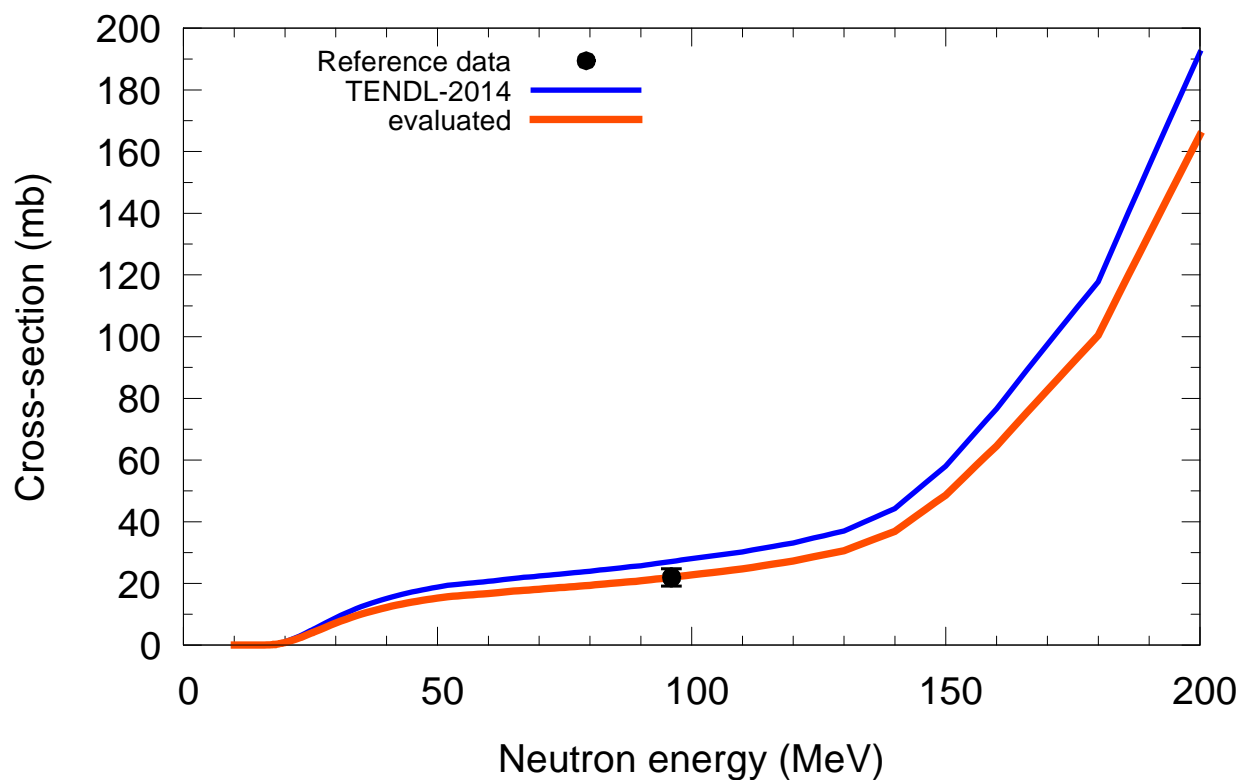
$^{105}\text{Pd}(n,x)t$



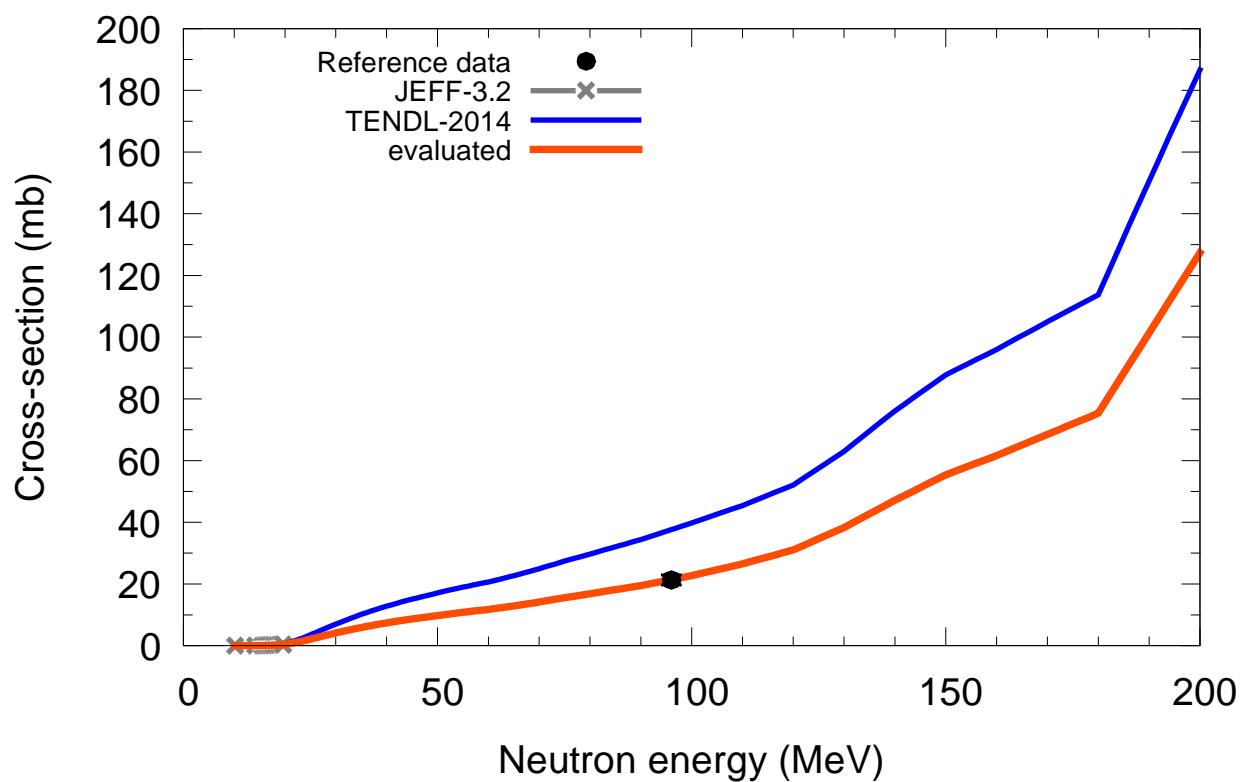
$^{106}\text{Pd}(n,x)t$



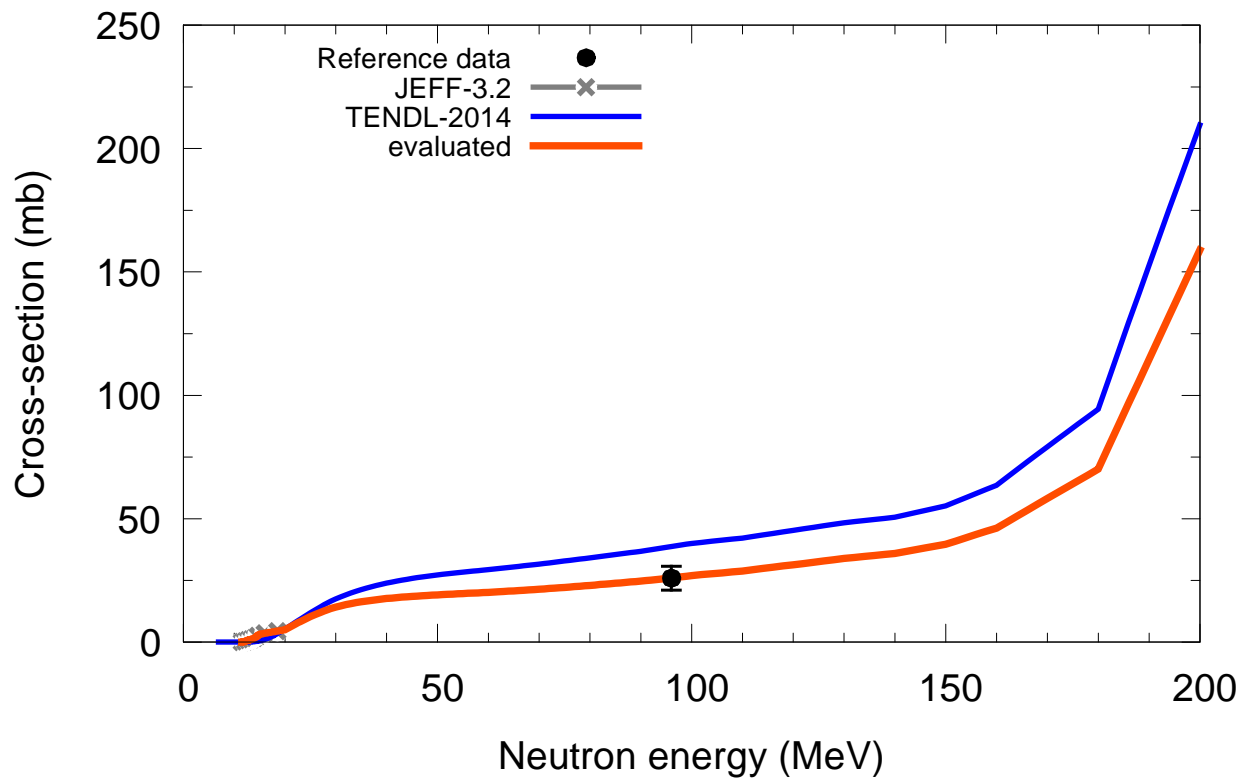
$^{108}\text{Pd}(n,x)t$



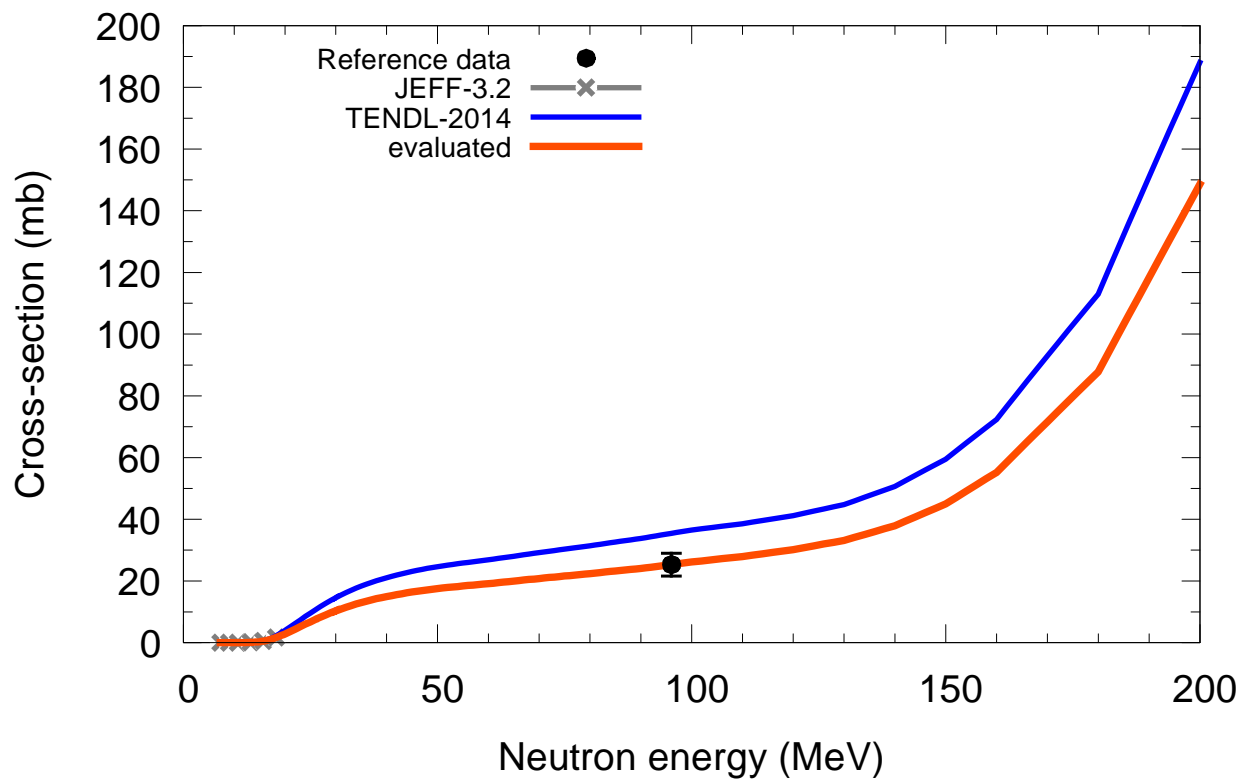
$^{110}\text{Pd}(n,x)t$



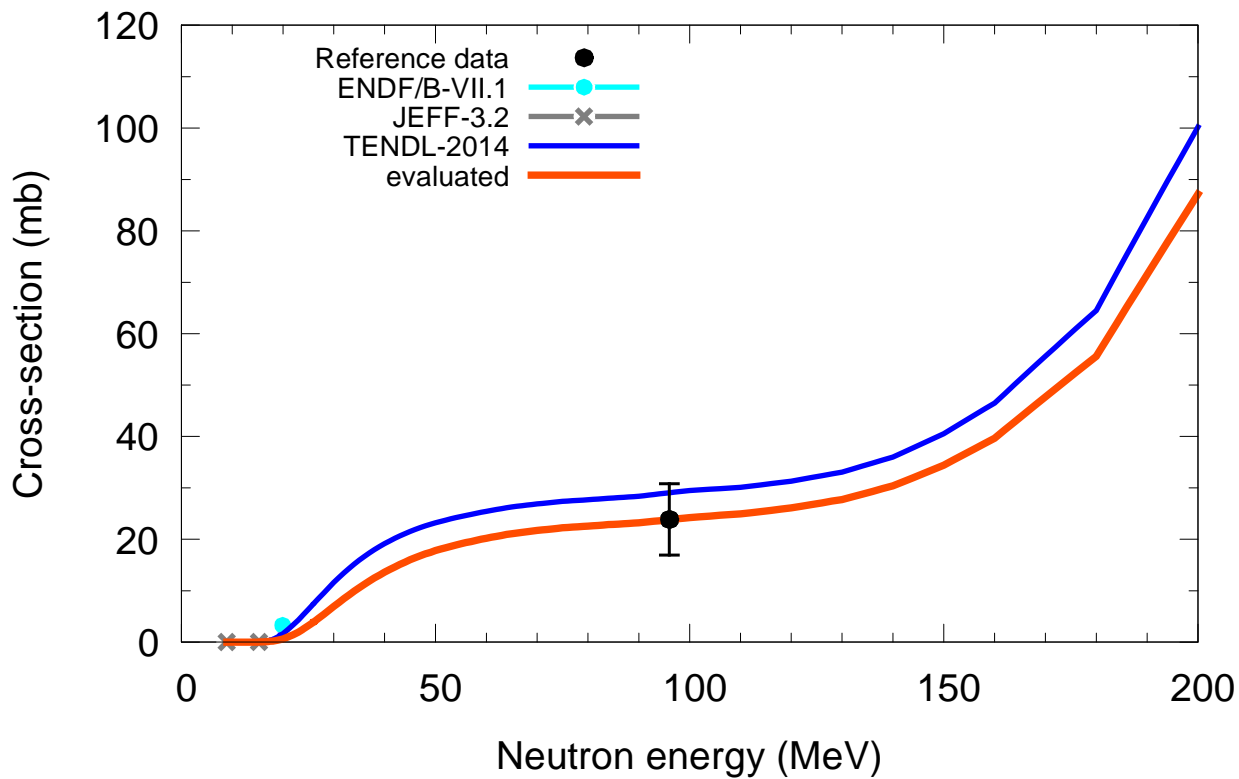
$^{107}\text{Ag}(n,x)t$



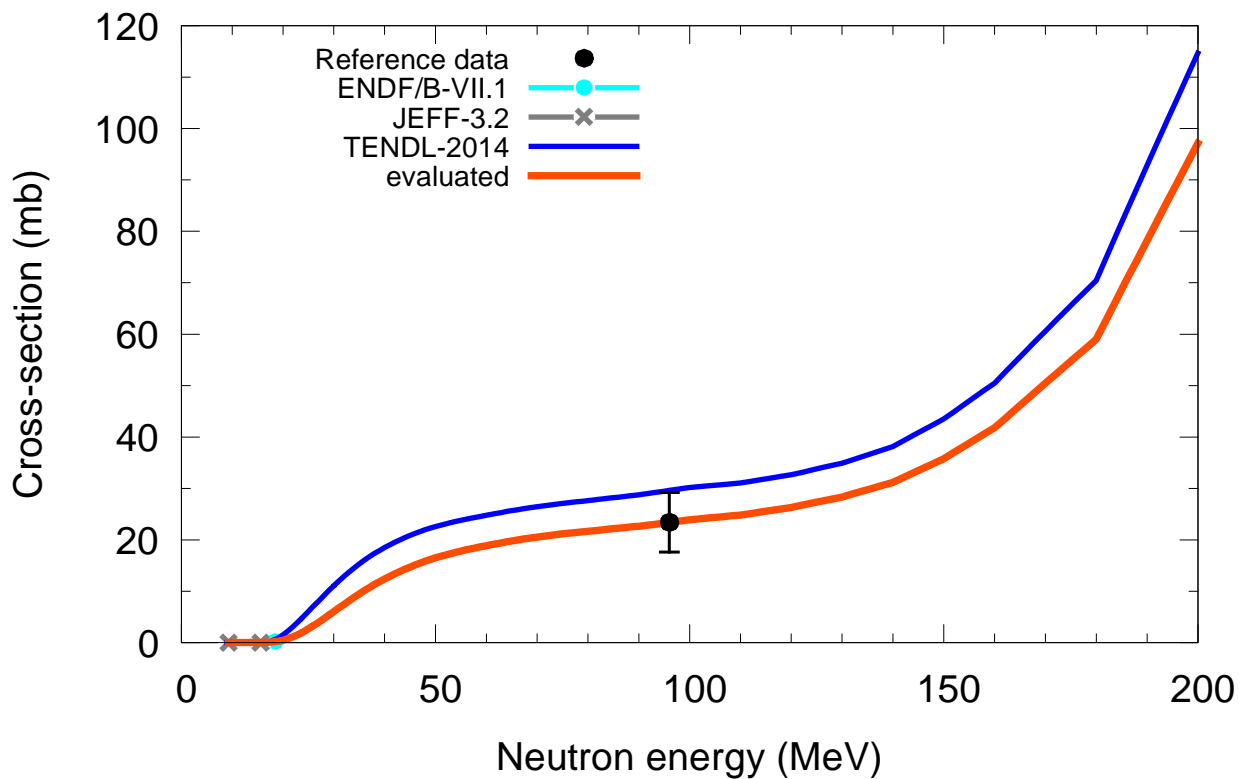
$^{109}\text{Ag}(n,x)t$



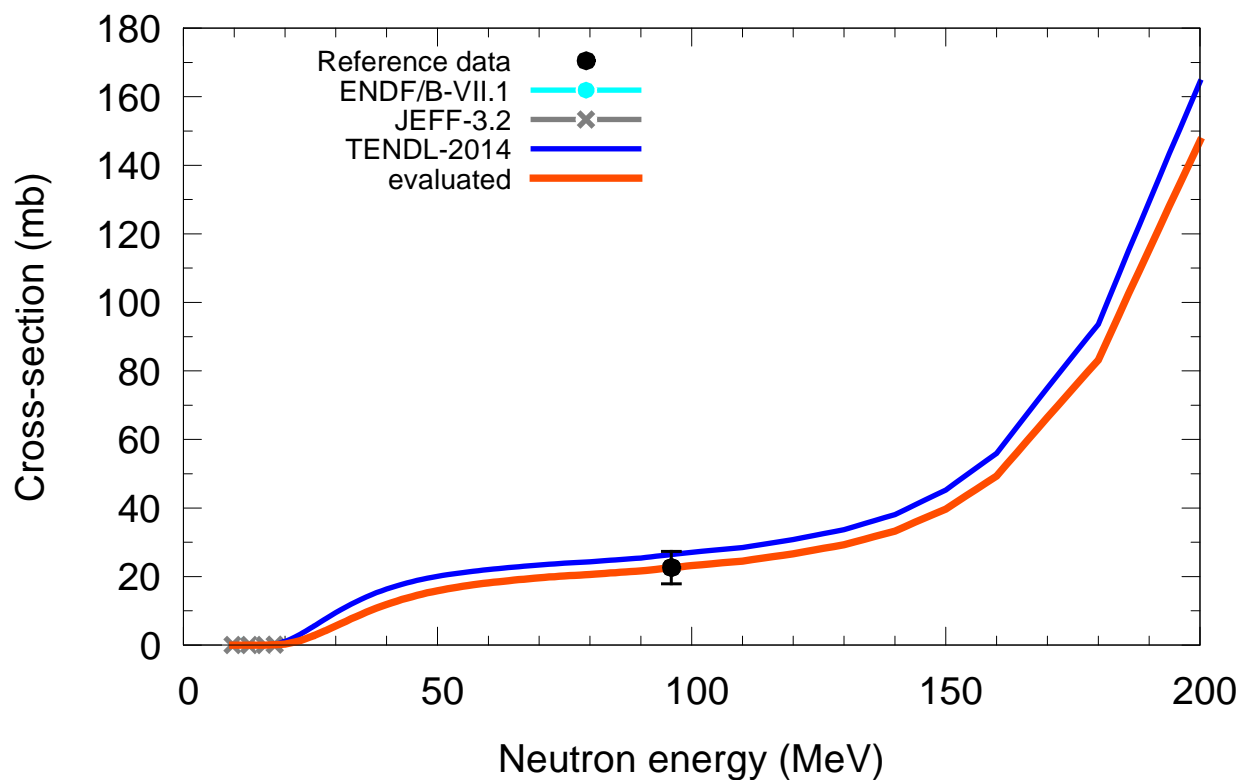
### $^{106}\text{Cd}(n,x)t$



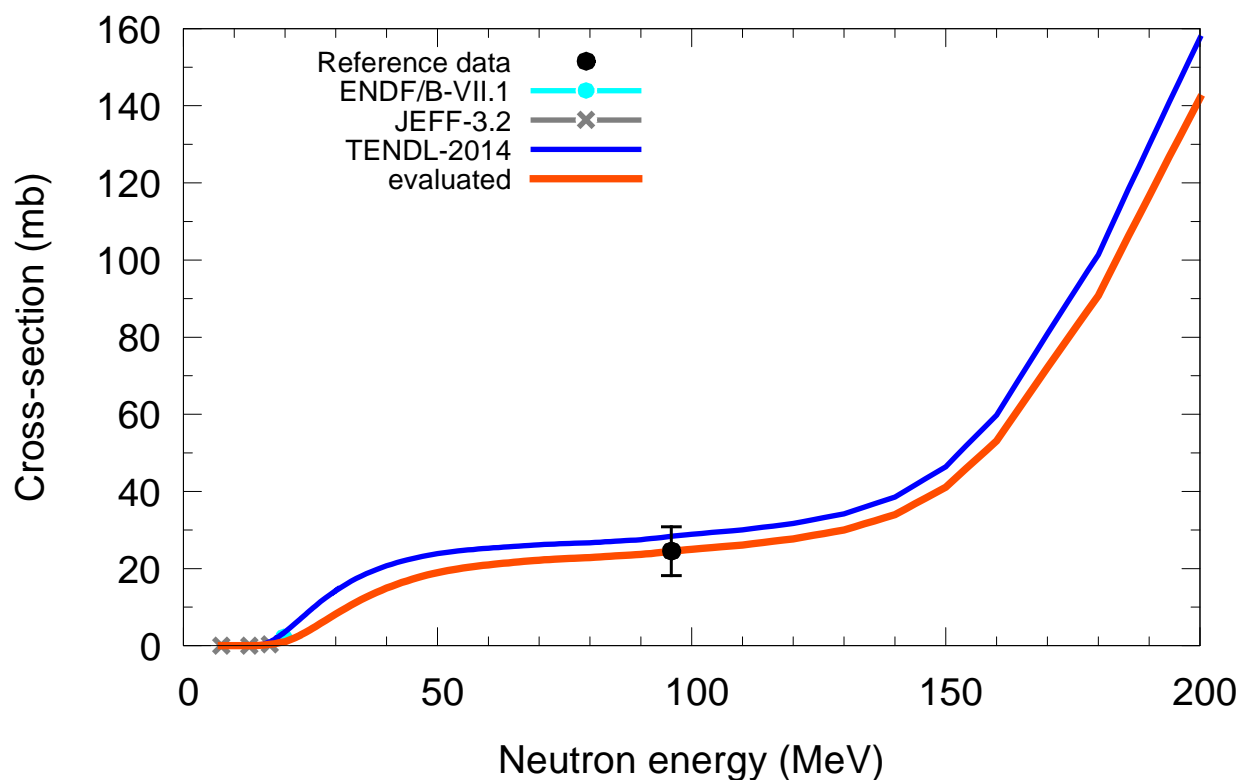
### $^{108}\text{Cd}(n,x)t$



### $^{110}\text{Cd}(n,x)t$

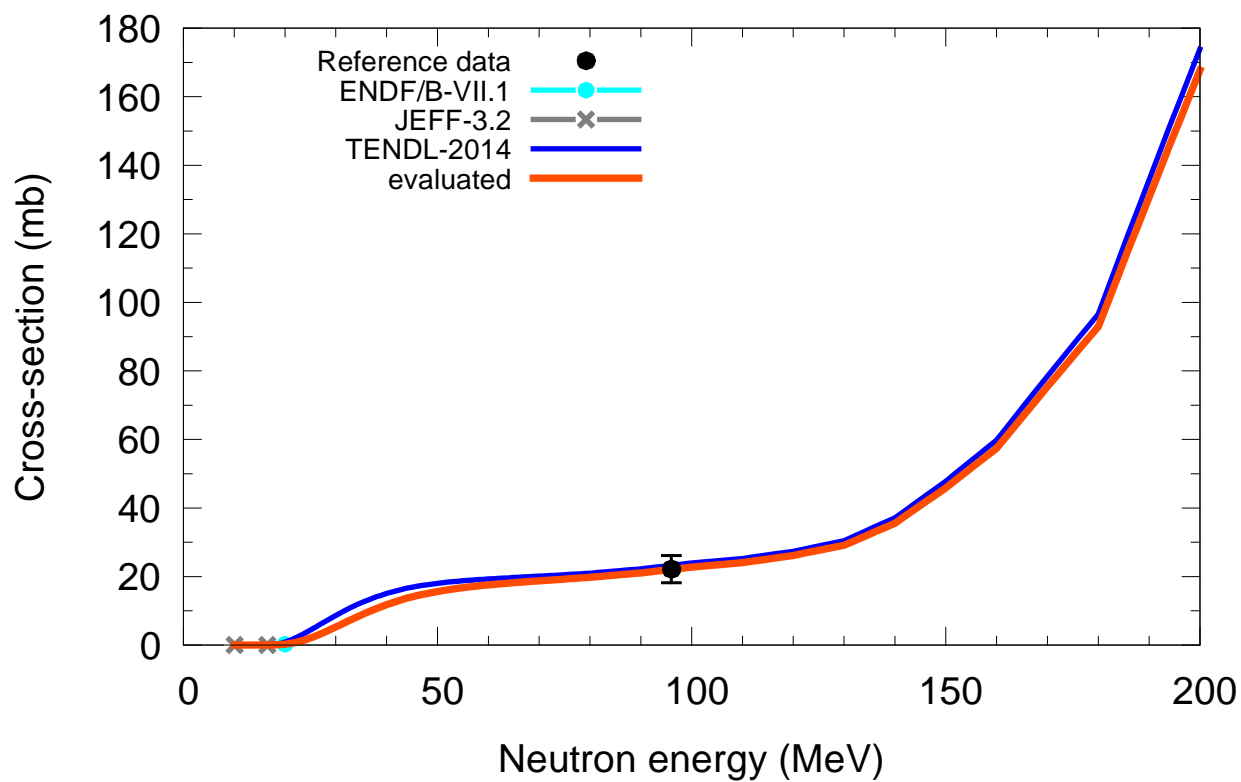


### $^{111}\text{Cd}(n,x)t$

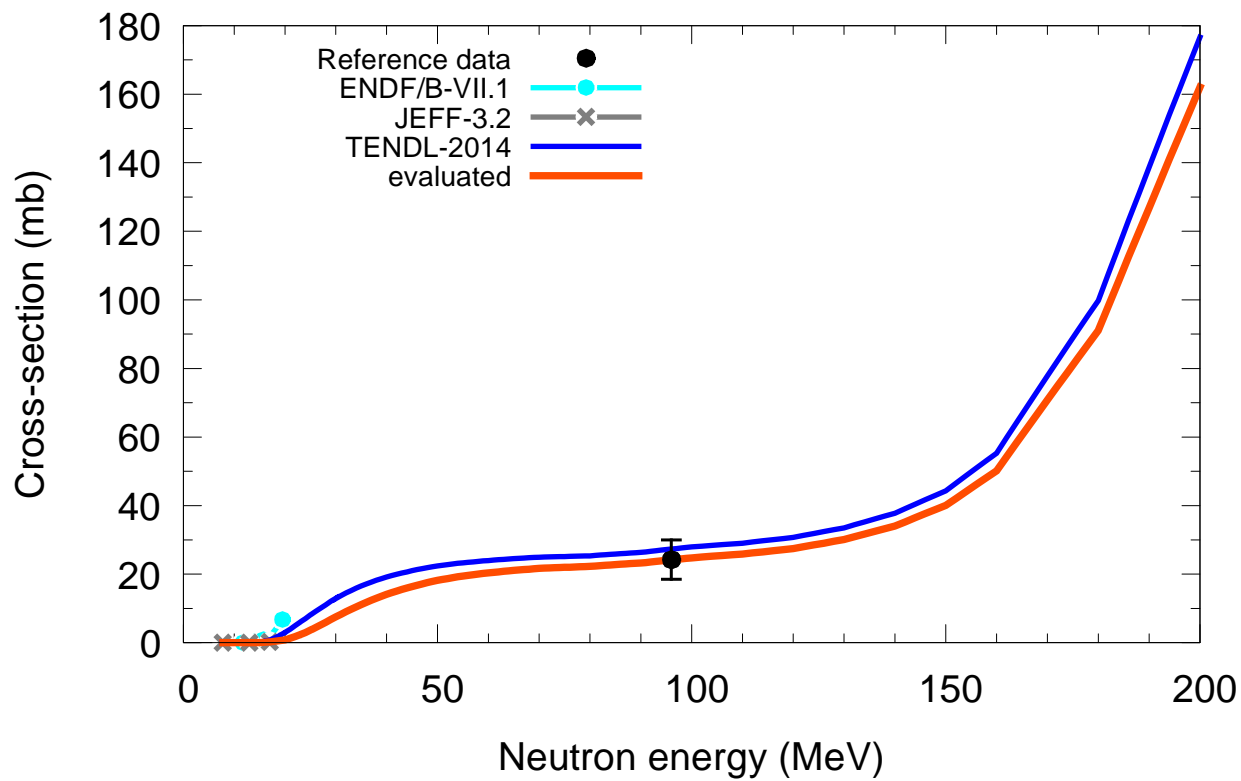




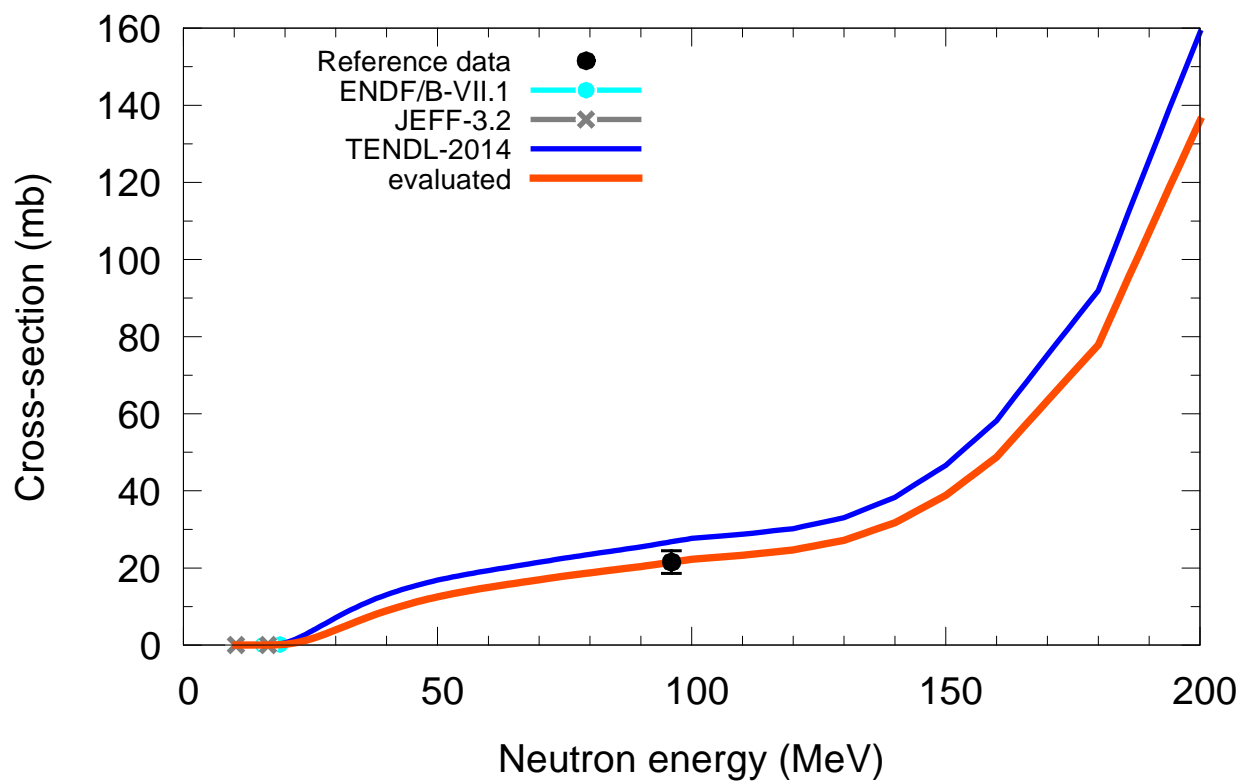
### $^{112}\text{Cd}(n,x)t$



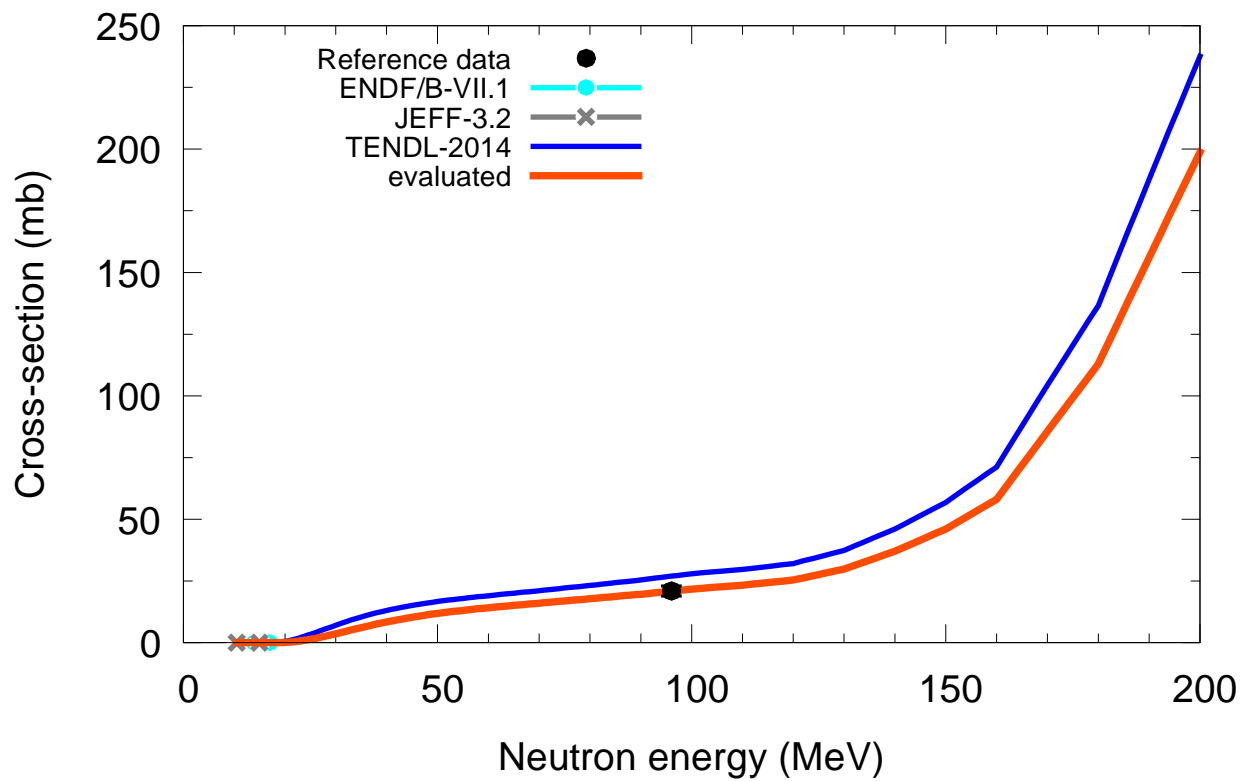
### $^{113}\text{Cd}(n,x)t$



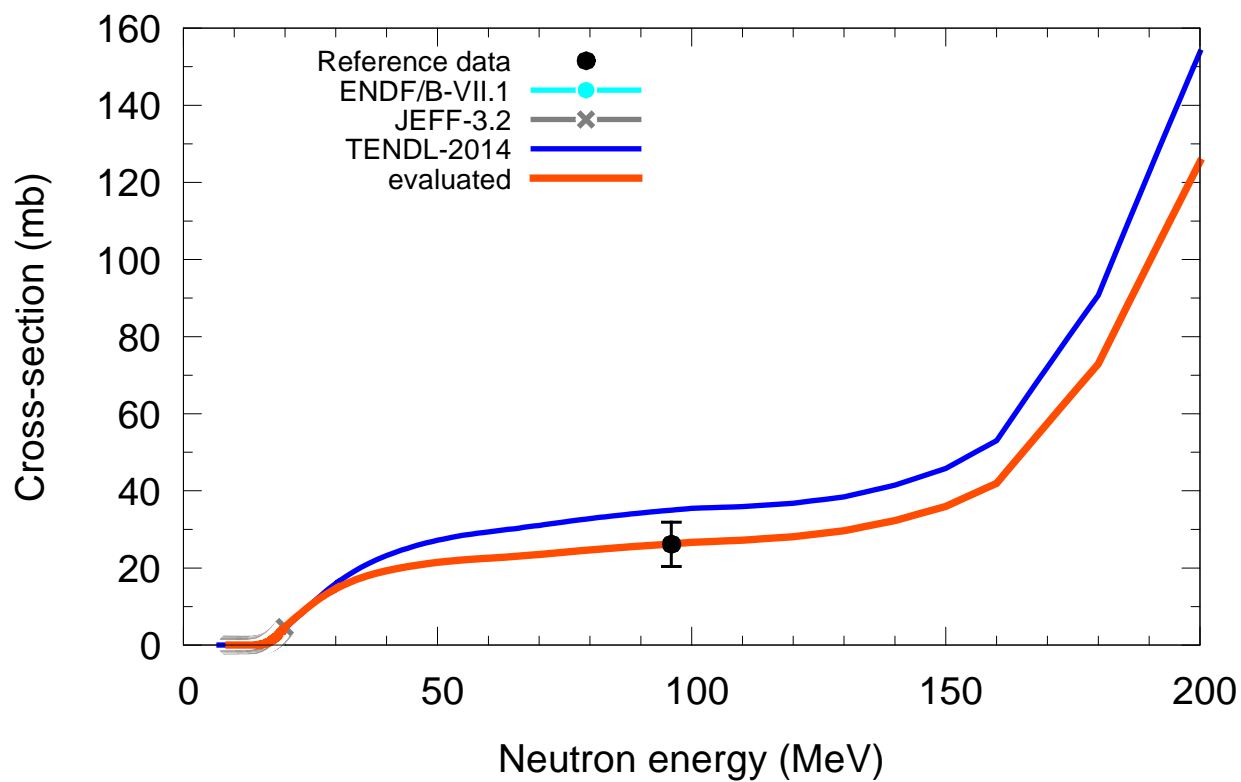
### $^{114}\text{Cd}(n,x)t$



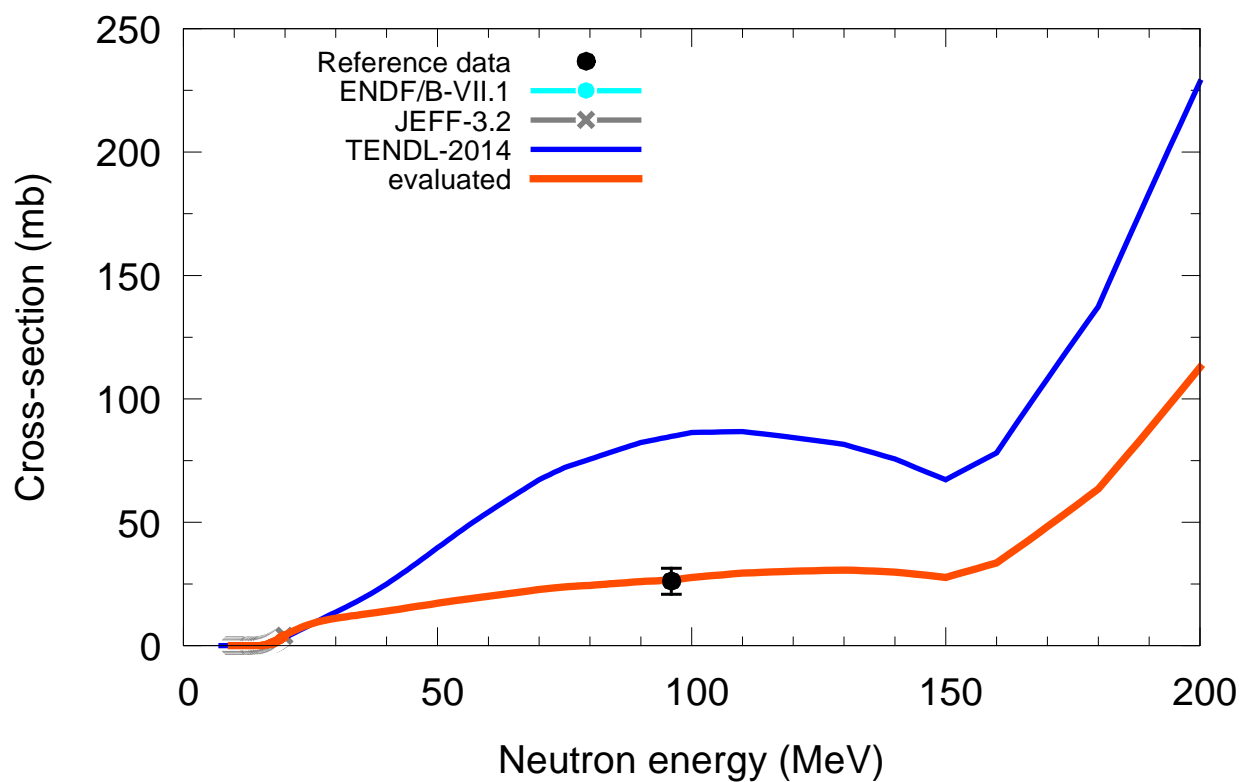
### $^{116}\text{Cd}(n,x)t$



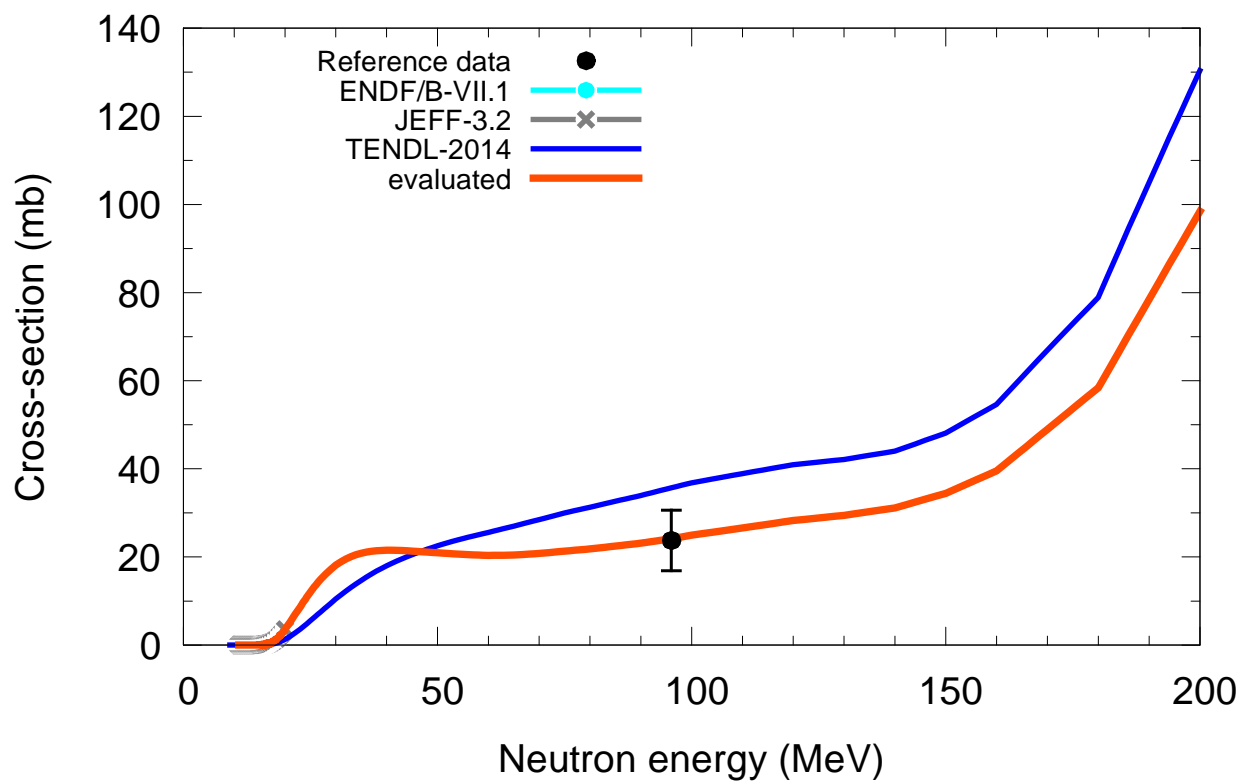
$^{113}\text{In}(n,x)t$



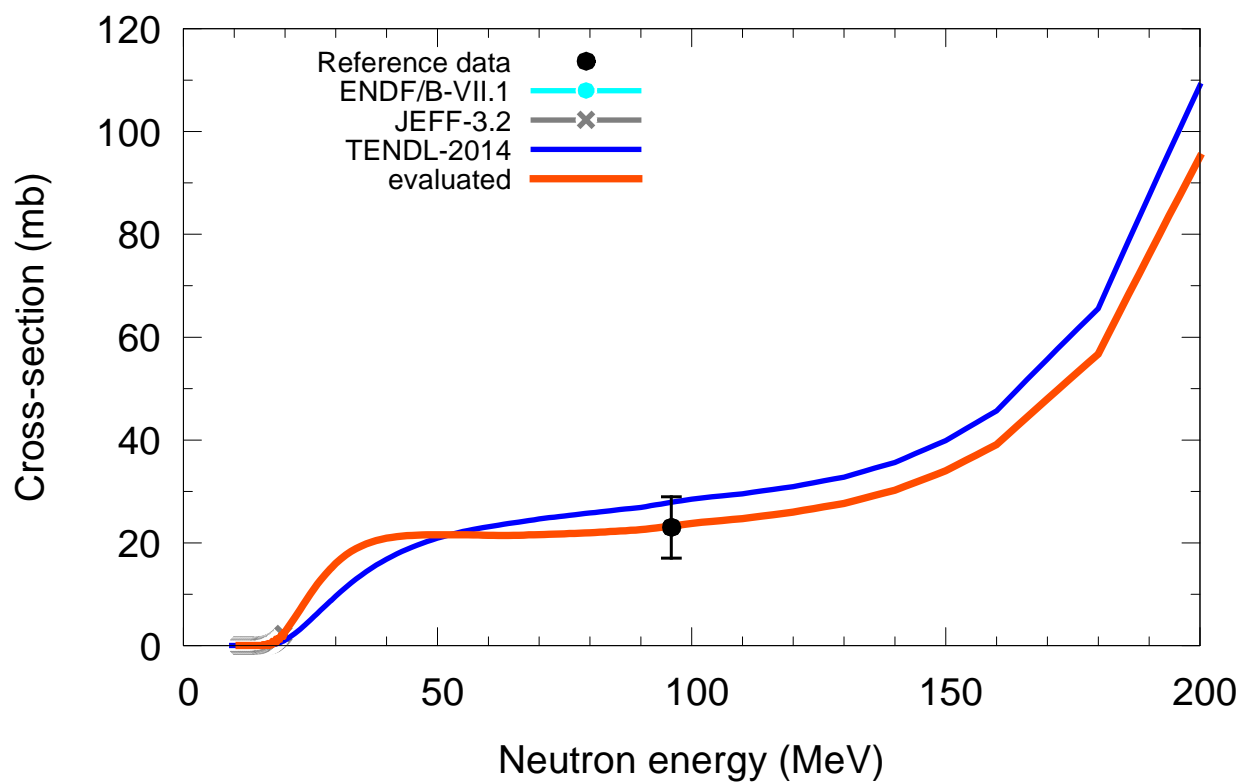
$^{115}\text{In}(n,x)t$



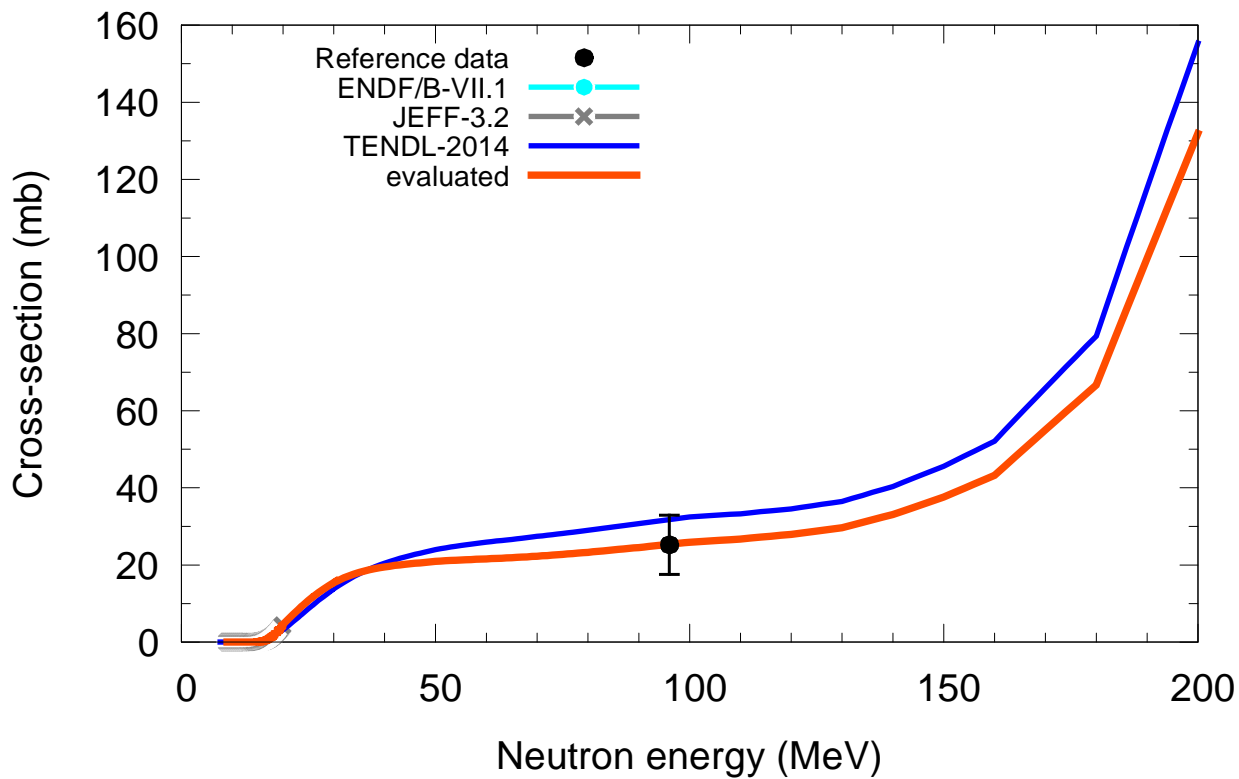
### $^{112}\text{Sn}(n,x)t$



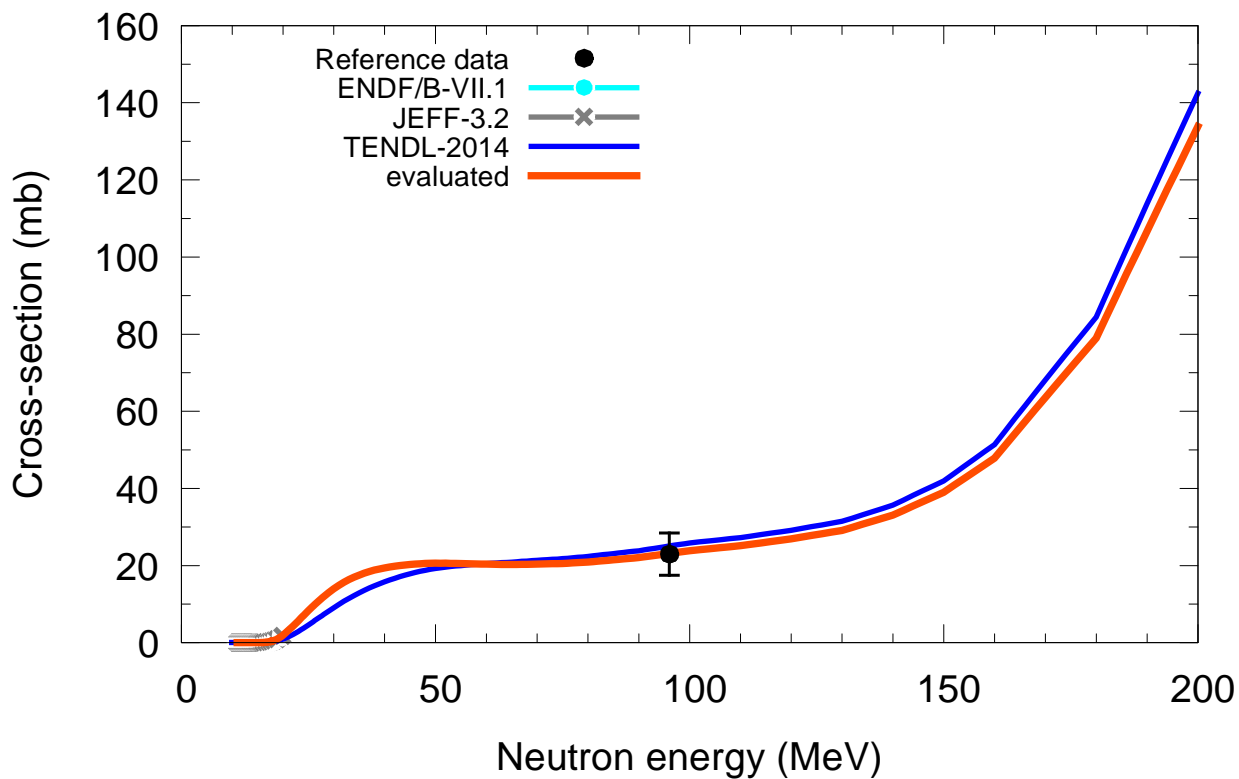
### $^{114}\text{Sn}(n,x)t$



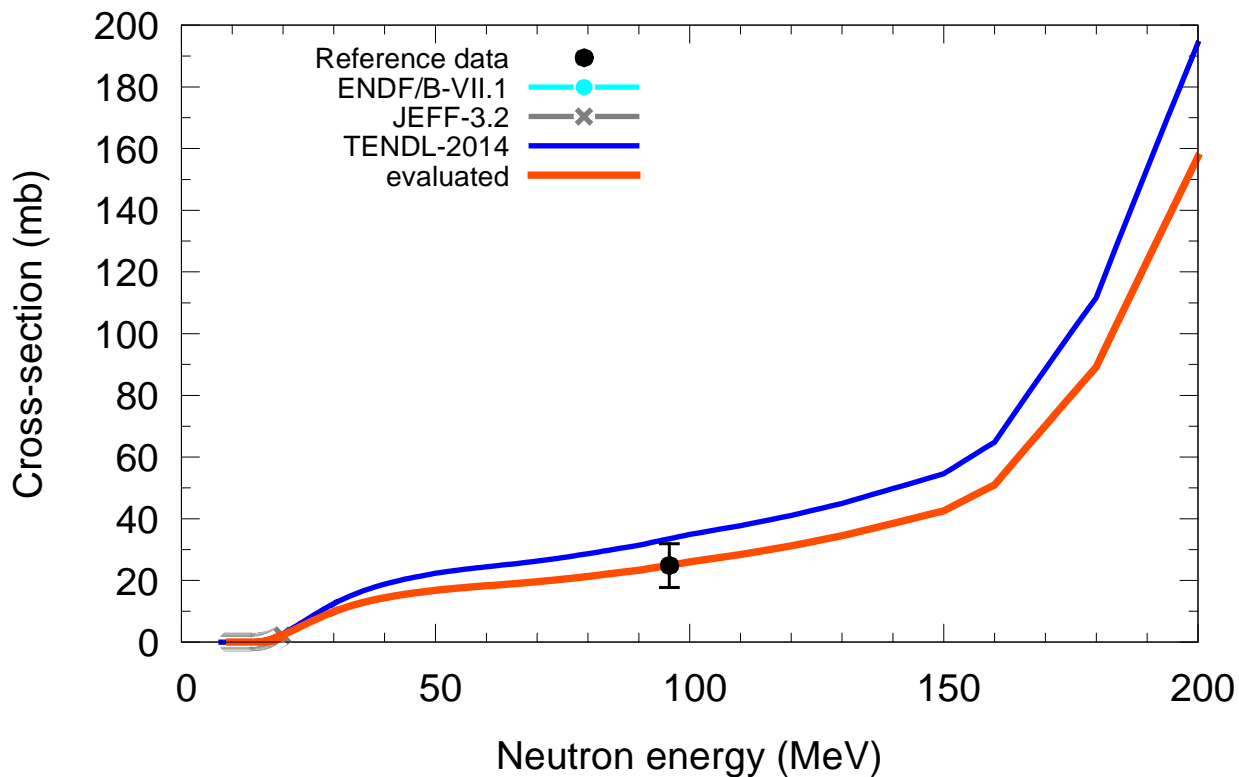
### $^{115}\text{Sn}(n,x)t$



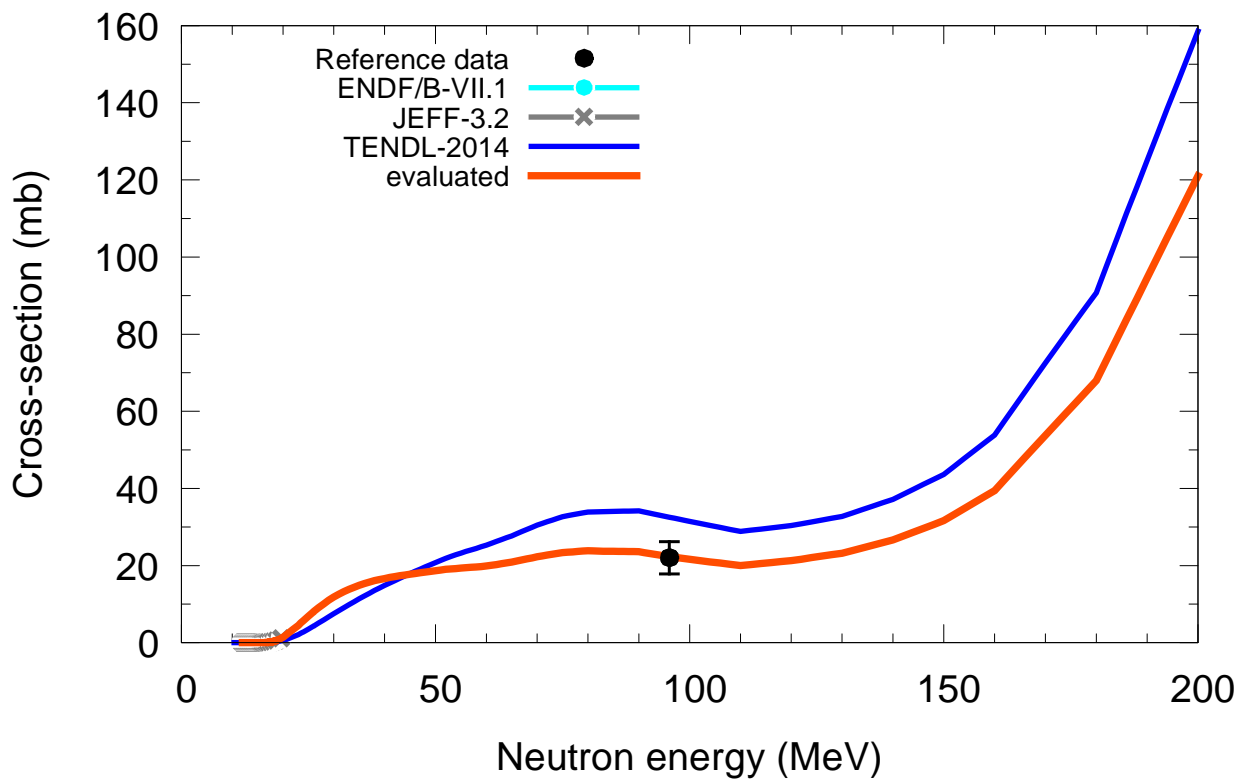
### $^{116}\text{Sn}(n,x)t$



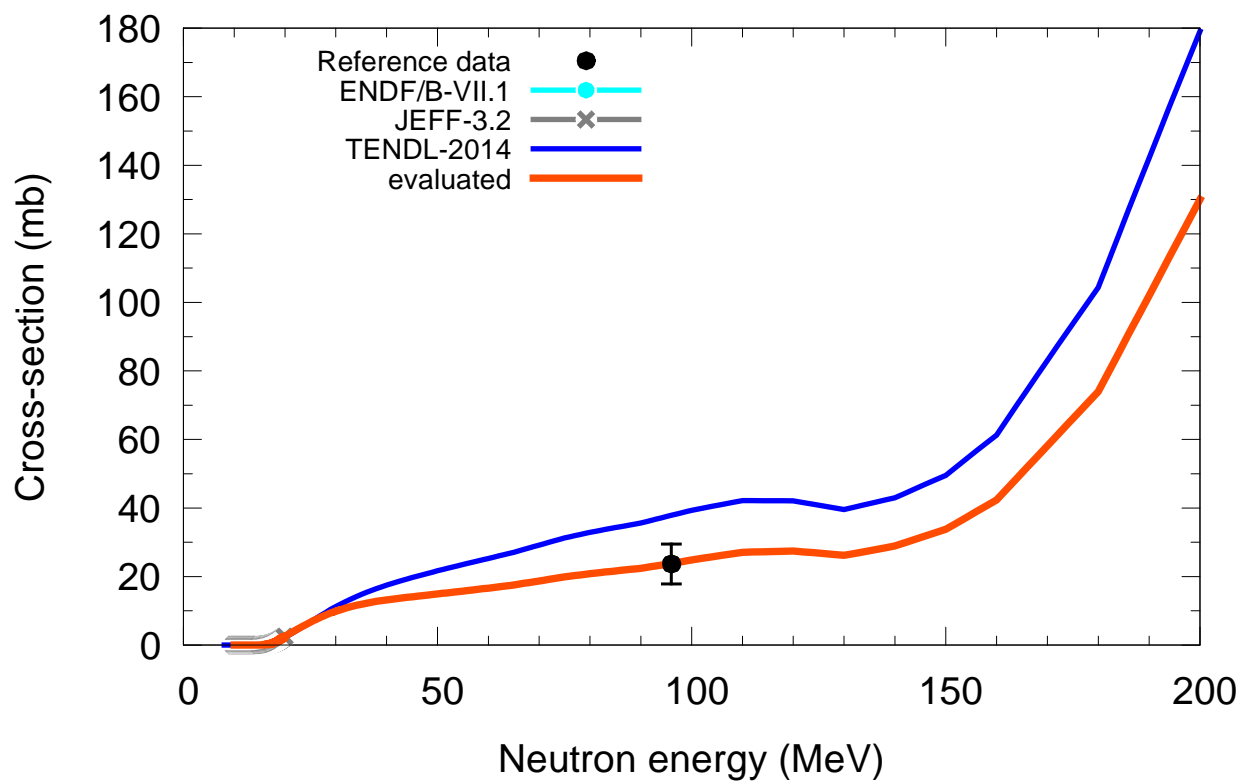
### $^{117}\text{Sn}(n,x)t$



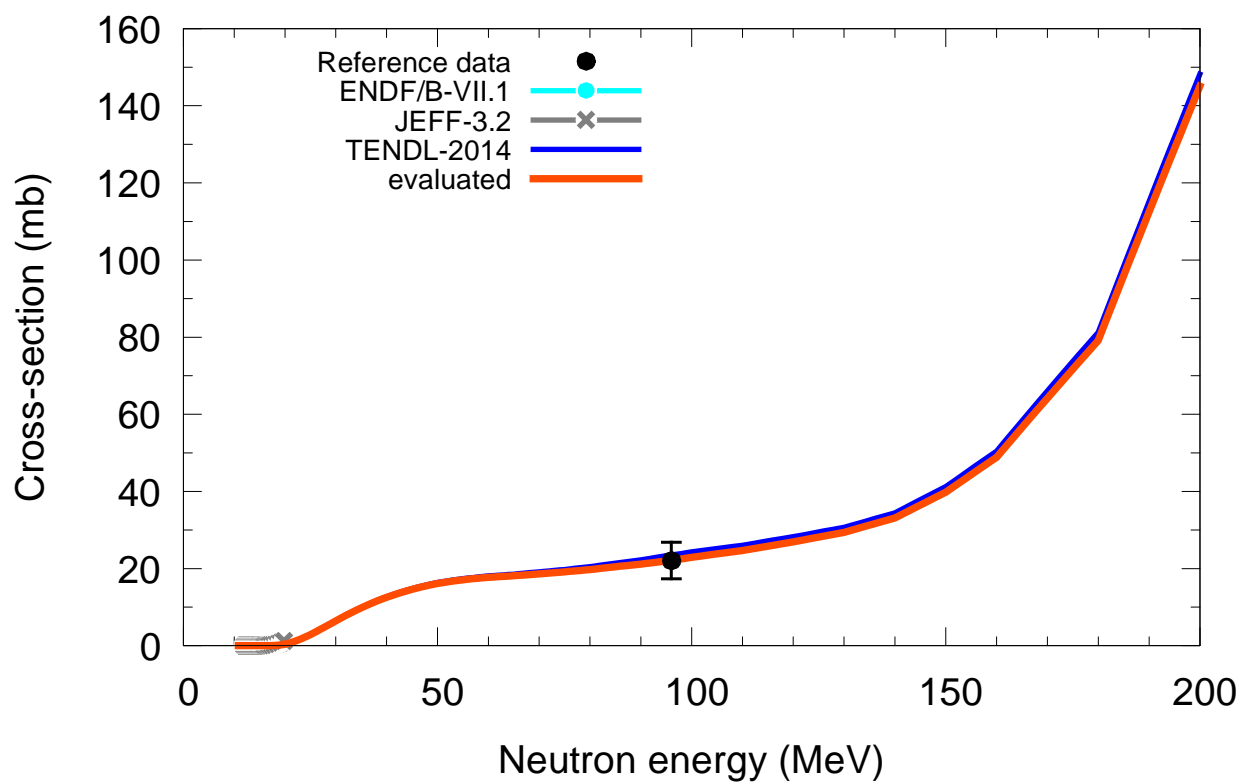
### $^{118}\text{Sn}(n,x)t$



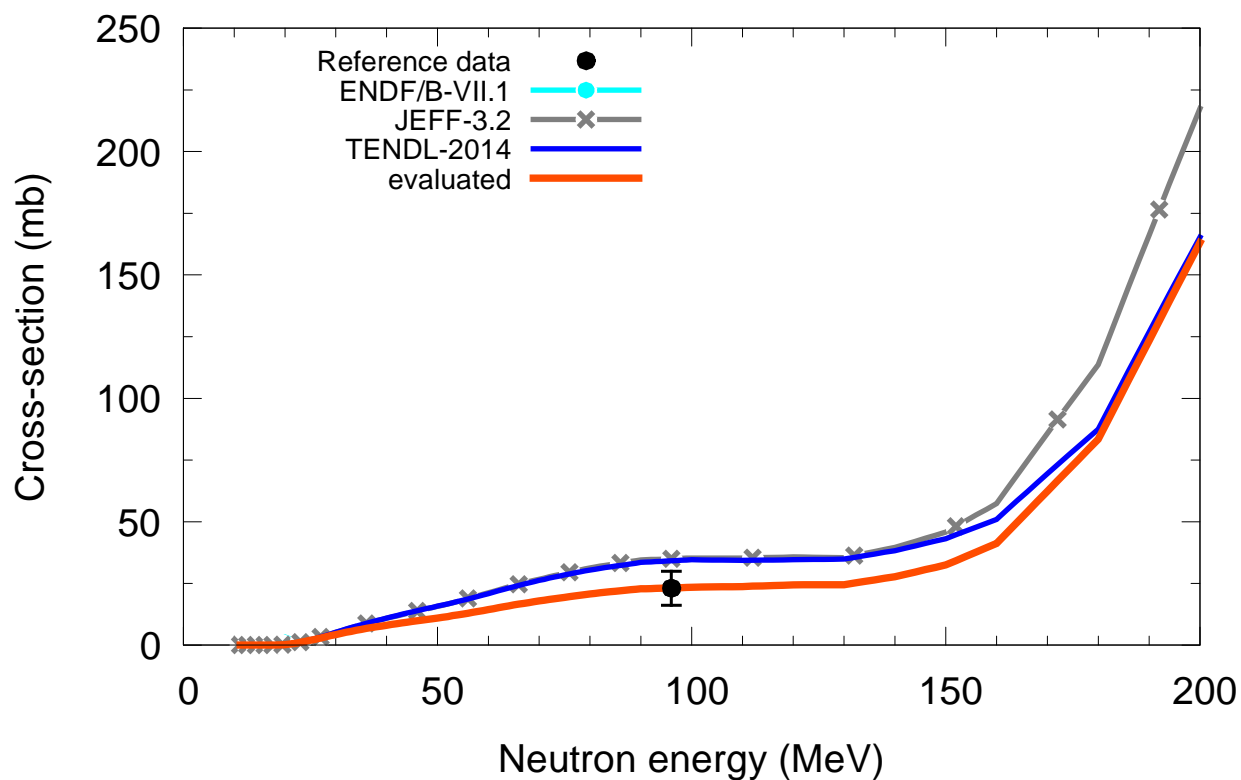
### $^{119}\text{Sn}(n,x)t$



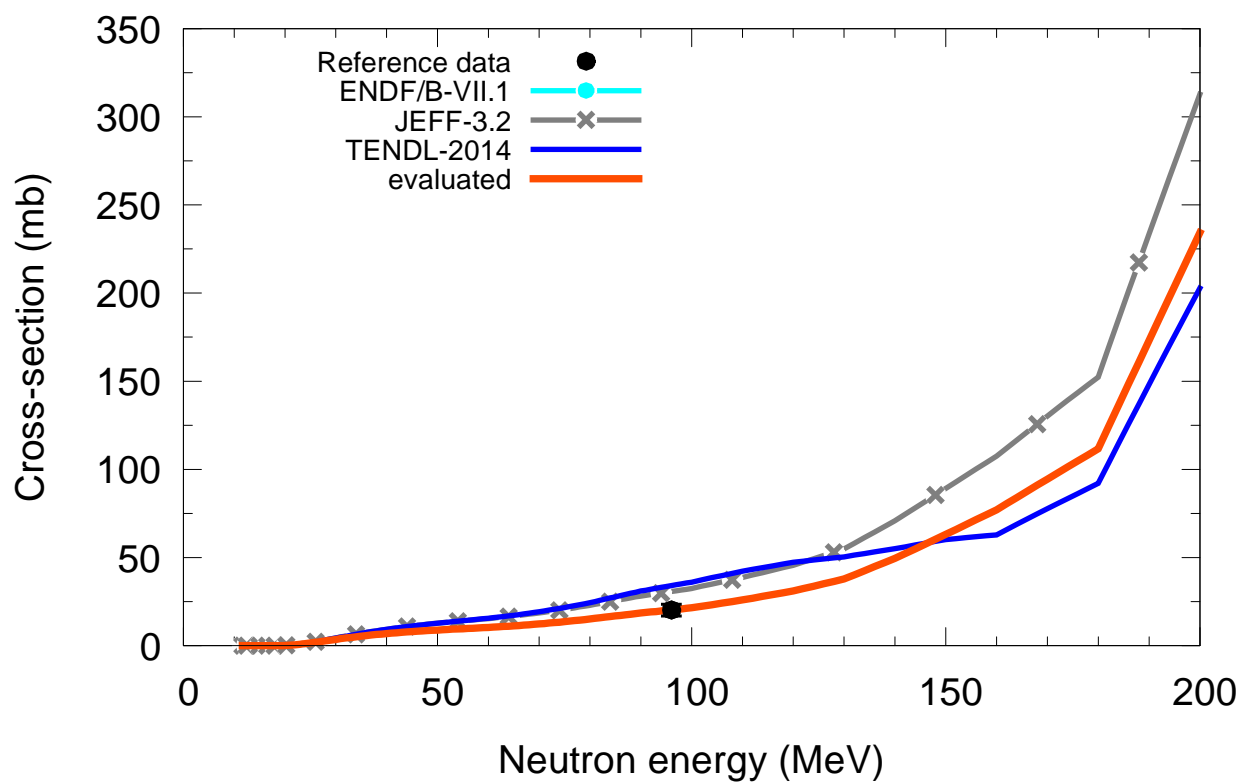
### $^{120}\text{Sn}(n,x)t$



### $^{122}\text{Sn}(n,x)t$

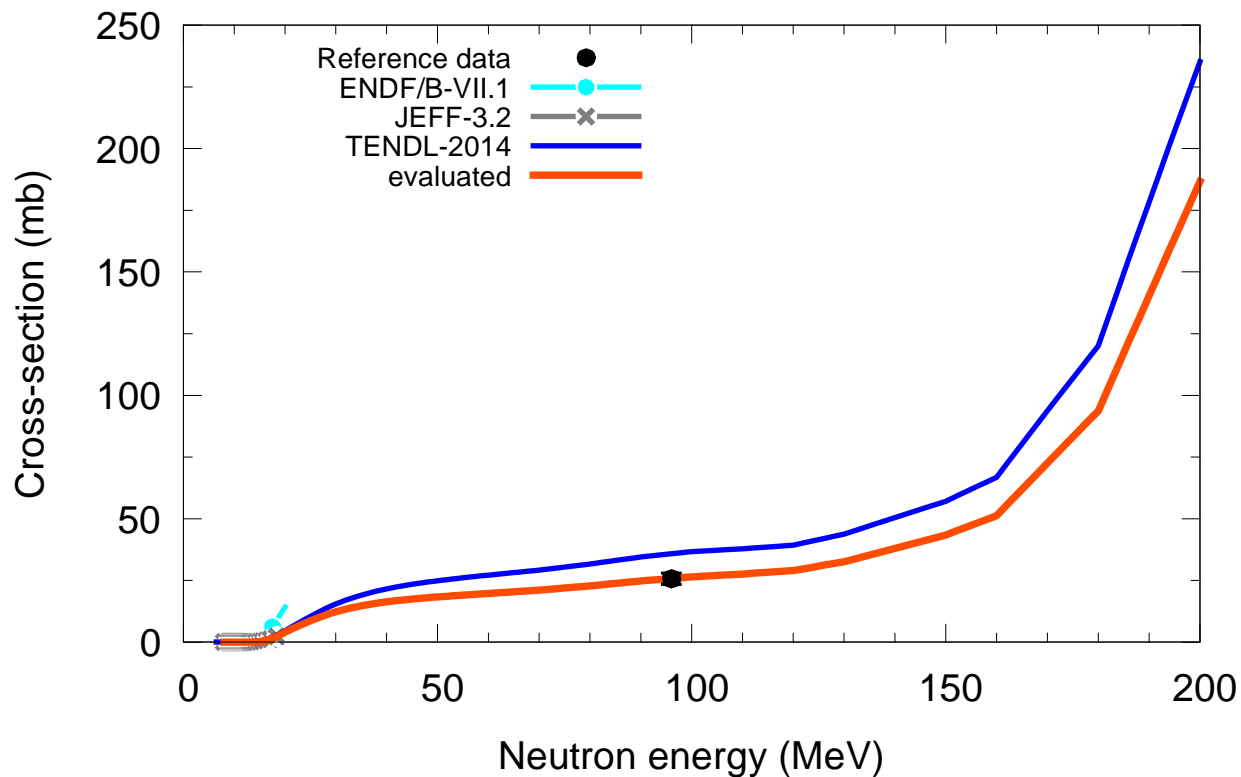


### $^{124}\text{Sn}(n,x)t$

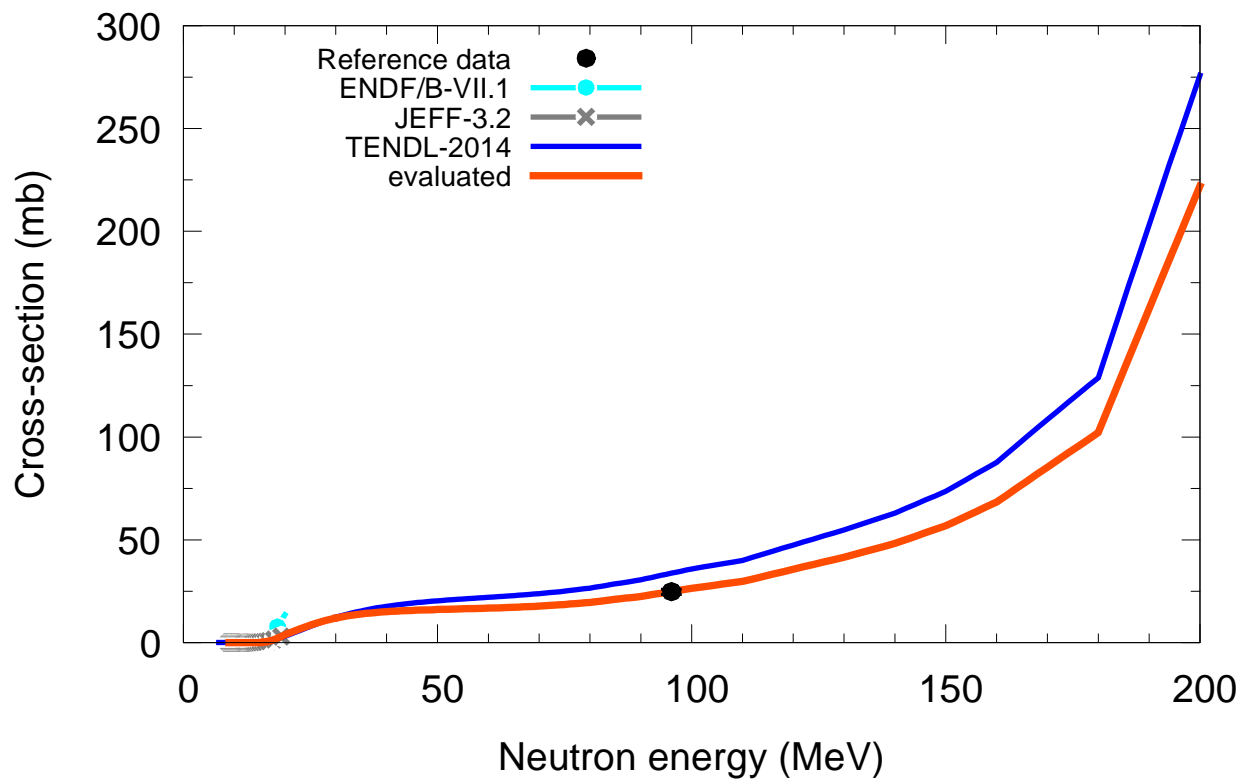


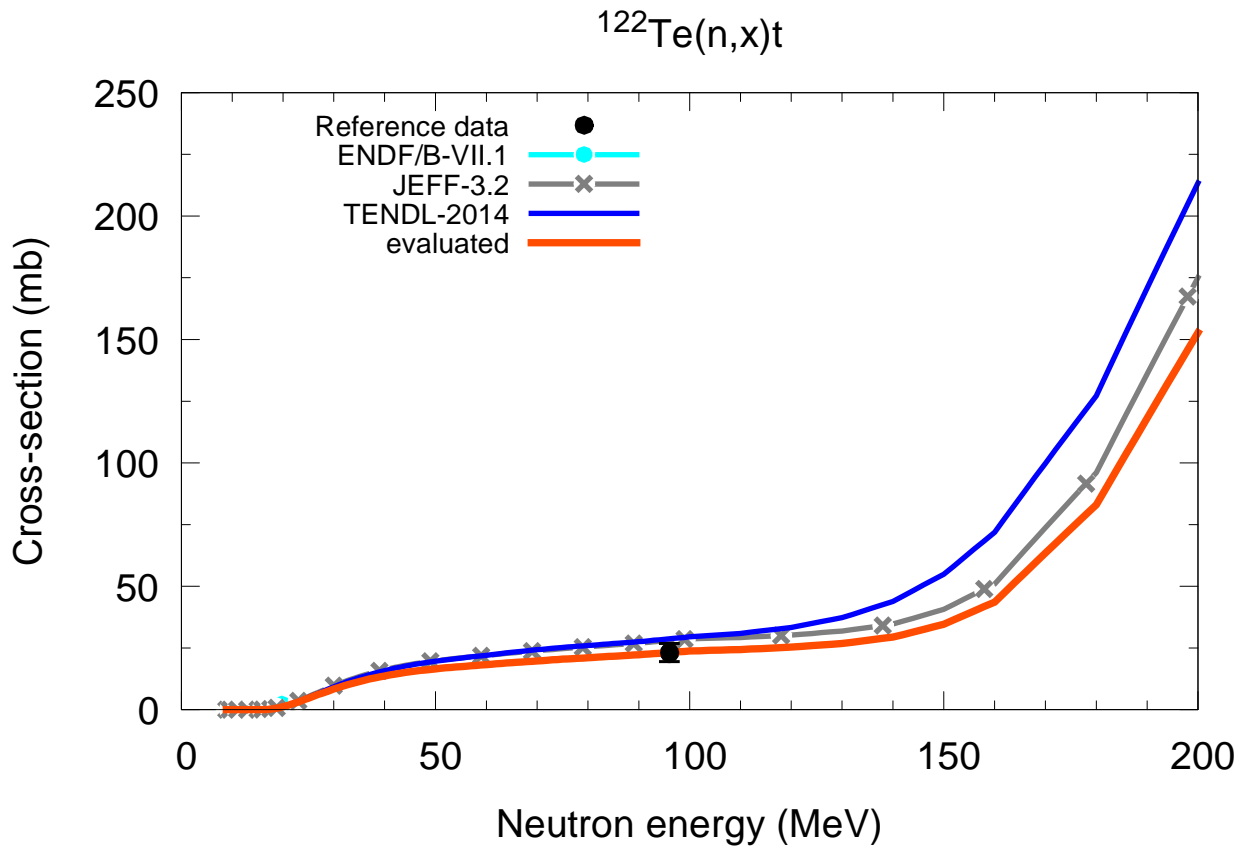
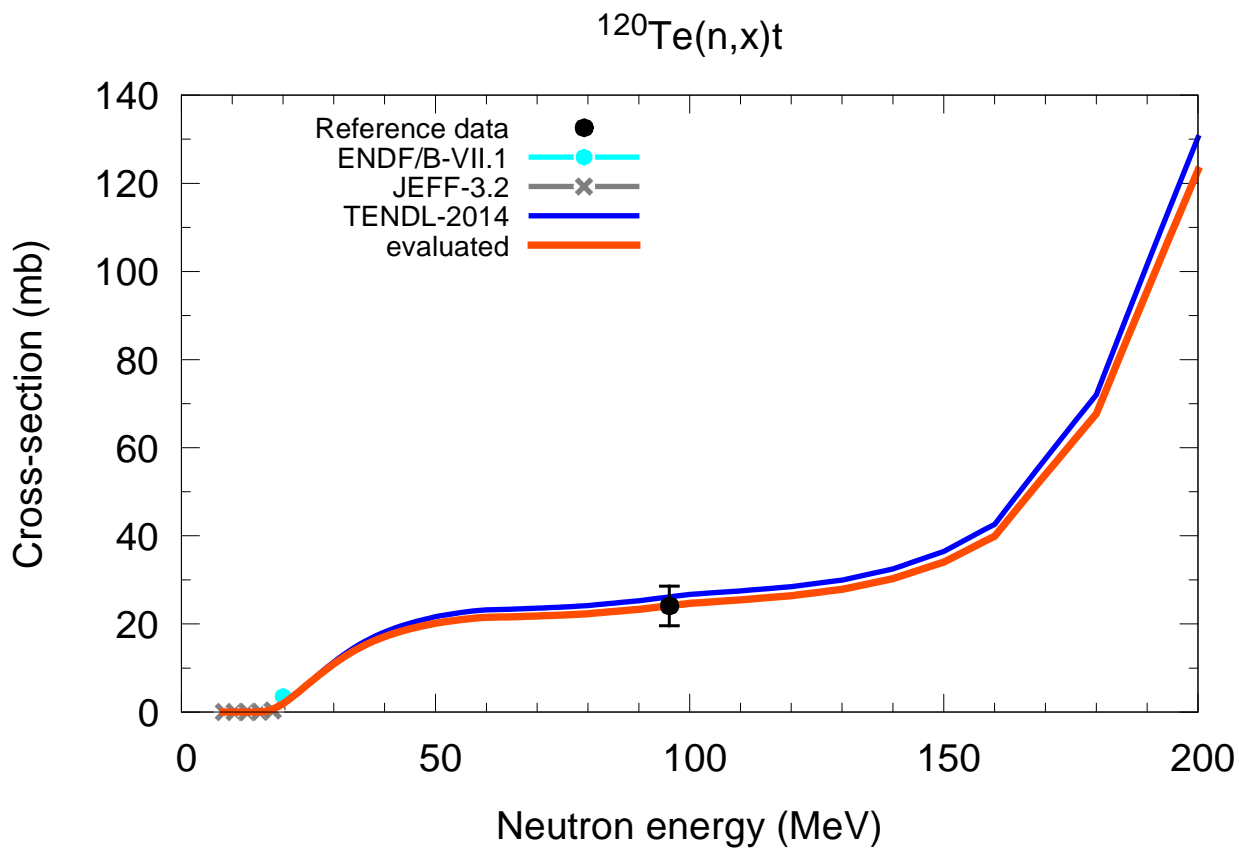


$^{121}\text{Sb}(n,x)t$

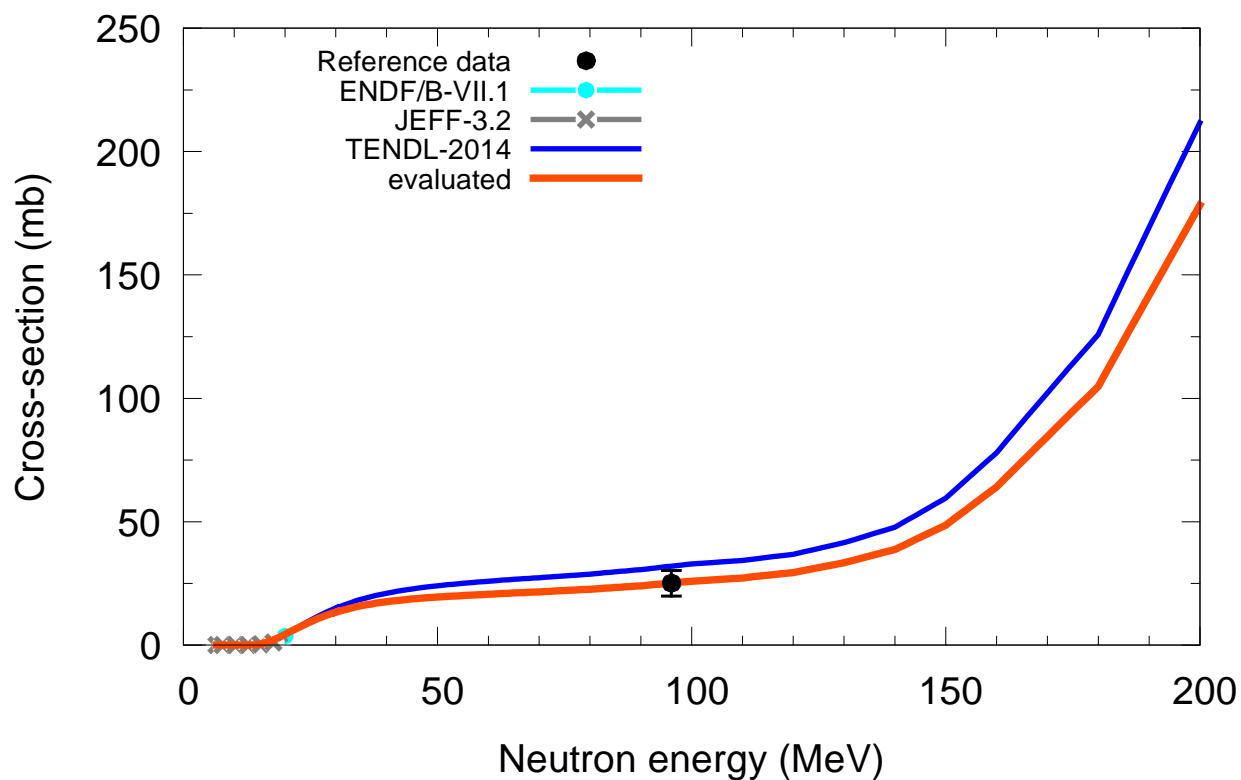


$^{123}\text{Sb}(n,x)t$

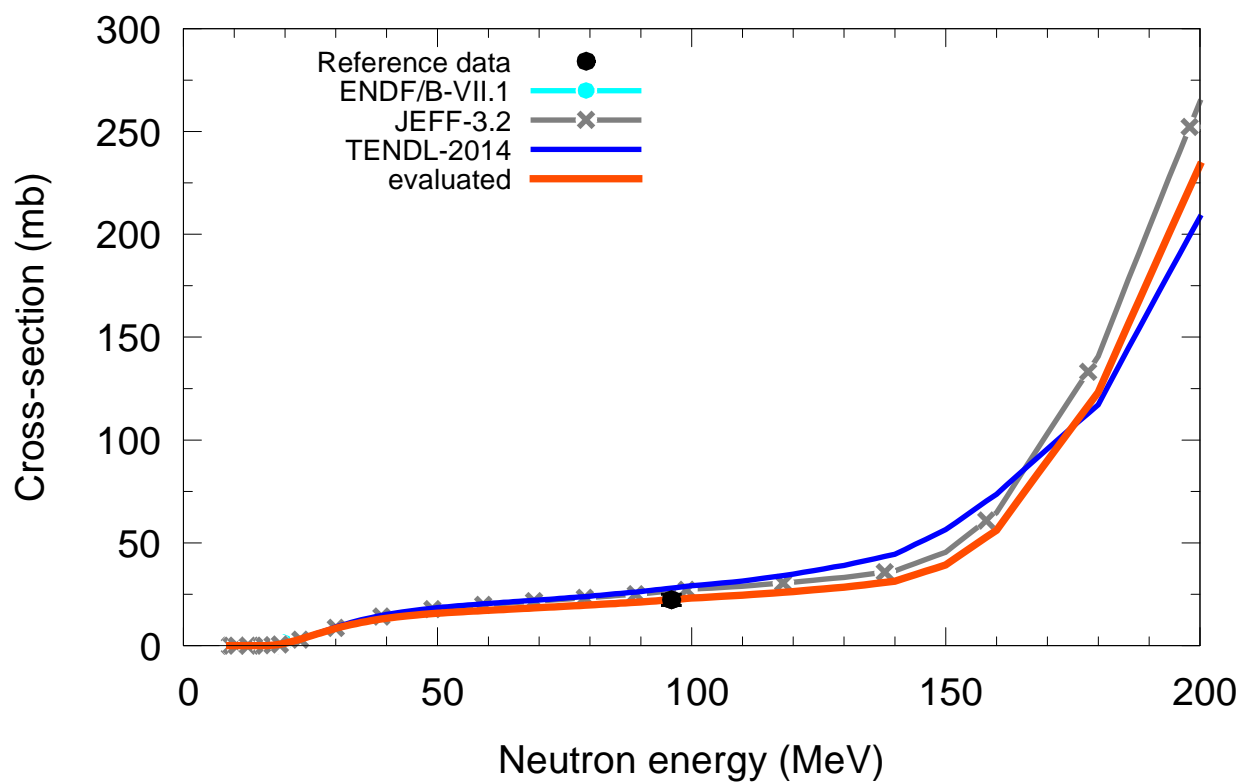




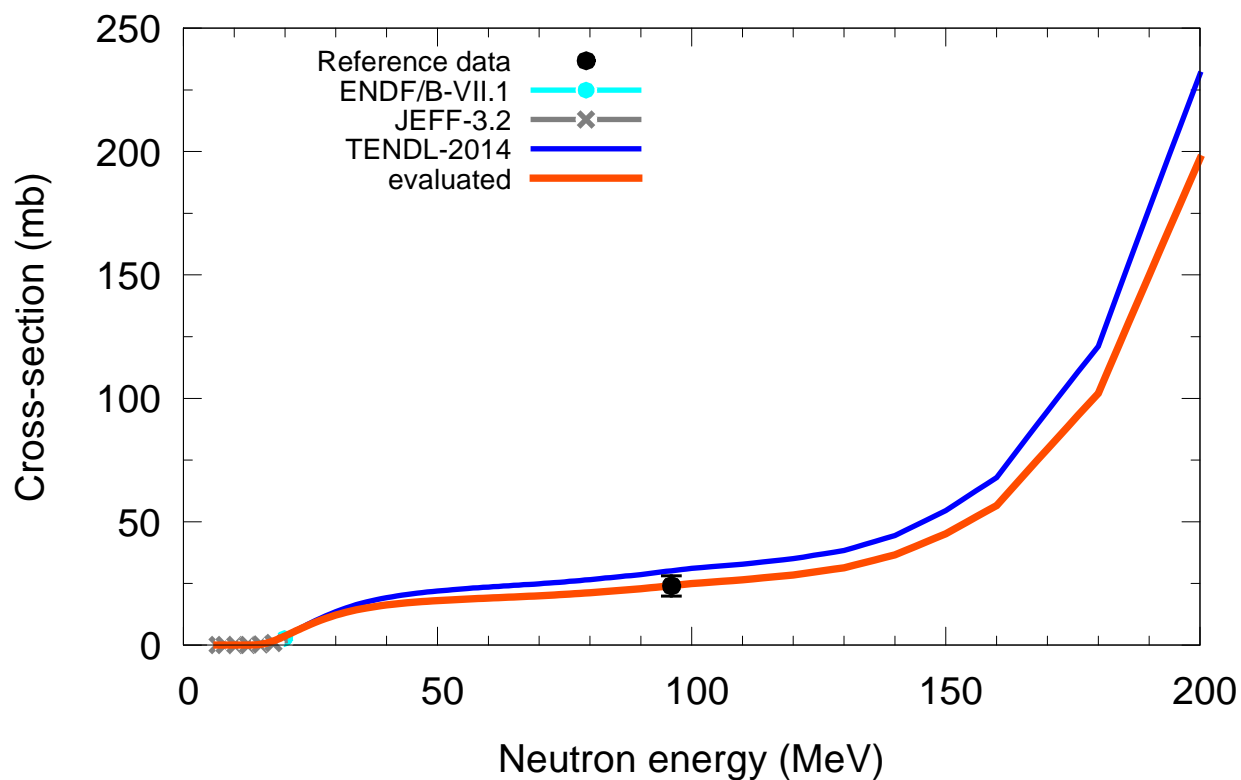
### $^{123}\text{Te}(n,x)t$



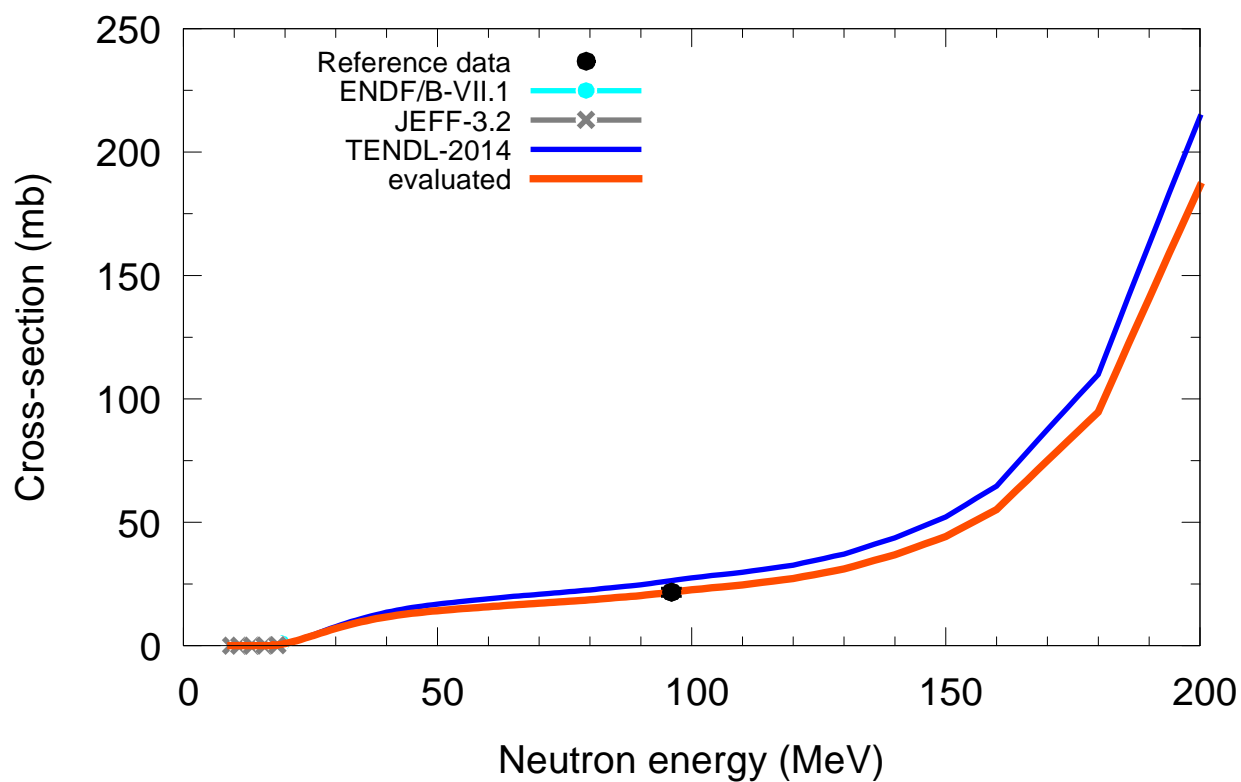
### $^{124}\text{Te}(n,x)t$



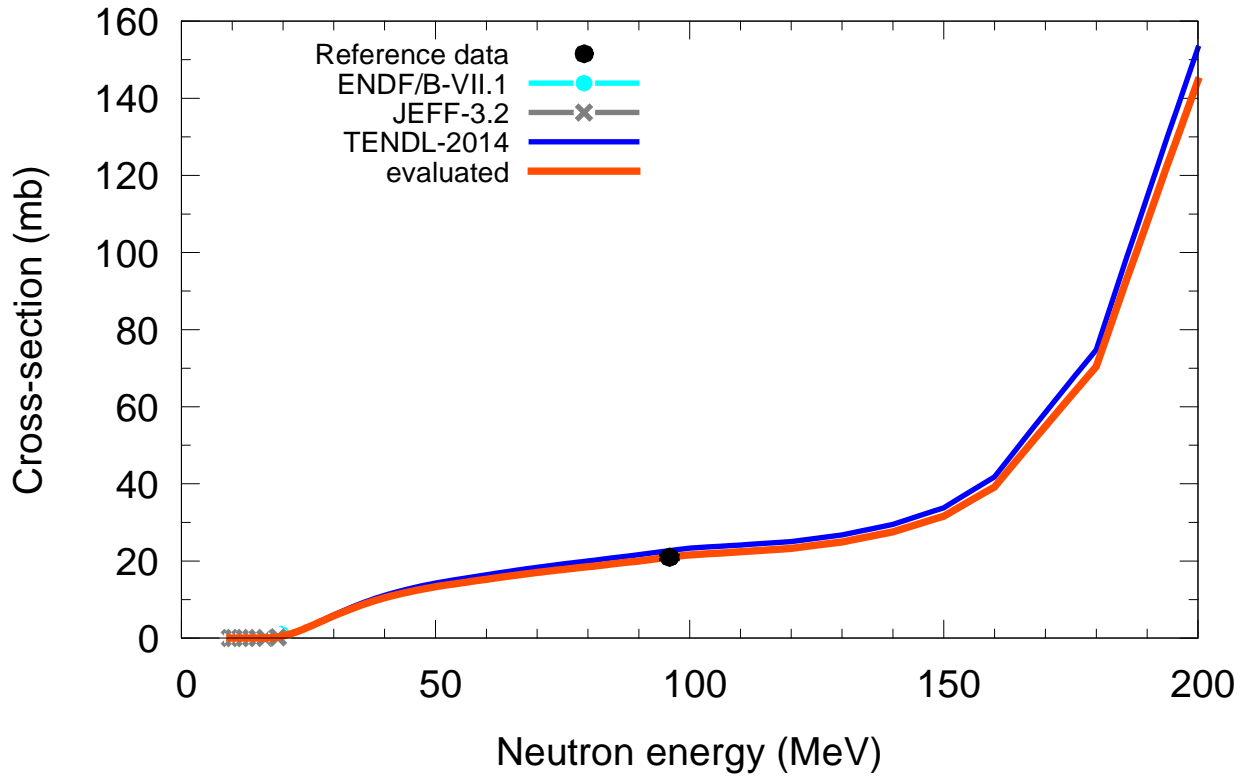
$^{125}\text{Te}(n,x)t$



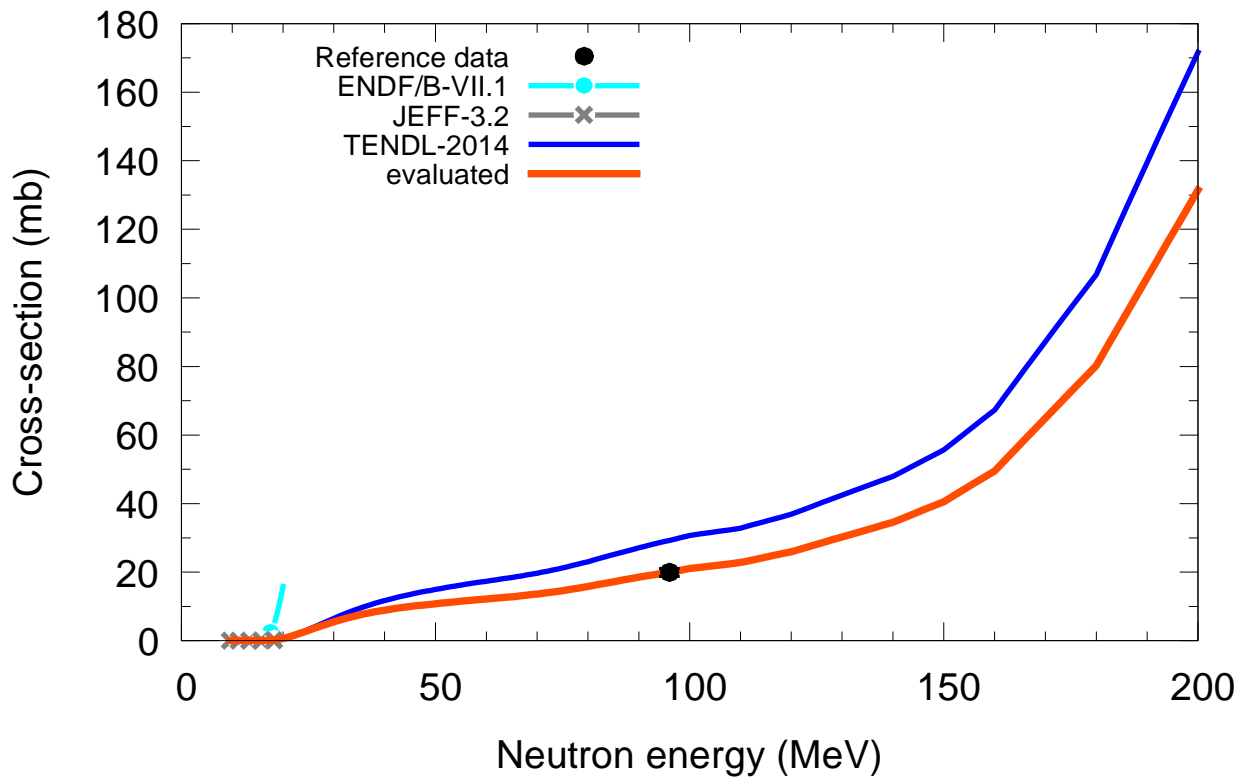
$^{126}\text{Te}(n,x)t$



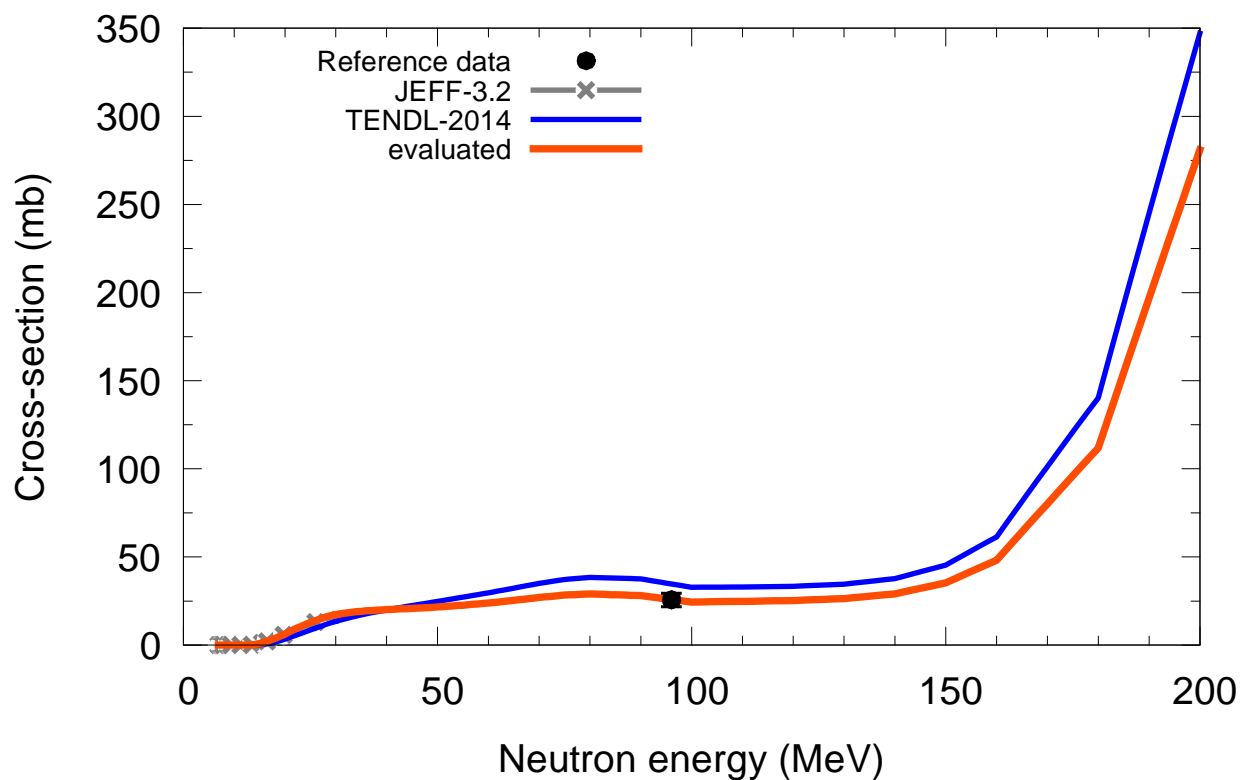
### $^{128}\text{Te}(n,x)t$



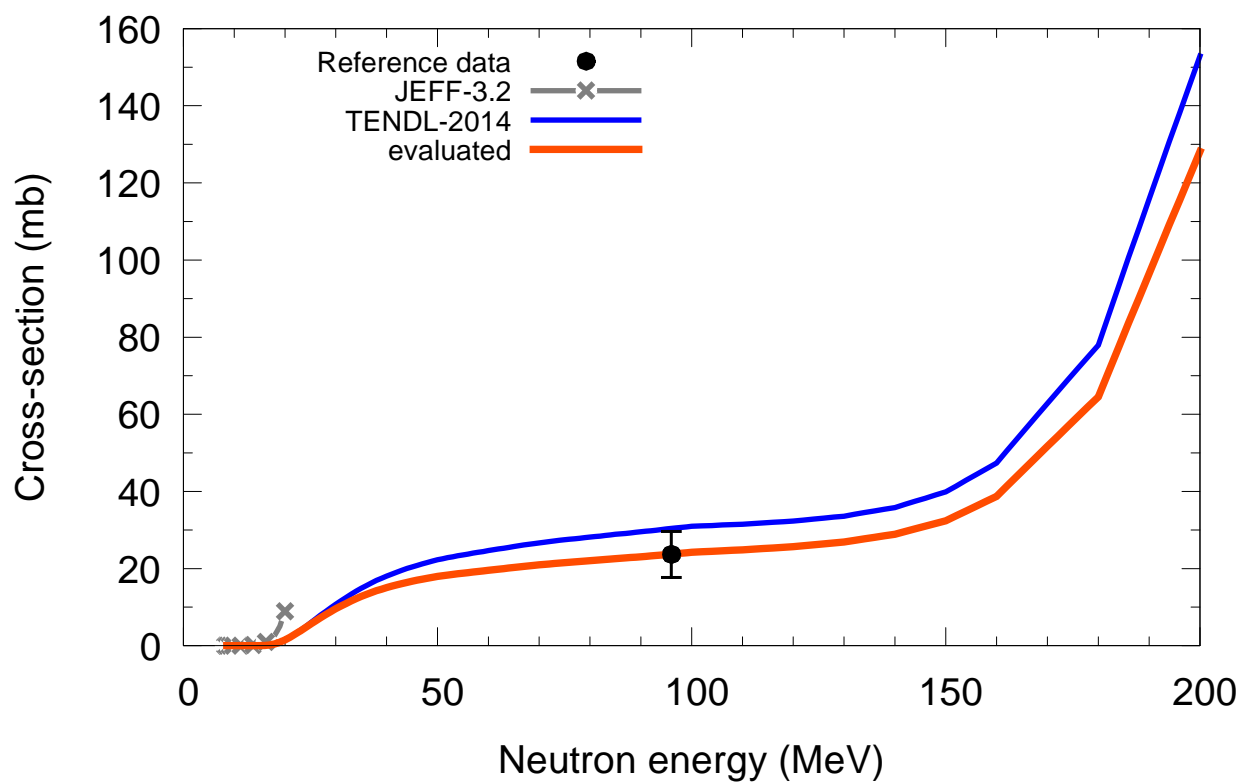
### $^{130}\text{Te}(n,x)t$

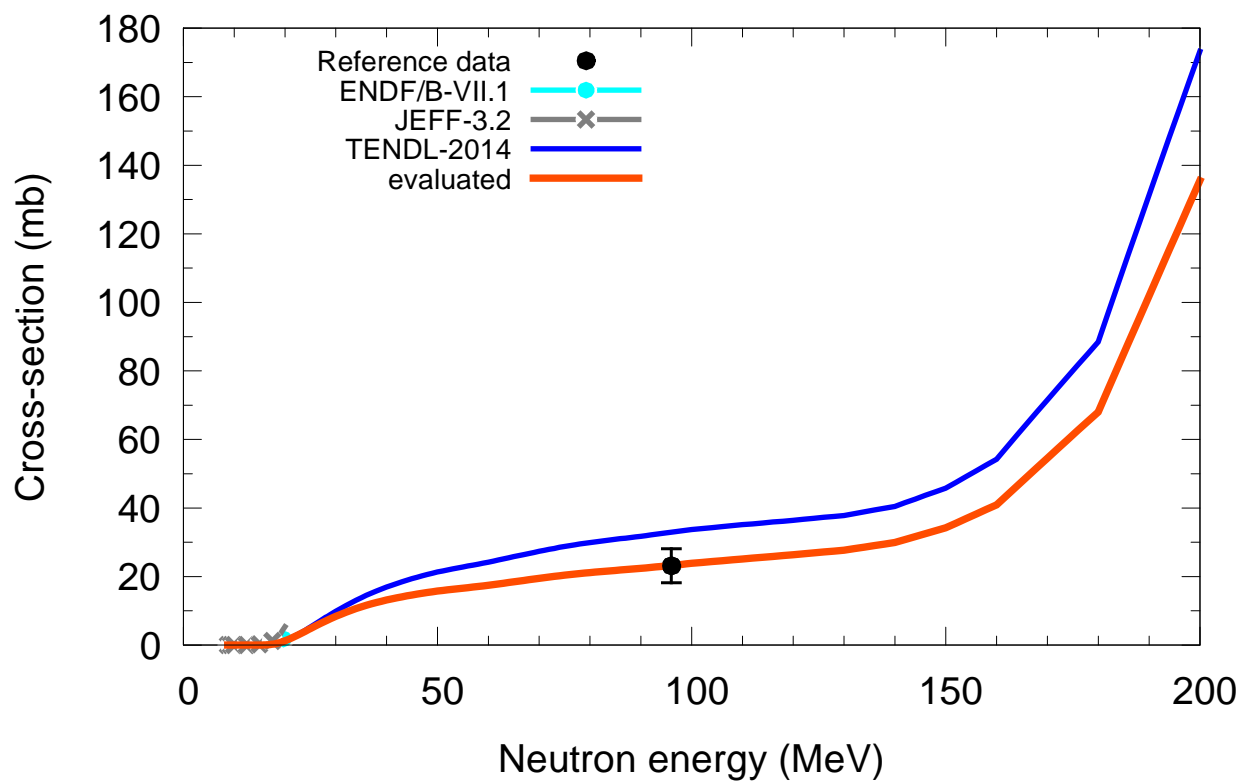
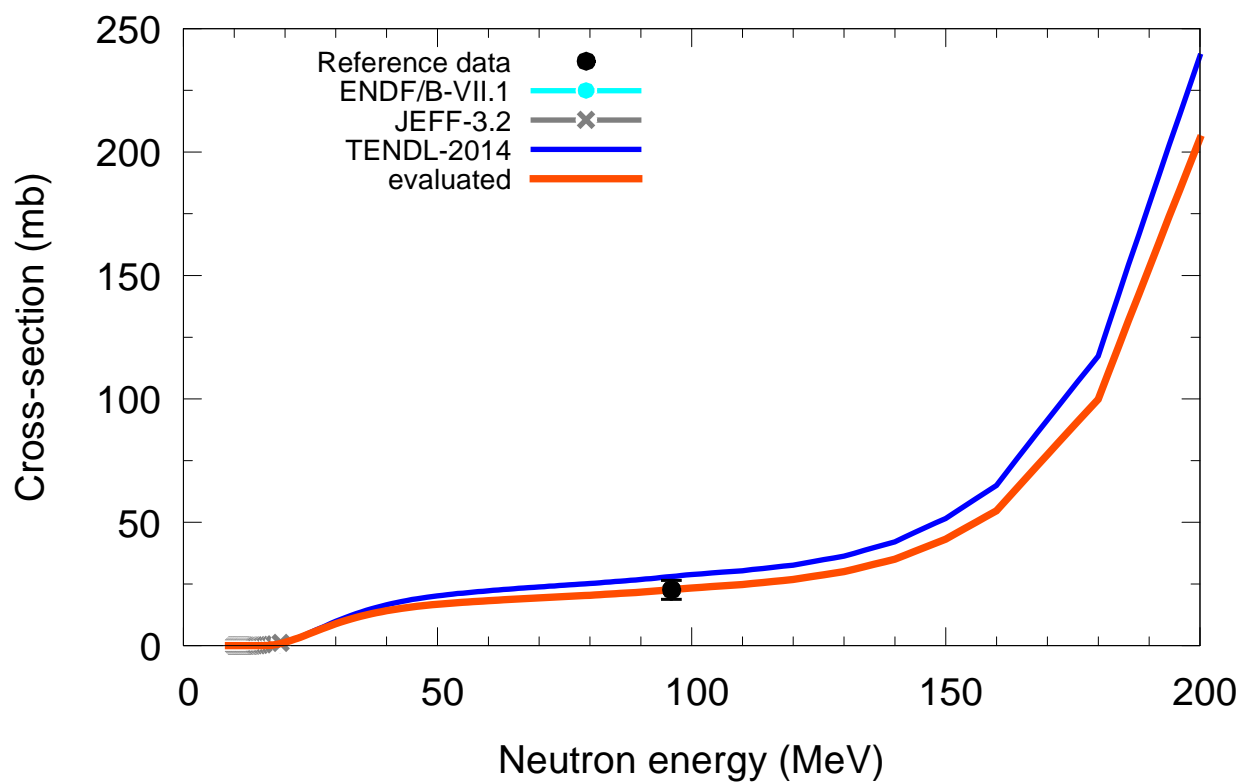


$^{127}\text{I}(n,x)t$

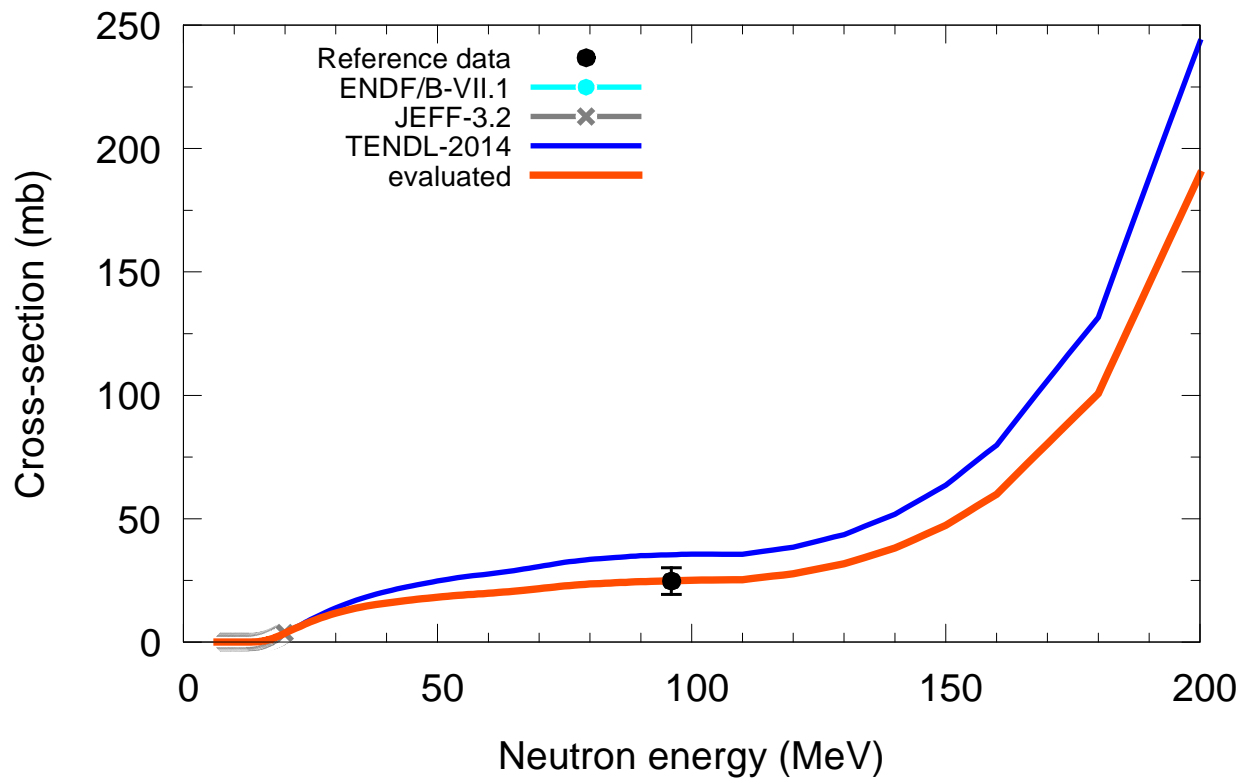


$^{124}\text{Xe}(n,x)t$

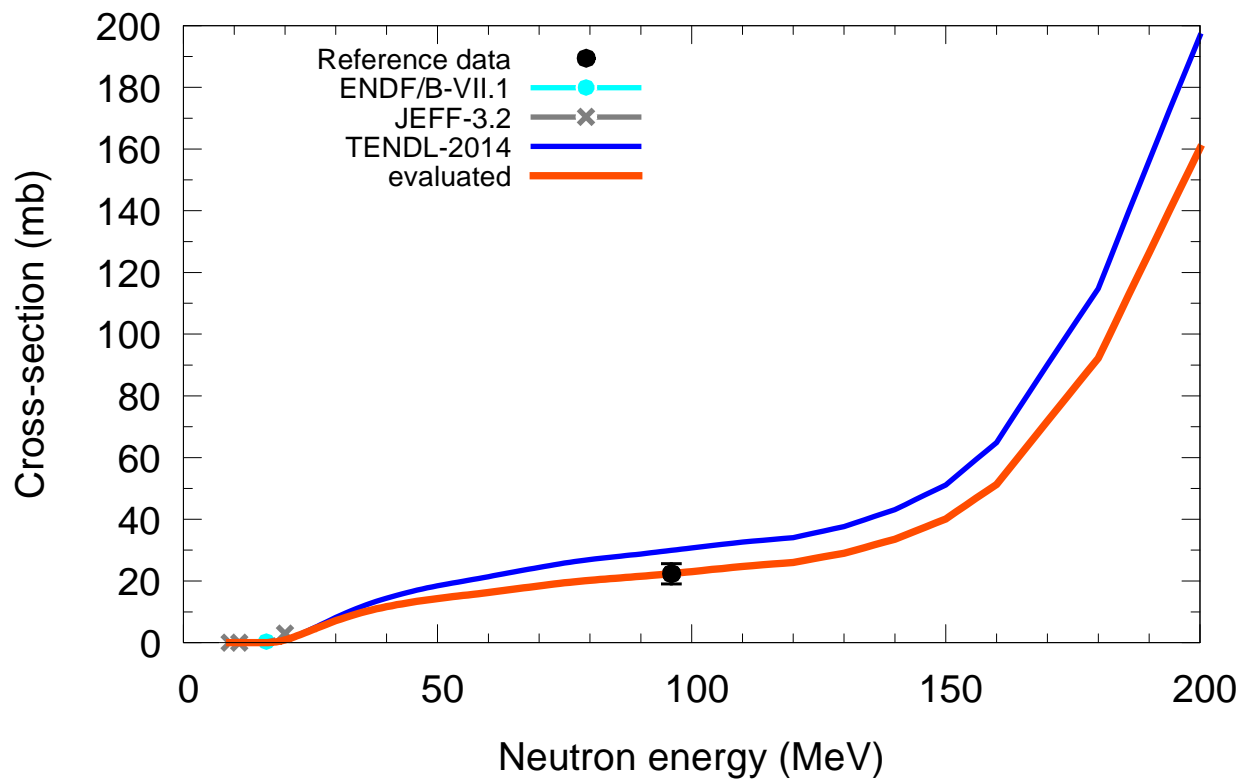


$^{126}\text{Xe}(n,x)t$  $^{128}\text{Xe}(n,x)t$ 

$^{129}\text{Xe}(n,x)t$

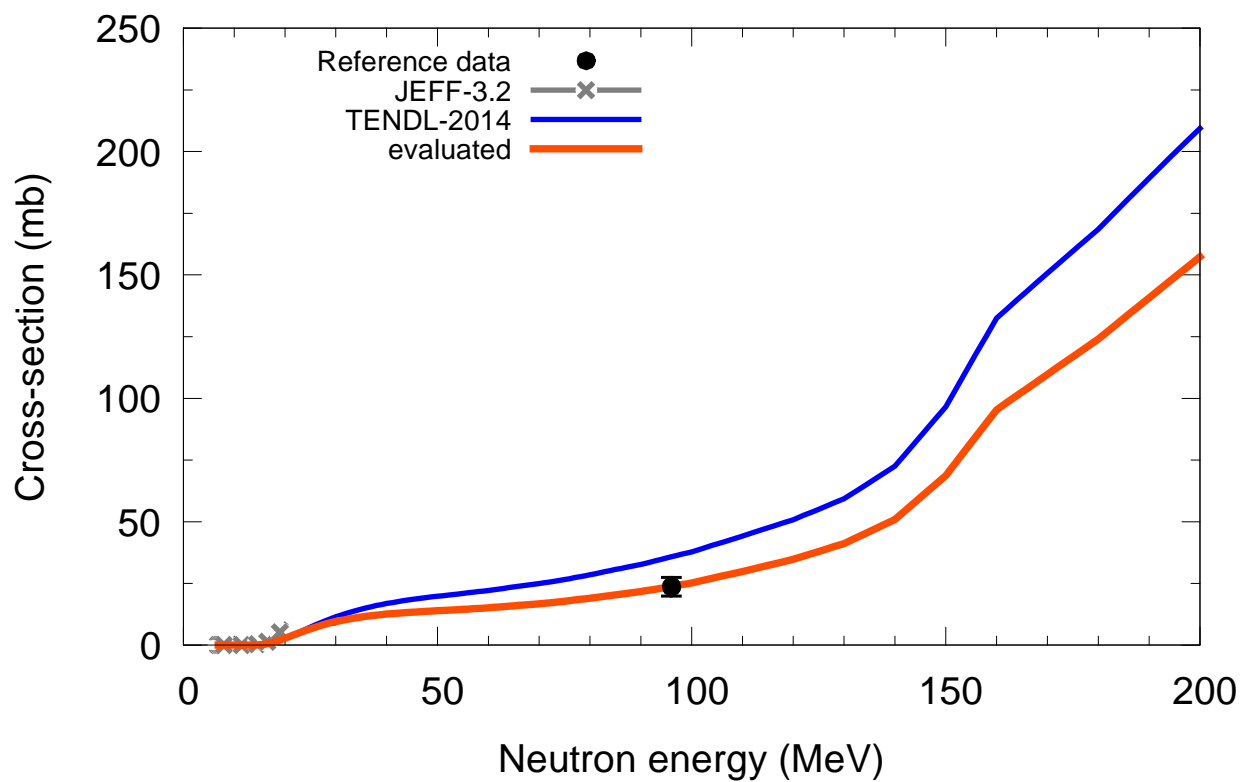


$^{130}\text{Xe}(n,x)t$

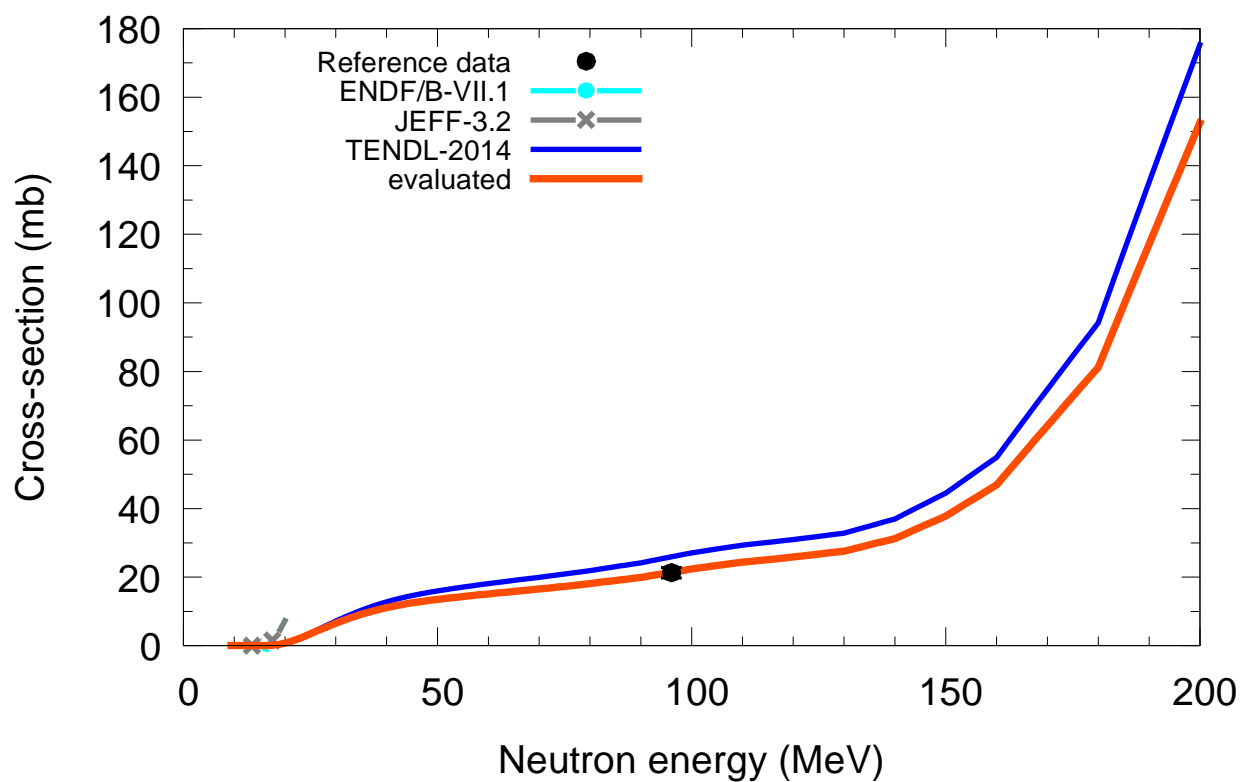




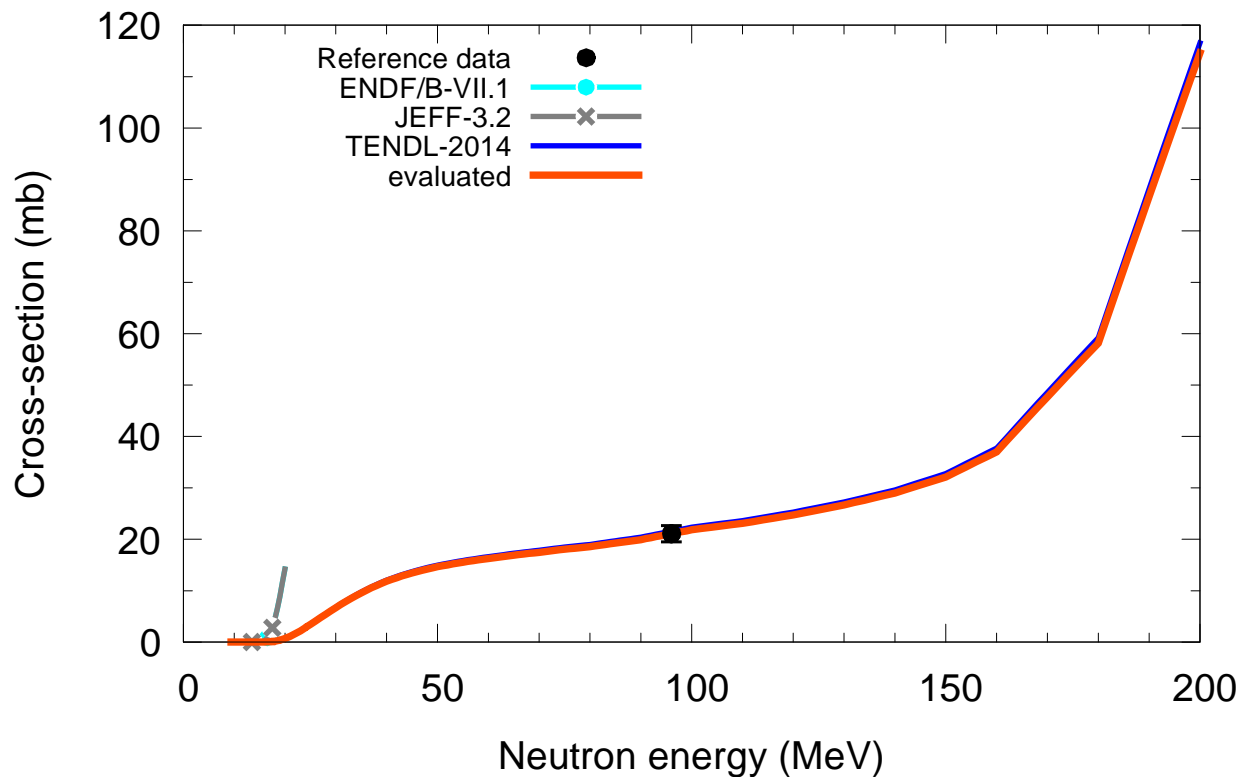
$^{131}\text{Xe}(n,x)t$



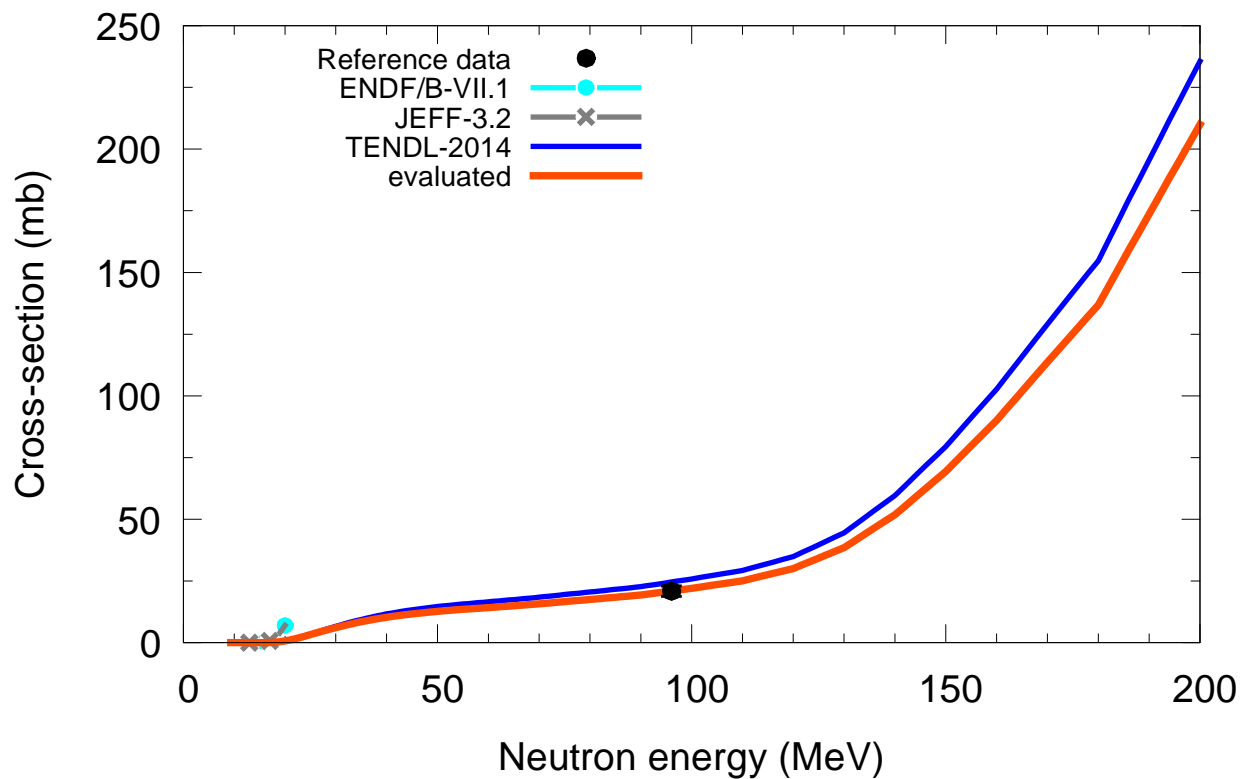
$^{132}\text{Xe}(n,x)t$



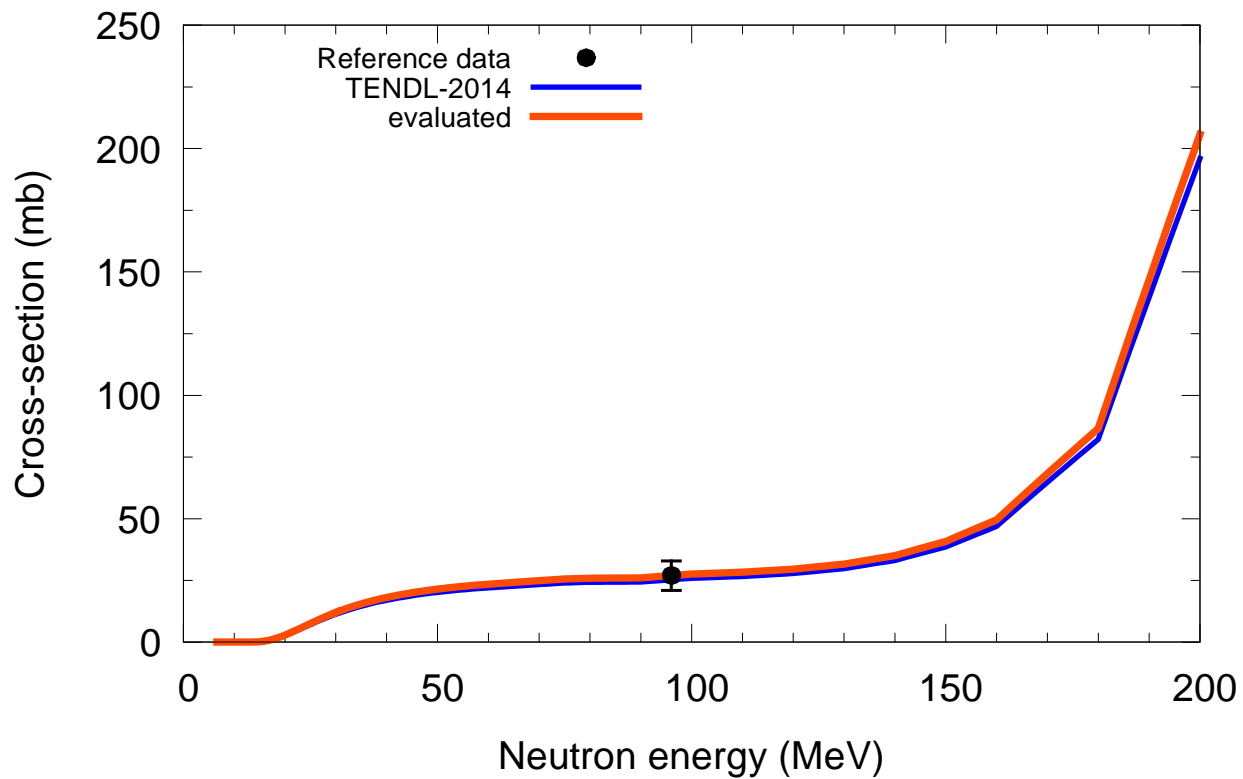
$^{134}\text{Xe}(n,x)t$



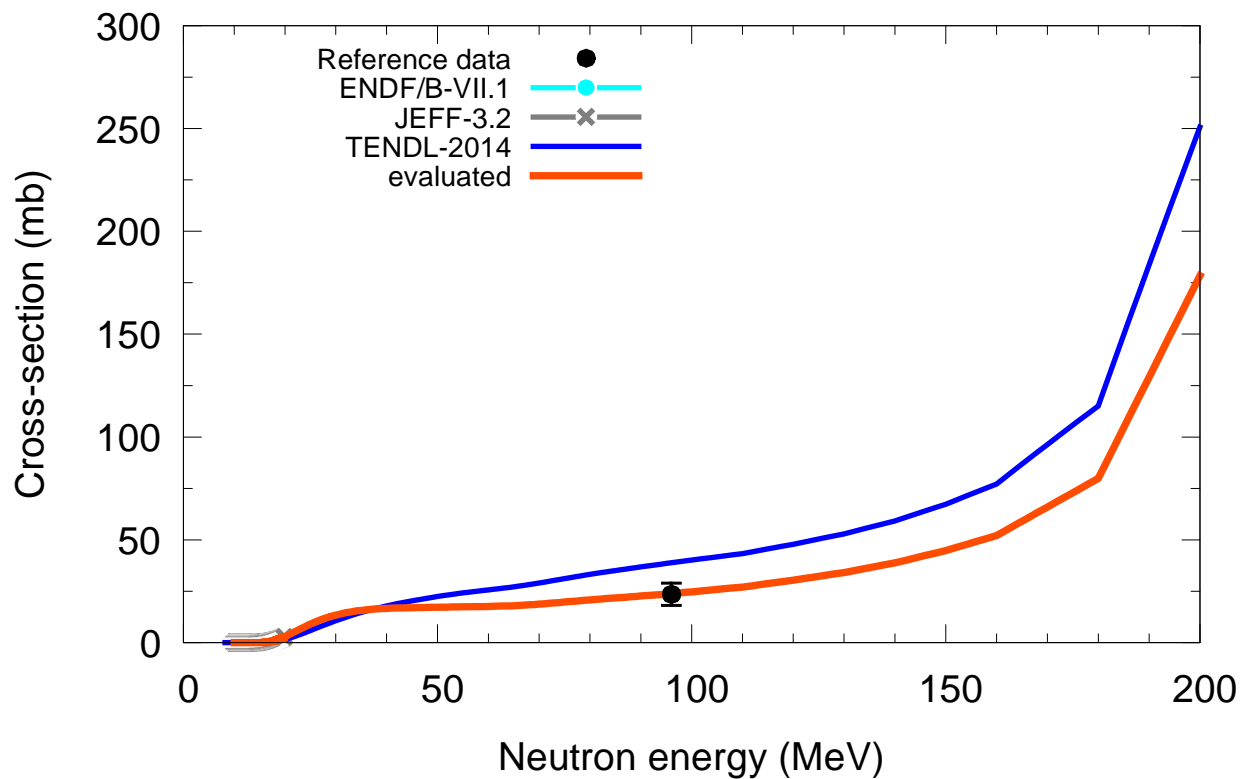
$^{136}\text{Xe}(n,x)t$



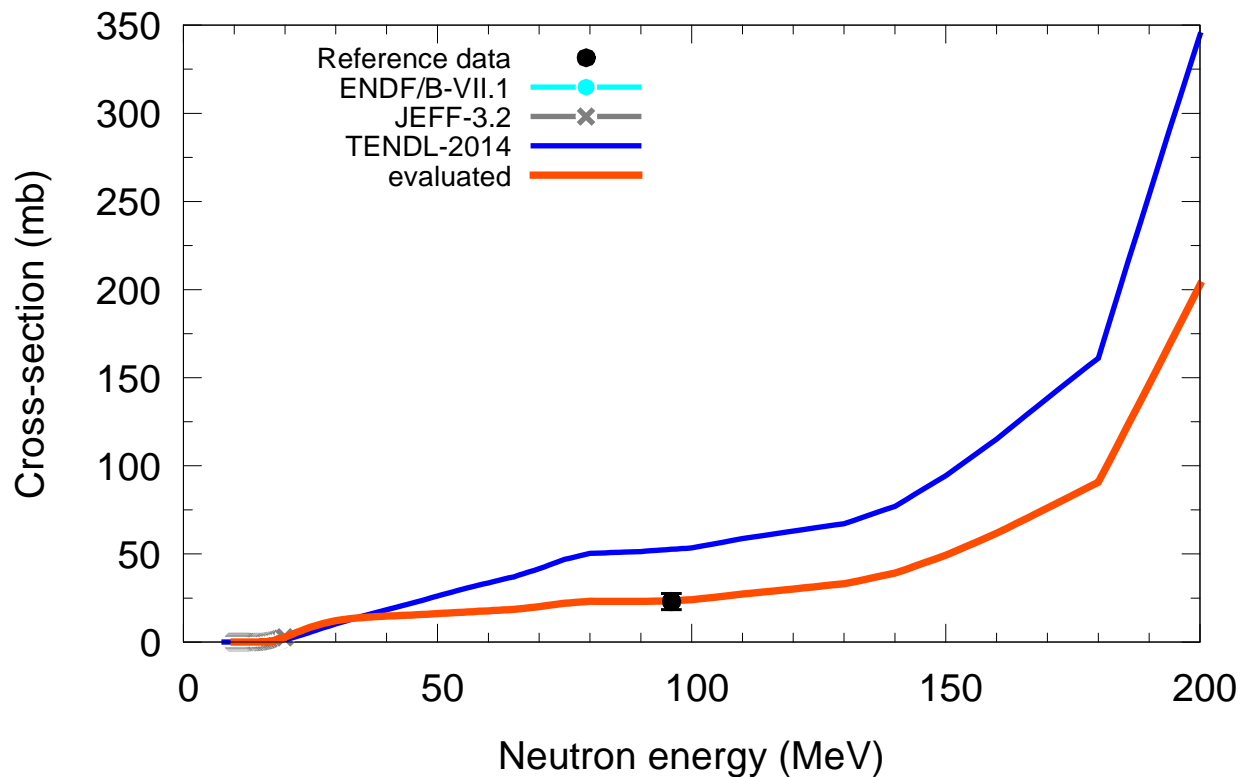
$^{133}\text{Cs}(n,x)t$



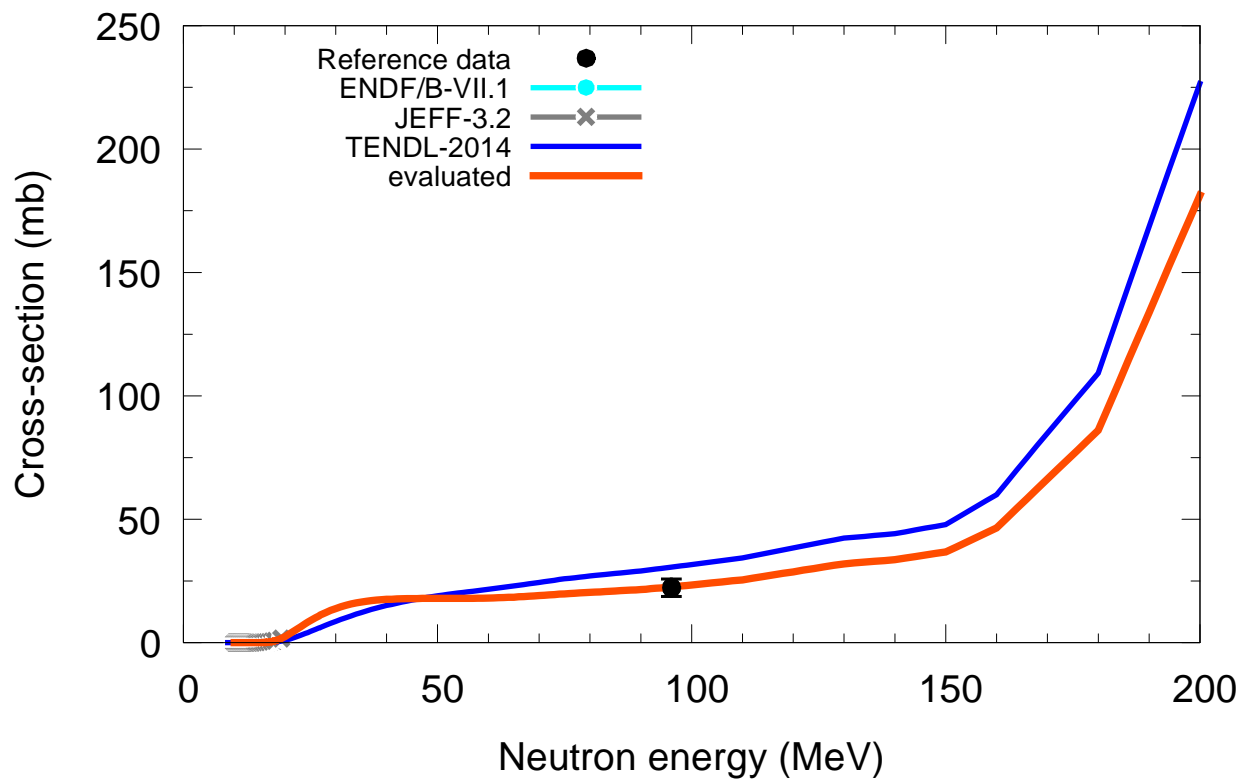
$^{130}\text{Ba}(n,x)t$



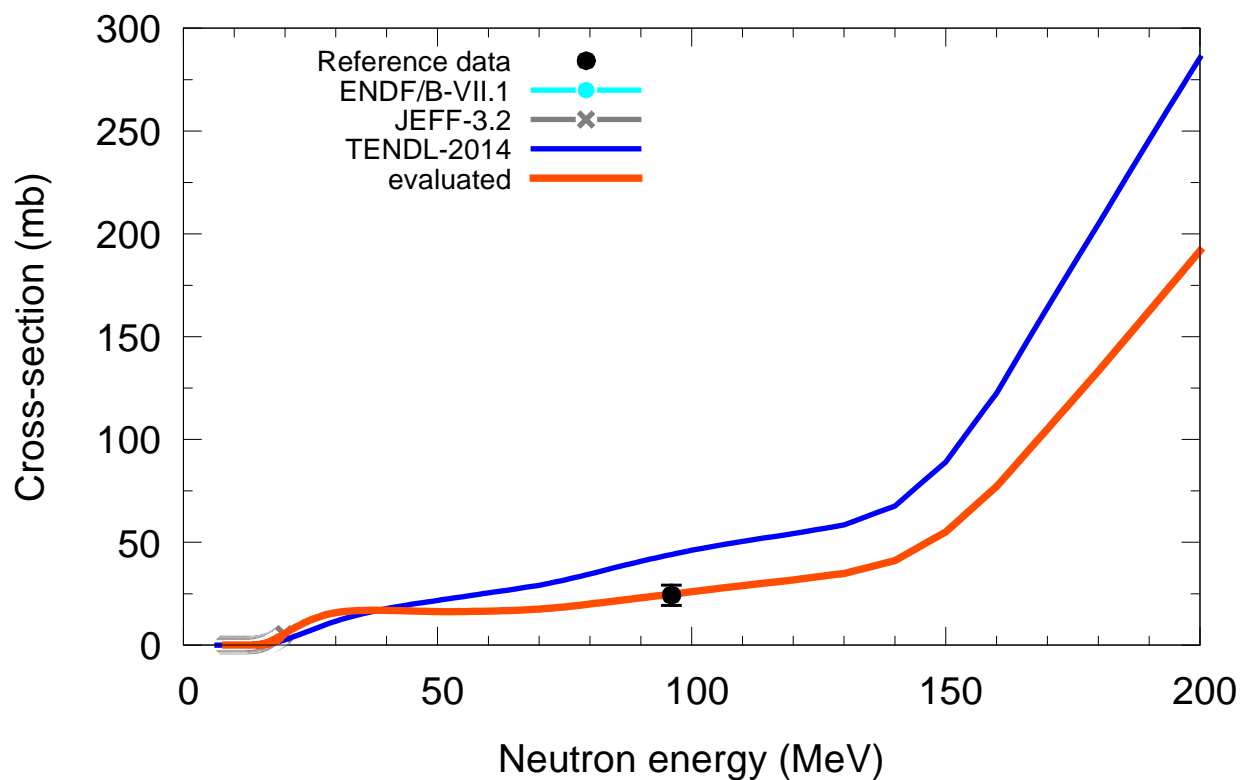
$^{132}\text{Ba}(n,x)t$



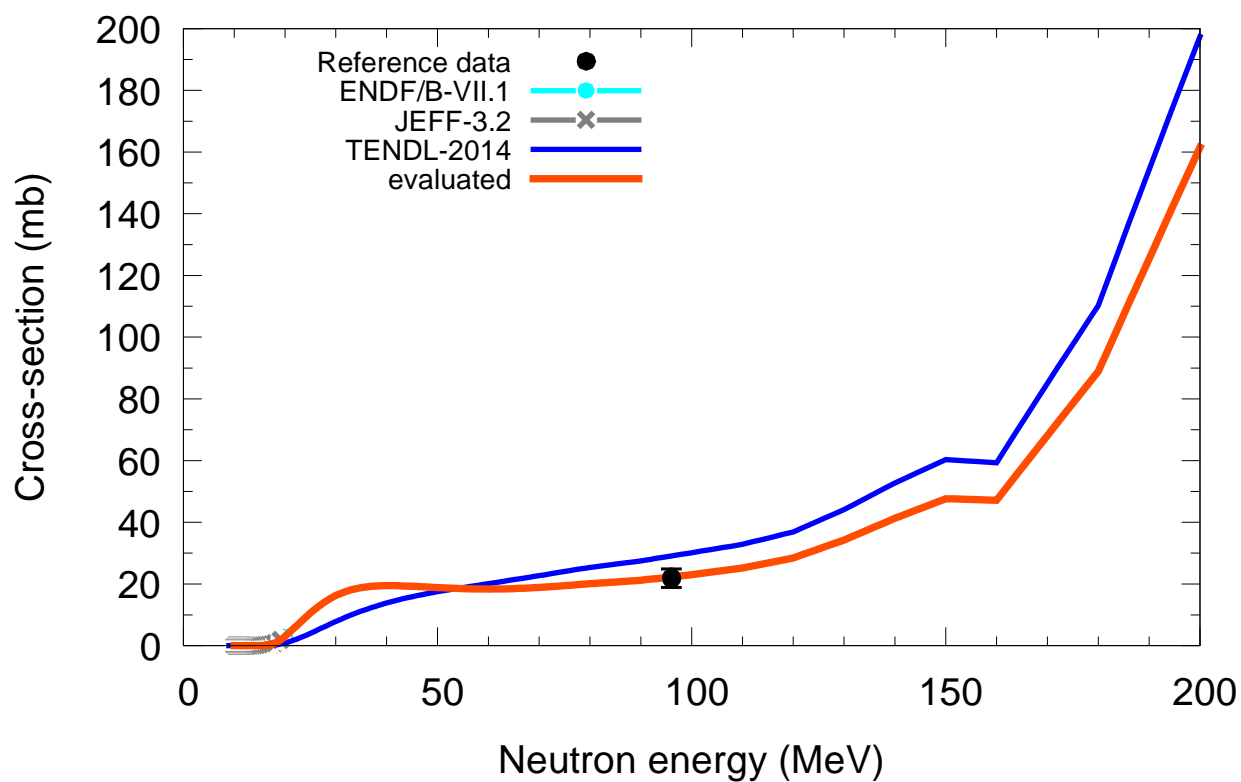
$^{134}\text{Ba}(n,x)t$



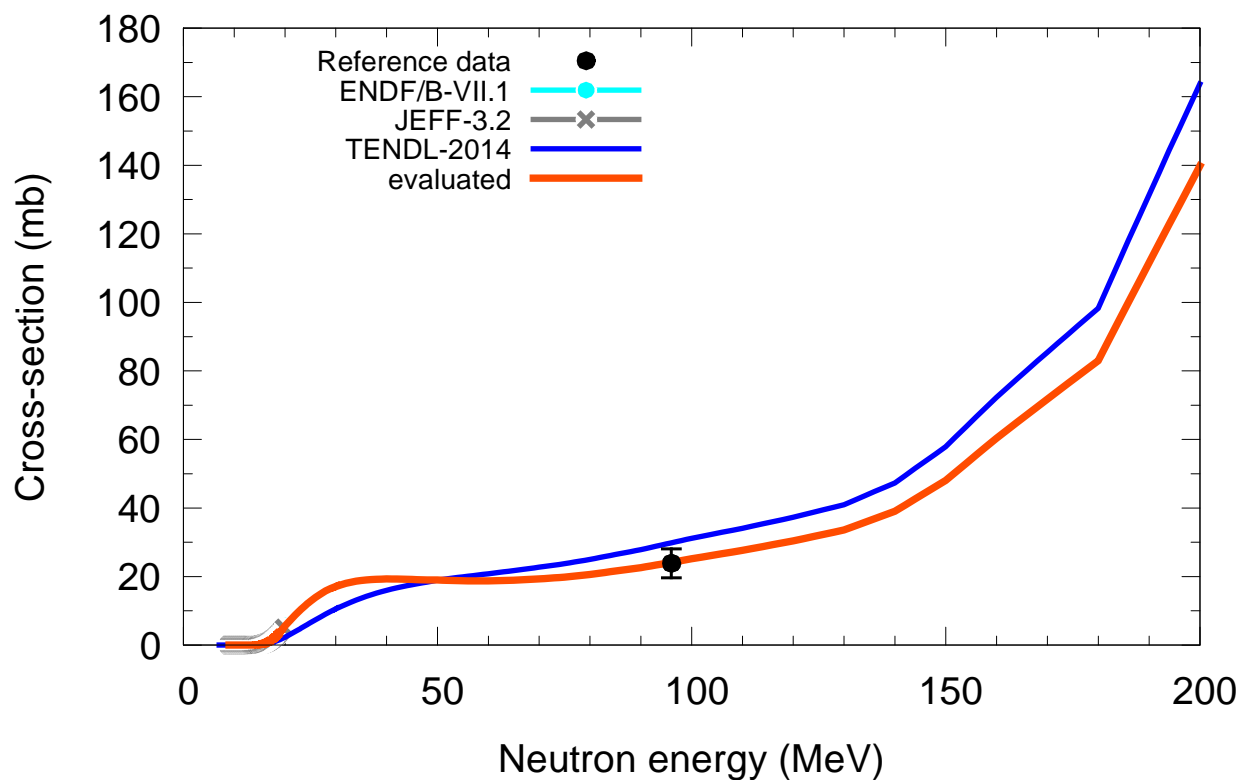
### $^{135}\text{Ba}(n,x)t$



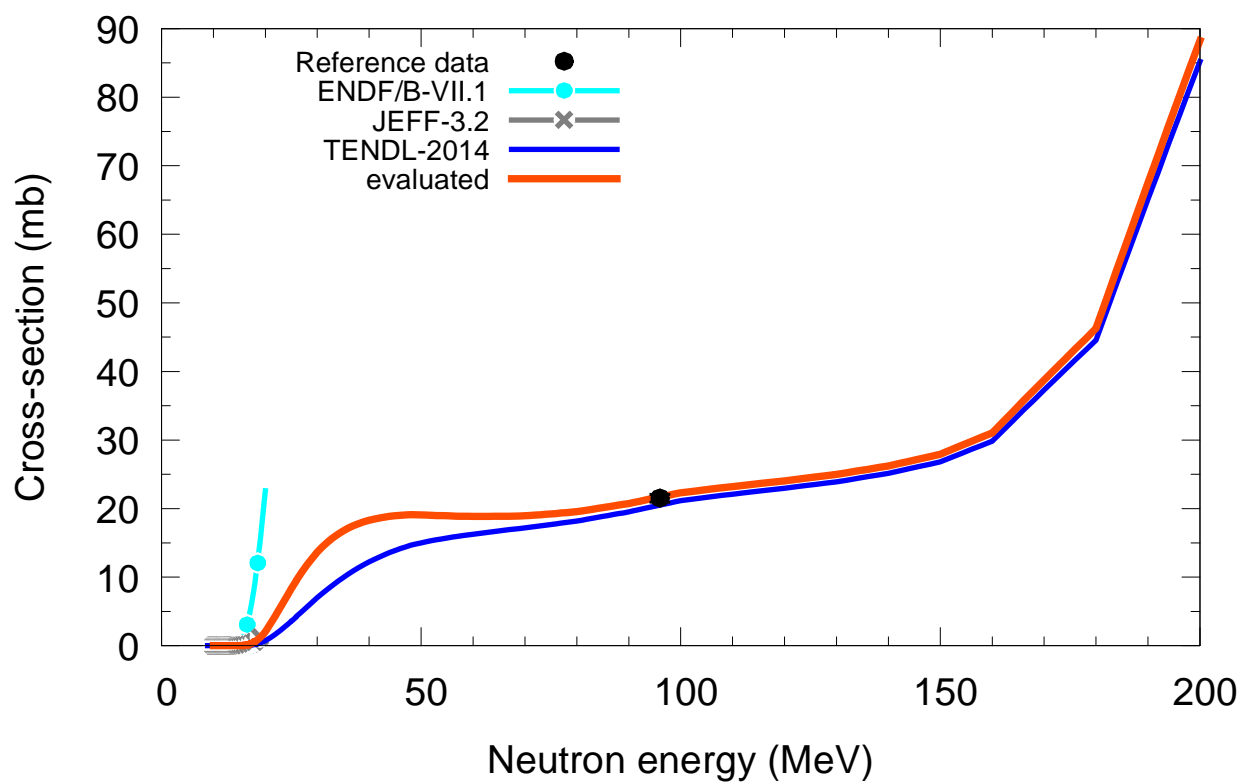
### $^{136}\text{Ba}(n,x)t$



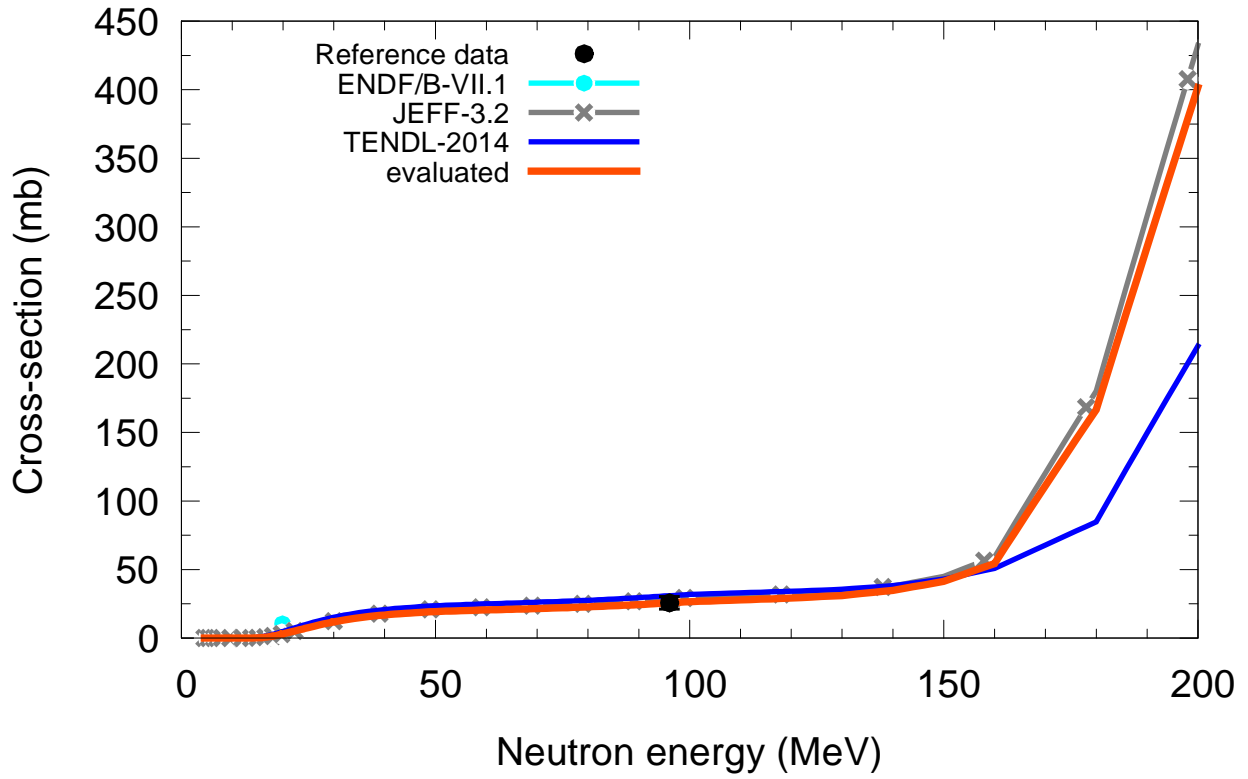
### $^{137}\text{Ba}(n,x)t$



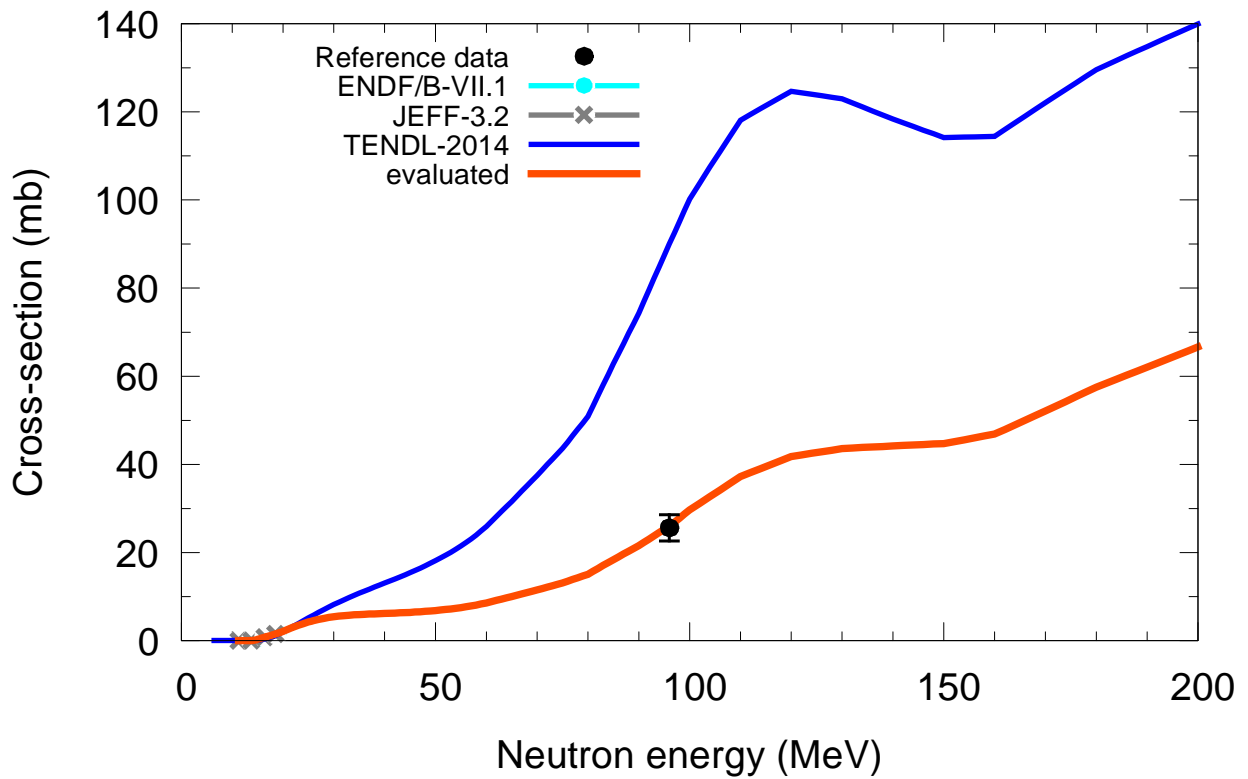
### $^{138}\text{Ba}(n,x)t$



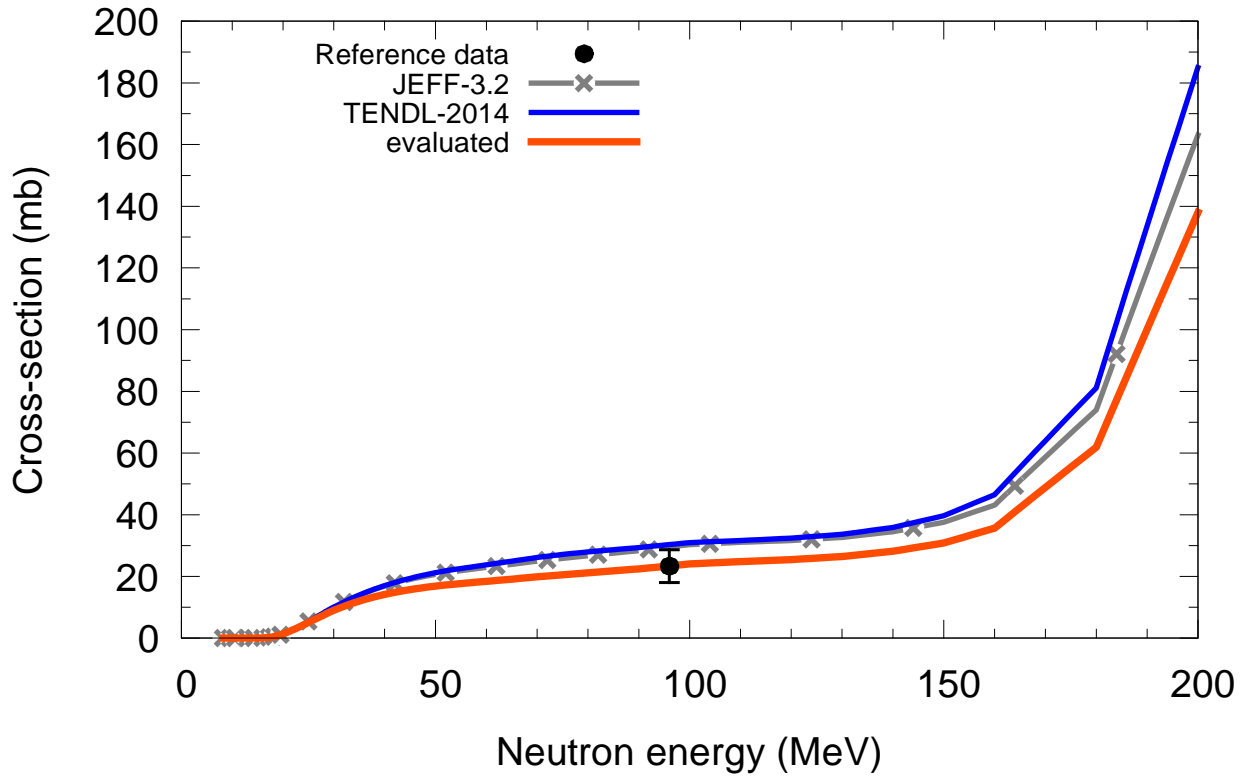
$^{138}\text{La}(n,x)t$



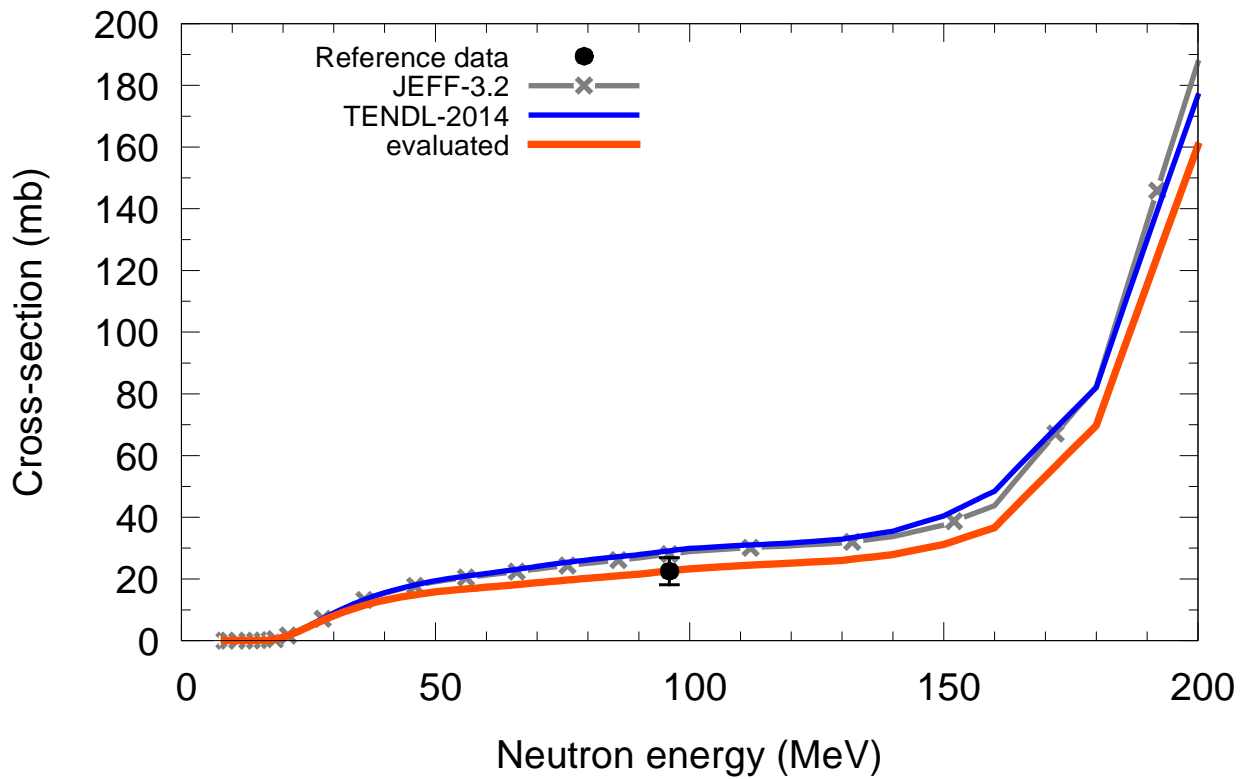
$^{139}\text{La}(n,x)t$



$^{136}\text{Ce}(n,x)t$

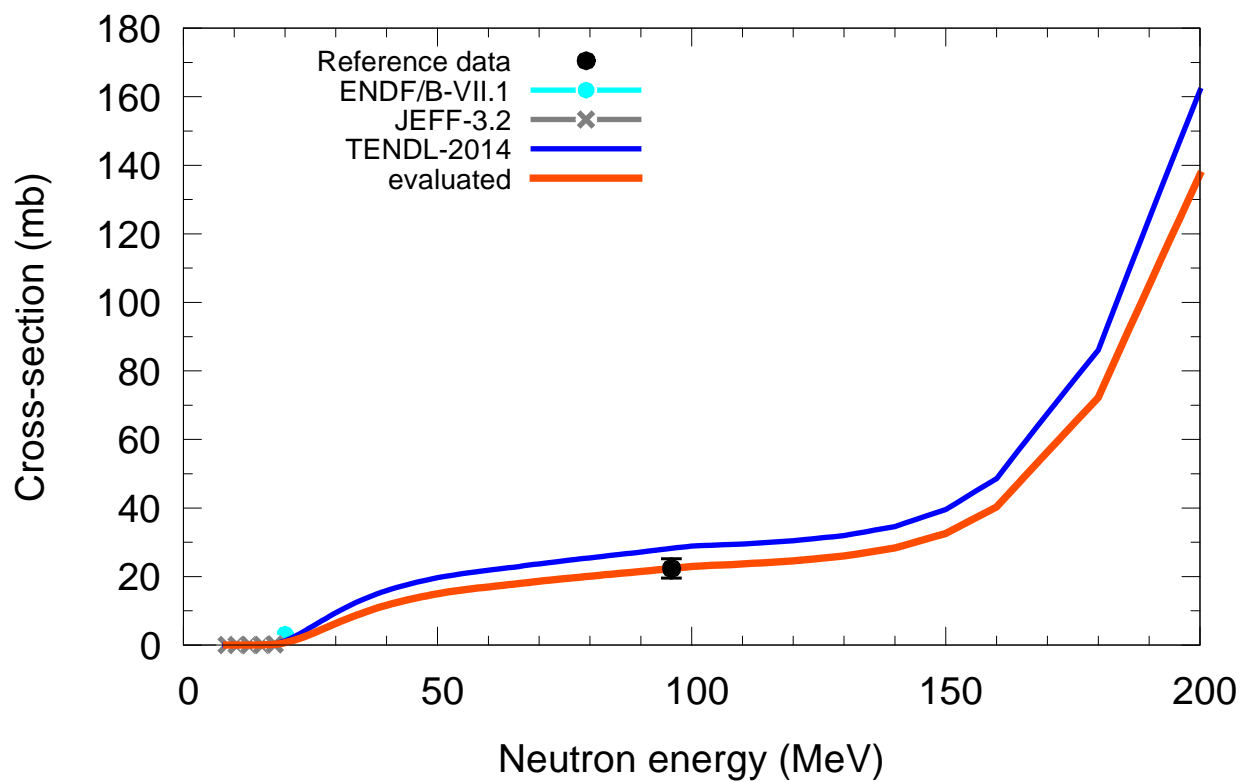


$^{138}\text{Ce}(n,x)t$

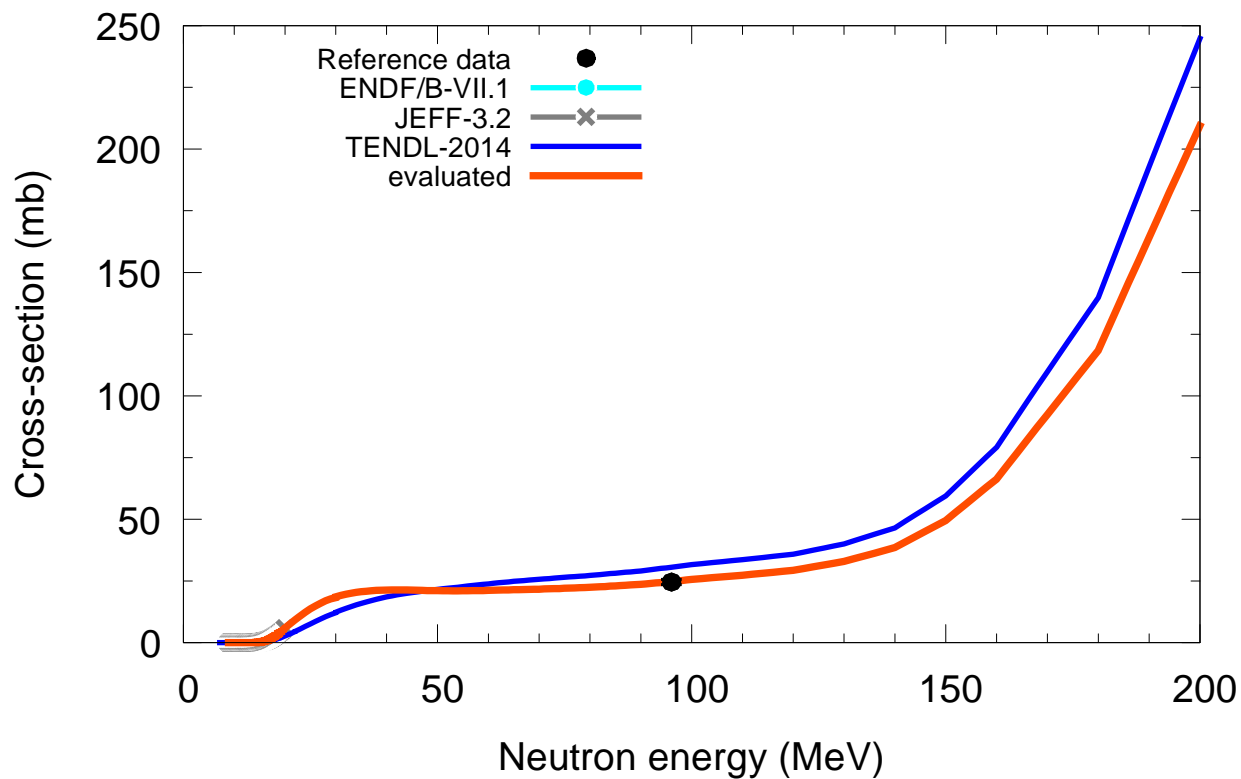




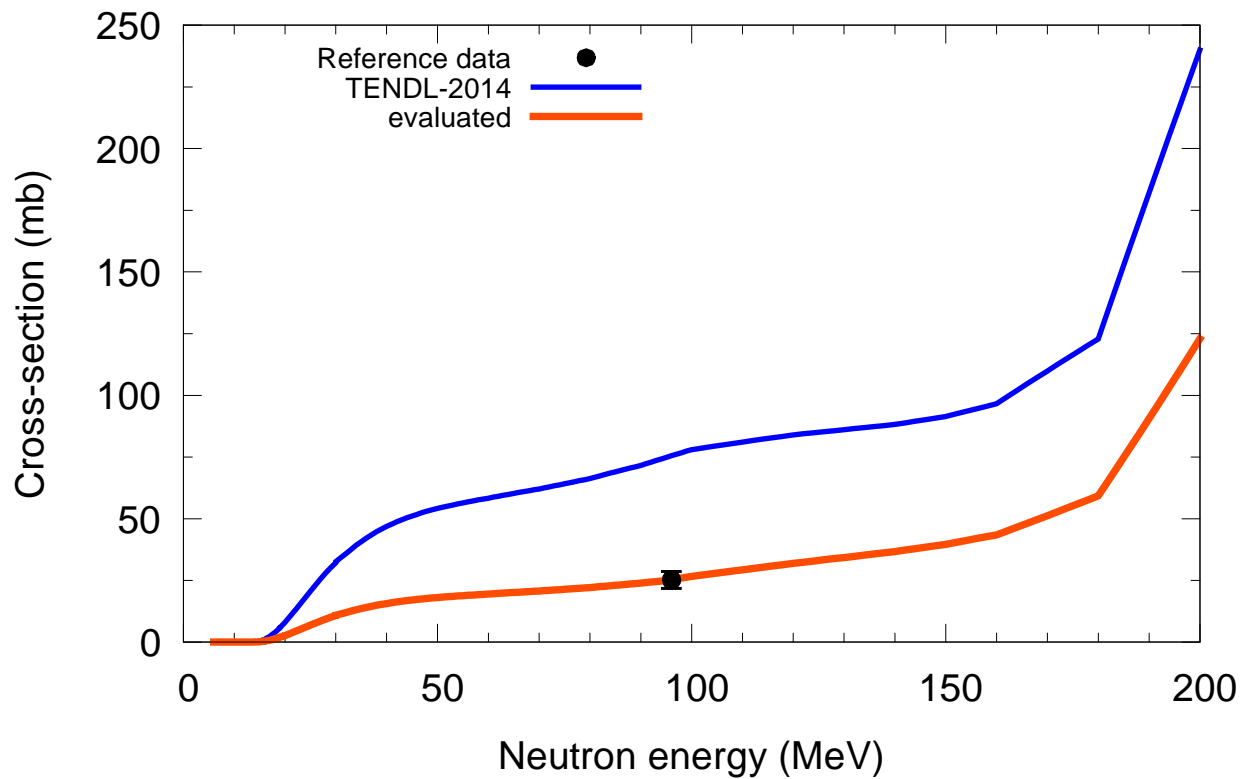
### $^{140}\text{Ce}(n,x)t$



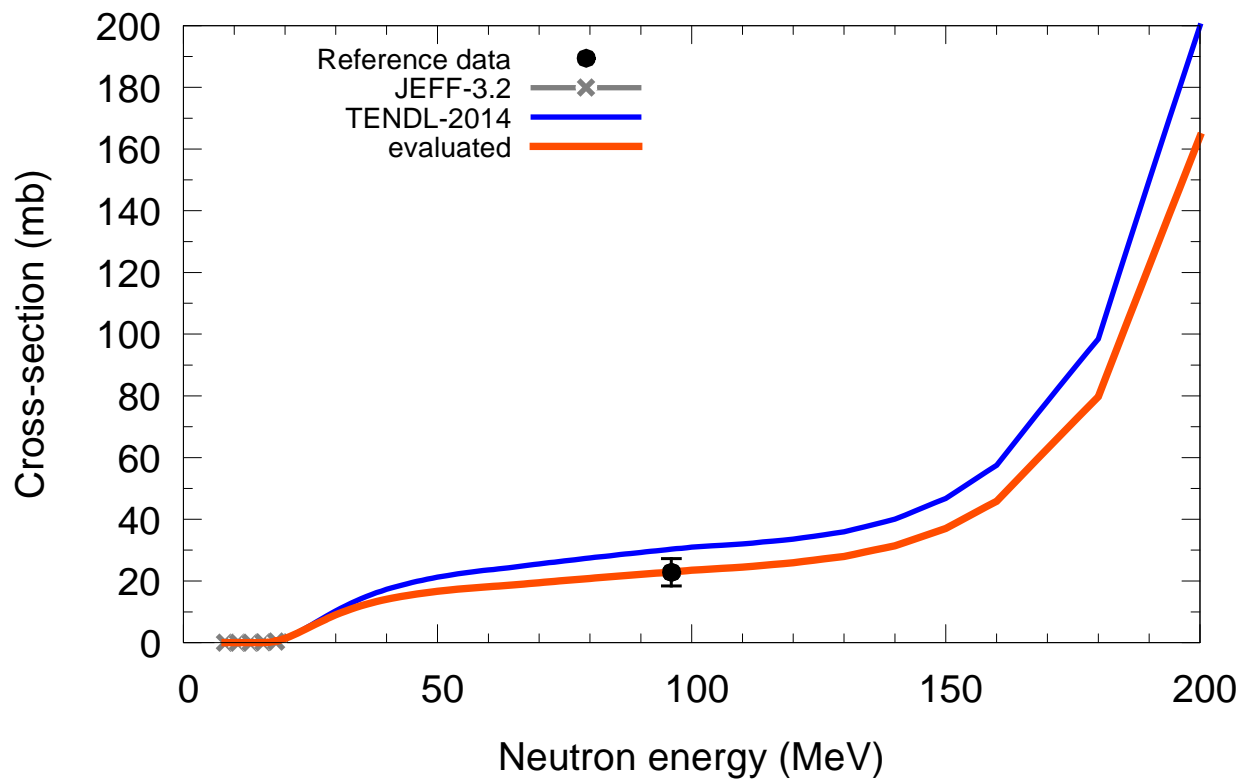
### $^{142}\text{Ce}(n,x)t$



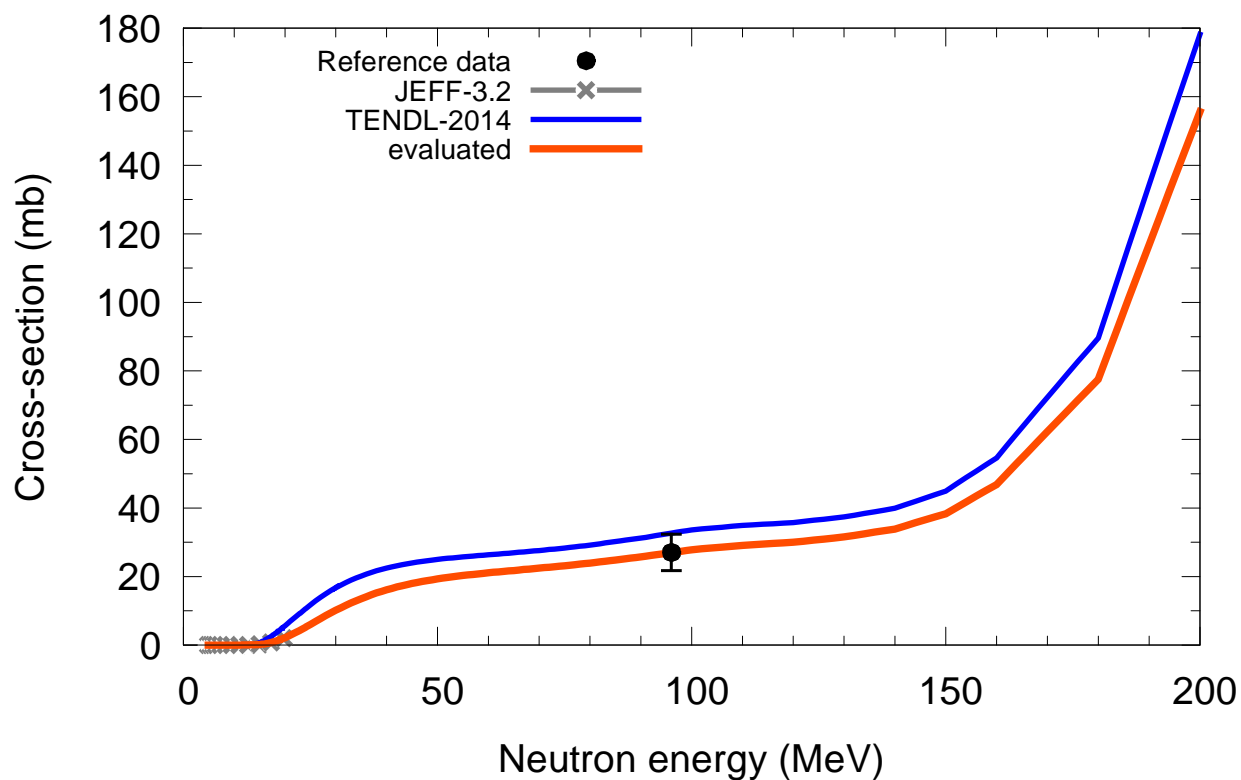
### $^{141}\text{Pr}(n,x)t$



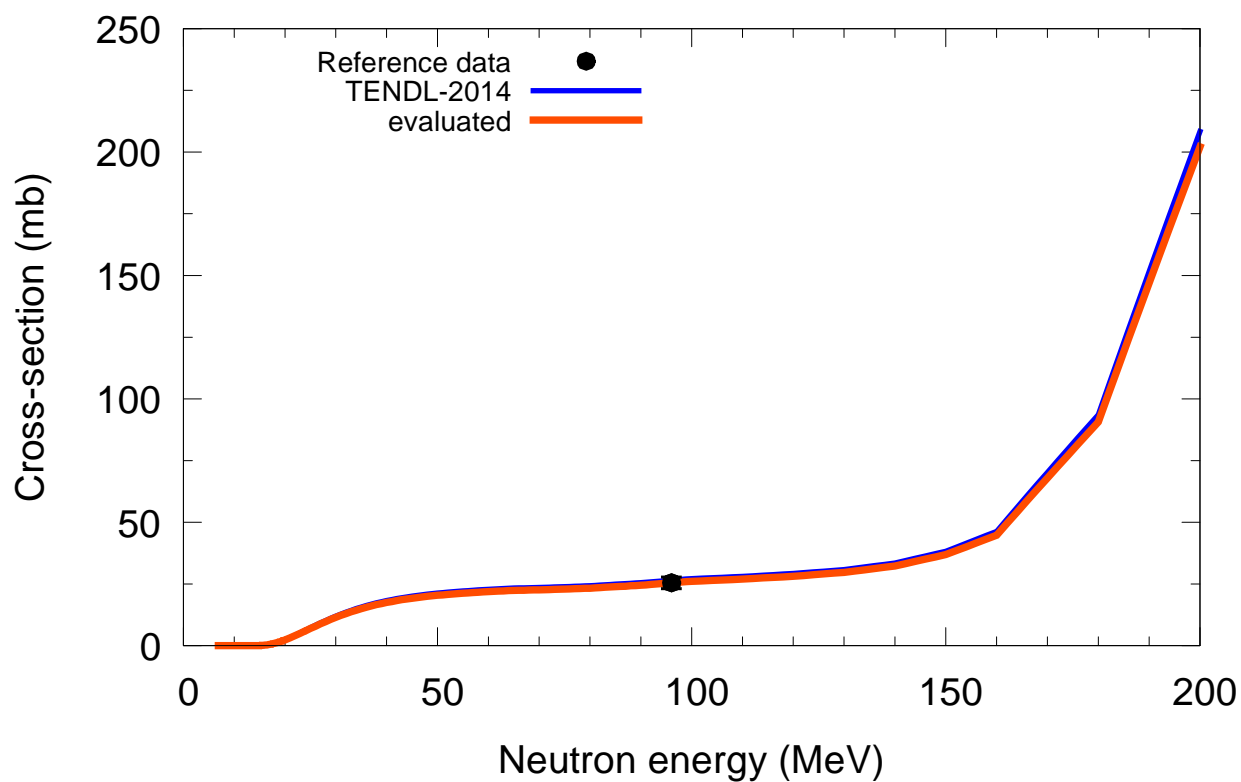
### $^{142}\text{Nd}(n,x)t$



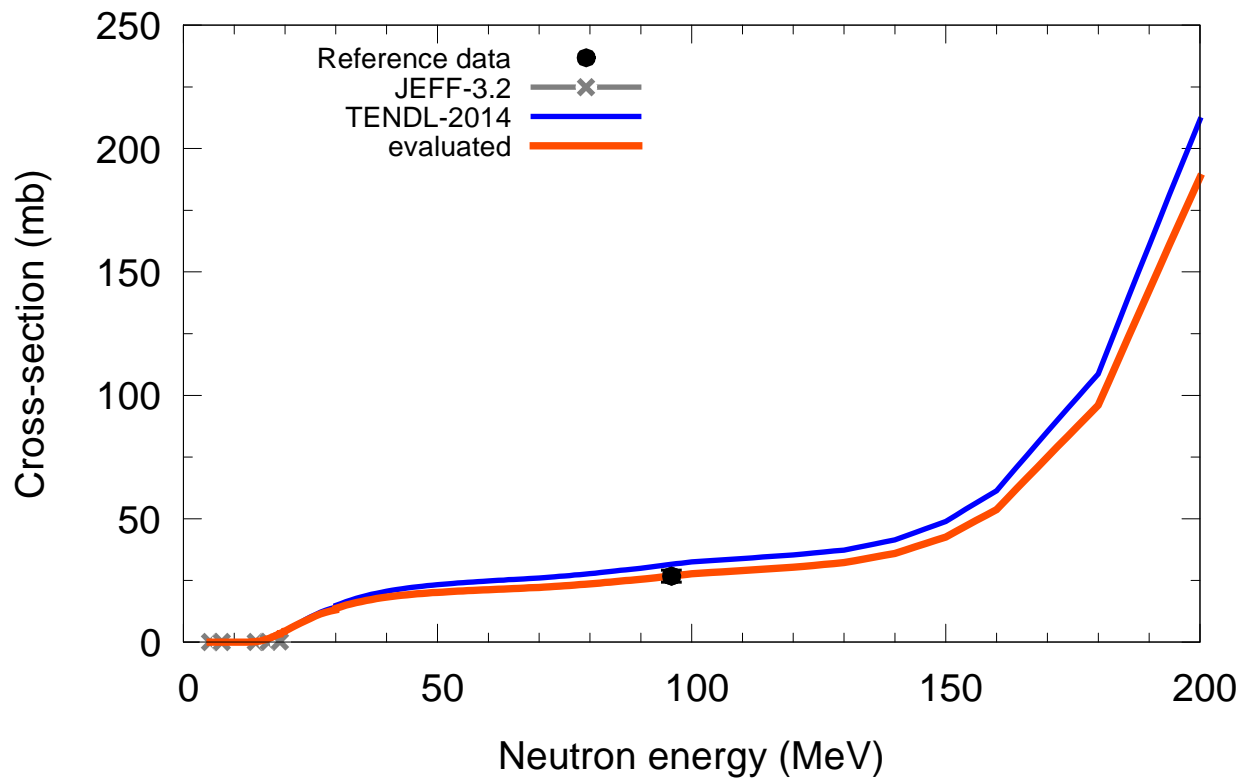
### $^{143}\text{Nd}(n,x)t$



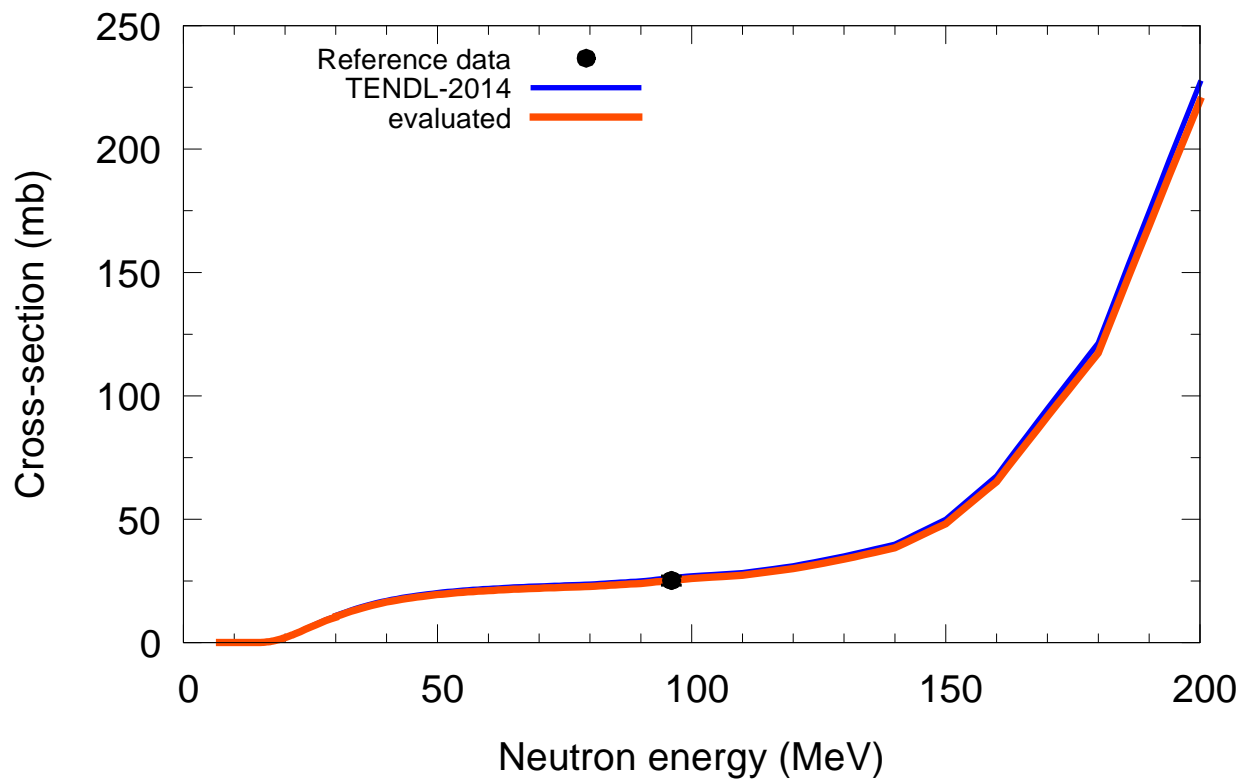
### $^{144}\text{Nd}(n,x)t$



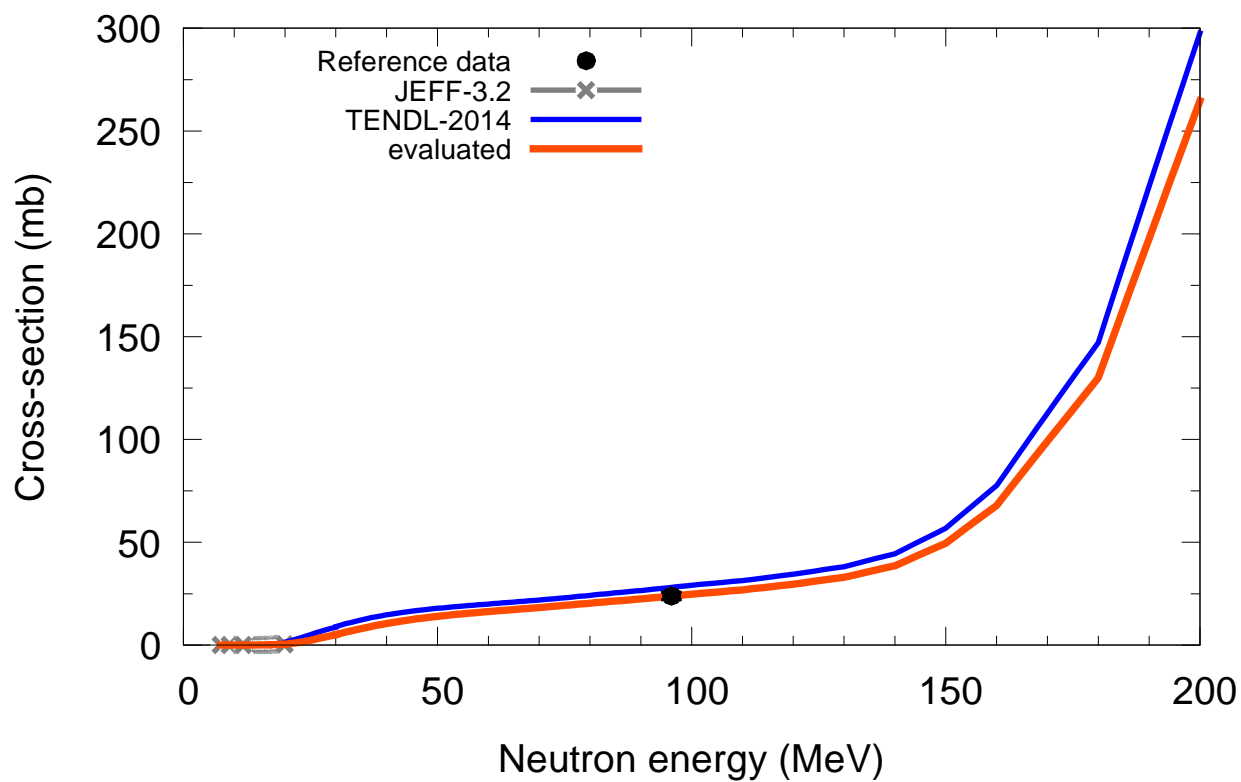
### $^{145}\text{Nd}(n,x)t$



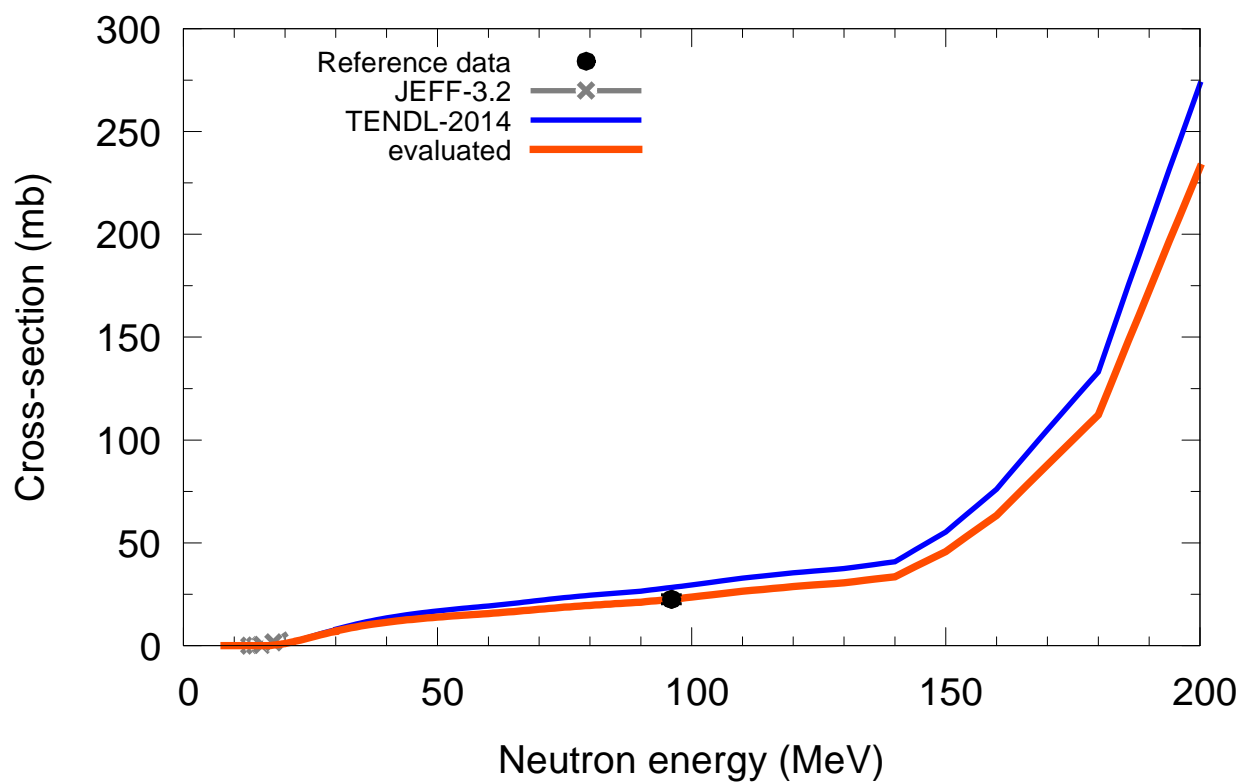
### $^{146}\text{Nd}(n,x)t$



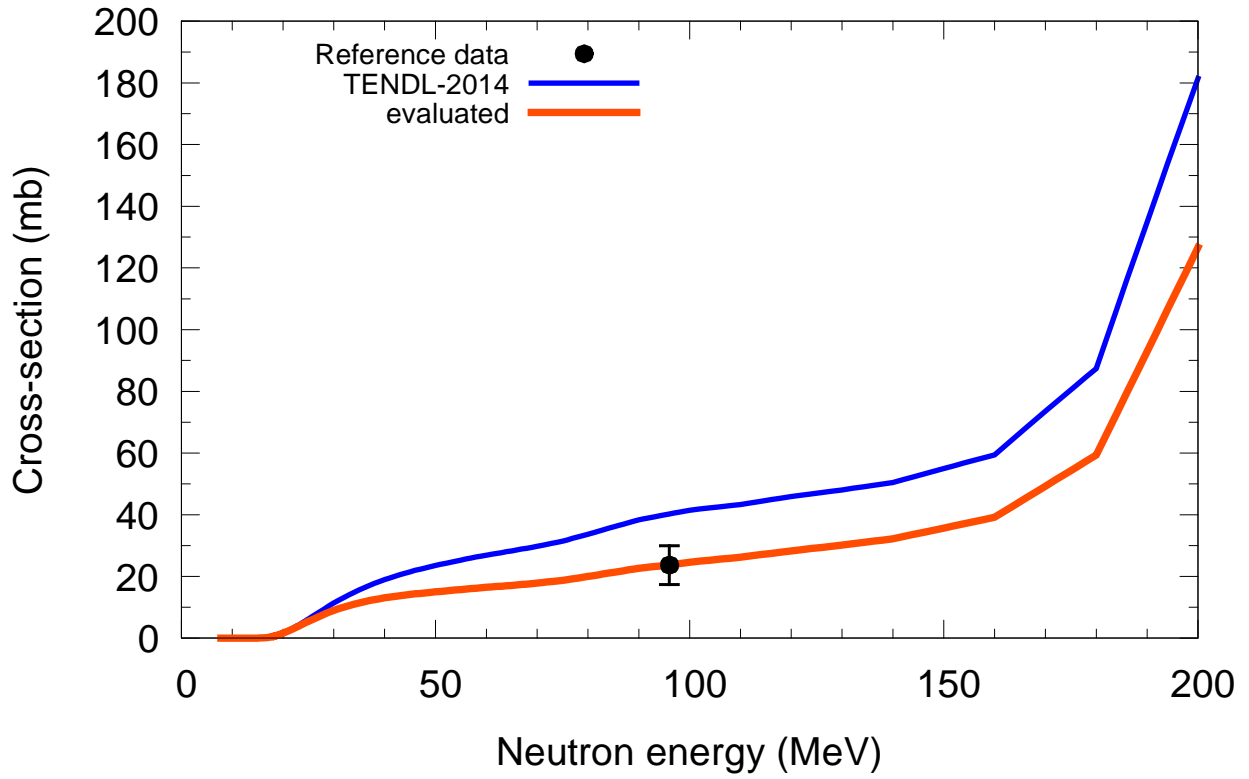
$^{148}\text{Nd}(n,x)t$



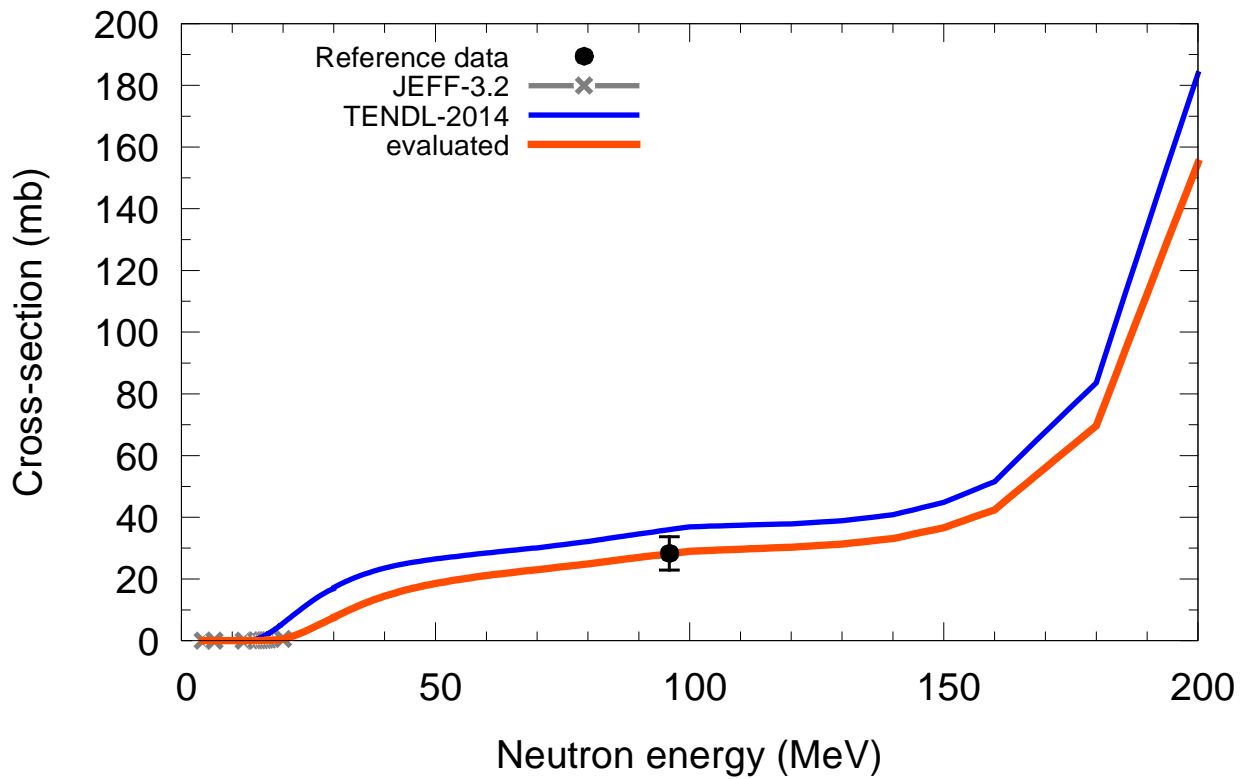
$^{150}\text{Nd}(n,x)t$



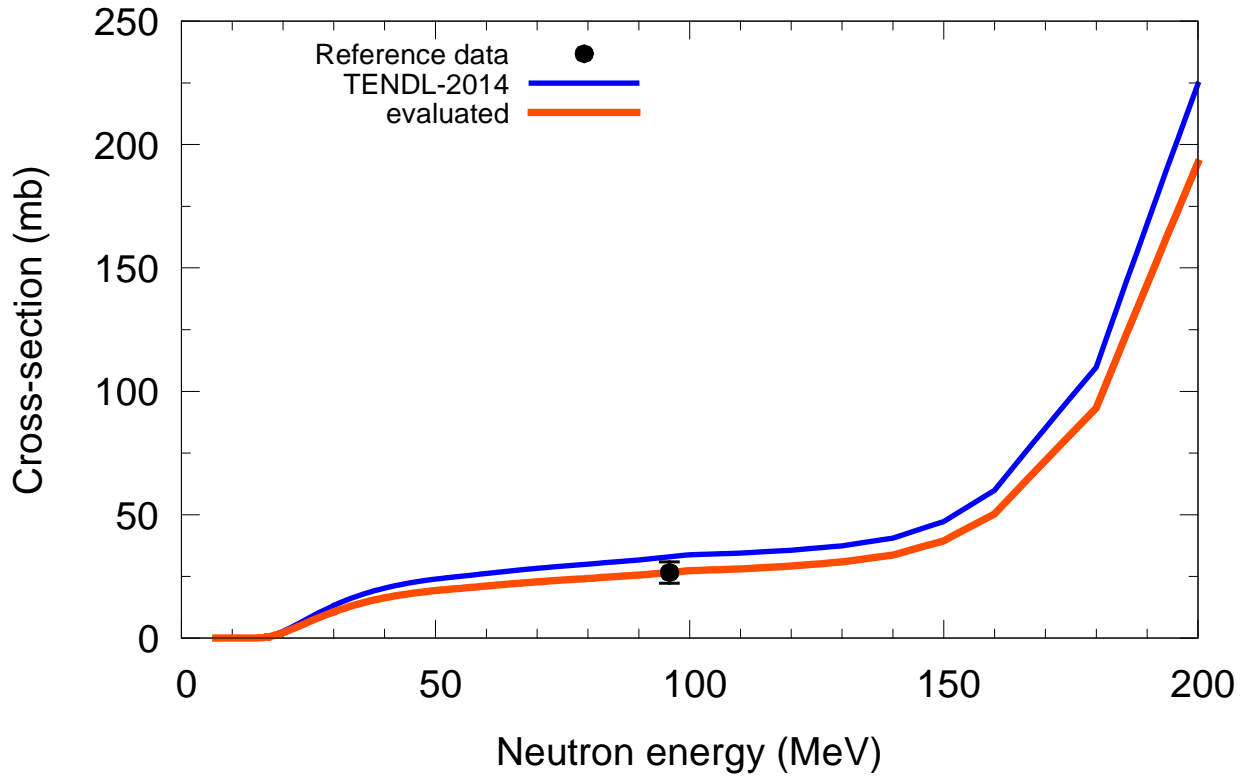
### $^{144}\text{Sm}(n,x)t$



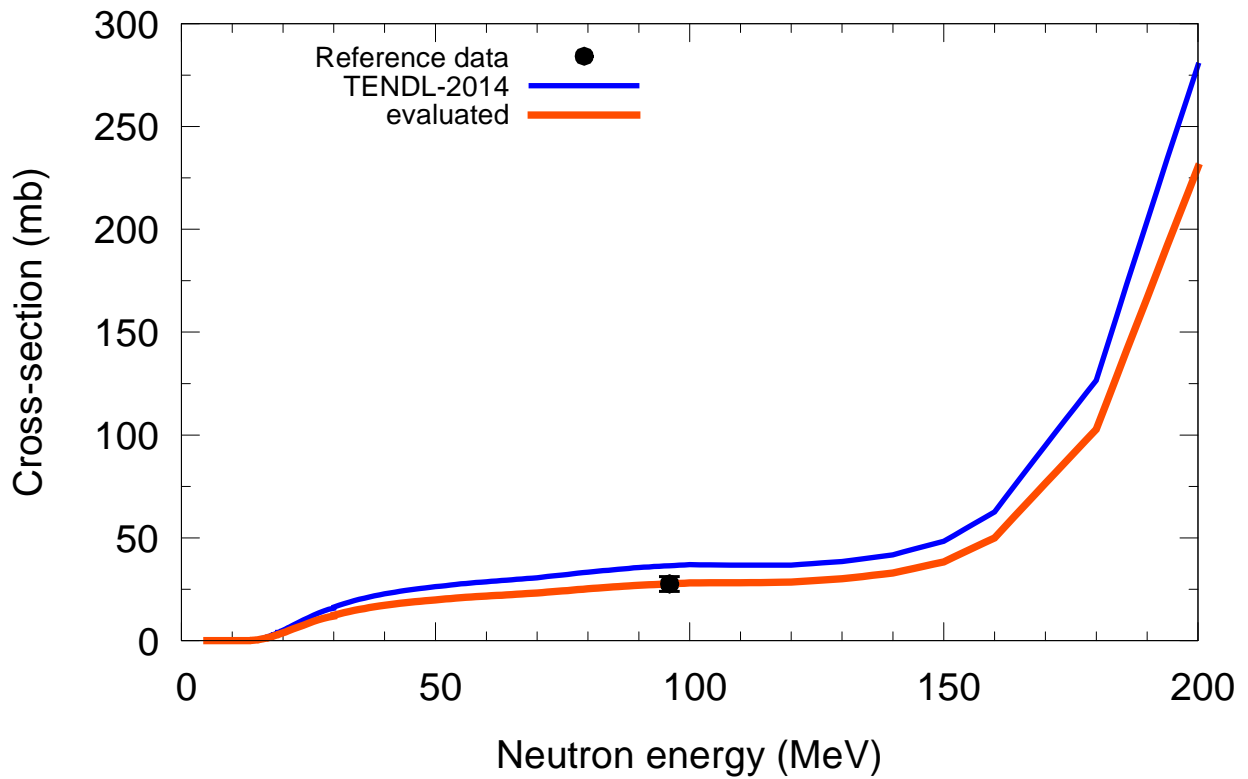
### $^{147}\text{Sm}(n,x)t$



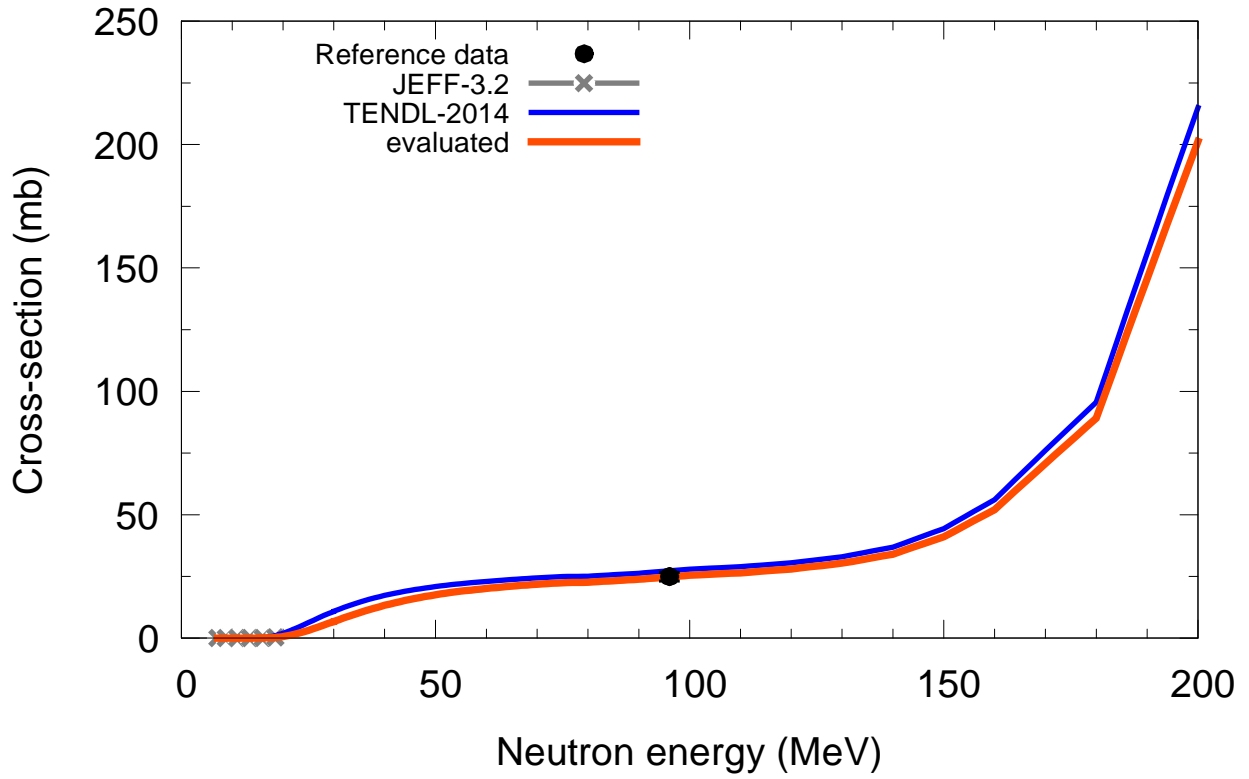
### $^{148}\text{Sm}(n,x)t$



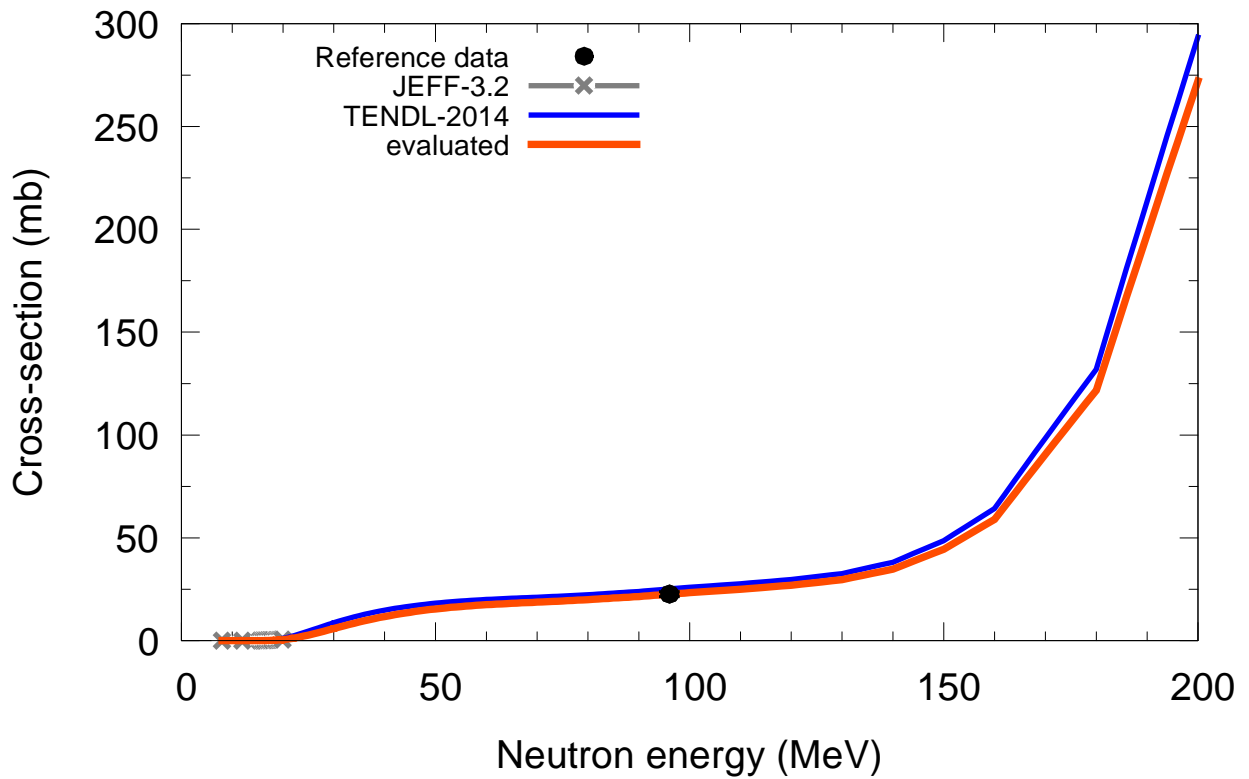
### $^{149}\text{Sm}(n,x)t$



$^{150}\text{Sm}(n,x)t$

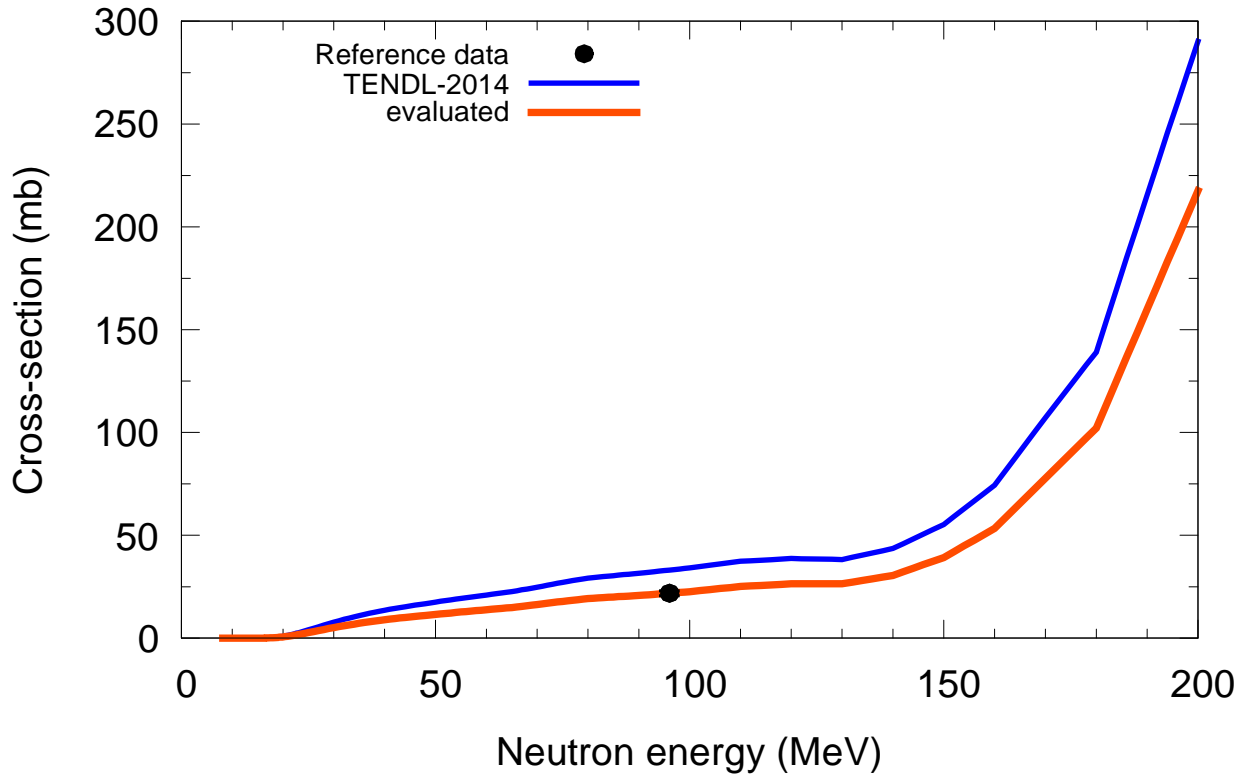


$^{152}\text{Sm}(n,x)t$

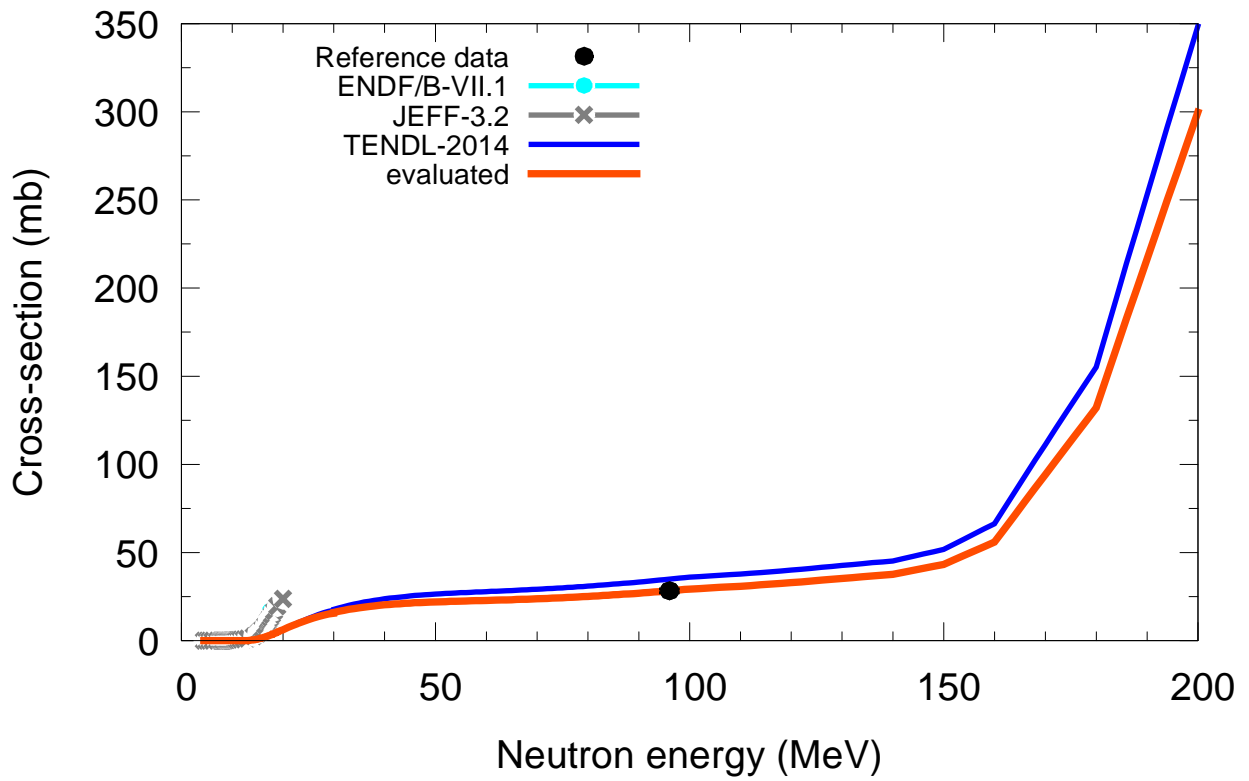




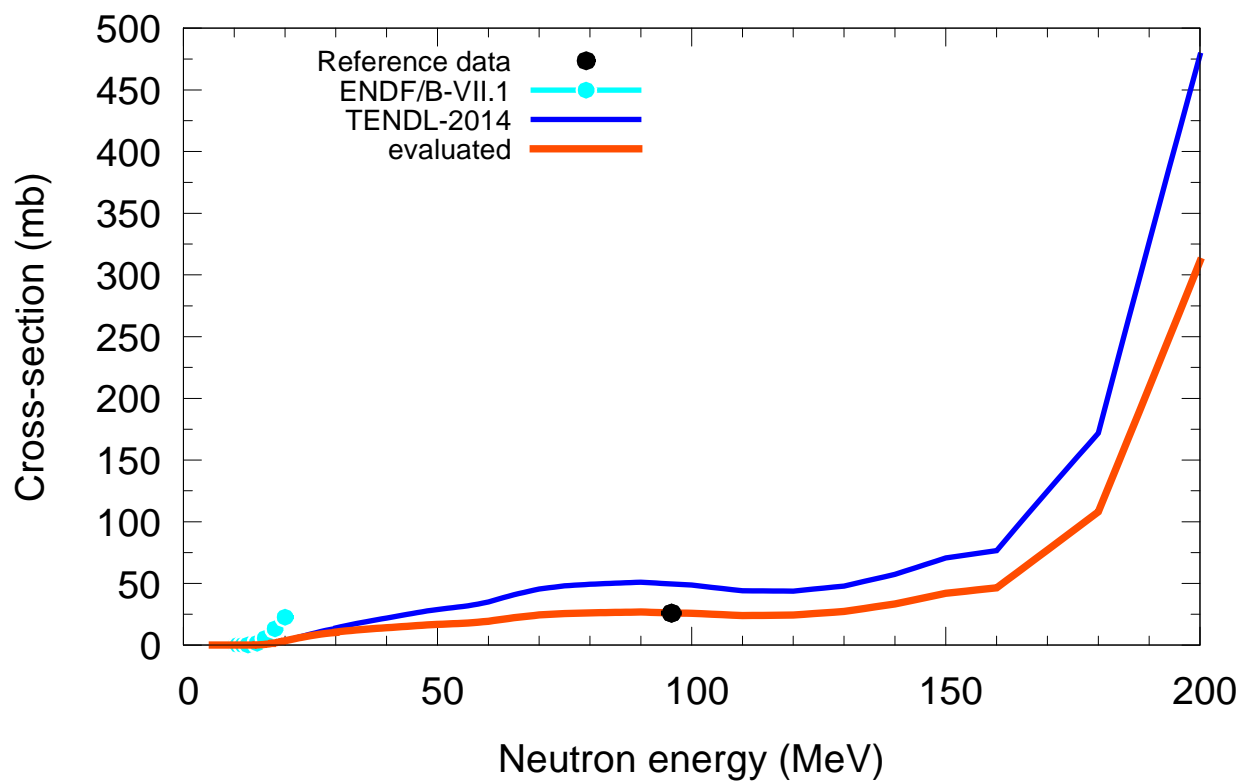
$^{154}\text{Sm}(n,x)t$



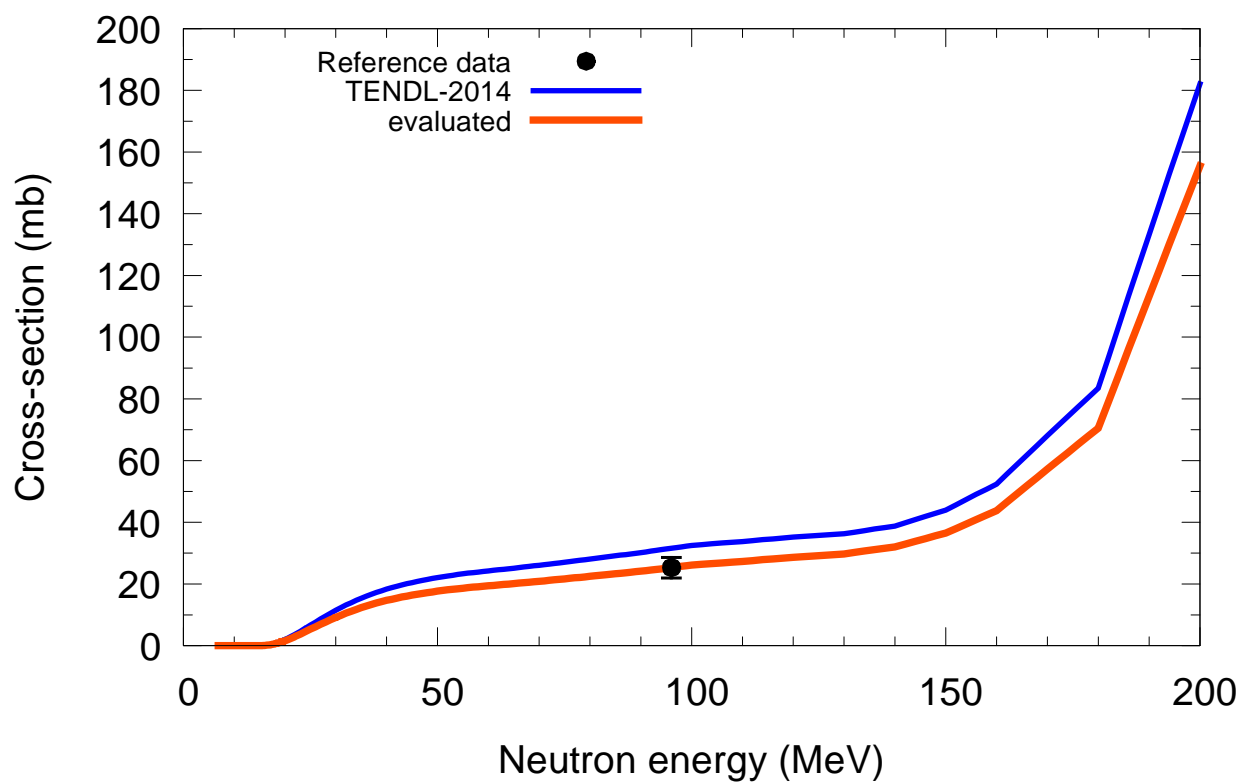
$^{151}\text{Eu}(n,x)t$



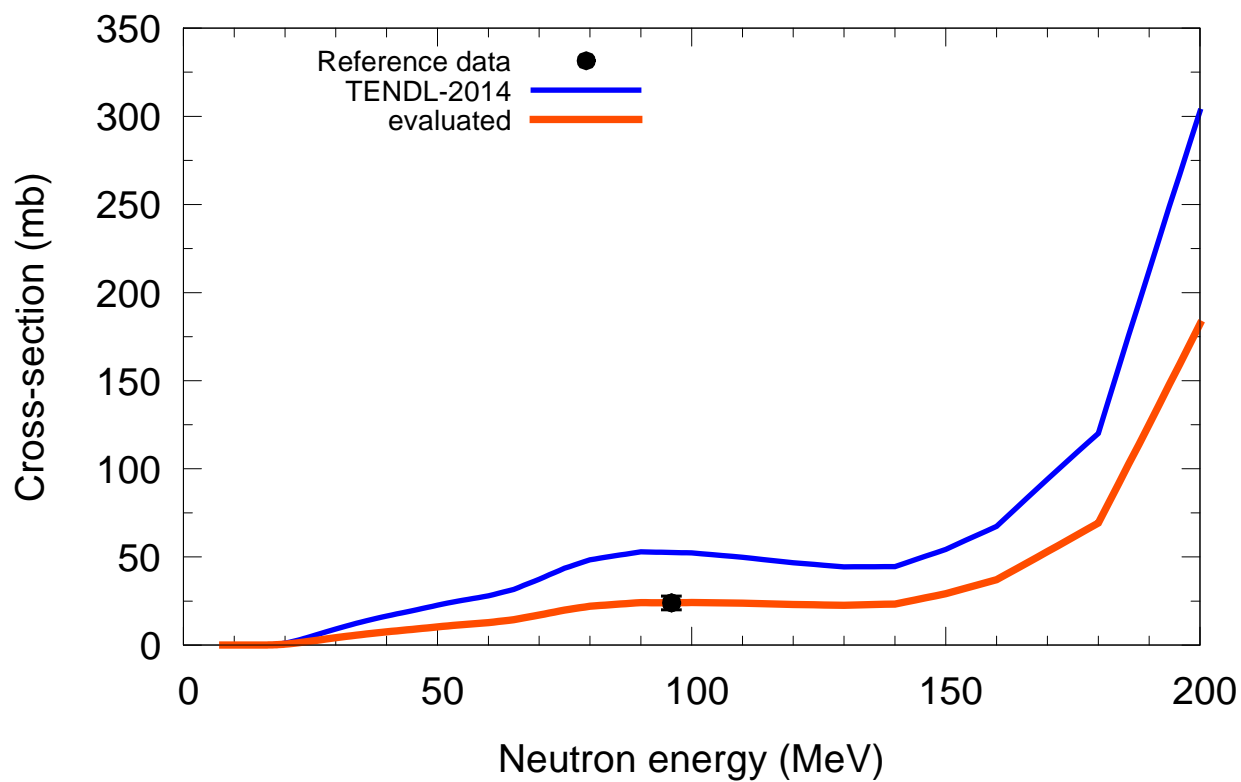
$^{153}\text{Eu}(n,x)t$



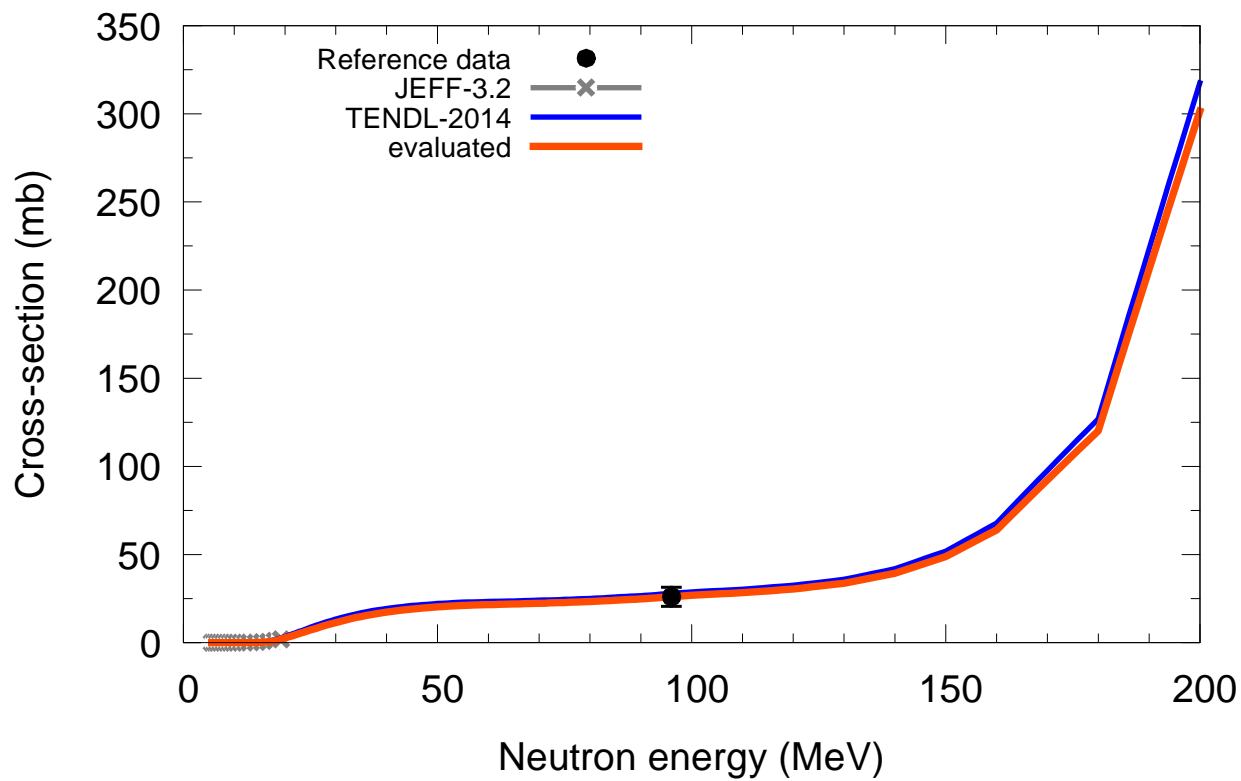
$^{152}\text{Gd}(n,x)t$



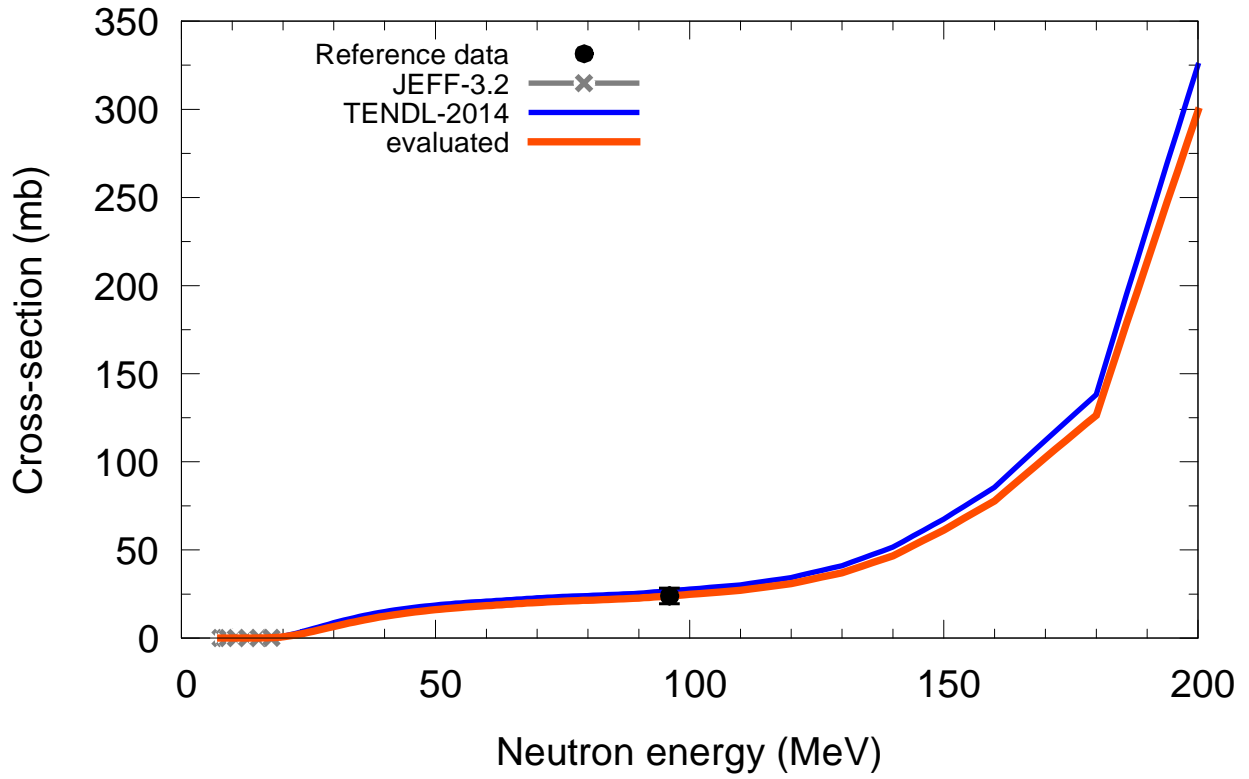
### $^{154}\text{Gd}(n,x)t$



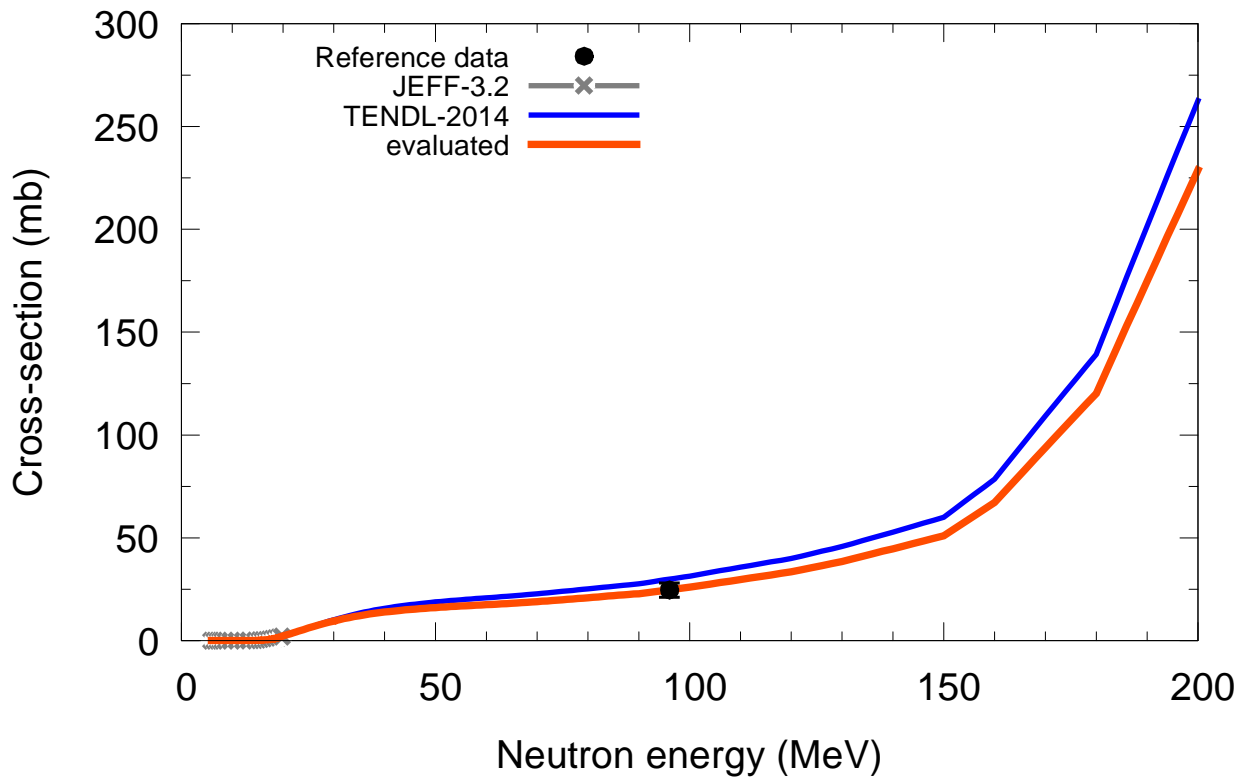
### $^{155}\text{Gd}(n,x)t$



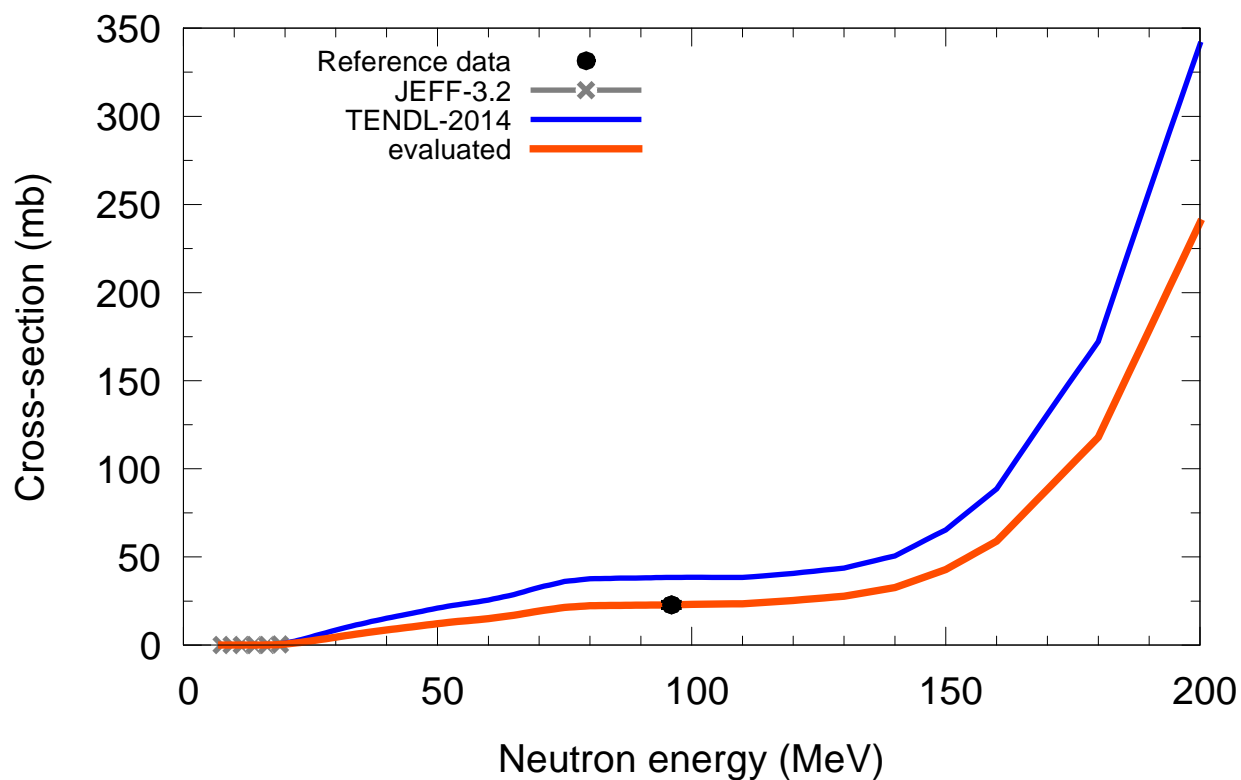
$^{156}\text{Gd}(n,x)t$



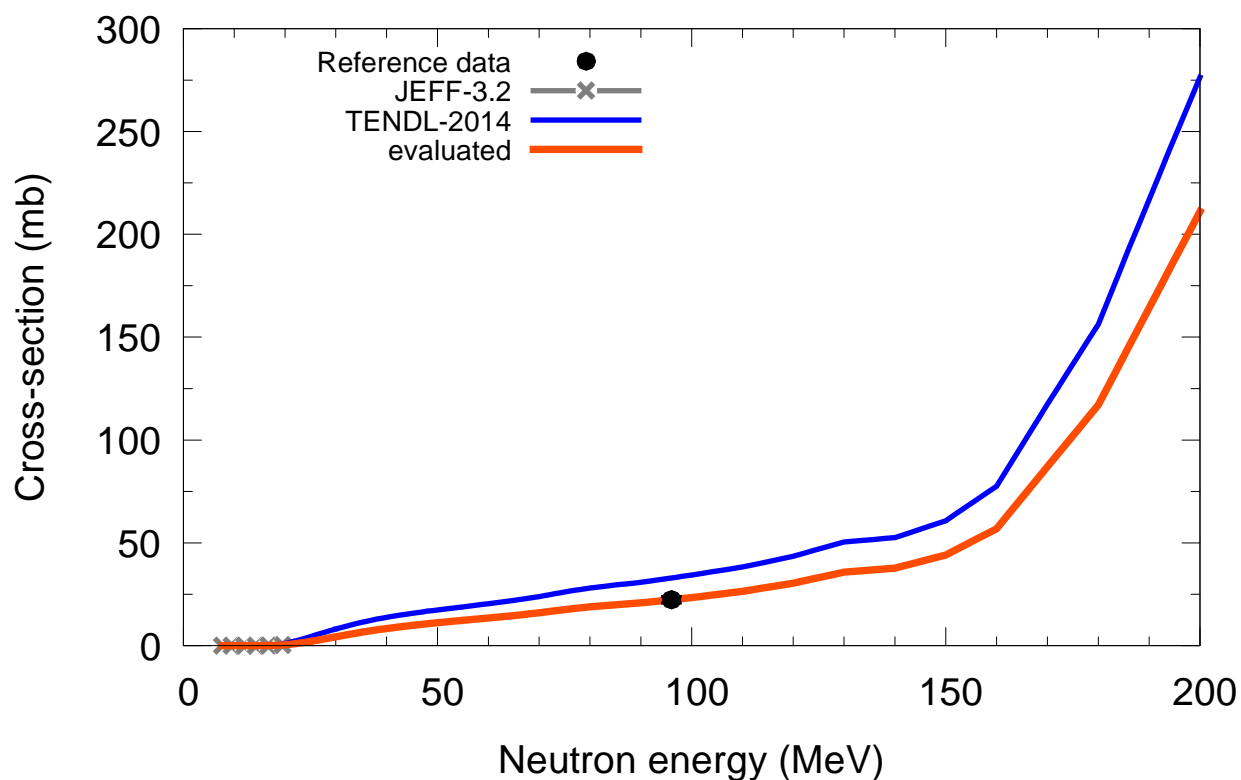
$^{157}\text{Gd}(n,x)t$



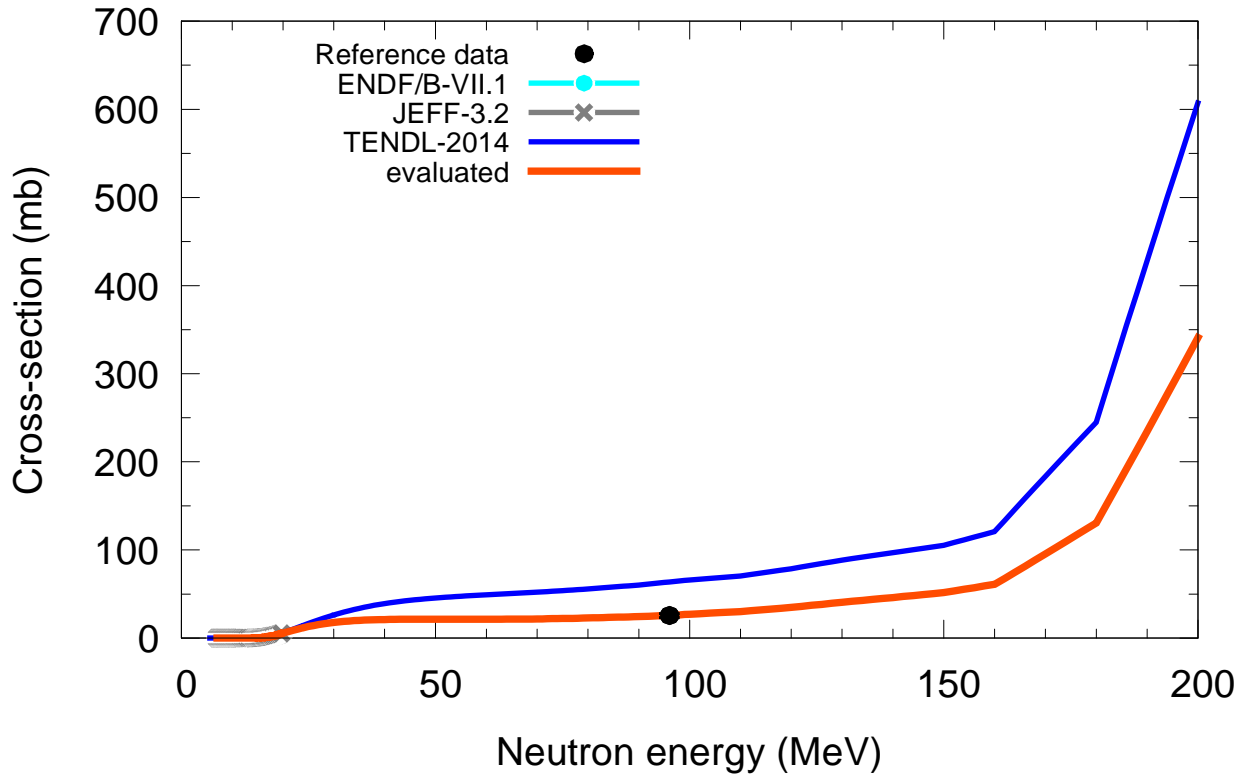
$^{158}\text{Gd}(n,x)t$



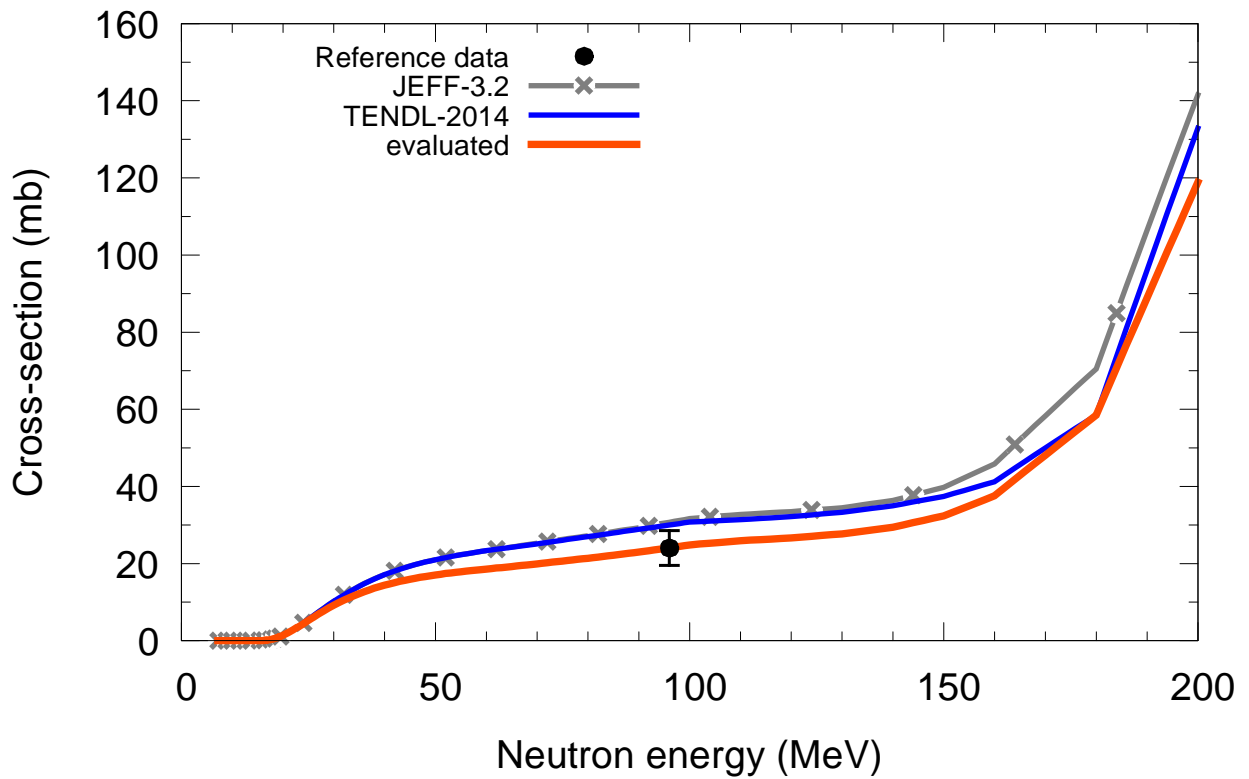
$^{160}\text{Gd}(n,x)t$



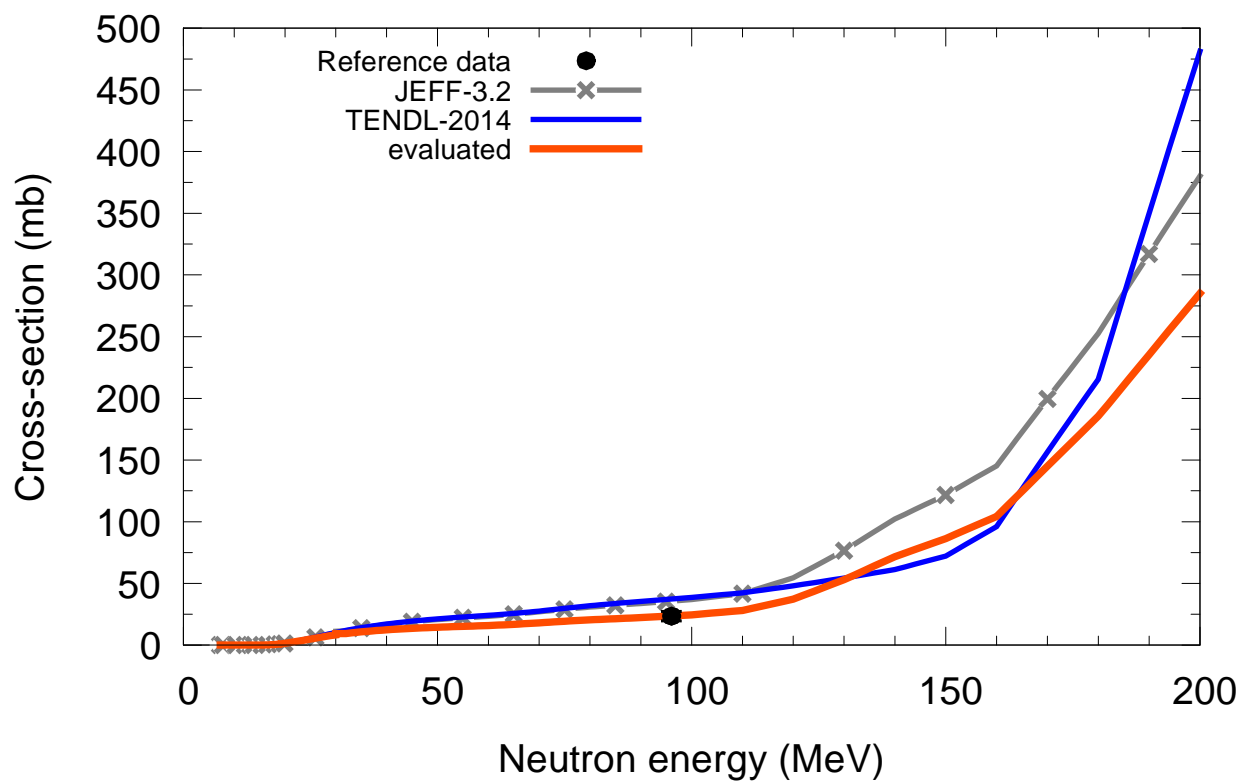
$^{159}\text{Tb}(n,x)t$



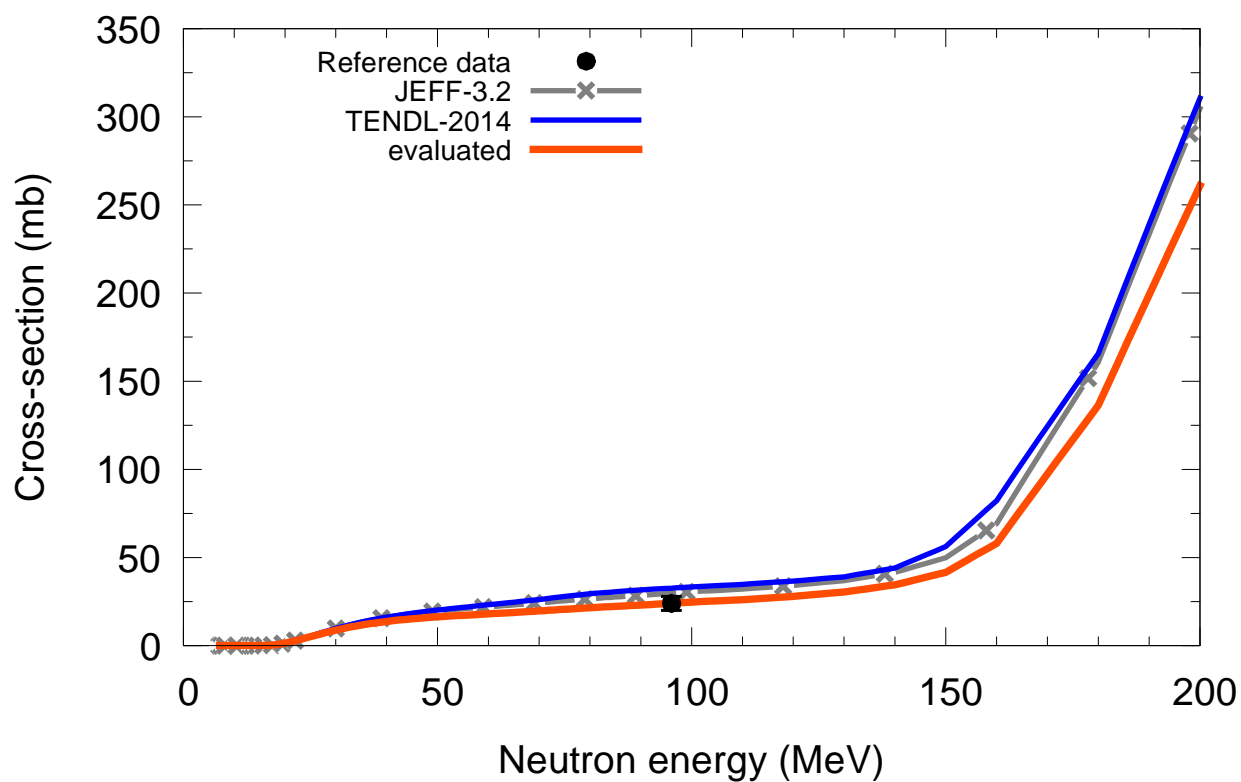
$^{156}\text{Dy}(n,x)t$



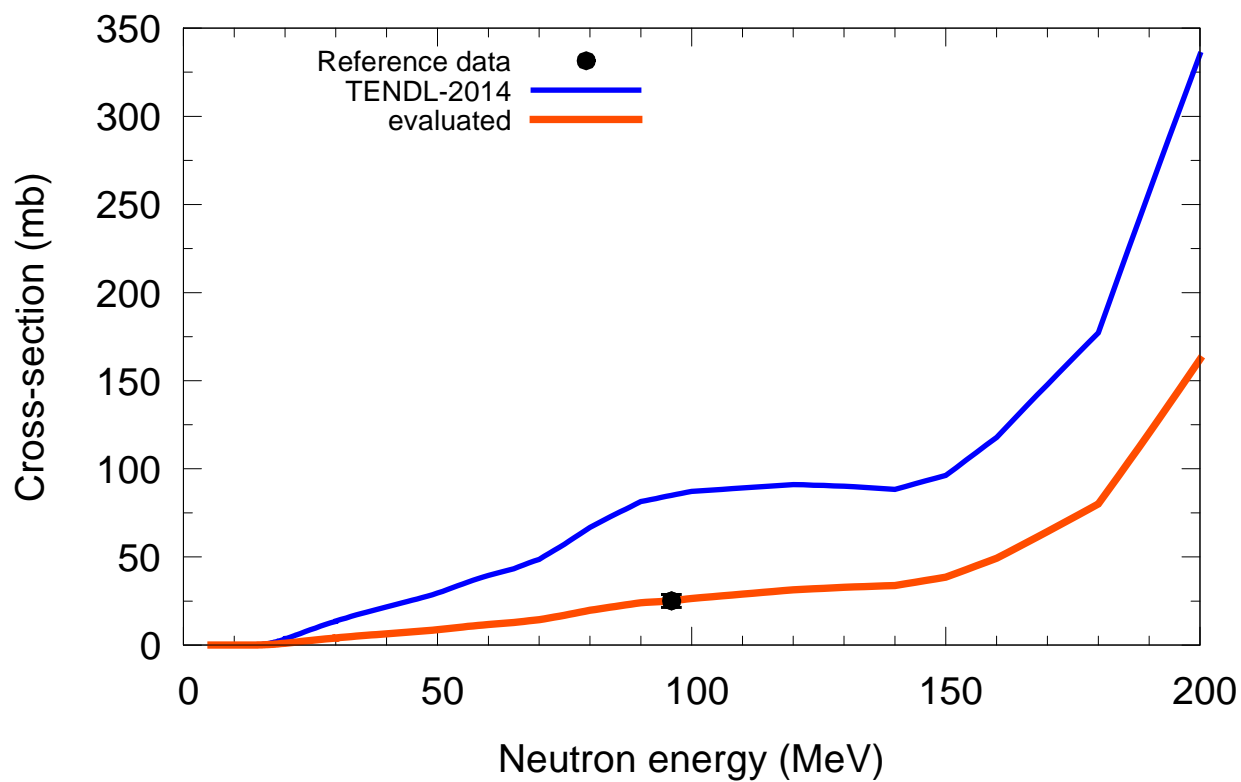
$^{158}\text{Dy}(n,x)t$



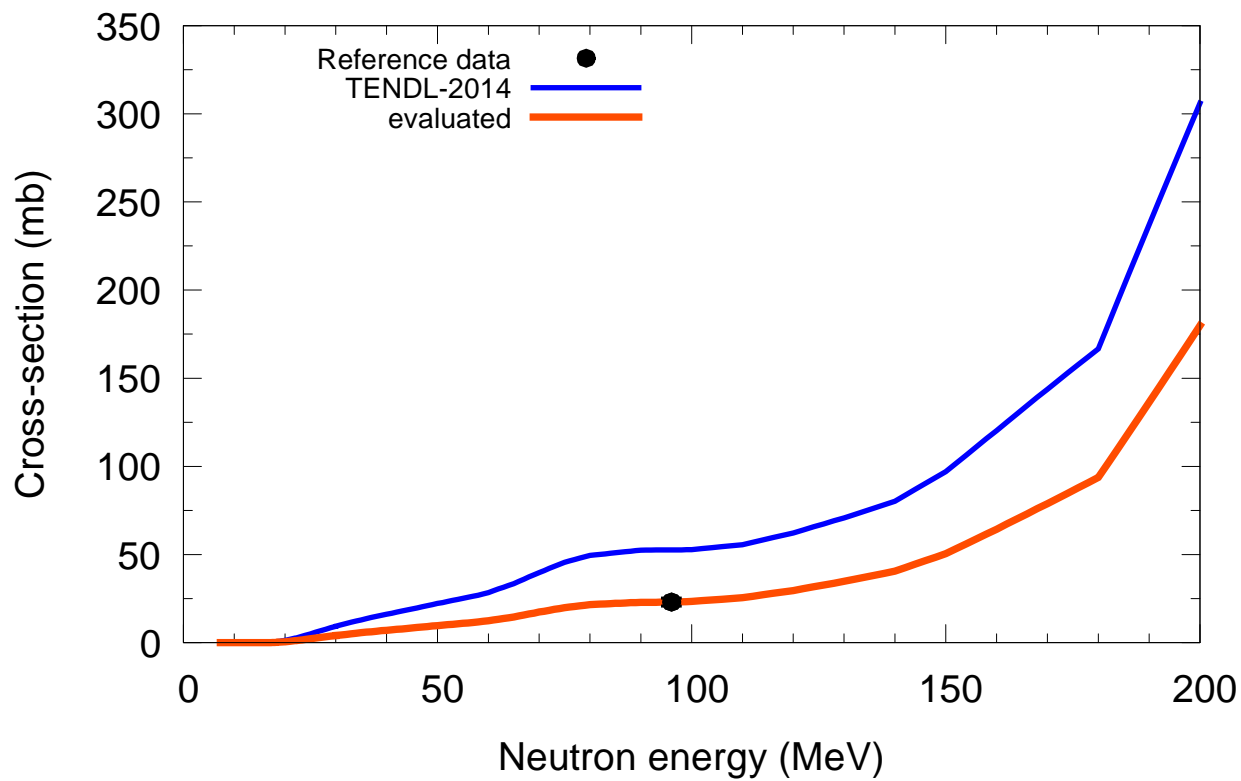
$^{160}\text{Dy}(n,x)t$



$^{161}\text{Dy}(n,x)t$

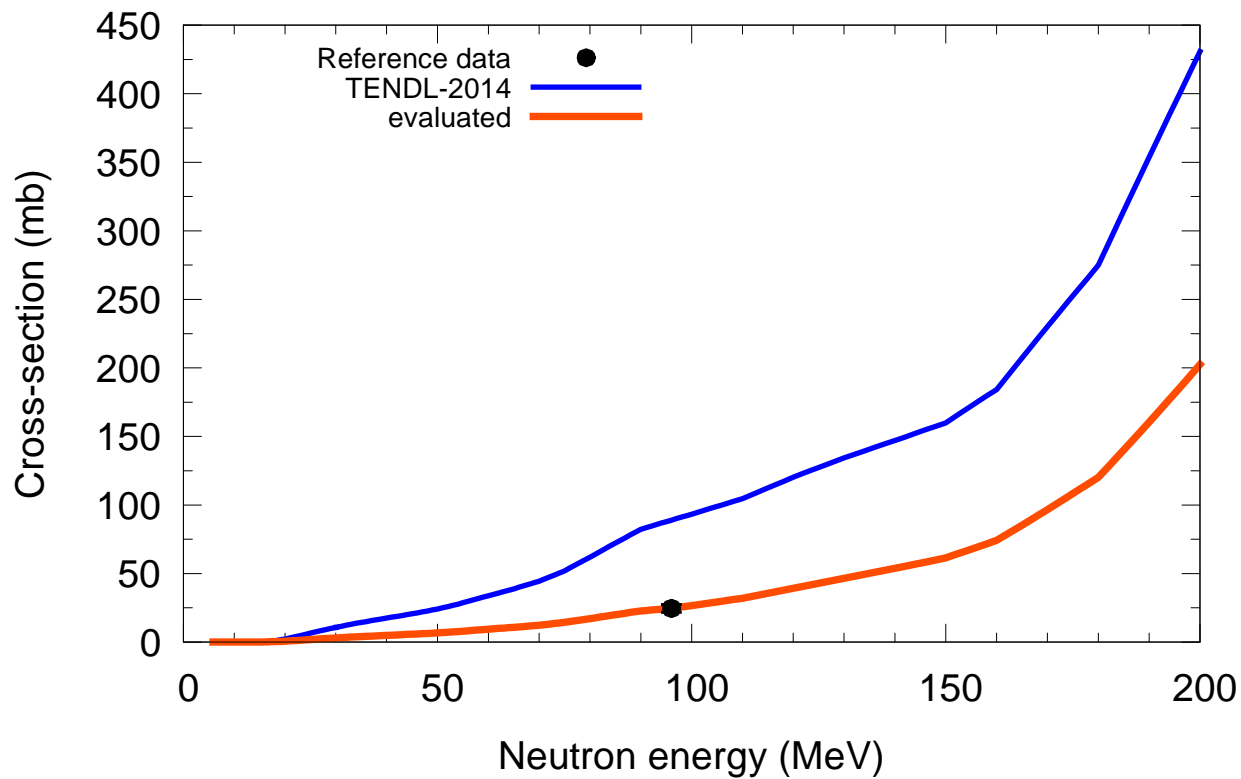


$^{162}\text{Dy}(n,x)t$

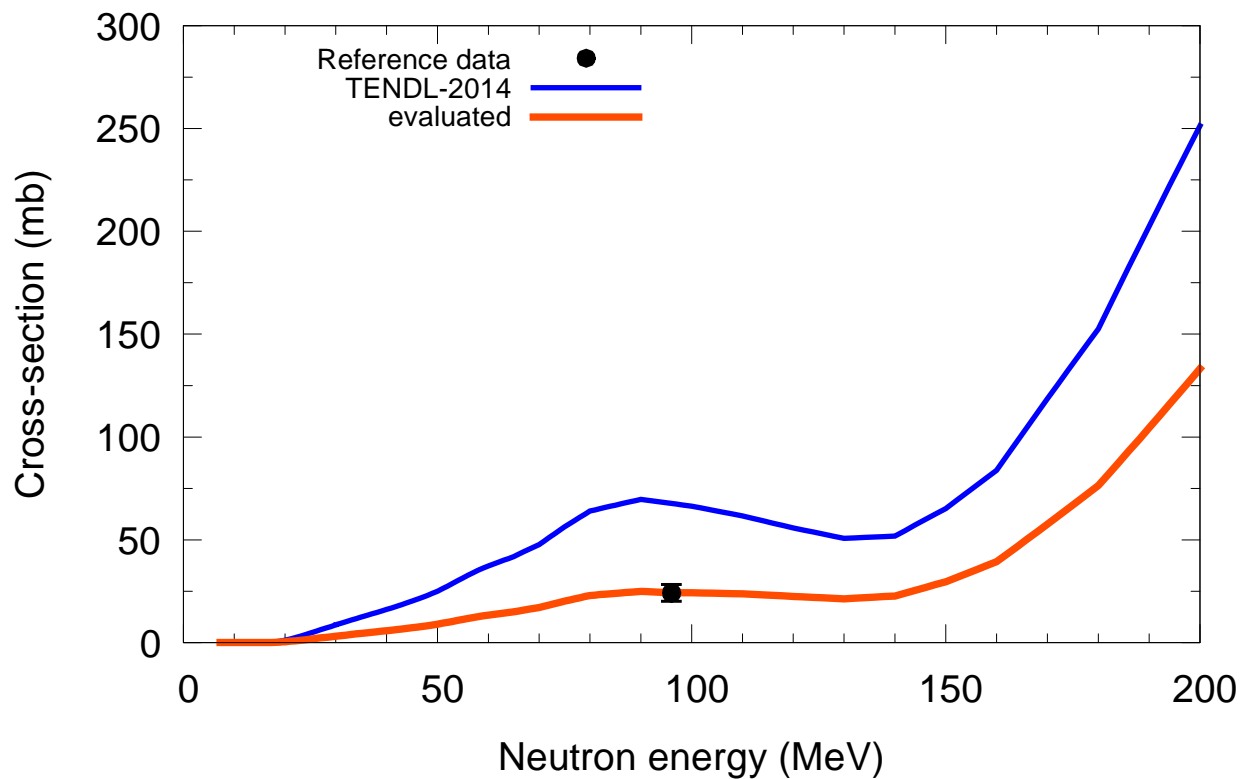




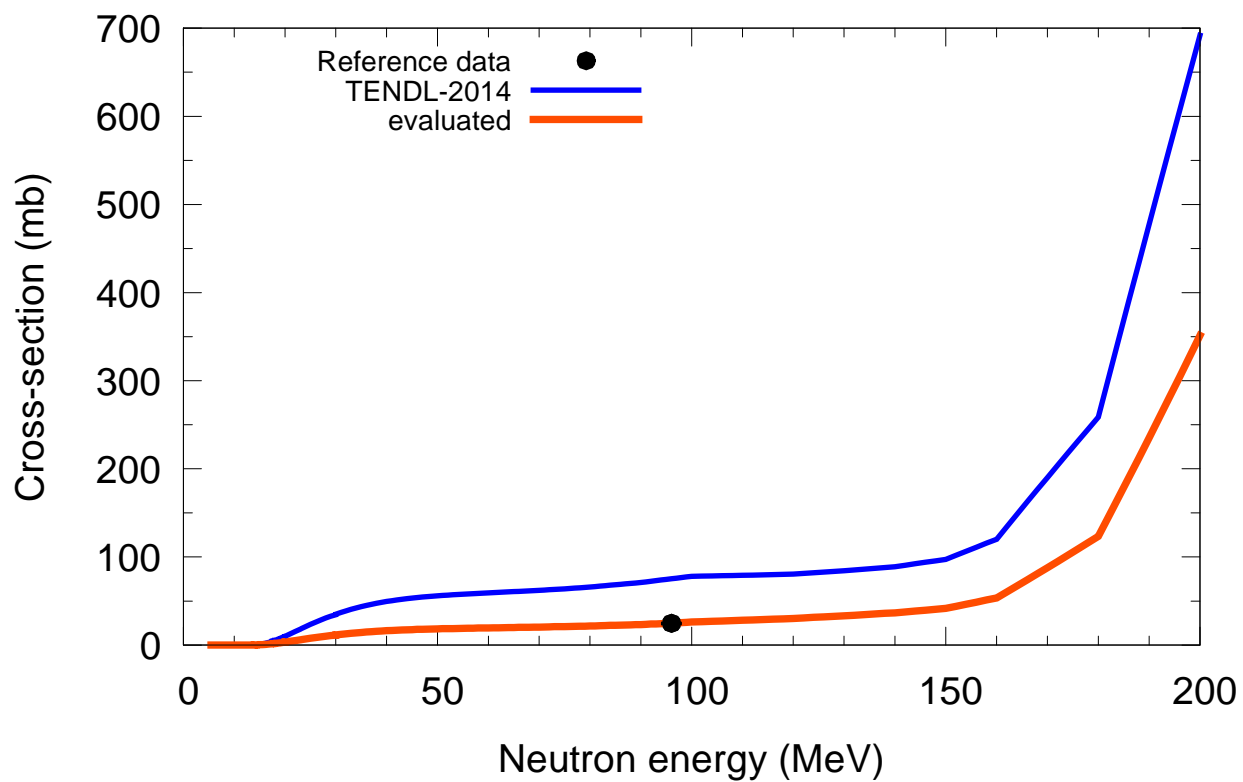
$^{163}\text{Dy}(n,x)t$



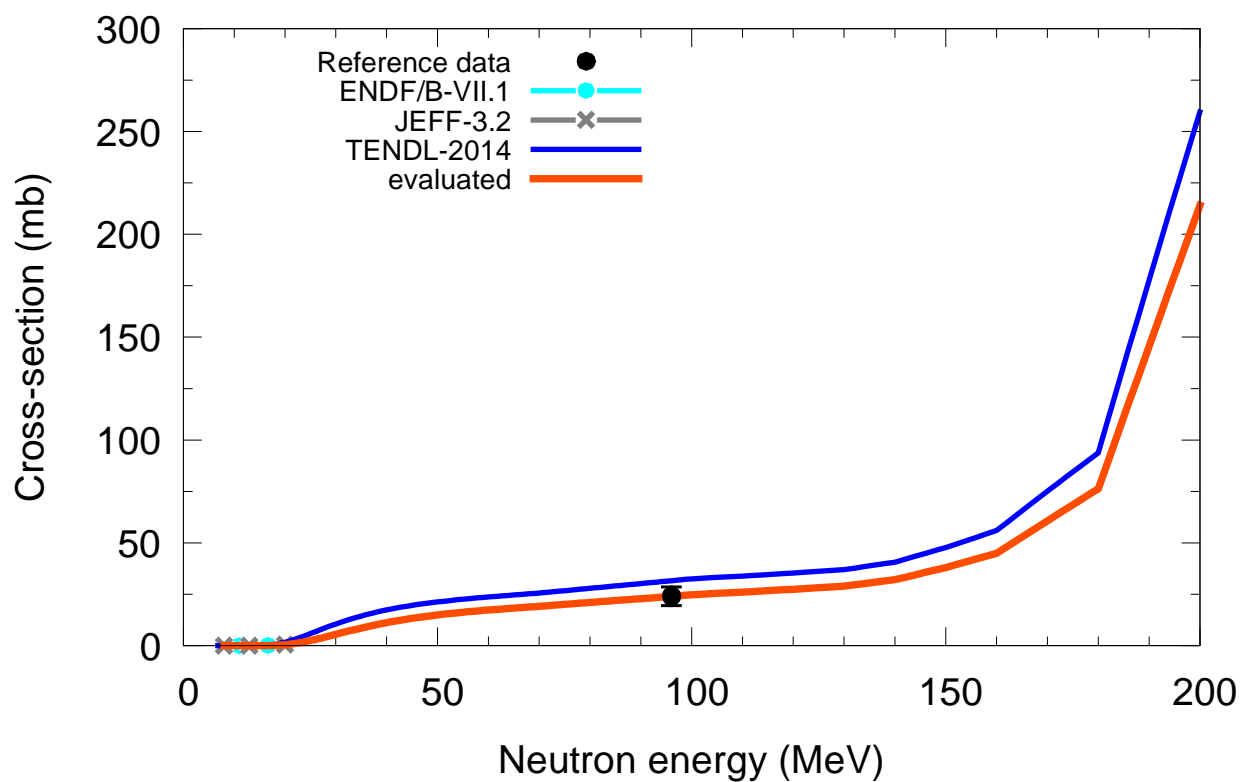
$^{164}\text{Dy}(n,x)t$



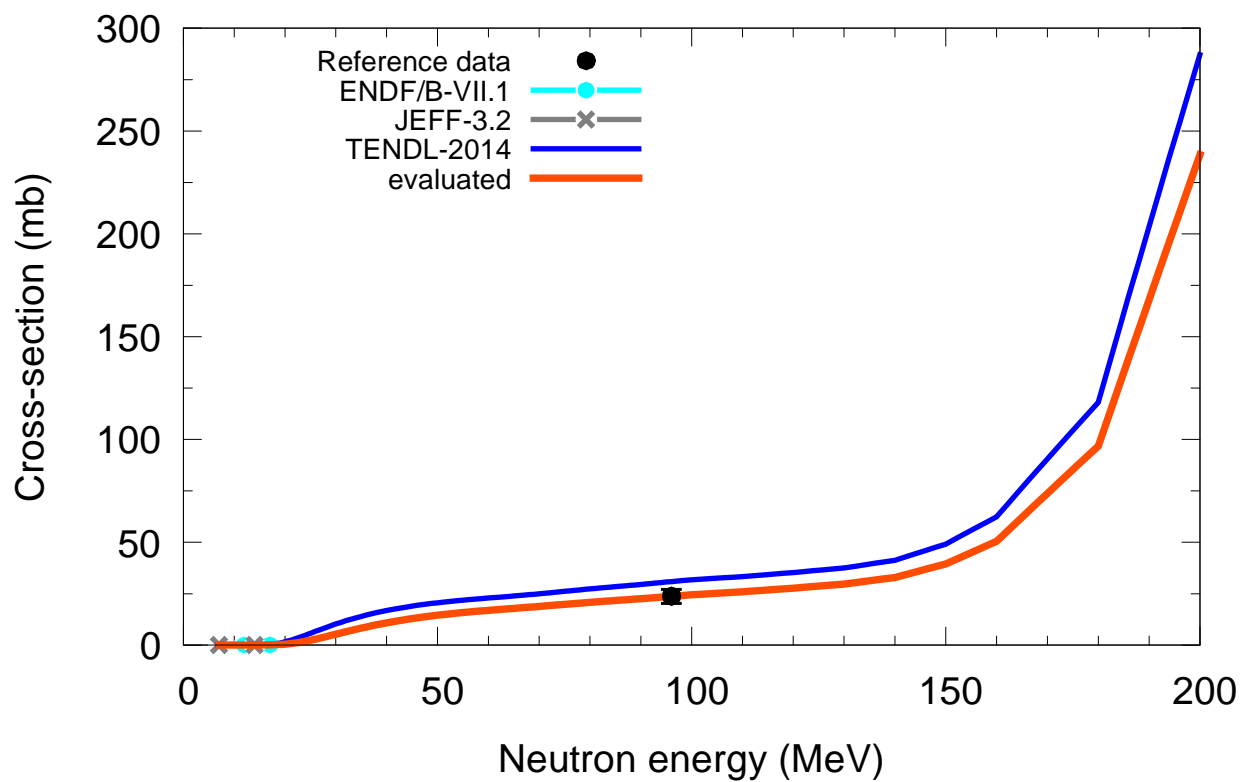
### $^{165}\text{Ho}(n,x)t$



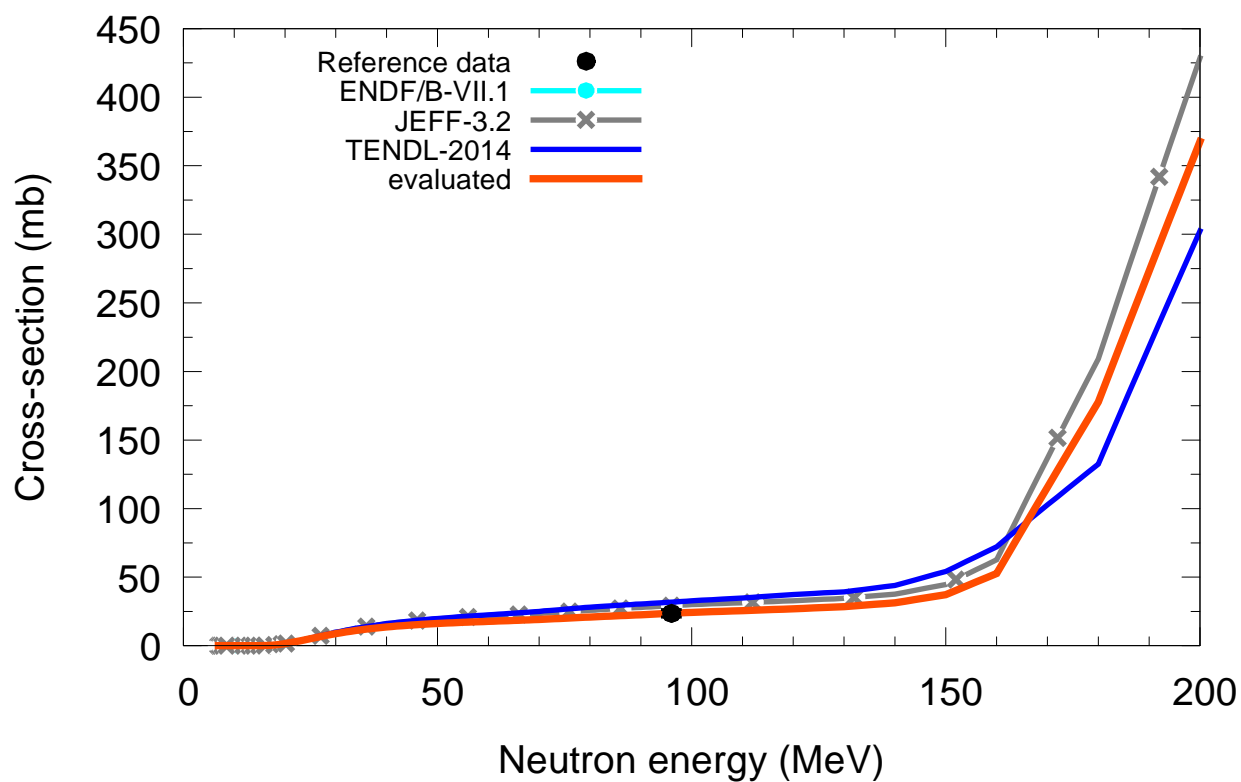
### $^{162}\text{Er}(n,x)t$



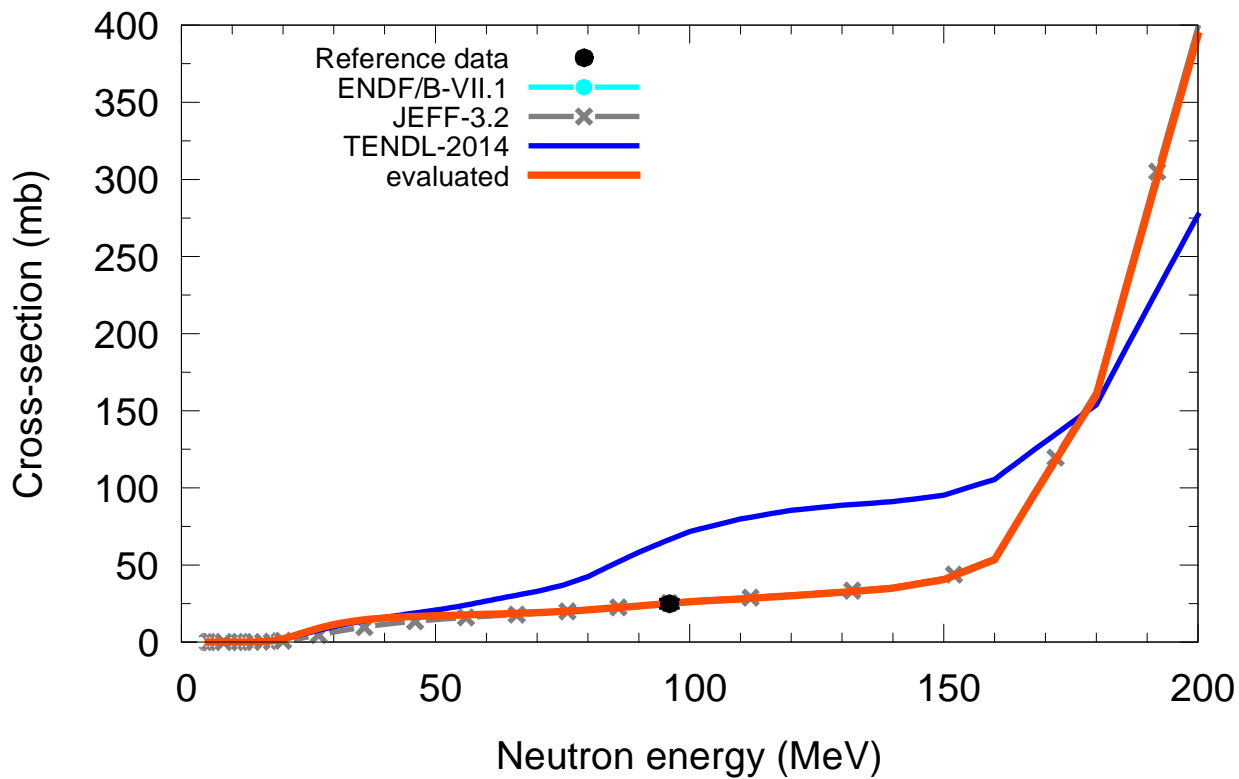
$^{164}\text{Er}(n,x)t$



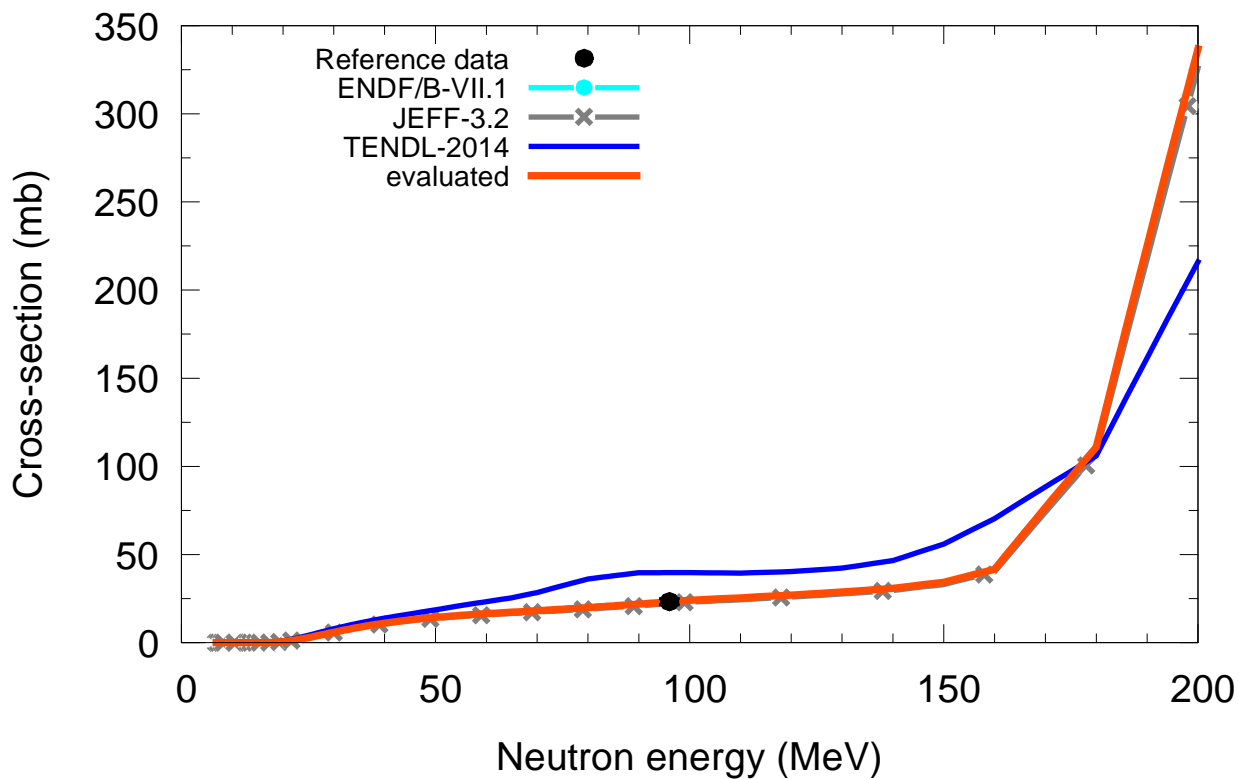
$^{166}\text{Er}(n,x)t$



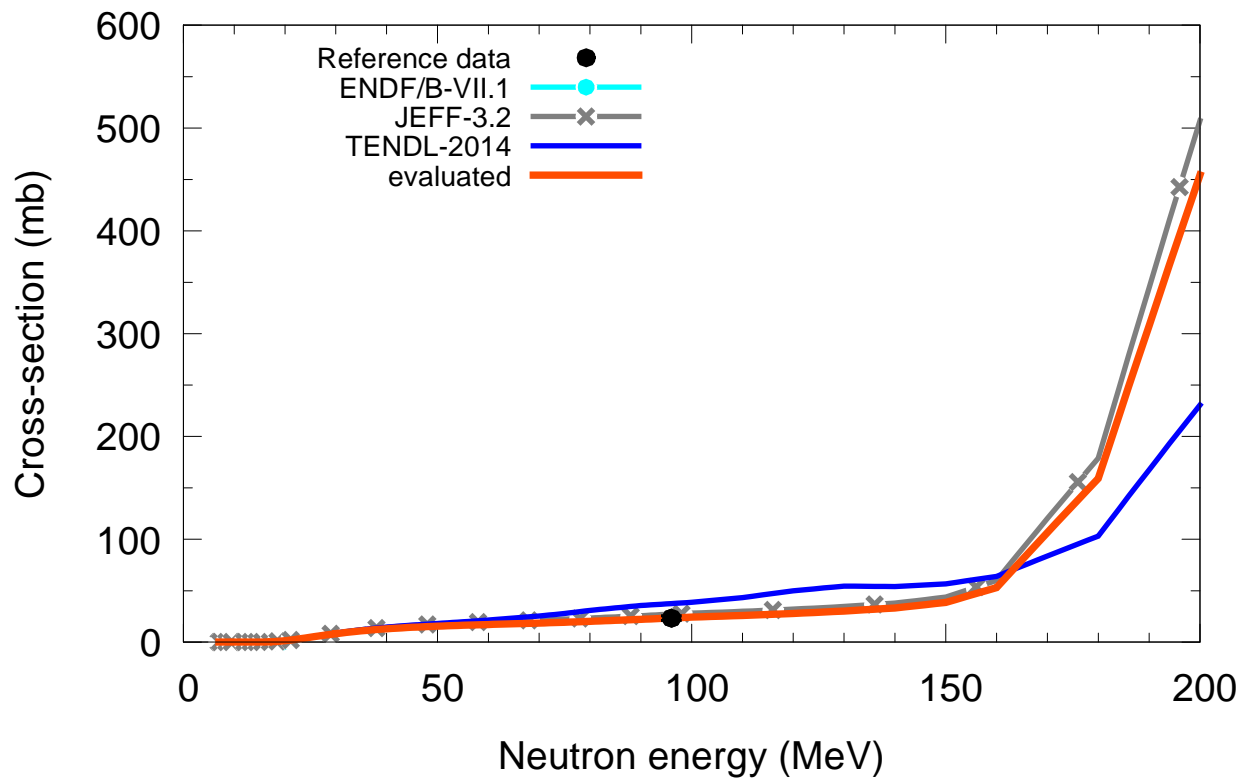
$^{167}\text{Er}(n,x)t$



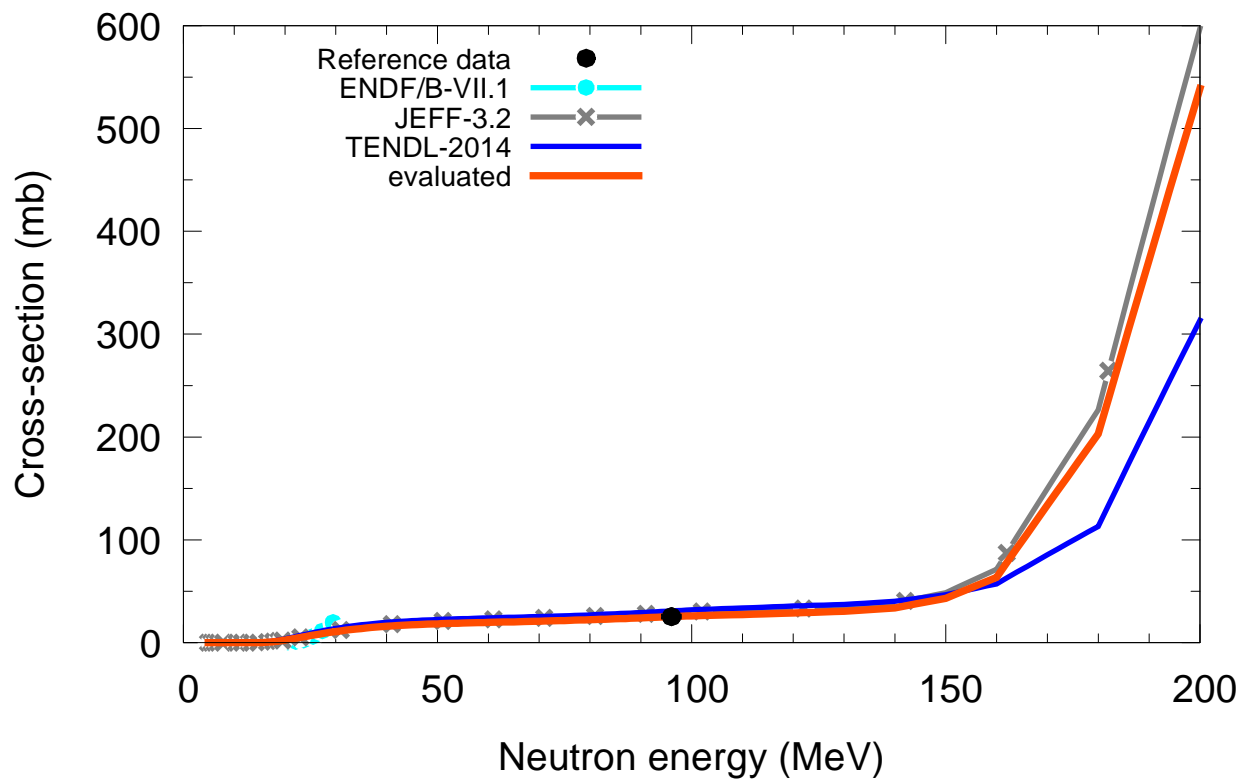
$^{168}\text{Er}(n,x)t$



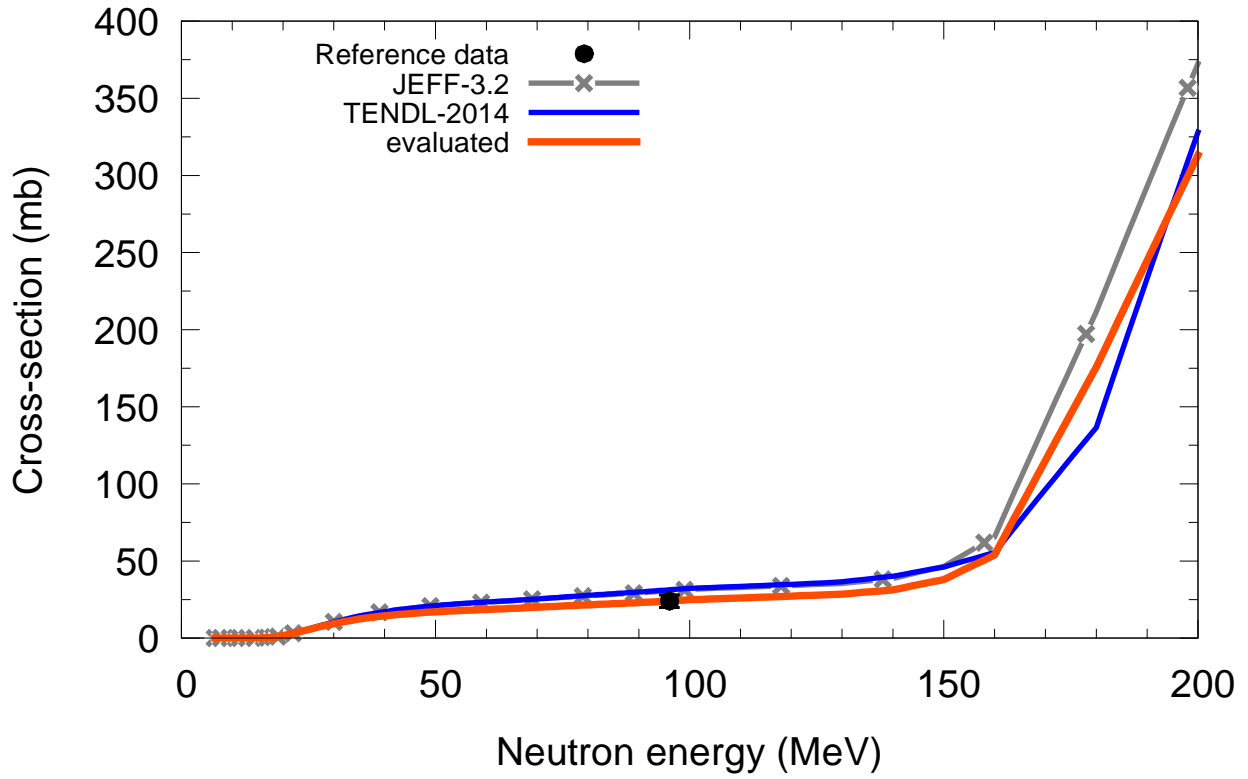
$^{170}\text{Er}(n,x)t$



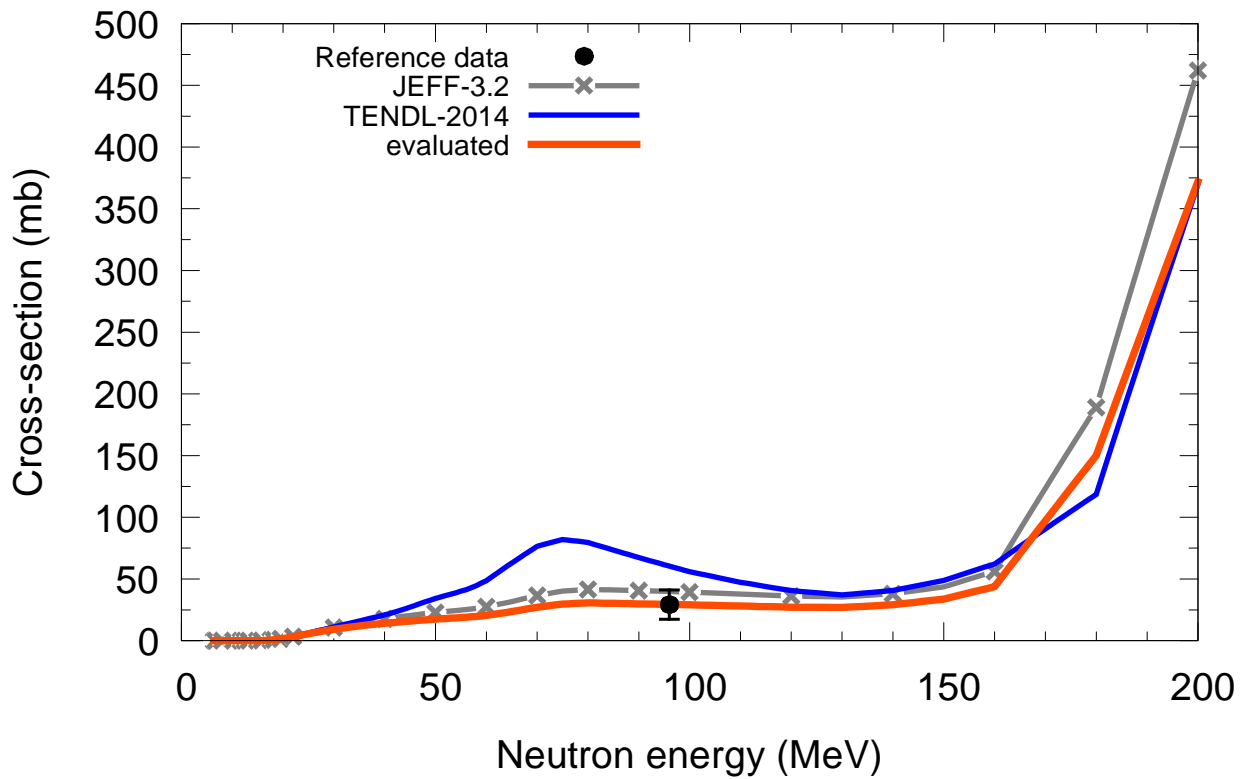
$^{169}\text{Tm}(n,x)t$



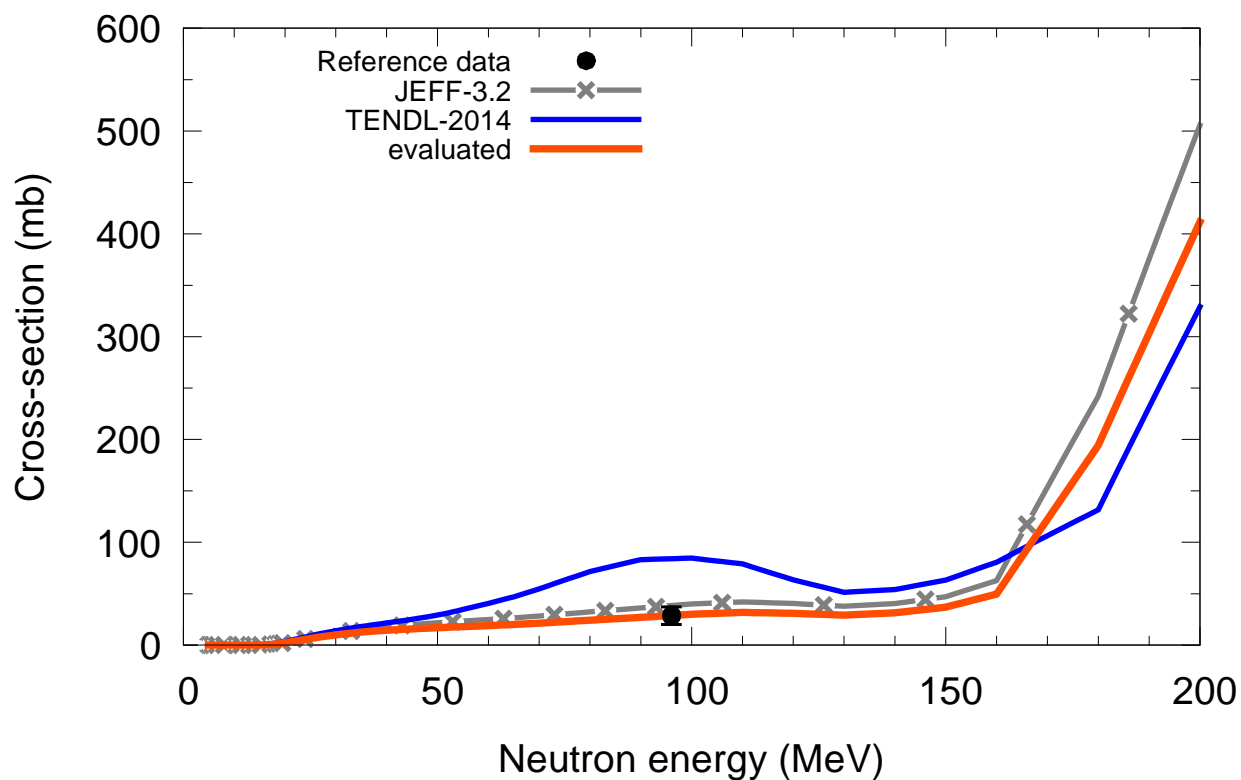
### $^{168}\text{Yb}(n,x)t$



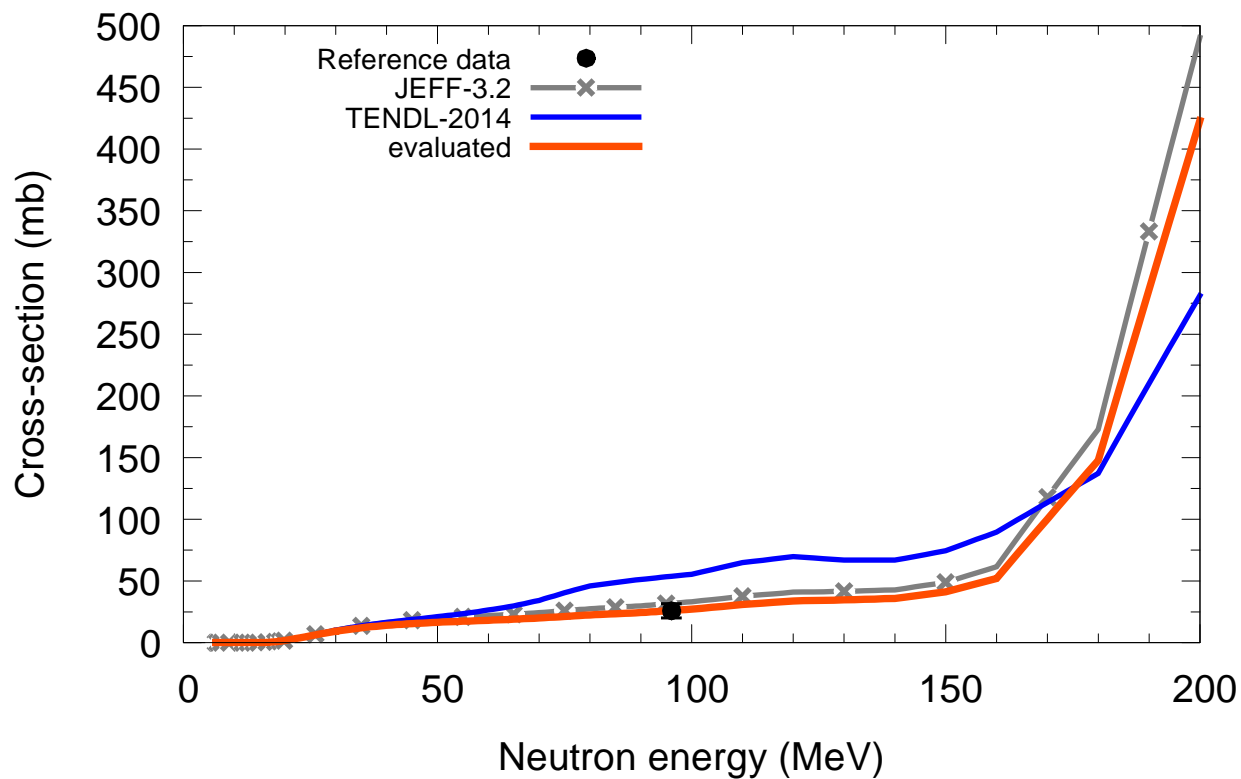
### $^{170}\text{Yb}(n,x)t$



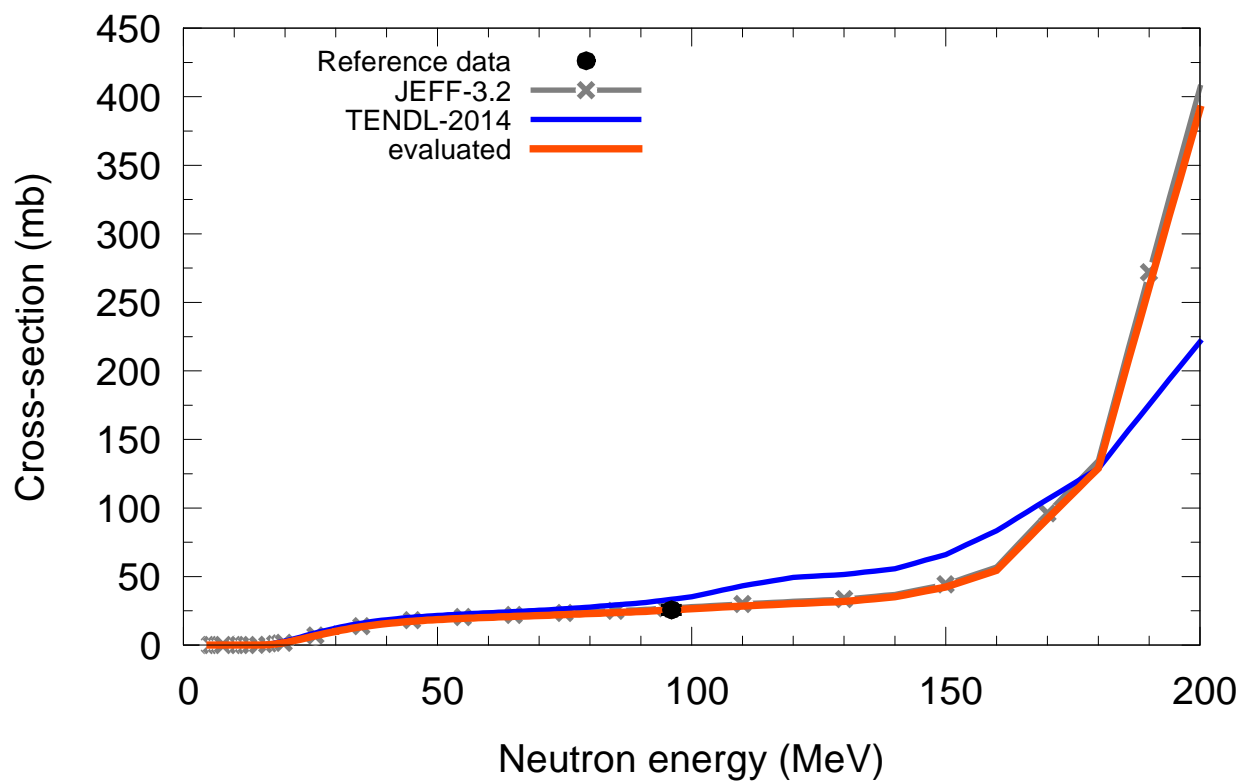
$^{171}\text{Yb}(n,x)t$



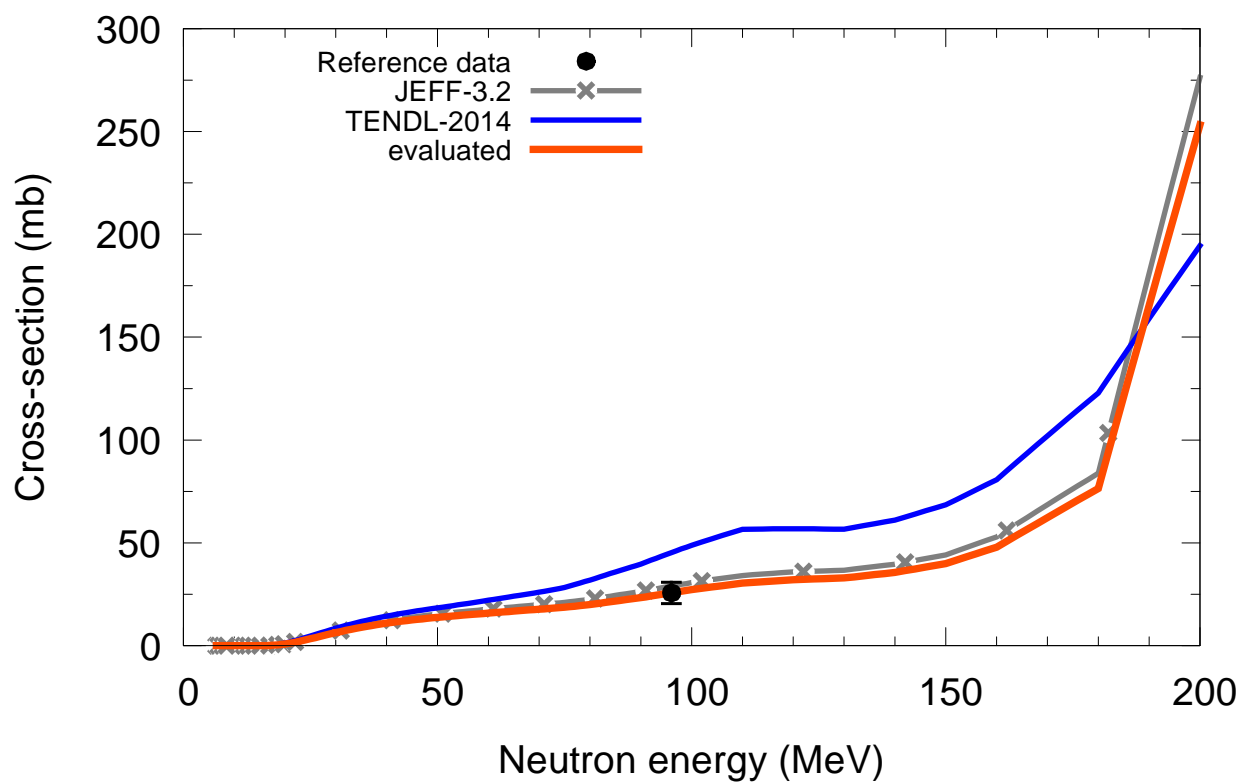
$^{172}\text{Yb}(n,x)t$



$^{173}\text{Yb}(n,x)t$

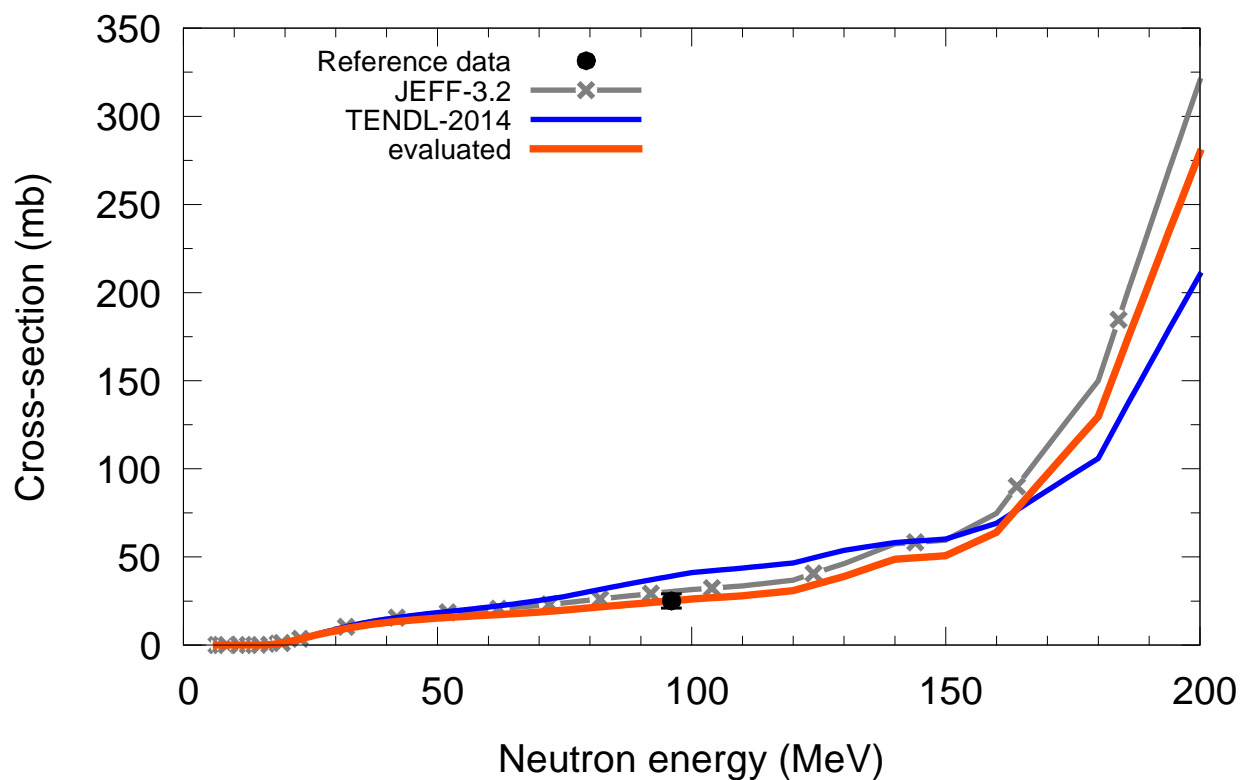


$^{174}\text{Yb}(n,x)t$

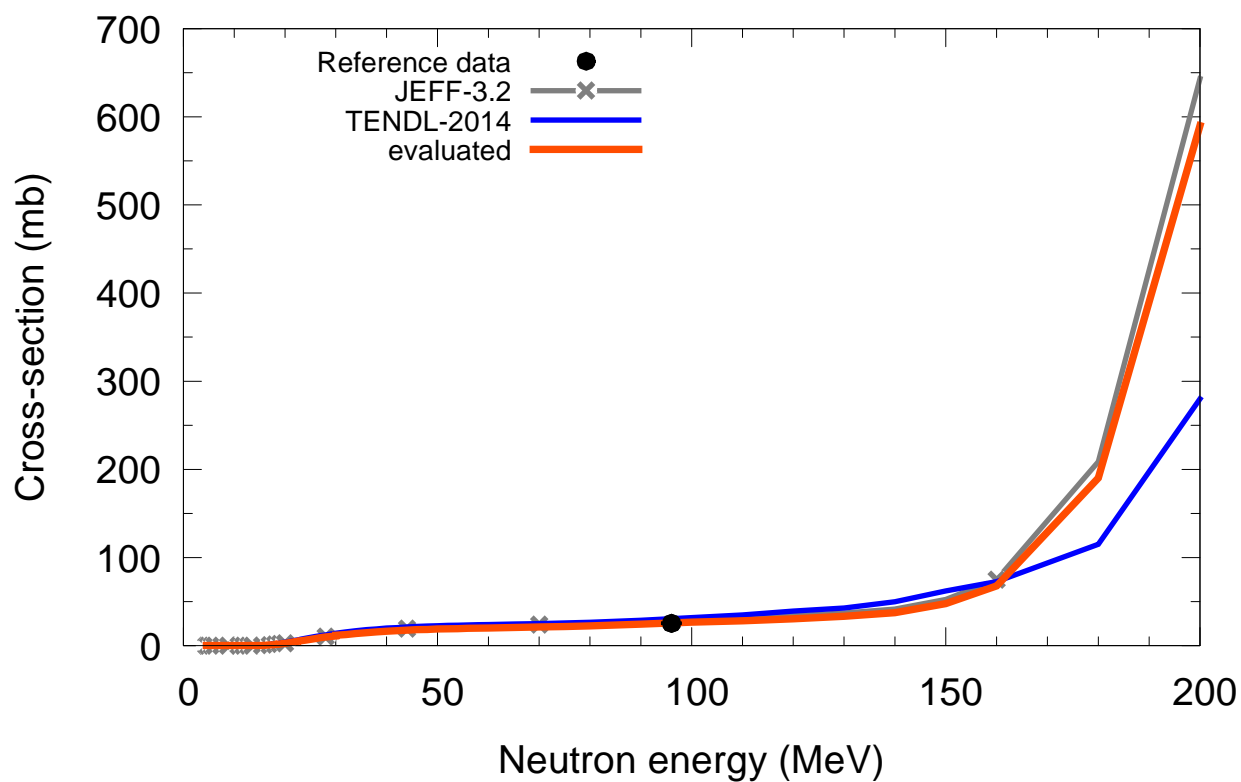




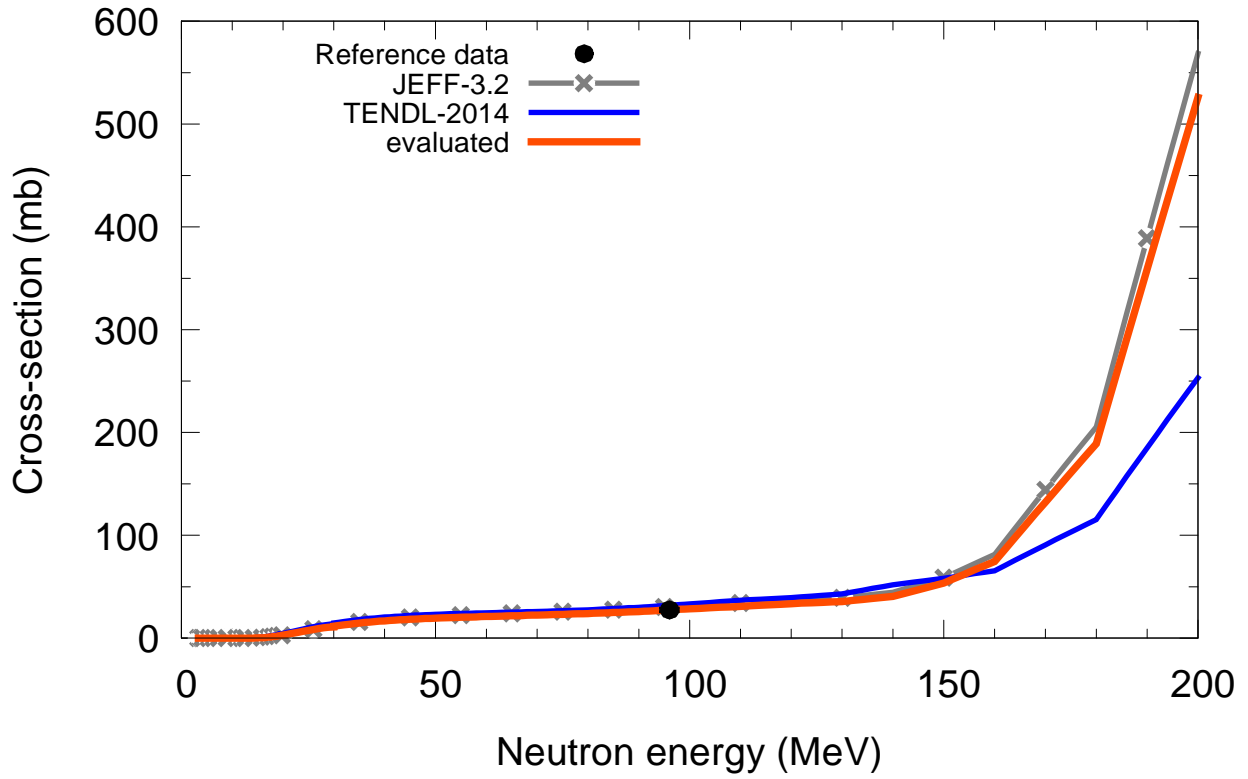
$^{176}\text{Yb}(n,x)t$



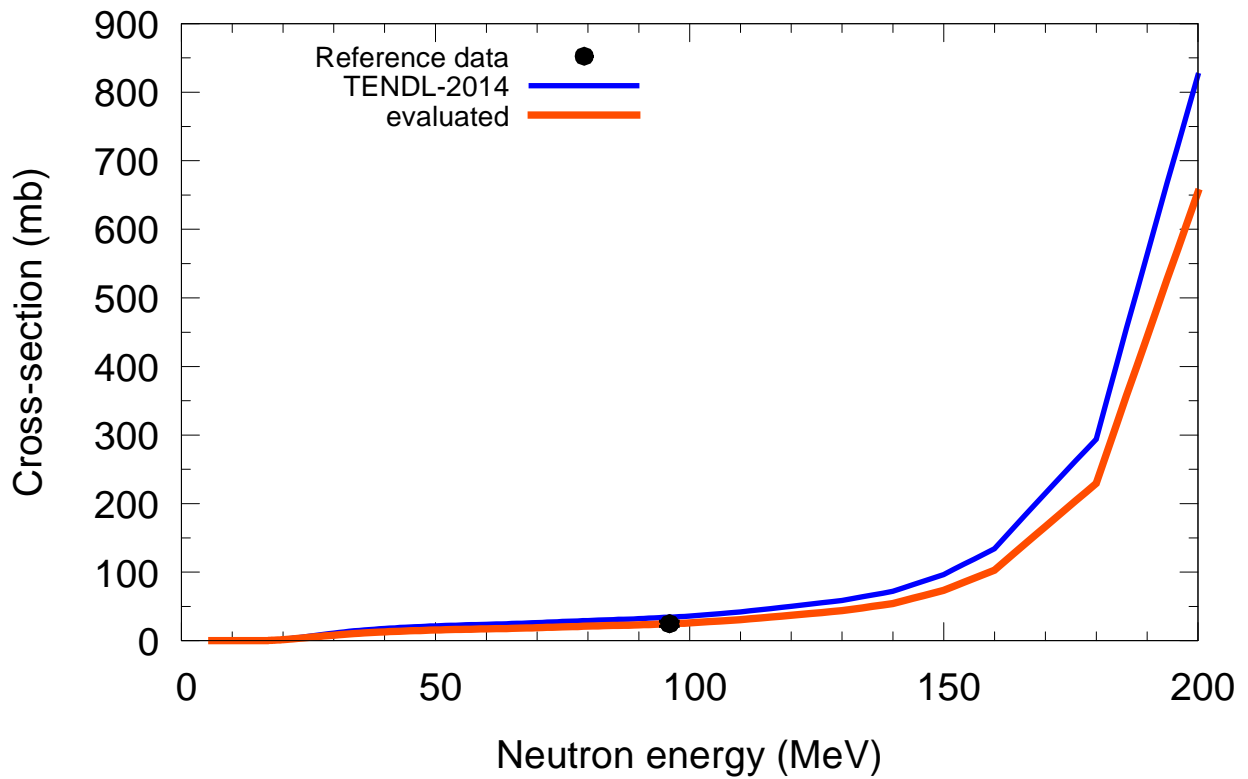
$^{175}\text{Lu}(n,x)t$



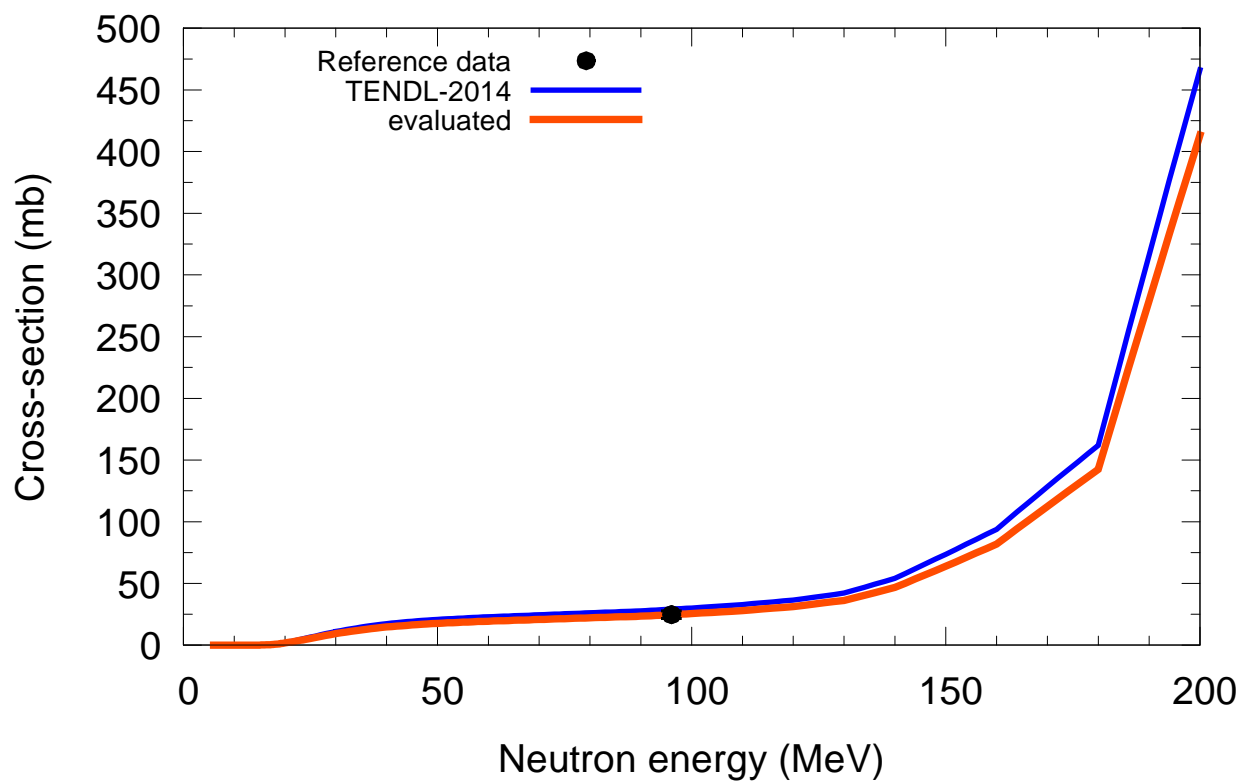
$^{176}\text{Lu}(n,x)t$



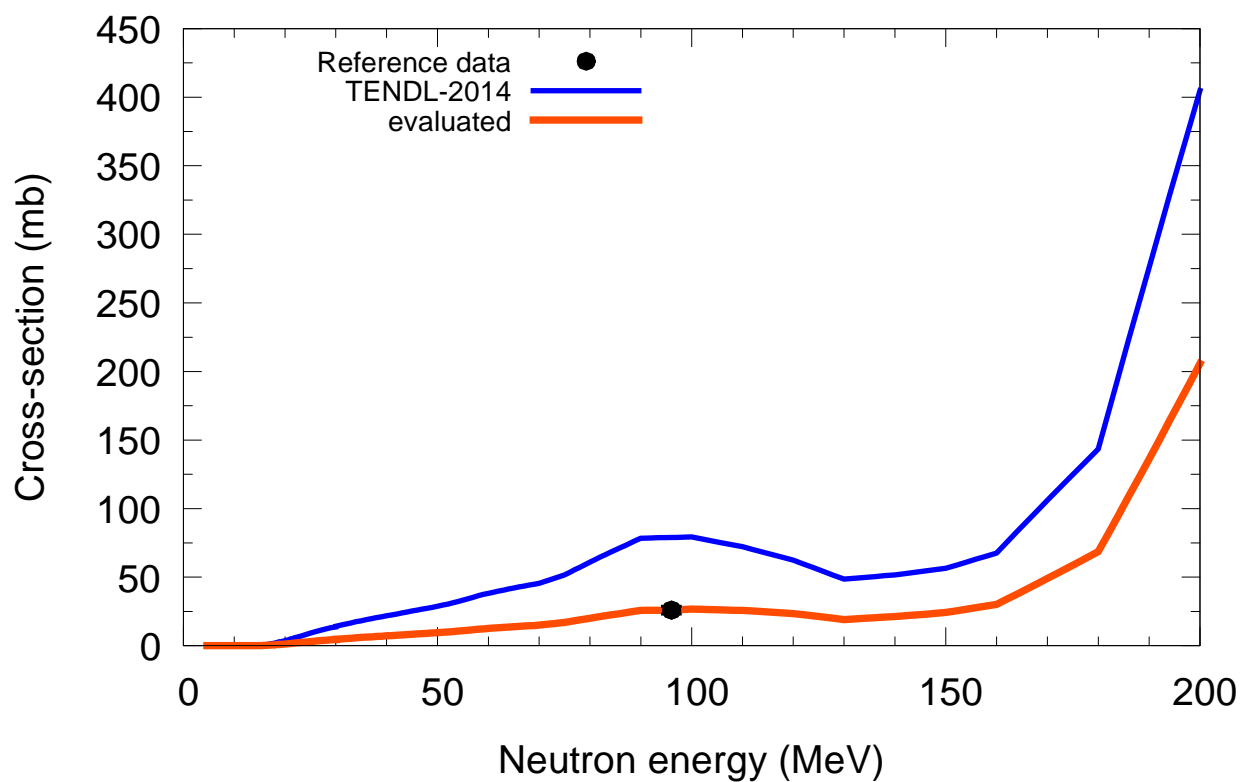
$^{174}\text{Hf}(n,x)t$



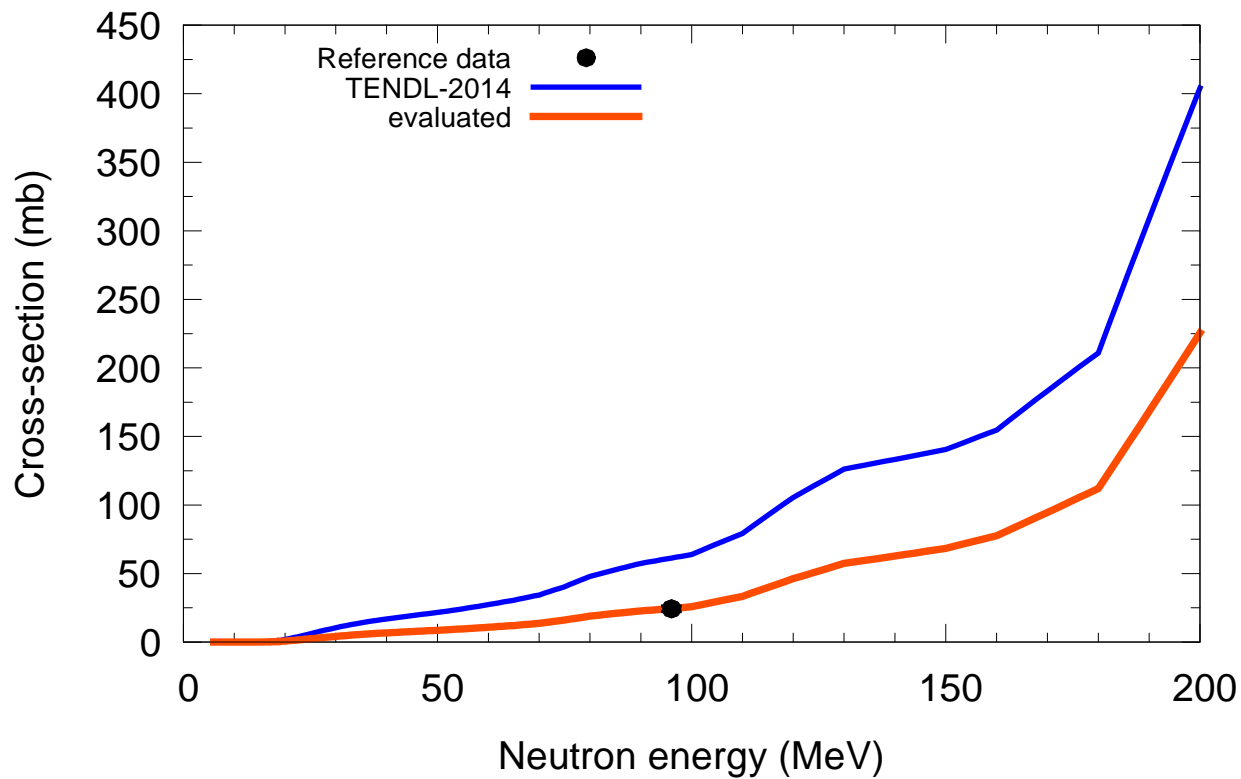
$^{176}\text{Hf}(n,x)t$



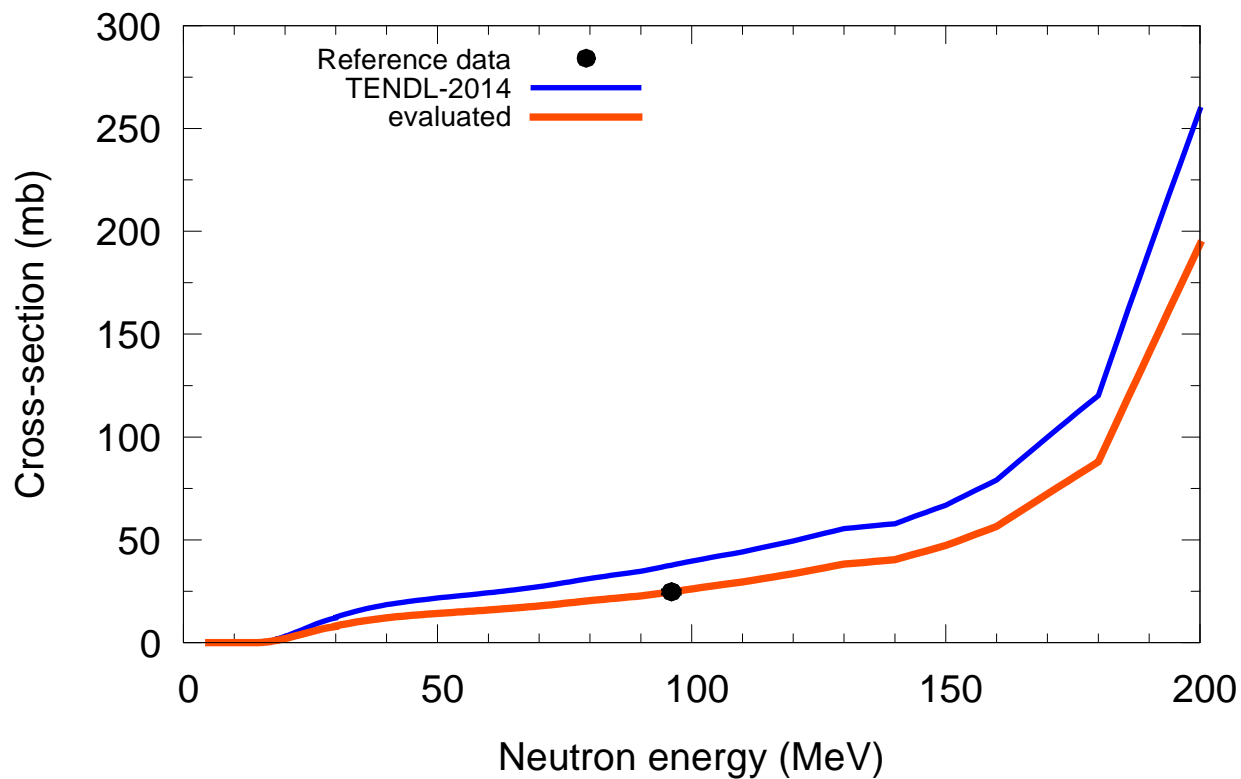
$^{177}\text{Hf}(n,x)t$



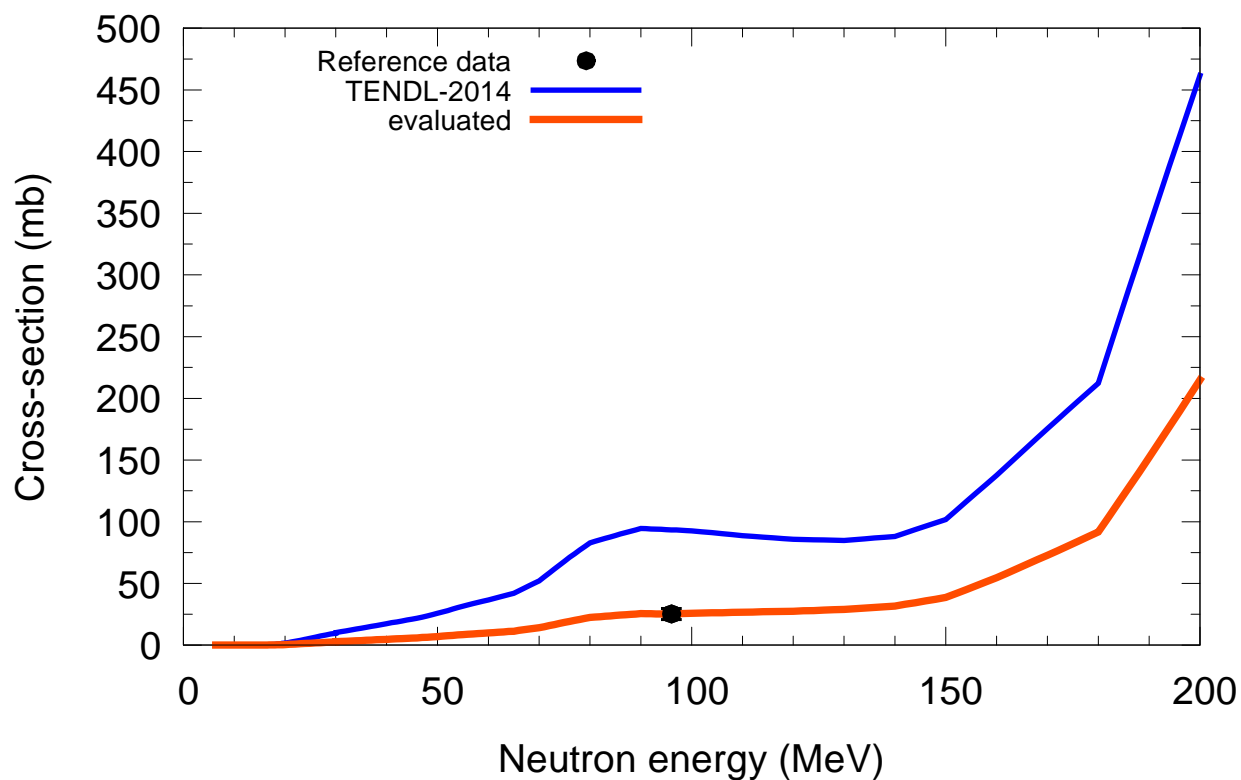
$^{178}\text{Hf}(n,x)t$



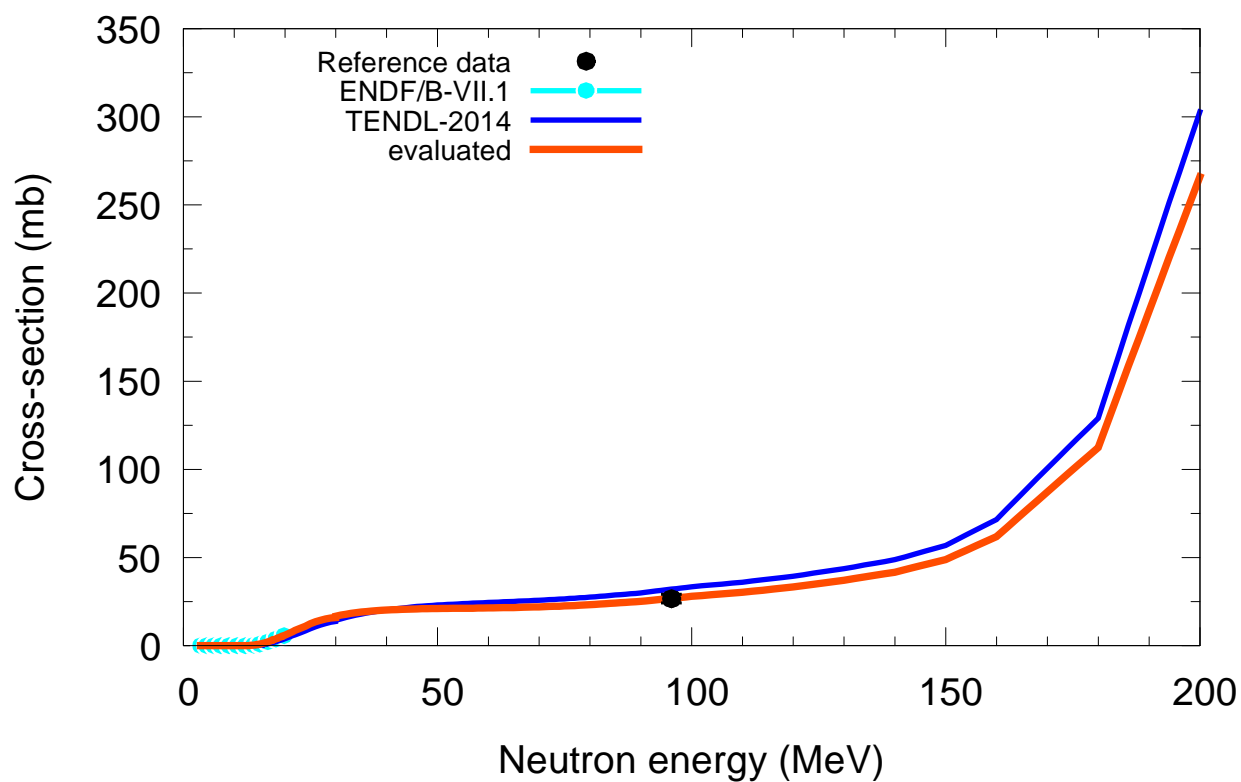
$^{179}\text{Hf}(n,x)t$



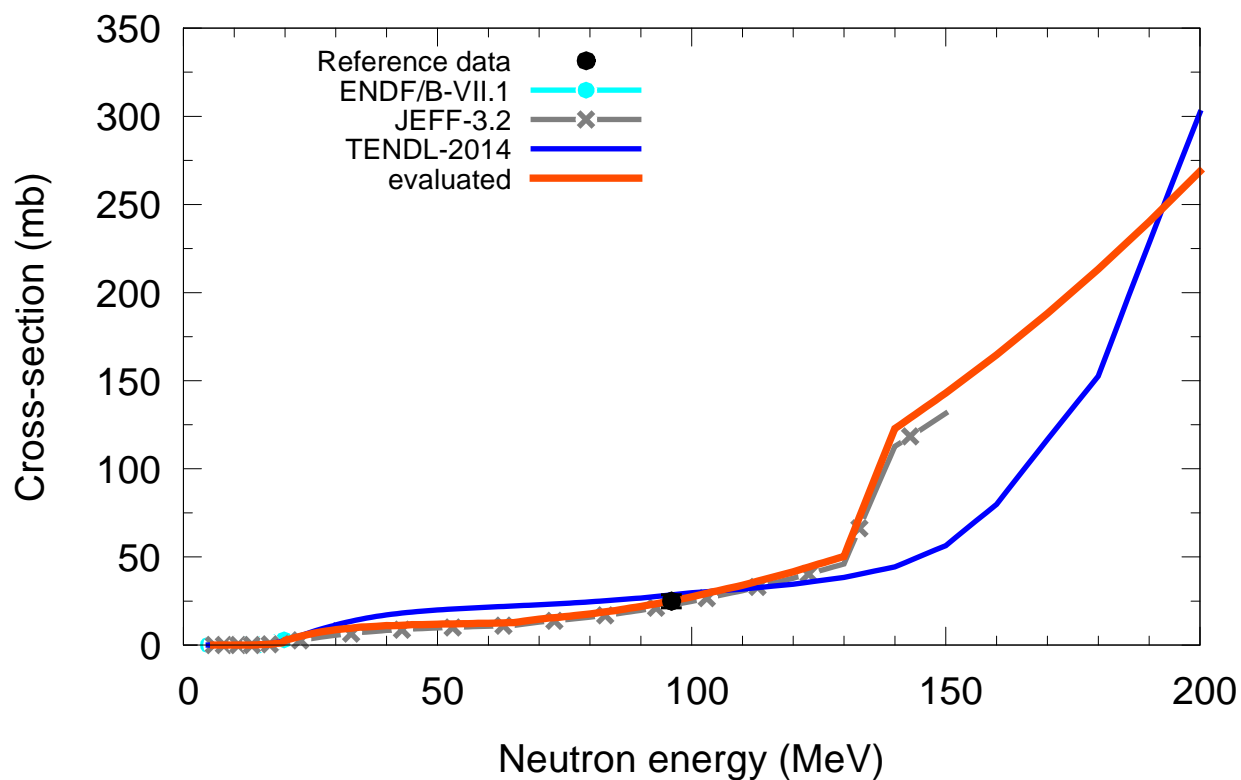
$^{180}\text{Hf}(n,x)t$



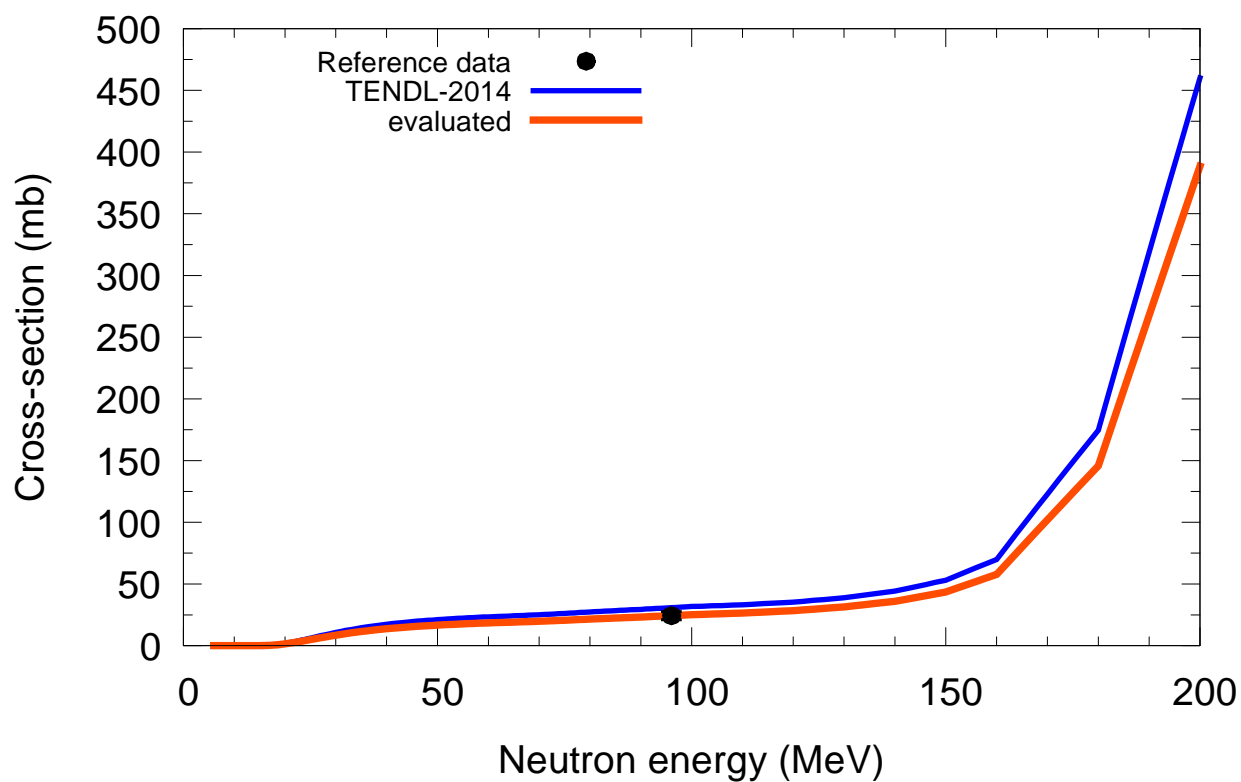
$^{180}\text{Ta}(n,x)t$



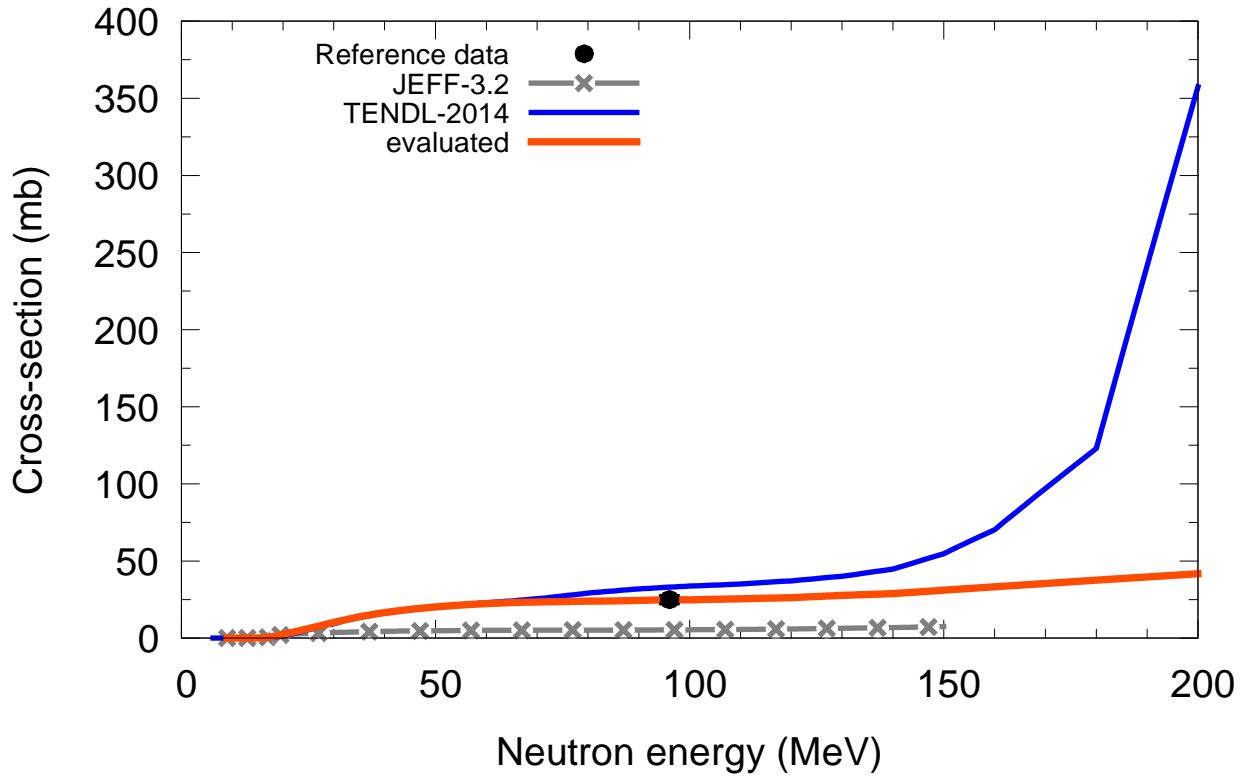
$^{181}\text{Ta}(n,x)t$



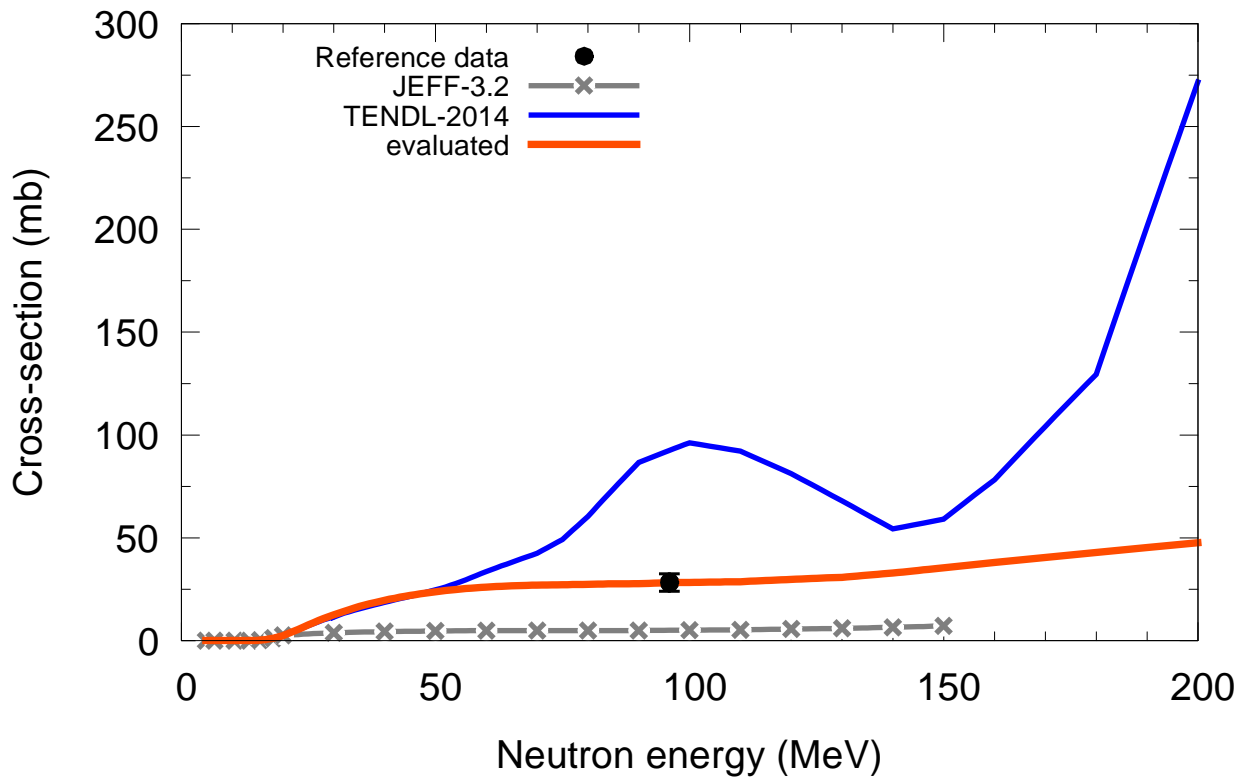
$^{180}\text{W}(n,x)t$



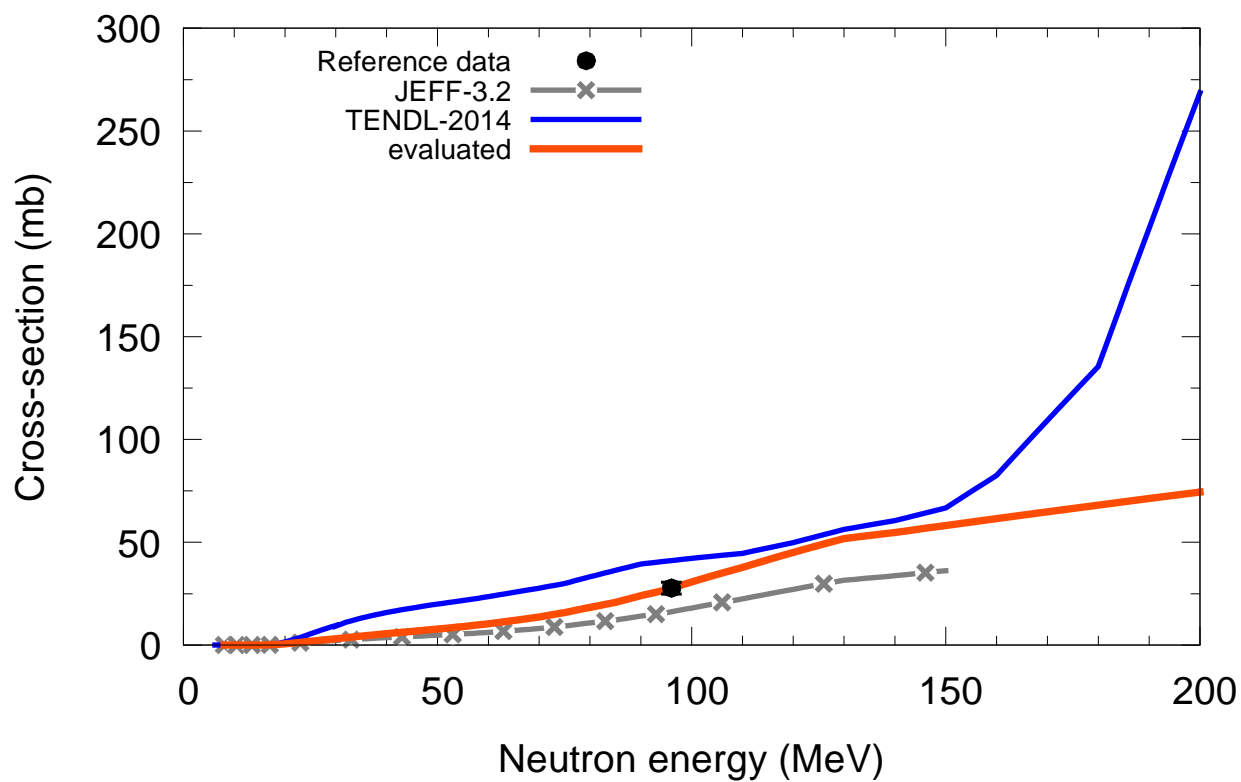
$^{182}\text{W}(n,x)t$



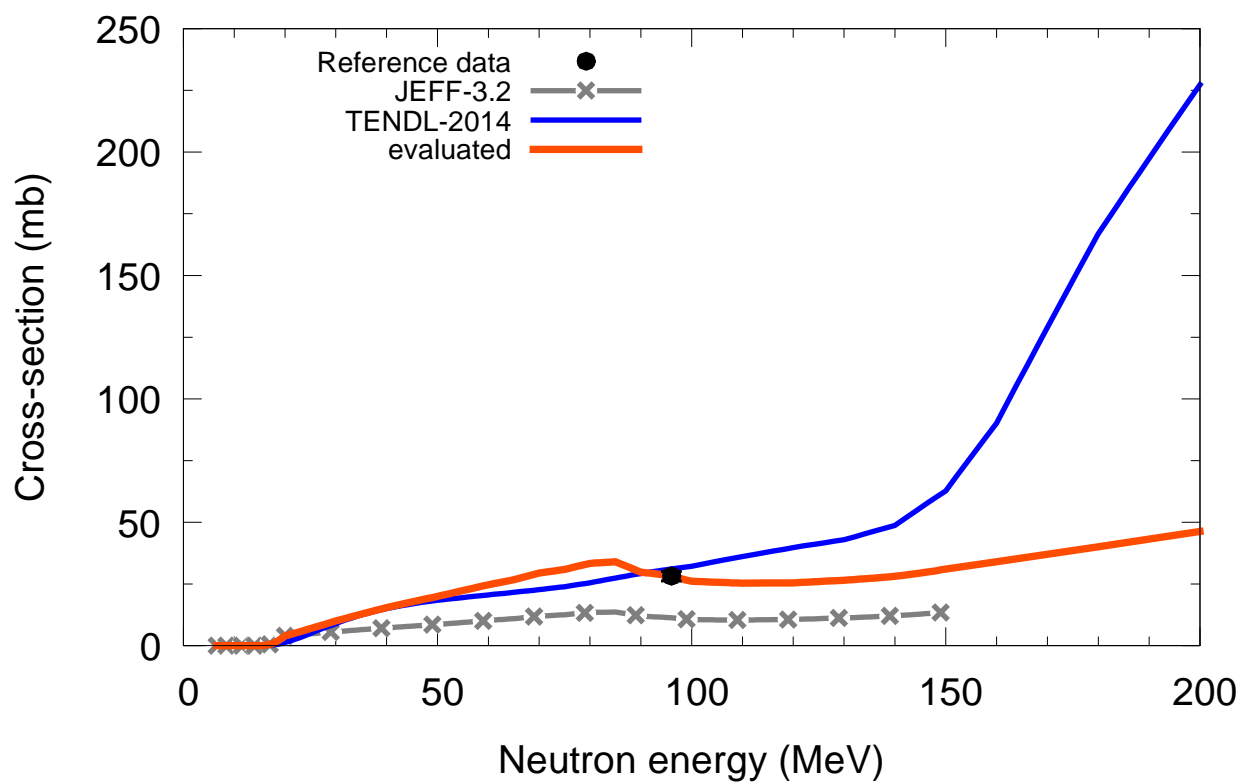
$^{183}\text{W}(n,x)t$



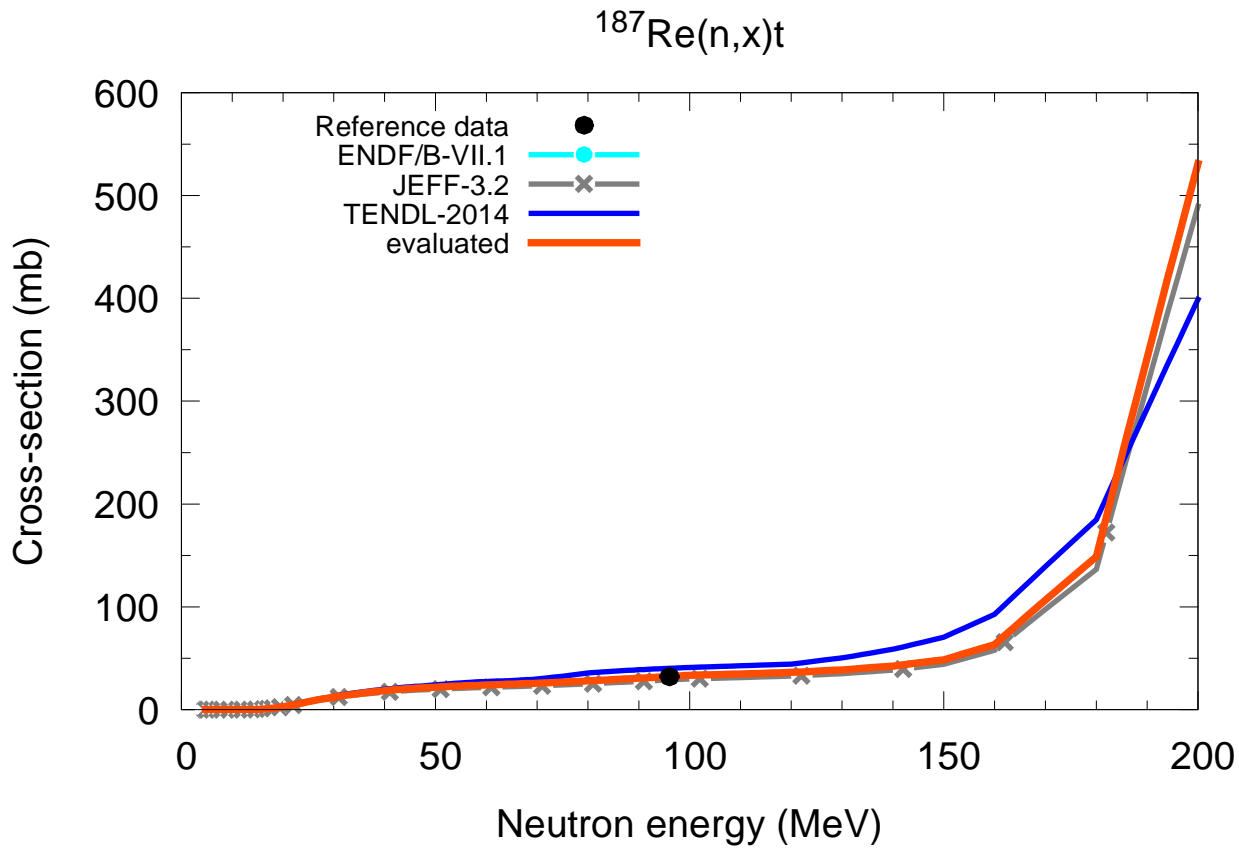
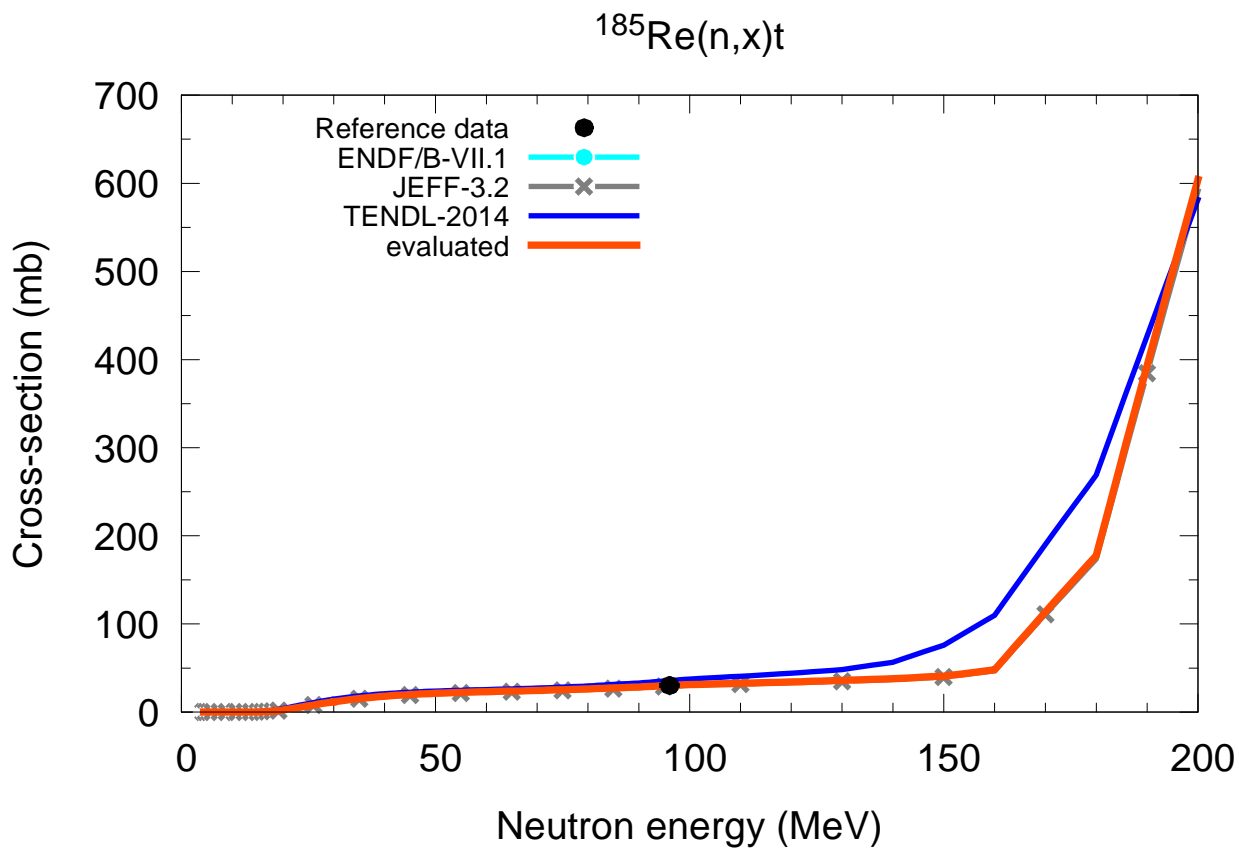
$^{184}\text{W}(n,x)t$



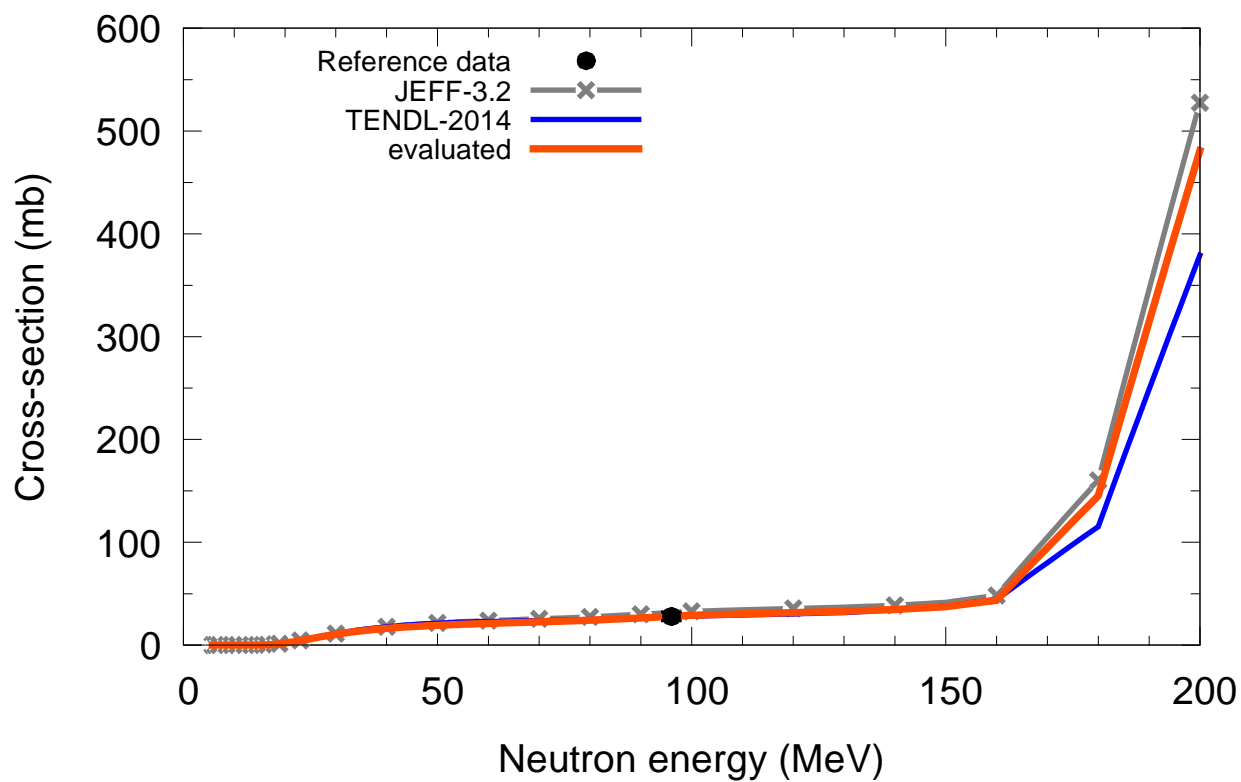
$^{186}\text{W}(n,x)t$



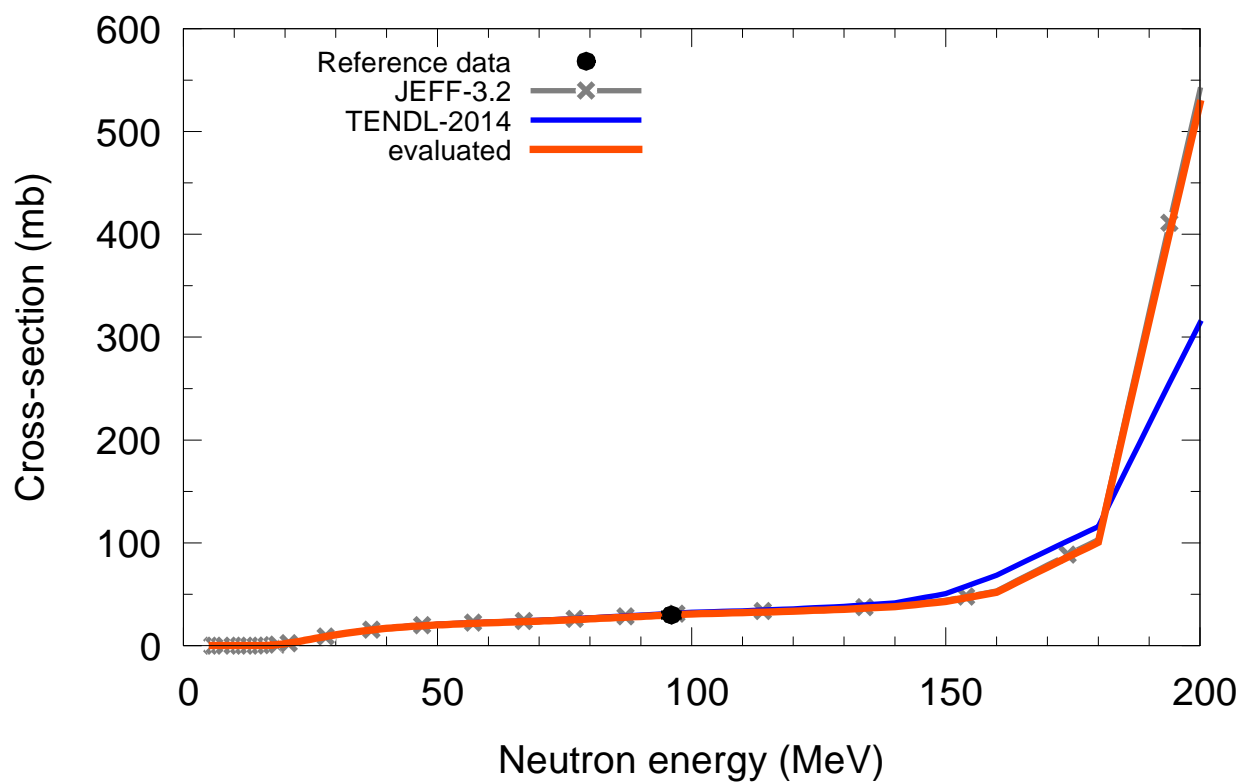




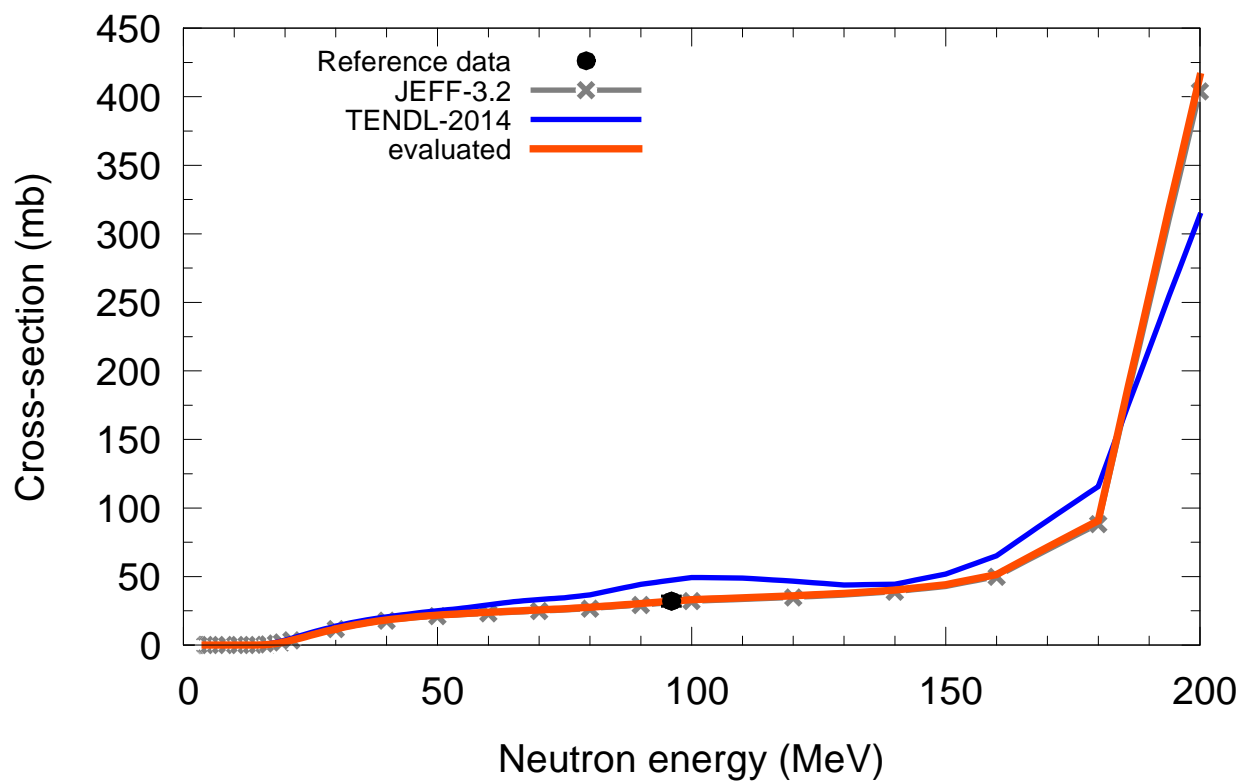
$^{184}\text{Os}(n,x)t$



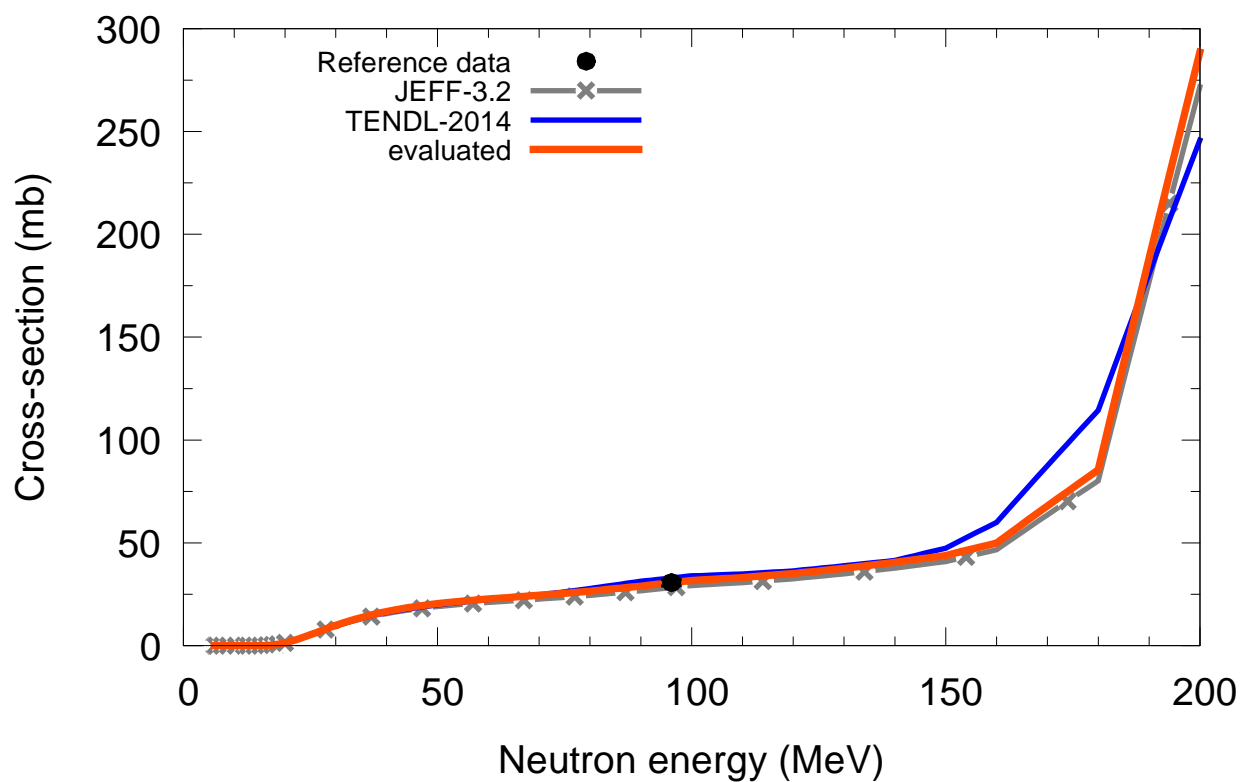
$^{186}\text{Os}(n,x)t$



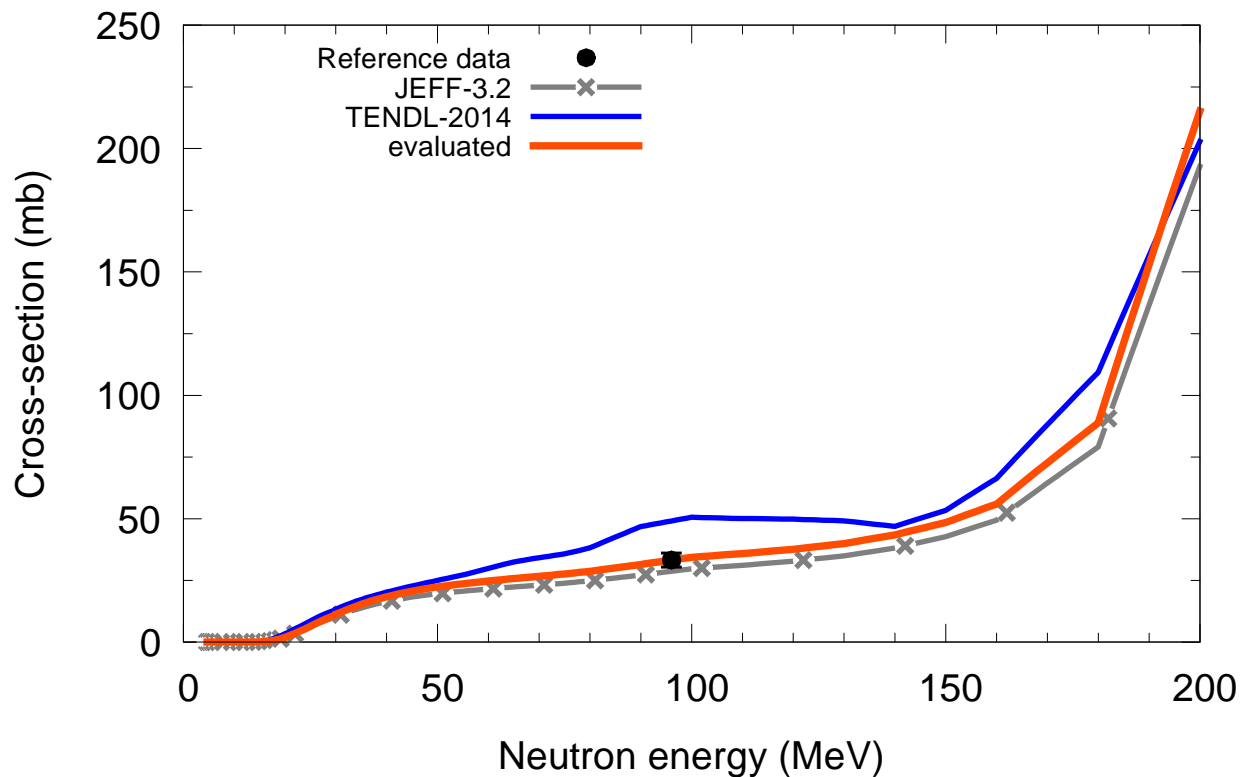
$^{187}\text{Os}(n,x)t$



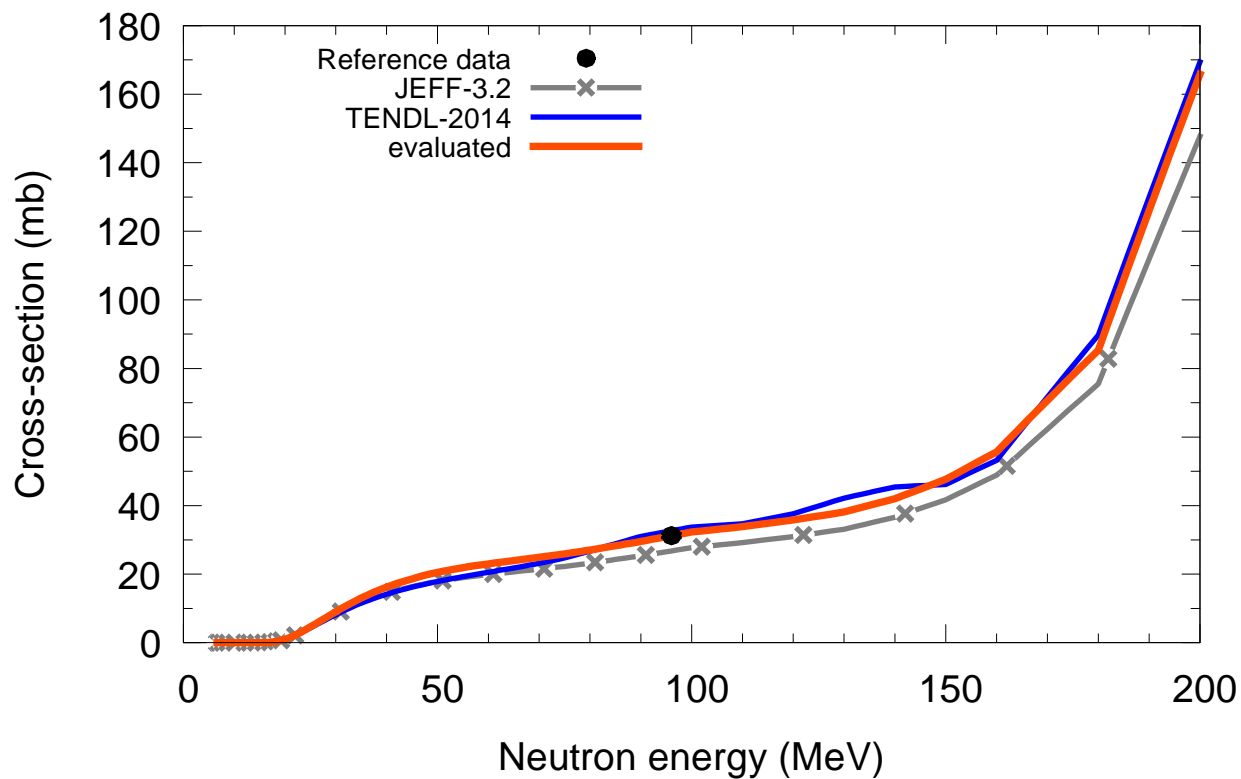
$^{188}\text{Os}(n,x)t$



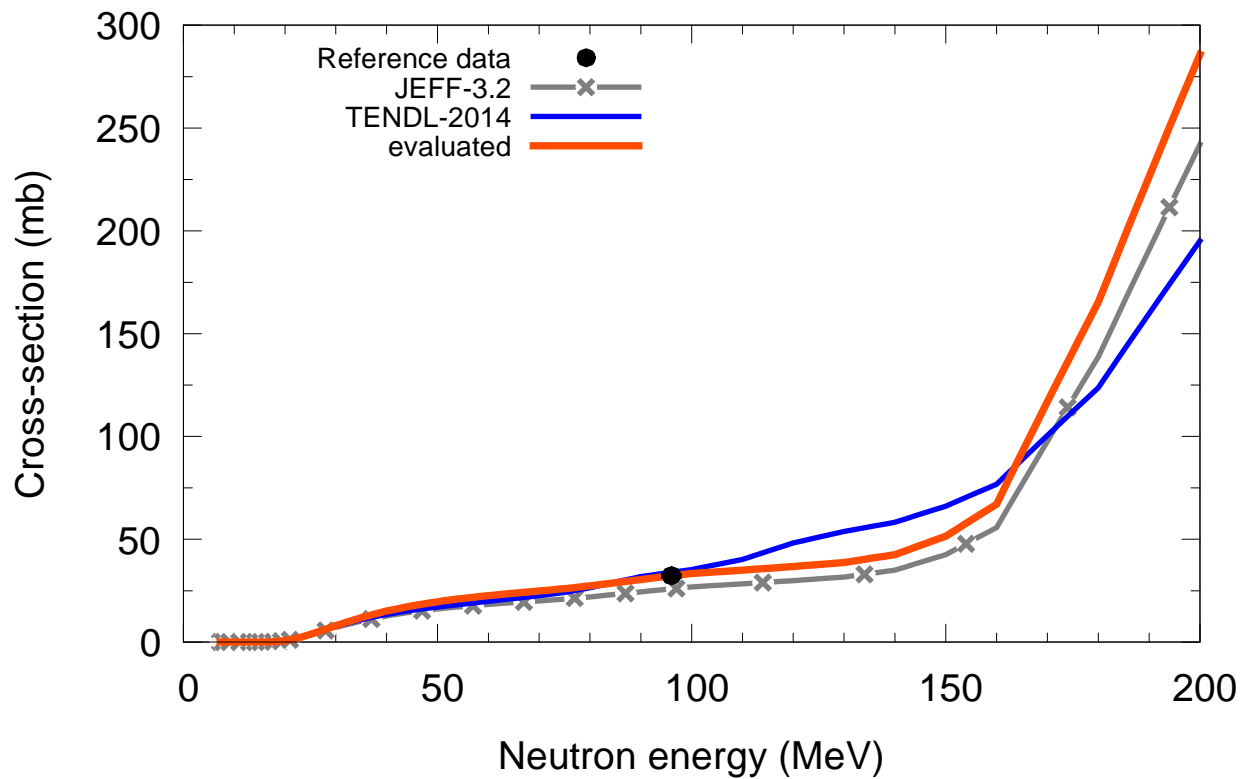
$^{189}\text{Os}(n,x)t$



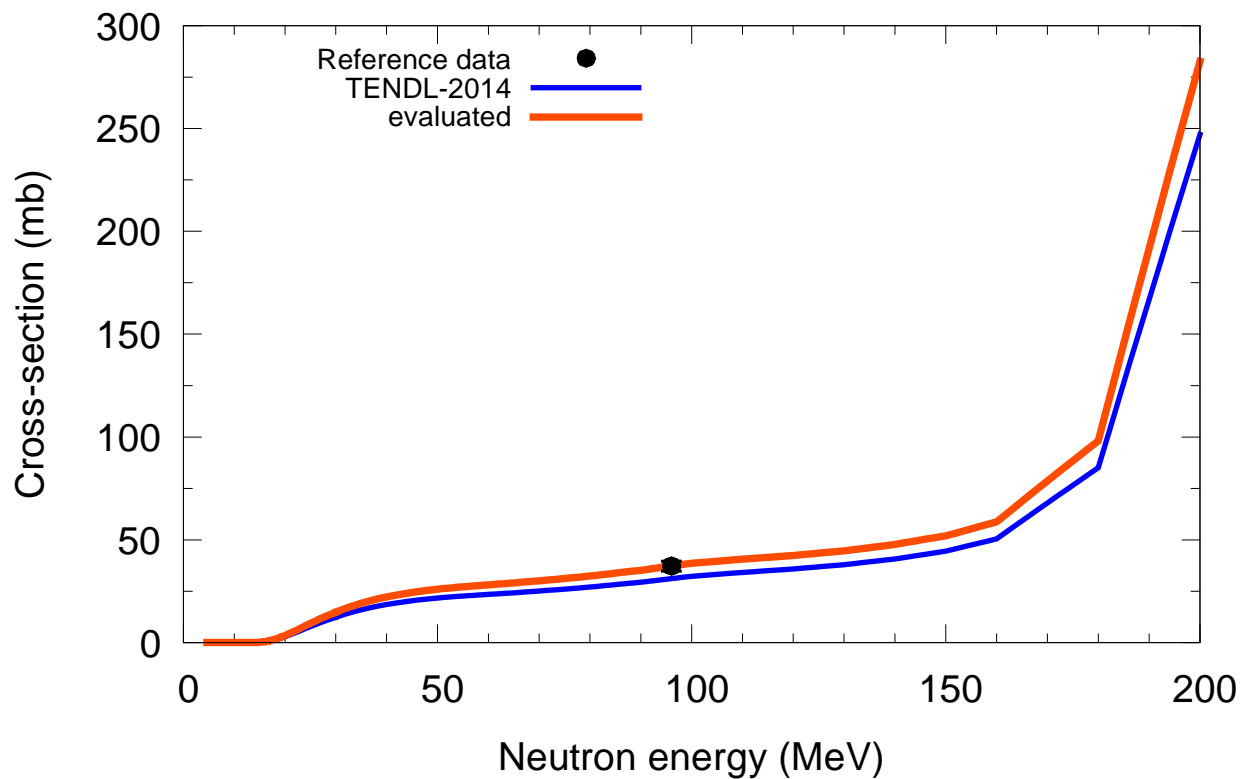
$^{190}\text{Os}(n,x)t$



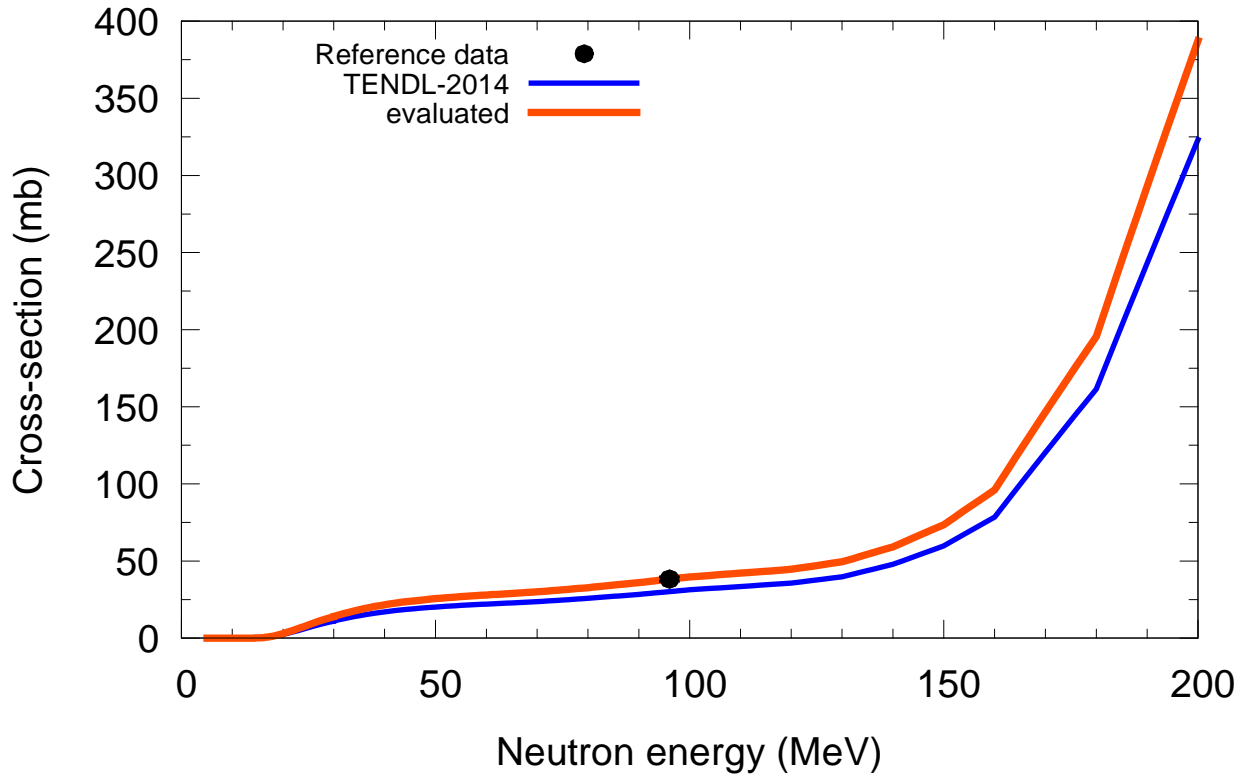
$^{192}\text{Os}(n,x)t$



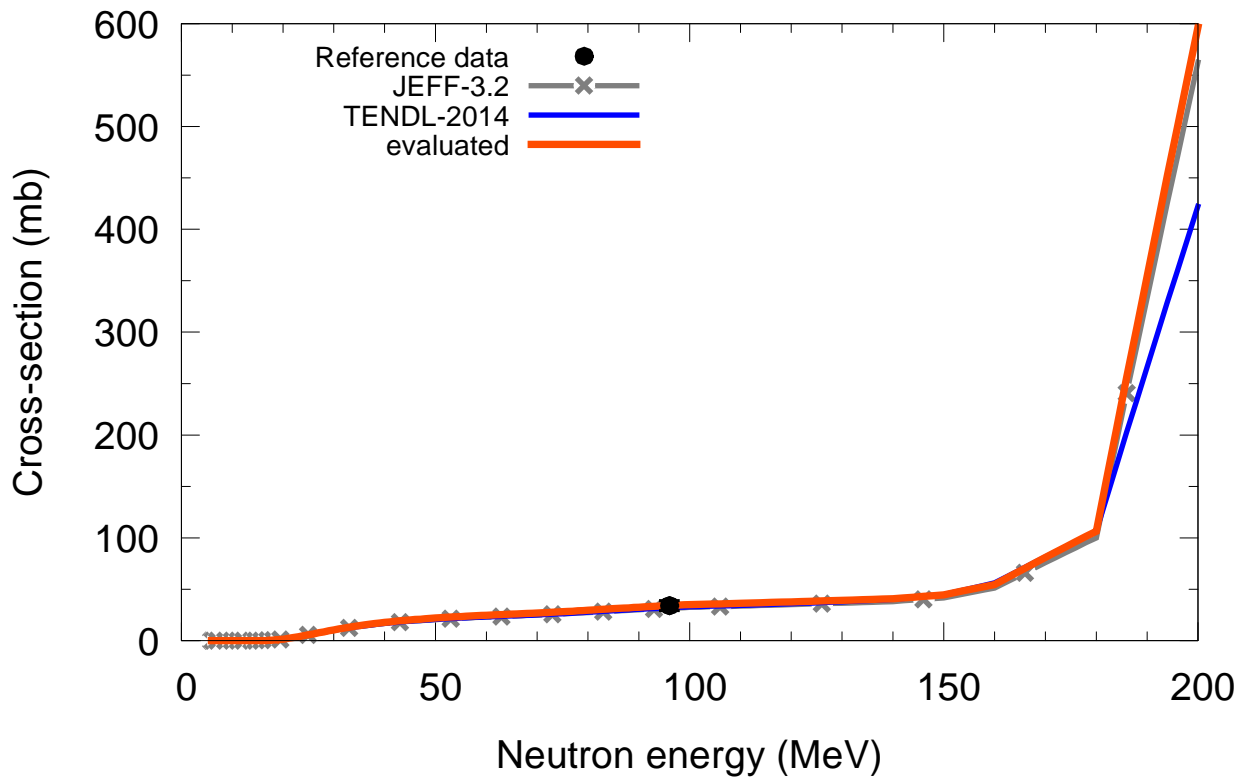
$^{191}\text{Ir}(n,x)t$



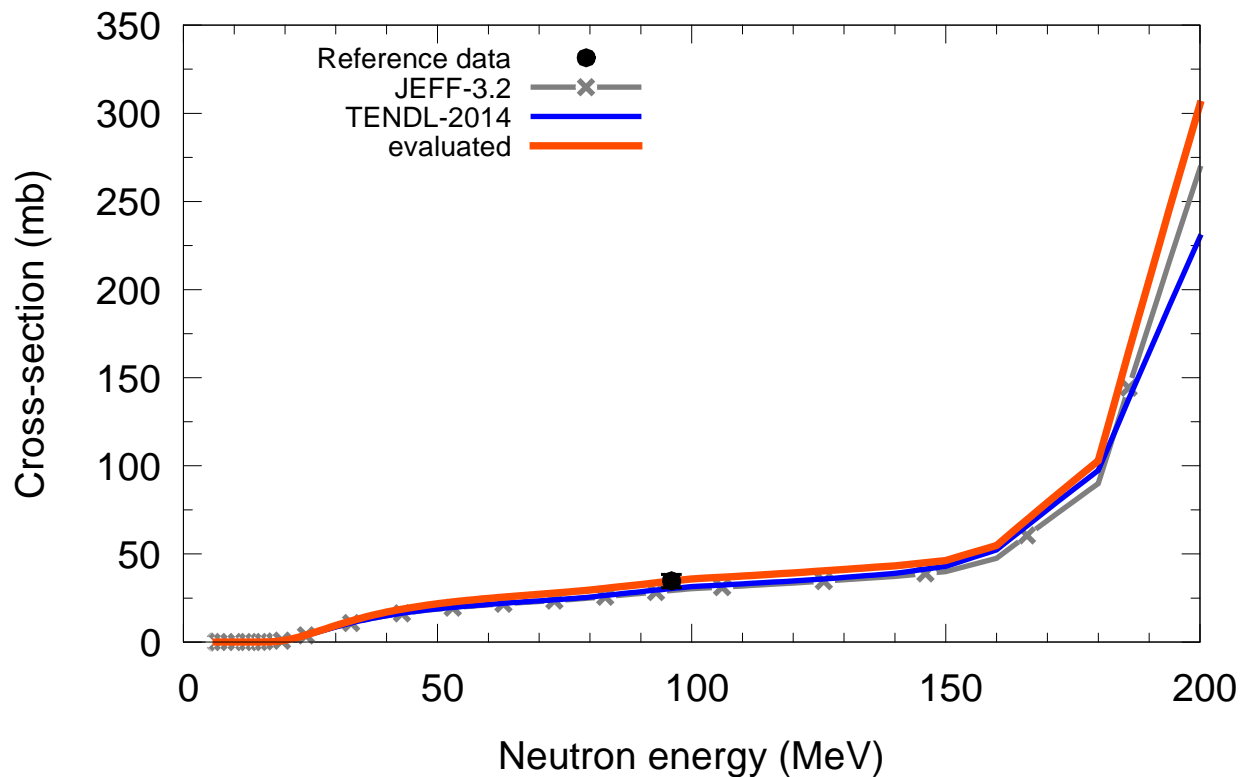
$^{193}\text{Ir}(n,x)t$



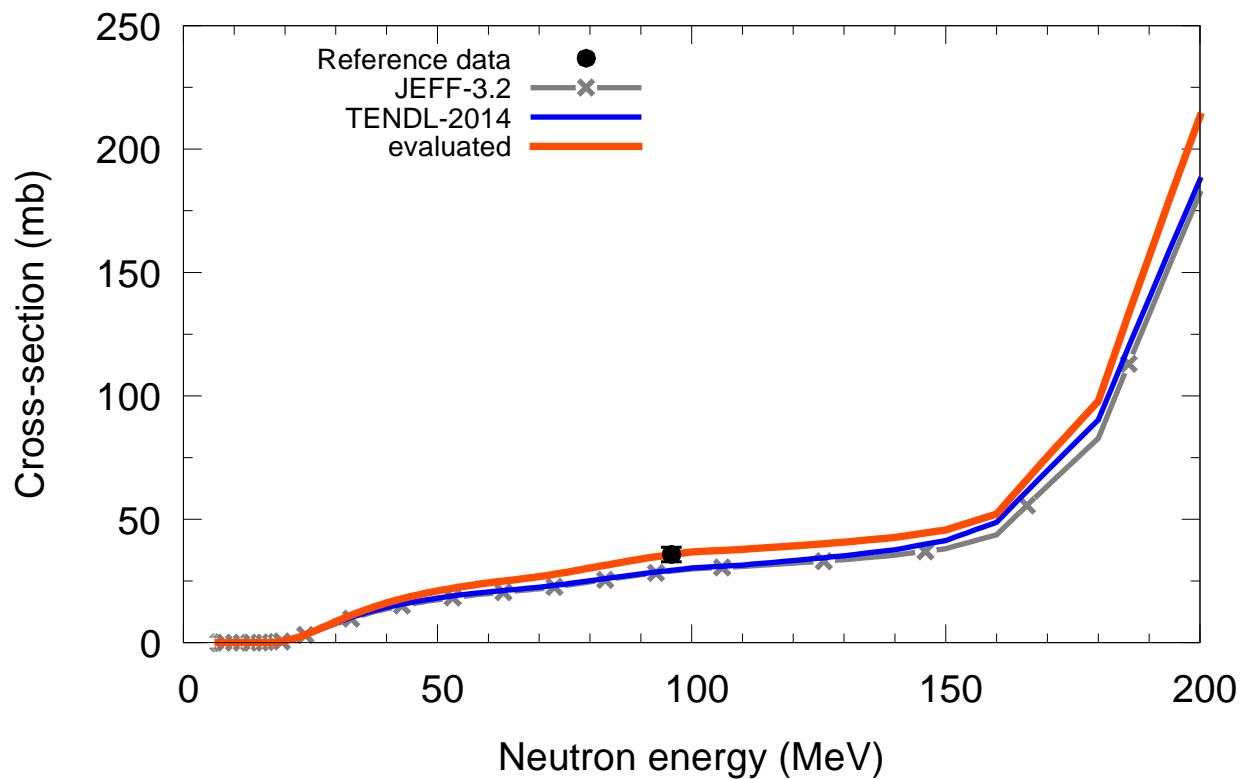
$^{190}\text{Pt}(n,x)t$



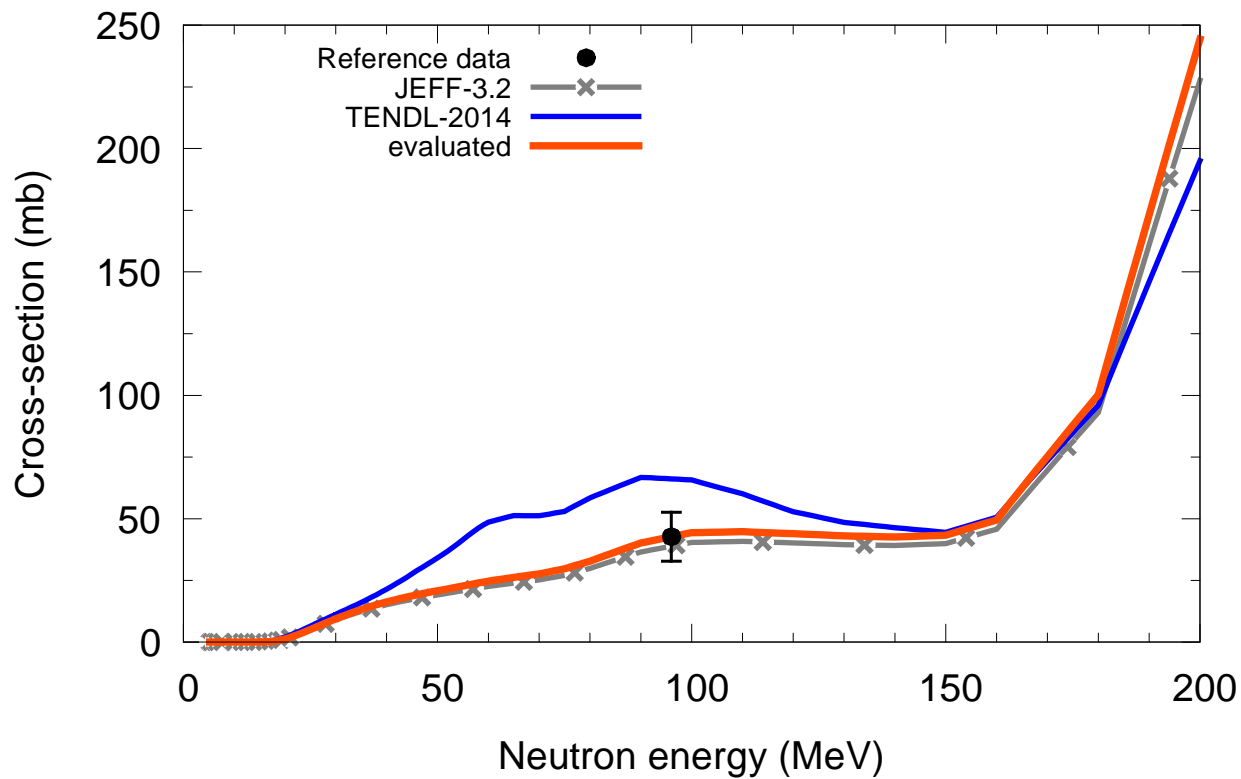
$^{192}\text{Pt}(n,x)t$



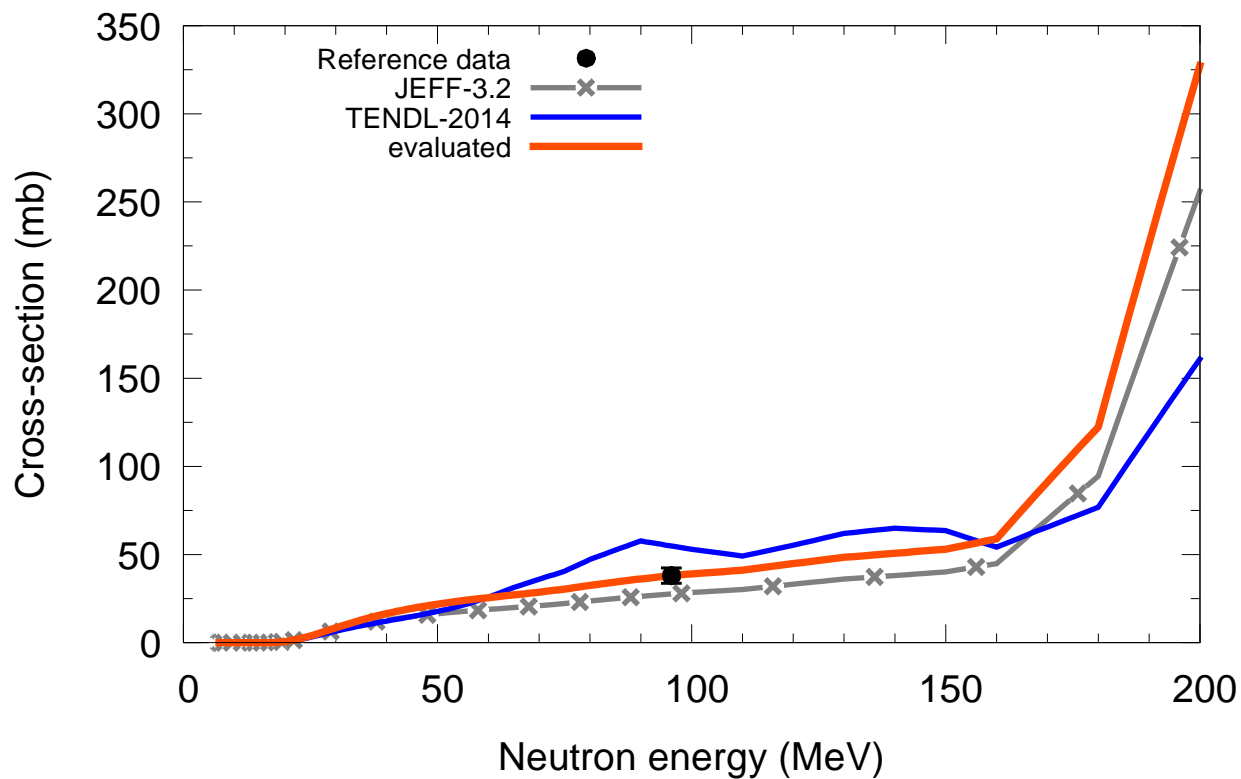
$^{194}\text{Pt}(n,x)t$



$^{195}\text{Pt}(n,x)t$

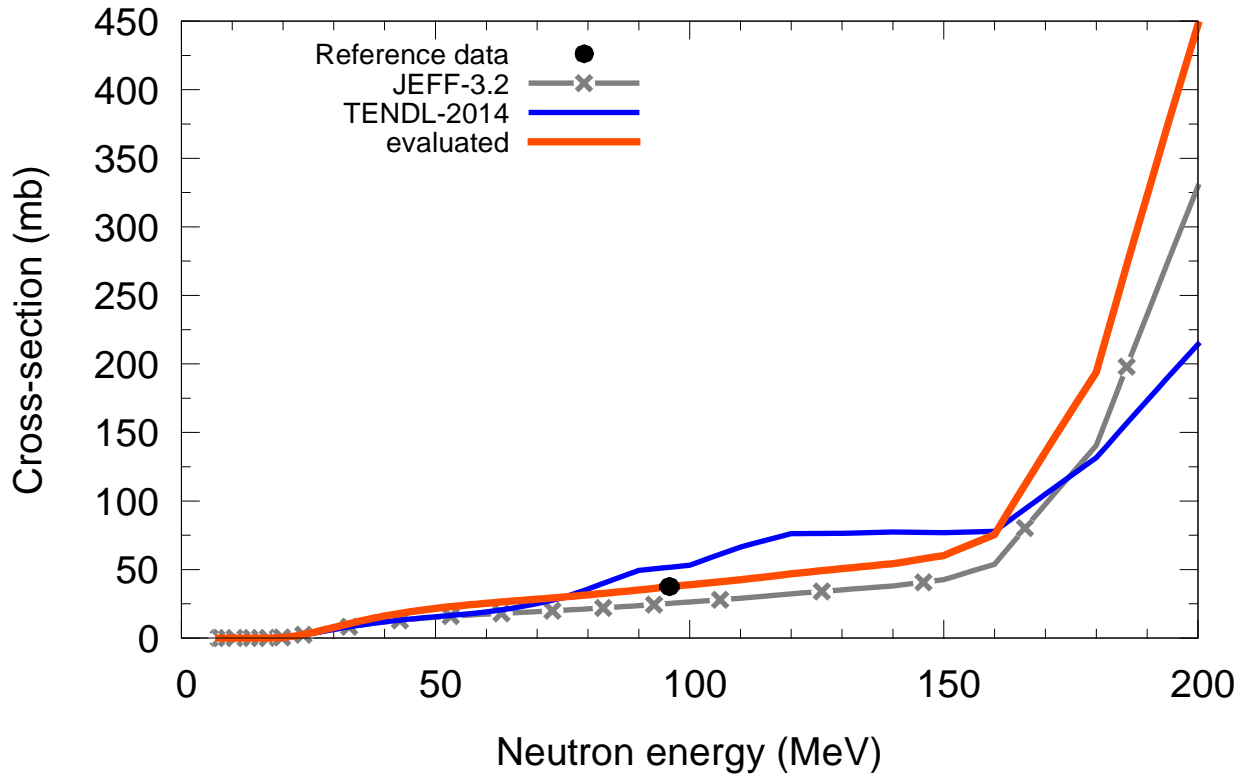


$^{196}\text{Pt}(n,x)t$

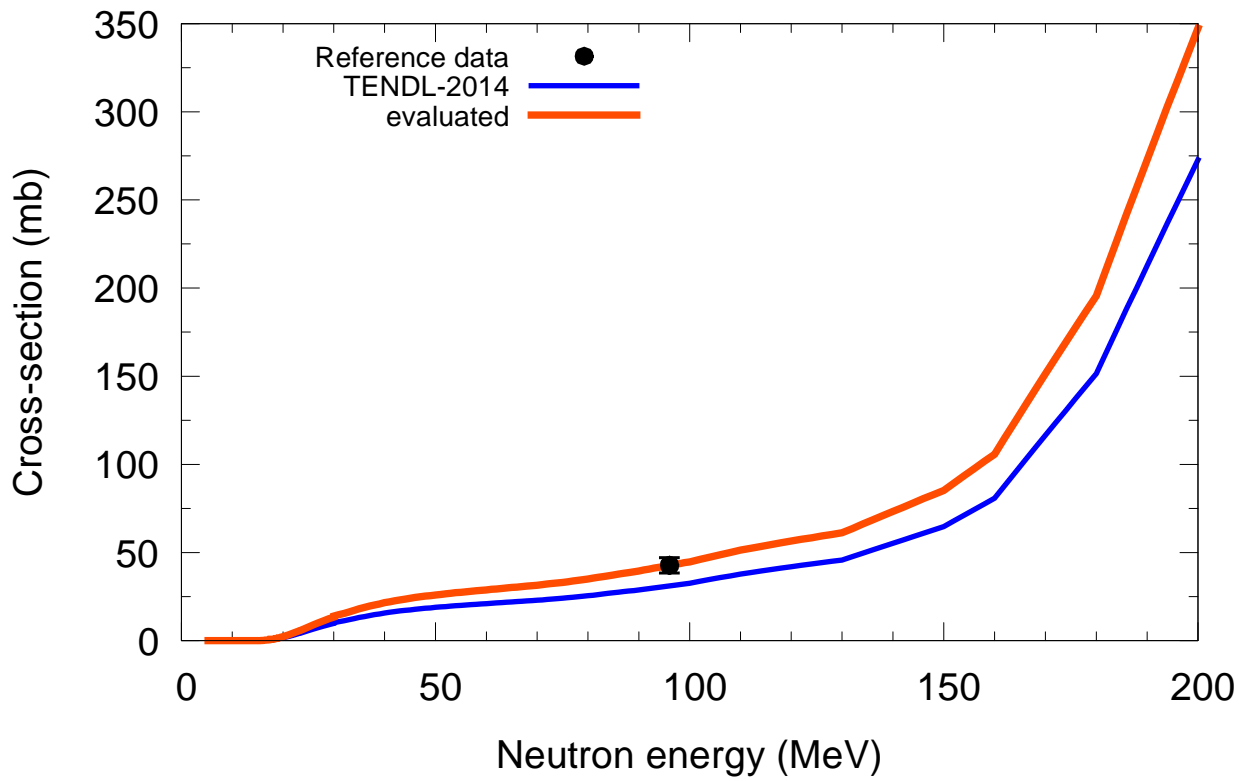




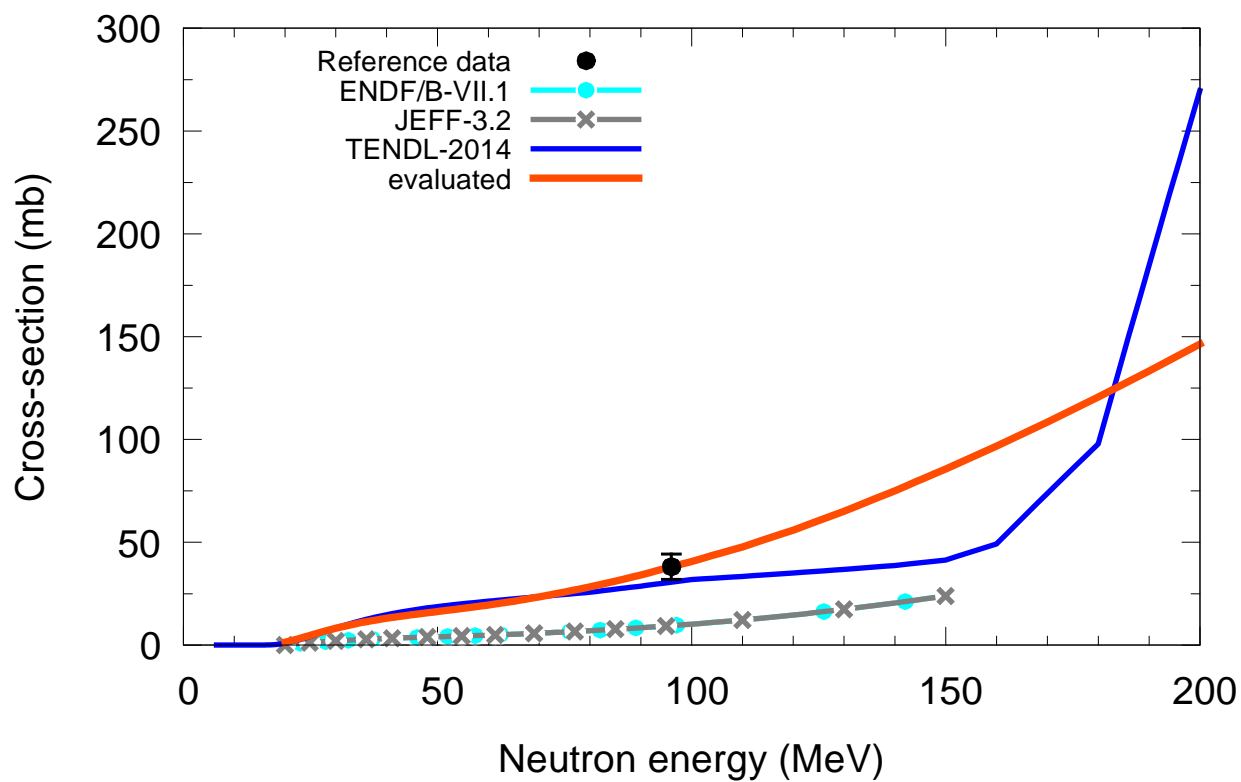
$^{198}\text{Pt}(n,x)t$



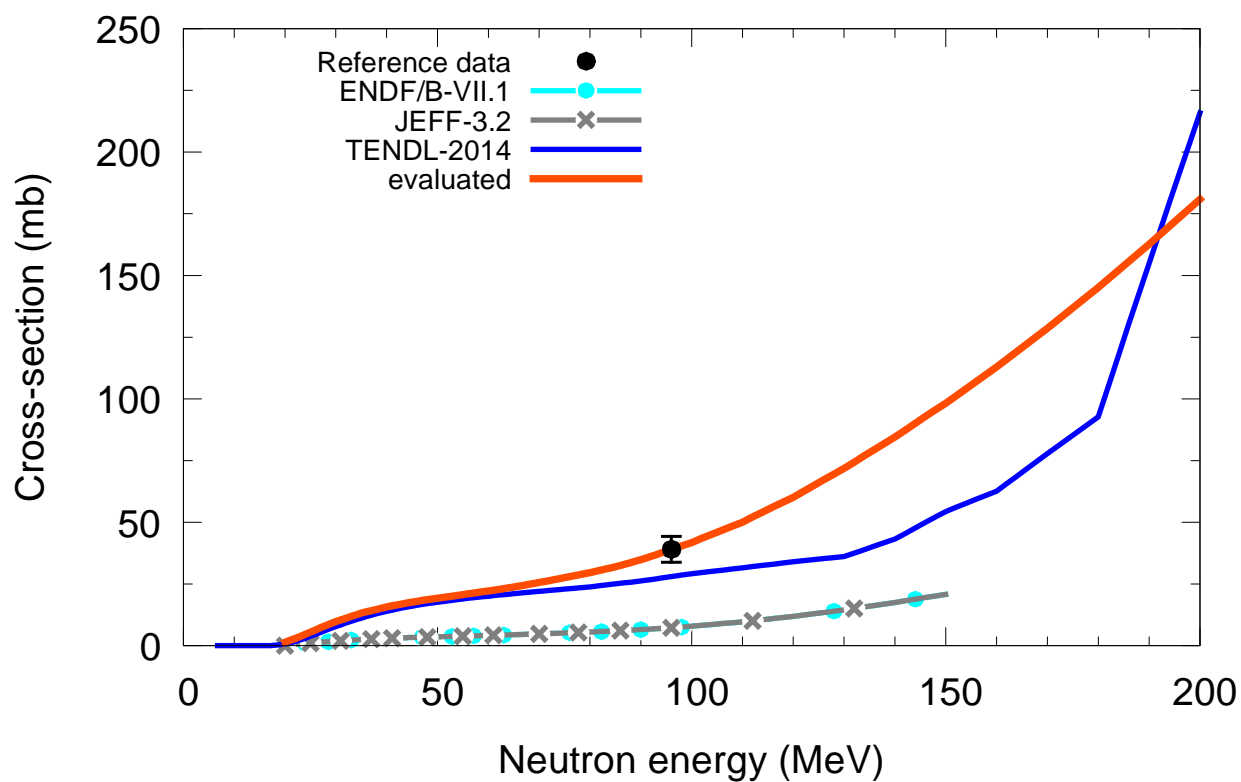
$^{197}\text{Au}(n,x)t$

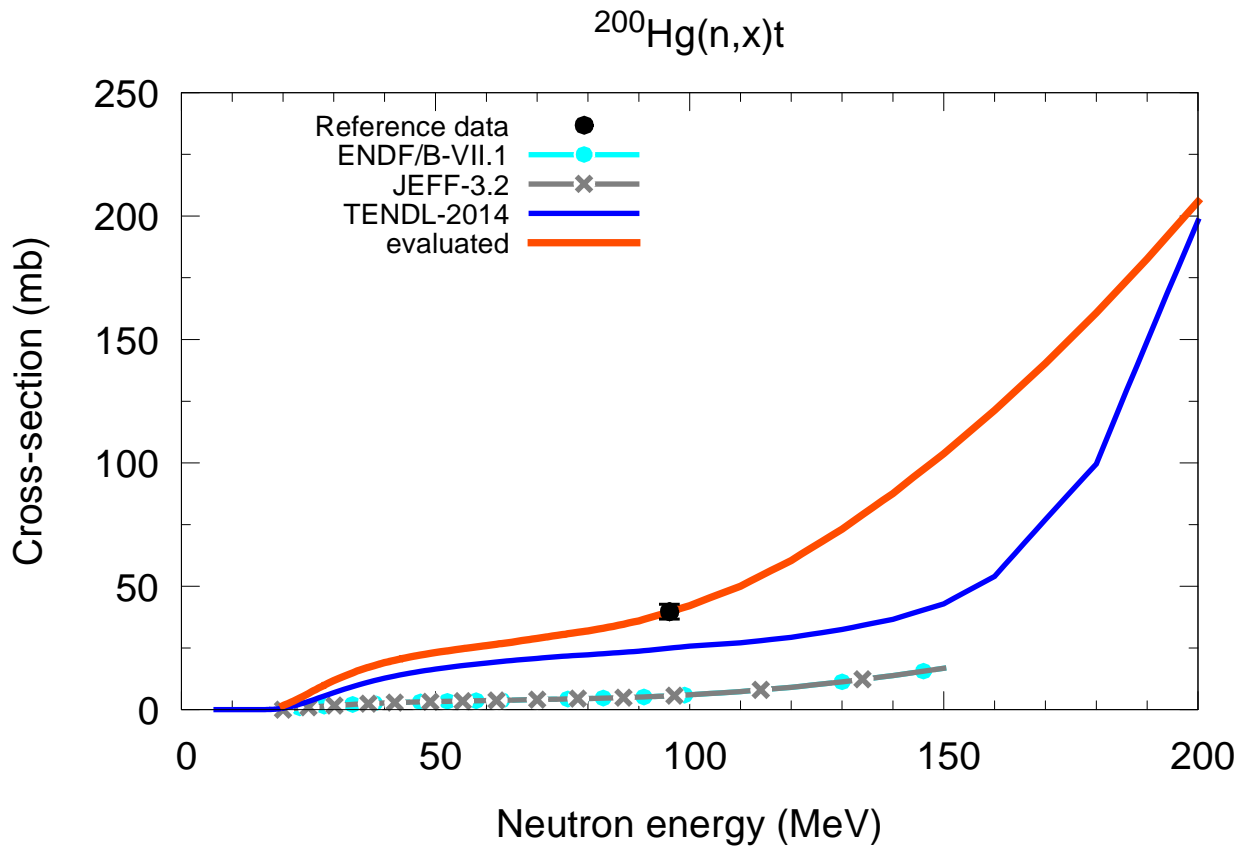
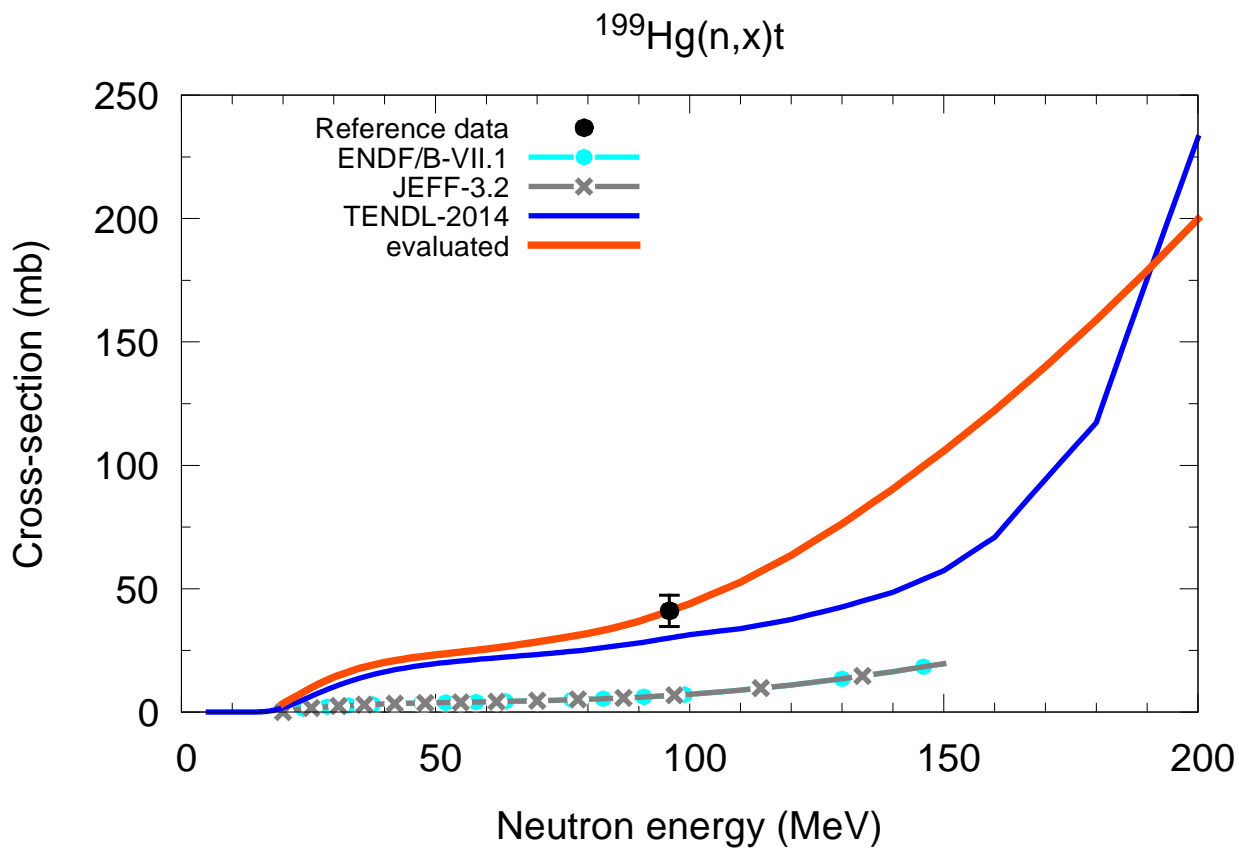


### $^{196}\text{Hg}(n,x)t$

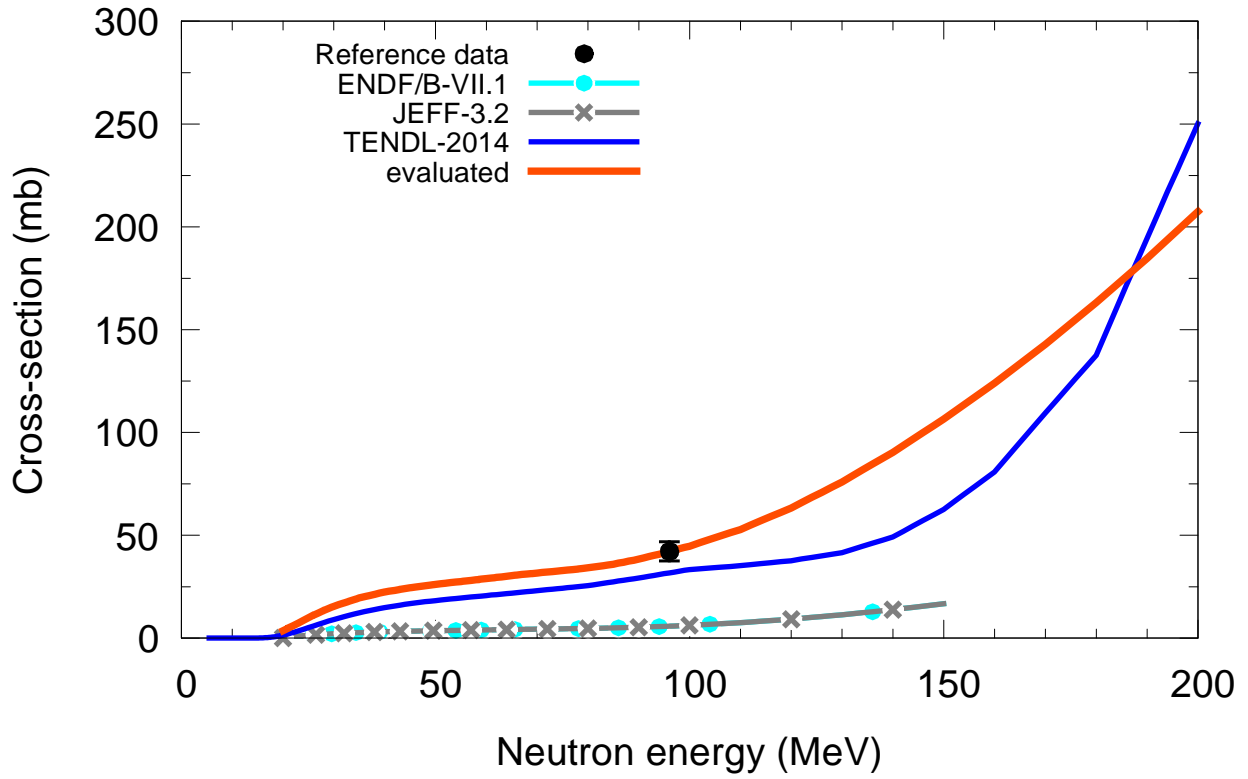


### $^{198}\text{Hg}(n,x)t$

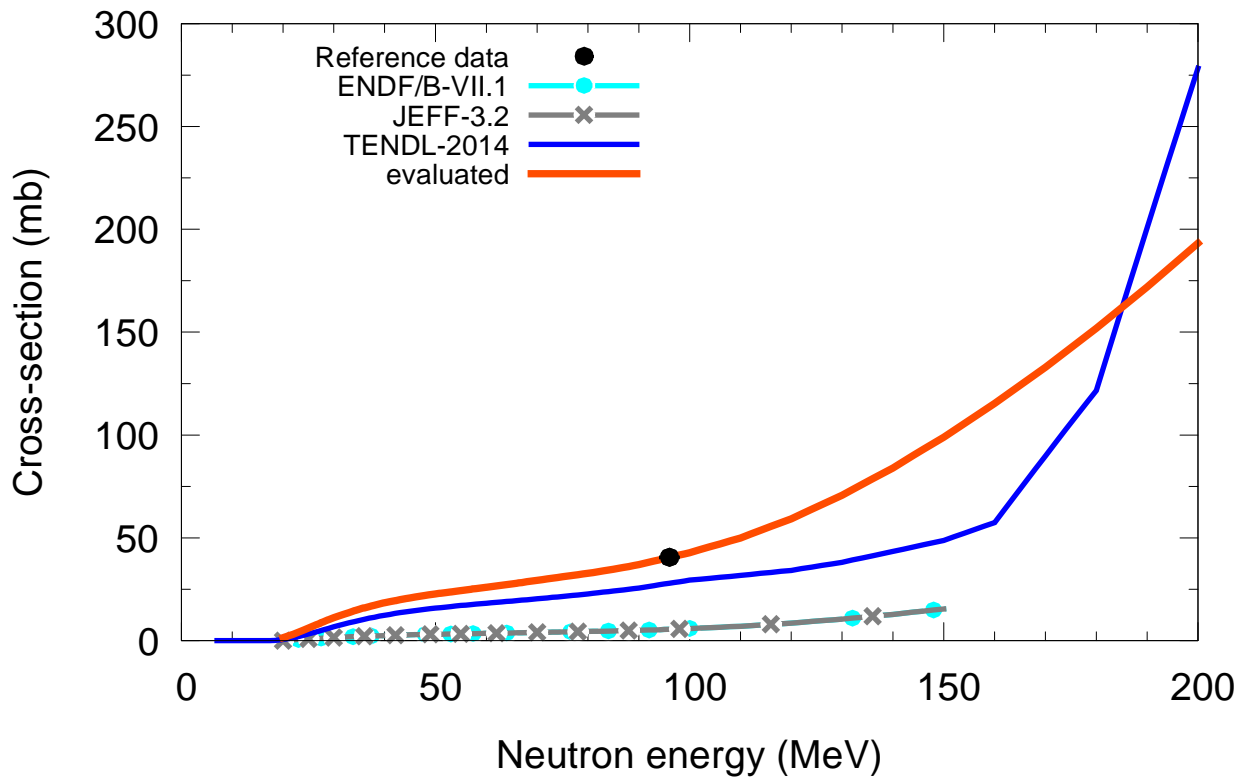




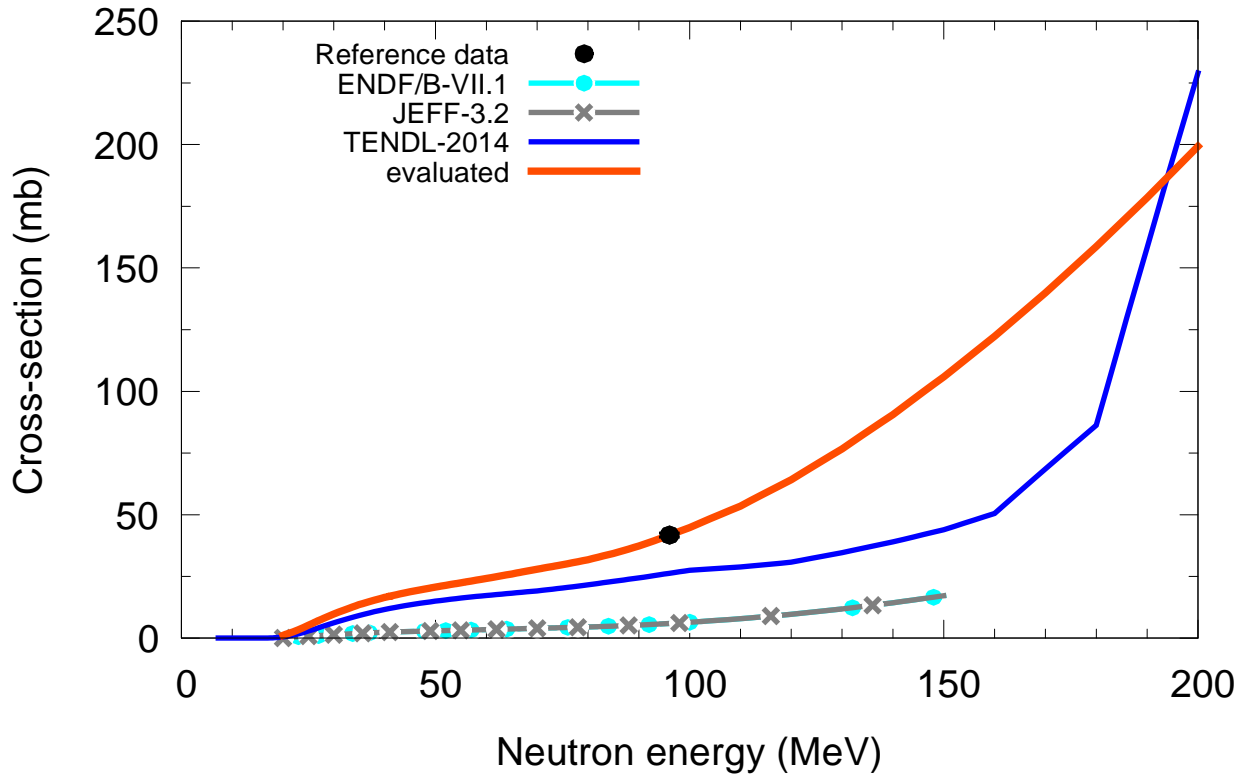
### $^{201}\text{Hg}(n,x)t$



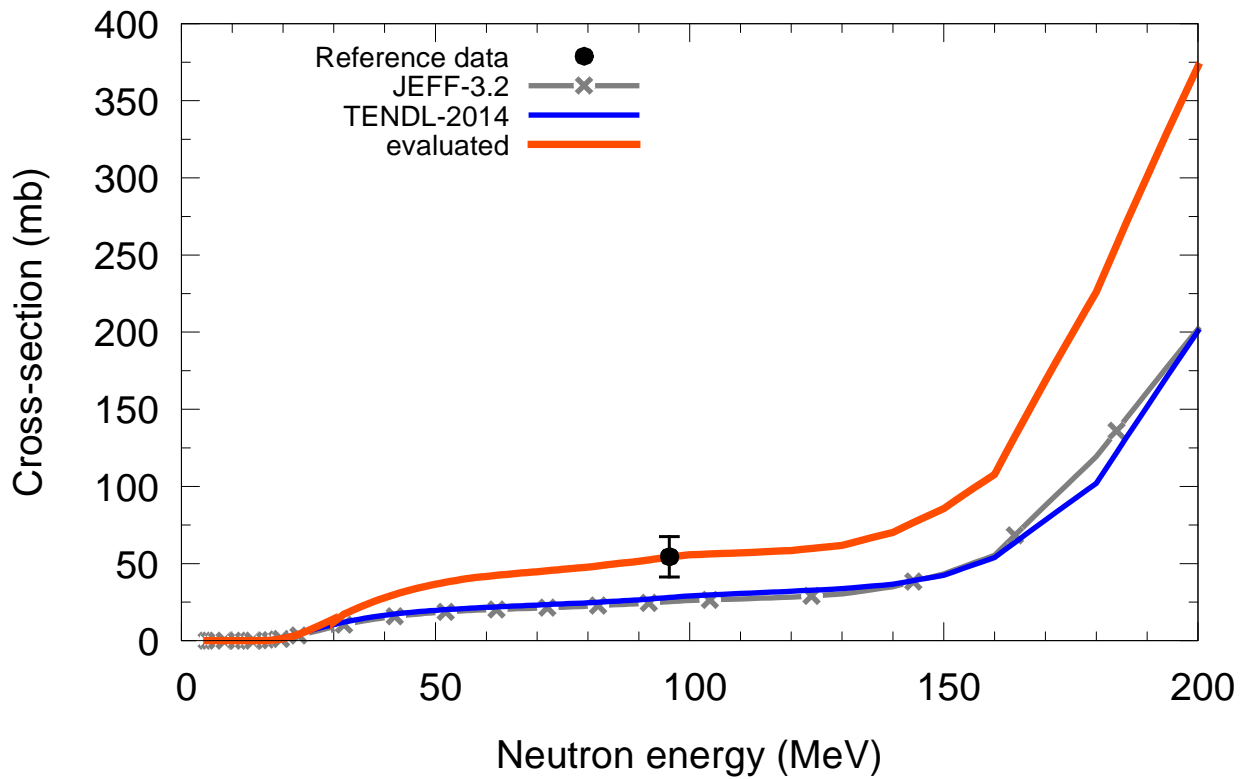
### $^{202}\text{Hg}(n,x)t$

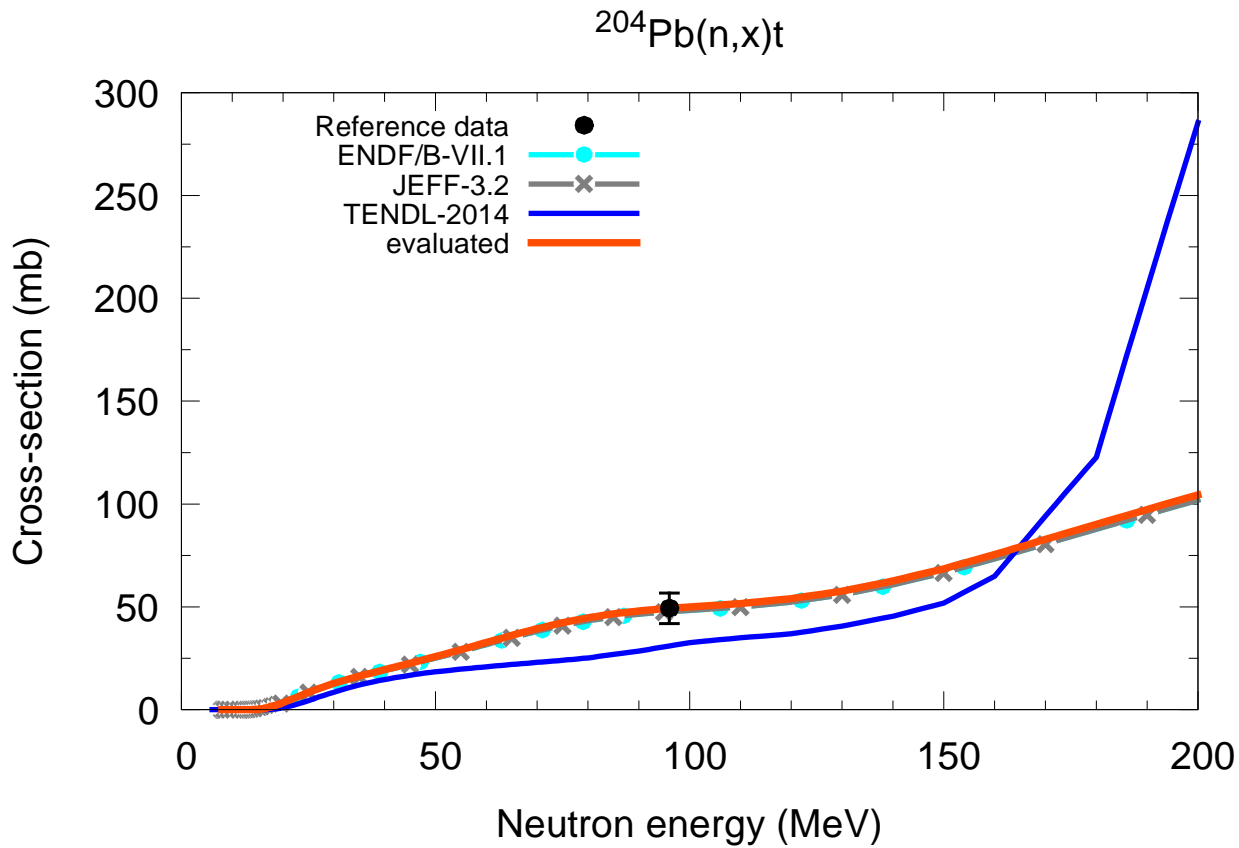
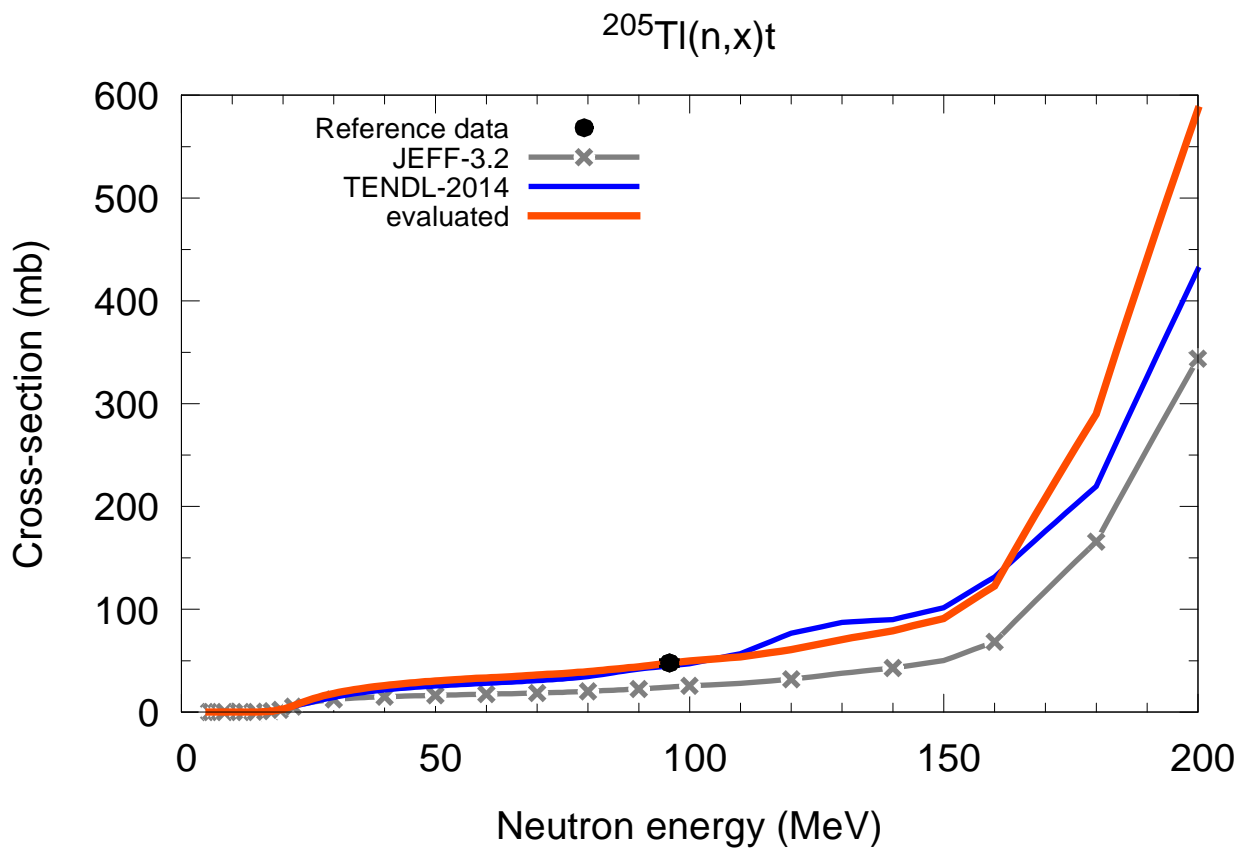


$^{204}\text{Hg}(n,x)t$

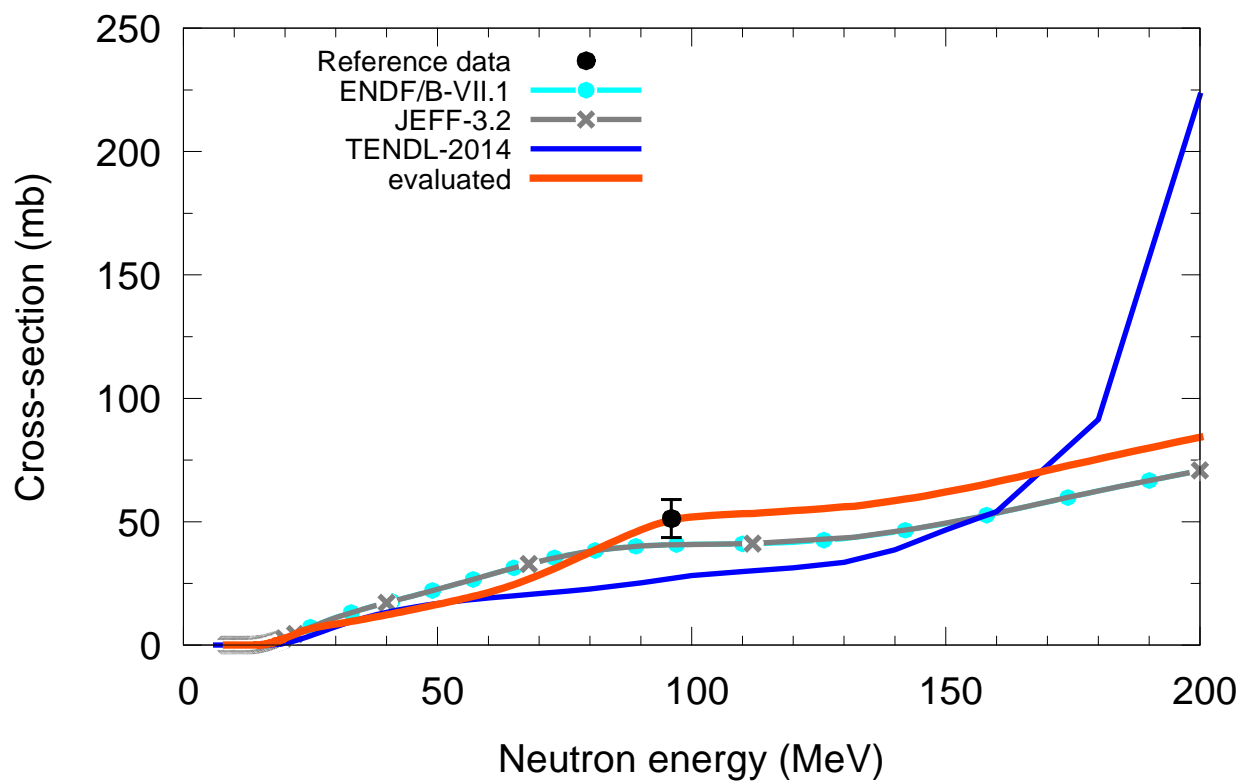


$^{203}\text{Tl}(n,x)t$

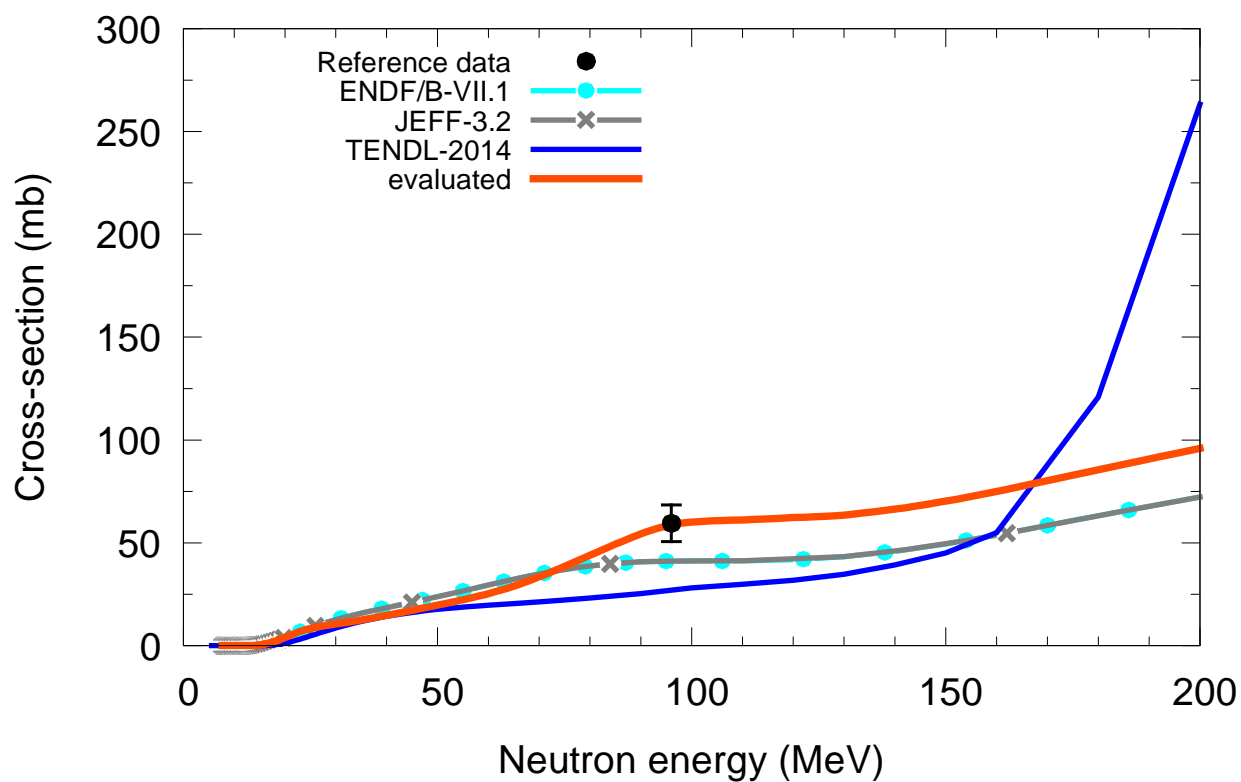




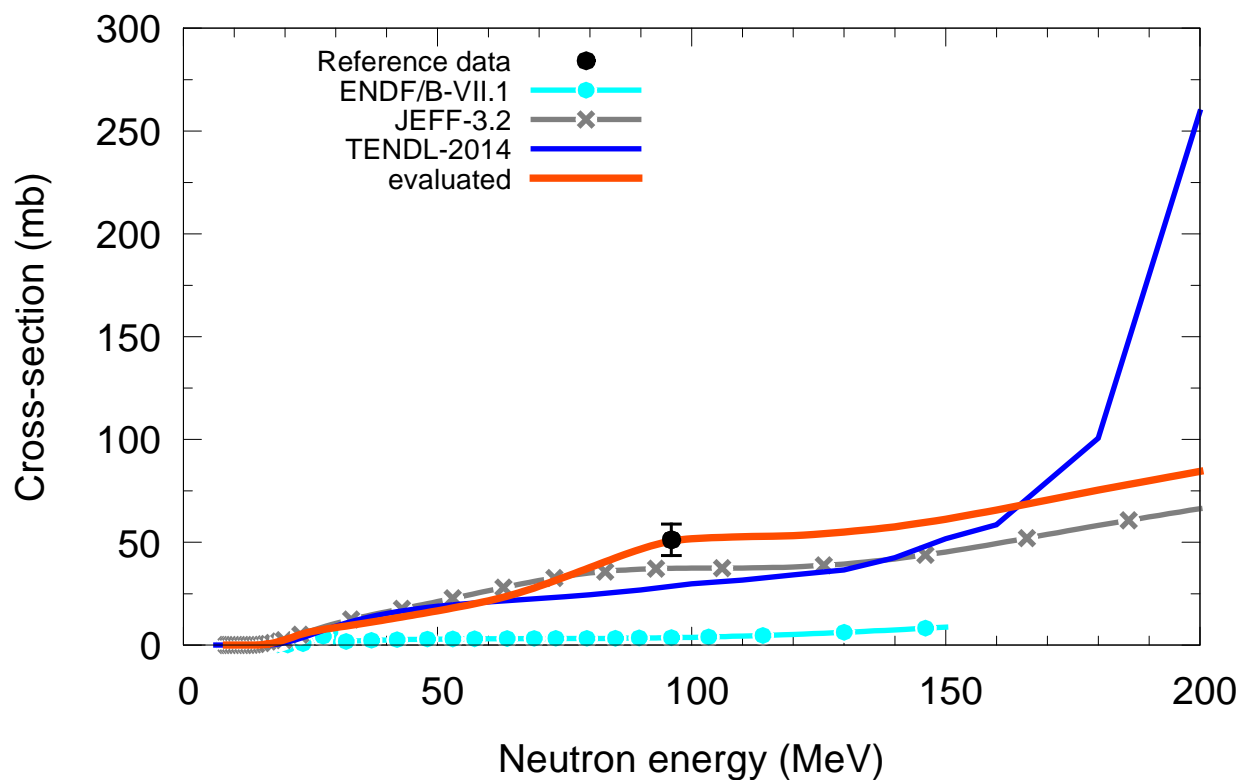
### $^{206}\text{Pb}(n,x)t$



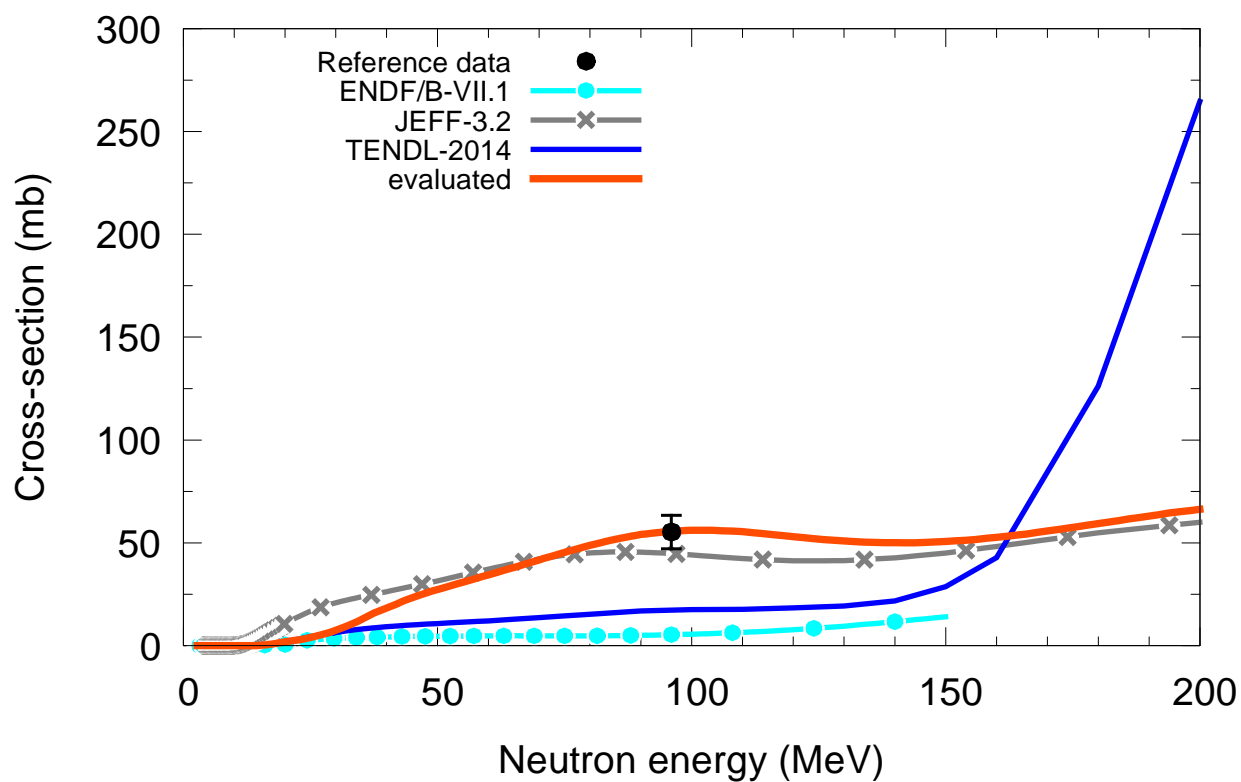
### $^{207}\text{Pb}(n,x)t$



### $^{208}\text{Pb}(n,x)t$



### $^{209}\text{Bi}(n,x)t$

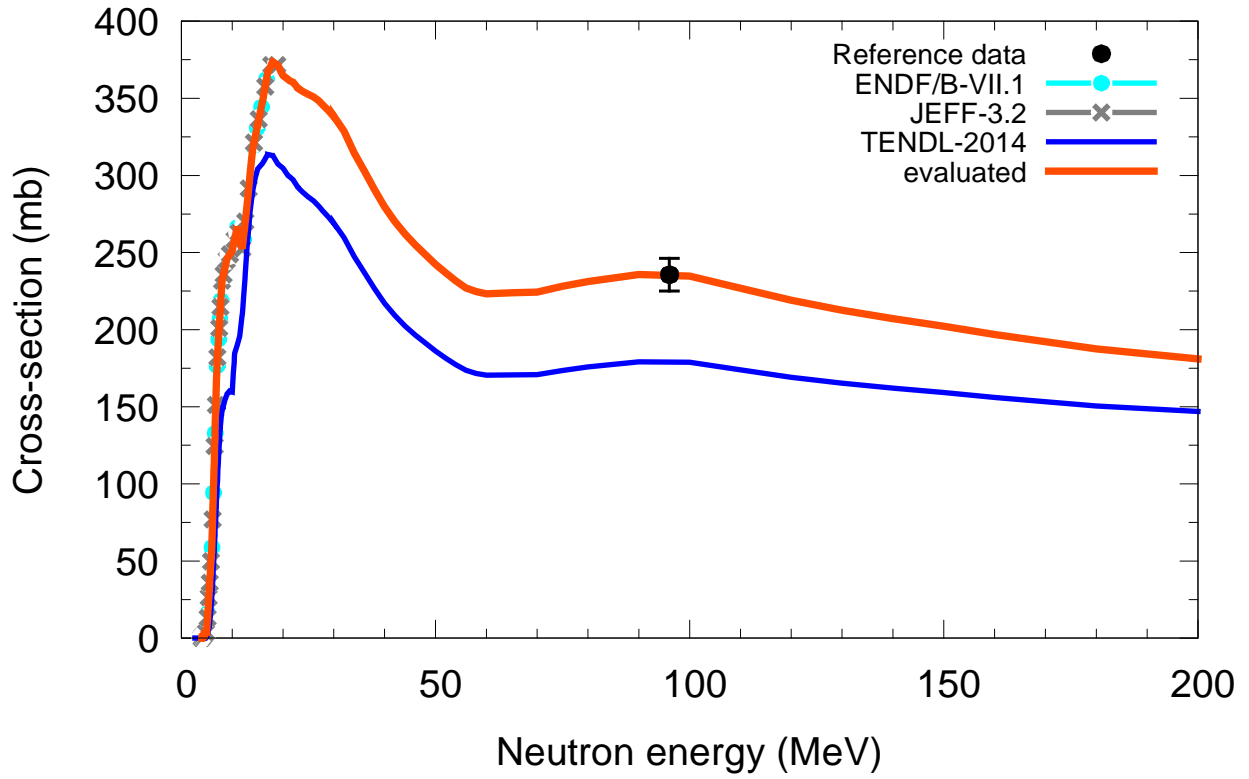




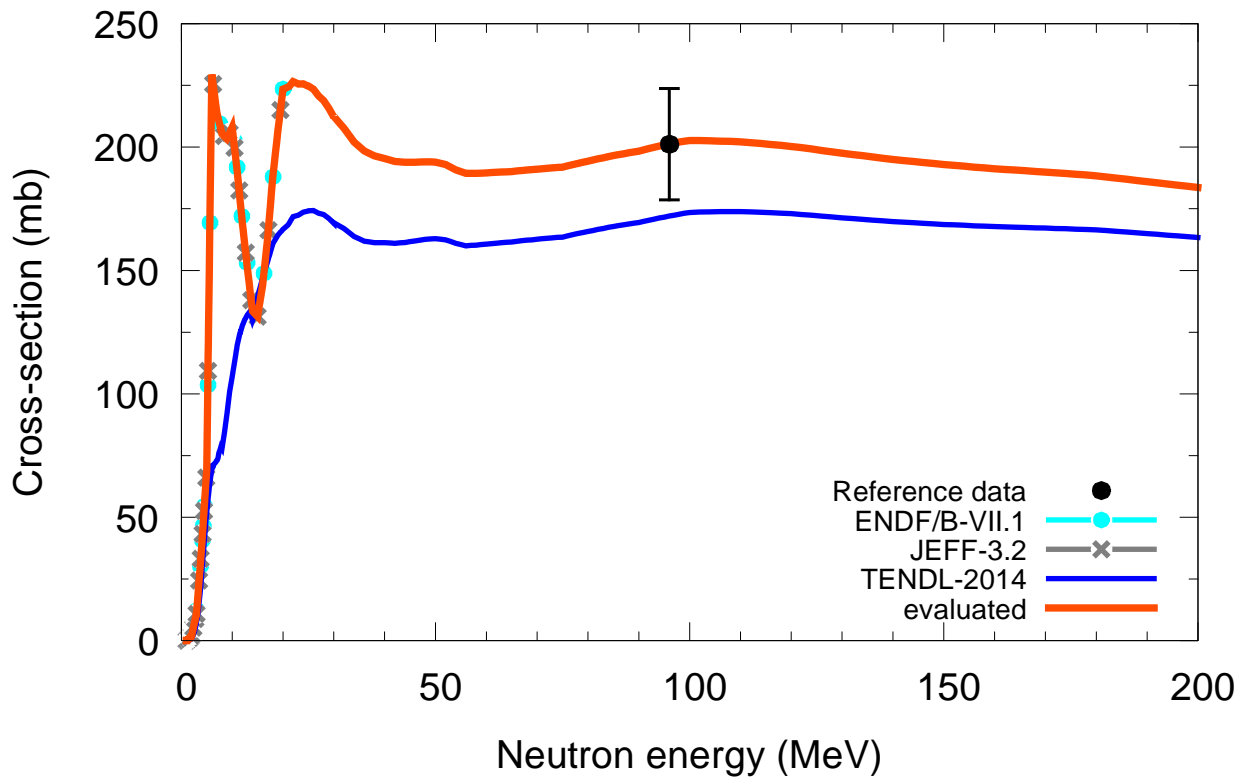
## Appendix D

Evaluated  $\alpha$ -particle production cross-sections, data from ENDF/B-VII.1, JEFF-3.2, and TENDL-2014, and cross-sections at 96 MeV estimated using the  $\sigma(A)$ -dependence

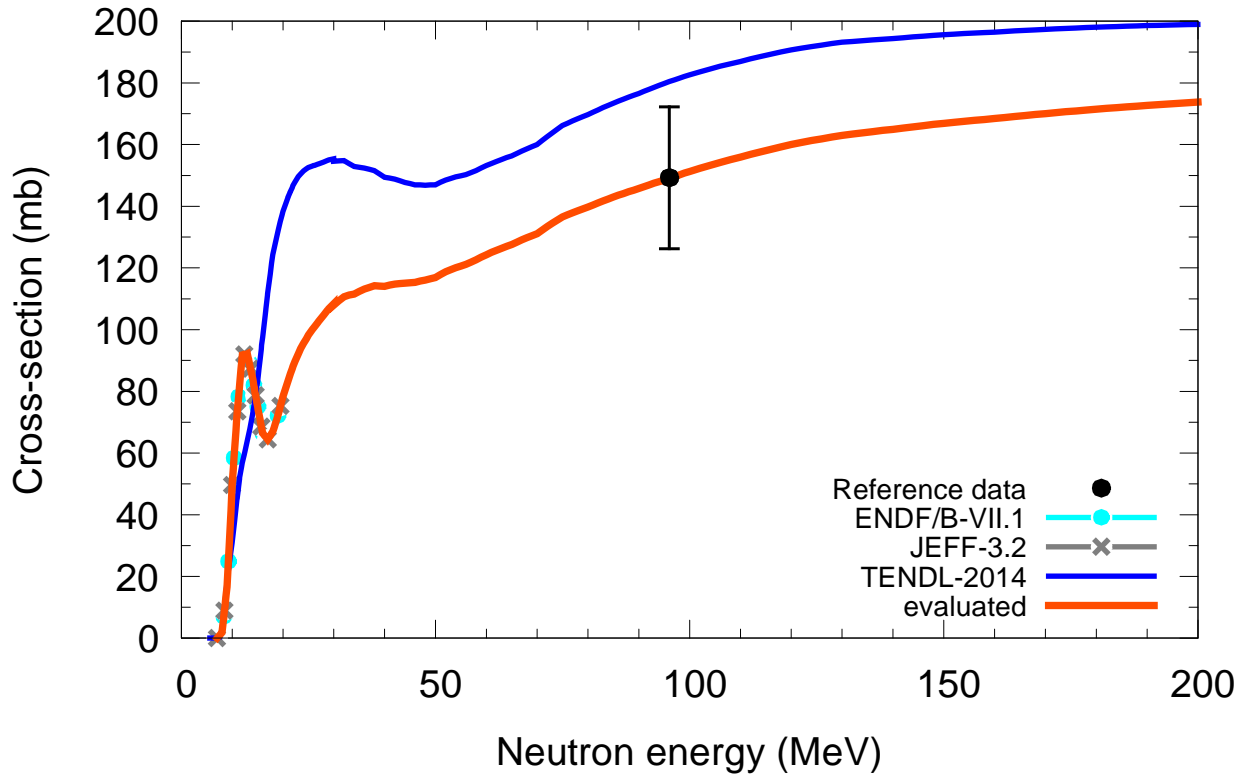
### $^{24}\text{Mg}(n,x)^4\text{He}$



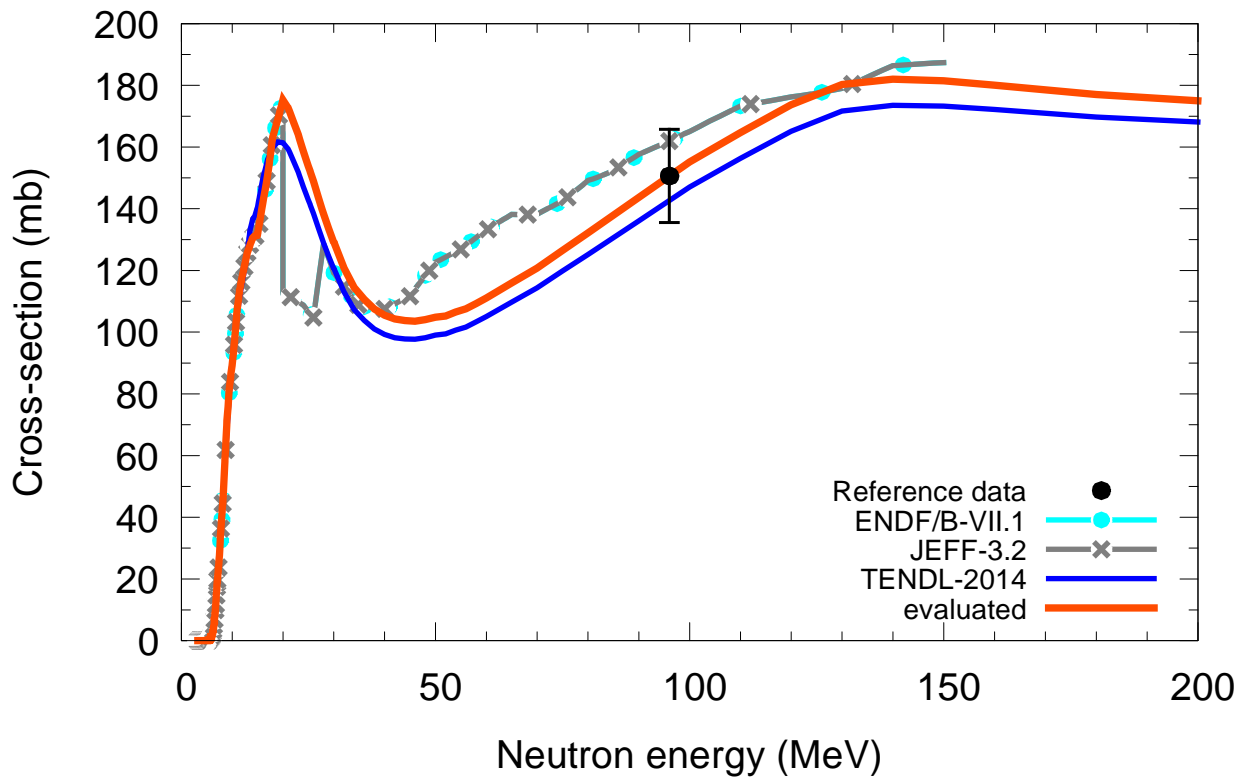
### $^{25}\text{Mg}(n,x)^4\text{He}$

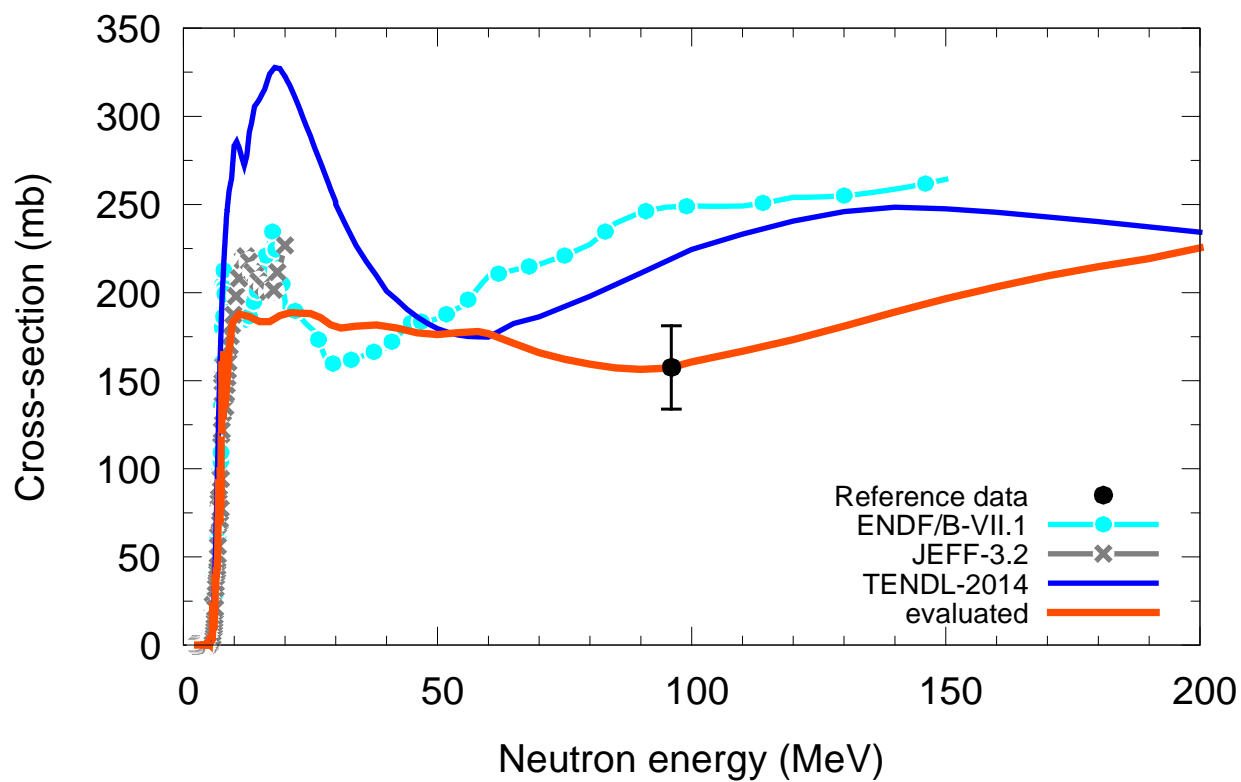
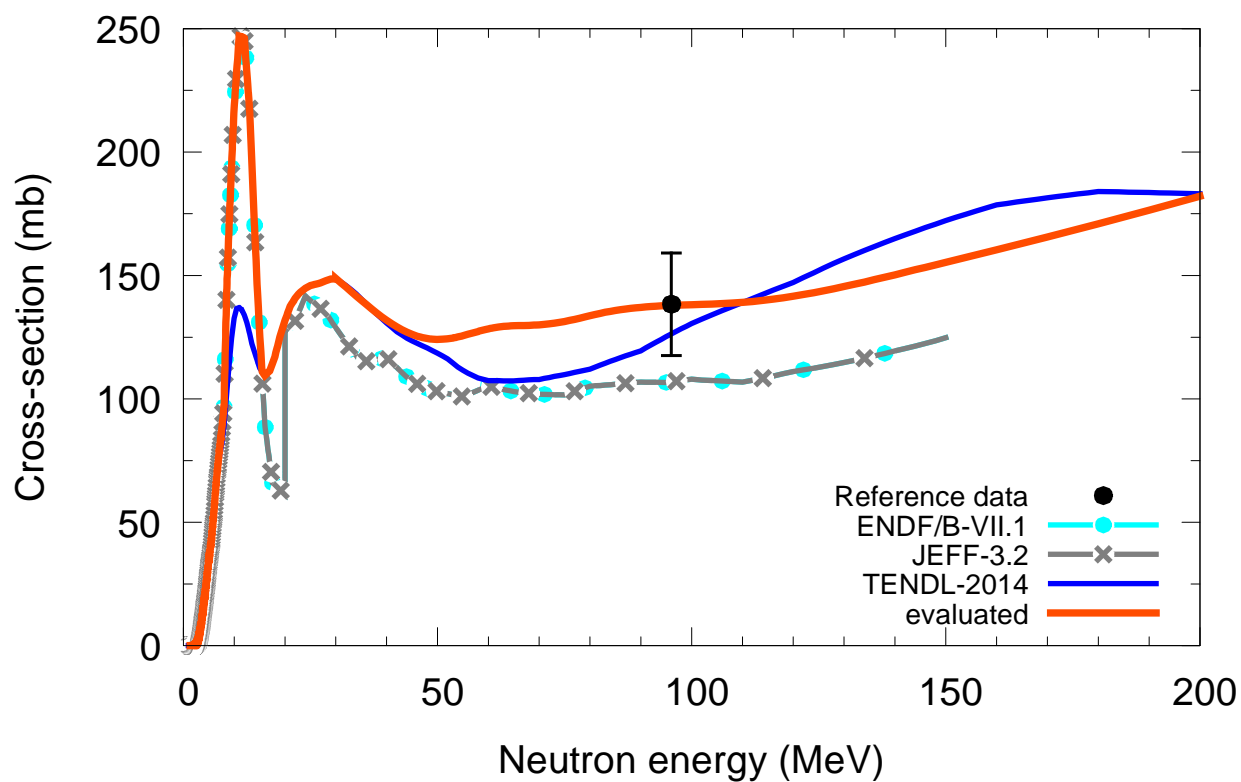


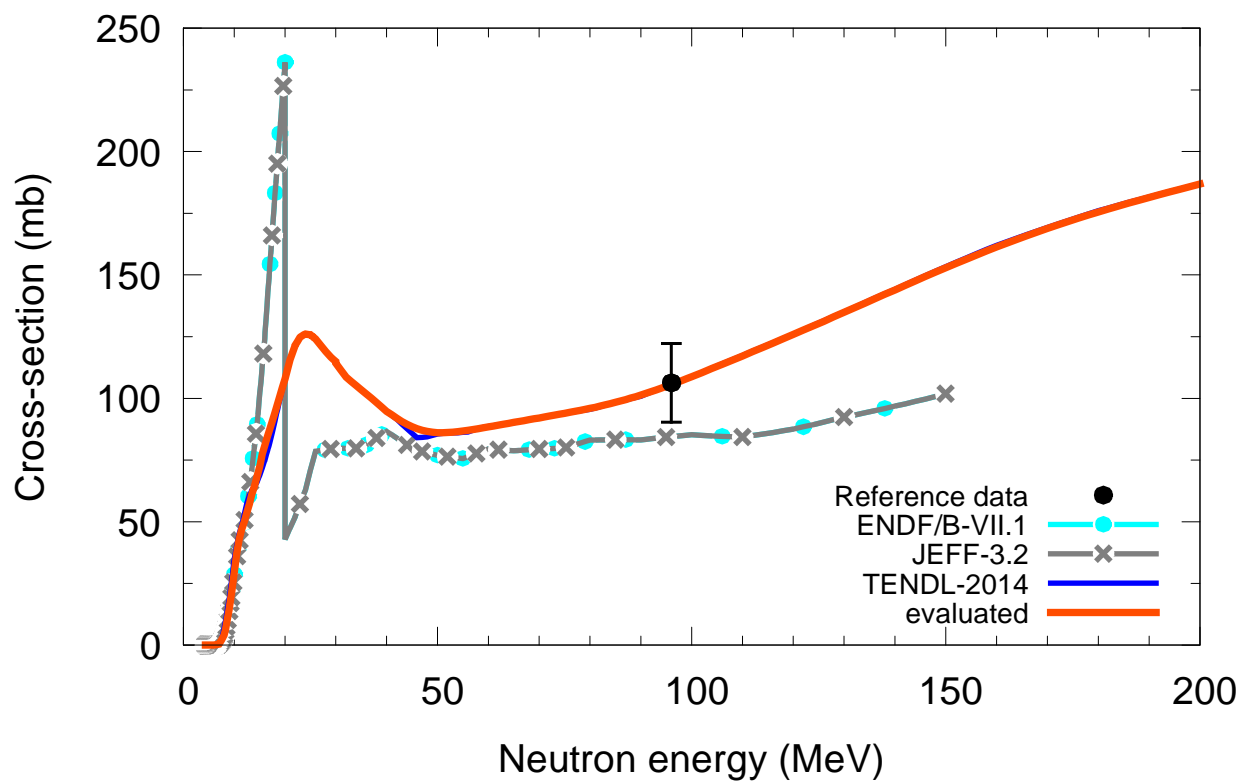
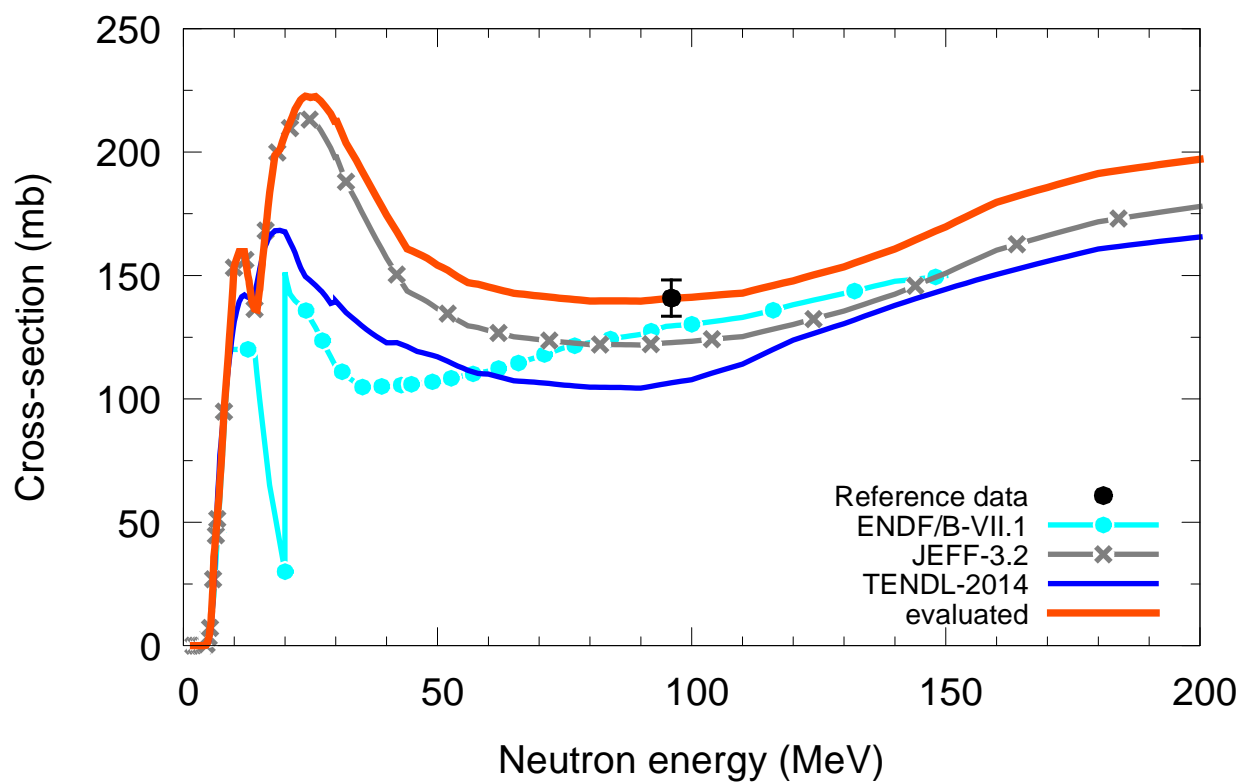
$^{26}\text{Mg}(n,x)^4\text{He}$

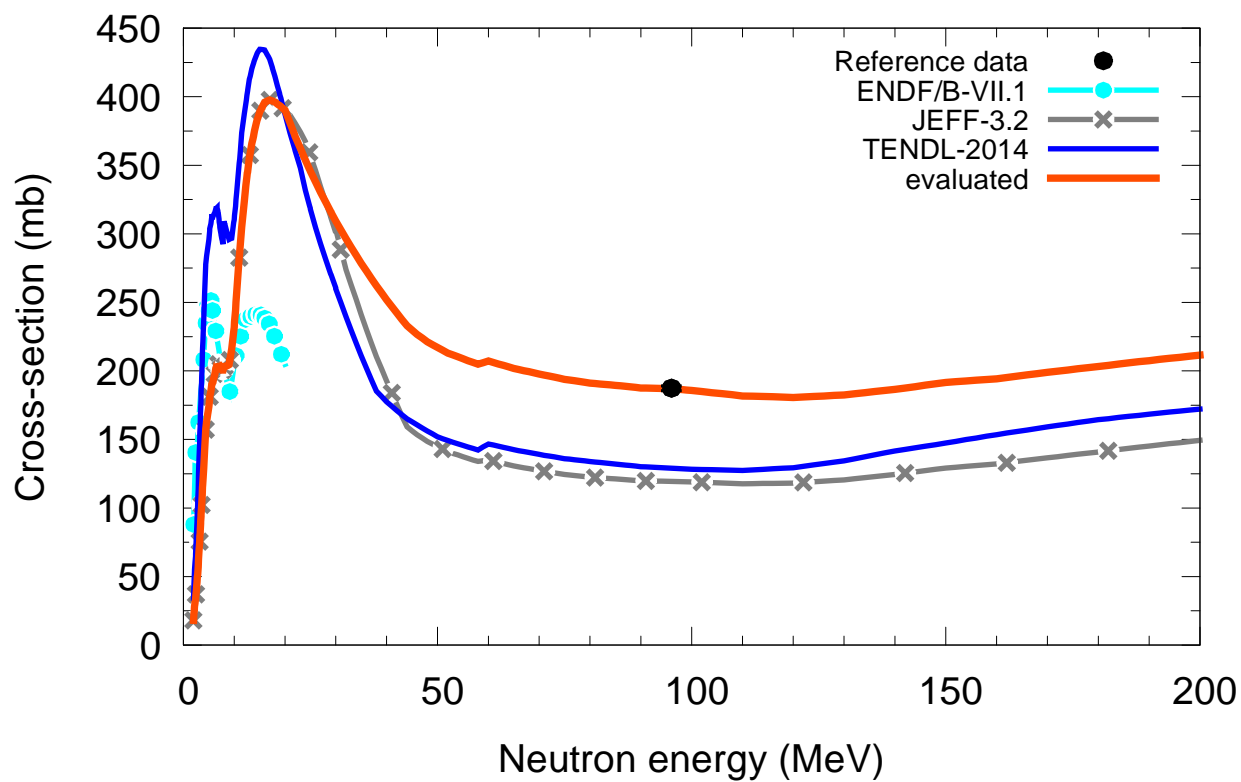
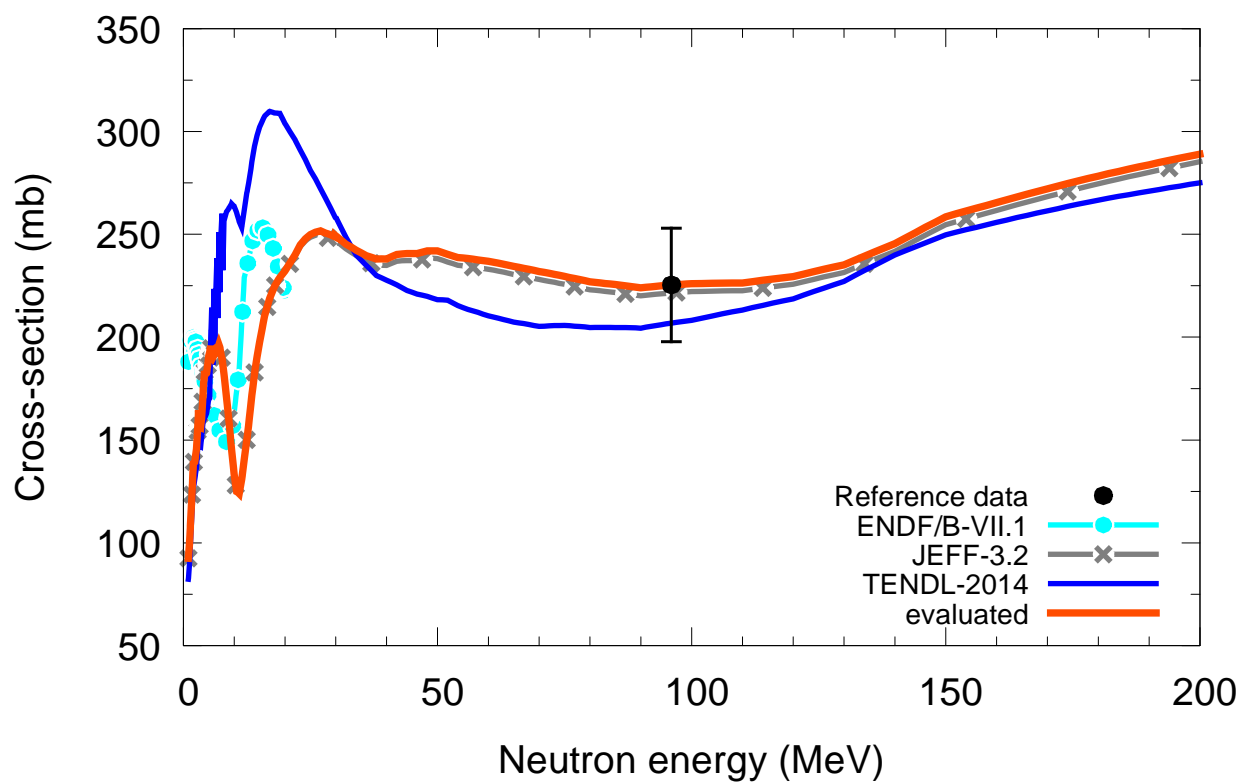


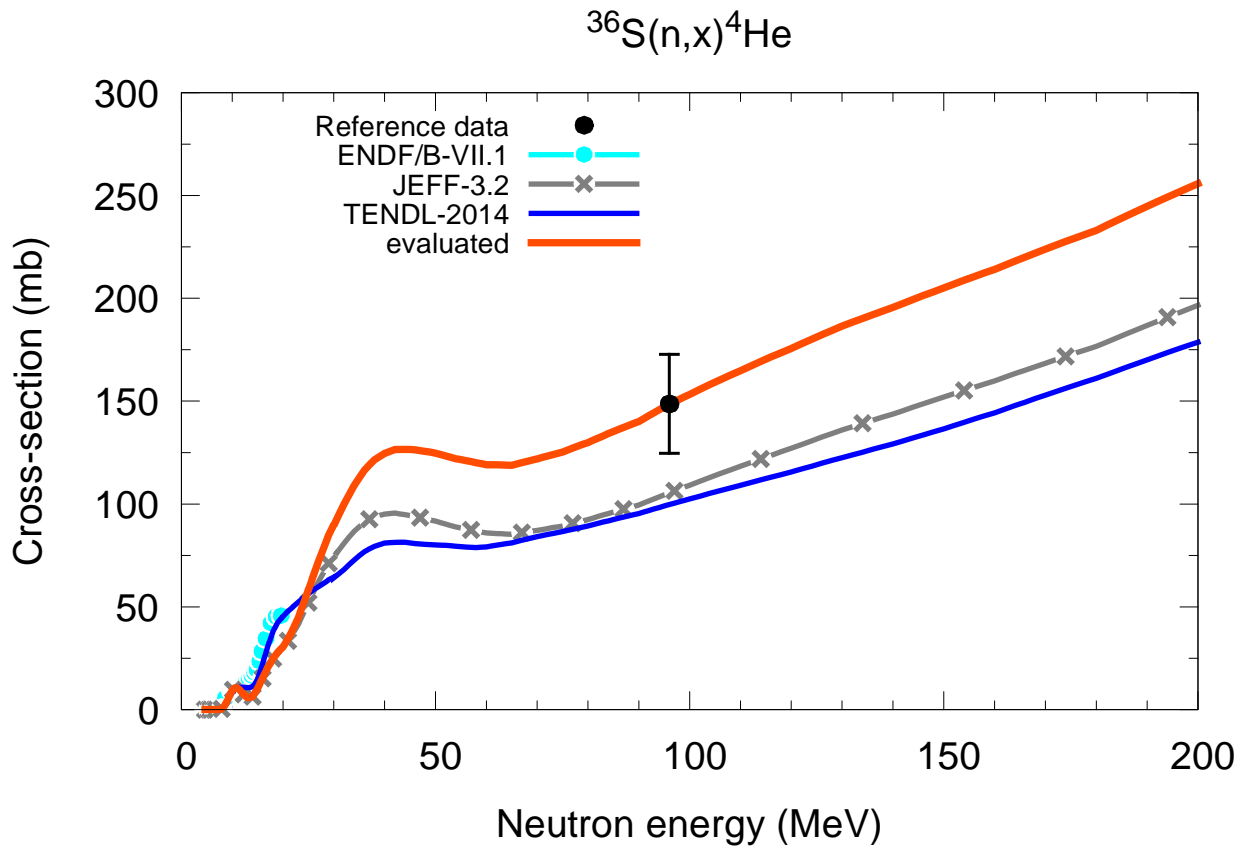
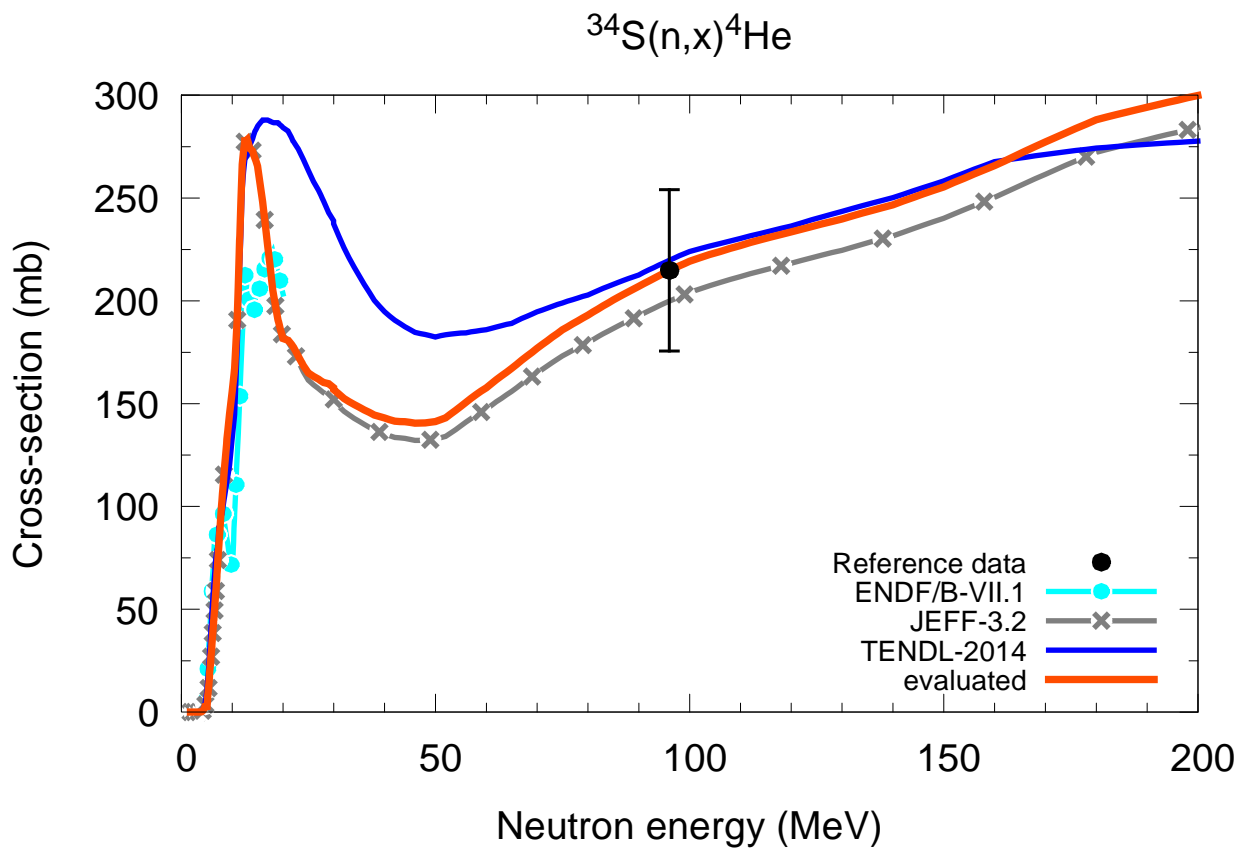
$^{27}\text{Al}(n,x)^4\text{He}$



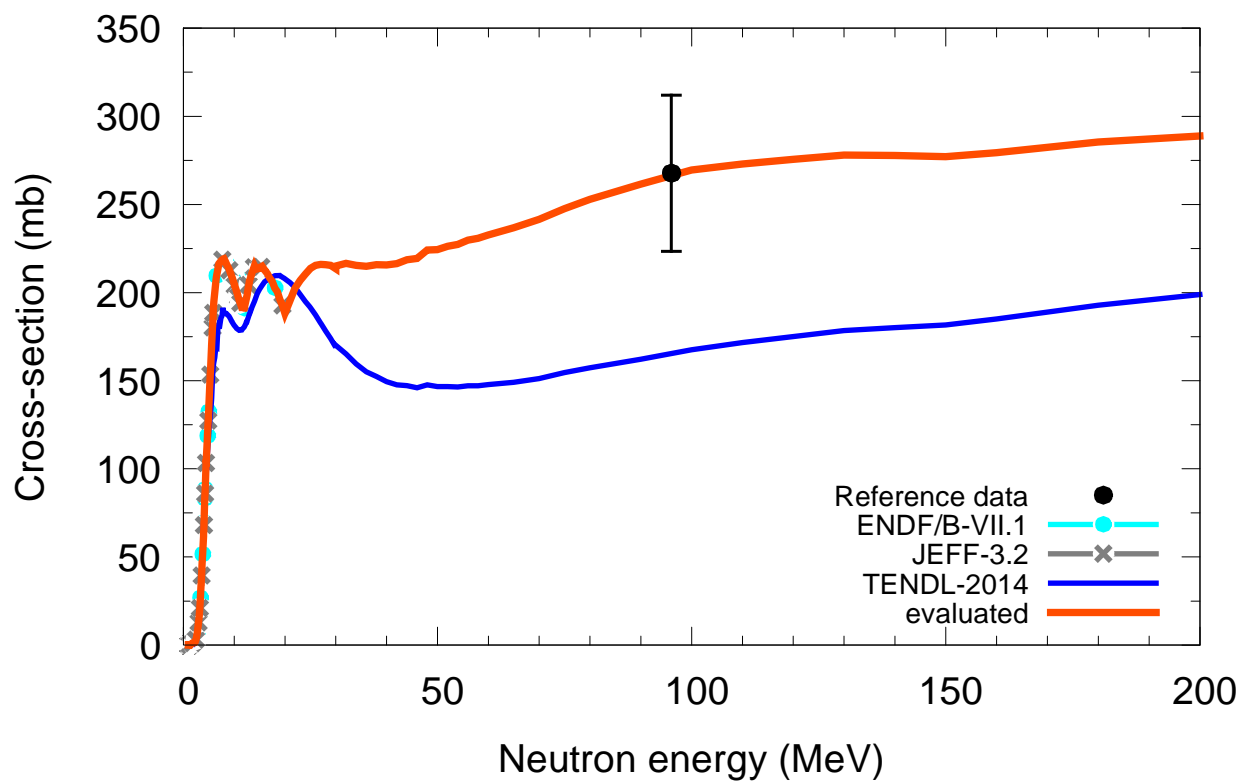
$^{28}\text{Si}(n,x)^4\text{He}$  $^{29}\text{Si}(n,x)^4\text{He}$ 

$^{30}\text{Si}(n,x)^4\text{He}$  $^{31}\text{P}(n,x)^4\text{He}$ 

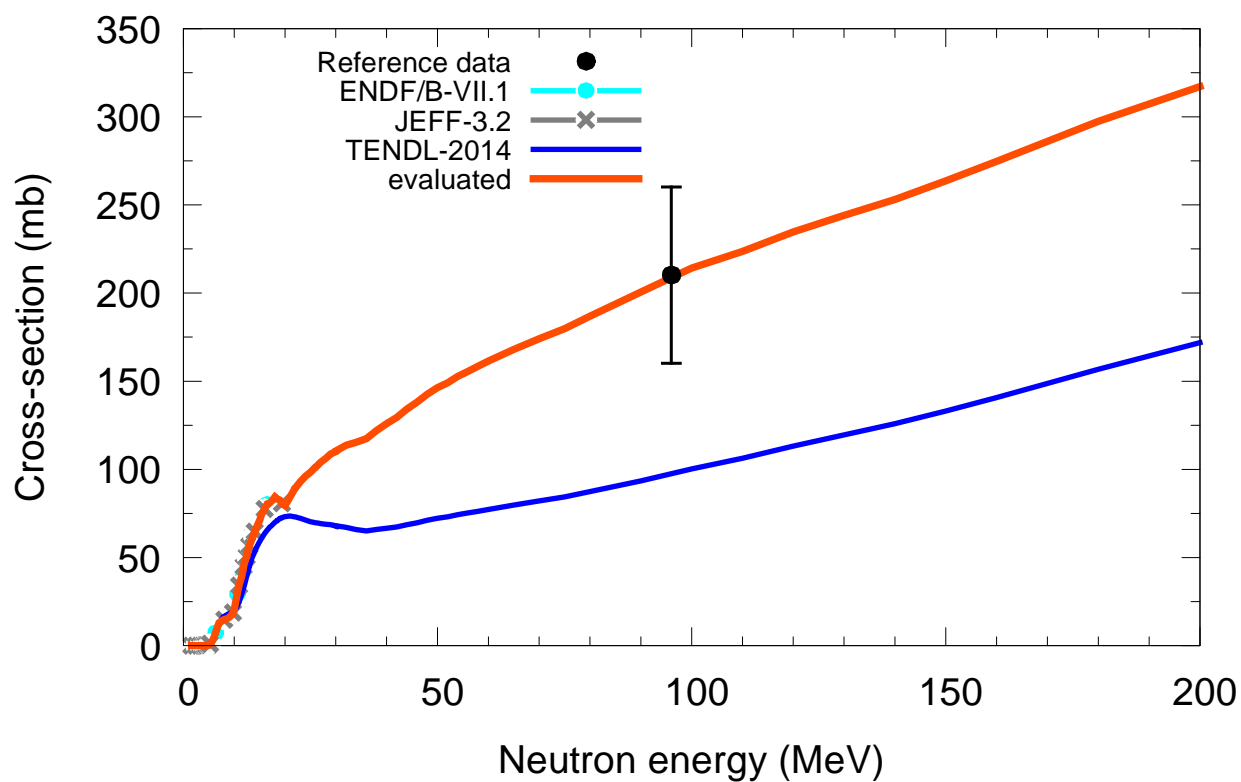
$^{32}\text{S}(n,x)^4\text{He}$  $^{33}\text{S}(n,x)^4\text{He}$ 



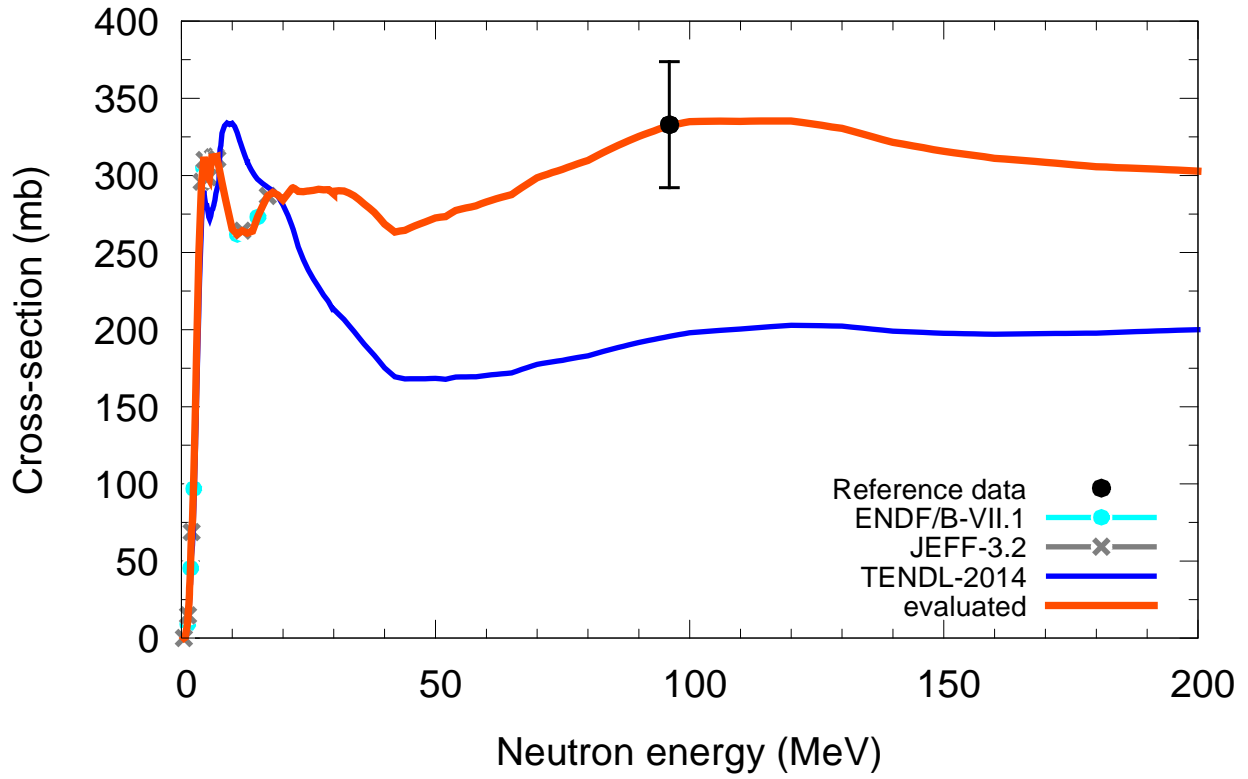
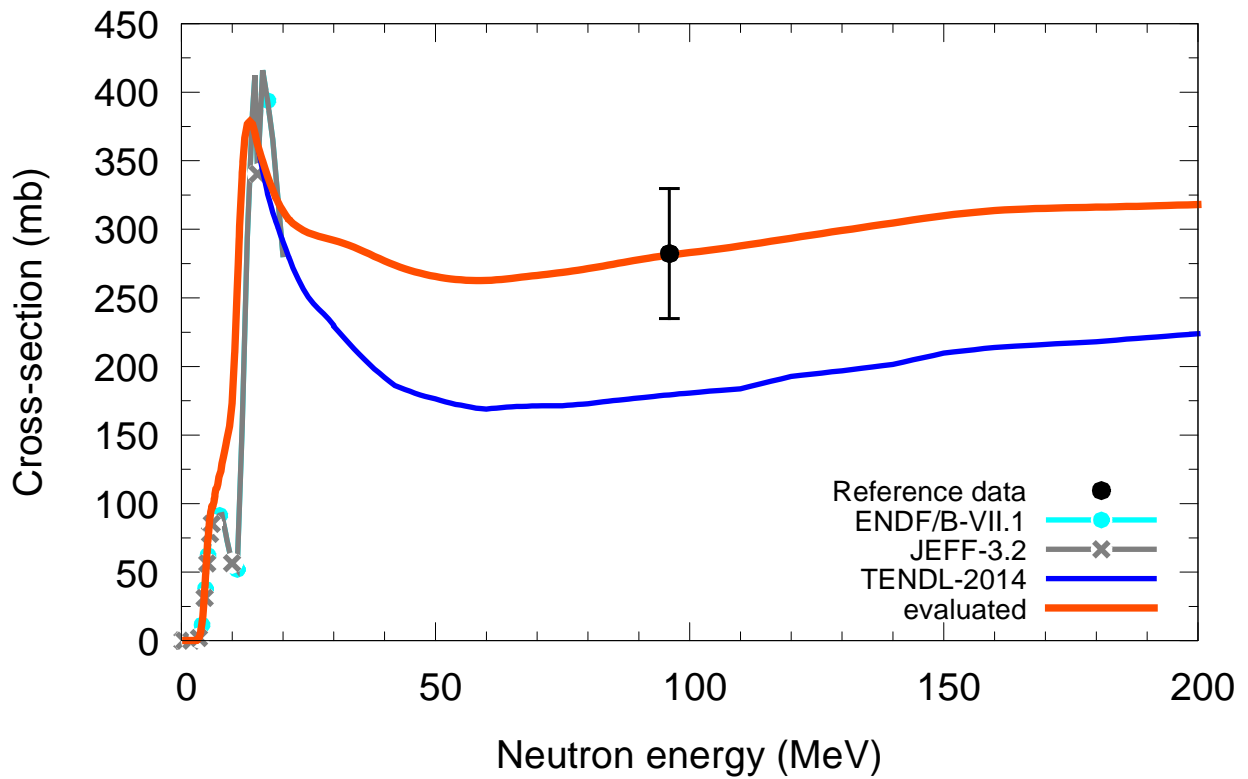
$^{35}\text{Cl}(n,x)^4\text{He}$

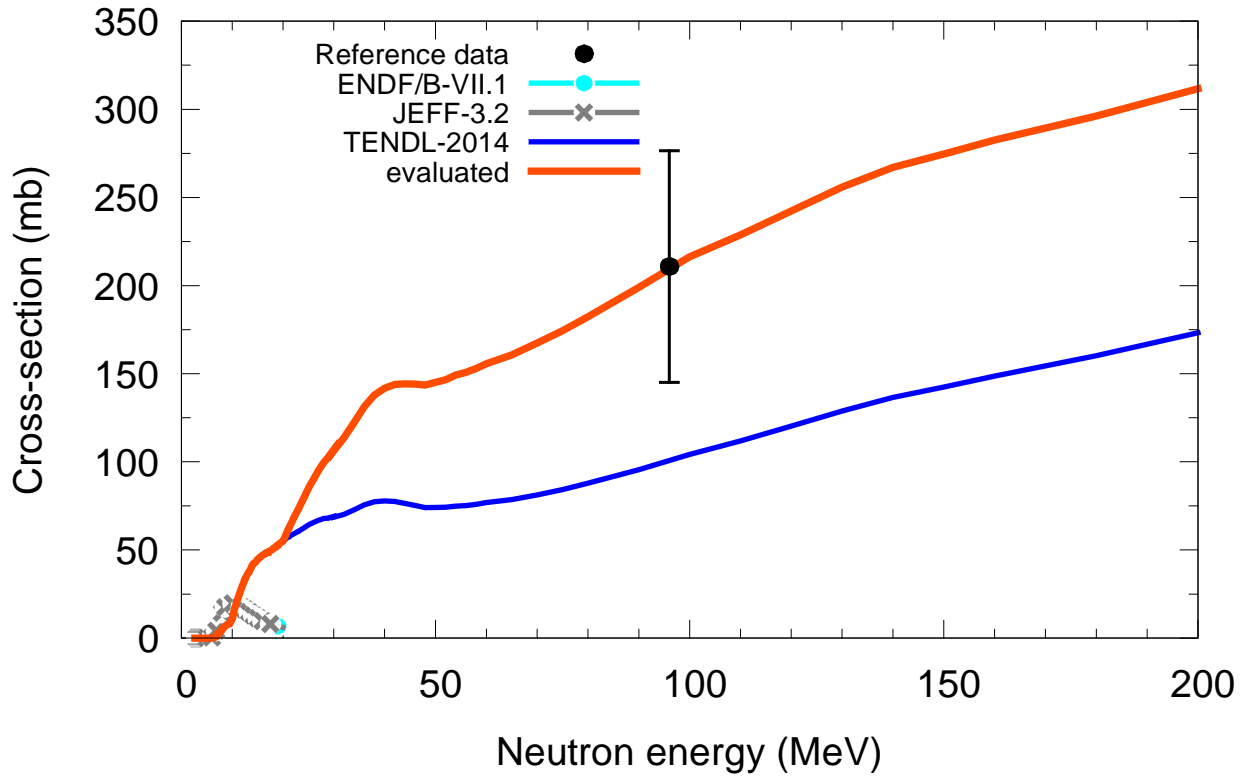
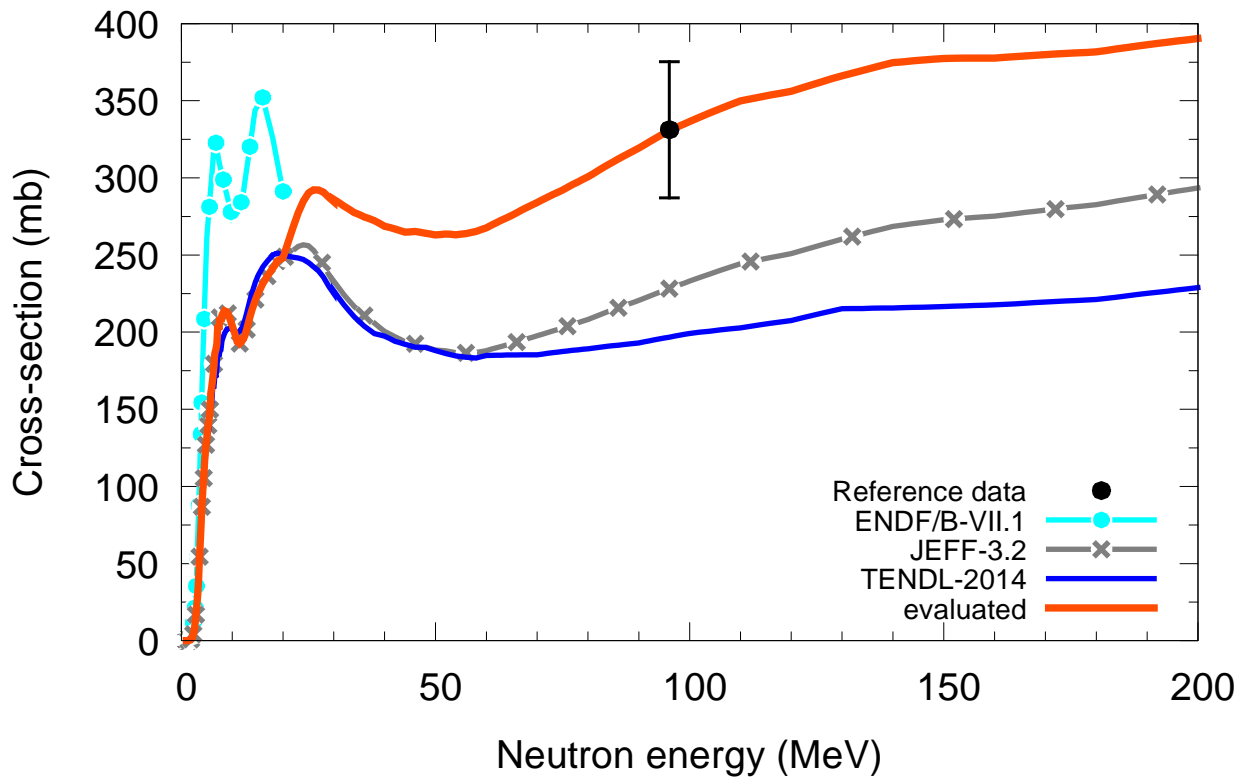


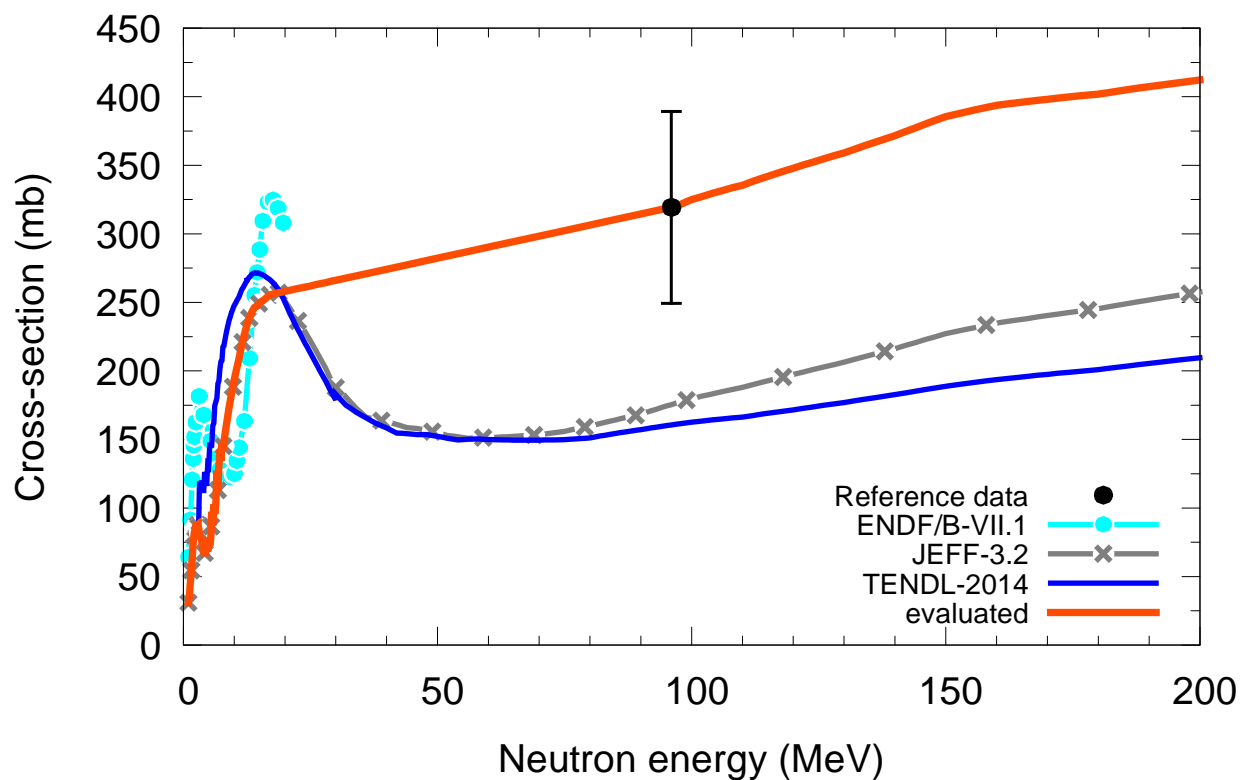
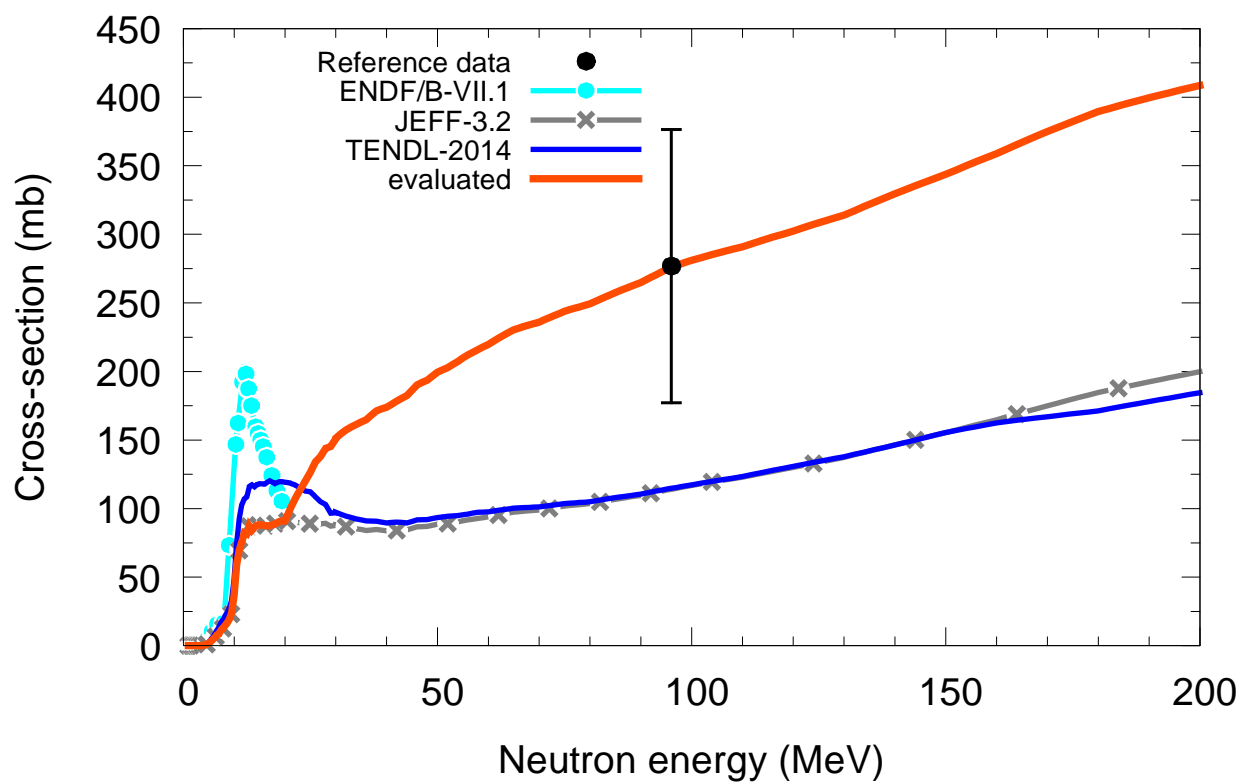
$^{37}\text{Cl}(n,x)^4\text{He}$

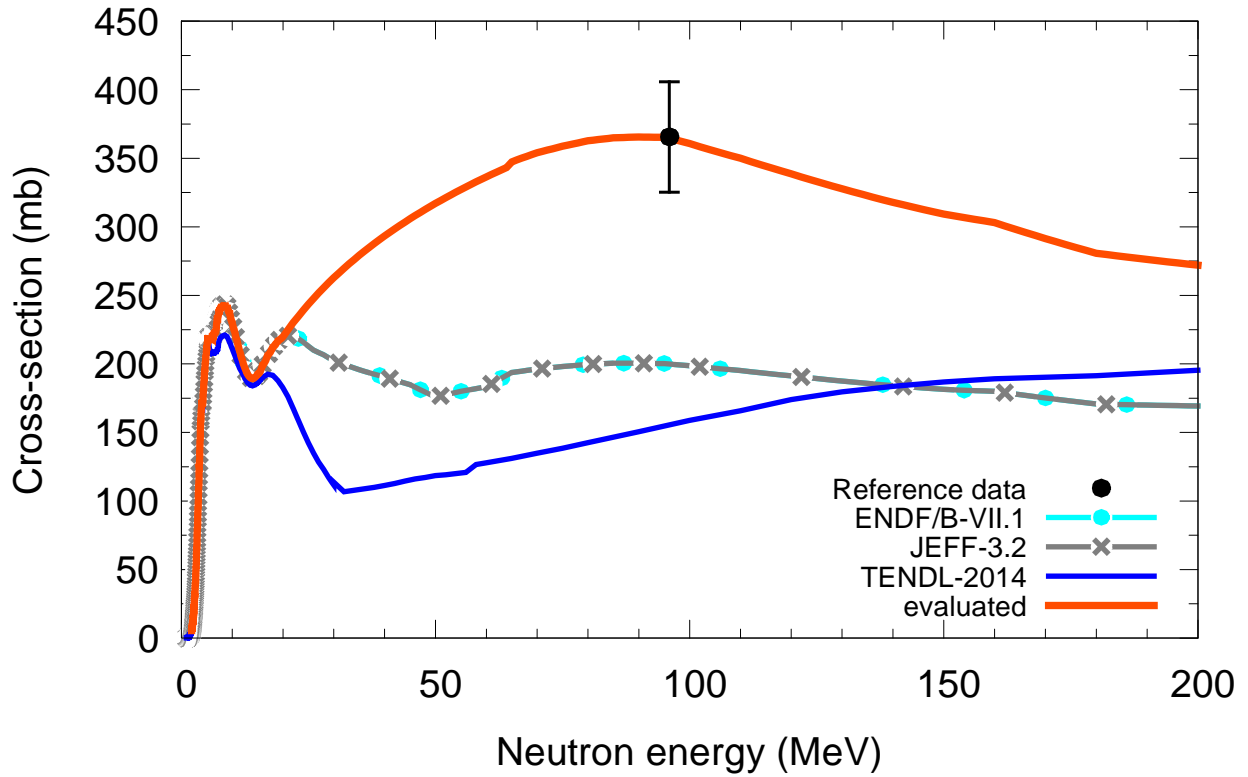
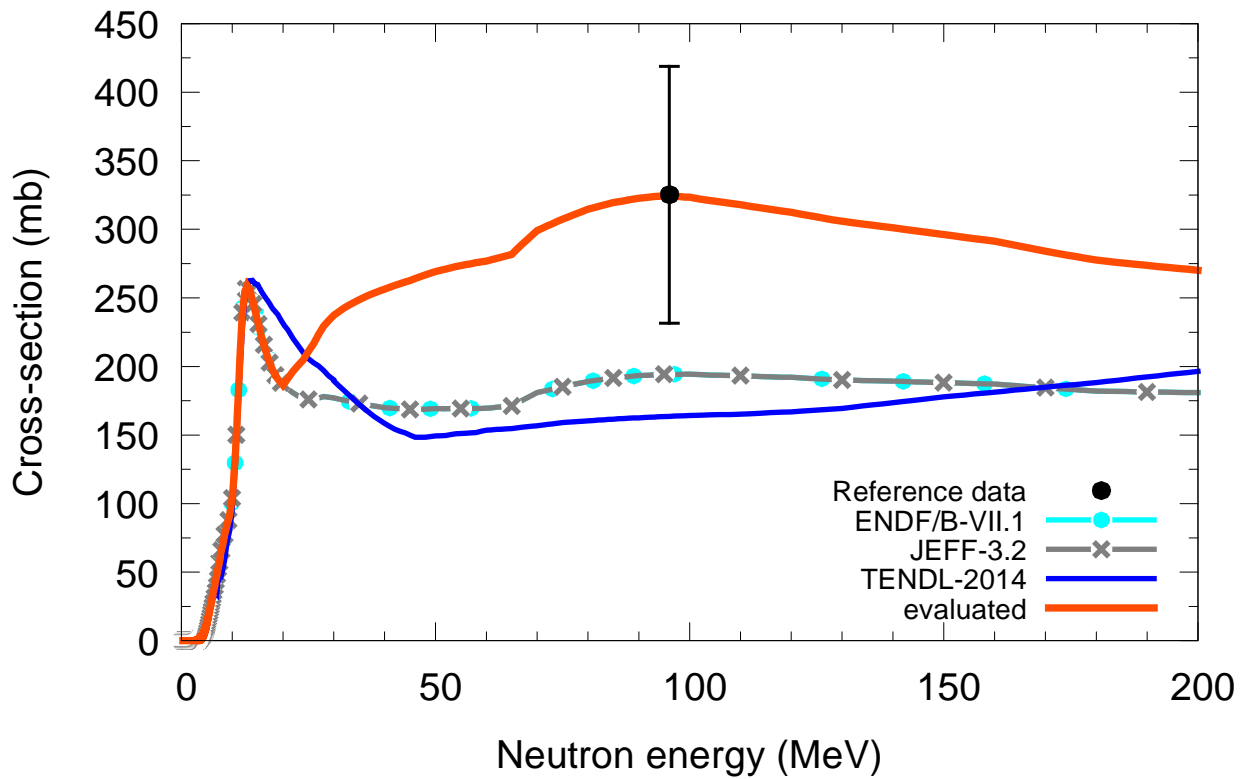


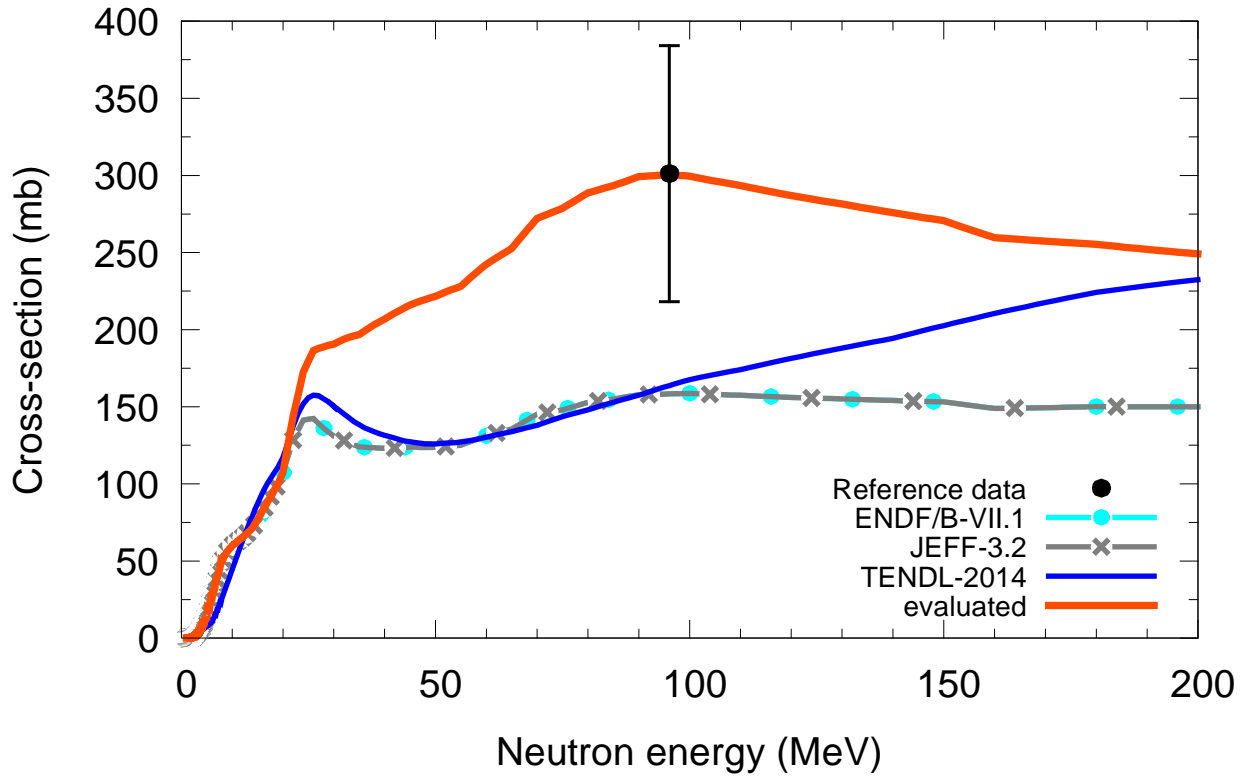
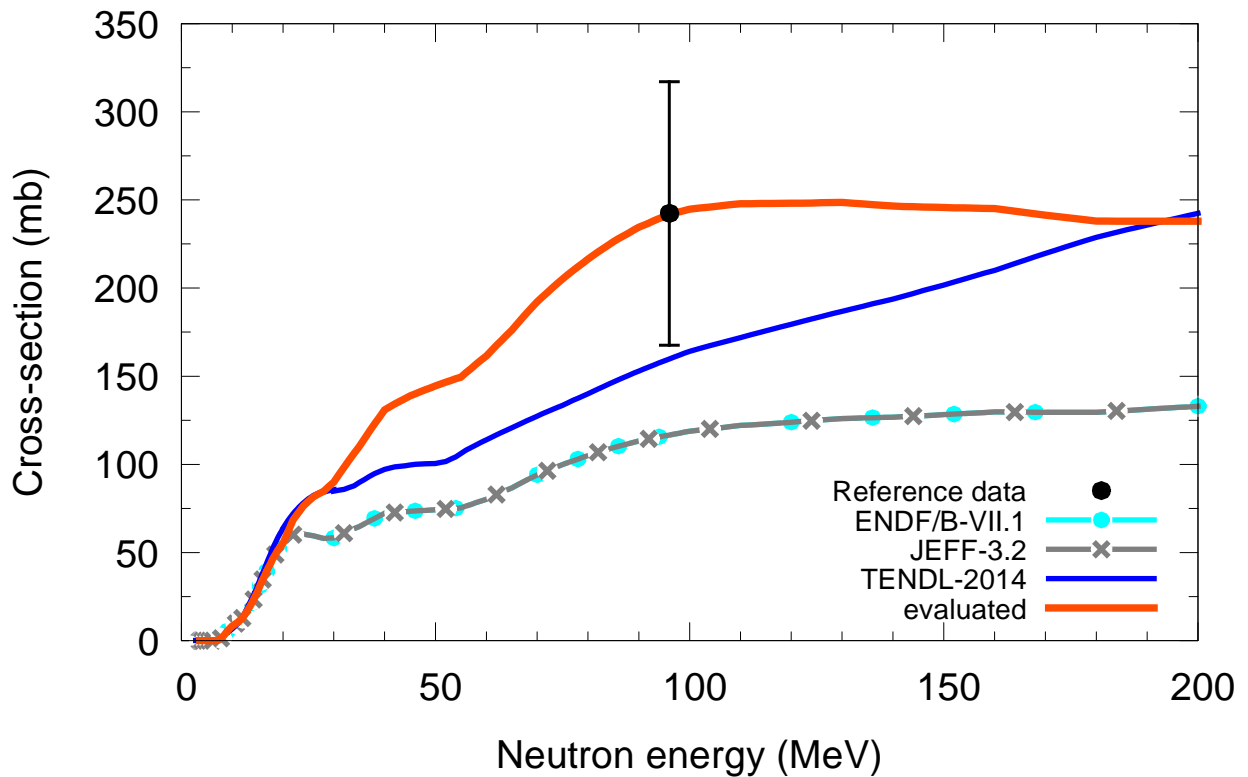


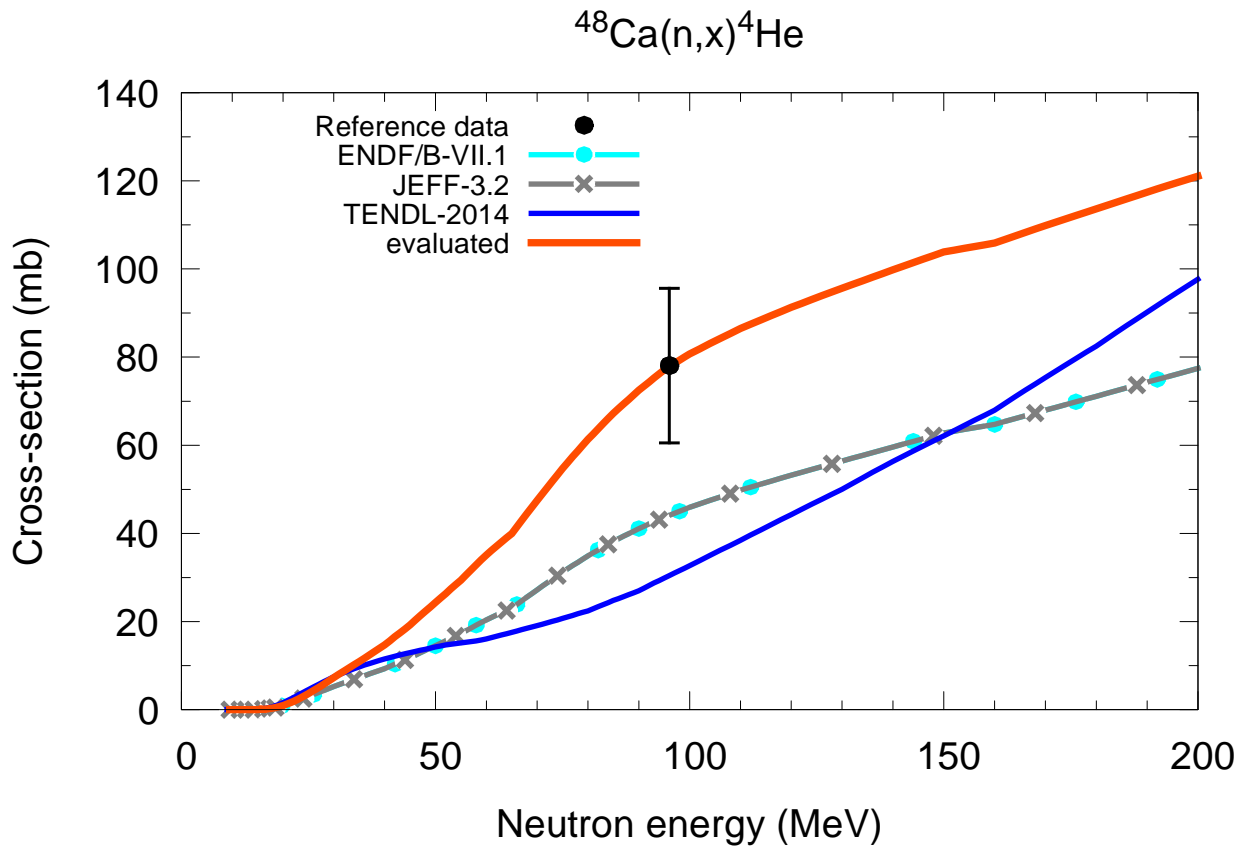
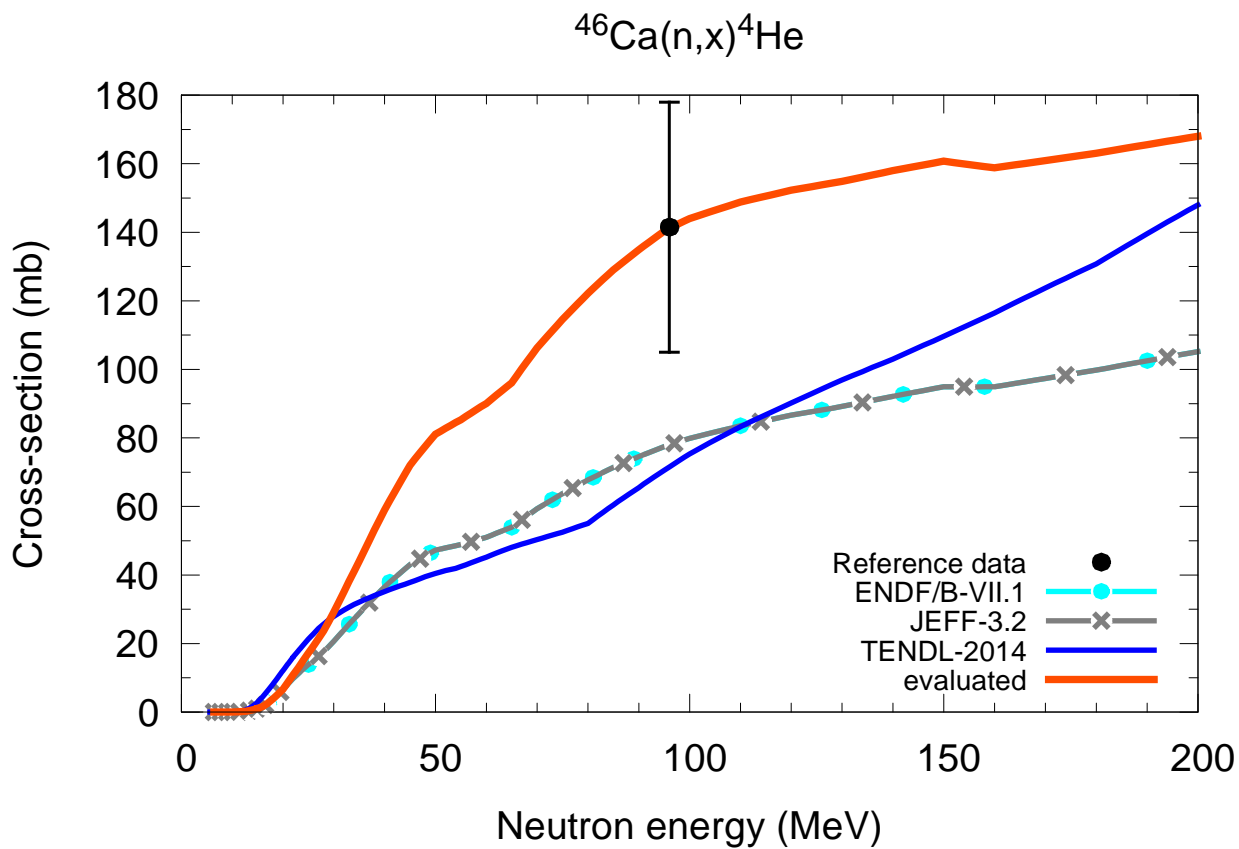
$^{36}\text{Ar}(n,x)^4\text{He}$  $^{38}\text{Ar}(n,x)^4\text{He}$ 

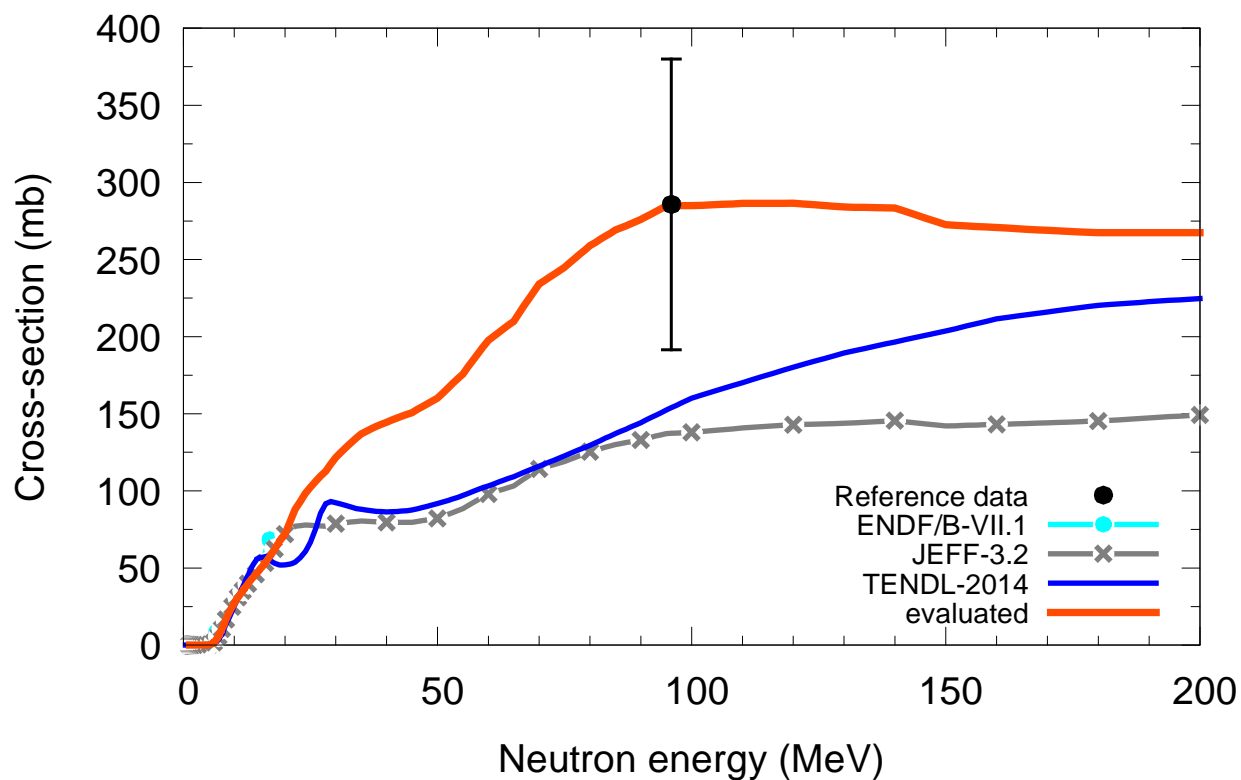
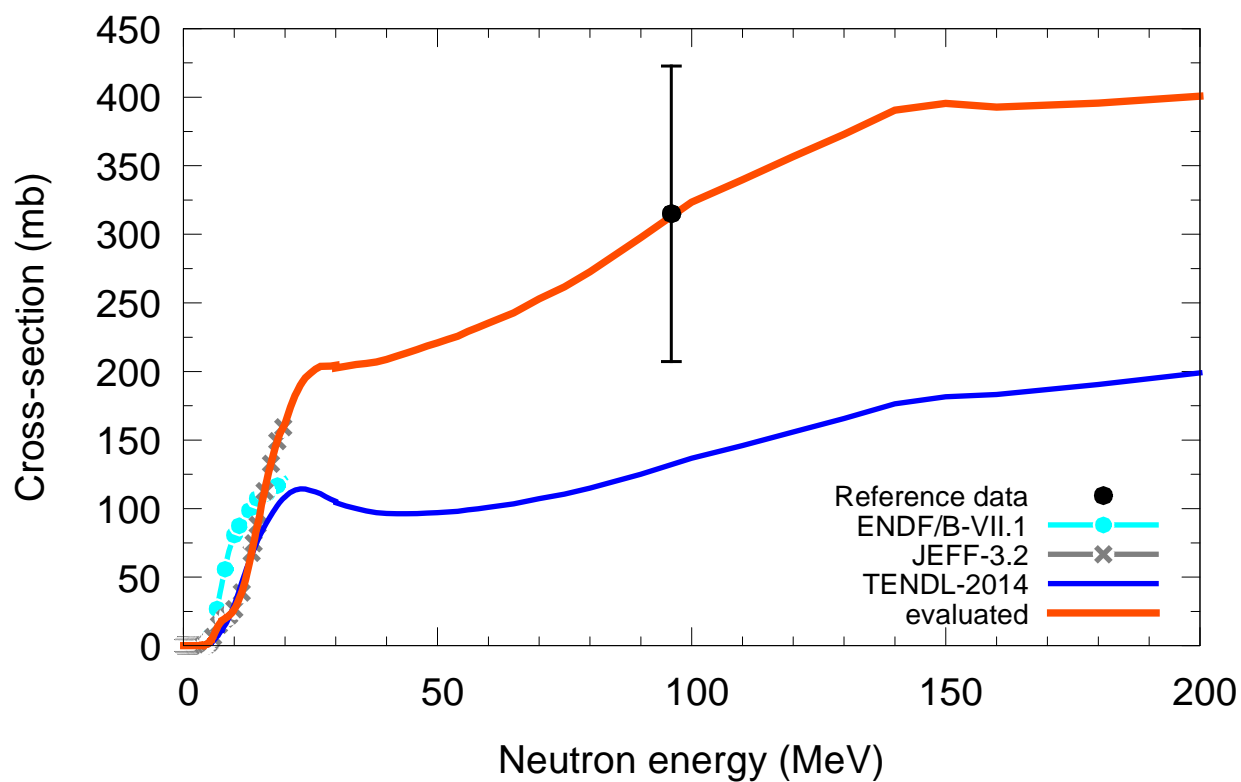
$^{40}\text{Ar}(n,x)^4\text{He}$  $^{39}\text{K}(n,x)^4\text{He}$ 

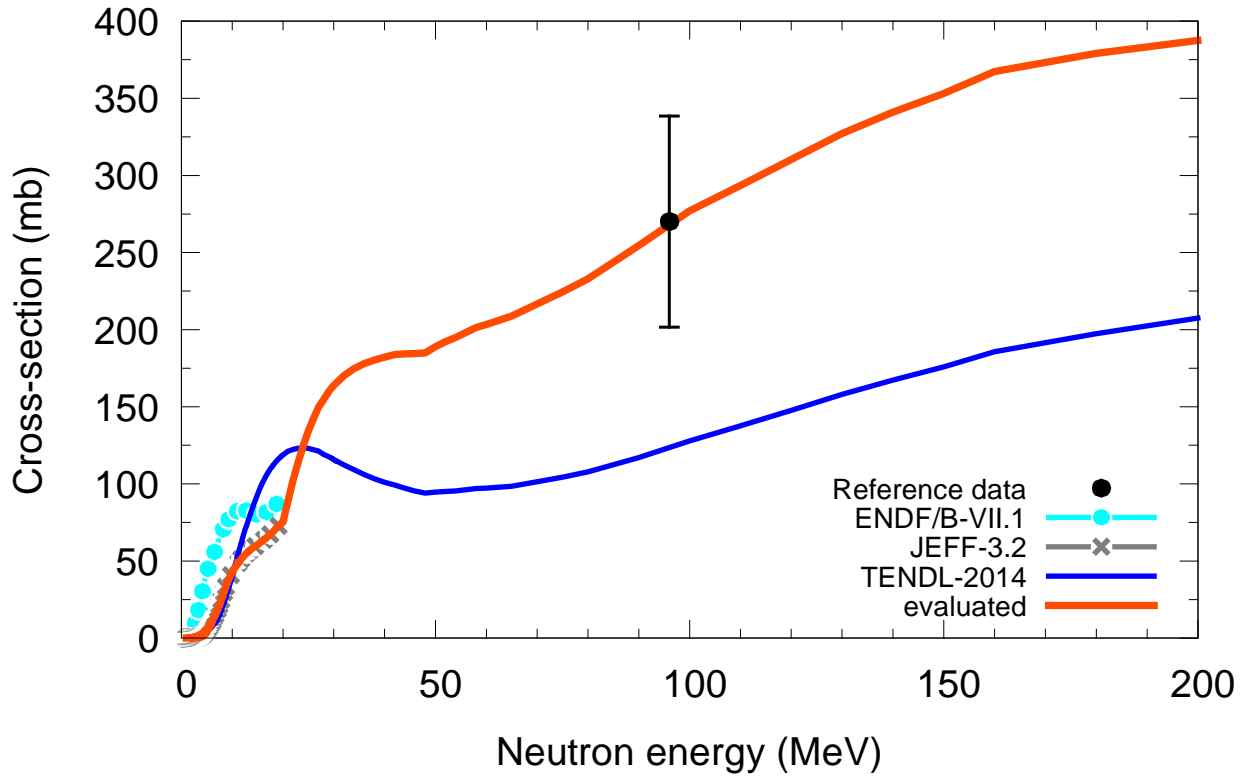
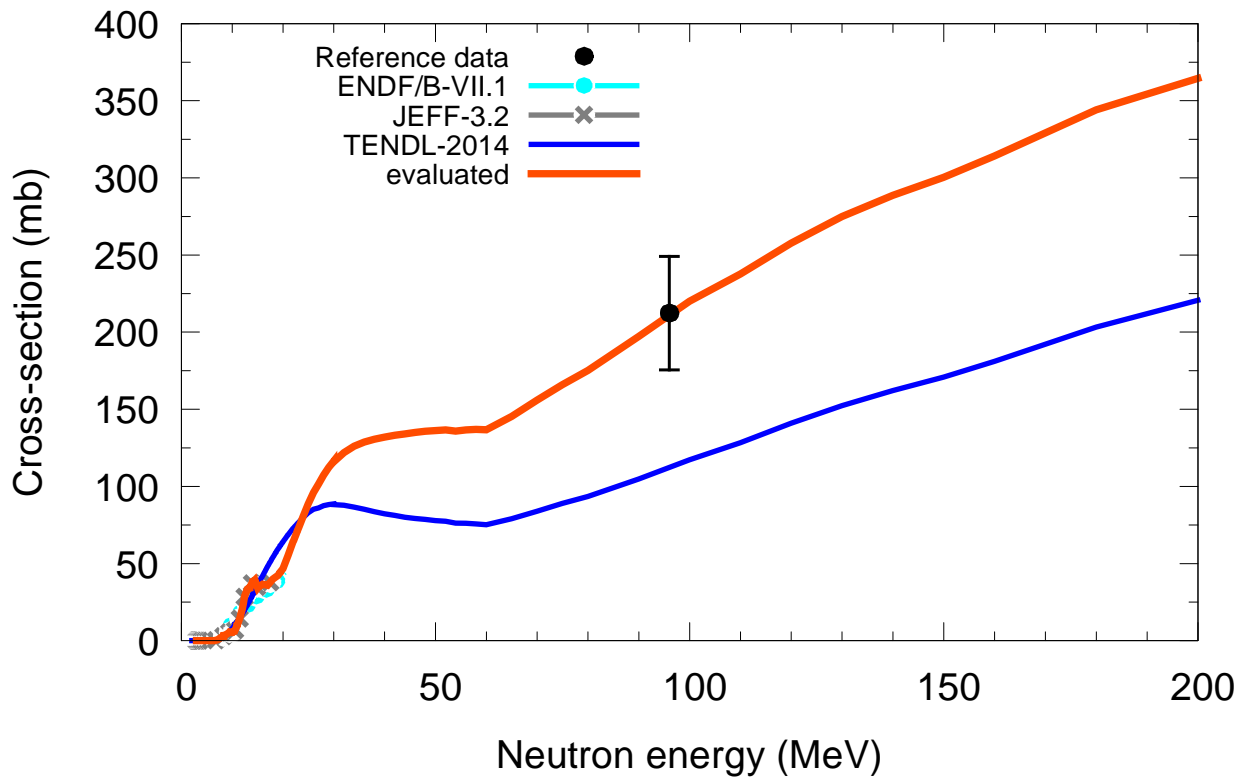
$^{40}\text{K}(n,x)^4\text{He}$  $^{41}\text{K}(n,x)^4\text{He}$ 

$^{40}\text{Ca}(n,x)^4\text{He}$  $^{42}\text{Ca}(n,x)^4\text{He}$ 

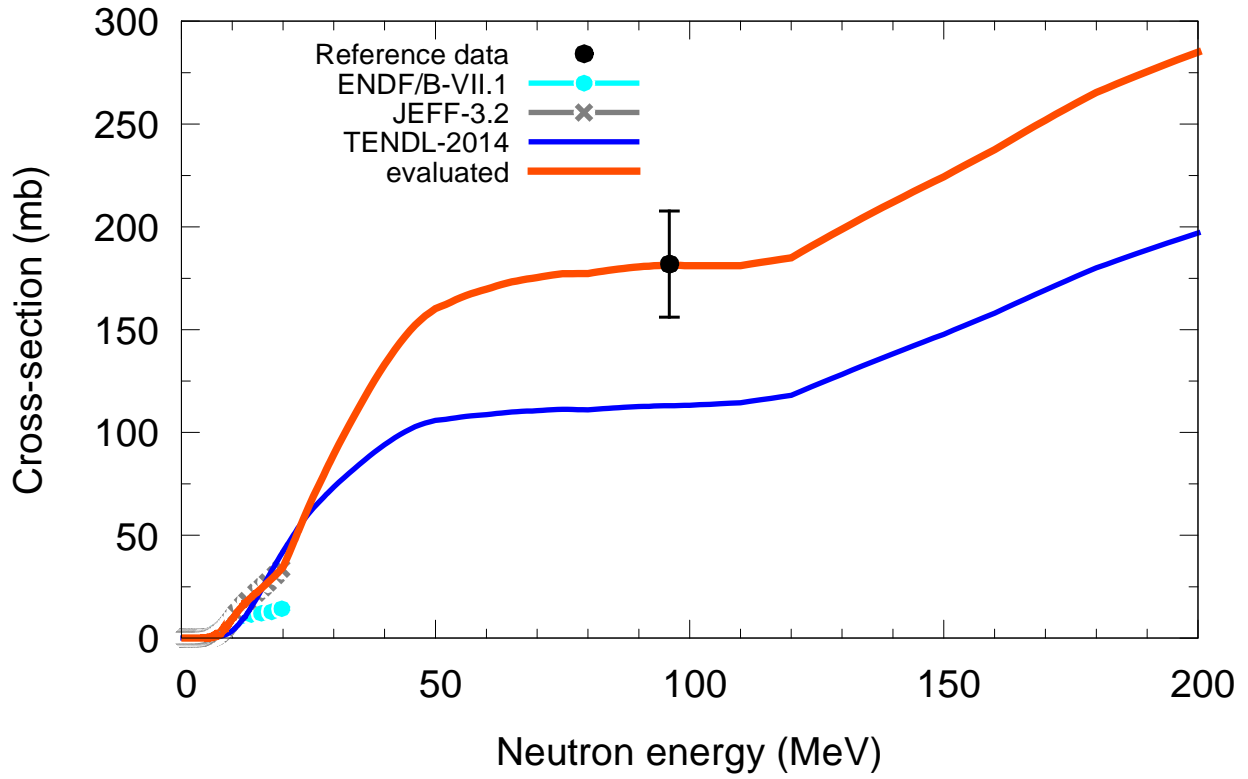
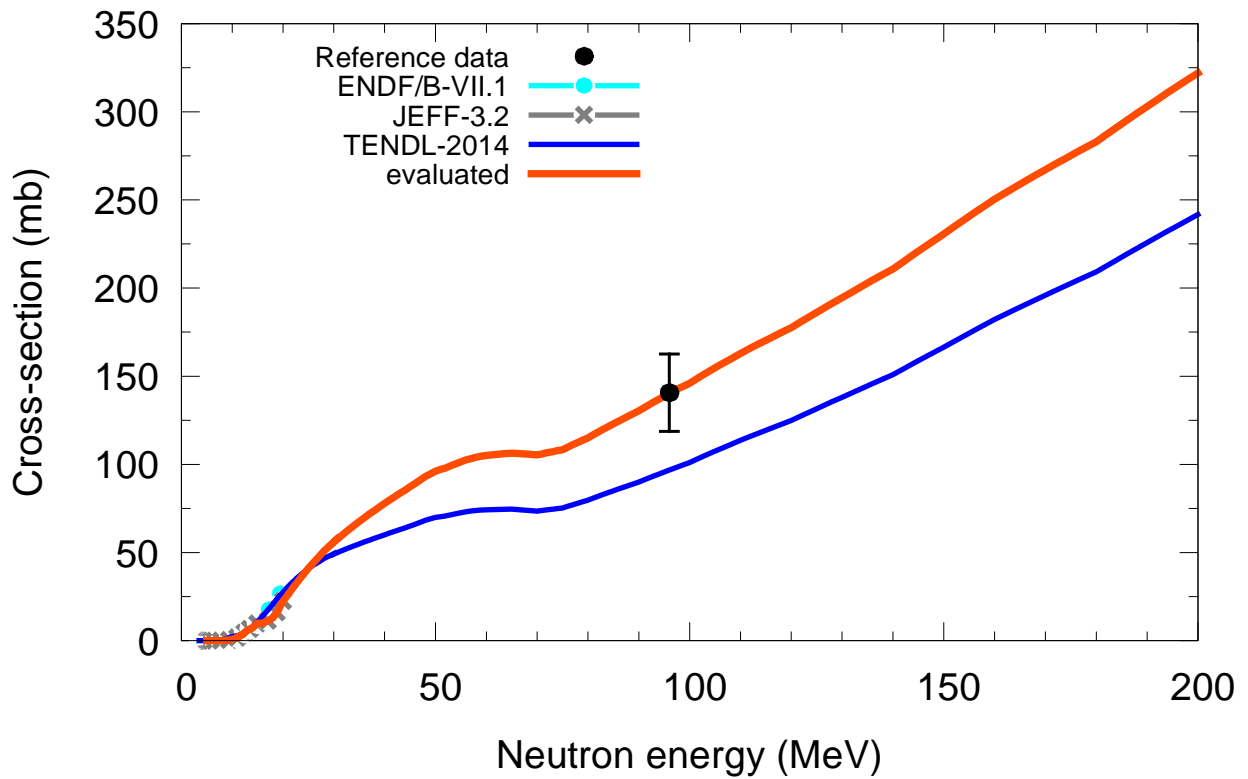
$^{43}\text{Ca}(n,x)^4\text{He}$  $^{44}\text{Ca}(n,x)^4\text{He}$ 



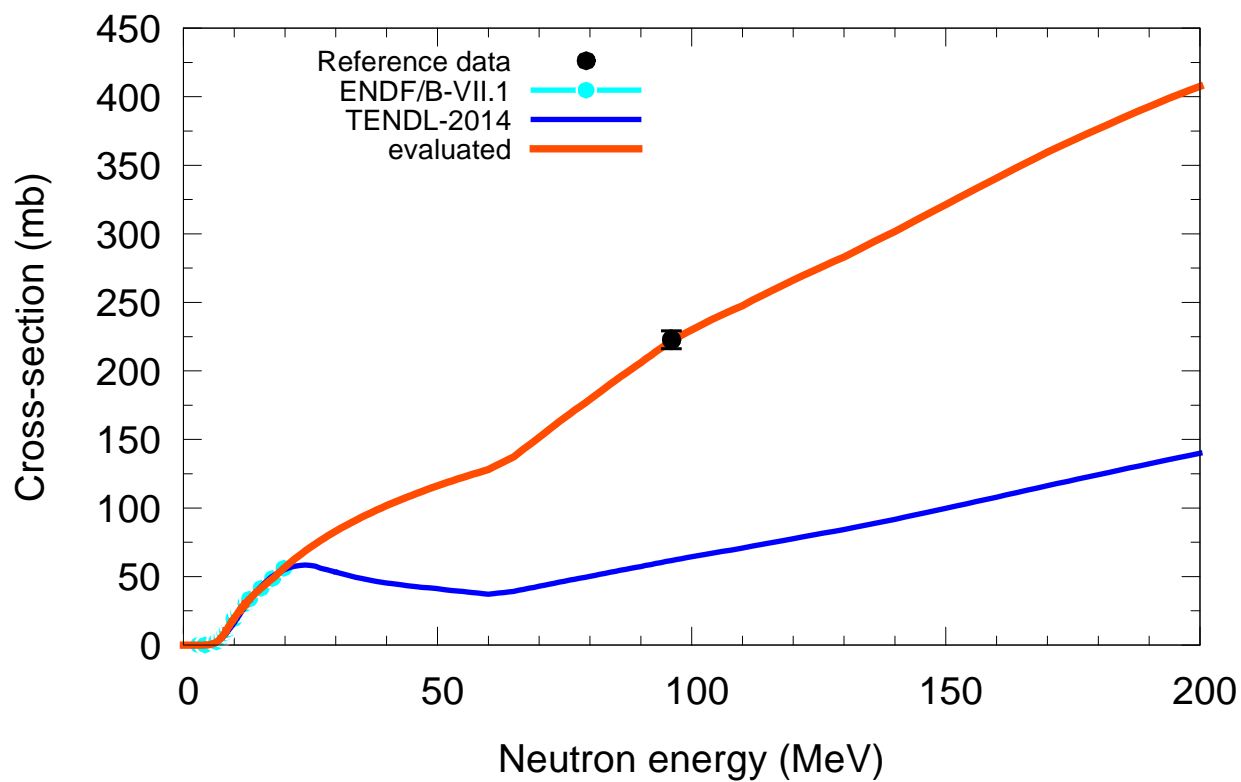
$^{45}\text{Sc}(n,x)^4\text{He}$  $^{46}\text{Ti}(n,x)^4\text{He}$ 

$^{47}\text{Ti}(n,x)^4\text{He}$  $^{48}\text{Ti}(n,x)^4\text{He}$ 

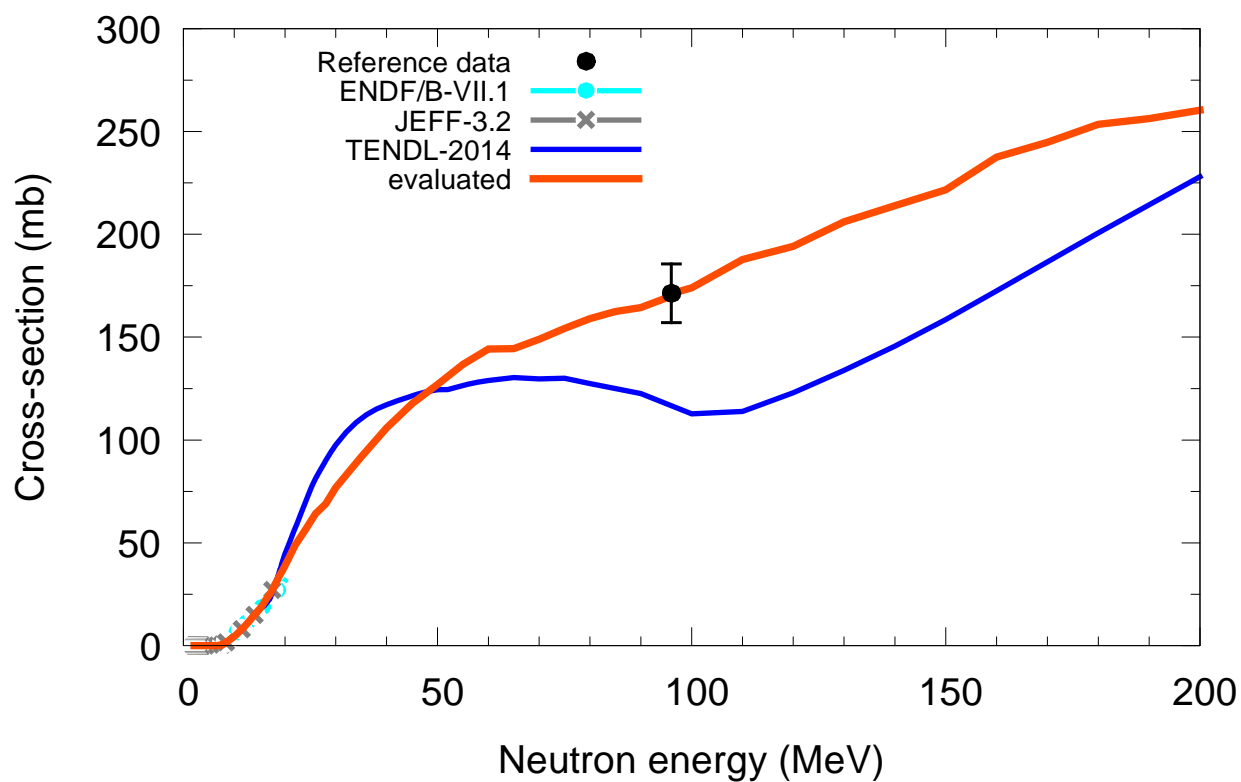


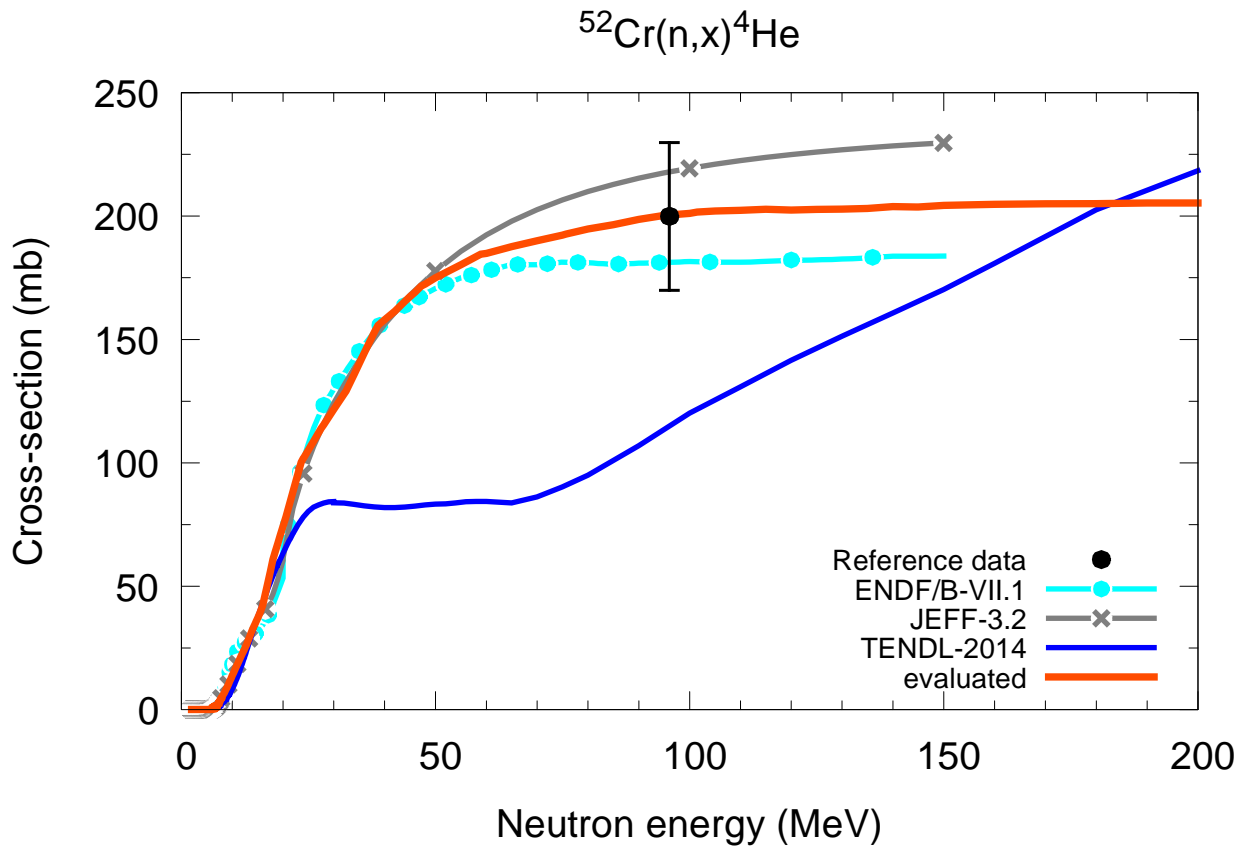
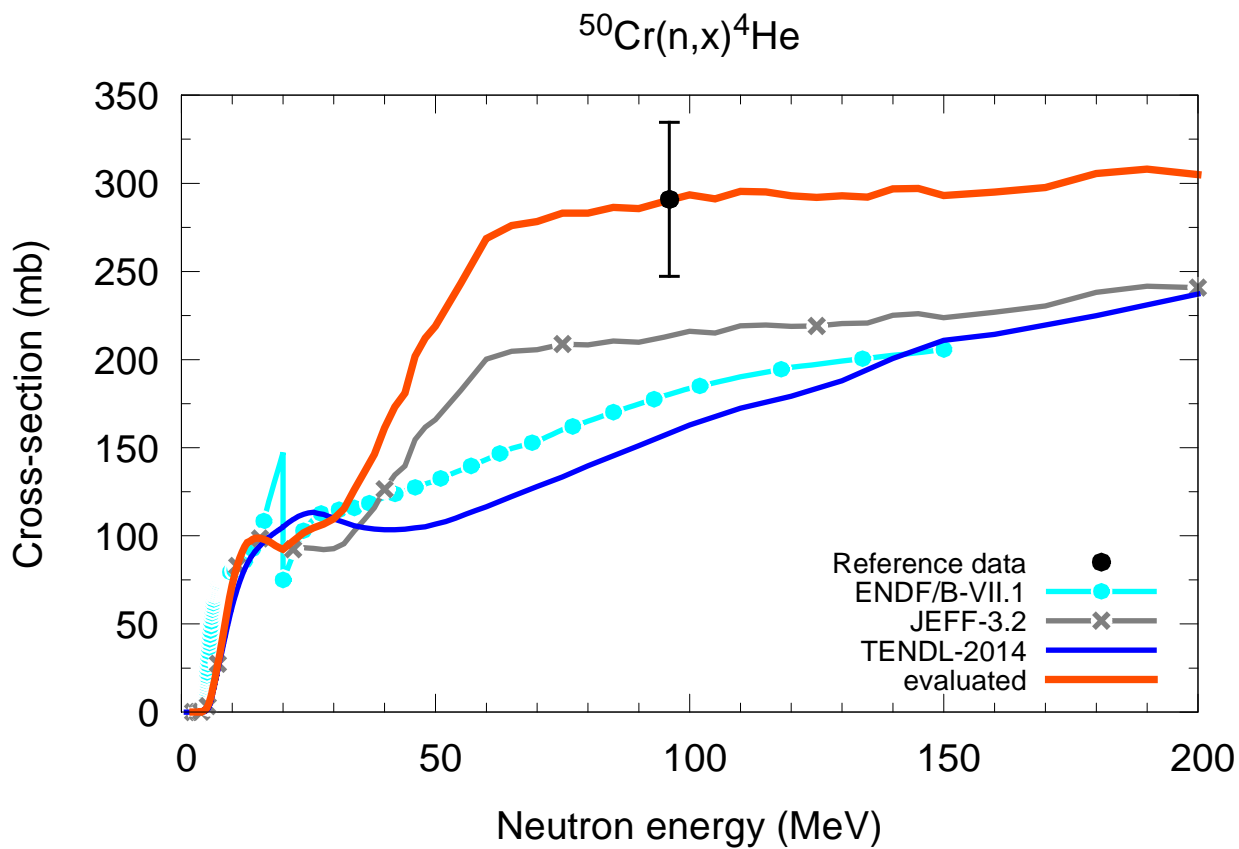
$^{49}\text{Ti}(n,x)^4\text{He}$  $^{50}\text{Ti}(n,x)^4\text{He}$ 

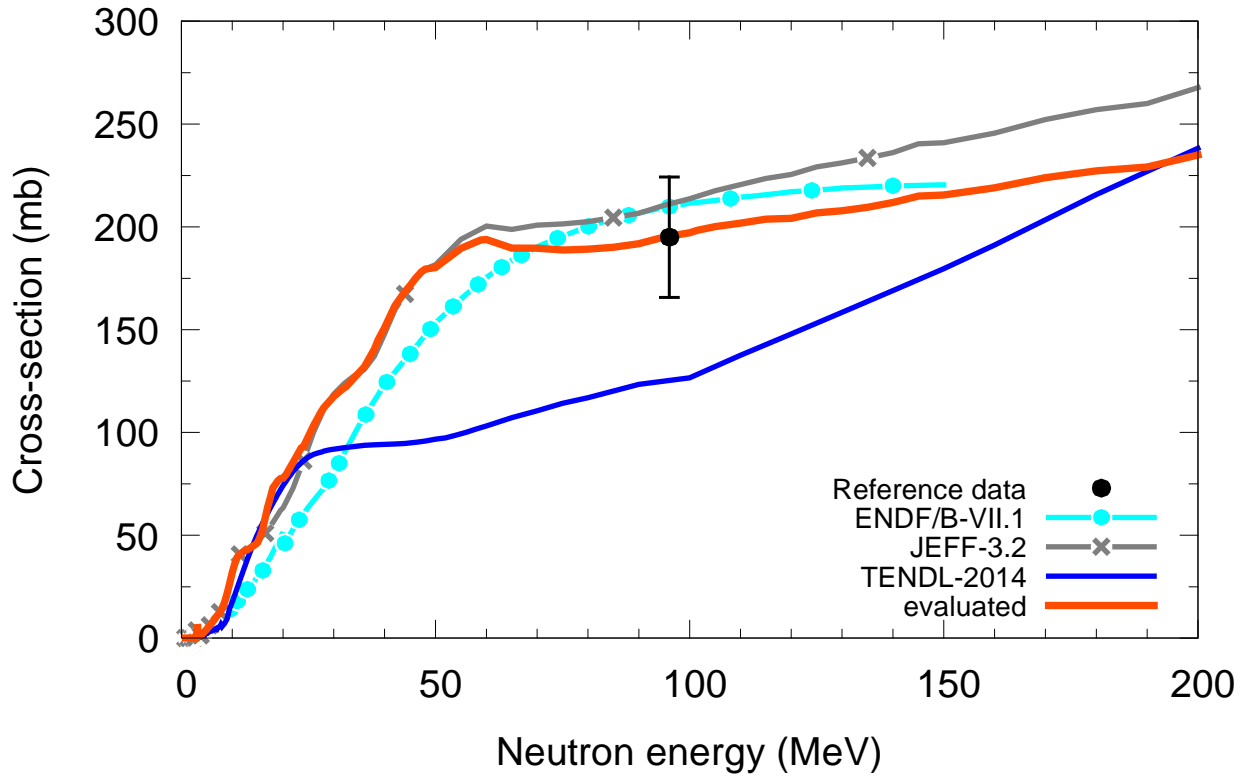
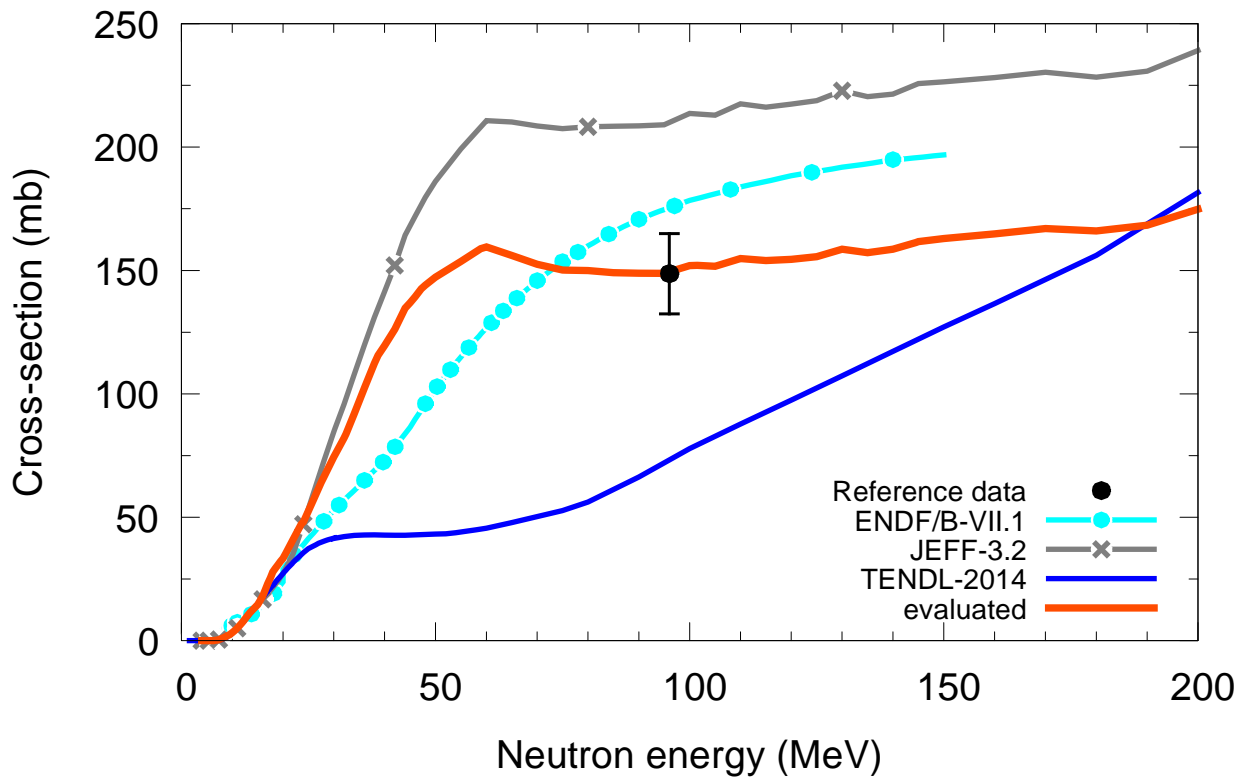
$^{50}\text{V}(n,x)^4\text{He}$

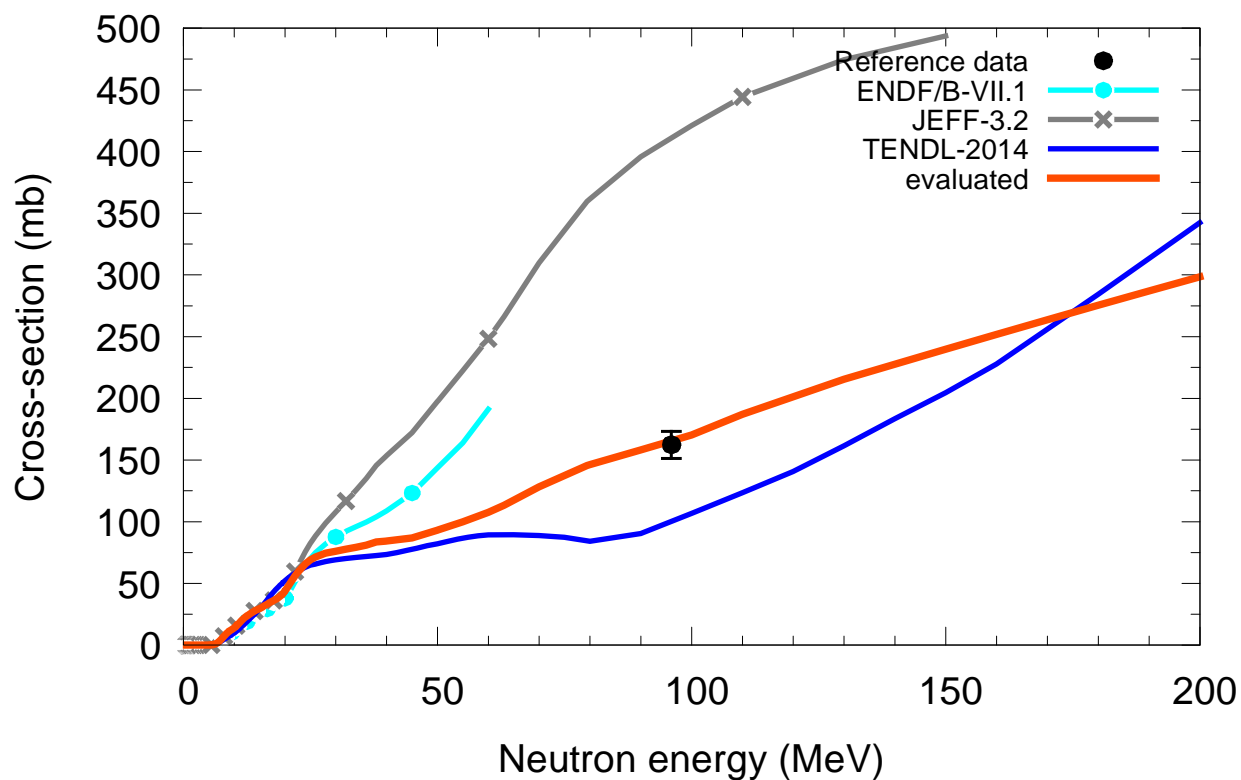
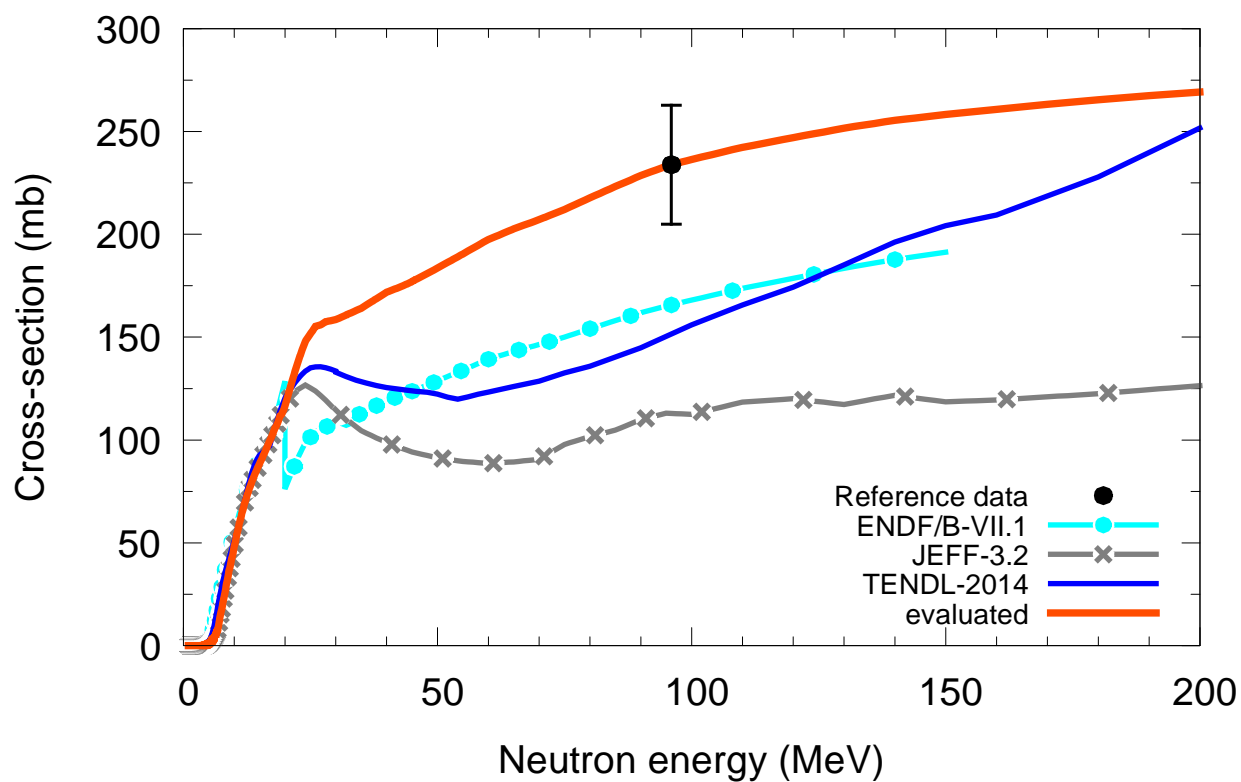


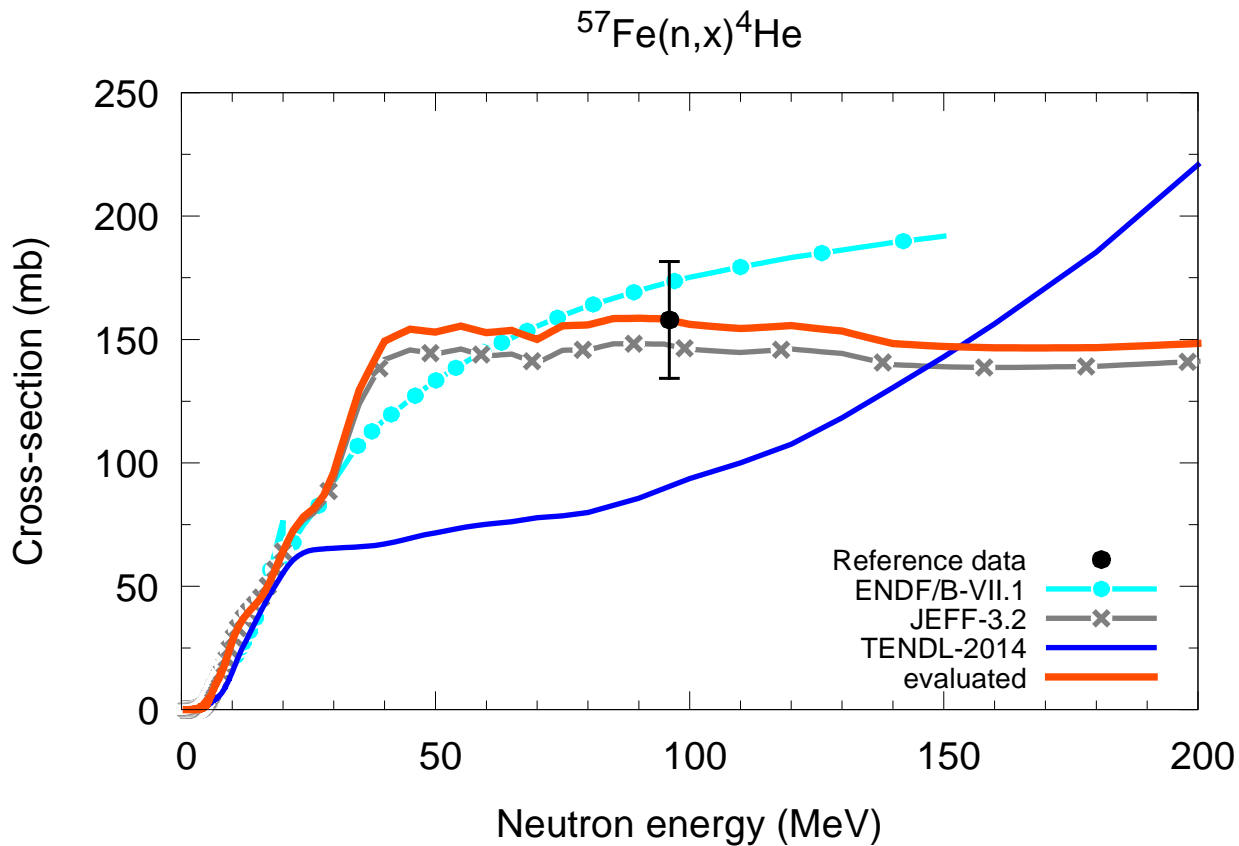
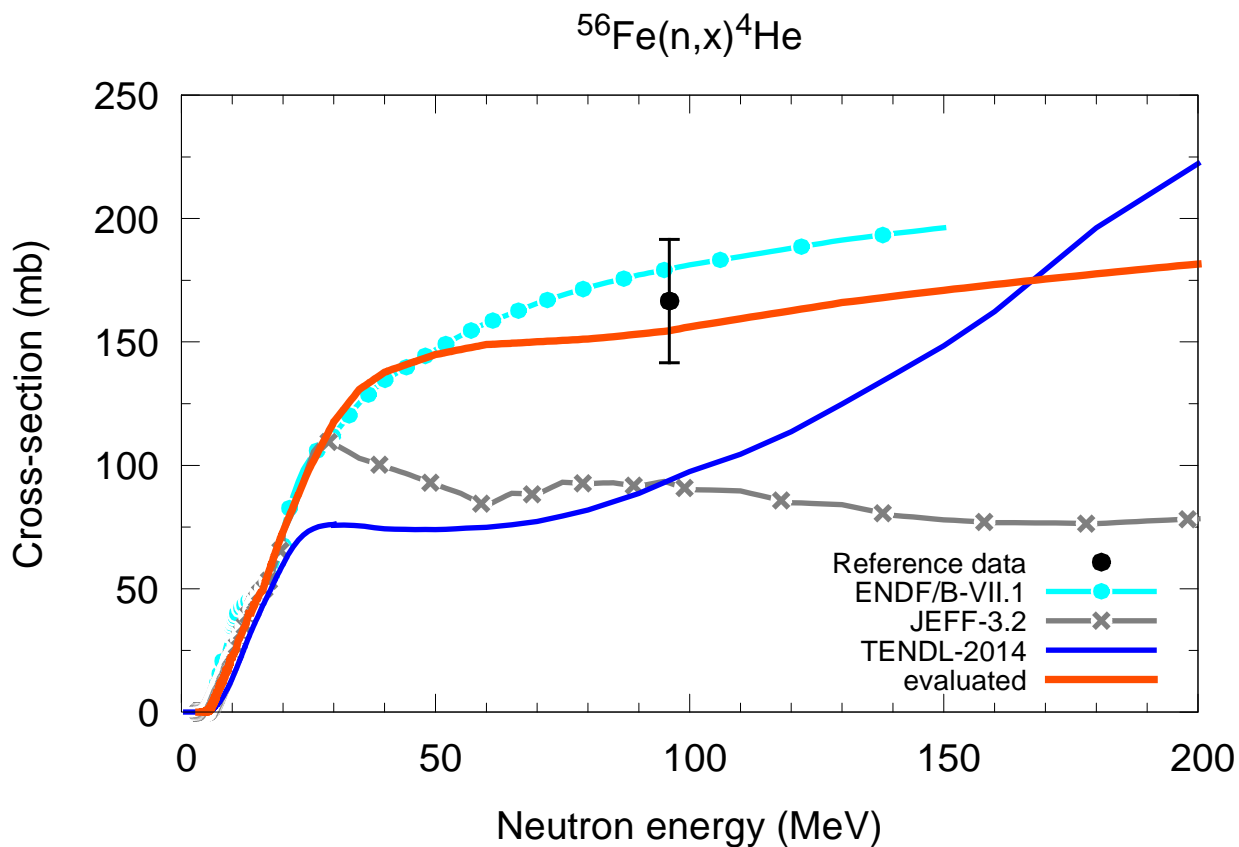
$^{51}\text{V}(n,x)^4\text{He}$

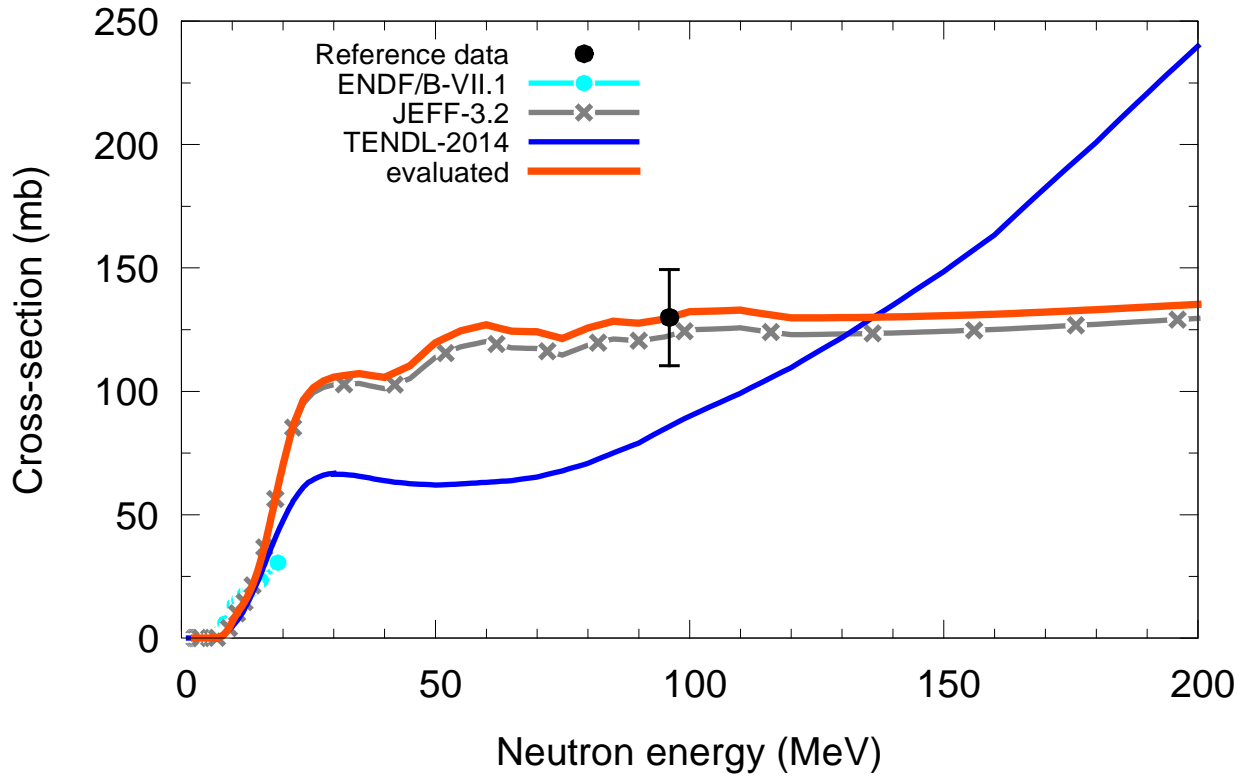
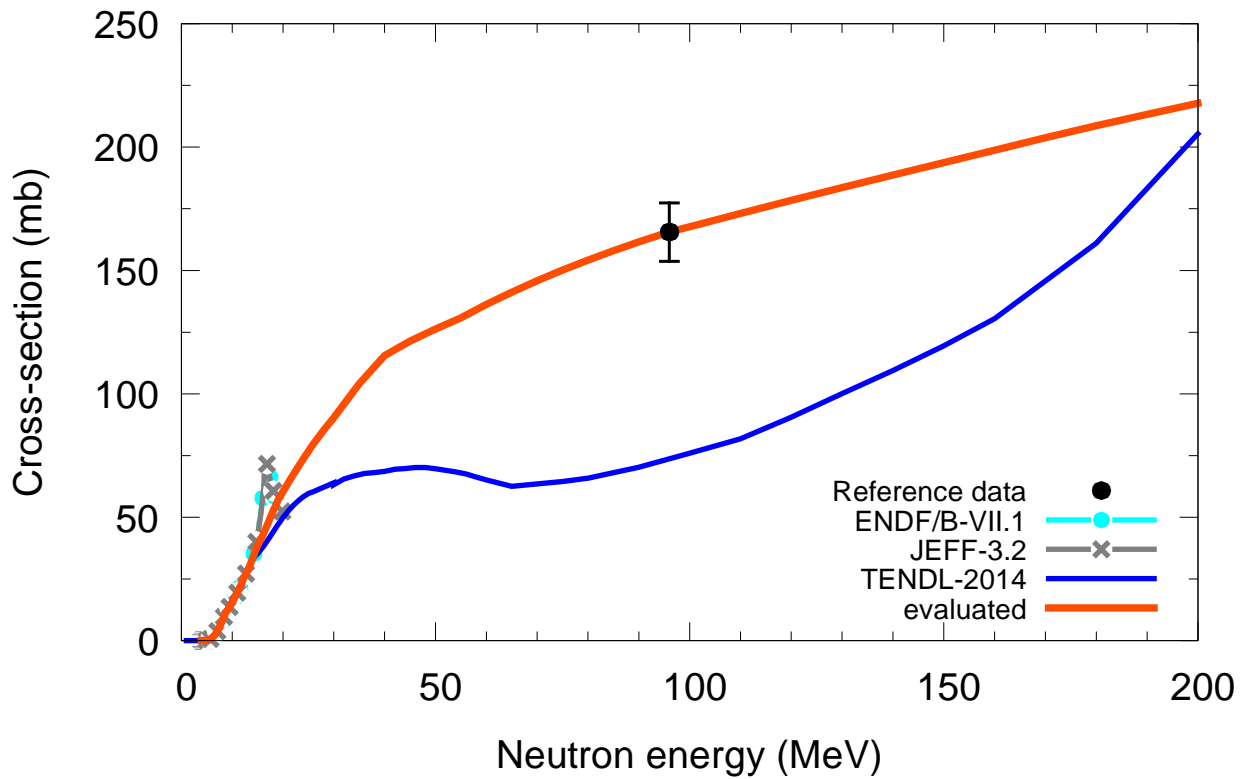


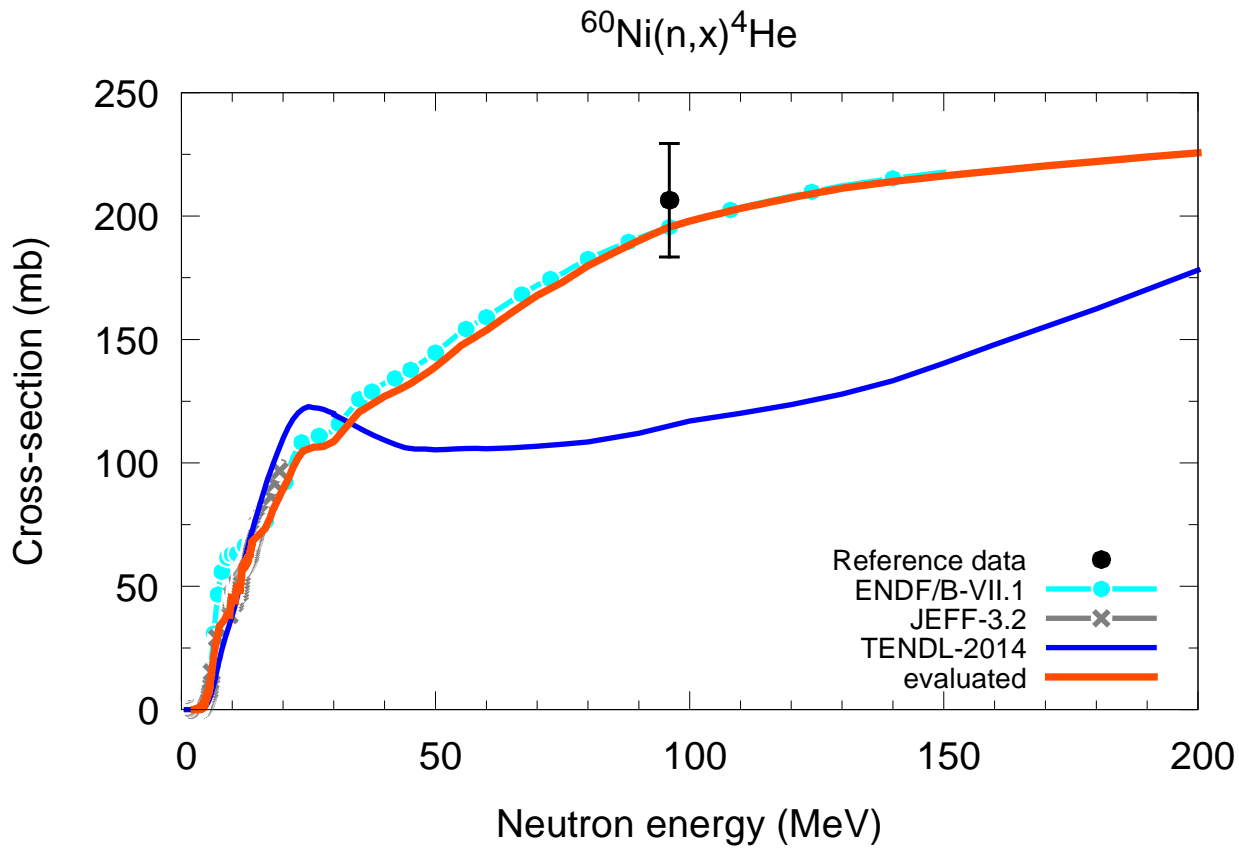
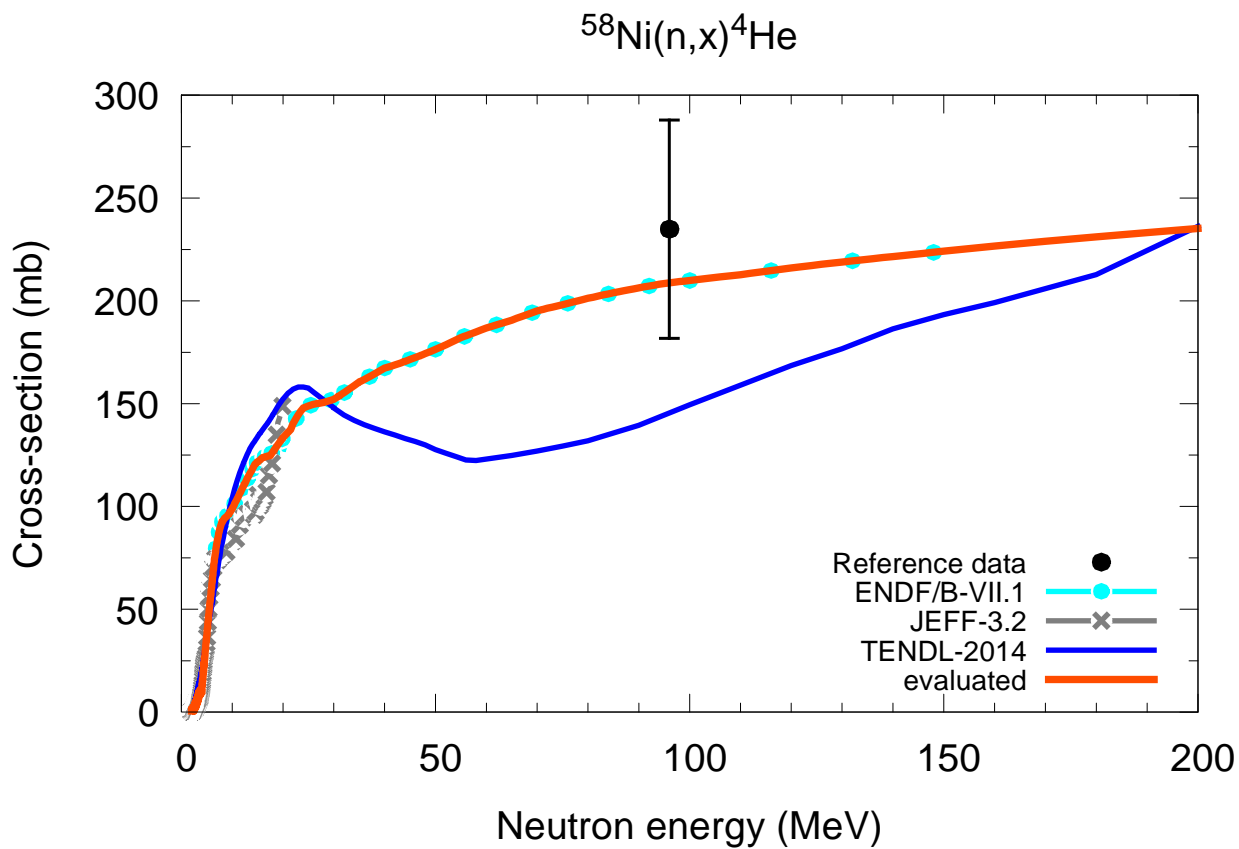


$^{53}\text{Cr}(n,x)^4\text{He}$  $^{54}\text{Cr}(n,x)^4\text{He}$ 

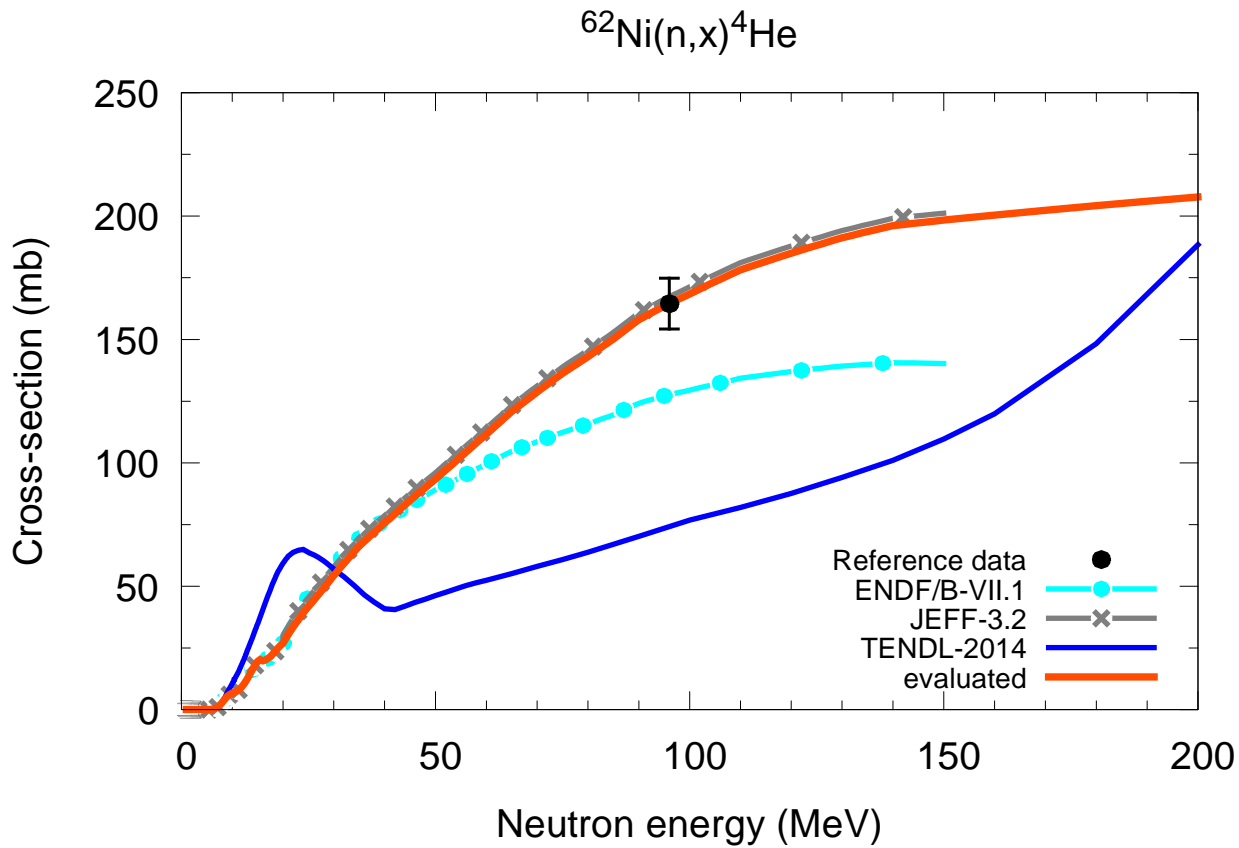
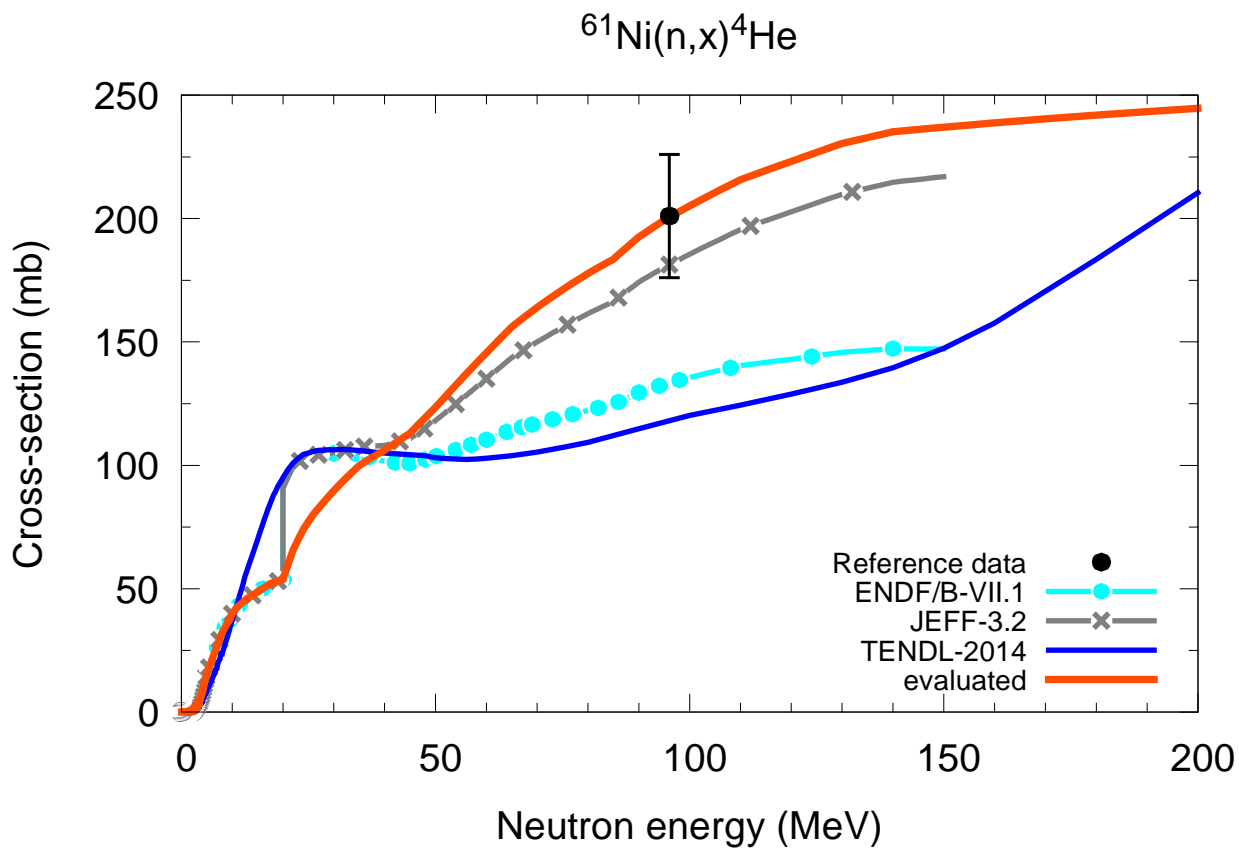
$^{55}\text{Mn}(n,x)^4\text{He}$  $^{54}\text{Fe}(n,x)^4\text{He}$ 



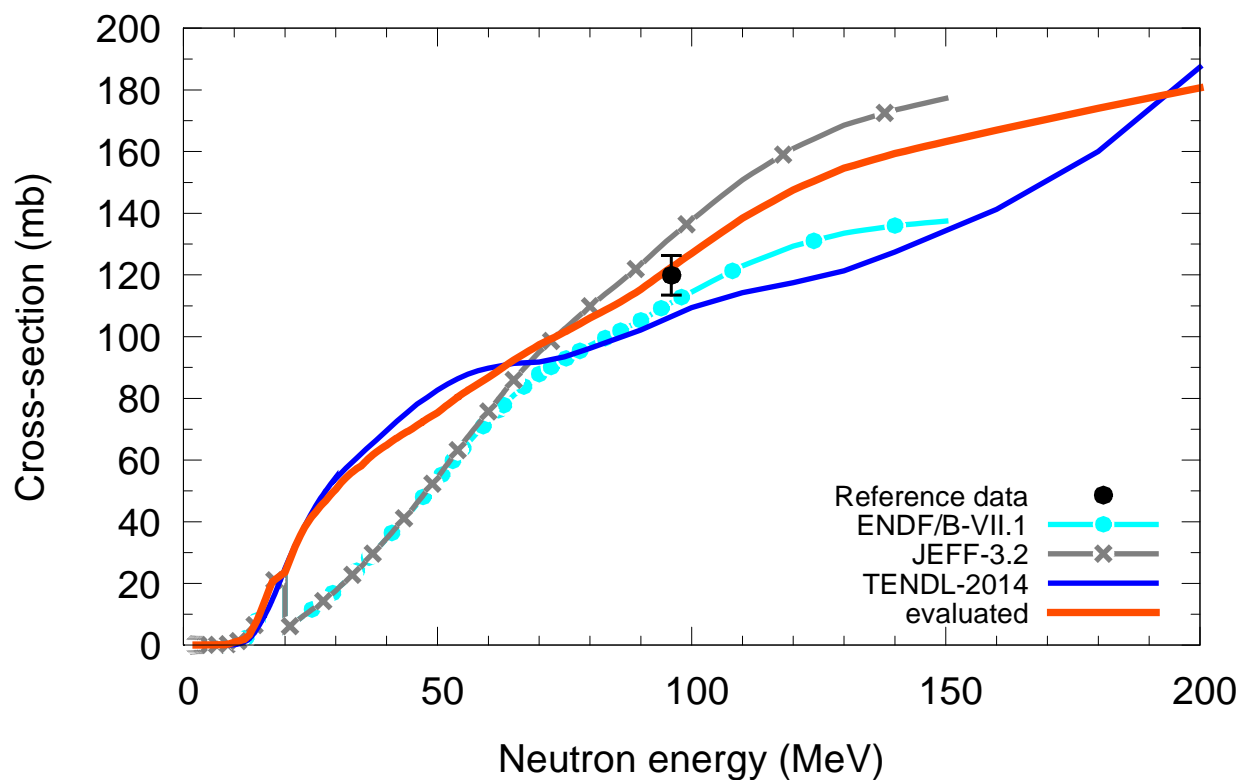
$^{58}\text{Fe}(n,x)^4\text{He}$  $^{59}\text{Co}(n,x)^4\text{He}$ 



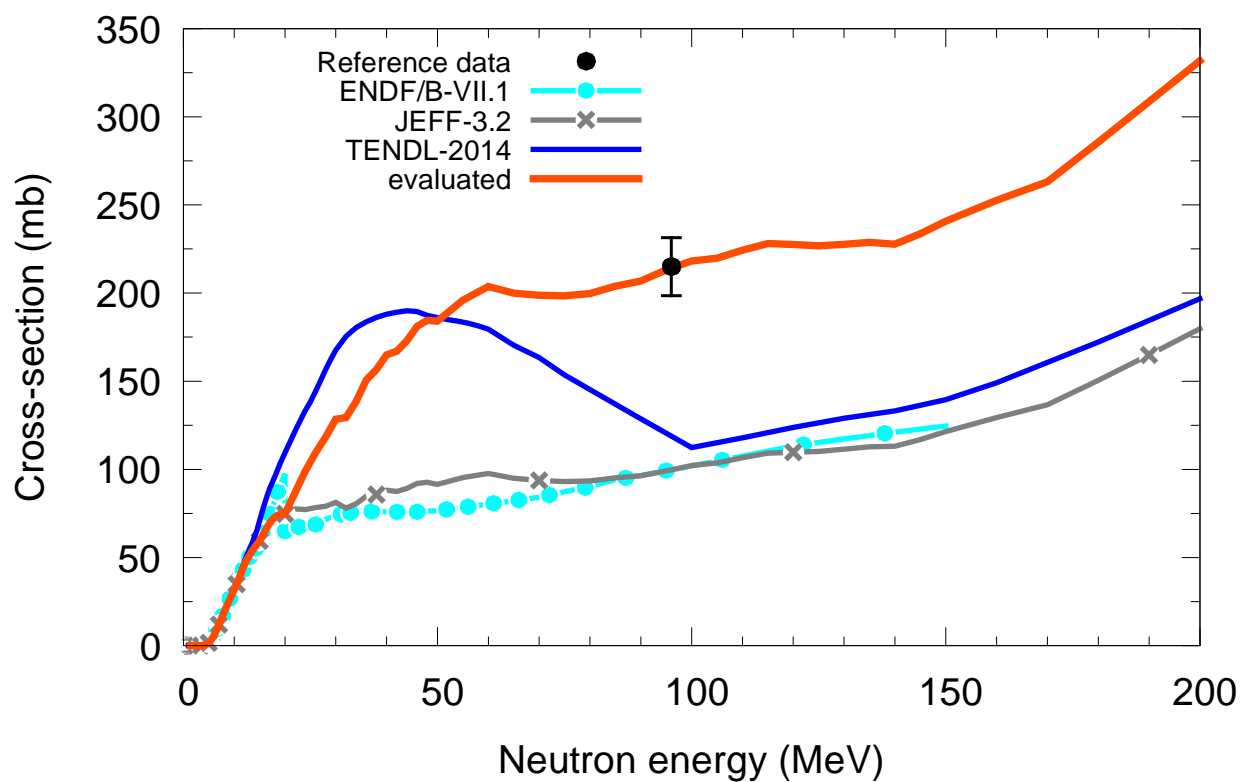


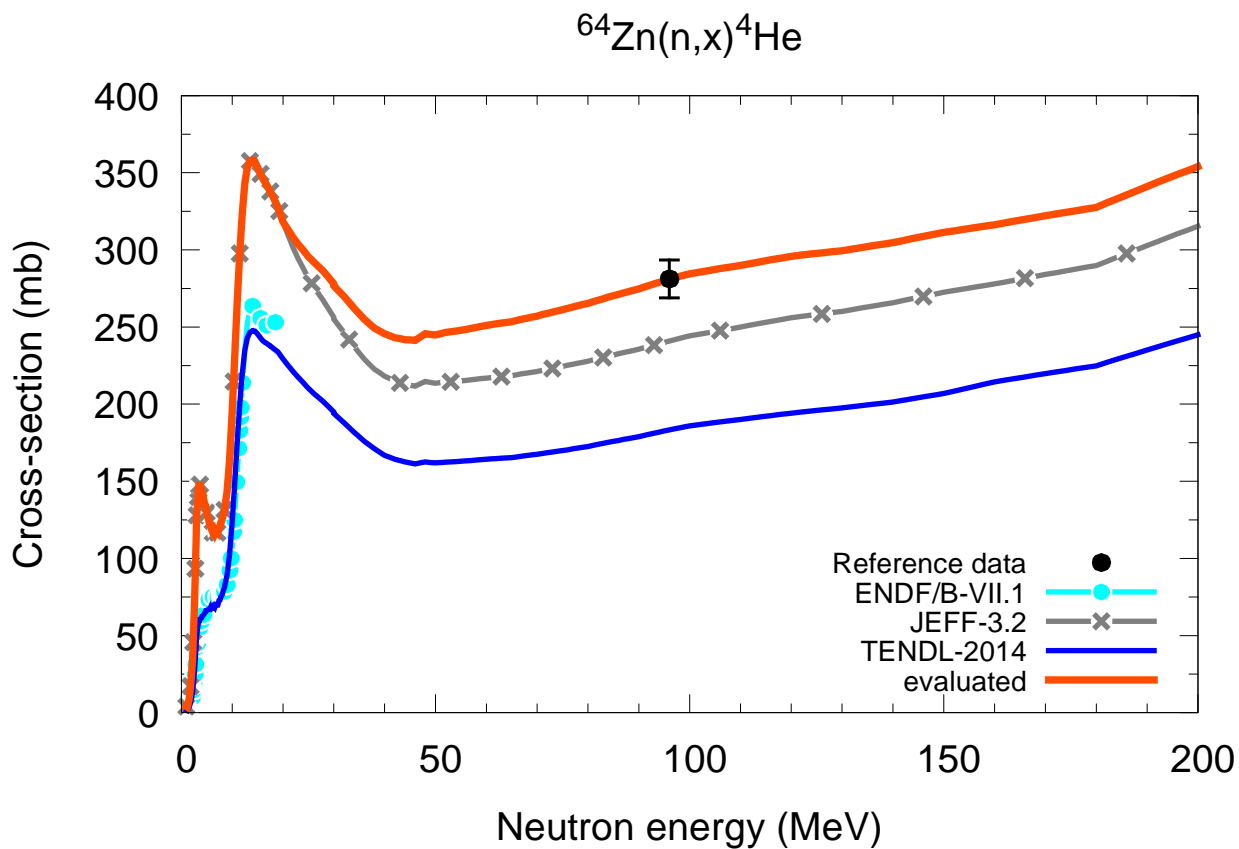
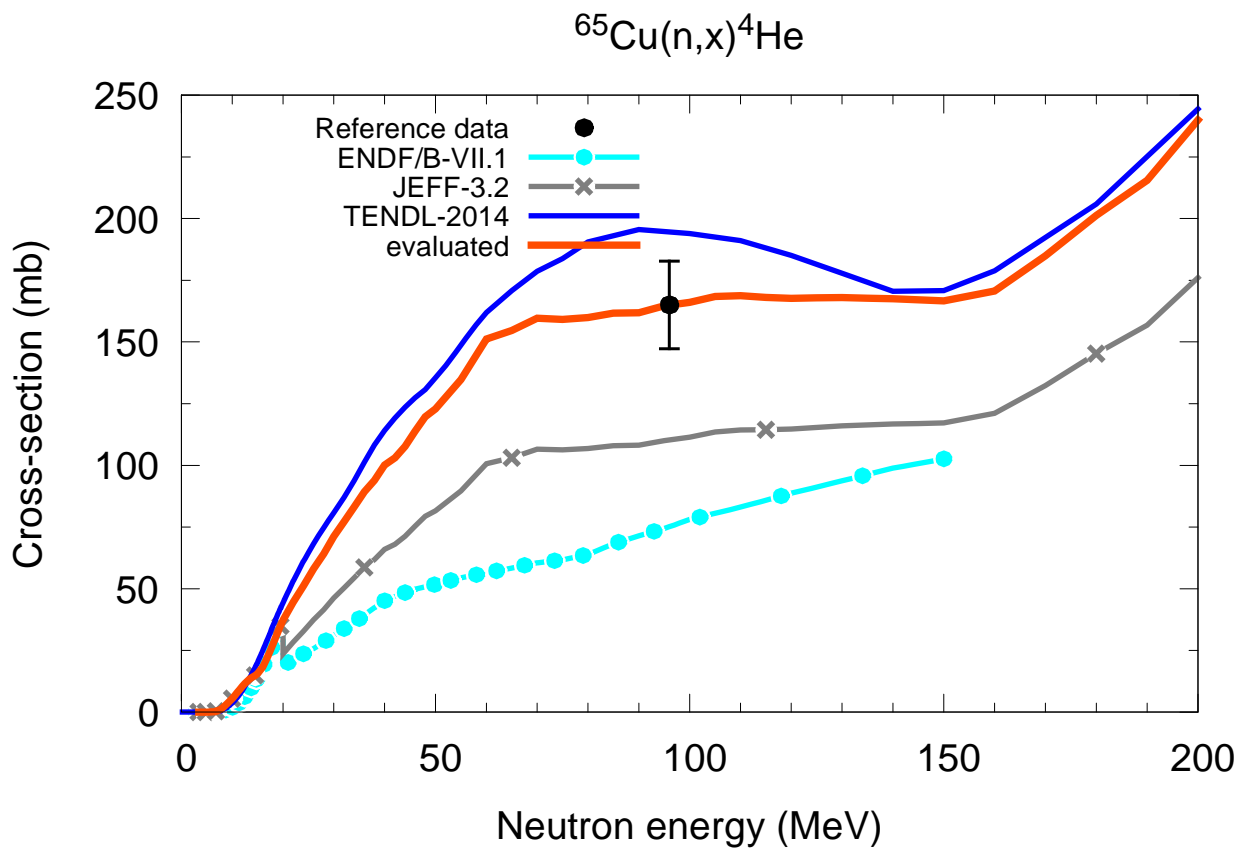


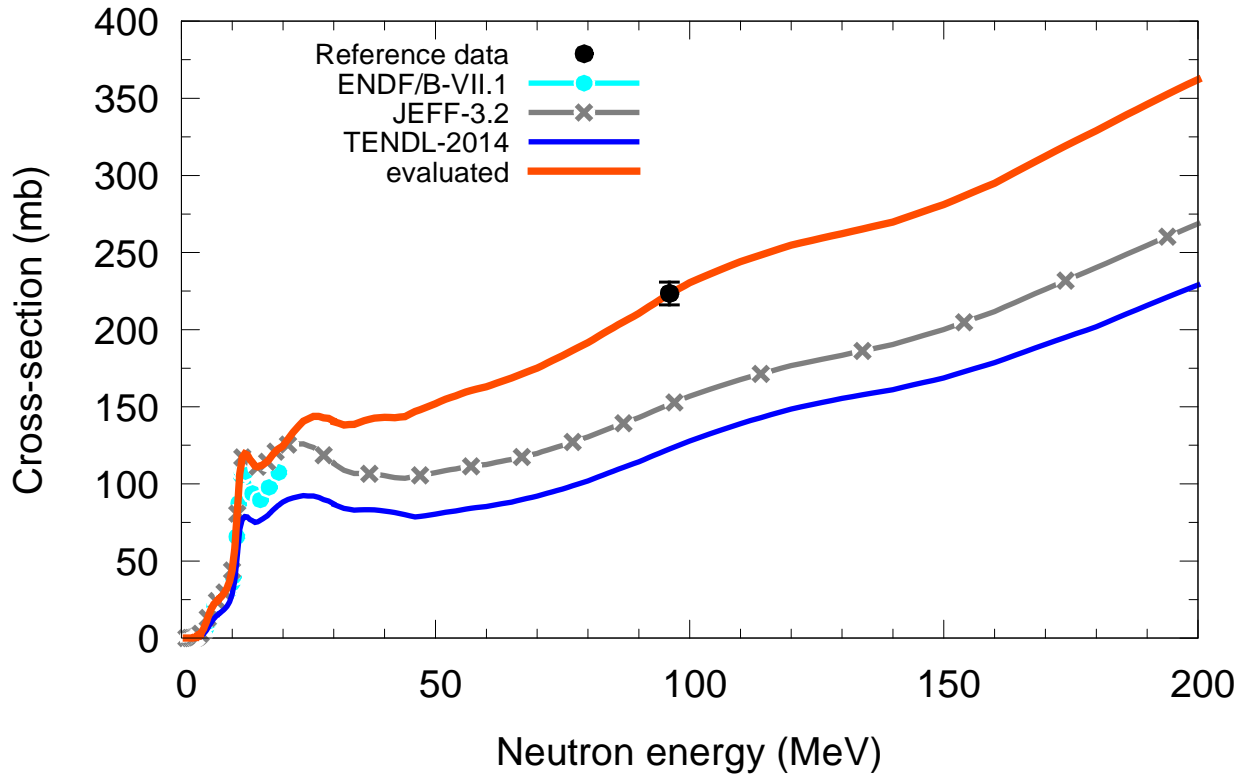
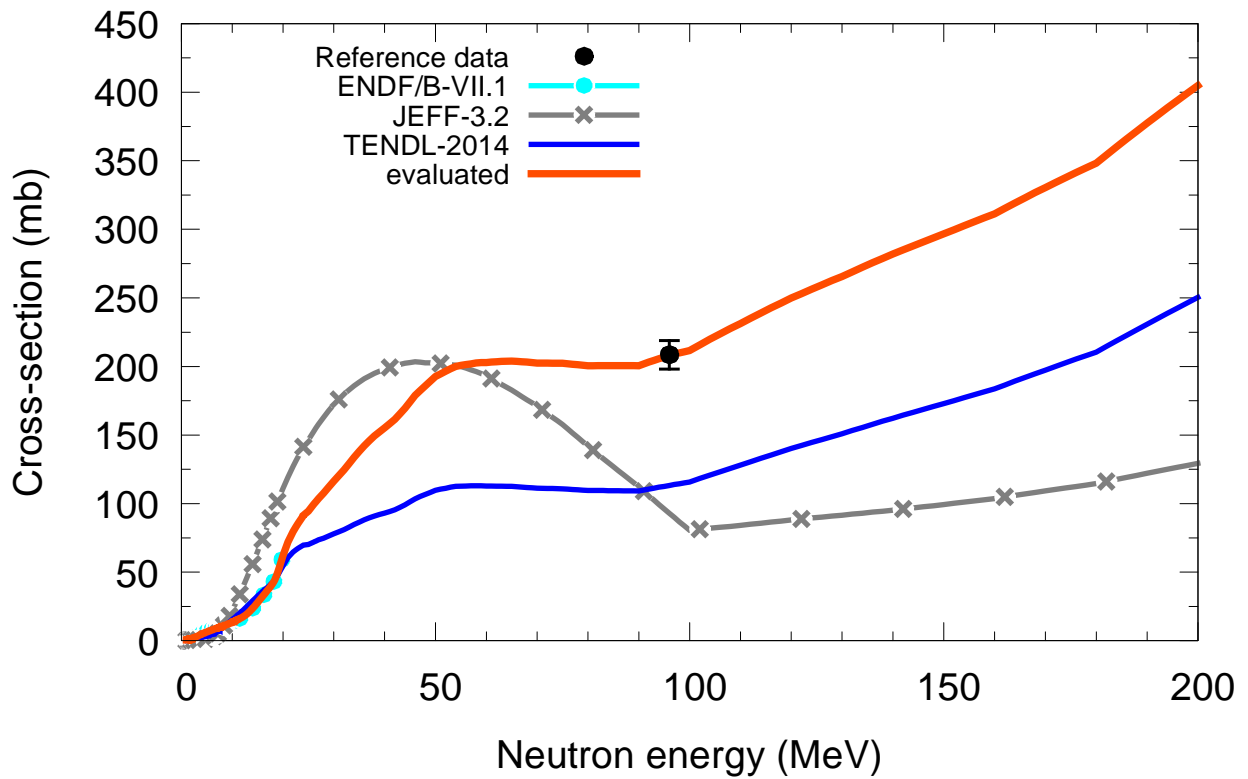
$^{64}\text{Ni}(n,x)^4\text{He}$

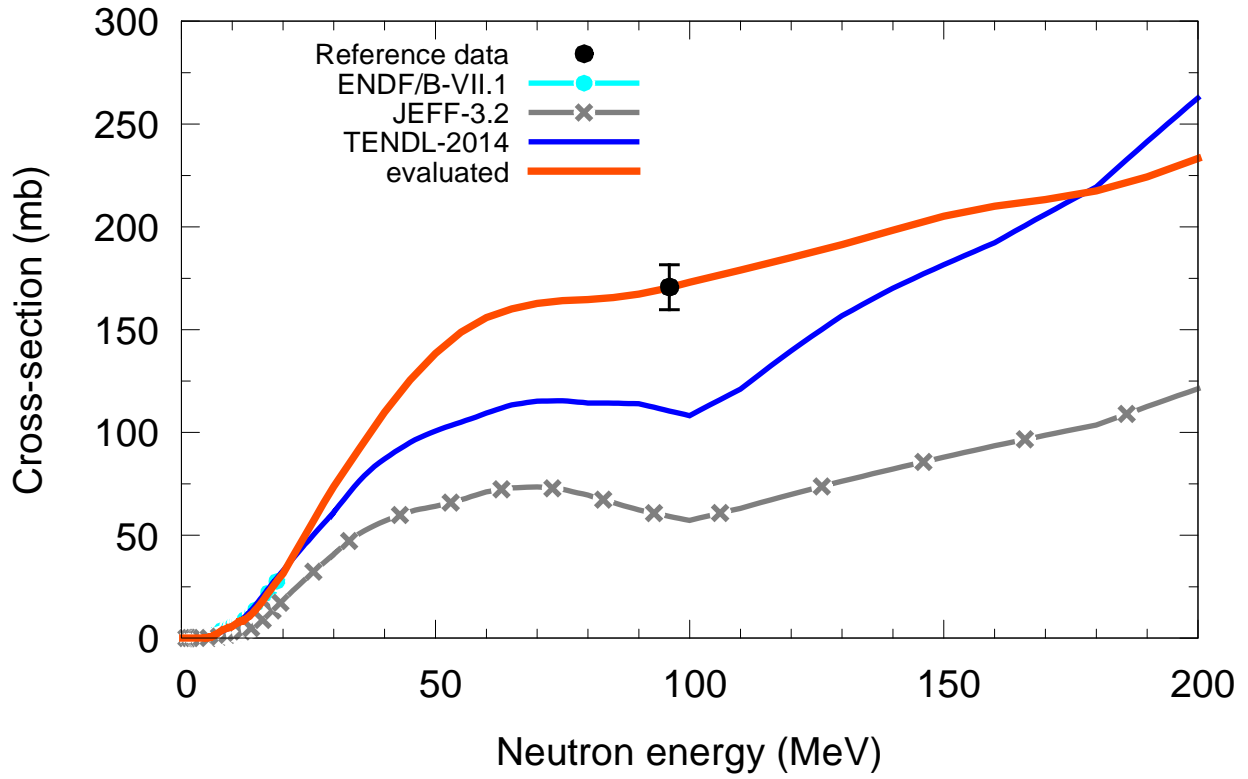
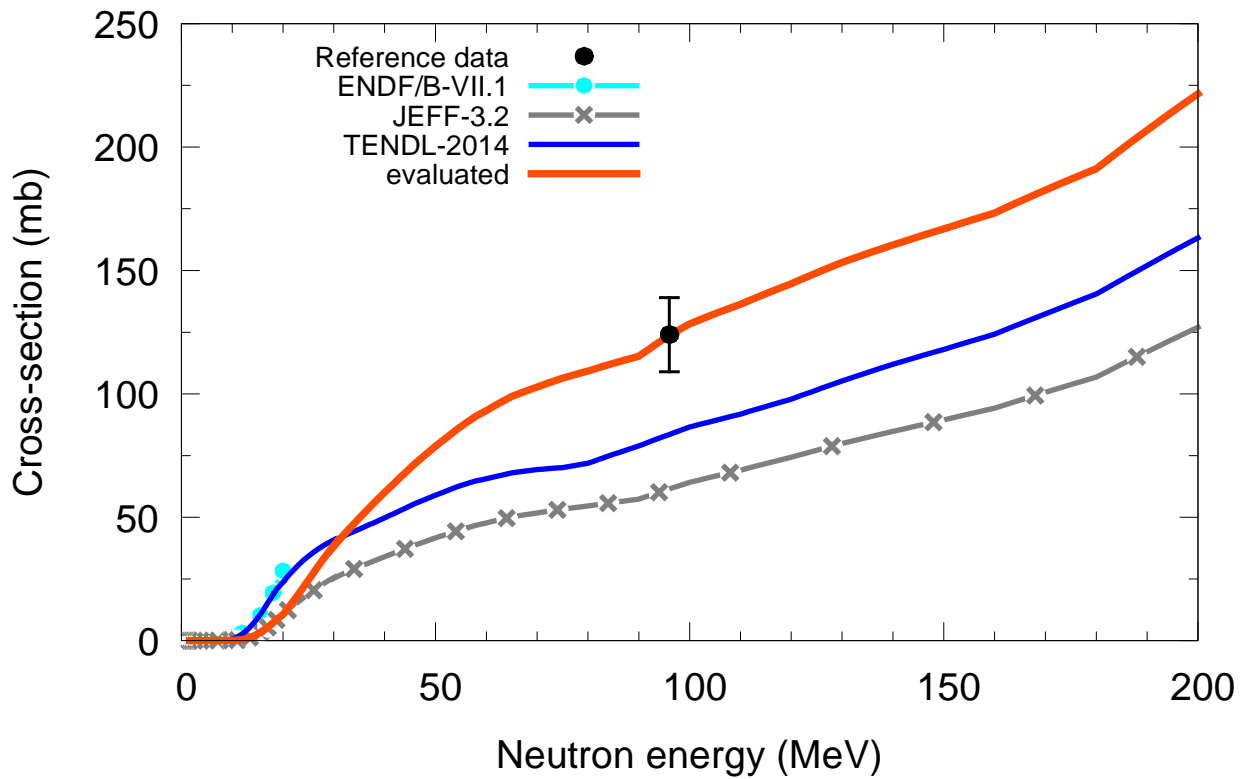


$^{63}\text{Cu}(n,x)^4\text{He}$

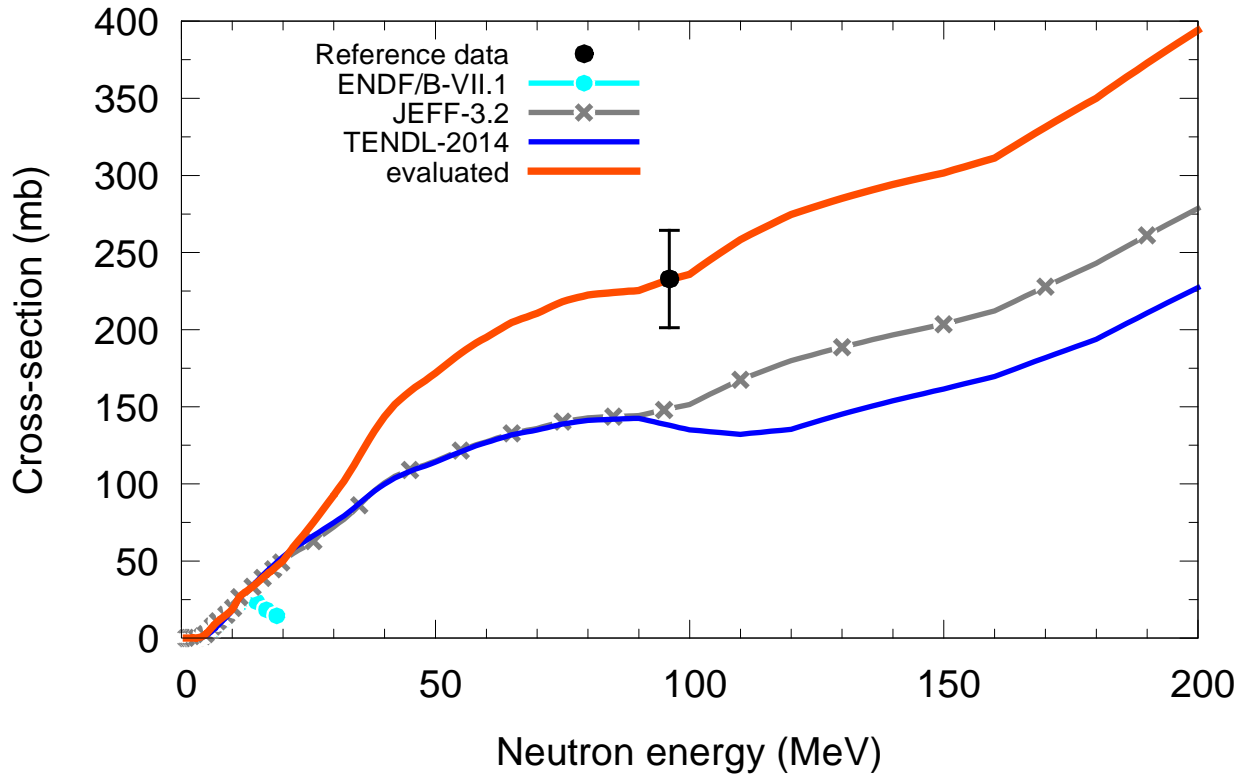




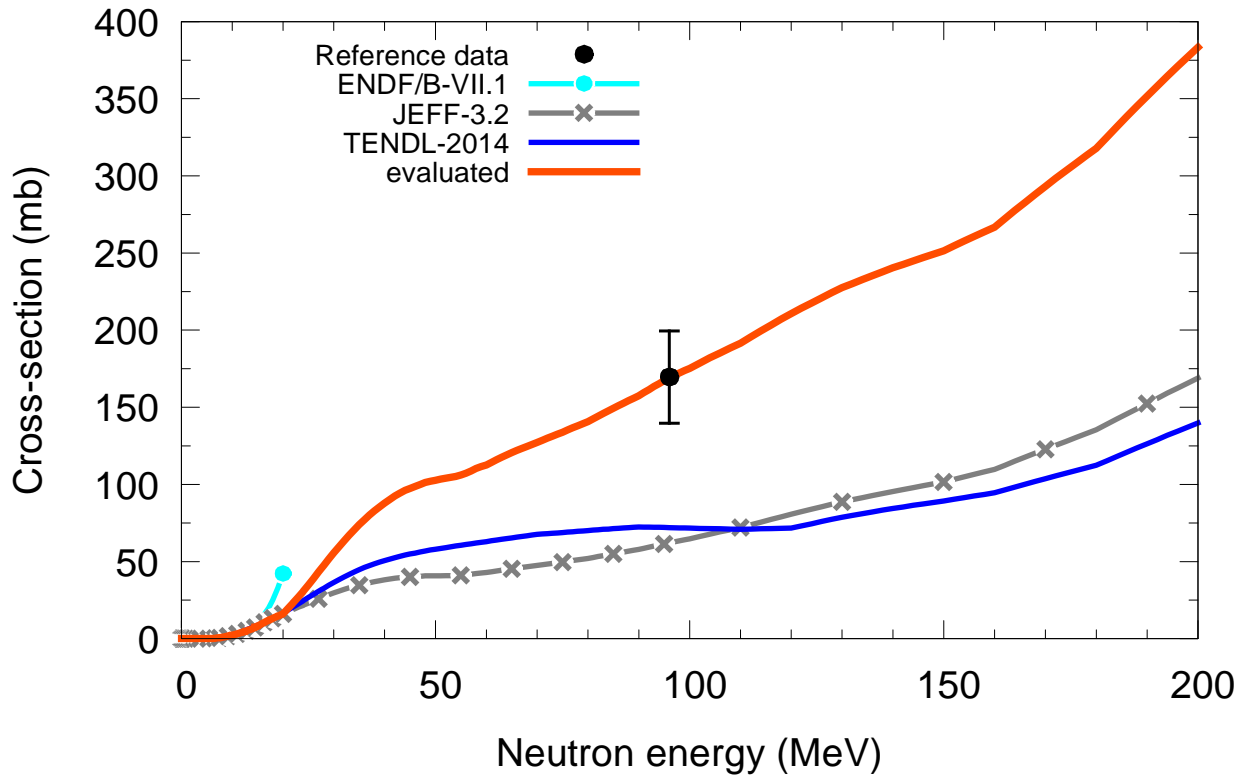
$^{66}\text{Zn}(n,x)^4\text{He}$  $^{67}\text{Zn}(n,x)^4\text{He}$ 

$^{68}\text{Zn}(n,x)^4\text{He}$  $^{70}\text{Zn}(n,x)^4\text{He}$ 

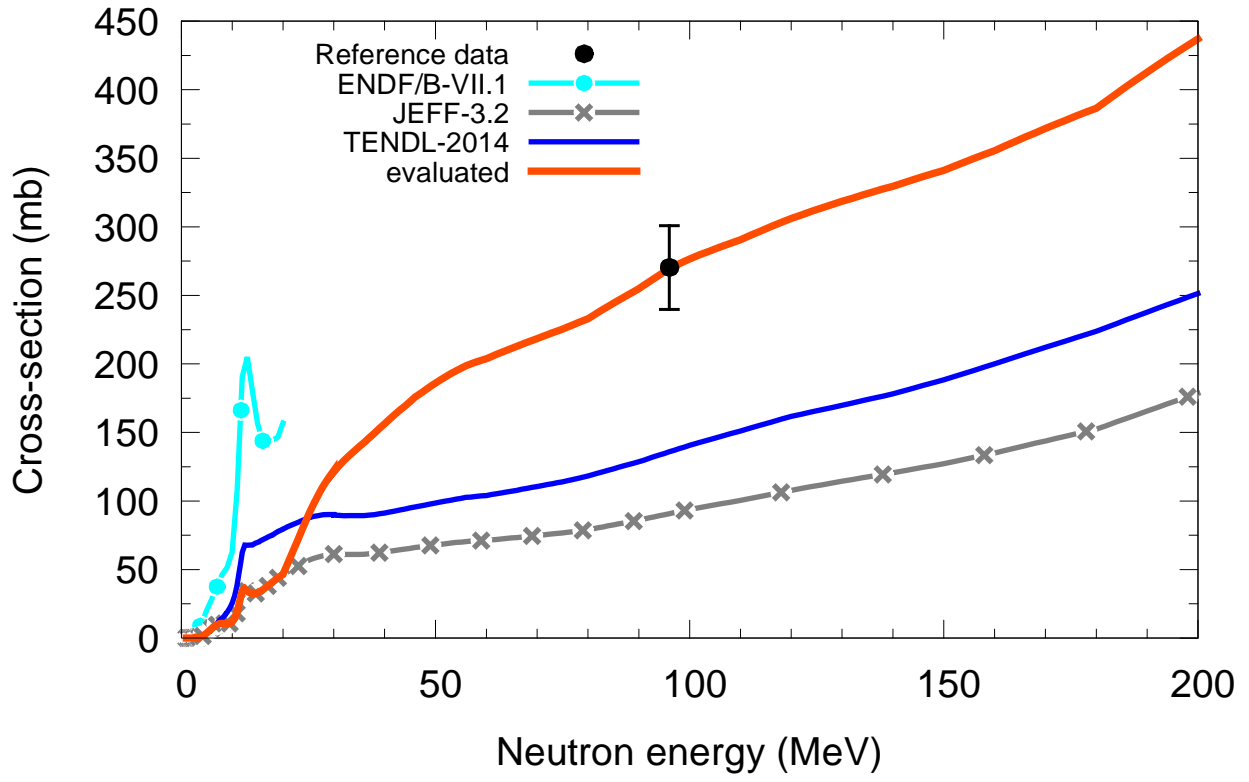
### $^{69}\text{Ga}(n,x)^4\text{He}$



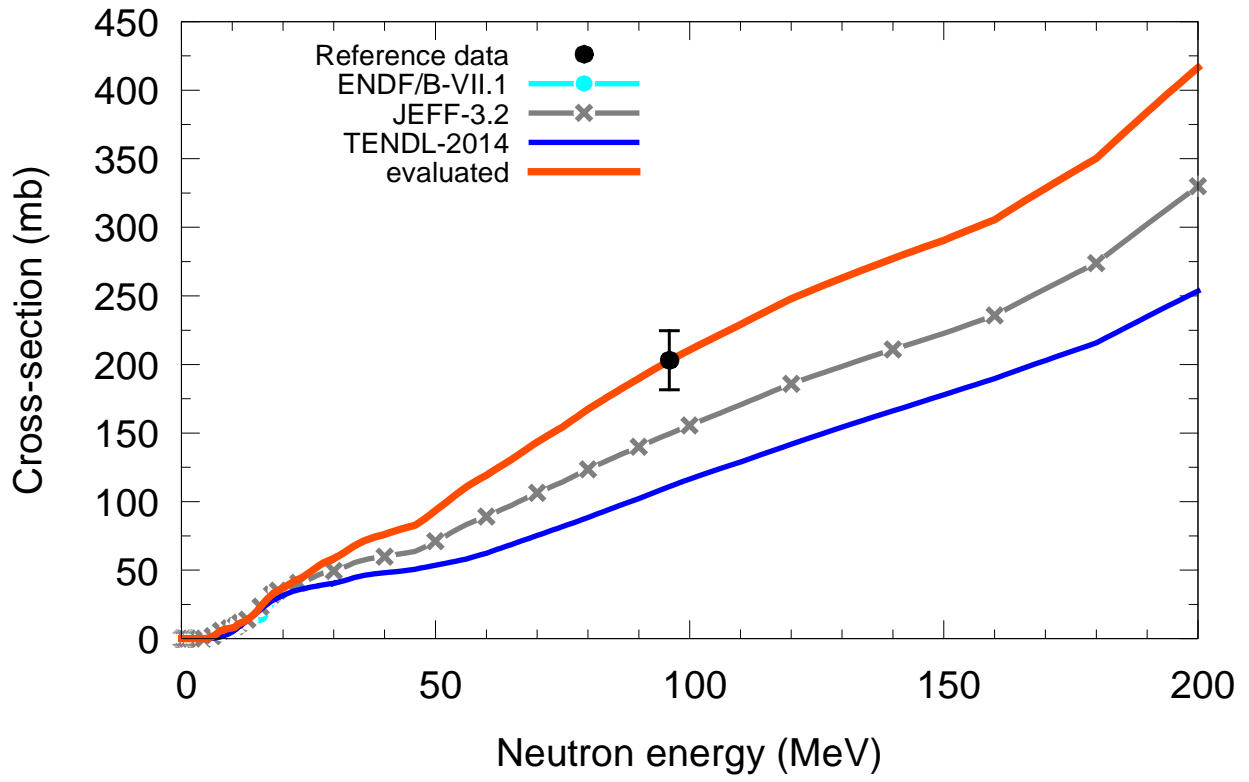
### $^{71}\text{Ga}(n,x)^4\text{He}$



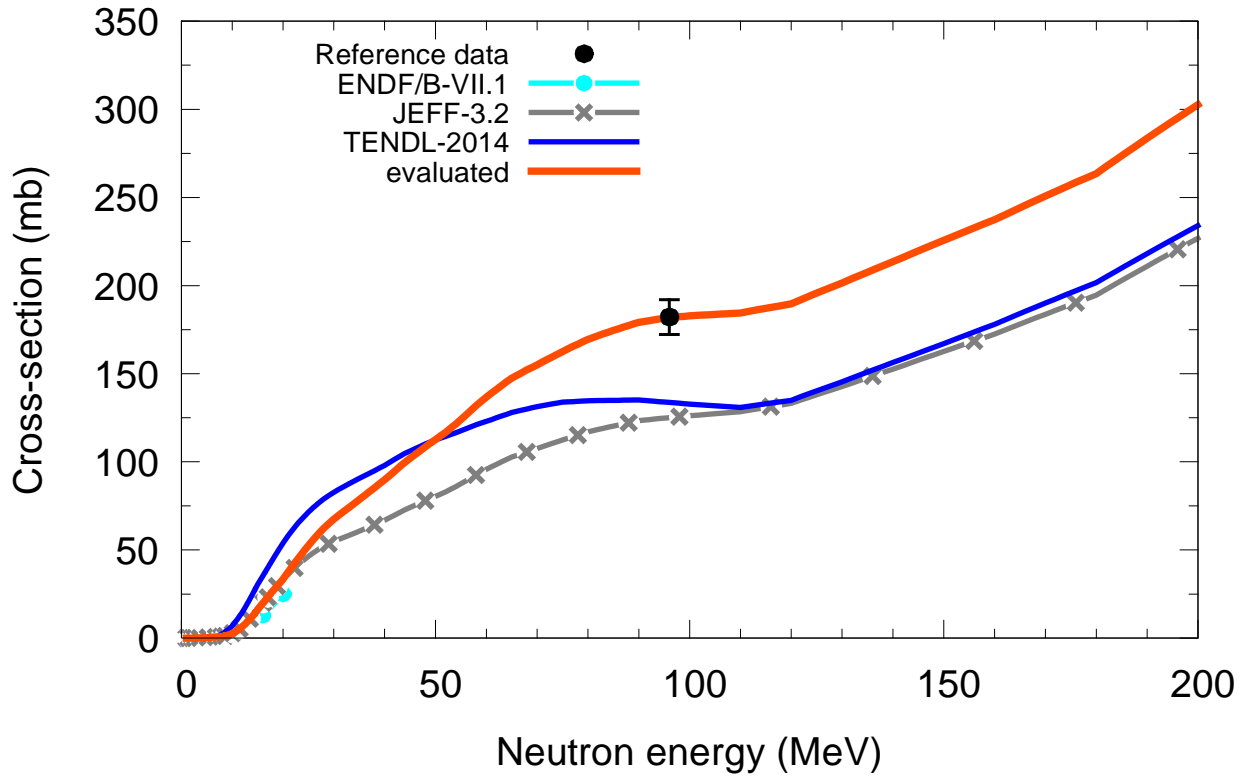
### $^{70}\text{Ge}(n,x)^4\text{He}$



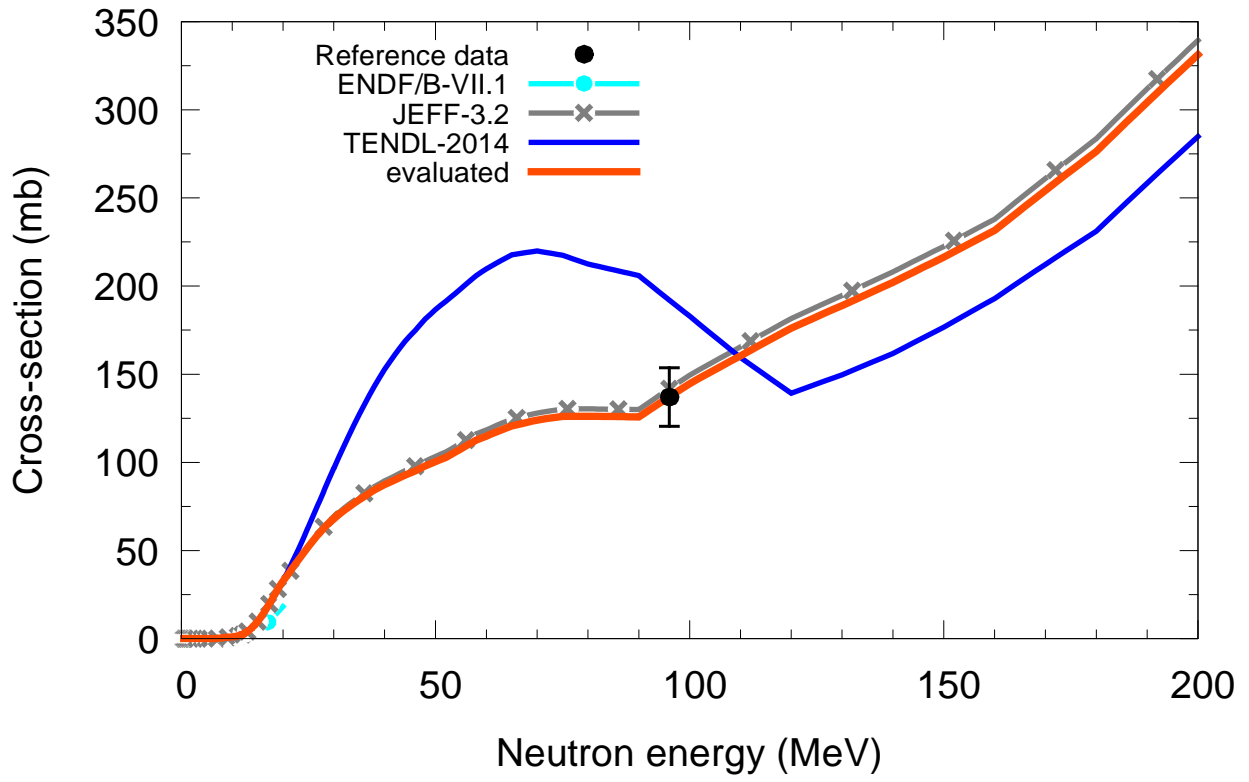
### $^{72}\text{Ge}(n,x)^4\text{He}$



$^{73}\text{Ge}(n,x)^4\text{He}$

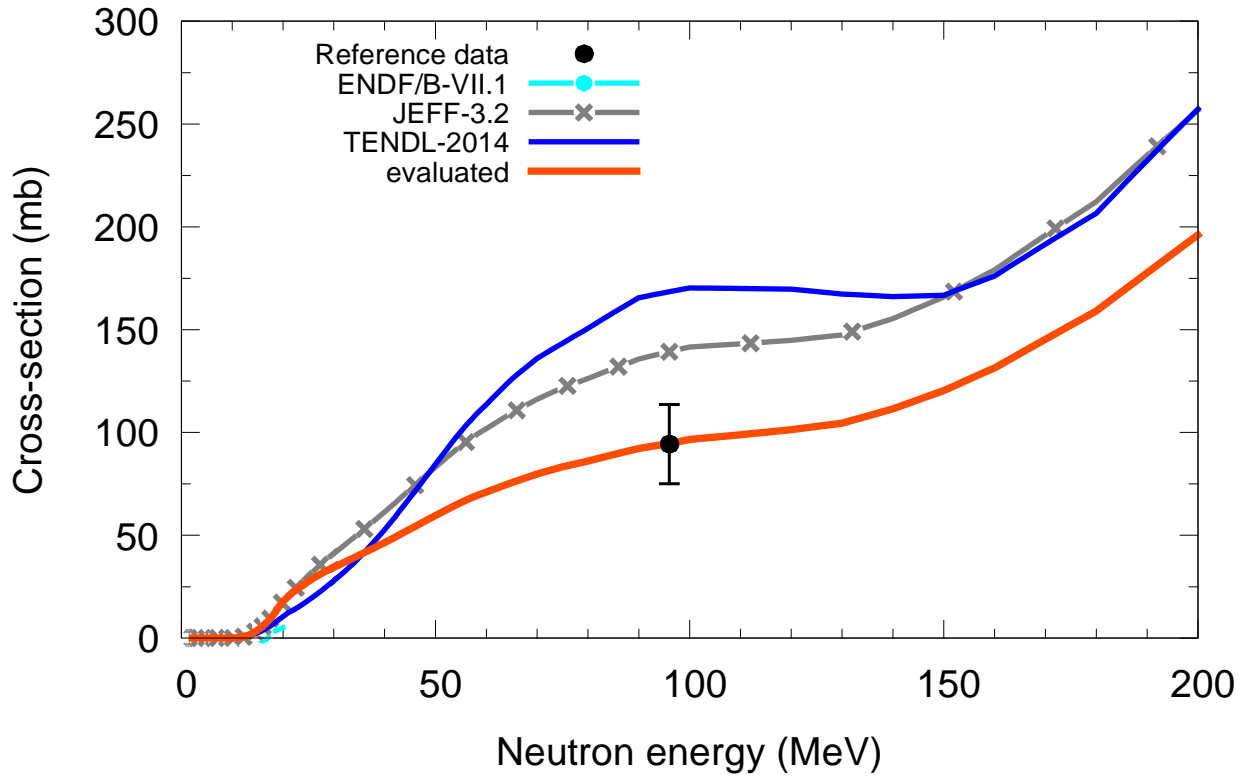


$^{74}\text{Ge}(n,x)^4\text{He}$

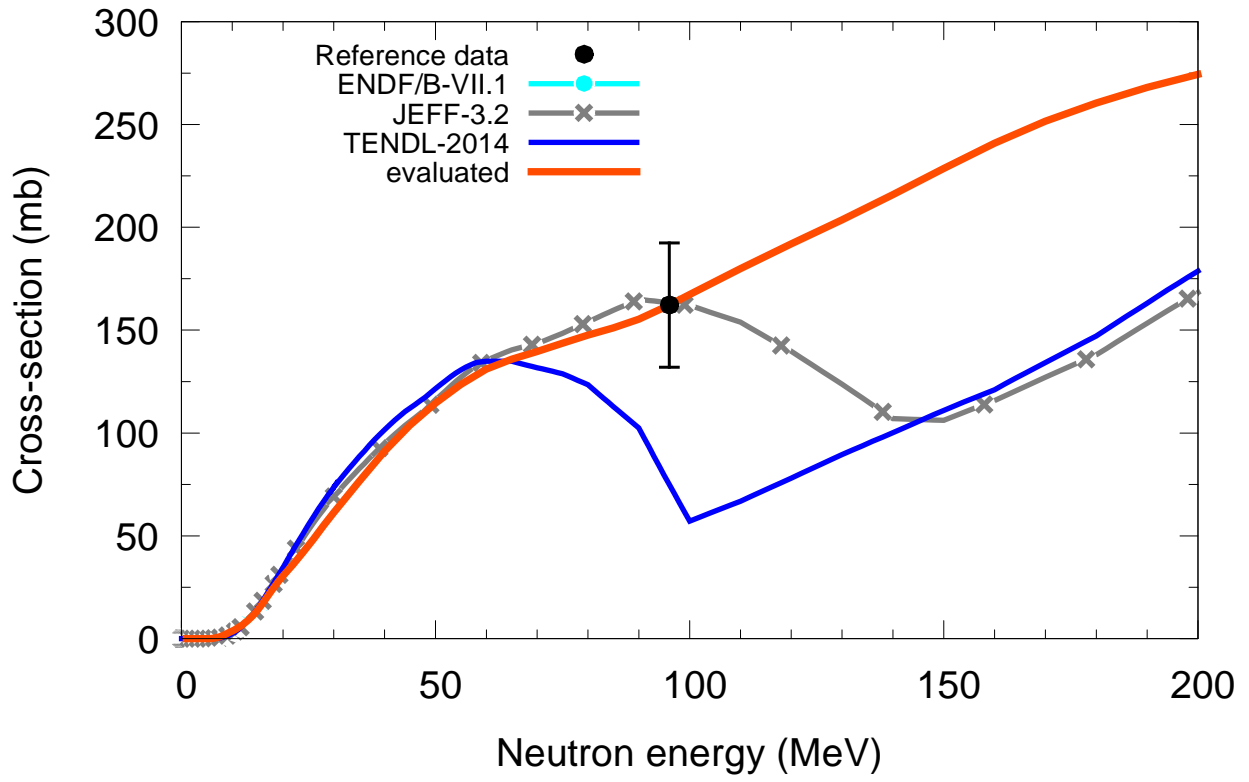


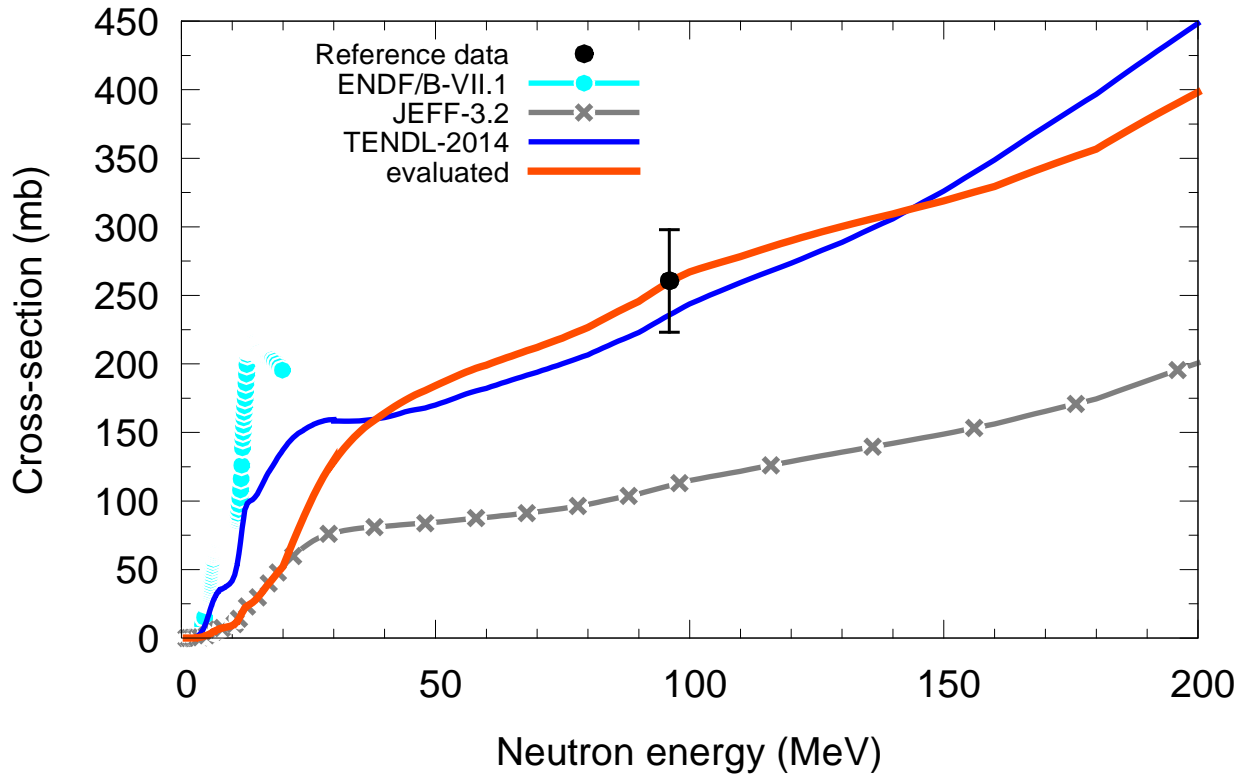
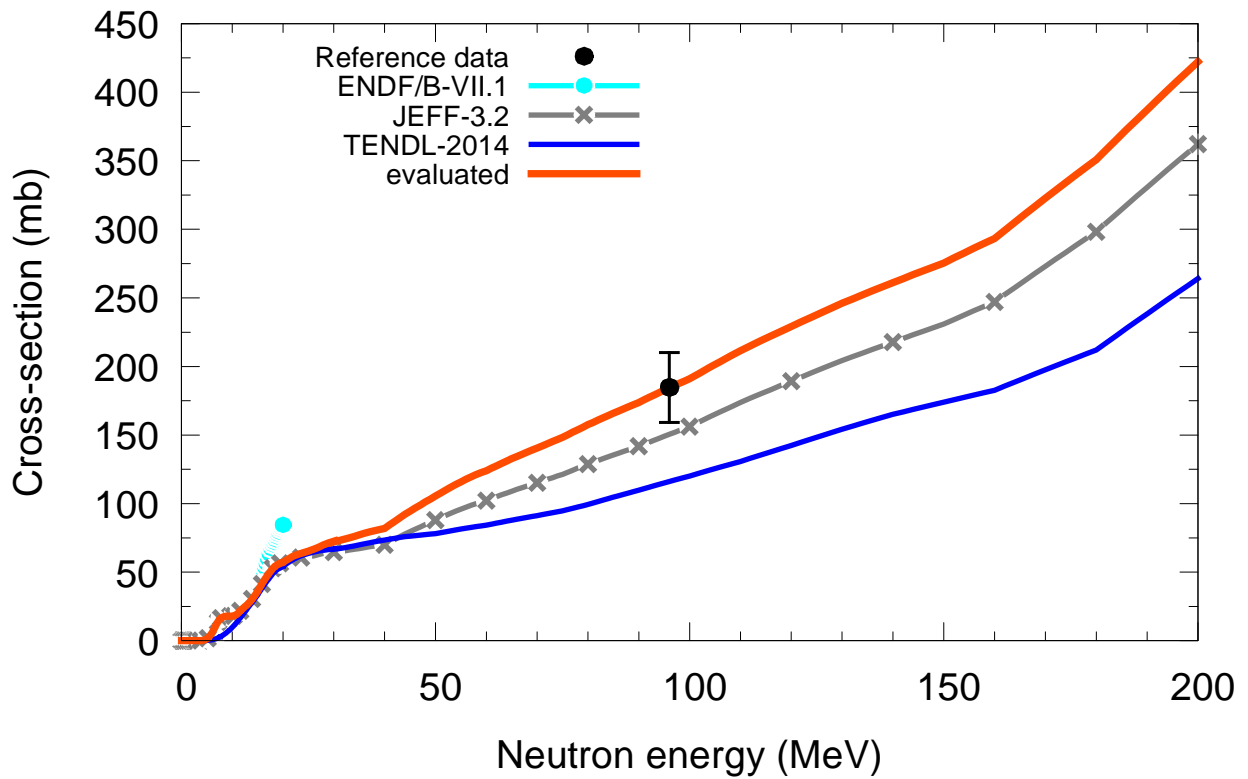


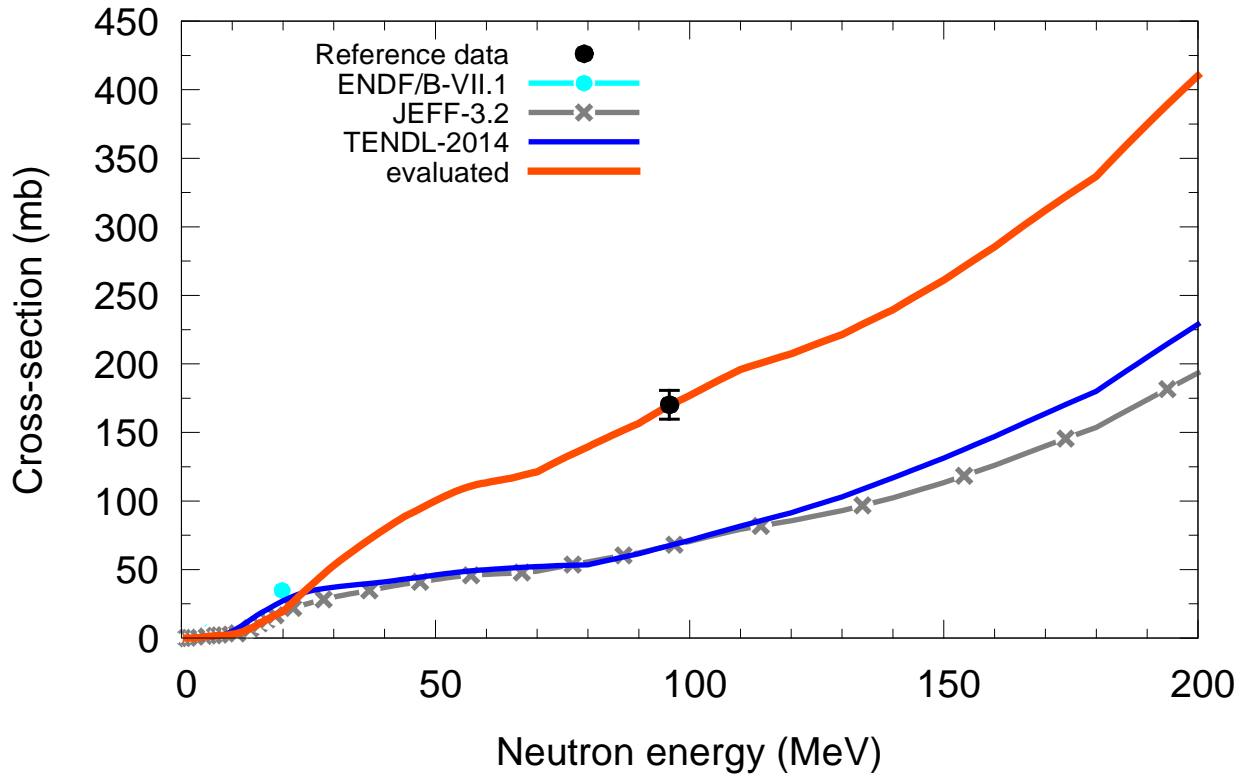
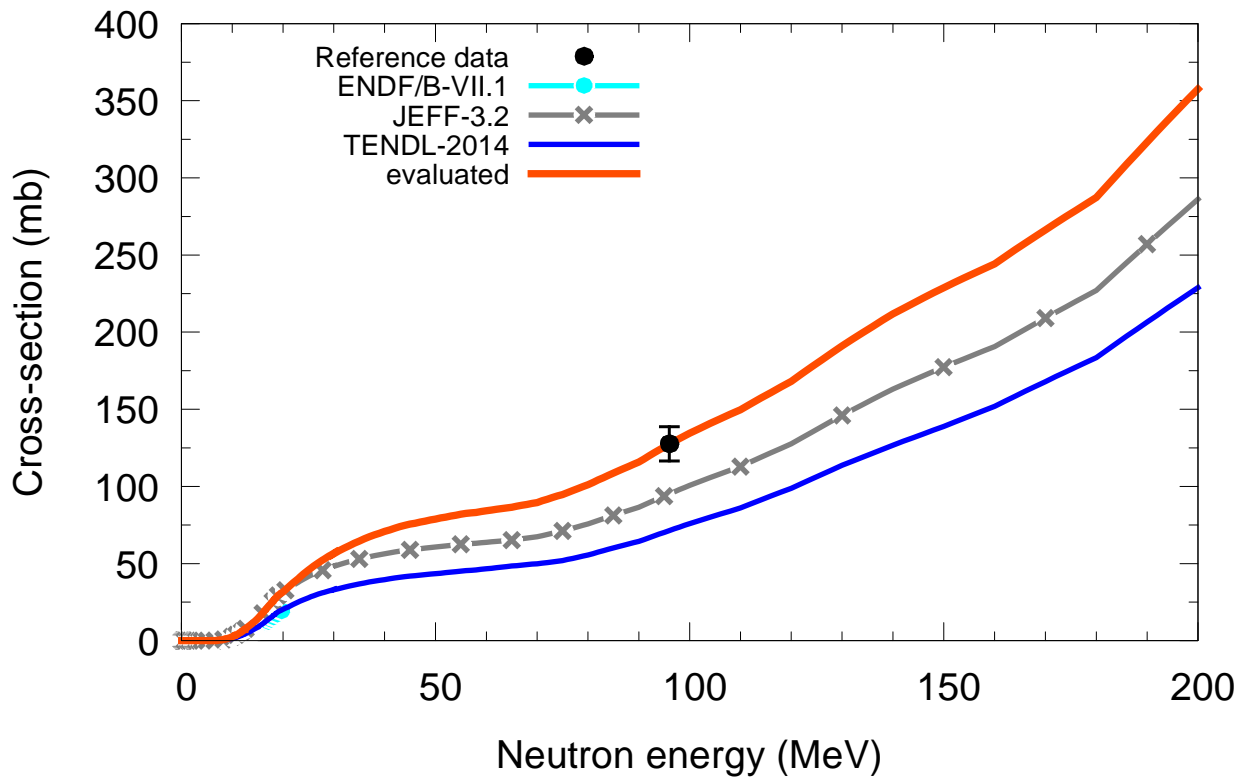
$^{76}\text{Ge}(n,x)^4\text{He}$

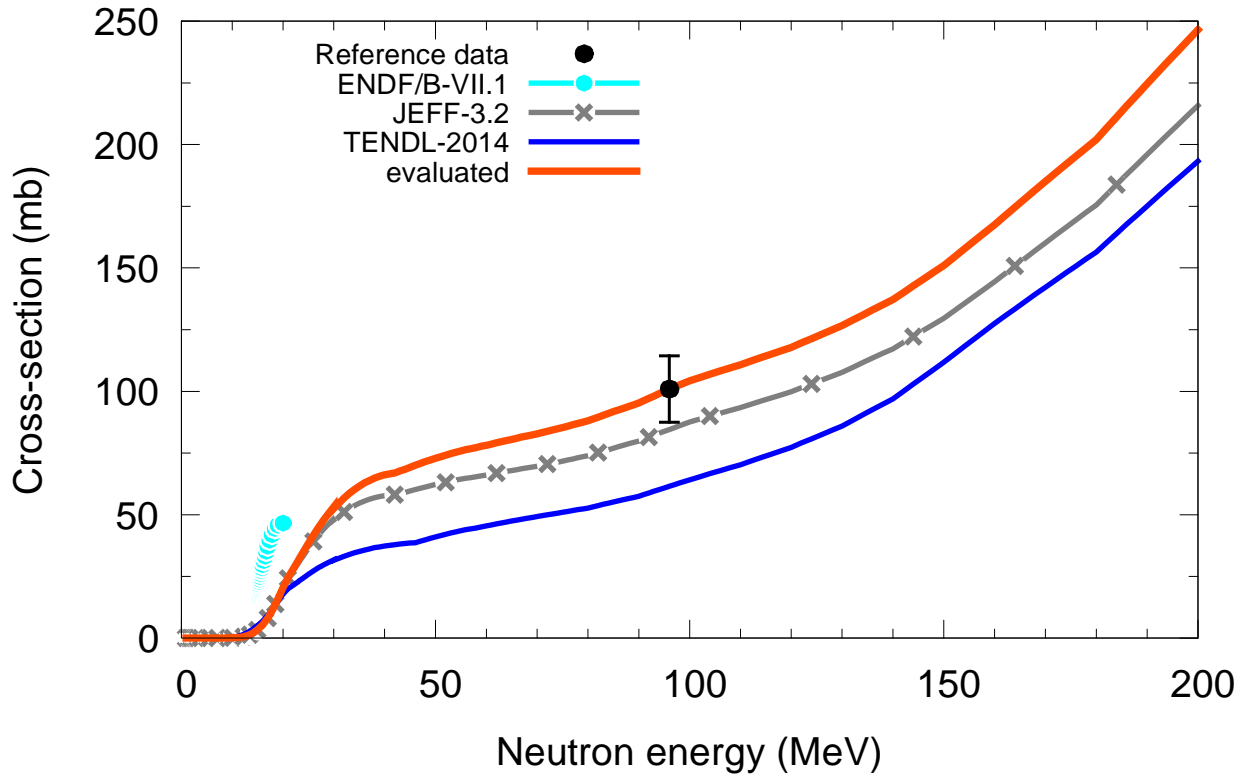
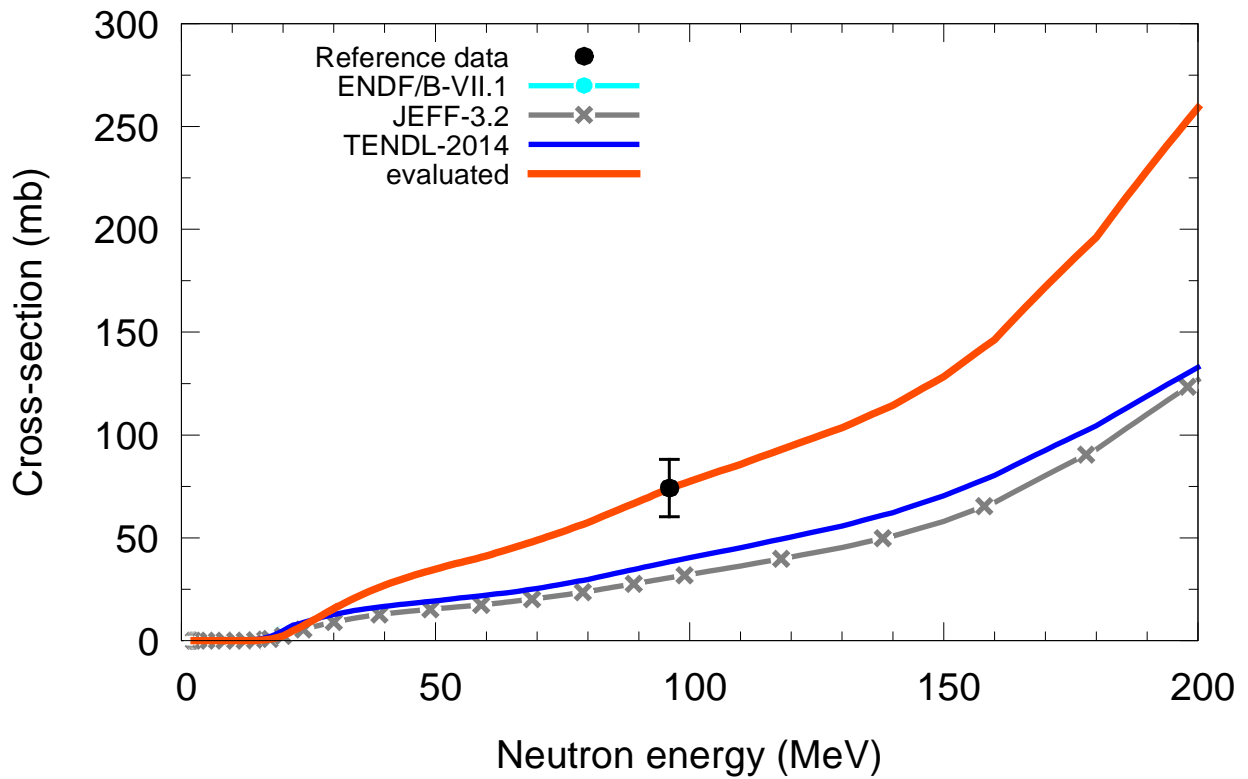


$^{75}\text{As}(n,x)^4\text{He}$

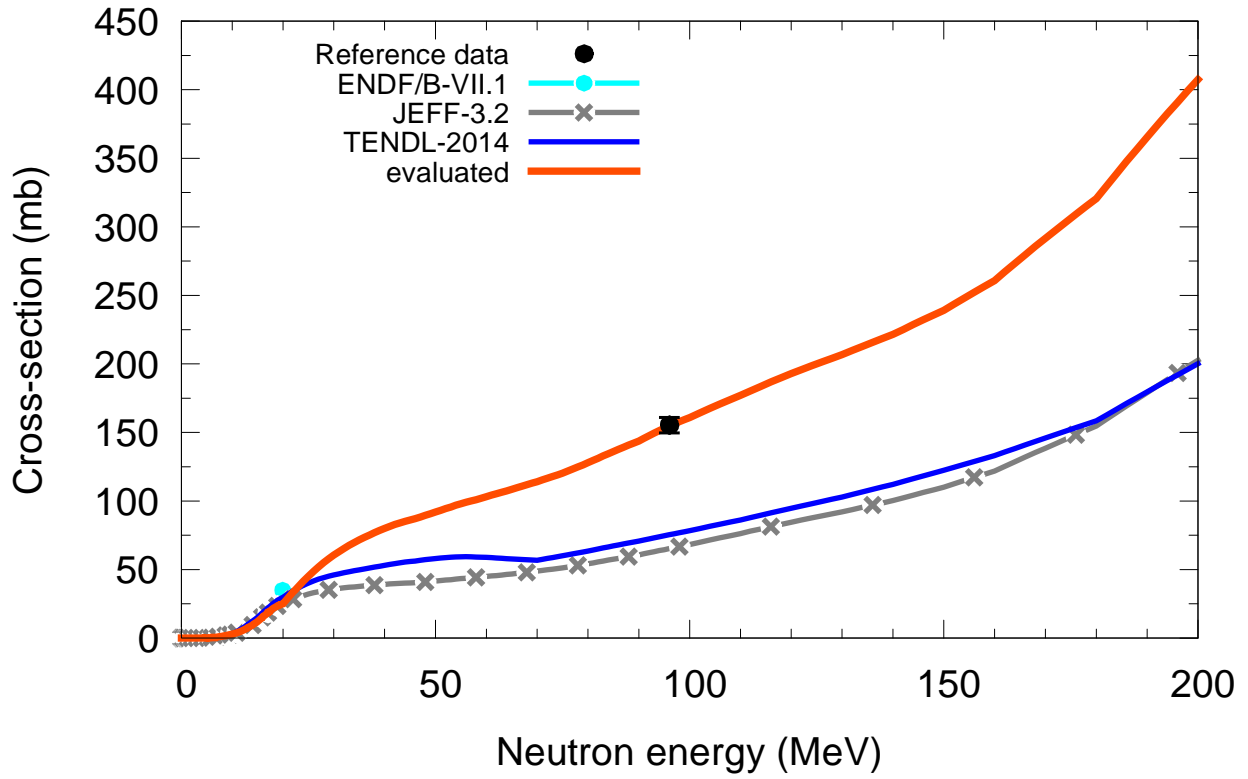


$^{74}\text{Se}(n,x)^4\text{He}$  $^{76}\text{Se}(n,x)^4\text{He}$ 

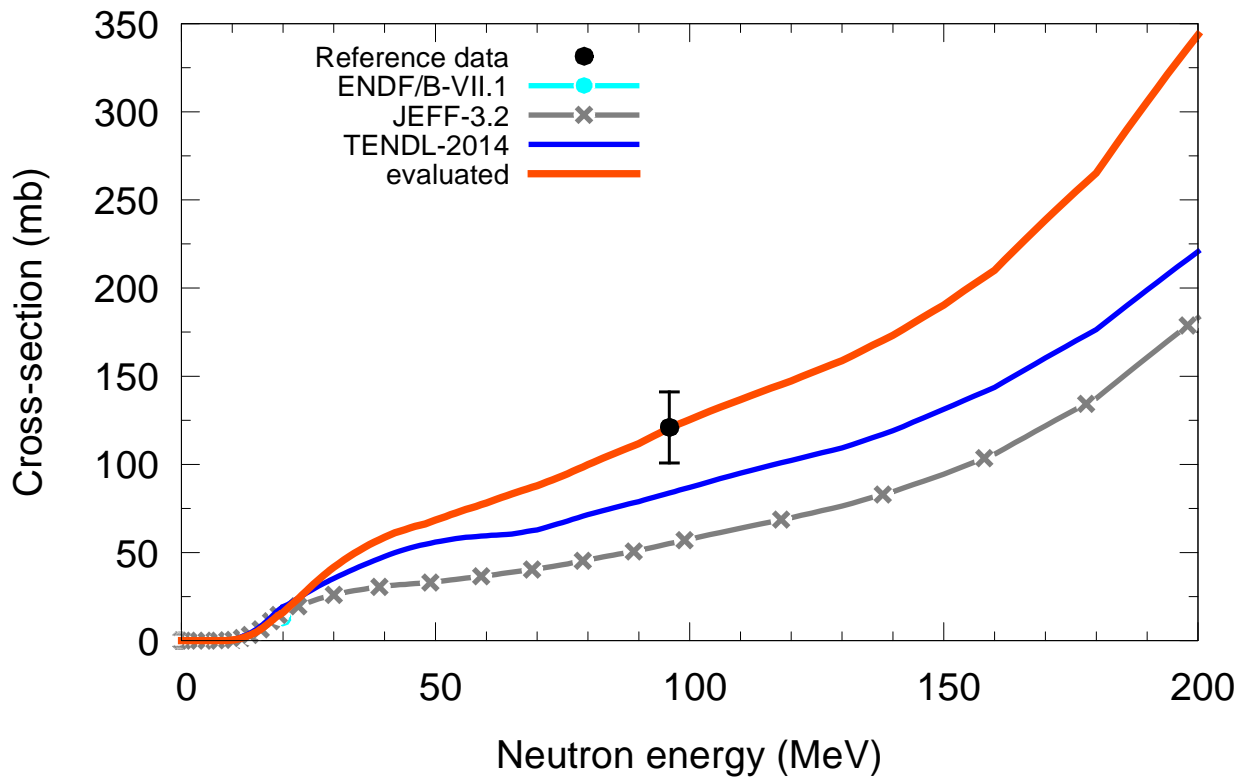
$^{77}\text{Se}(n,x)^4\text{He}$  $^{78}\text{Se}(n,x)^4\text{He}$ 

$^{80}\text{Se}(n,x)^4\text{He}$  $^{82}\text{Se}(n,x)^4\text{He}$ 

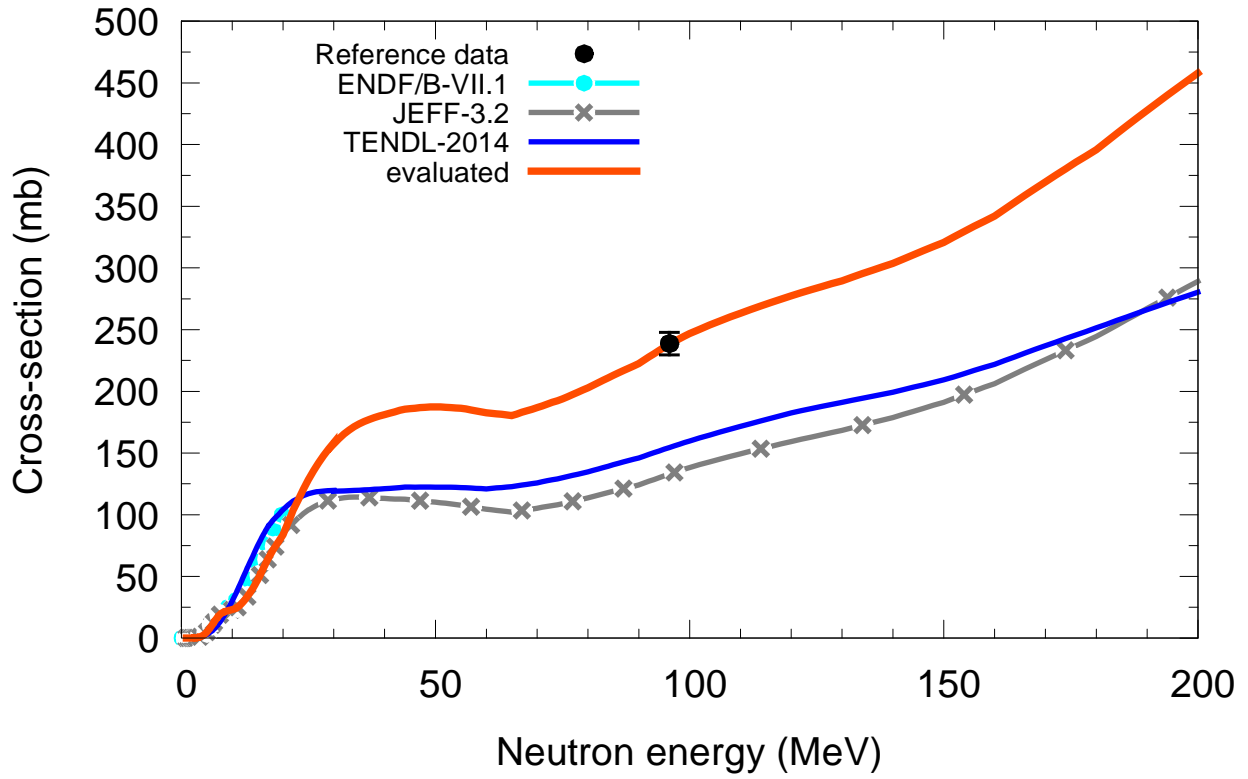
### $^{79}\text{Br}(n,x)^4\text{He}$



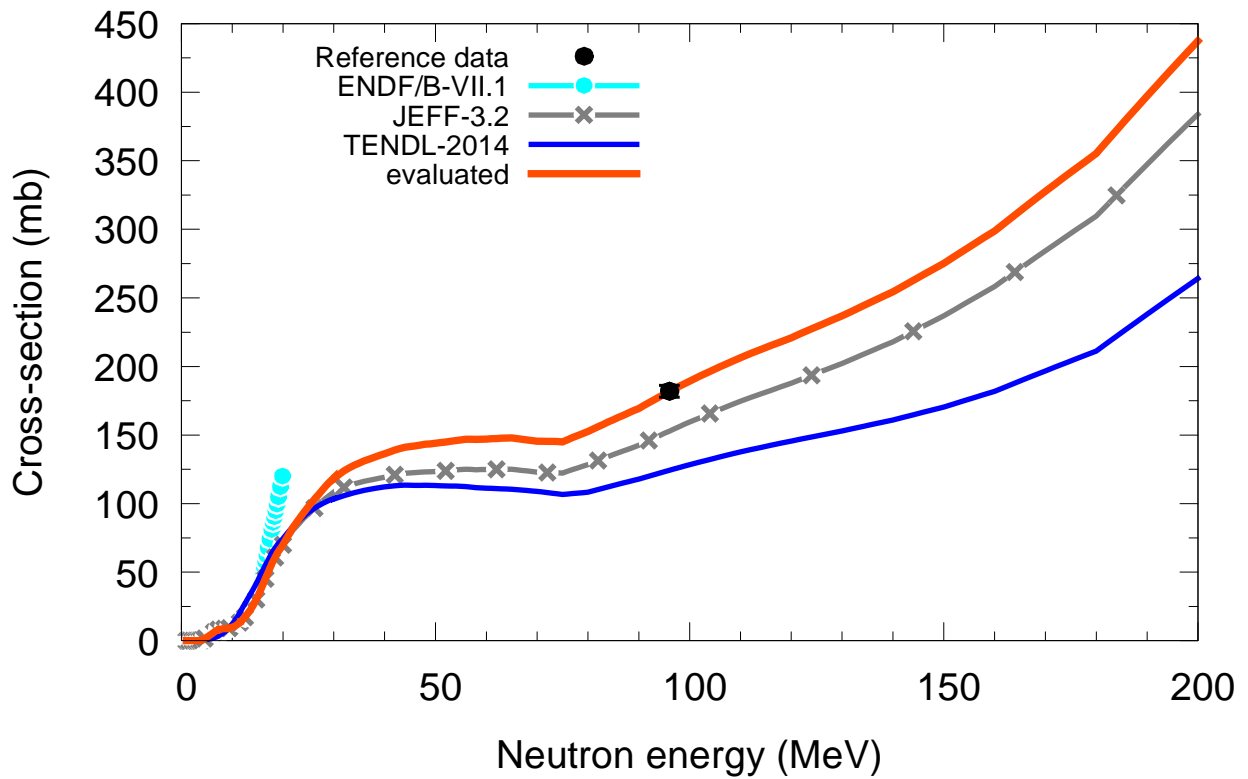
### $^{81}\text{Br}(n,x)^4\text{He}$



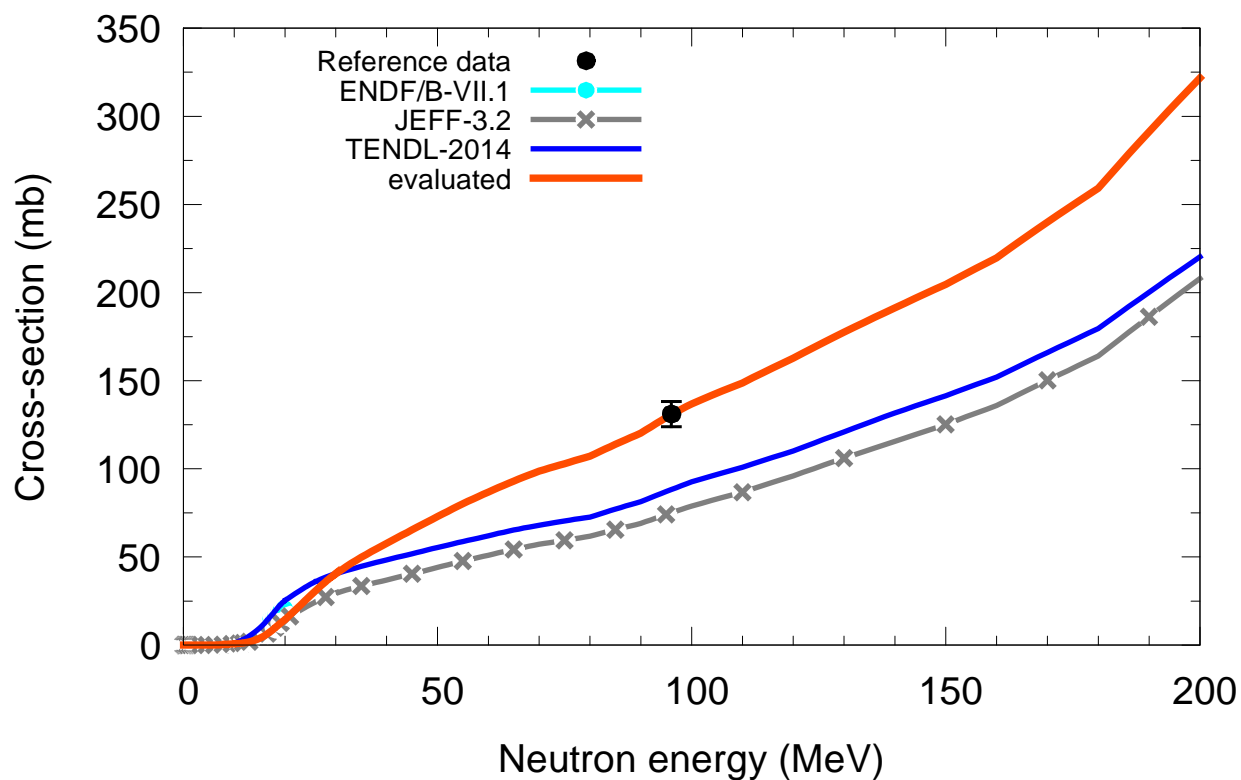
### $^{78}\text{Kr}(n,x)^4\text{He}$



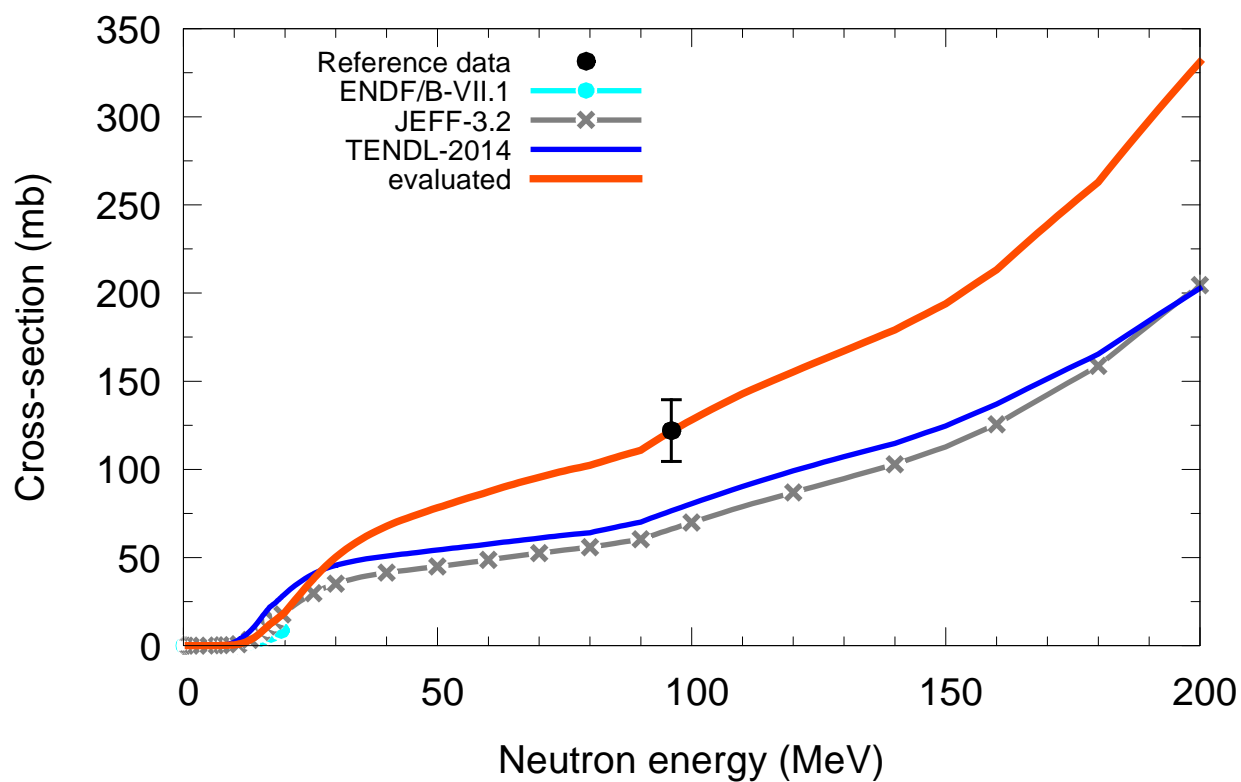
### $^{80}\text{Kr}(n,x)^4\text{He}$



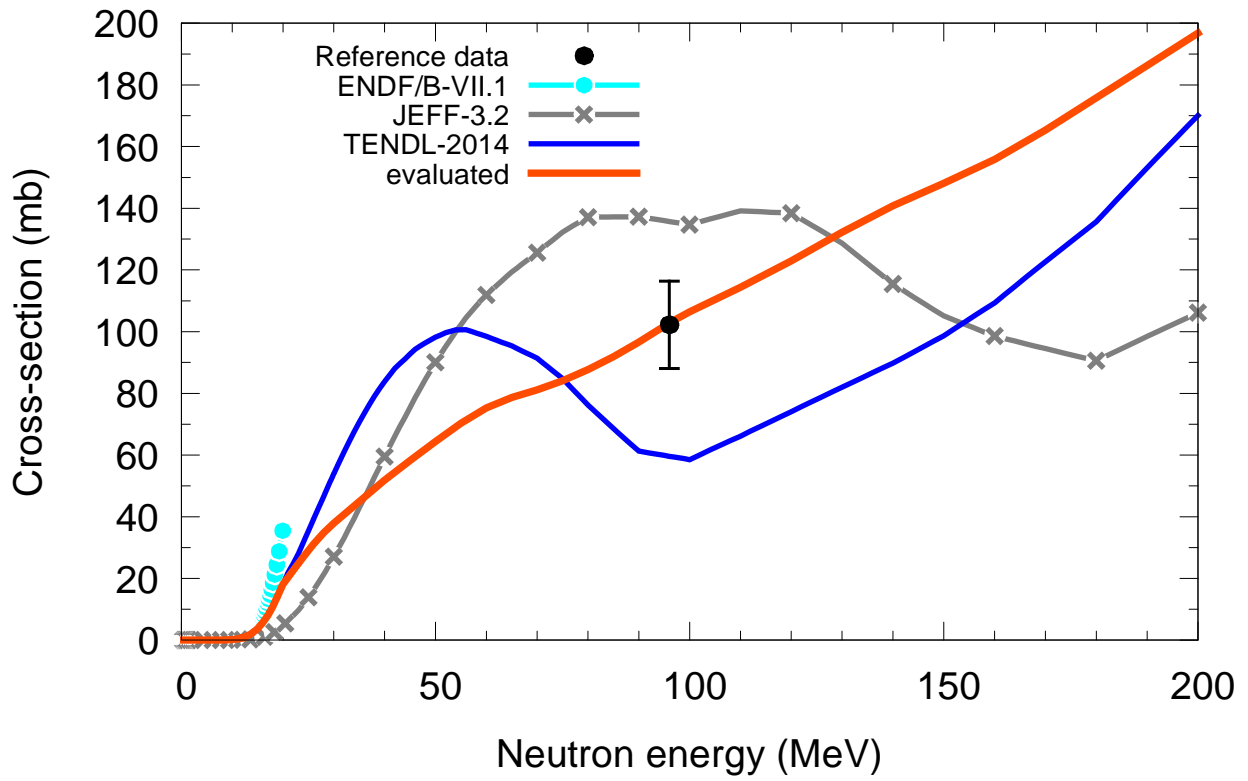
### $^{82}\text{Kr}(n,x)^4\text{He}$



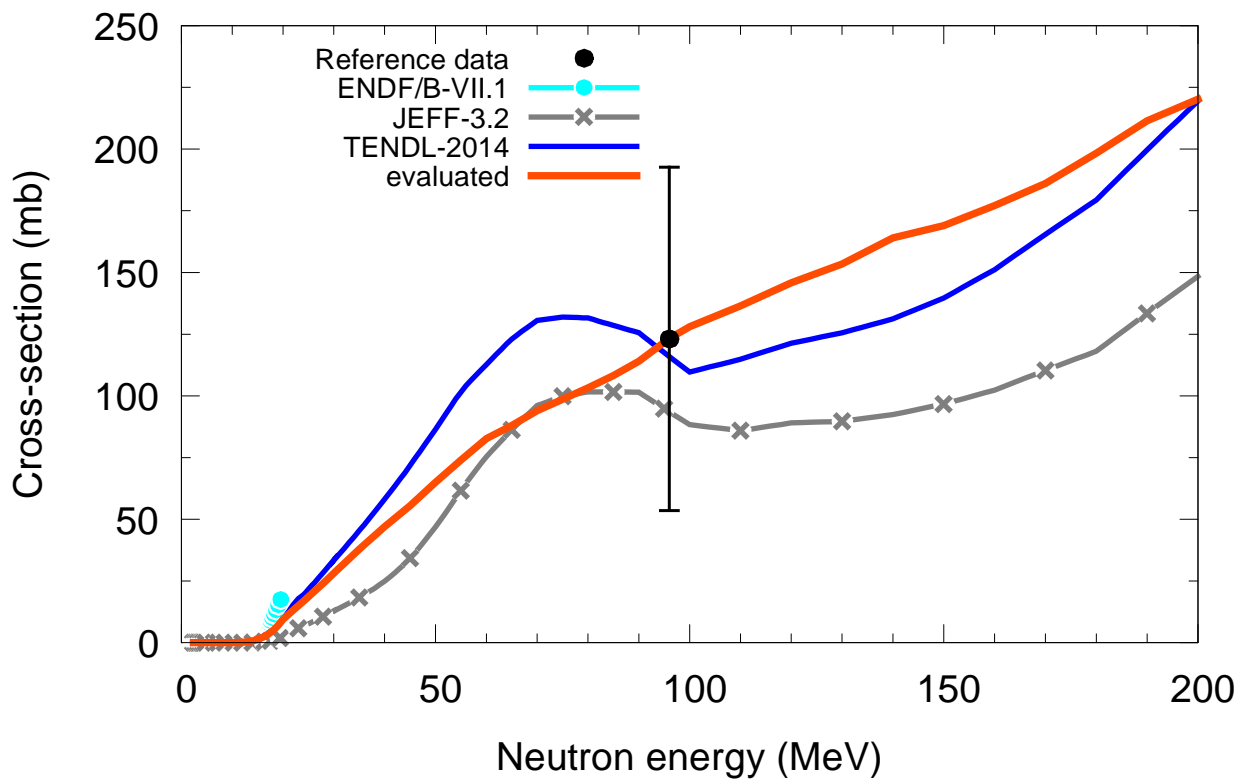
### $^{83}\text{Kr}(n,x)^4\text{He}$



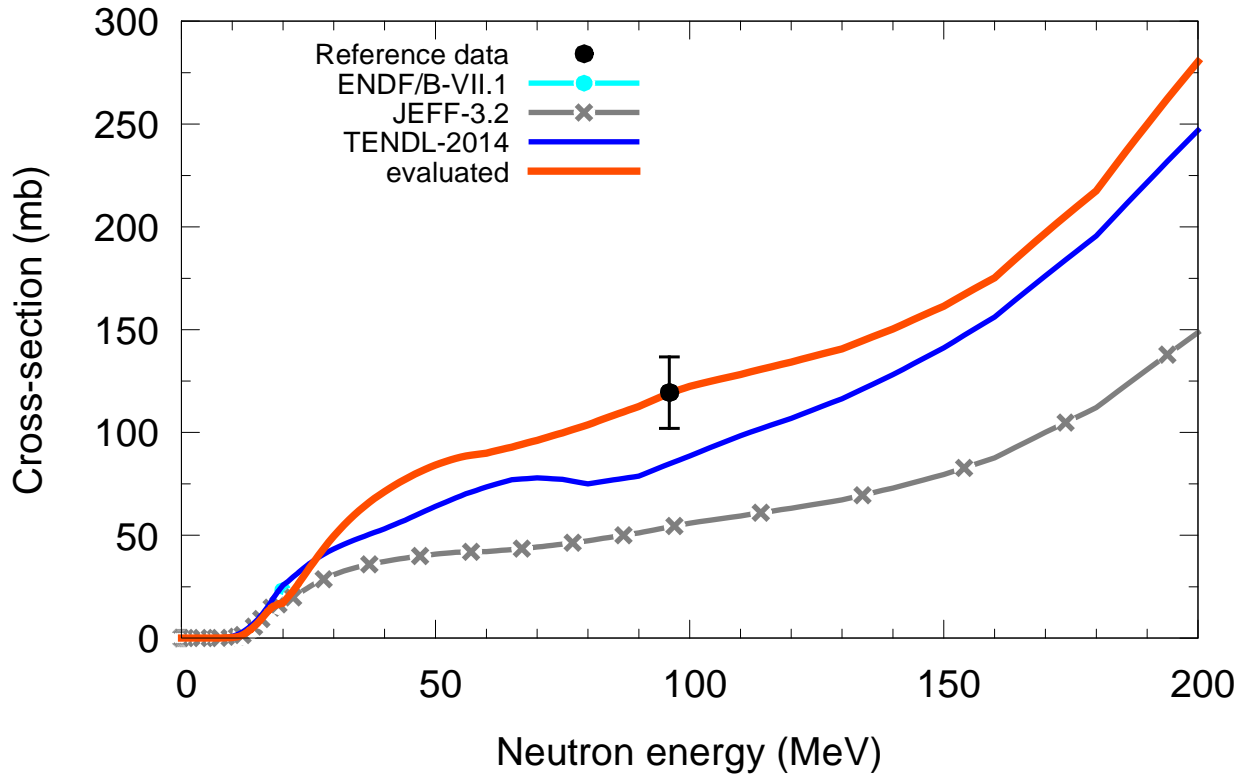
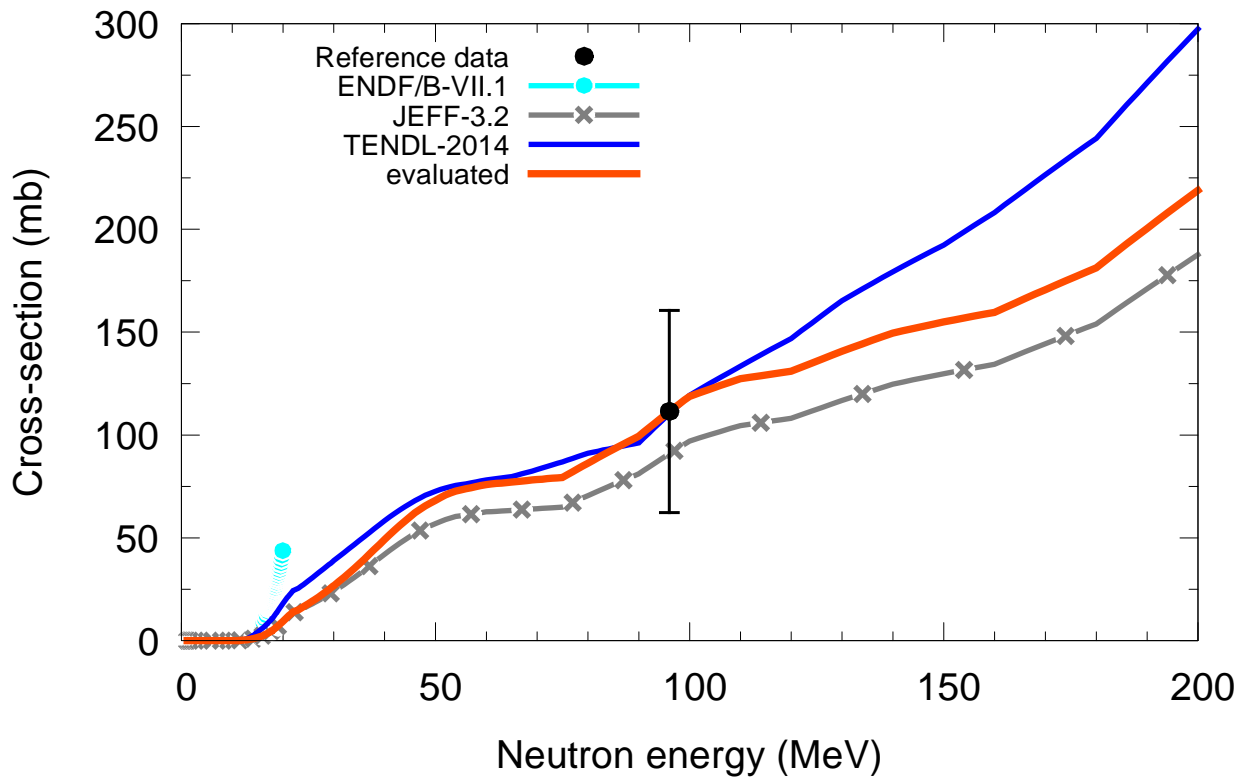
### $^{84}\text{Kr}(n,x)^4\text{He}$



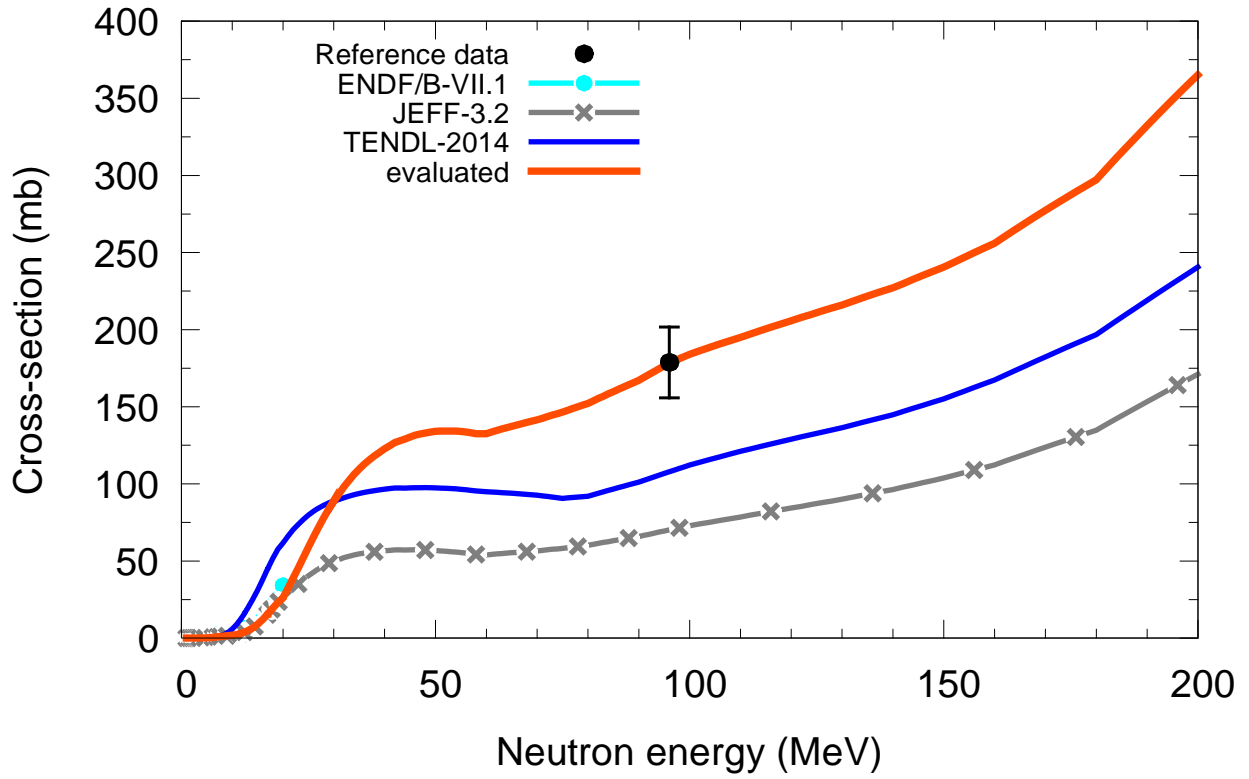
### $^{86}\text{Kr}(n,x)^4\text{He}$



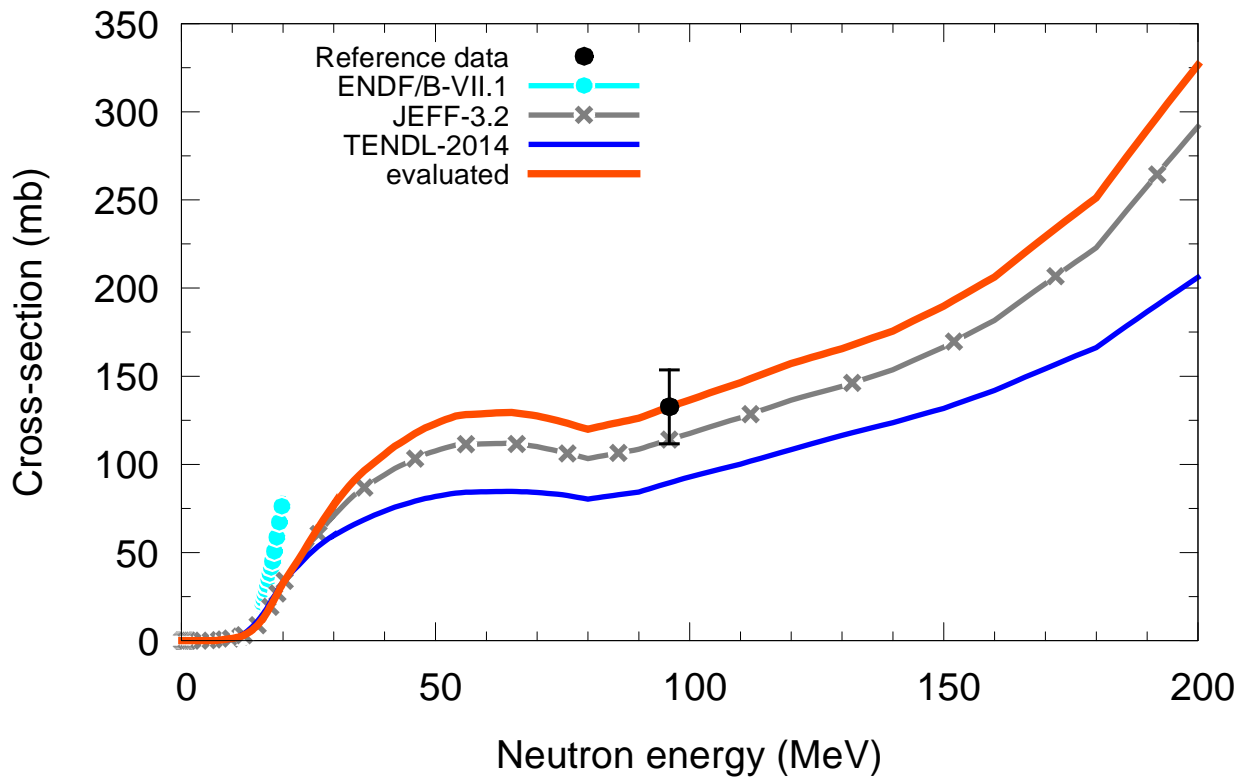


$^{85}\text{Rb}(n,x)^4\text{He}$  $^{87}\text{Rb}(n,x)^4\text{He}$ 

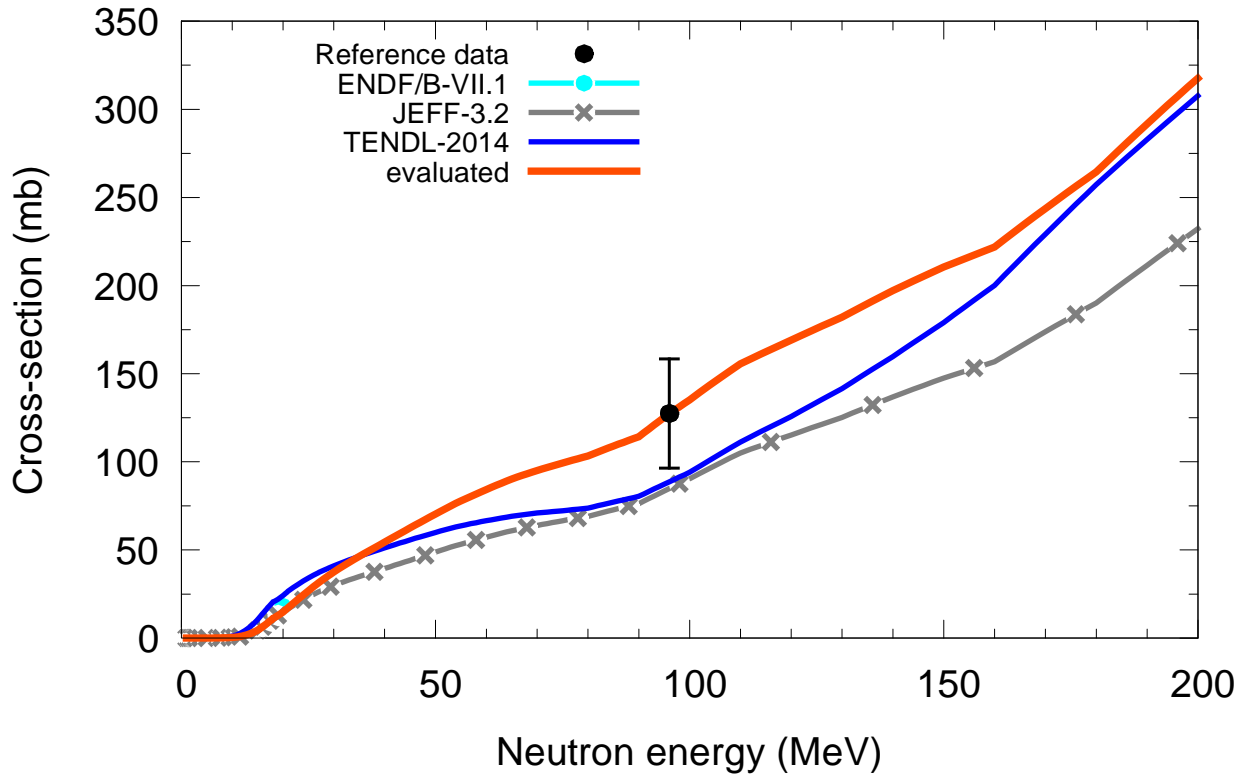
### $^{84}\text{Sr}(n,x)^4\text{He}$



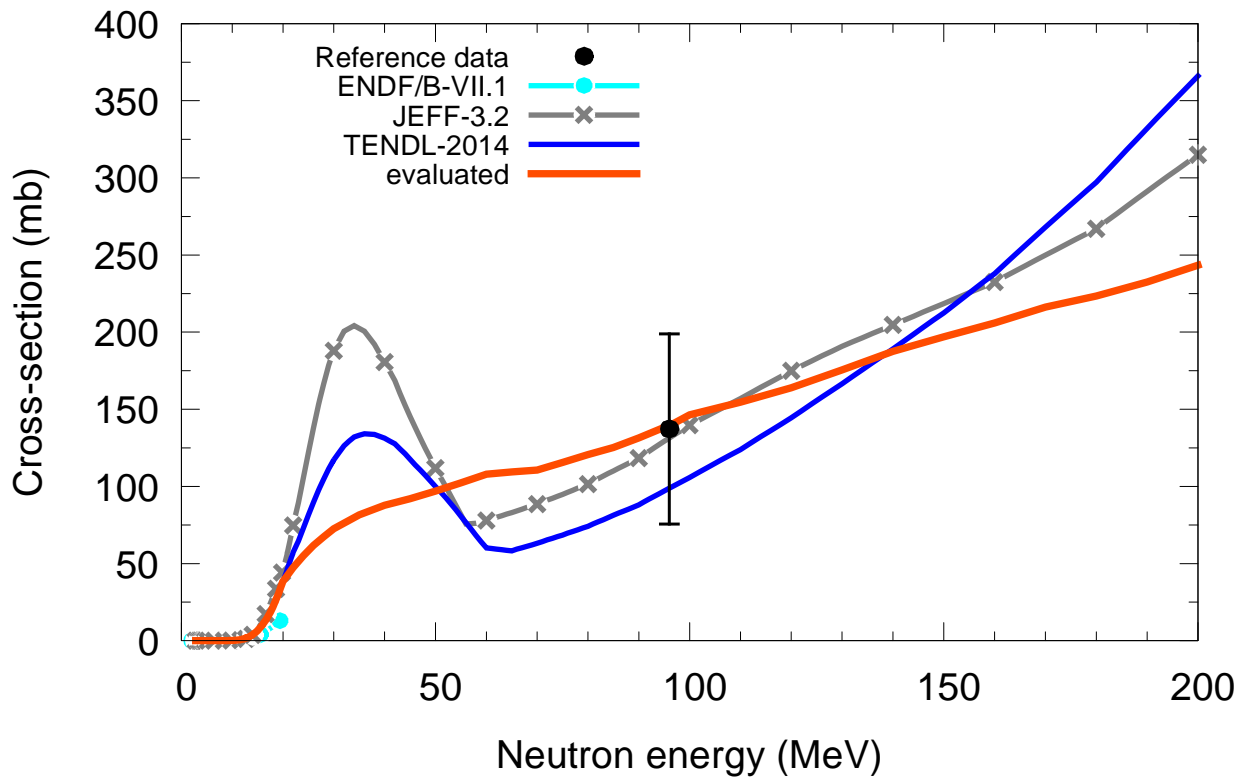
### $^{86}\text{Sr}(n,x)^4\text{He}$



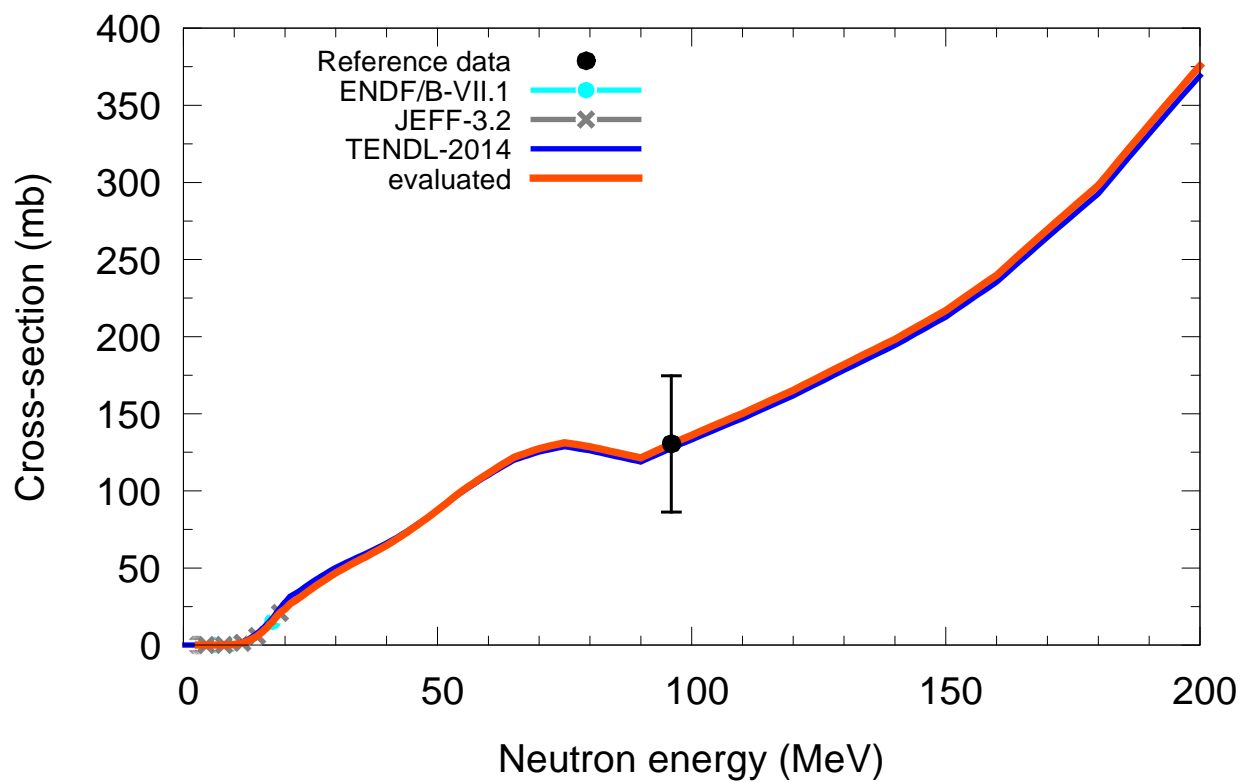
### $^{87}\text{Sr}(n,x)^4\text{He}$



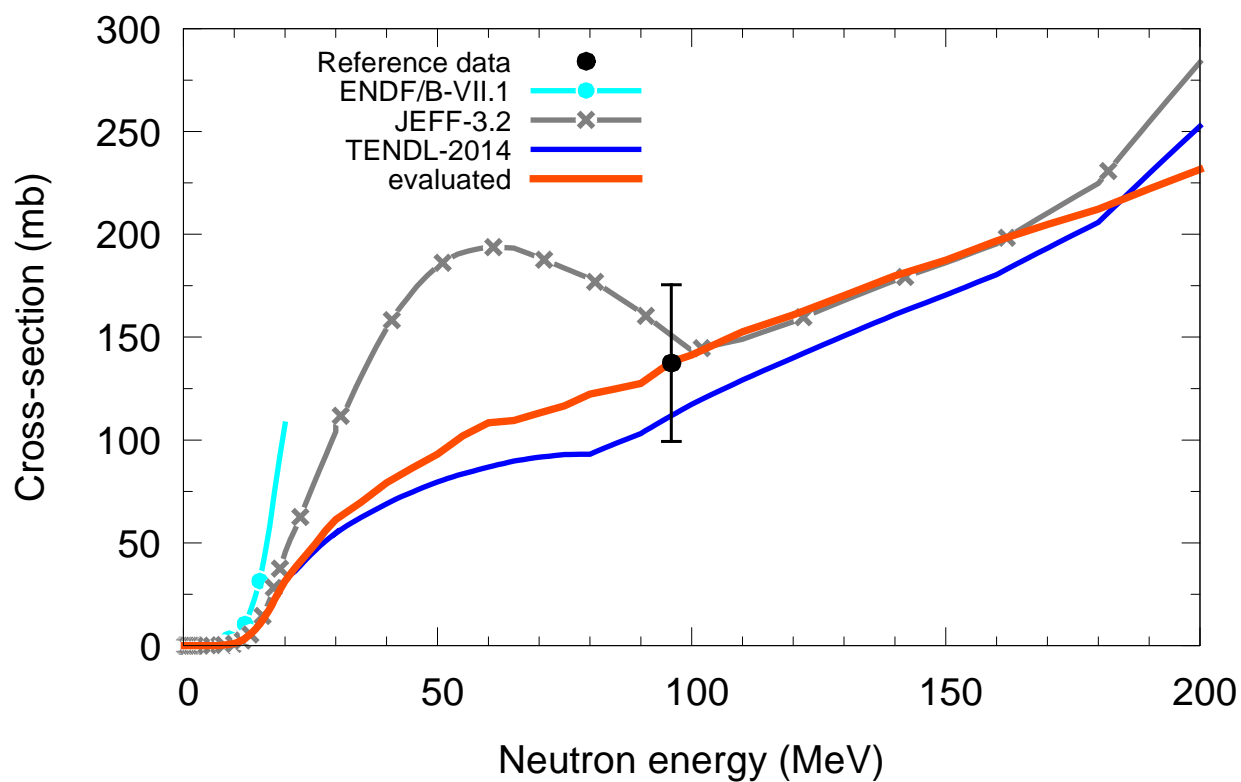
### $^{88}\text{Sr}(n,x)^4\text{He}$



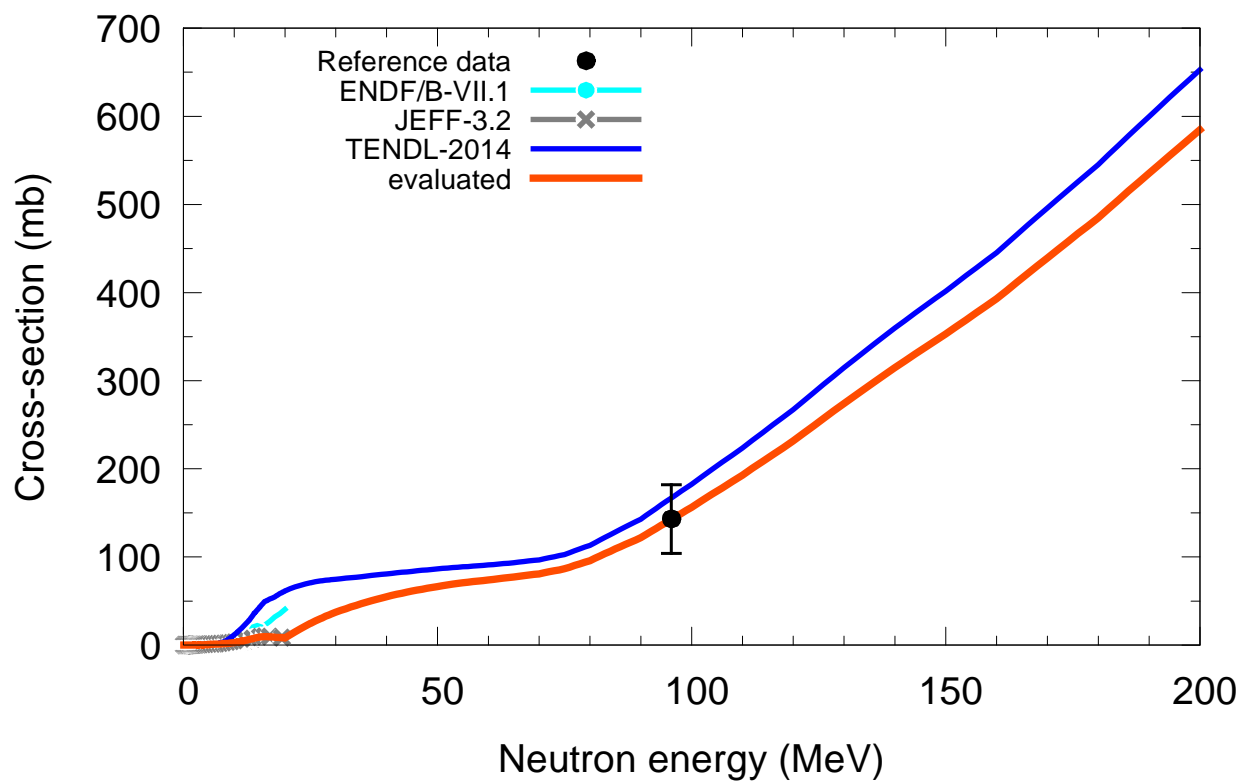
$^{89}\text{Y}(n,x)^4\text{He}$



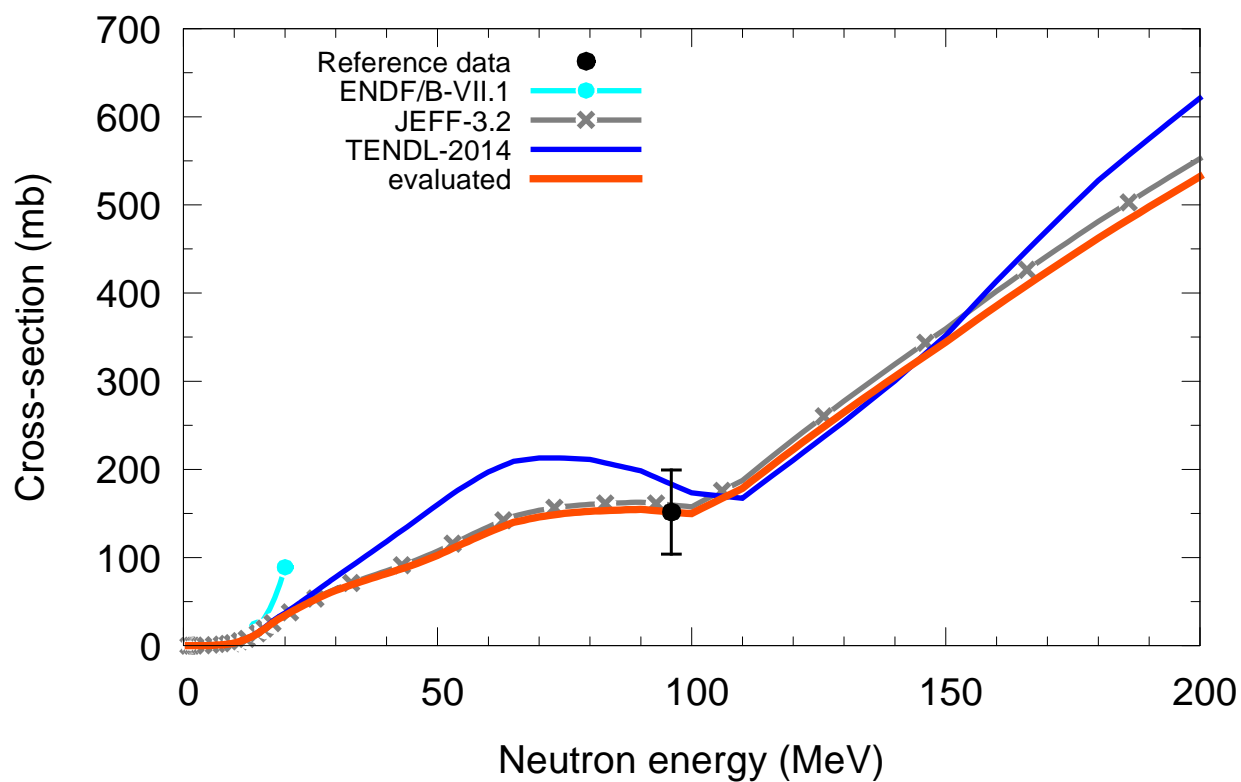
$^{90}\text{Zr}(n,x)^4\text{He}$



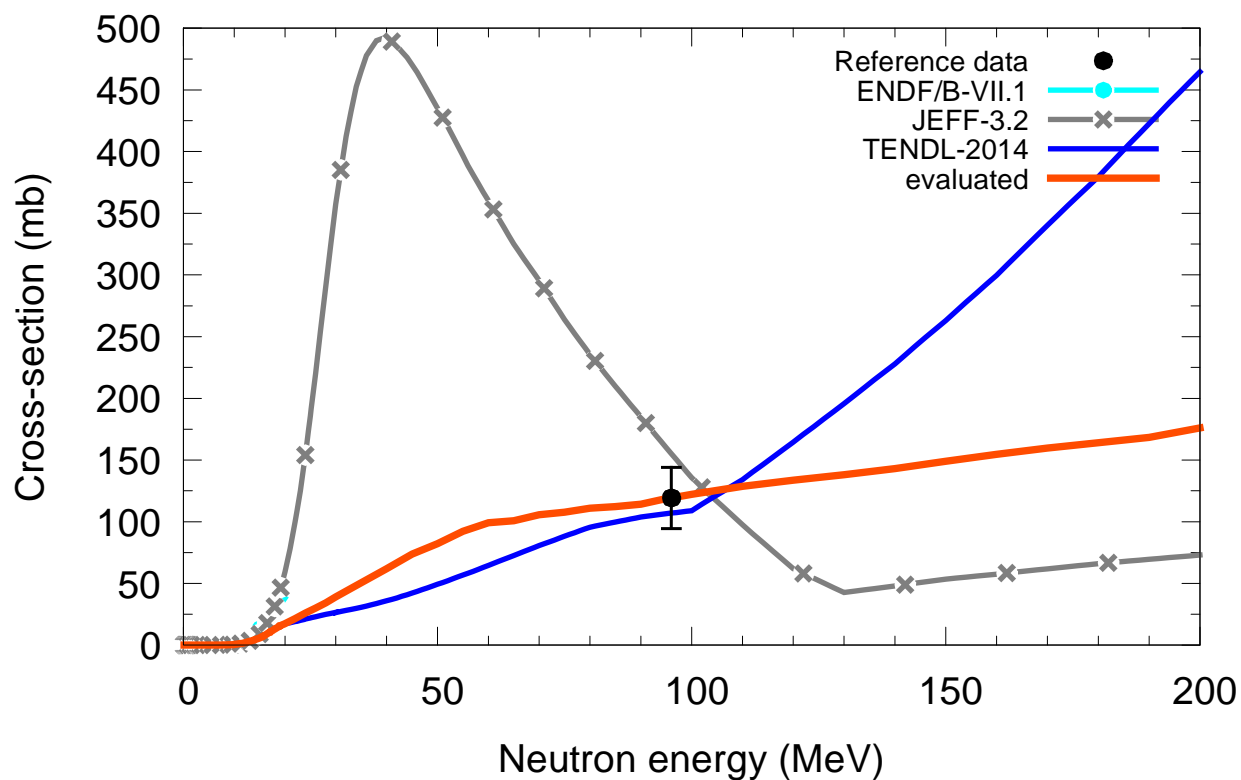
### $^{91}\text{Zr}(n,x)^4\text{He}$



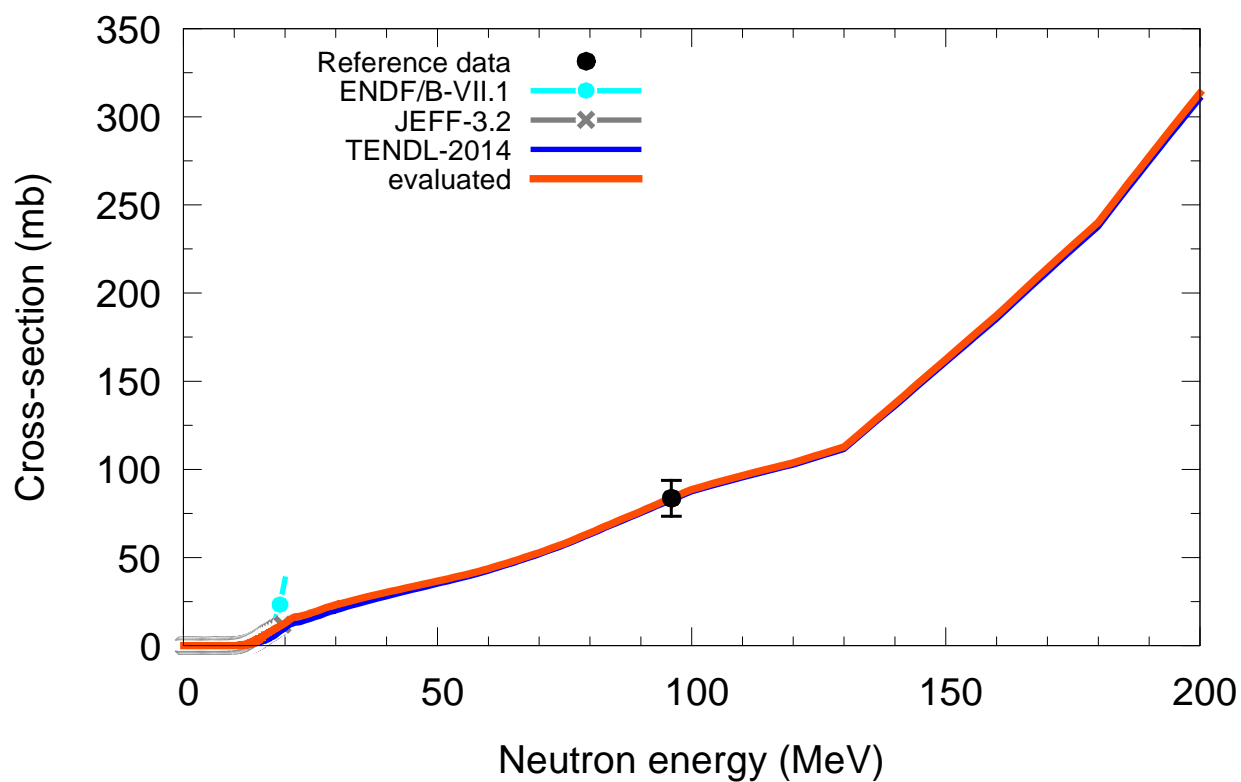
### $^{92}\text{Zr}(n,x)^4\text{He}$

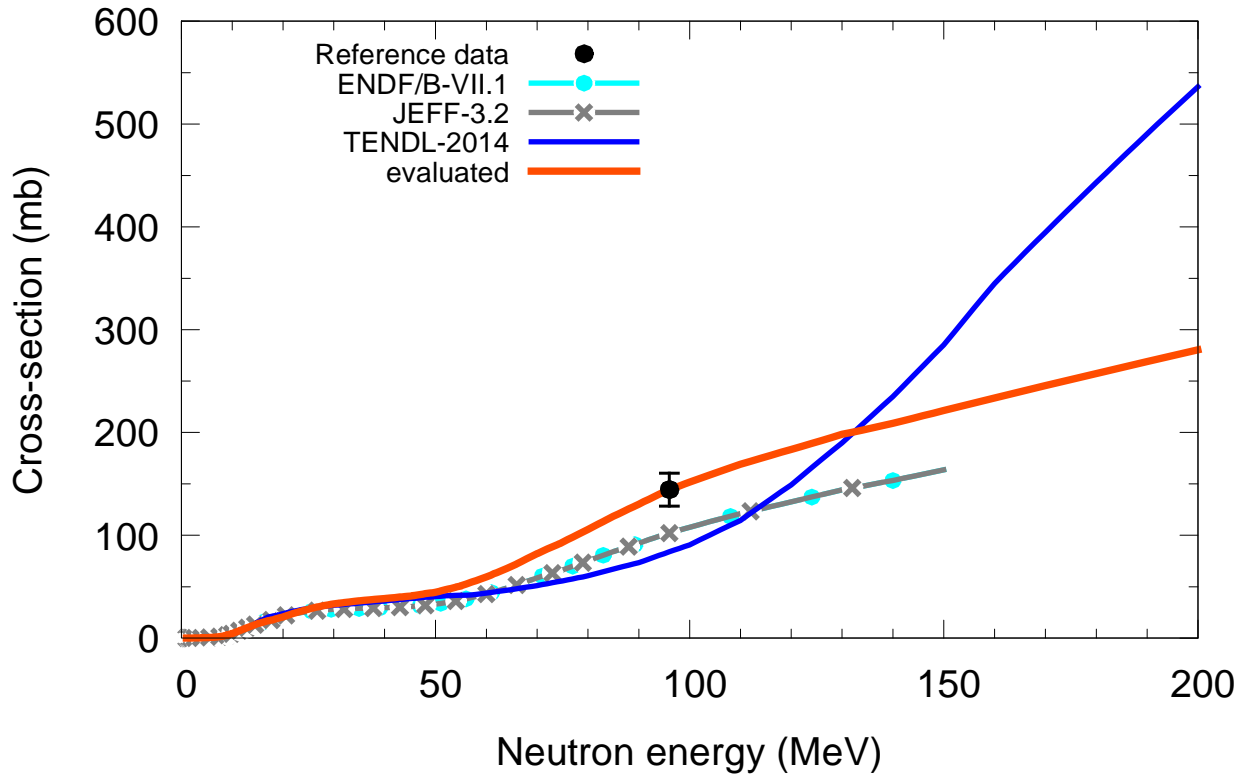
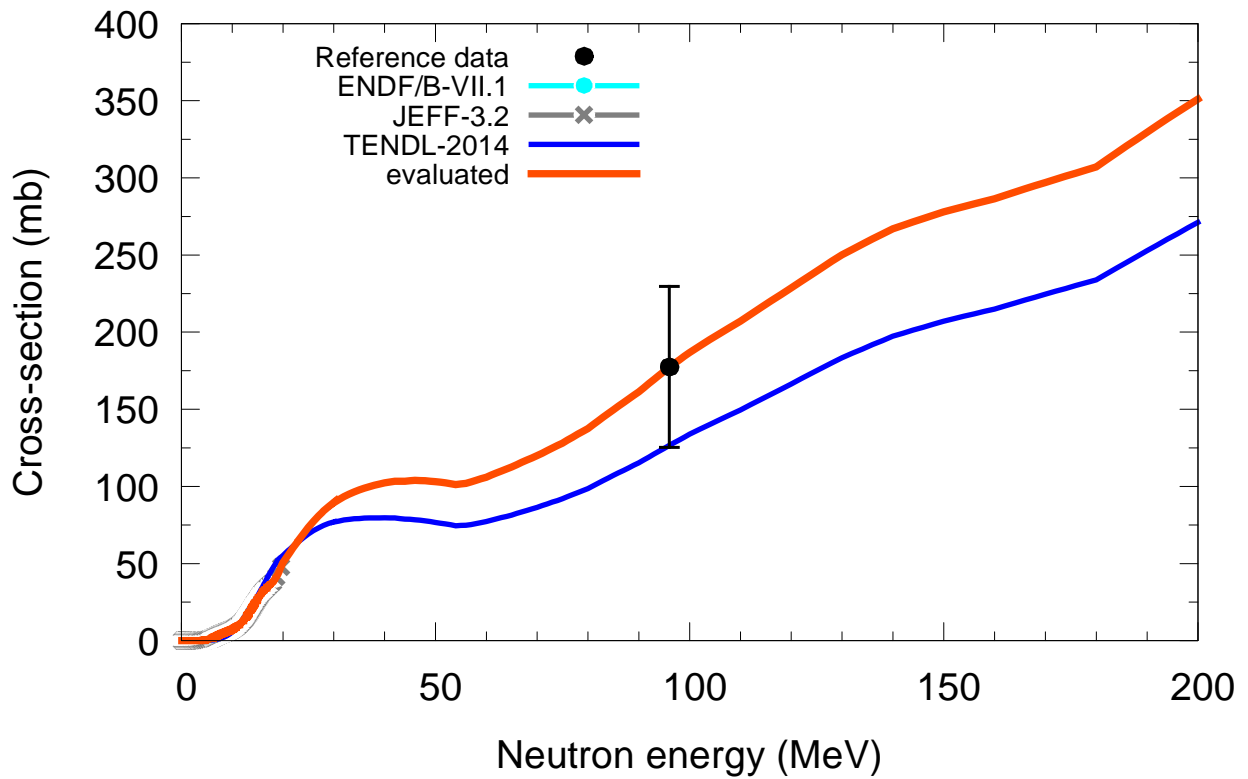


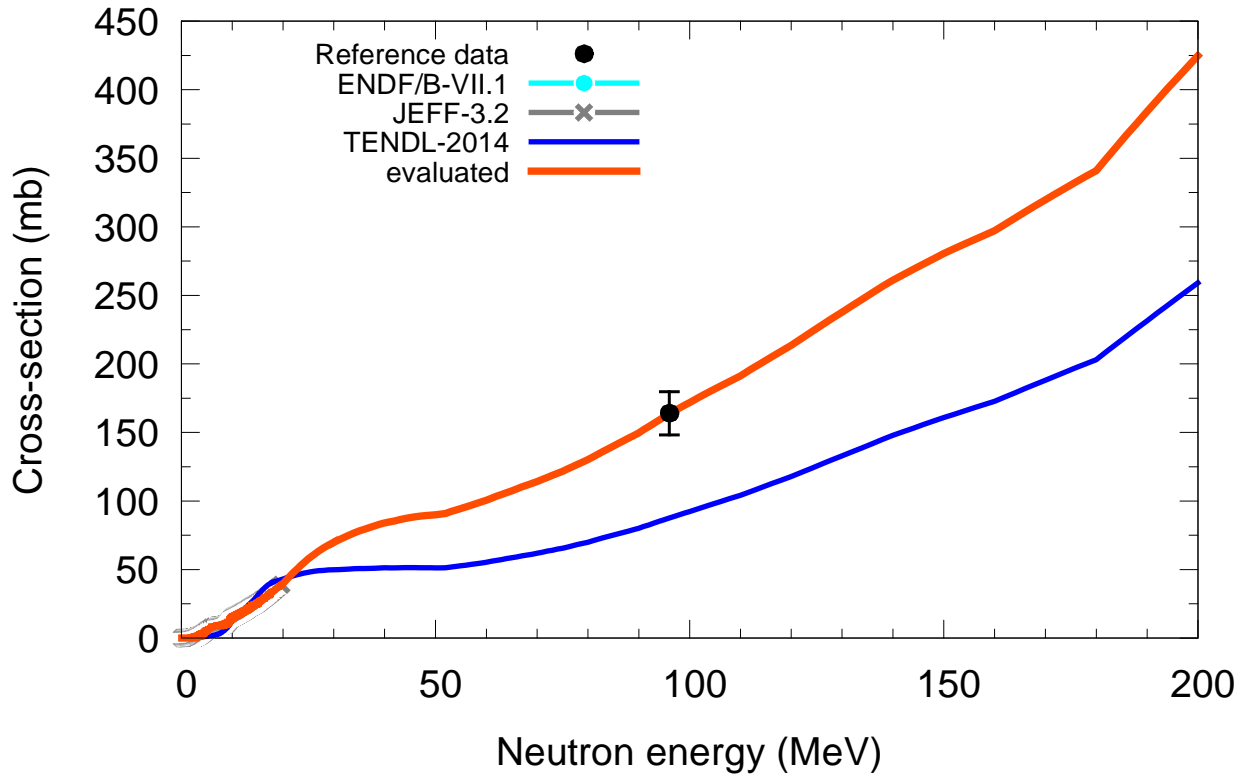
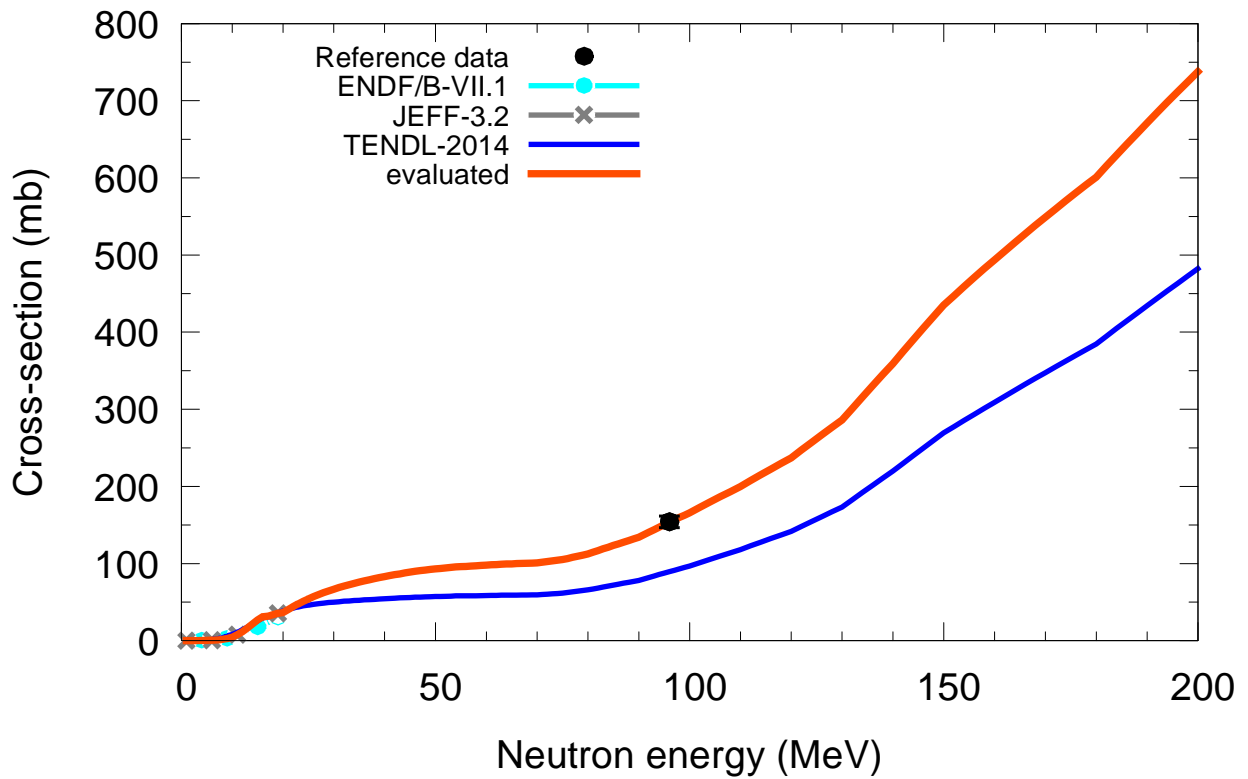
$^{94}\text{Zr}(n,x)^4\text{He}$



$^{96}\text{Zr}(n,x)^4\text{He}$

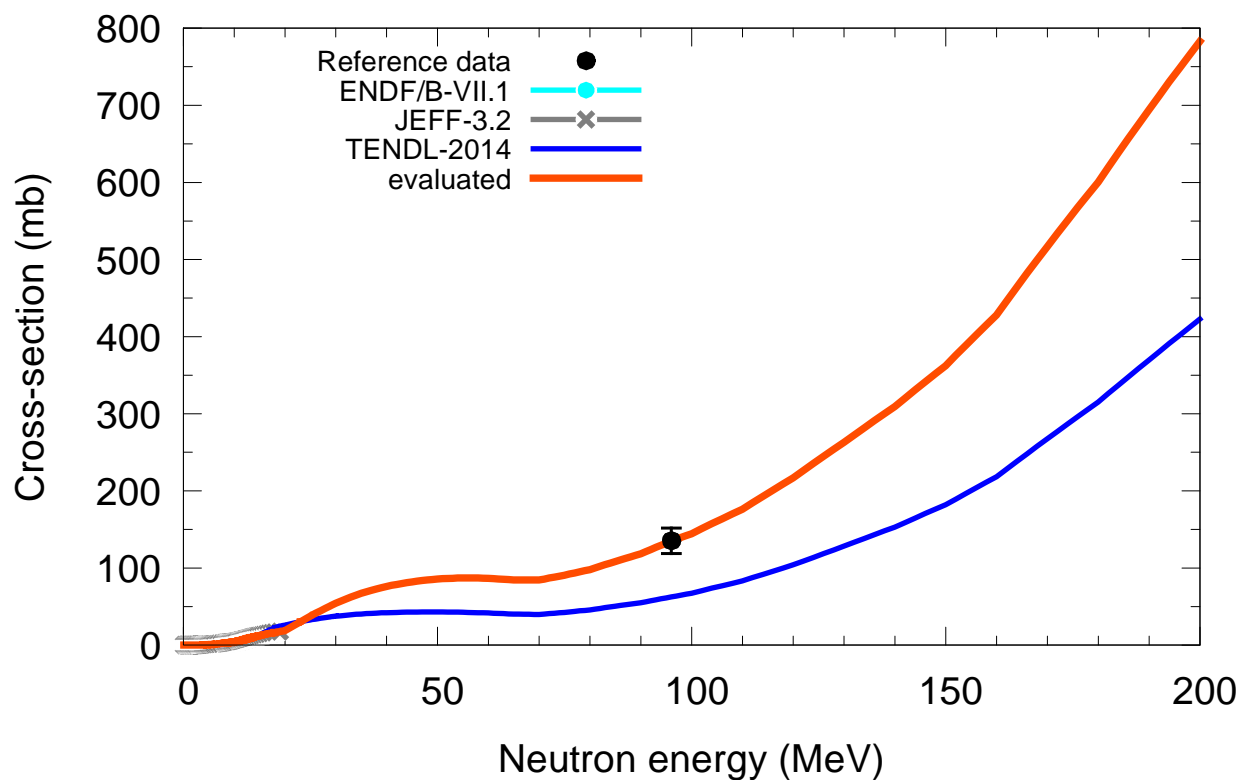


$^{93}\text{Nb}(n,x)^4\text{He}$  $^{92}\text{Mo}(n,x)^4\text{He}$ 

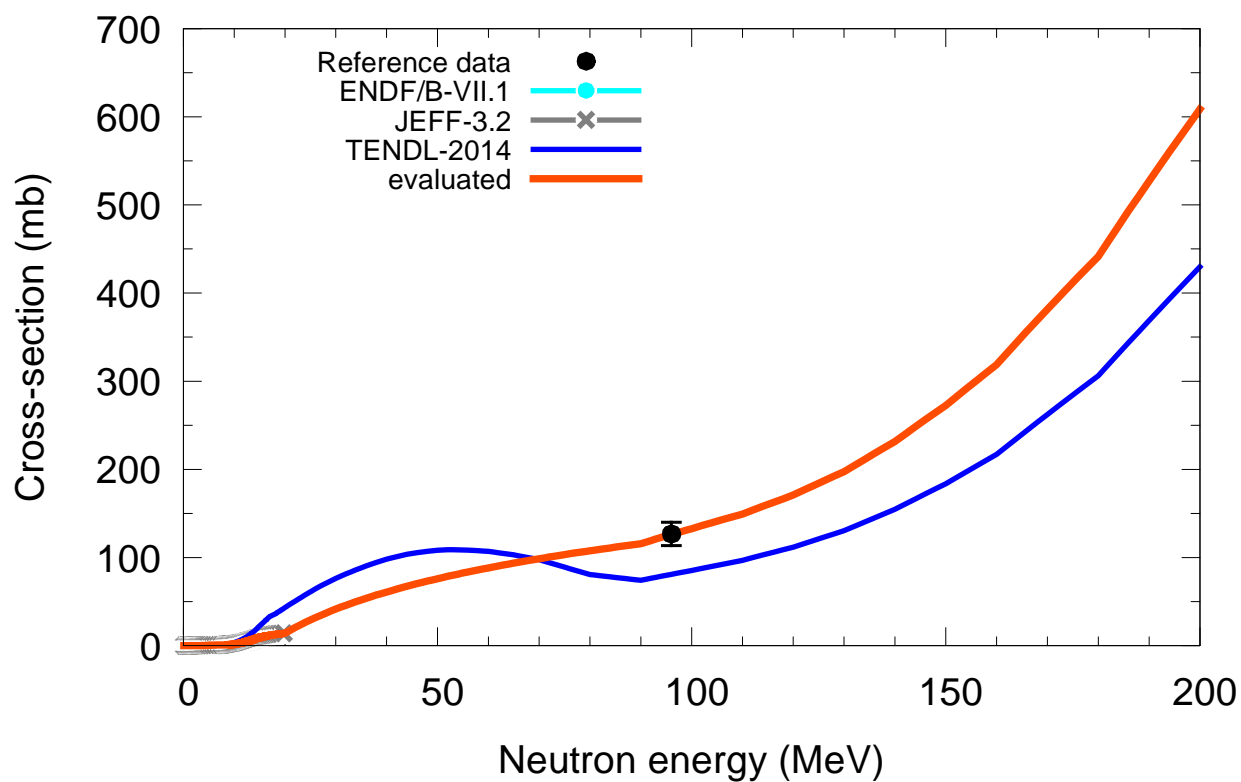
$^{94}\text{Mo}(n,x)^4\text{He}$  $^{95}\text{Mo}(n,x)^4\text{He}$ 



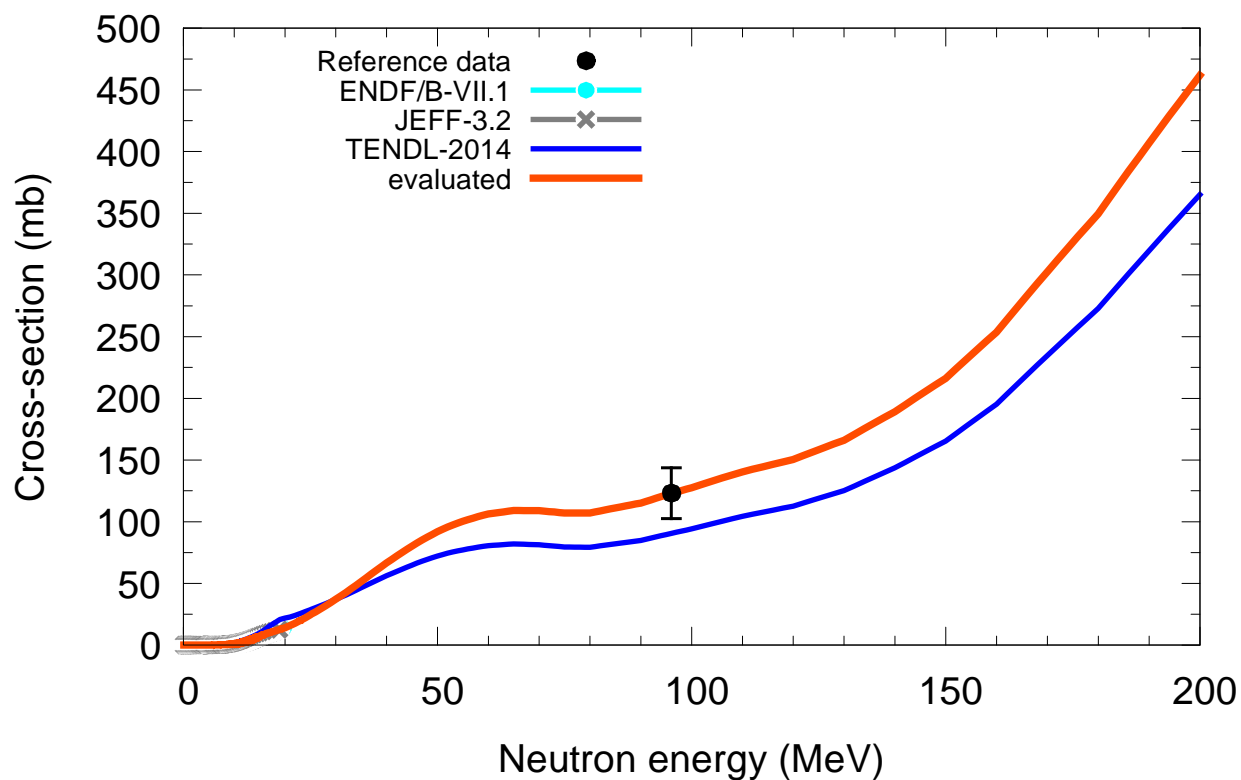
$^{96}\text{Mo}(n,x)^4\text{He}$



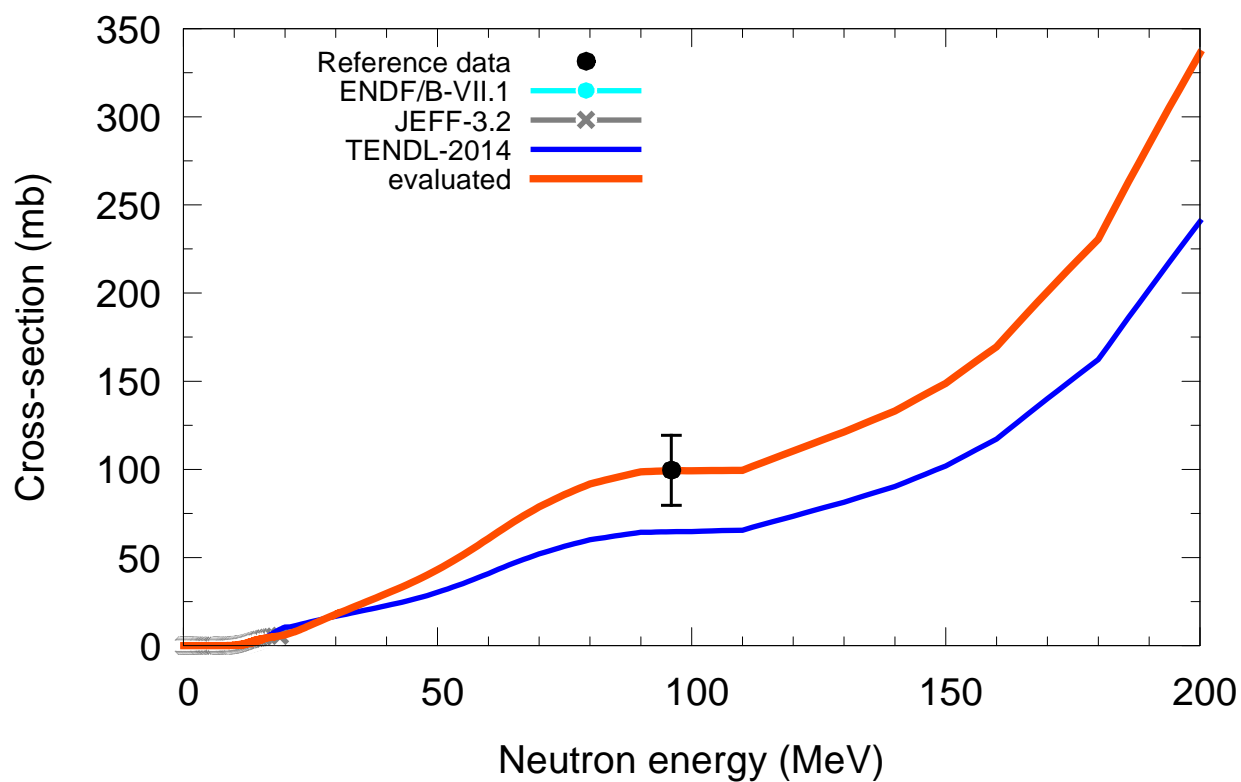
$^{97}\text{Mo}(n,x)^4\text{He}$

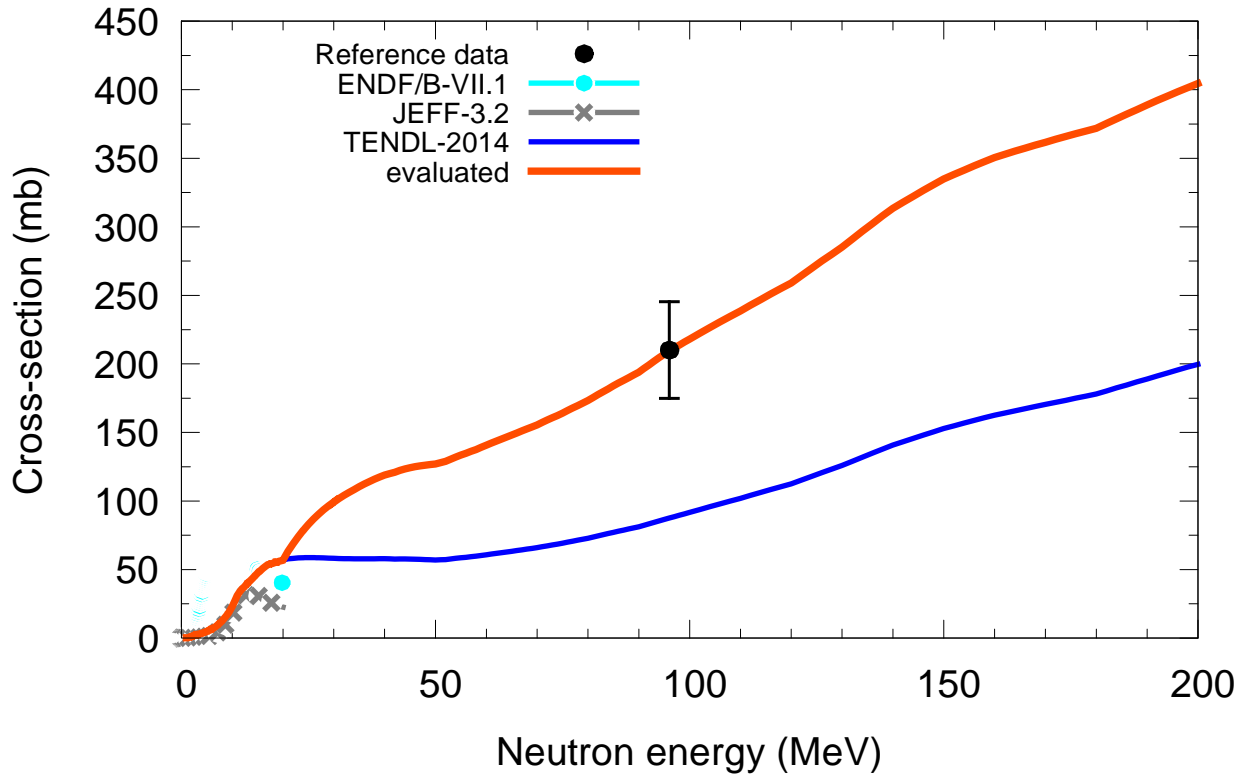
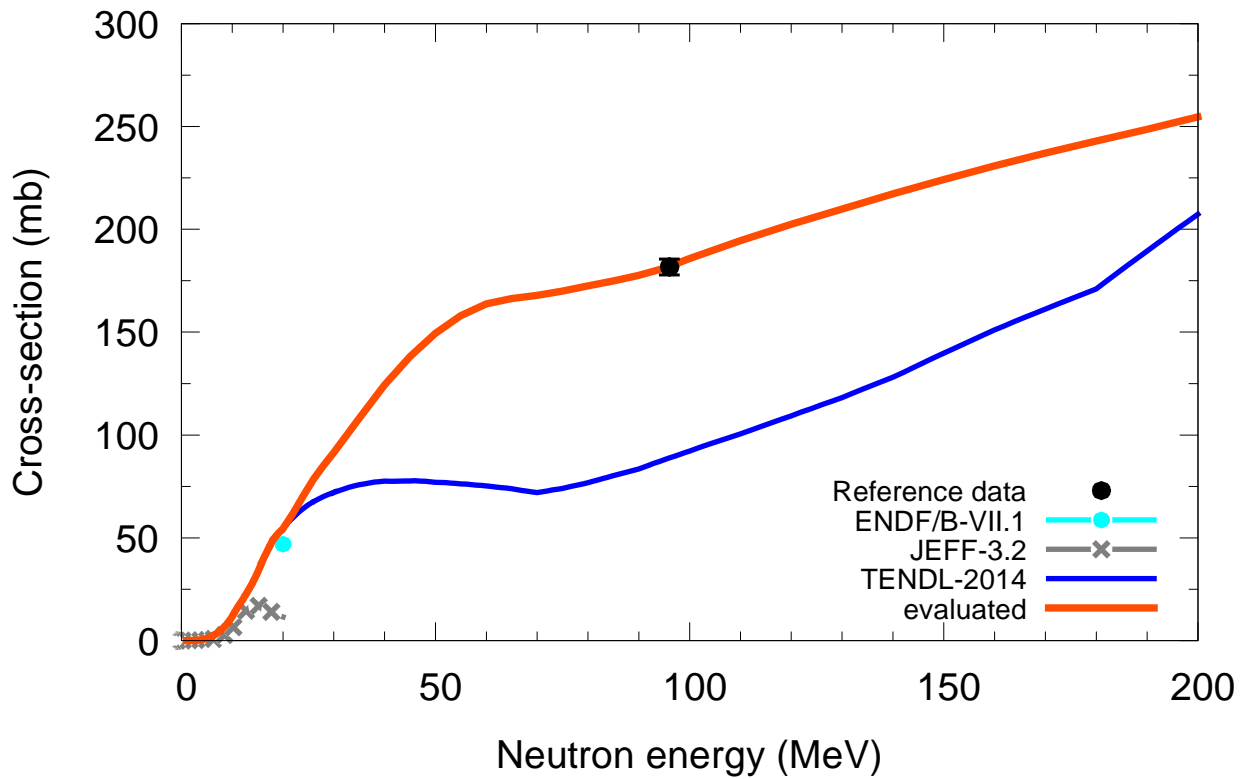


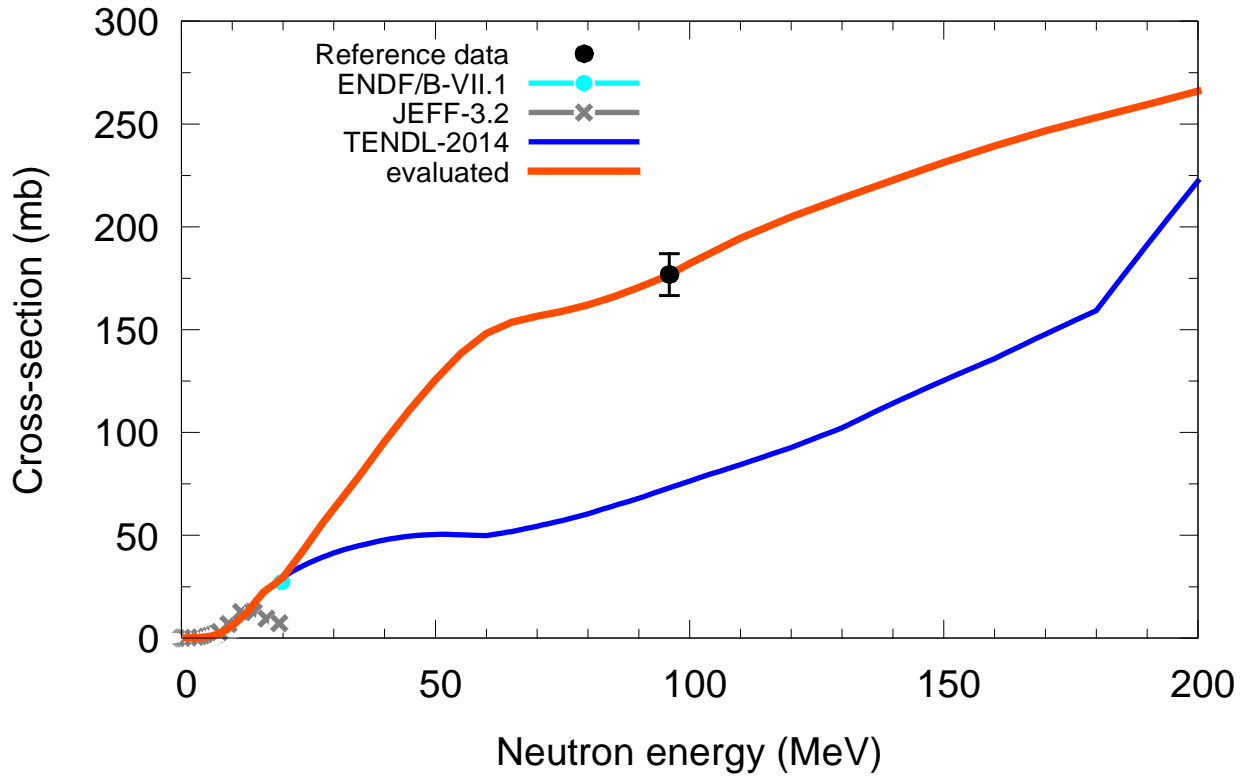
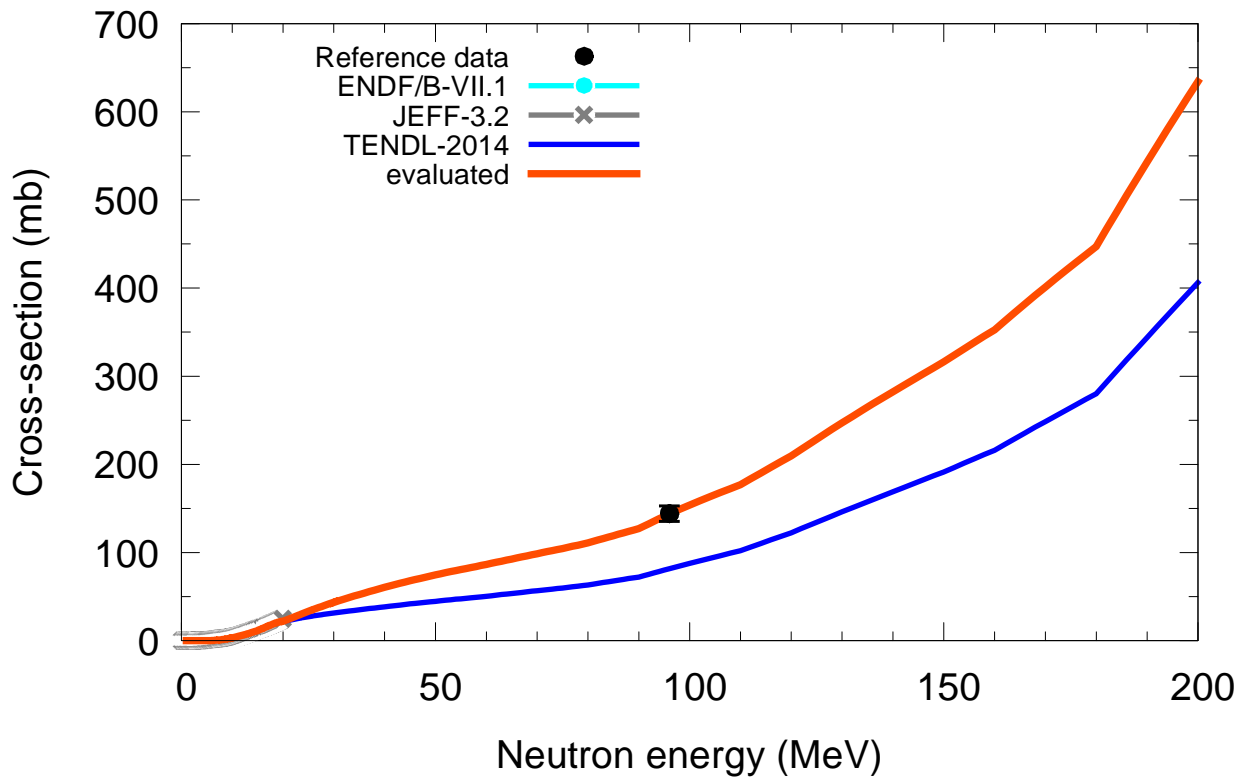
$^{98}\text{Mo}(n,x)^4\text{He}$



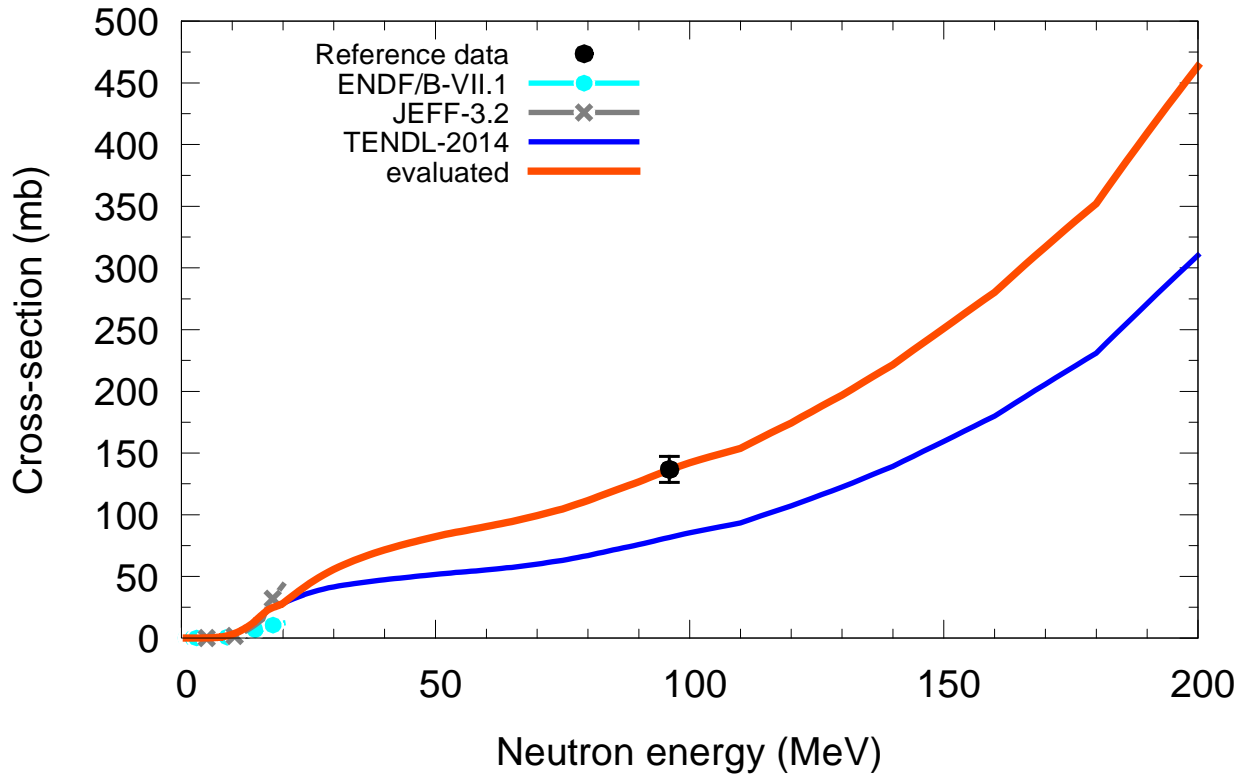
$^{100}\text{Mo}(n,x)^4\text{He}$



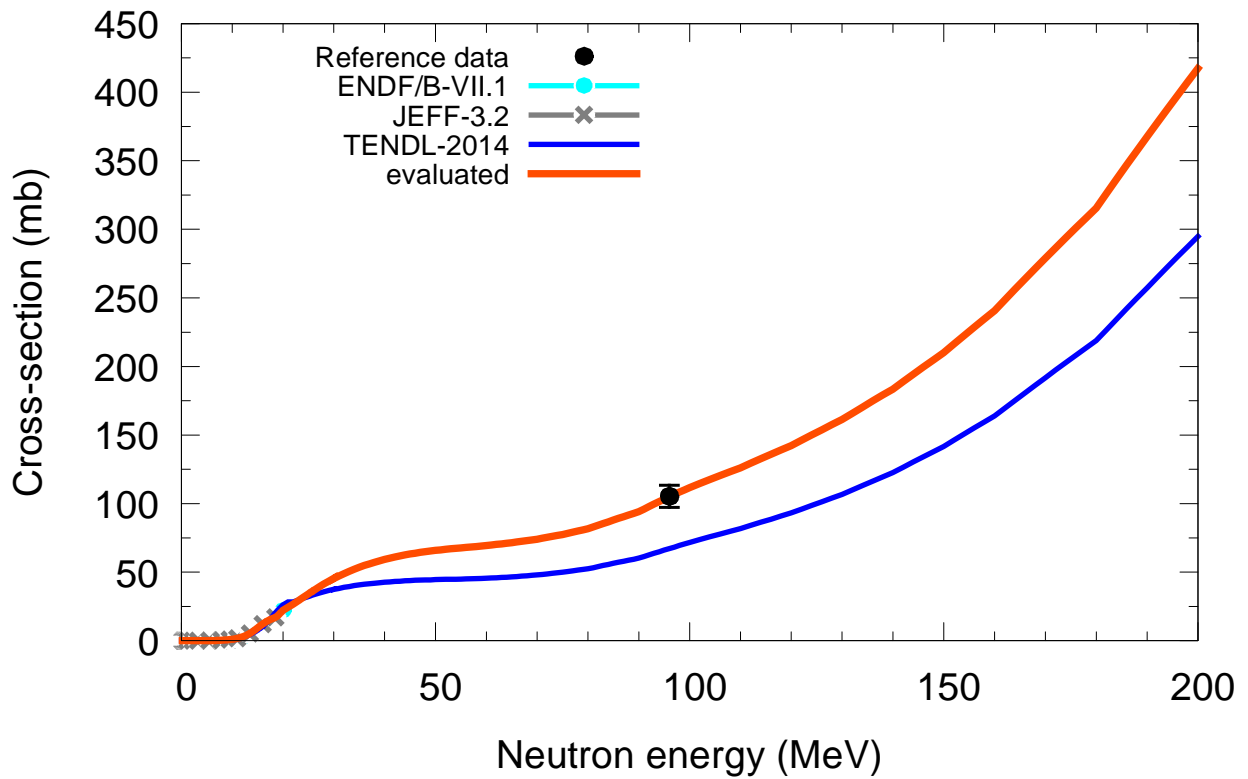
$^{96}\text{Ru}(n,x)^4\text{He}$  $^{98}\text{Ru}(n,x)^4\text{He}$ 

$^{99}\text{Ru}(n,x)^4\text{He}$  $^{100}\text{Ru}(n,x)^4\text{He}$ 

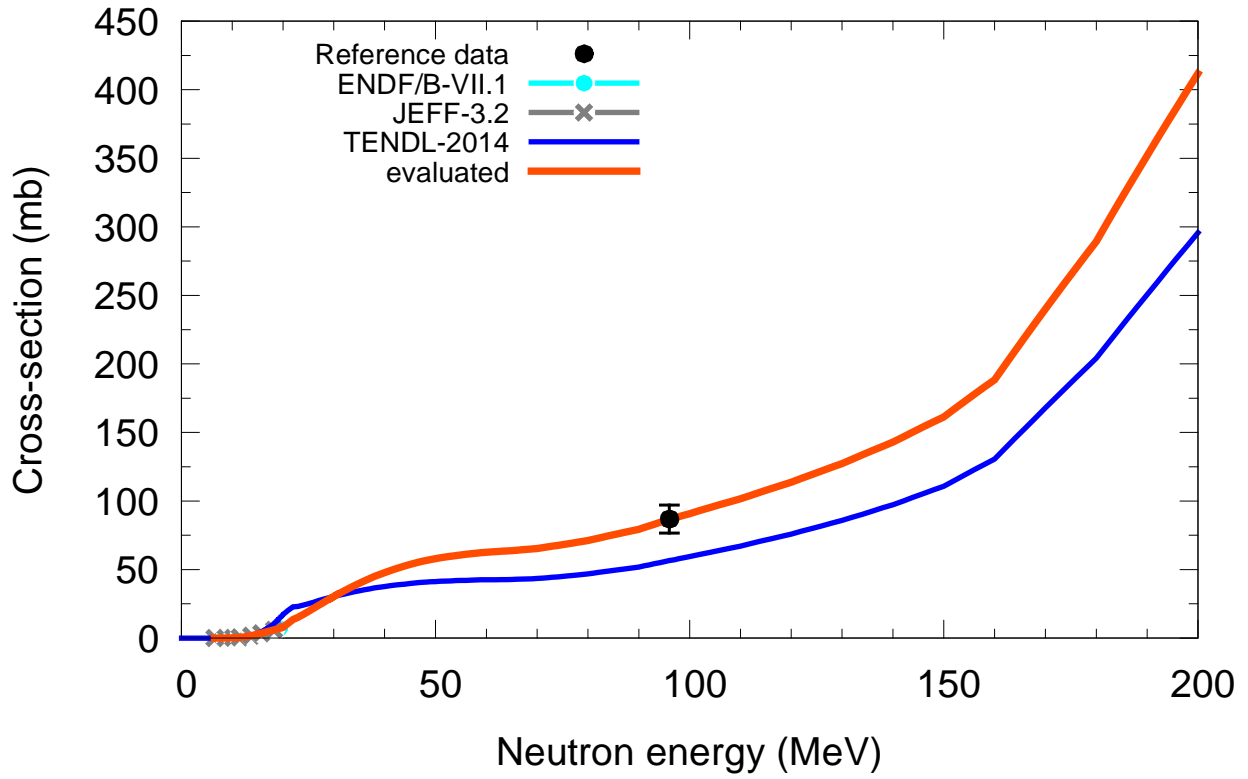
### $^{101}\text{Ru}(n,x)^4\text{He}$



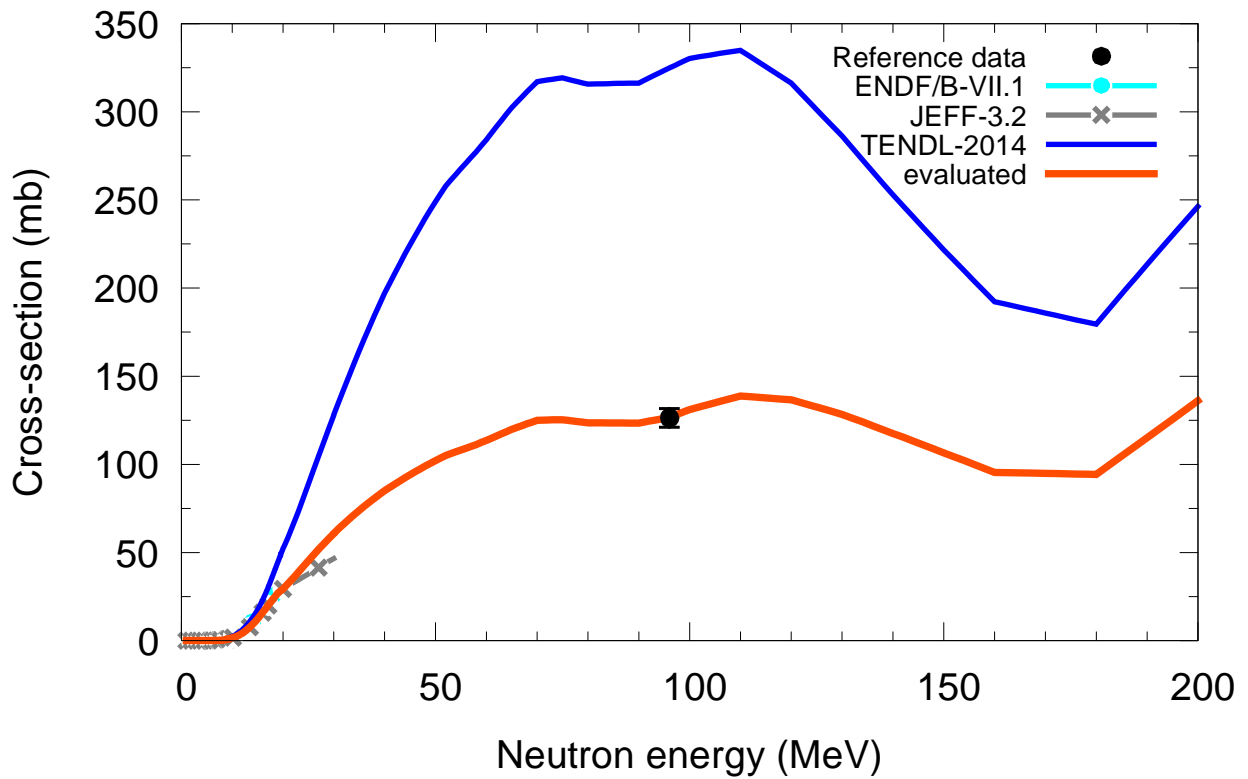
### $^{102}\text{Ru}(n,x)^4\text{He}$



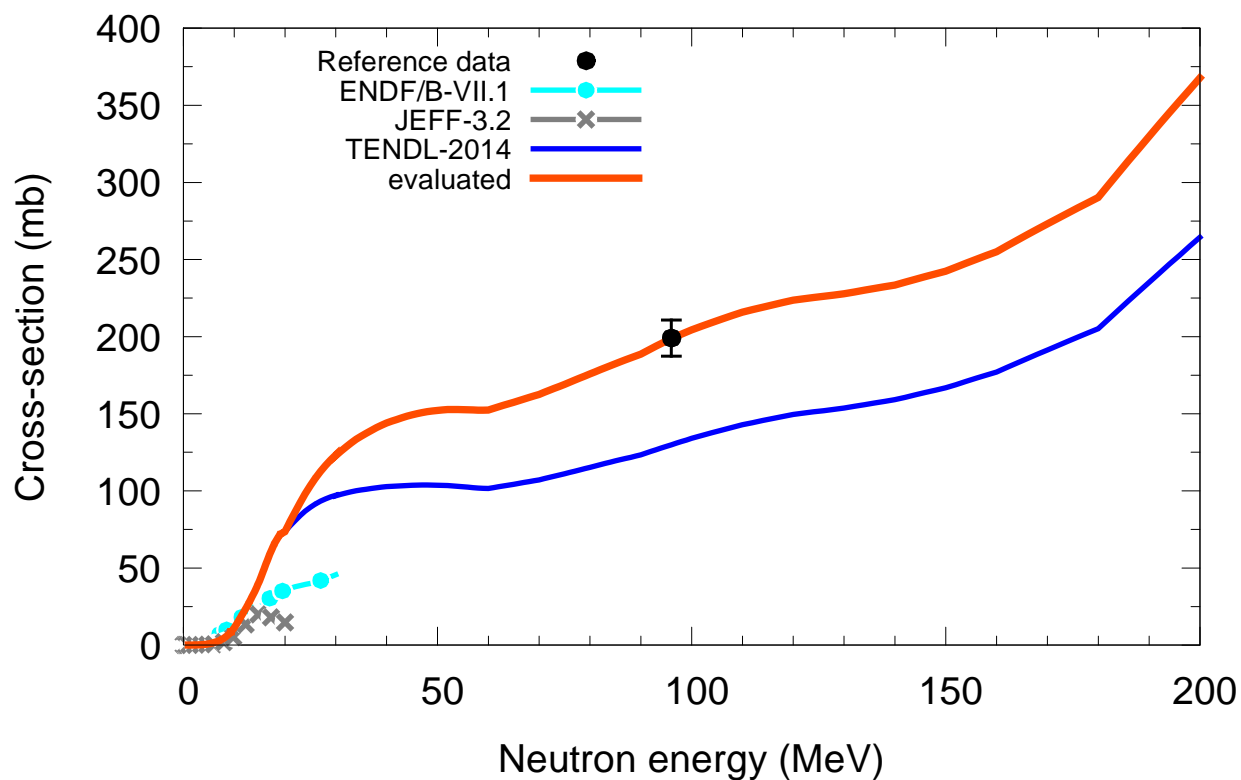
$^{104}\text{Ru}(n,x)^4\text{He}$



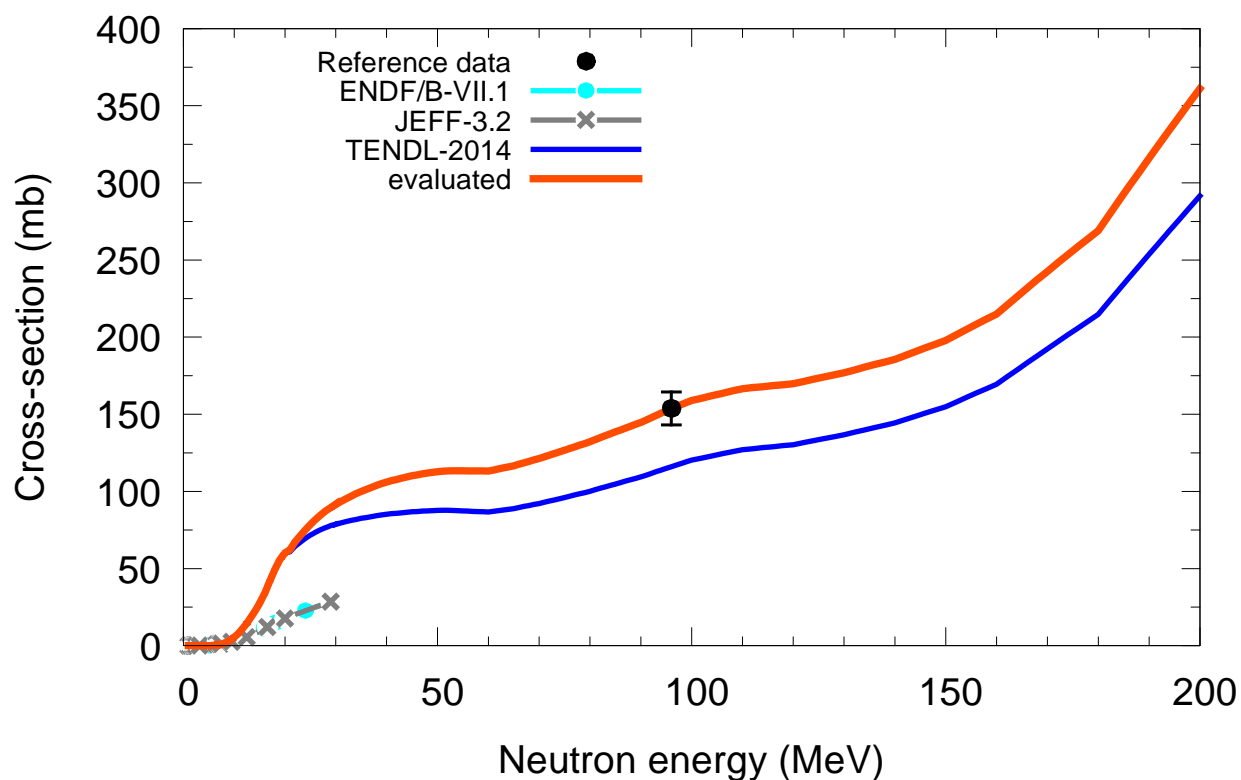
$^{103}\text{Rh}(n,x)^4\text{He}$



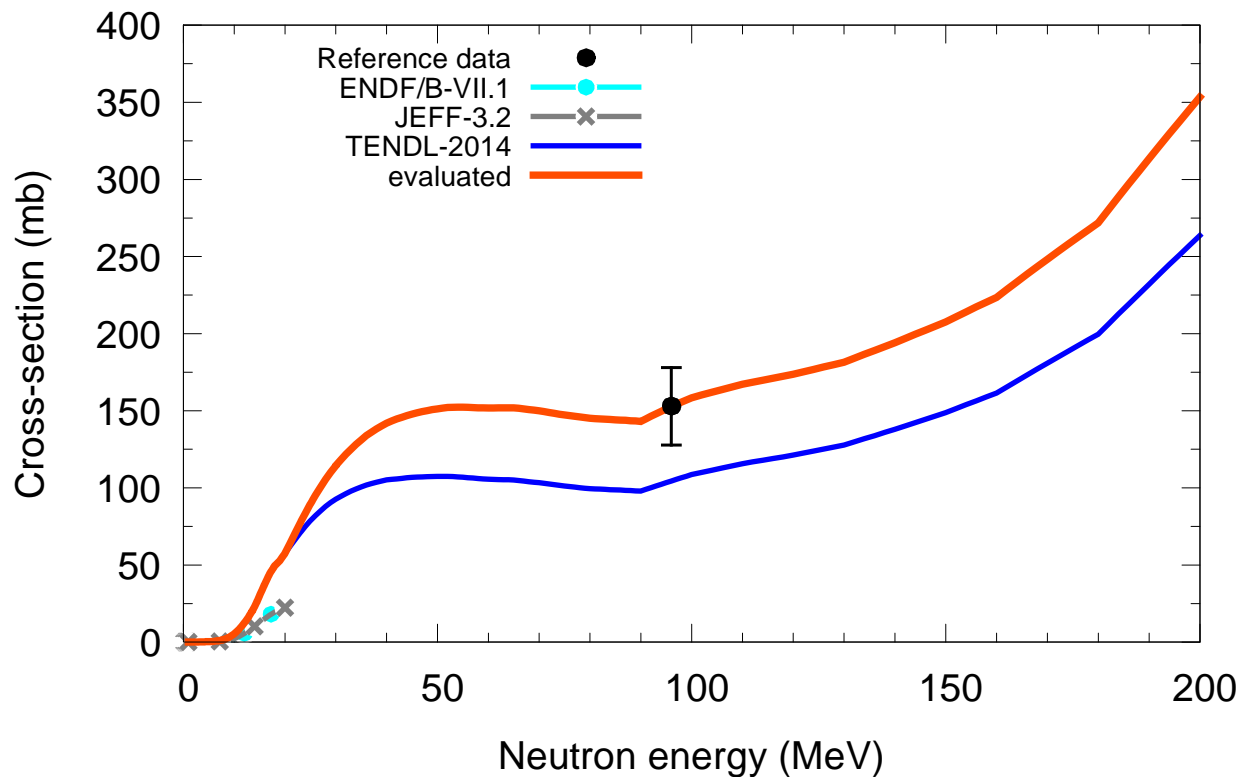
$^{102}\text{Pd}(n,x)^4\text{He}$



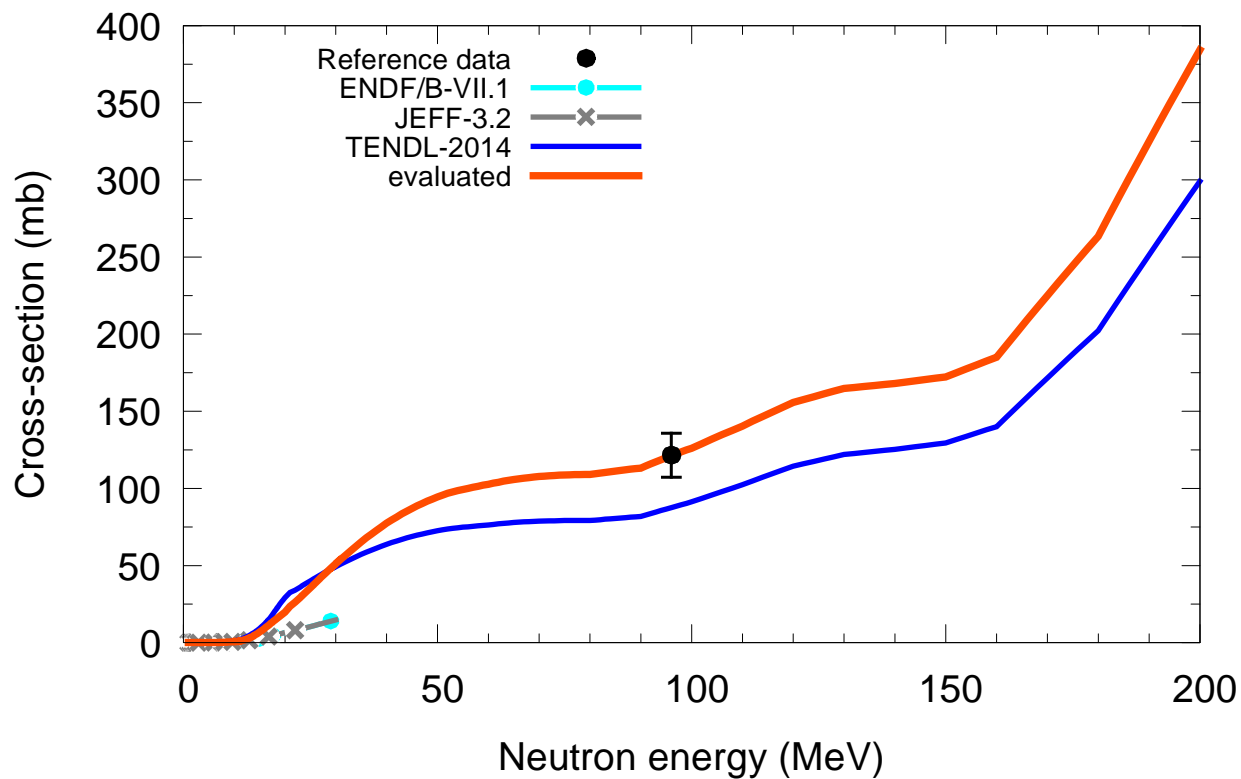
$^{104}\text{Pd}(n,x)^4\text{He}$



$^{105}\text{Pd}(n,x)^4\text{He}$

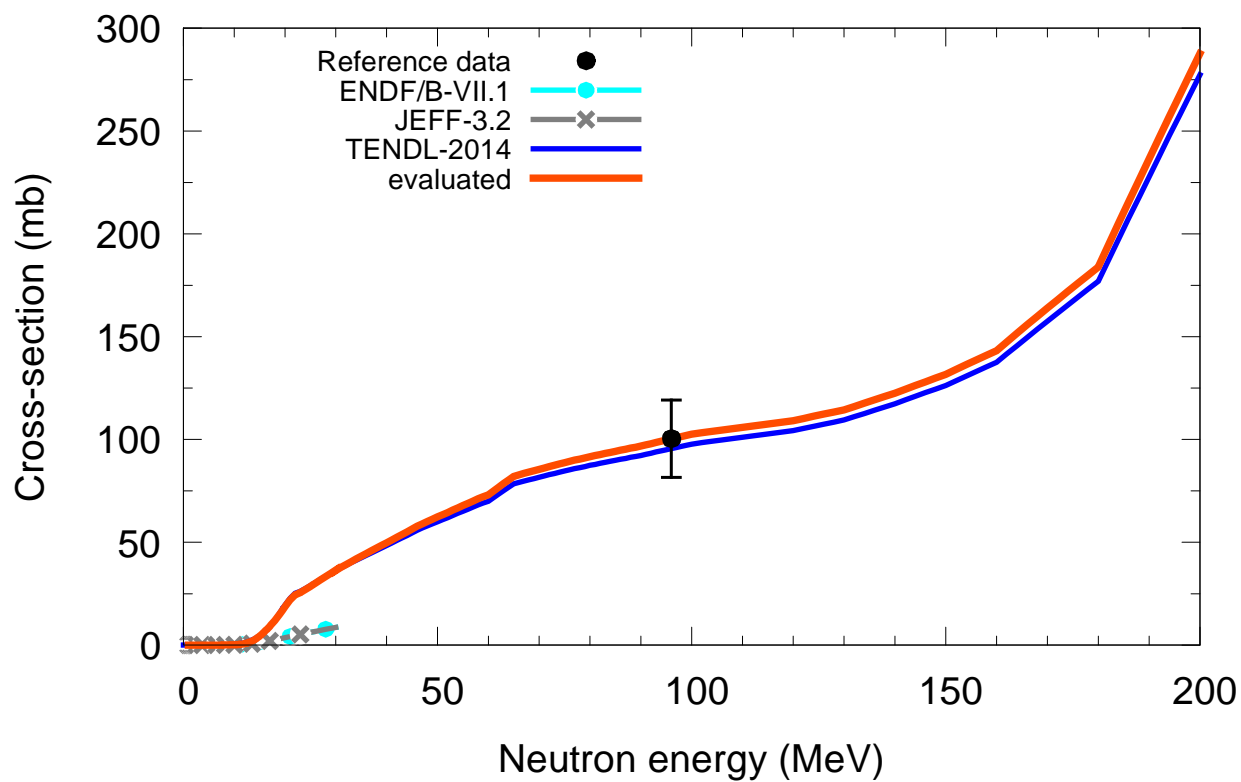


$^{106}\text{Pd}(n,x)^4\text{He}$

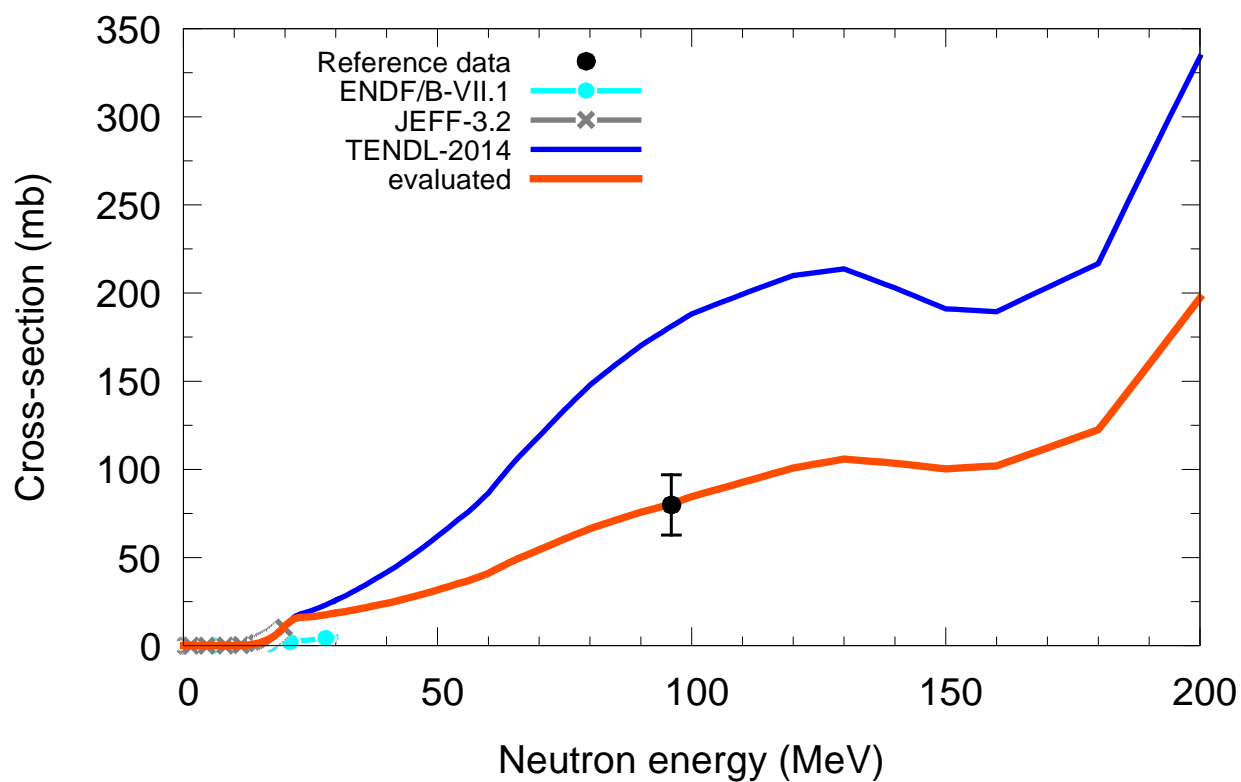




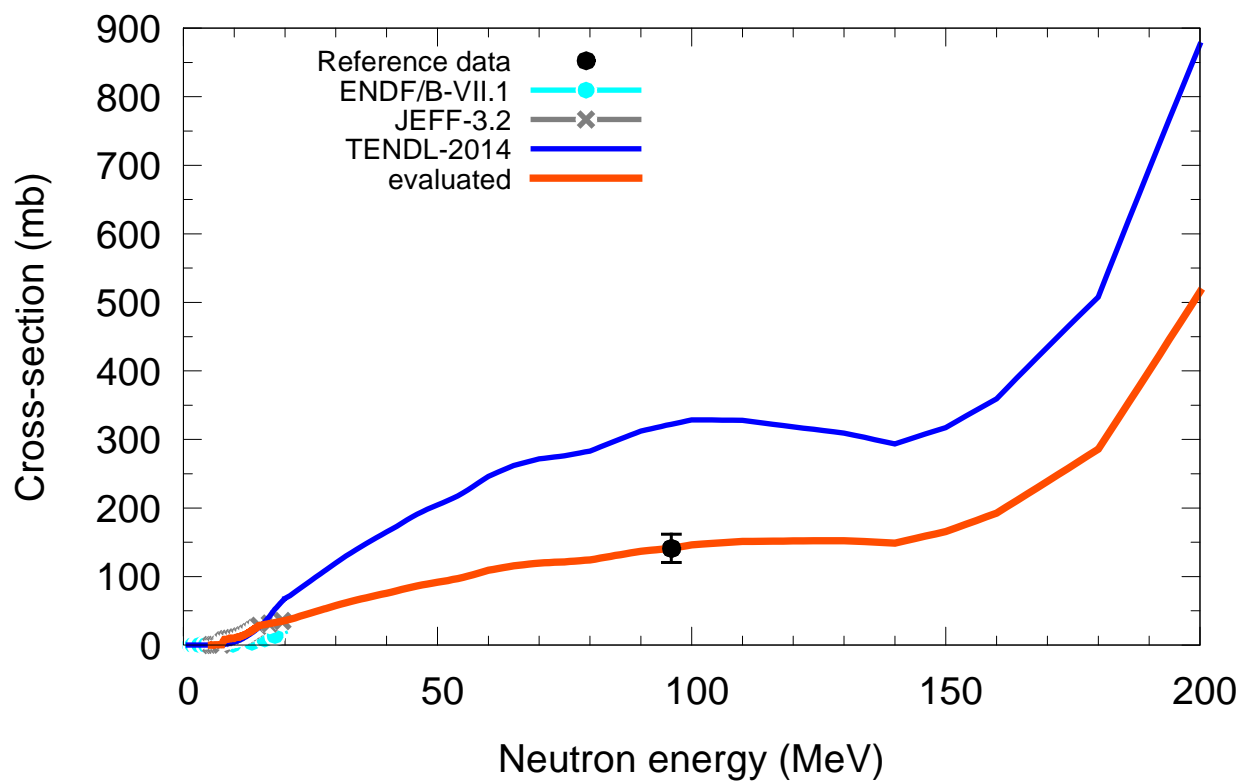
$^{108}\text{Pd}(n,x)^4\text{He}$



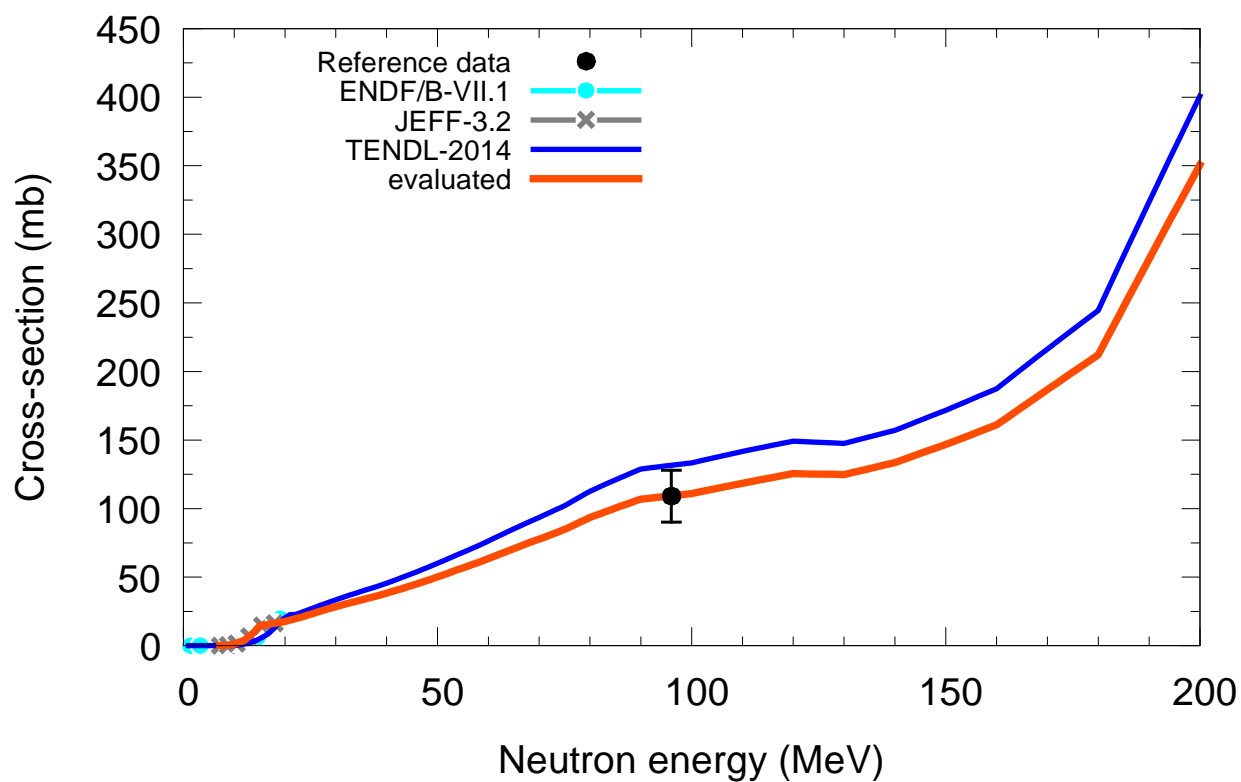
$^{110}\text{Pd}(n,x)^4\text{He}$

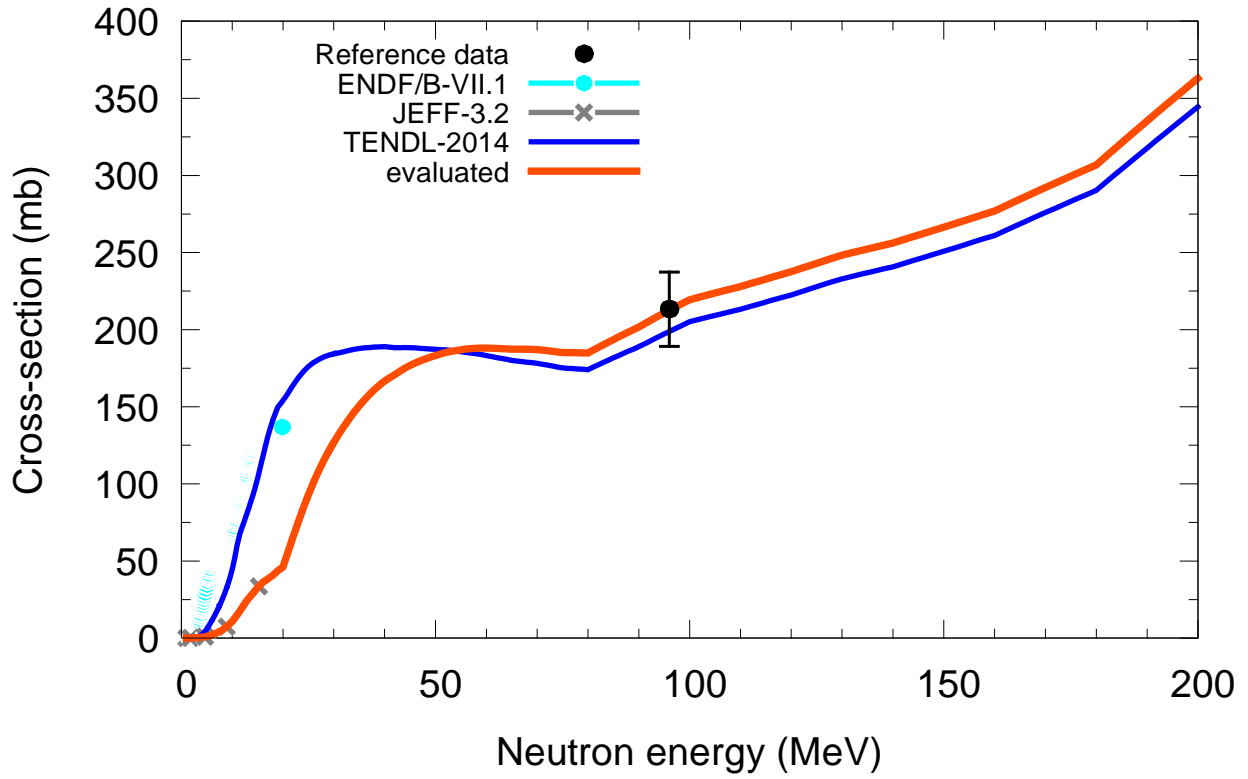
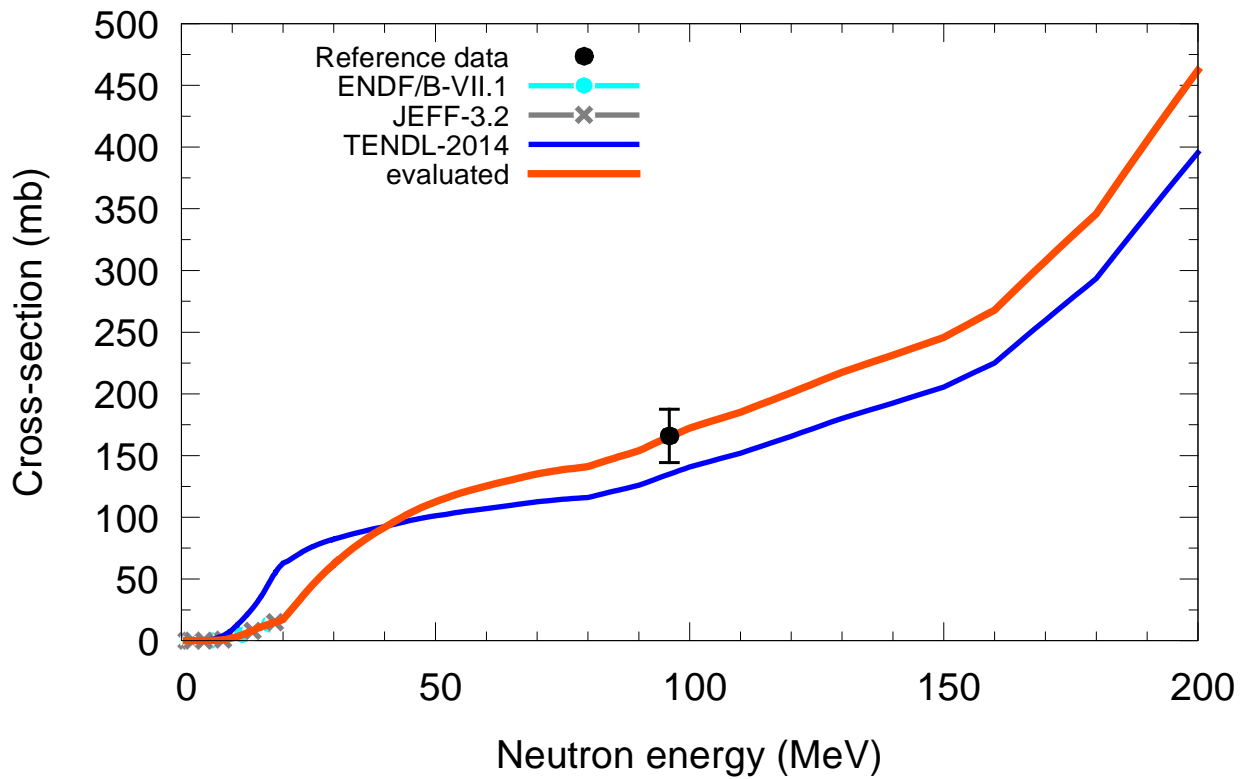


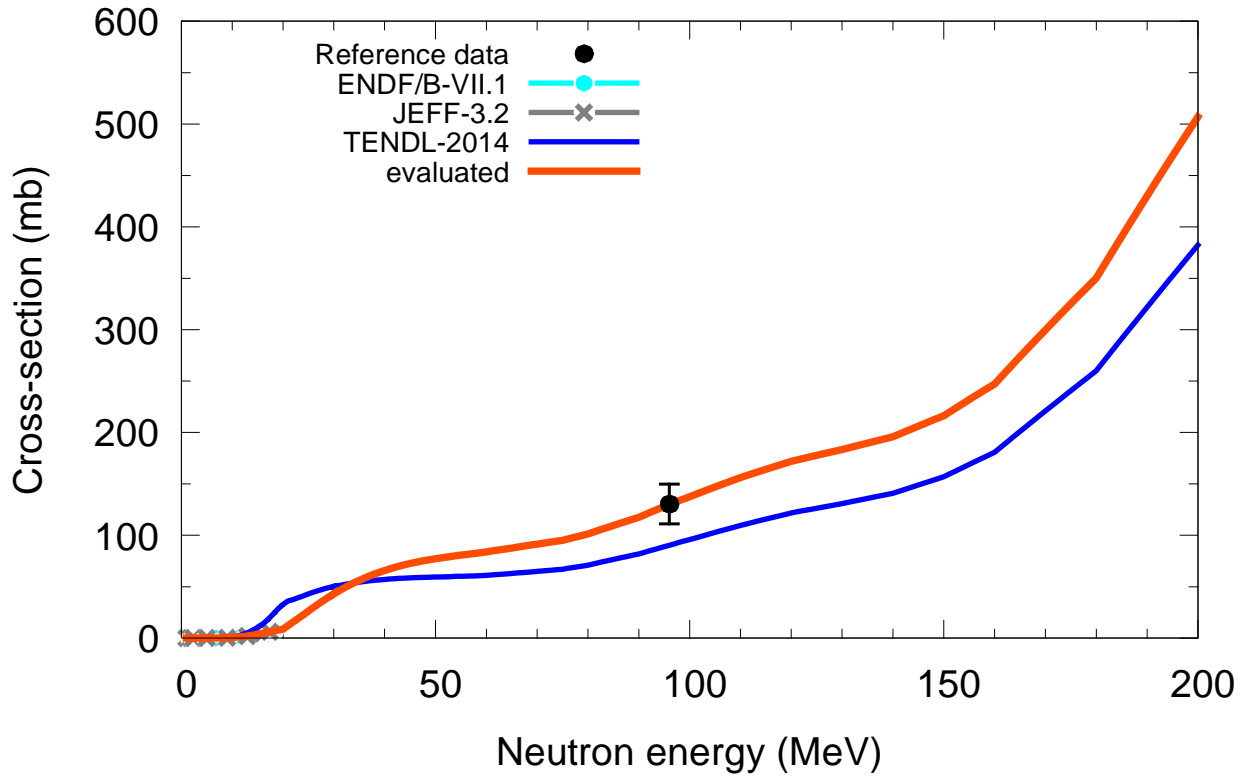
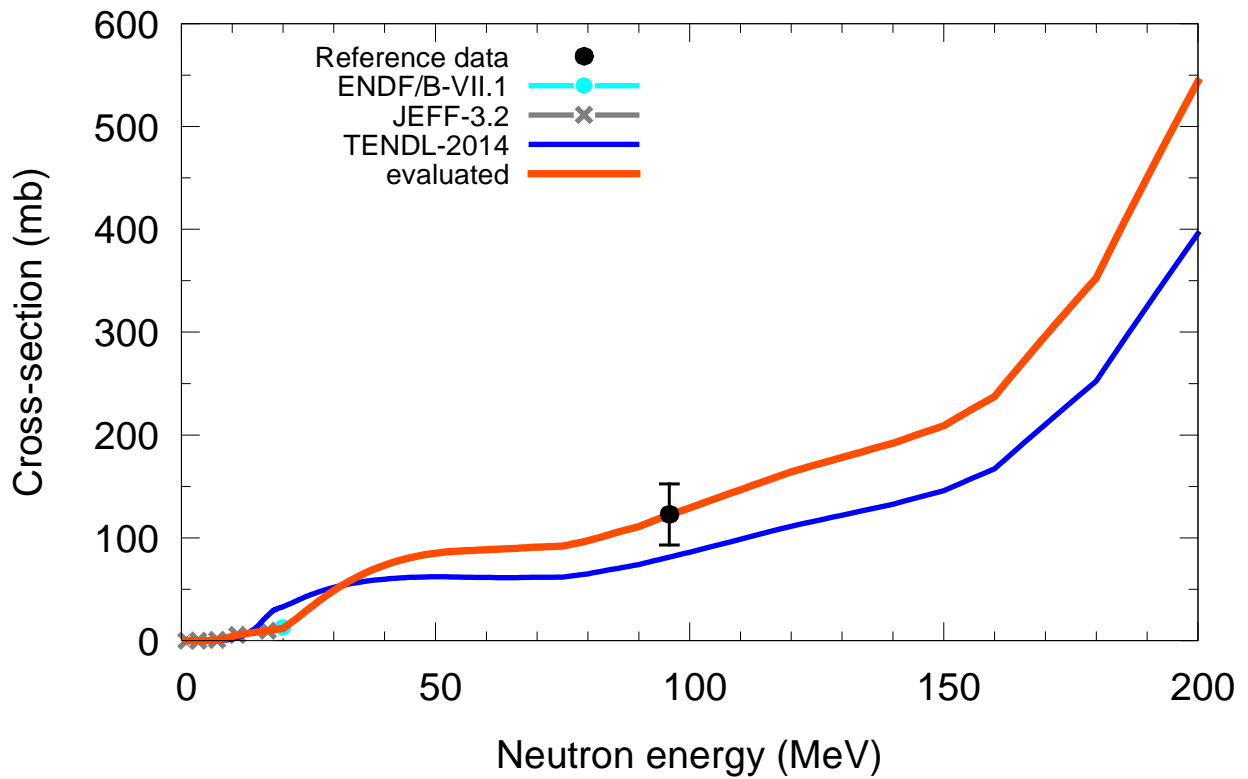
$^{107}\text{Ag}(n,x)^4\text{He}$



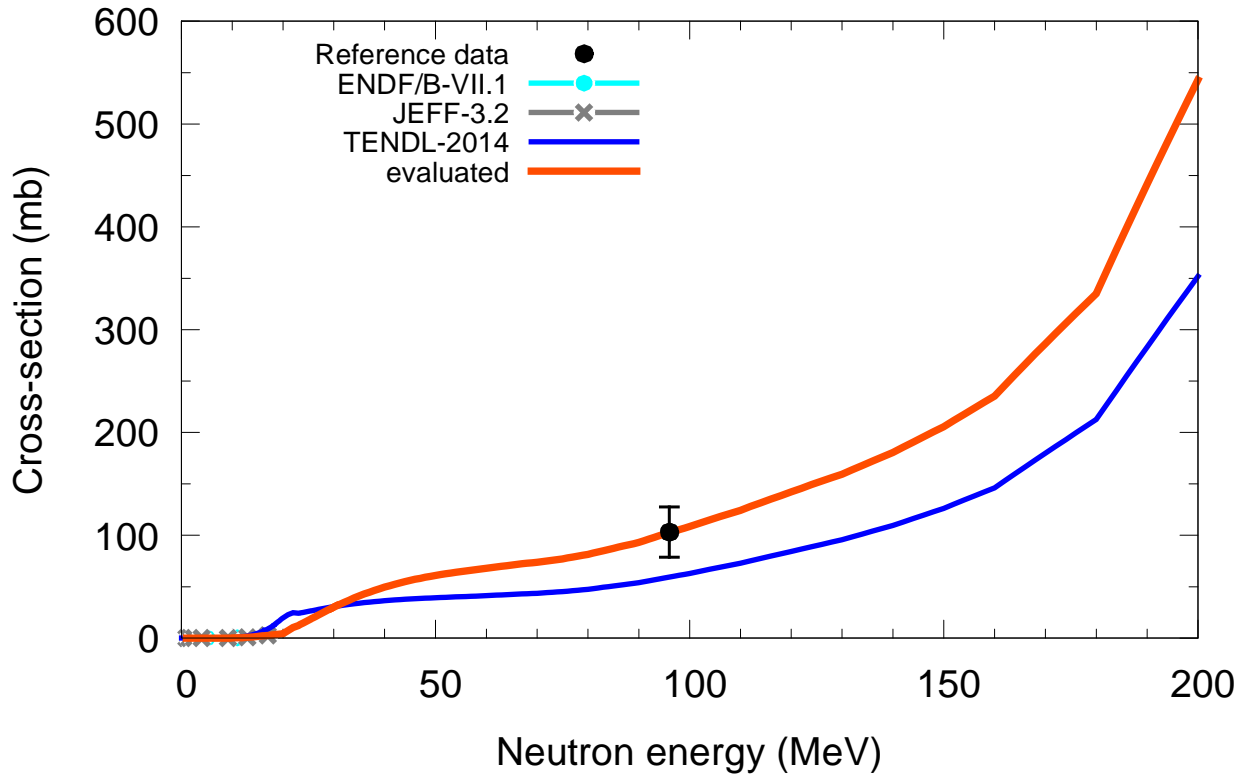
$^{109}\text{Ag}(n,x)^4\text{He}$



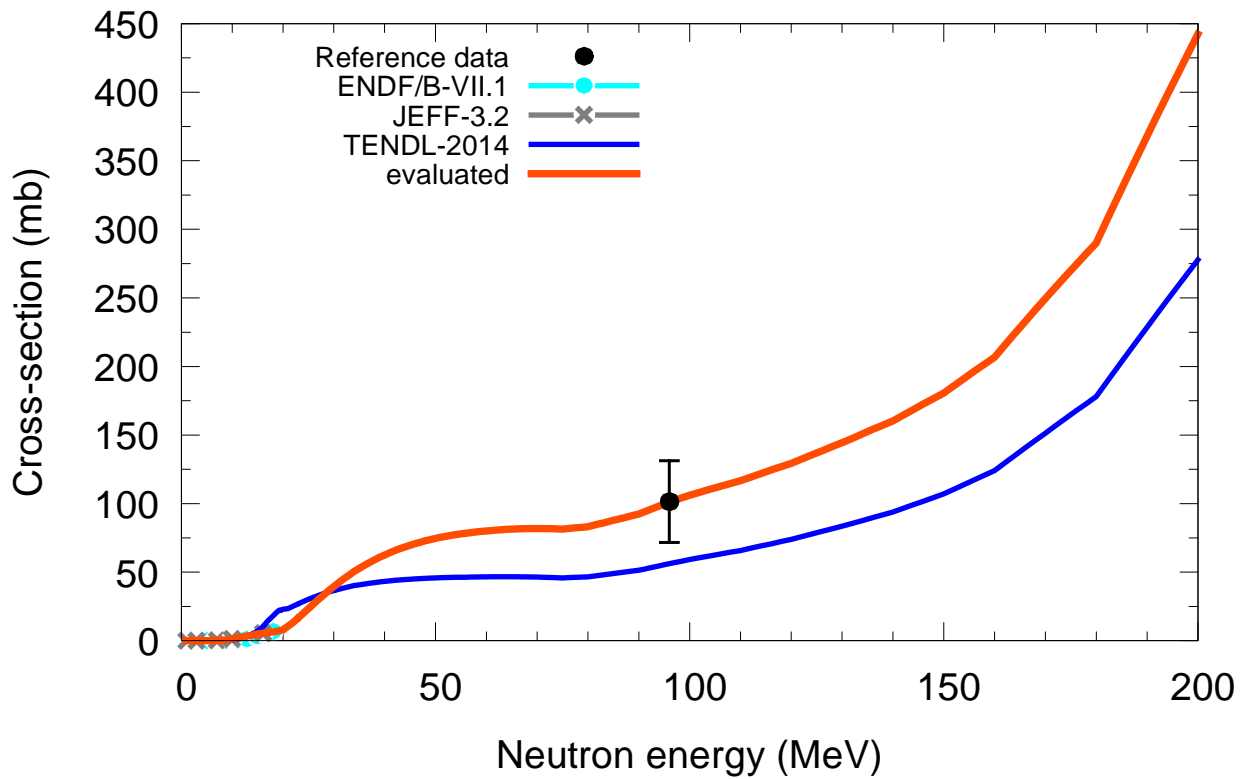
$^{106}\text{Cd}(n,x)^4\text{He}$  $^{108}\text{Cd}(n,x)^4\text{He}$ 

$^{110}\text{Cd}(n,x)^4\text{He}$  $^{111}\text{Cd}(n,x)^4\text{He}$ 

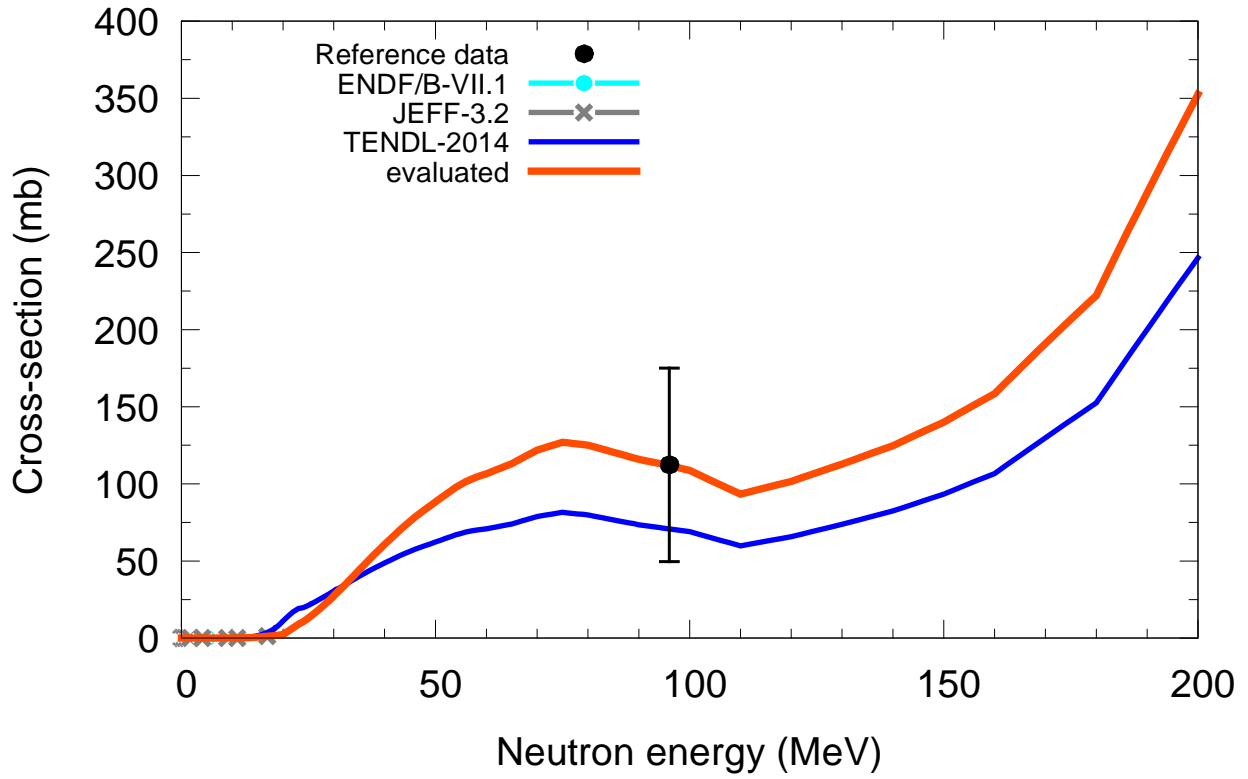
### $^{112}\text{Cd}(n,x)^4\text{He}$



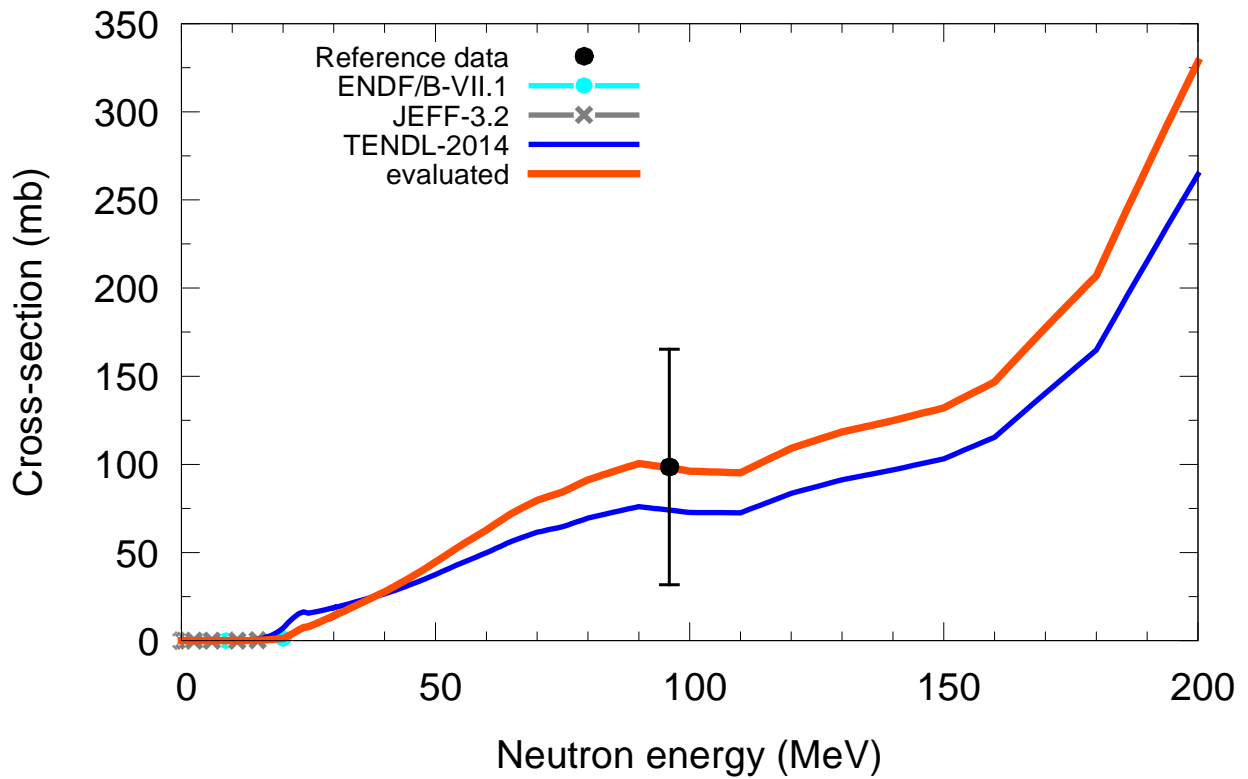
### $^{113}\text{Cd}(n,x)^4\text{He}$



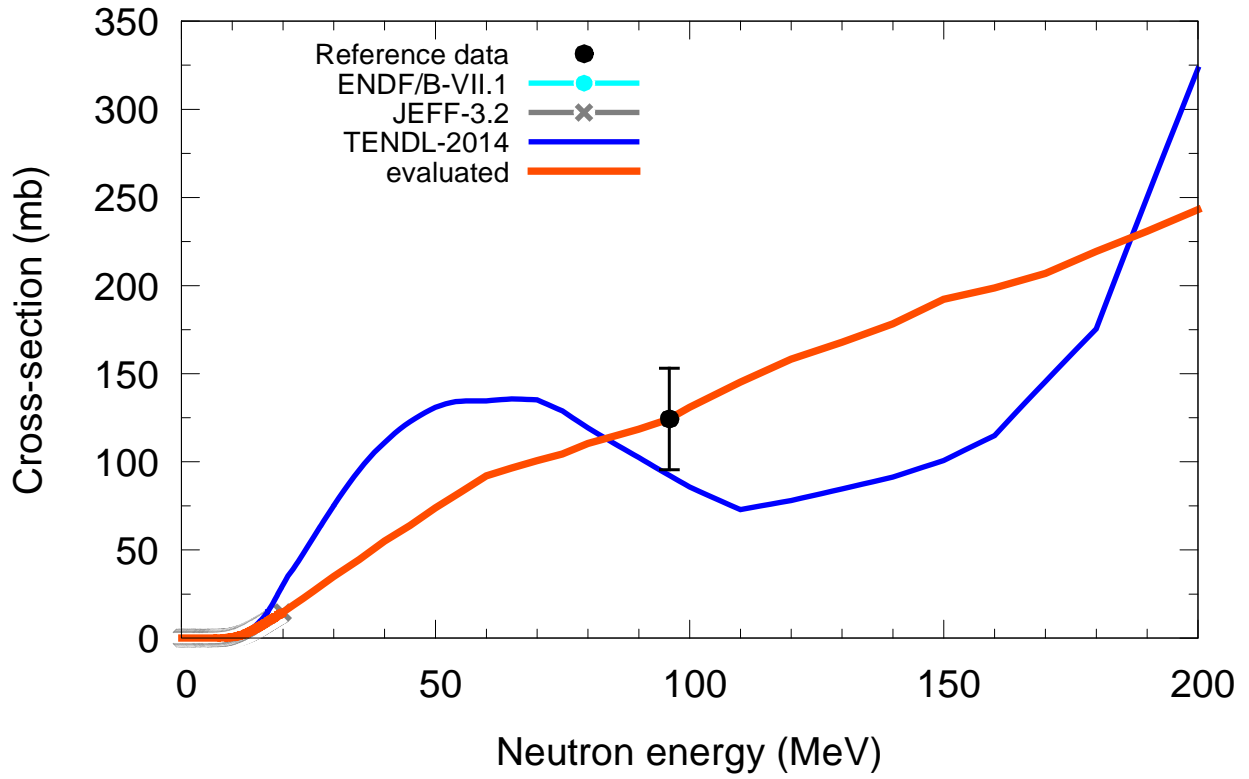
### $^{114}\text{Cd}(n,x)^4\text{He}$



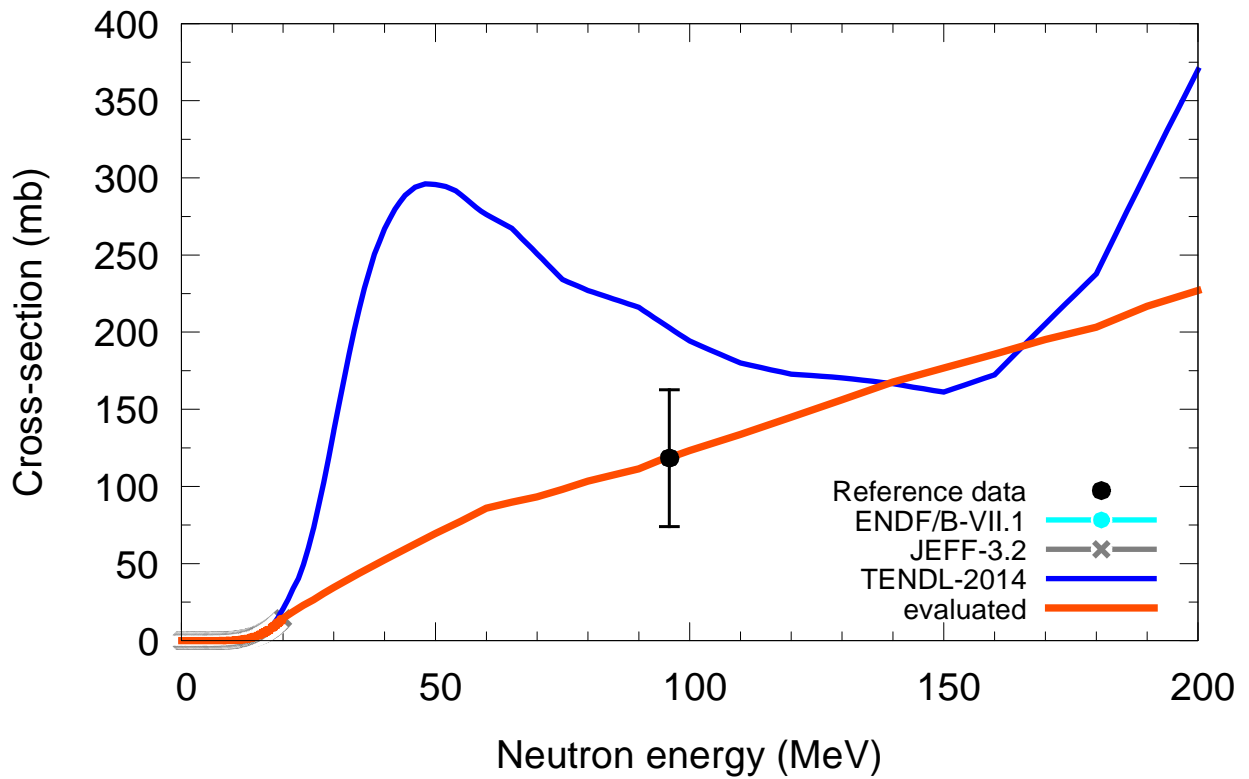
### $^{116}\text{Cd}(n,x)^4\text{He}$

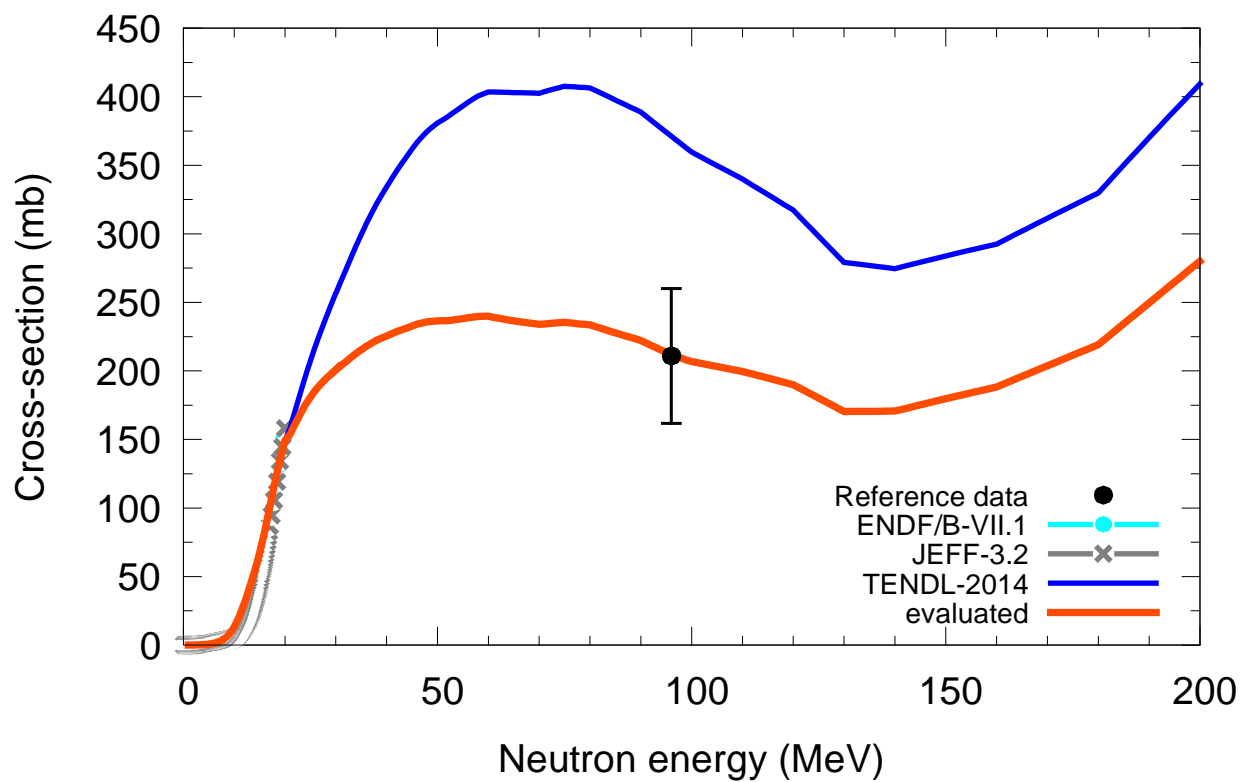
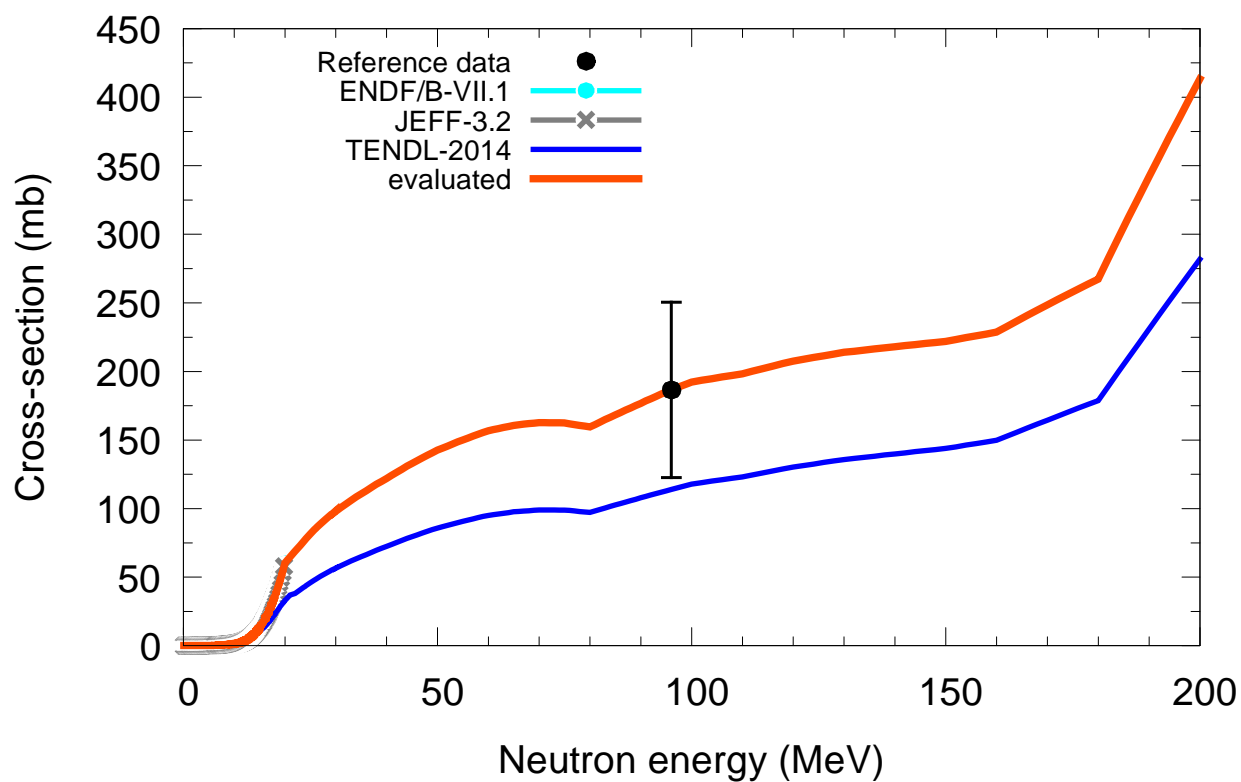


$^{113}\text{In}(n,x)^4\text{He}$



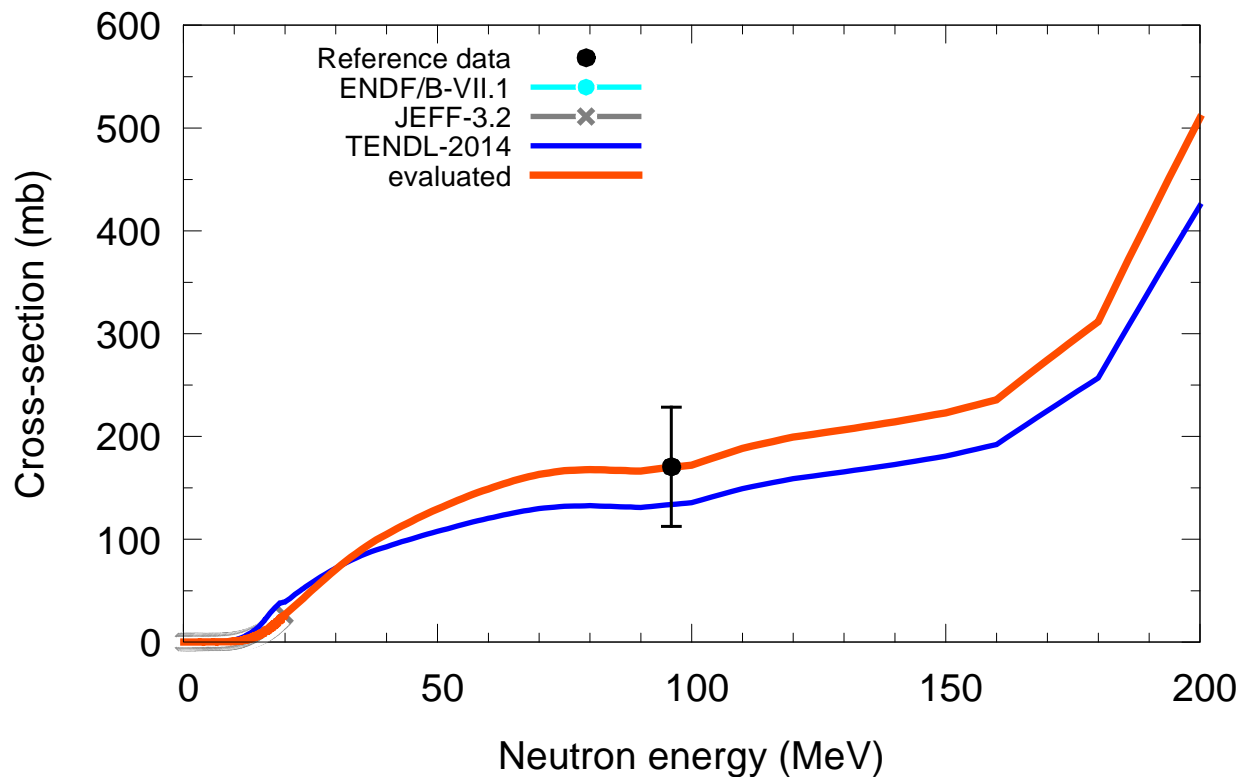
$^{115}\text{In}(n,x)^4\text{He}$



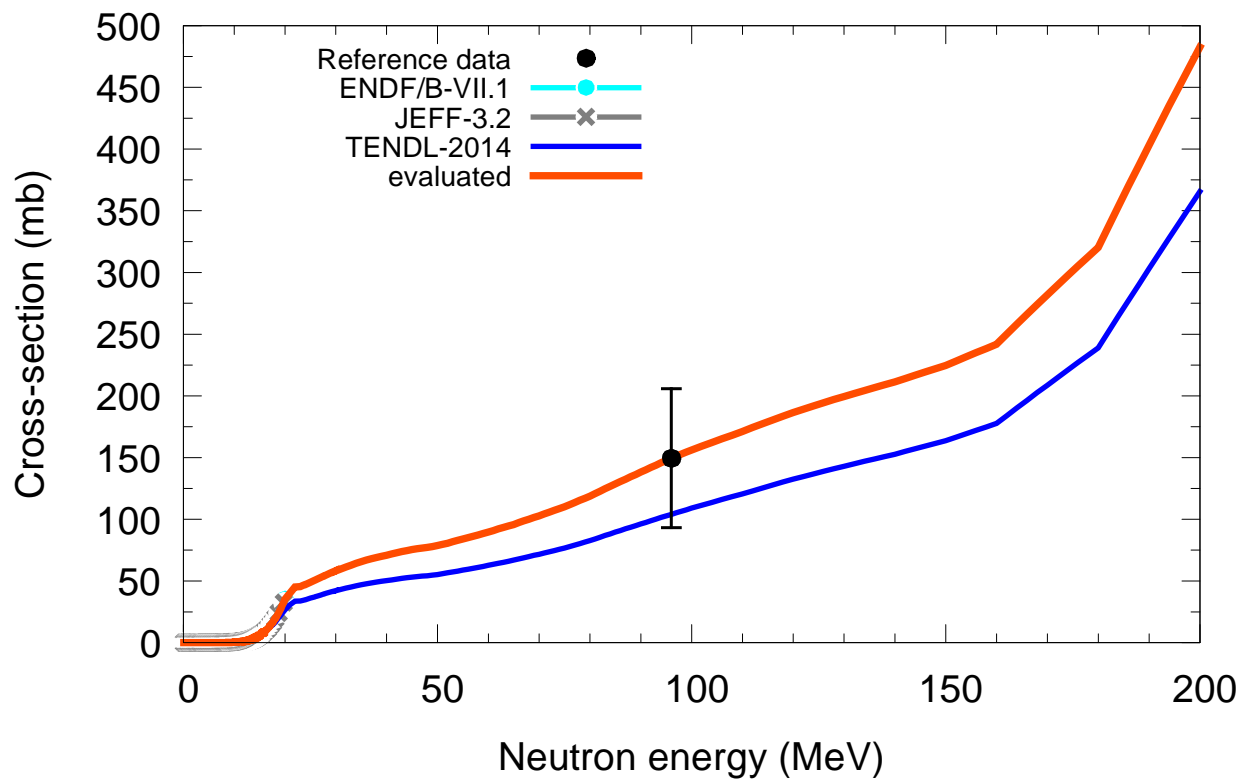
$^{112}\text{Sn}(n,x)^4\text{He}$  $^{114}\text{Sn}(n,x)^4\text{He}$ 



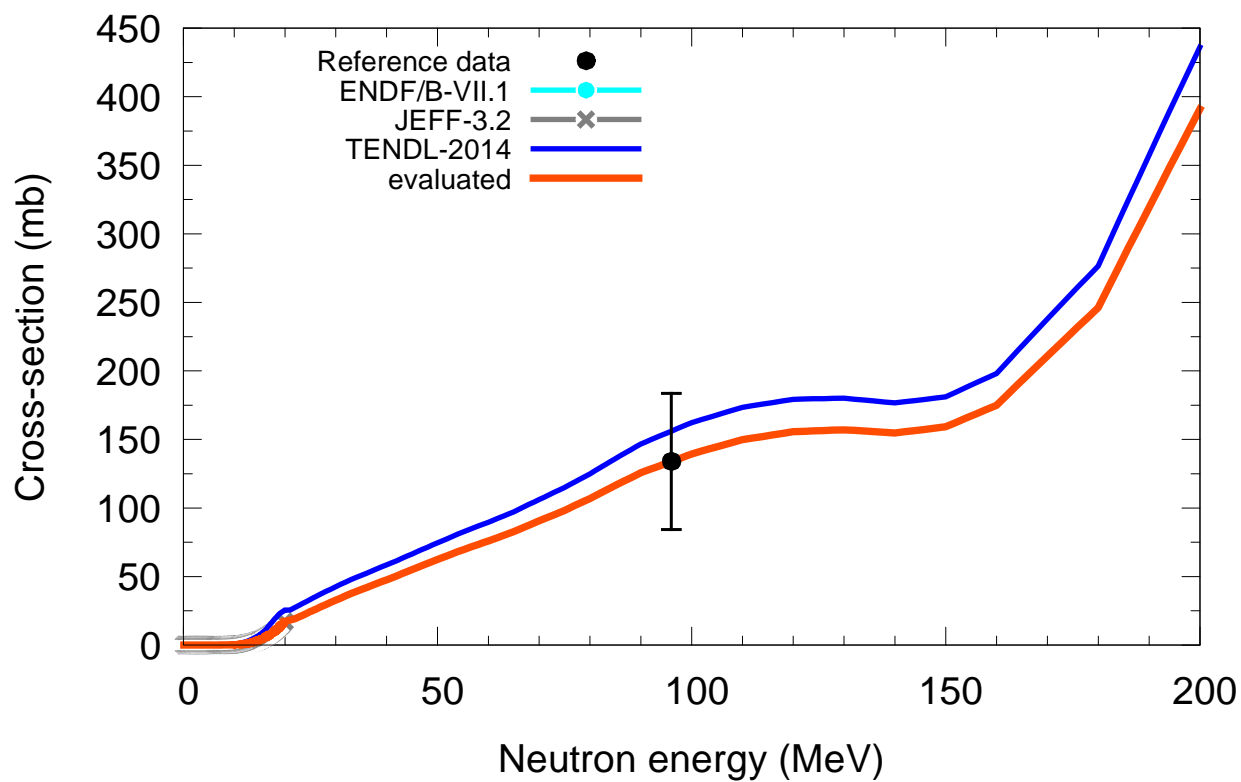
### $^{115}\text{Sn}(n,x)^4\text{He}$



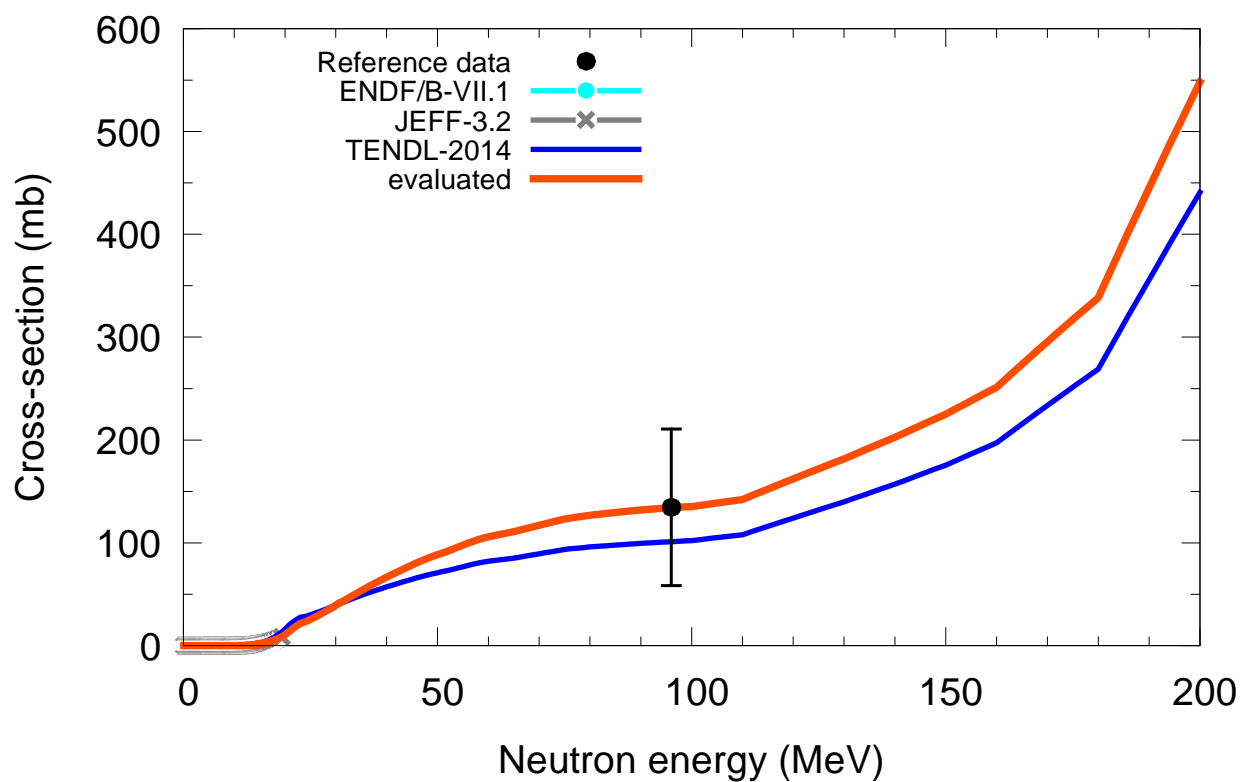
### $^{116}\text{Sn}(n,x)^4\text{He}$



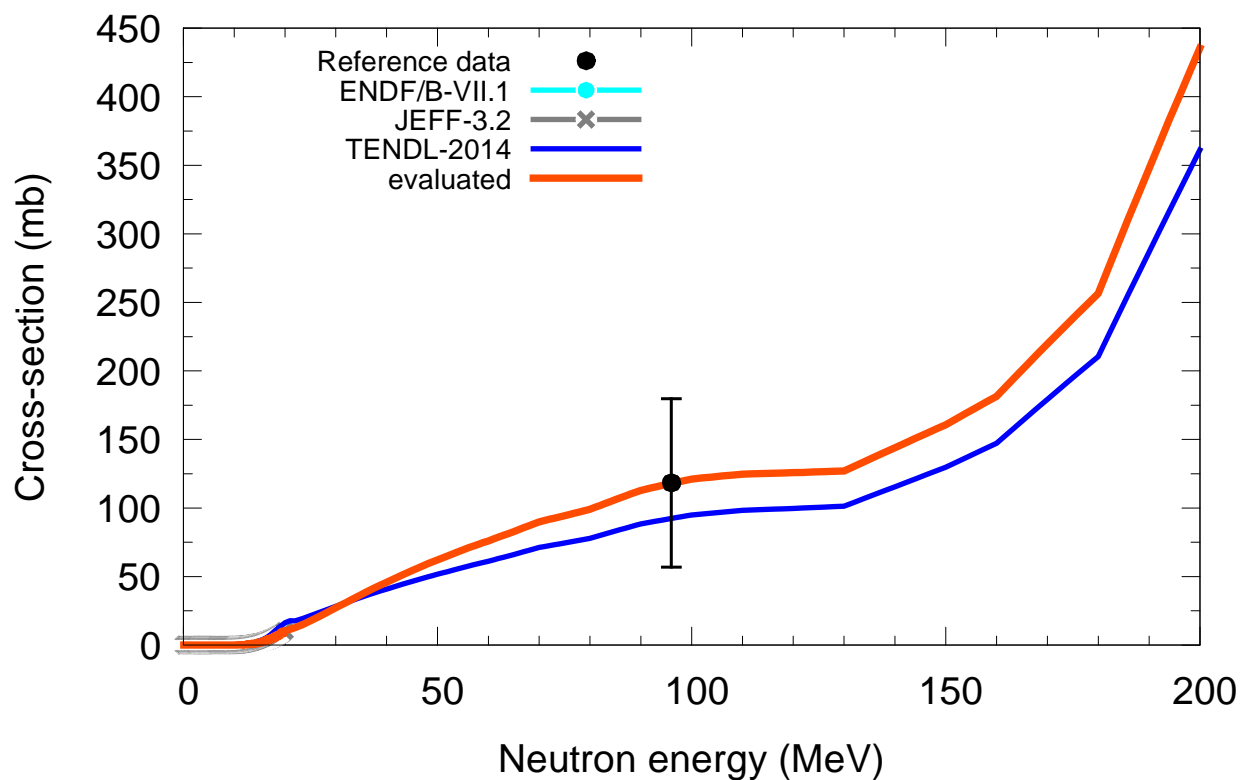
### $^{117}\text{Sn}(n,x)^4\text{He}$



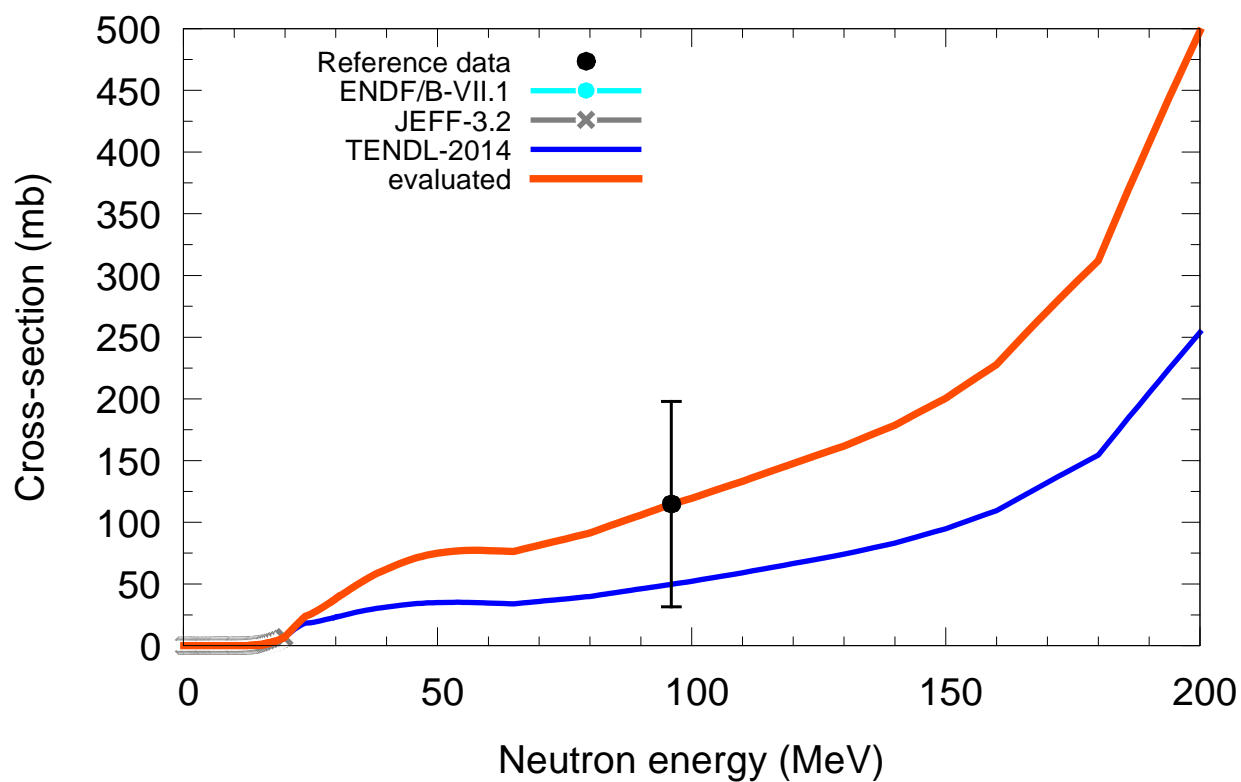
### $^{118}\text{Sn}(n,x)^4\text{He}$

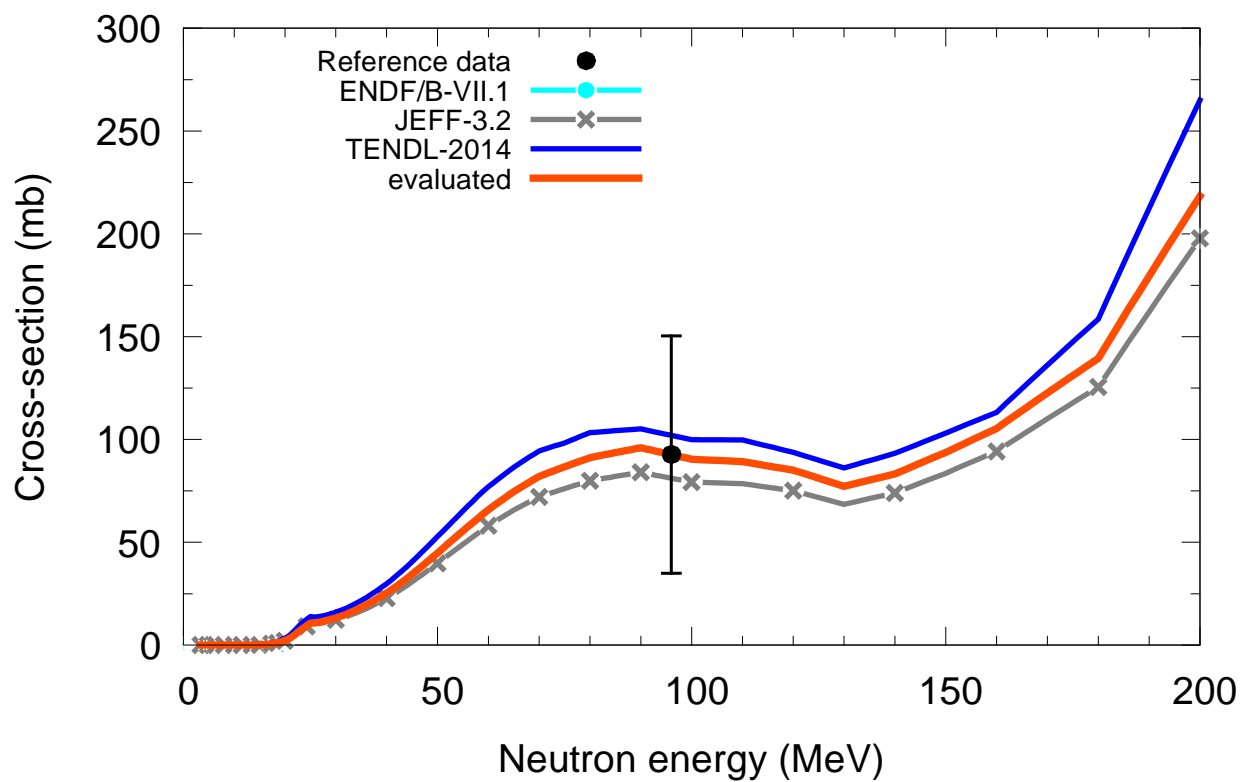
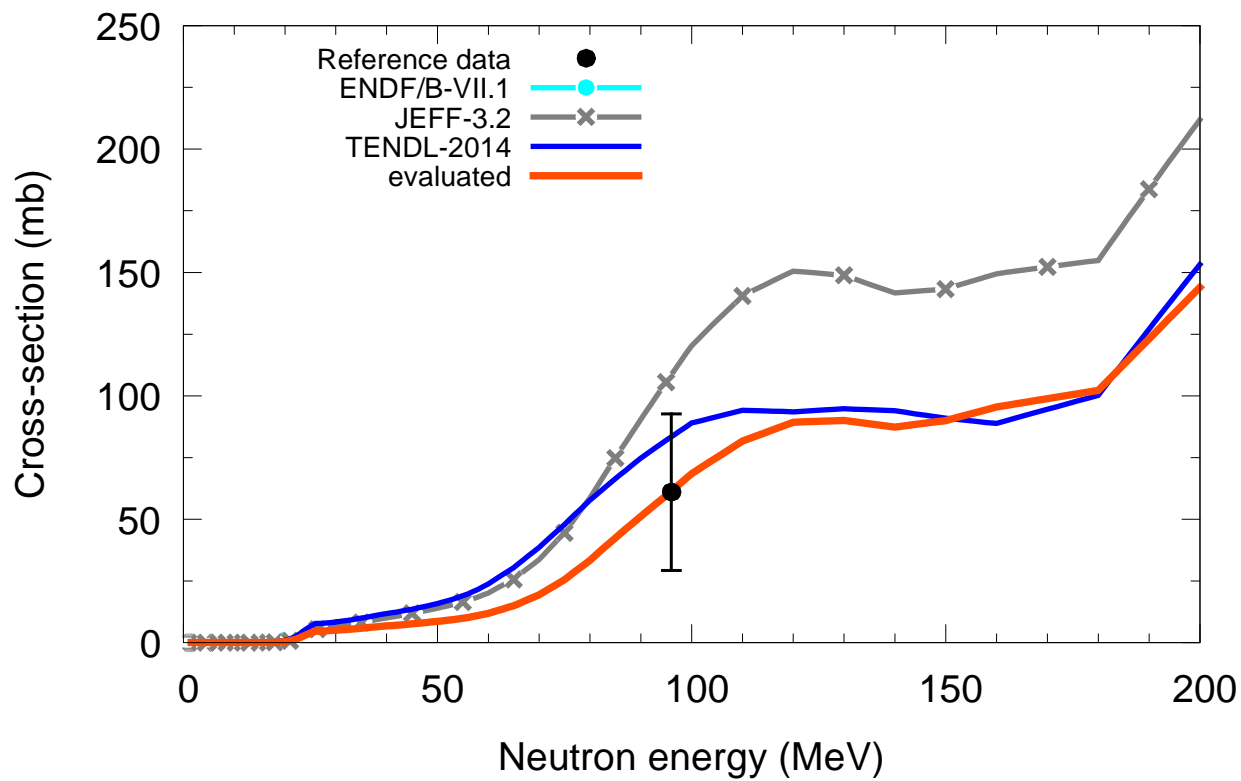


### $^{119}\text{Sn}(n,x)^4\text{He}$

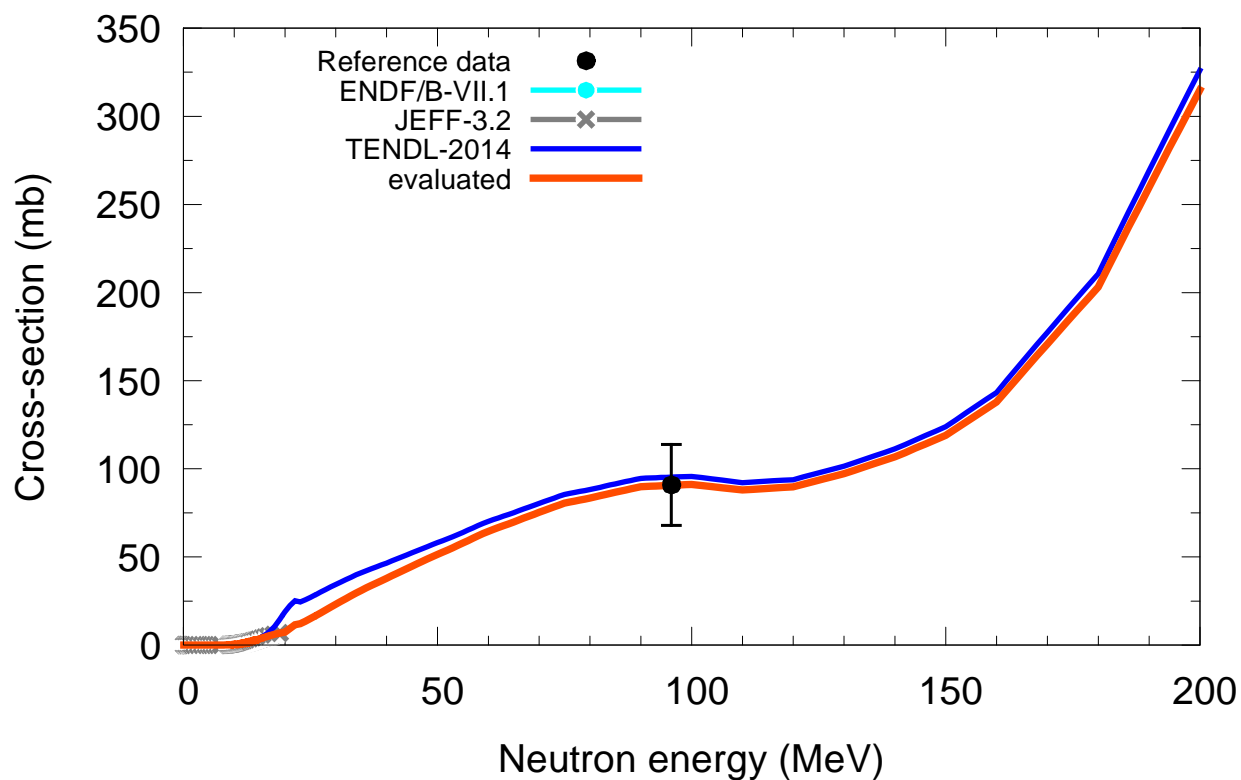


### $^{120}\text{Sn}(n,x)^4\text{He}$

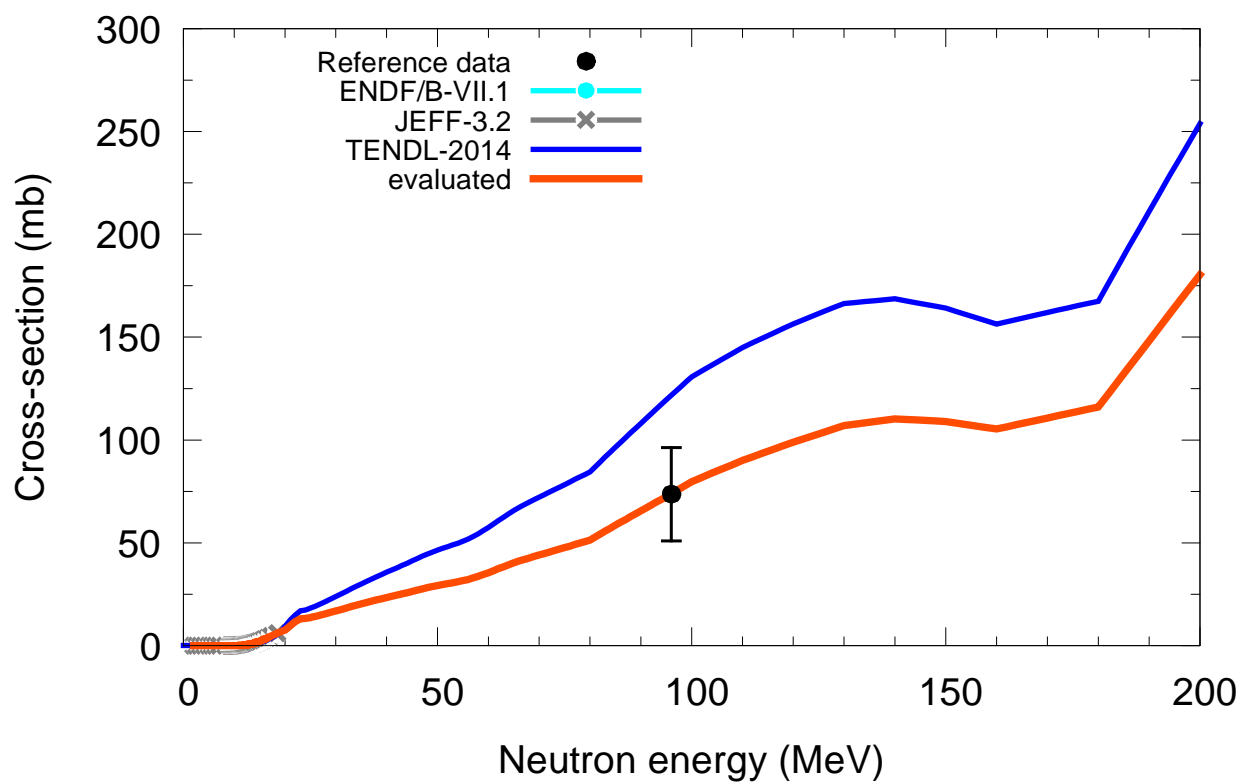


$^{122}\text{Sn}(n,x)^4\text{He}$  $^{124}\text{Sn}(n,x)^4\text{He}$ 

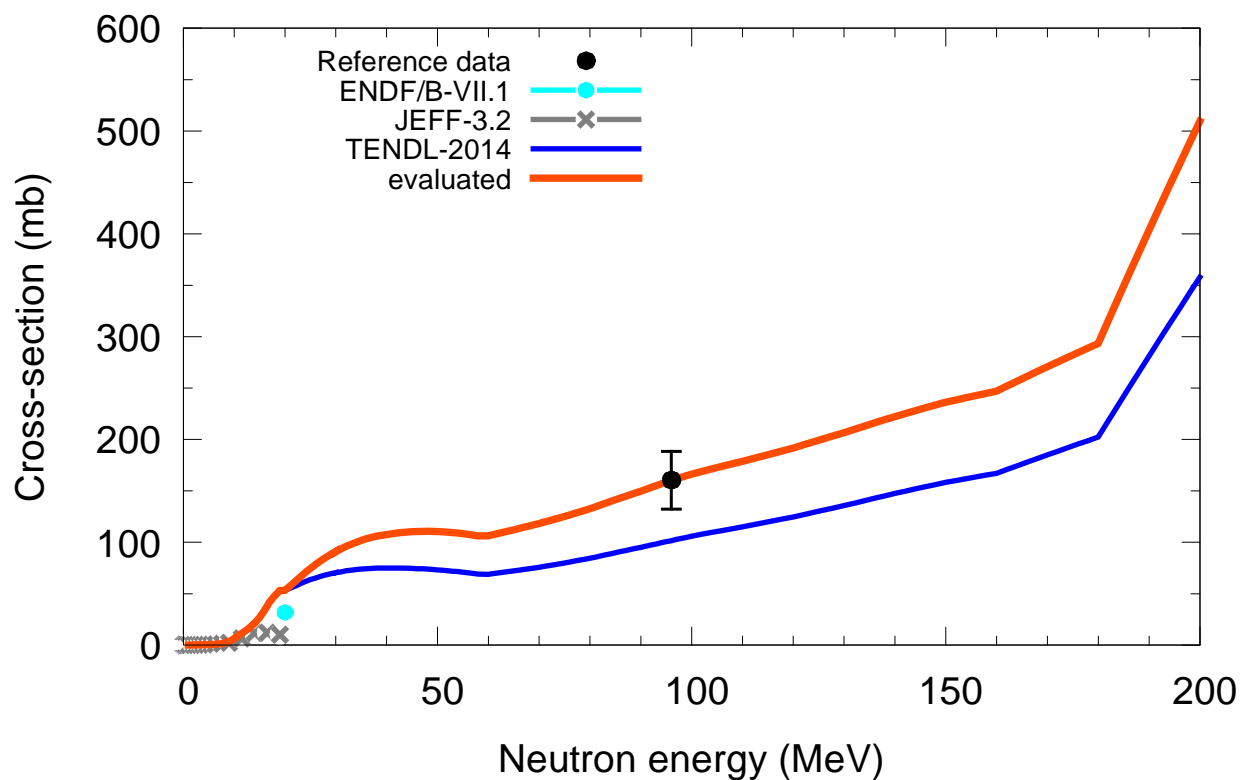
### $^{121}\text{Sb}(n,x)^4\text{He}$



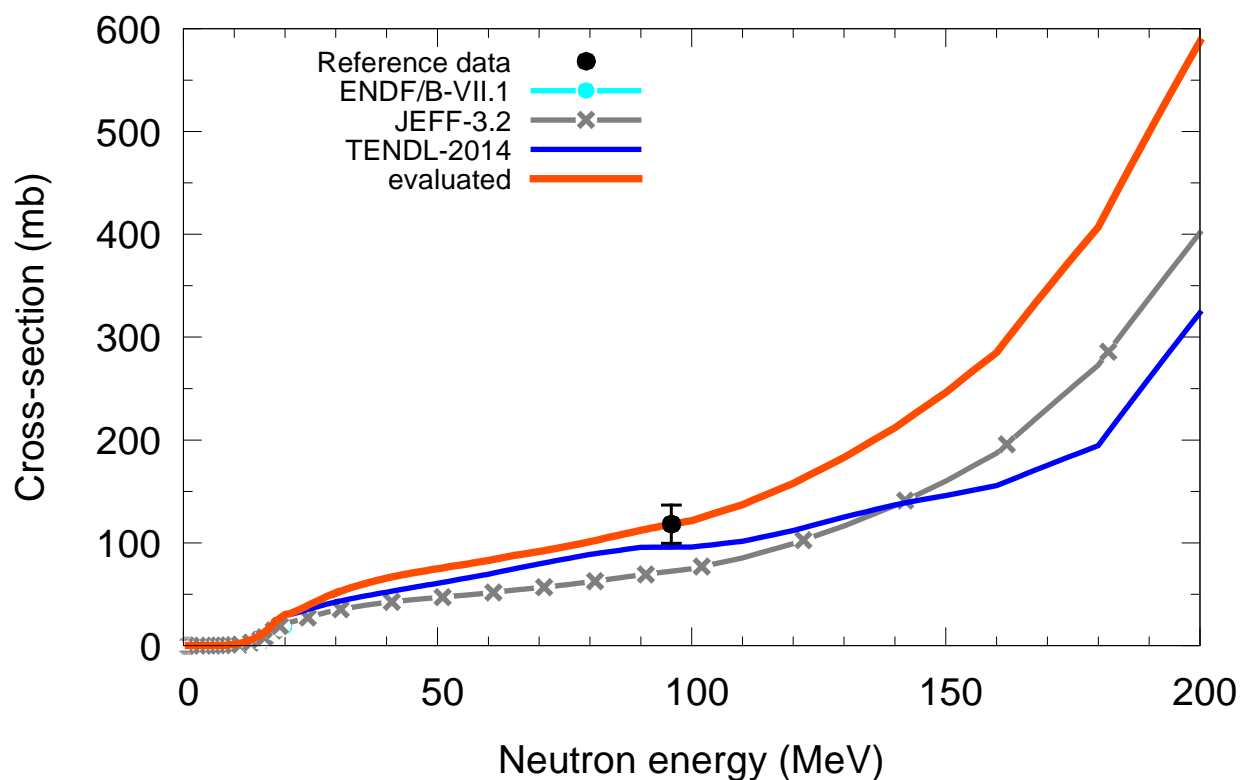
### $^{123}\text{Sb}(n,x)^4\text{He}$



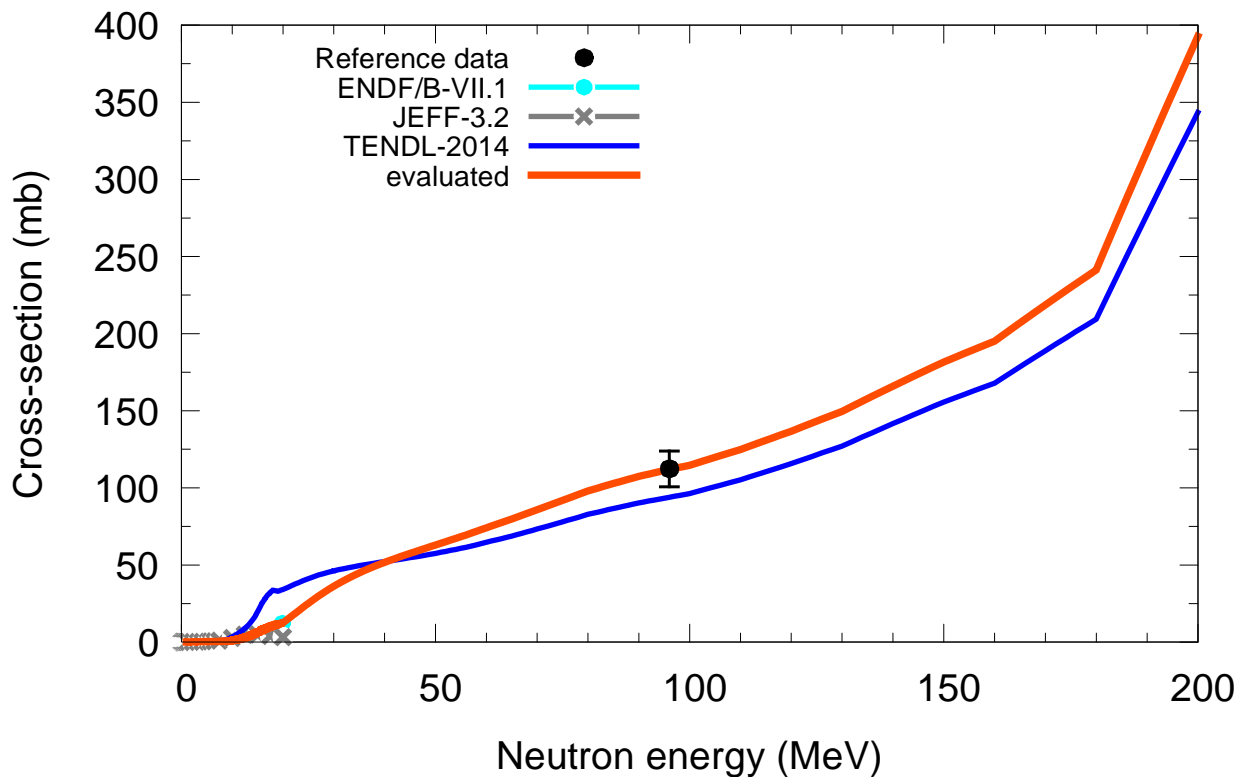
$^{120}\text{Te}(n,x)^4\text{He}$



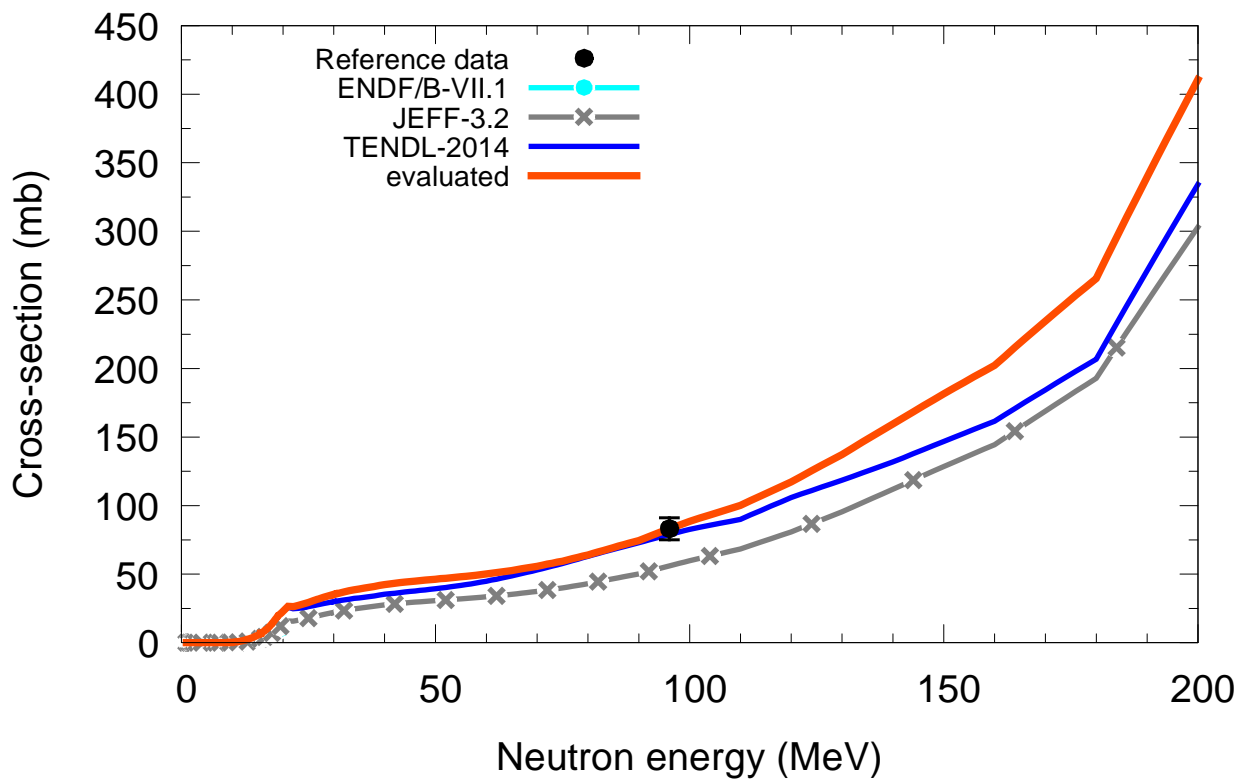
$^{122}\text{Te}(n,x)^4\text{He}$

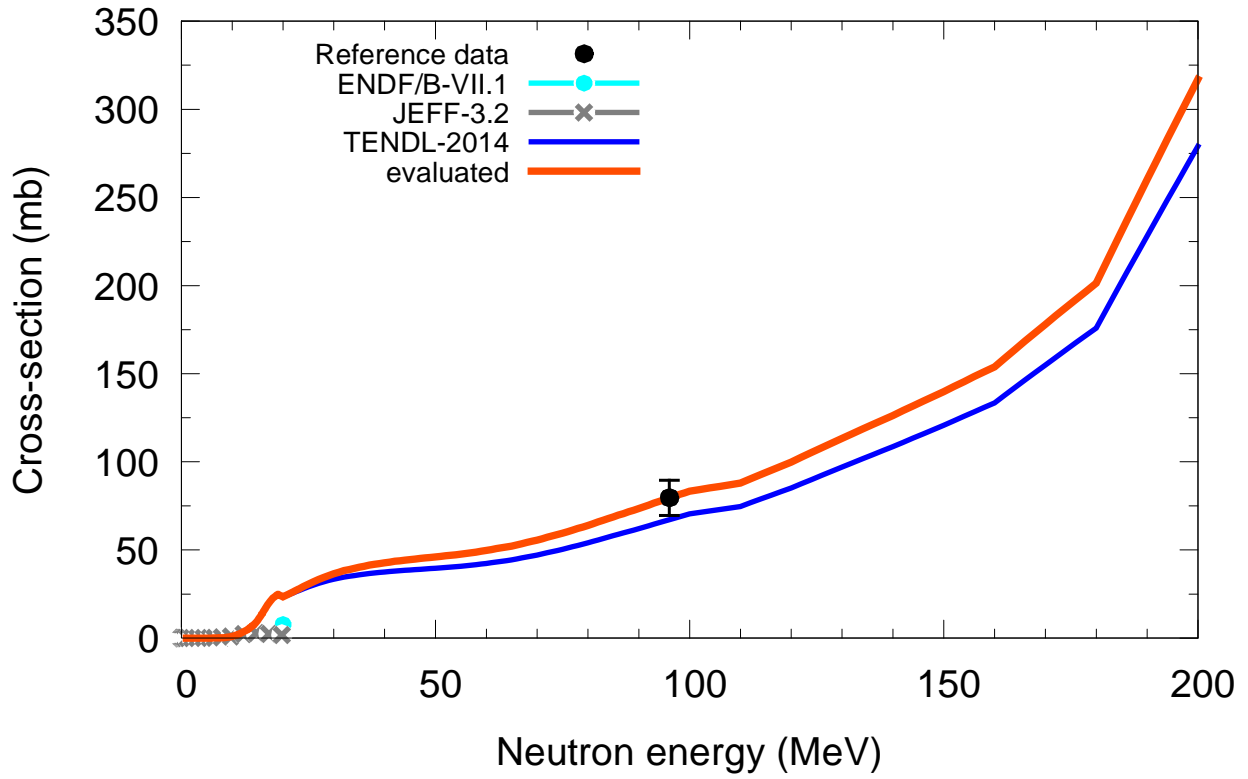
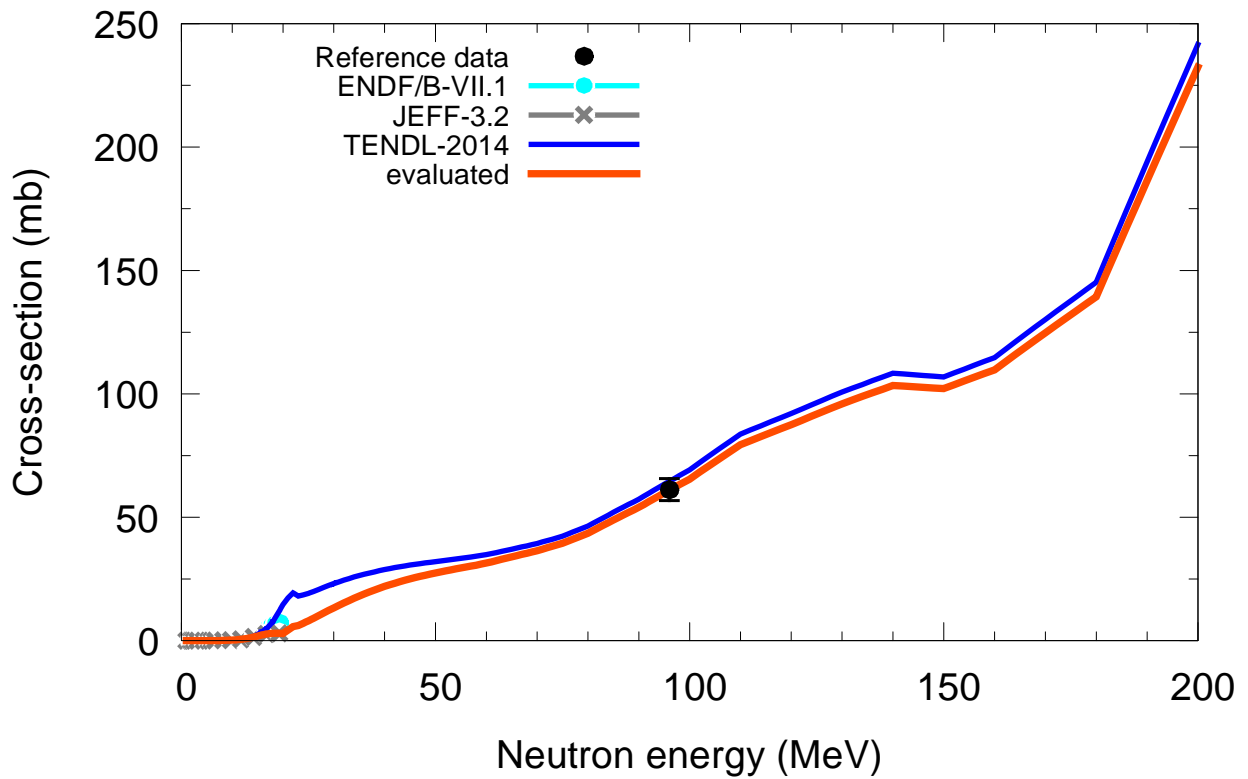


### $^{123}\text{Te}(n,x)^4\text{He}$

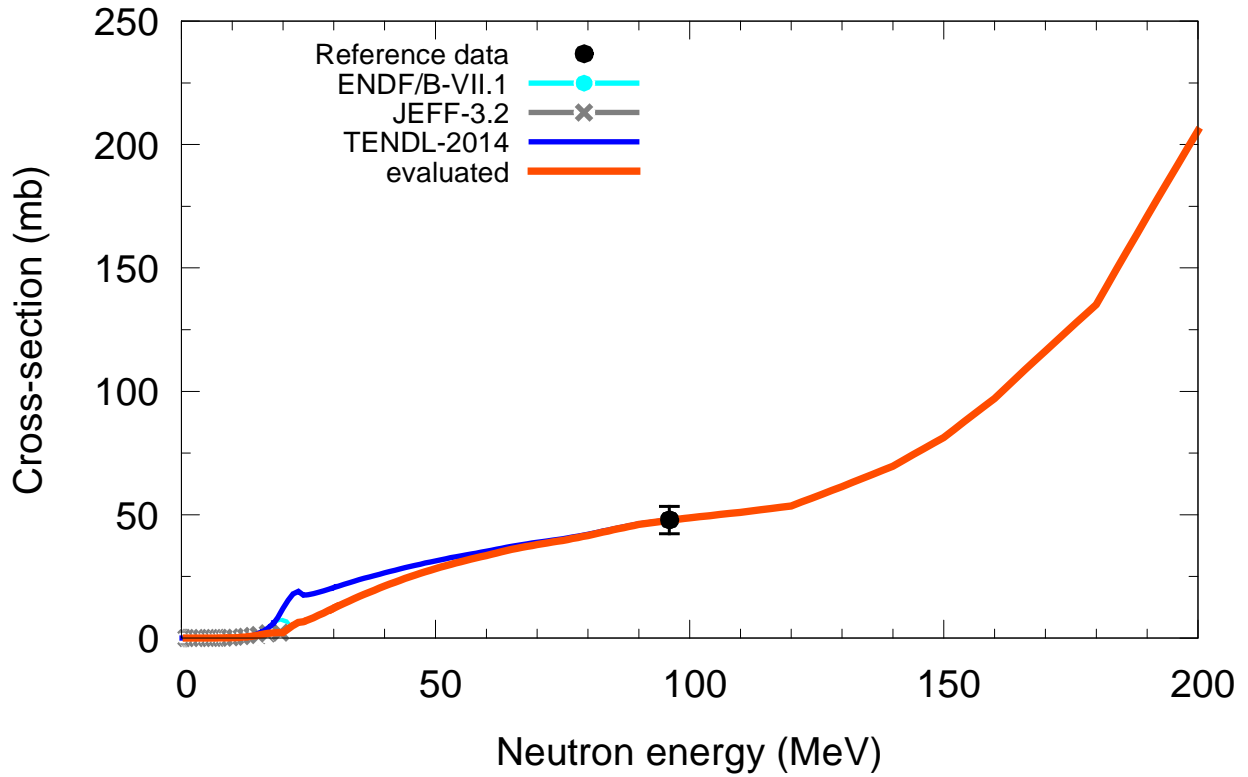
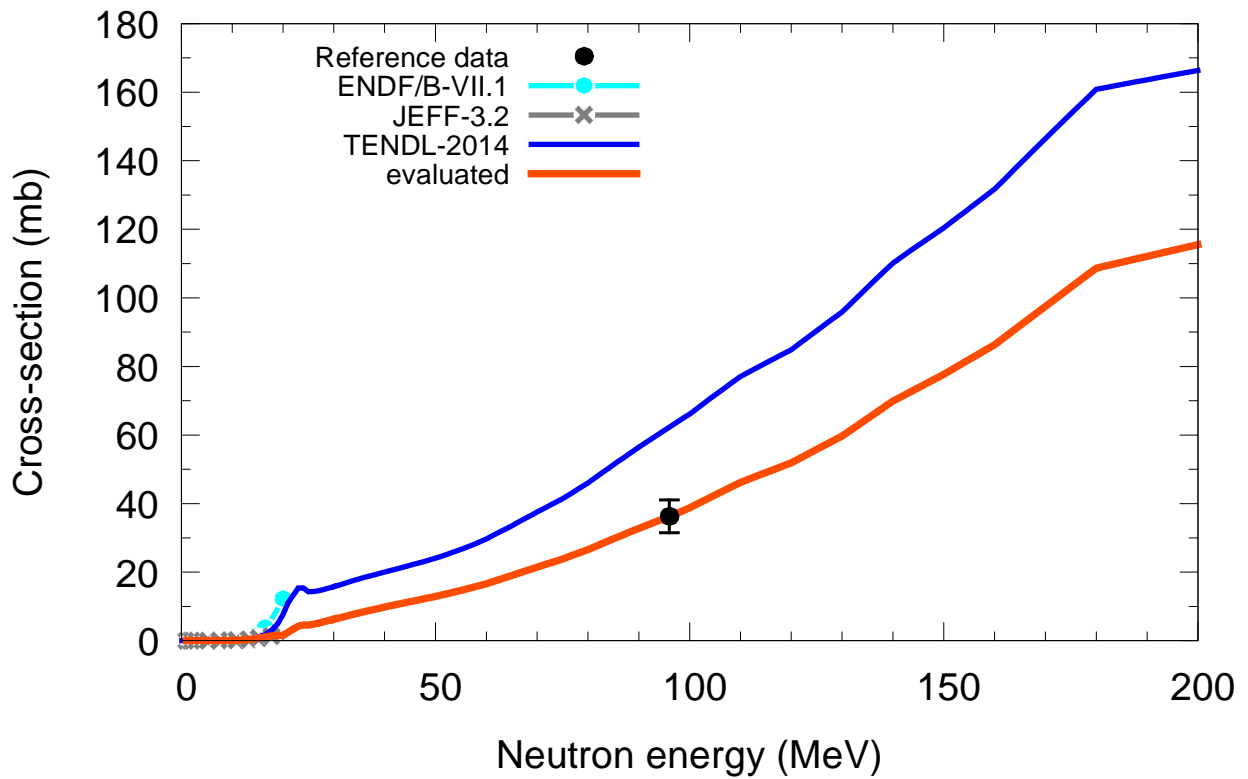


### $^{124}\text{Te}(n,x)^4\text{He}$

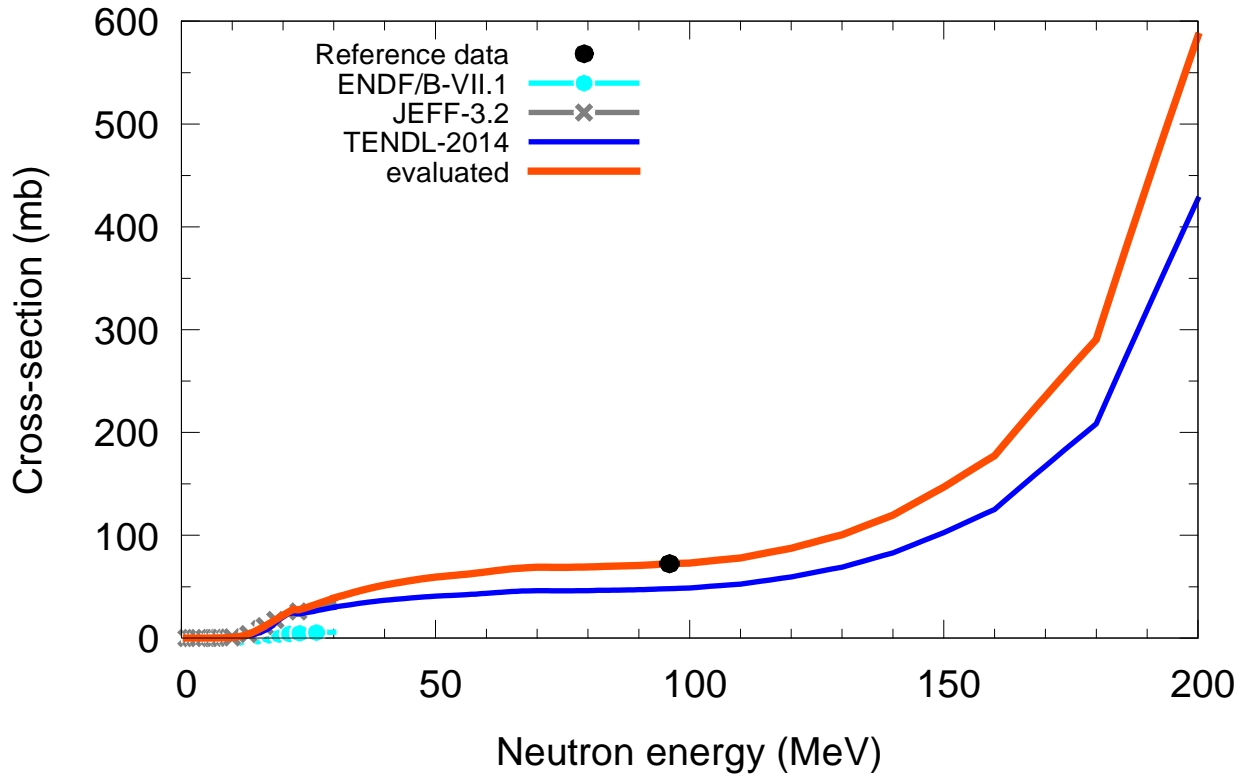


$^{125}\text{Te}(n,x)^4\text{He}$  $^{126}\text{Te}(n,x)^4\text{He}$ 

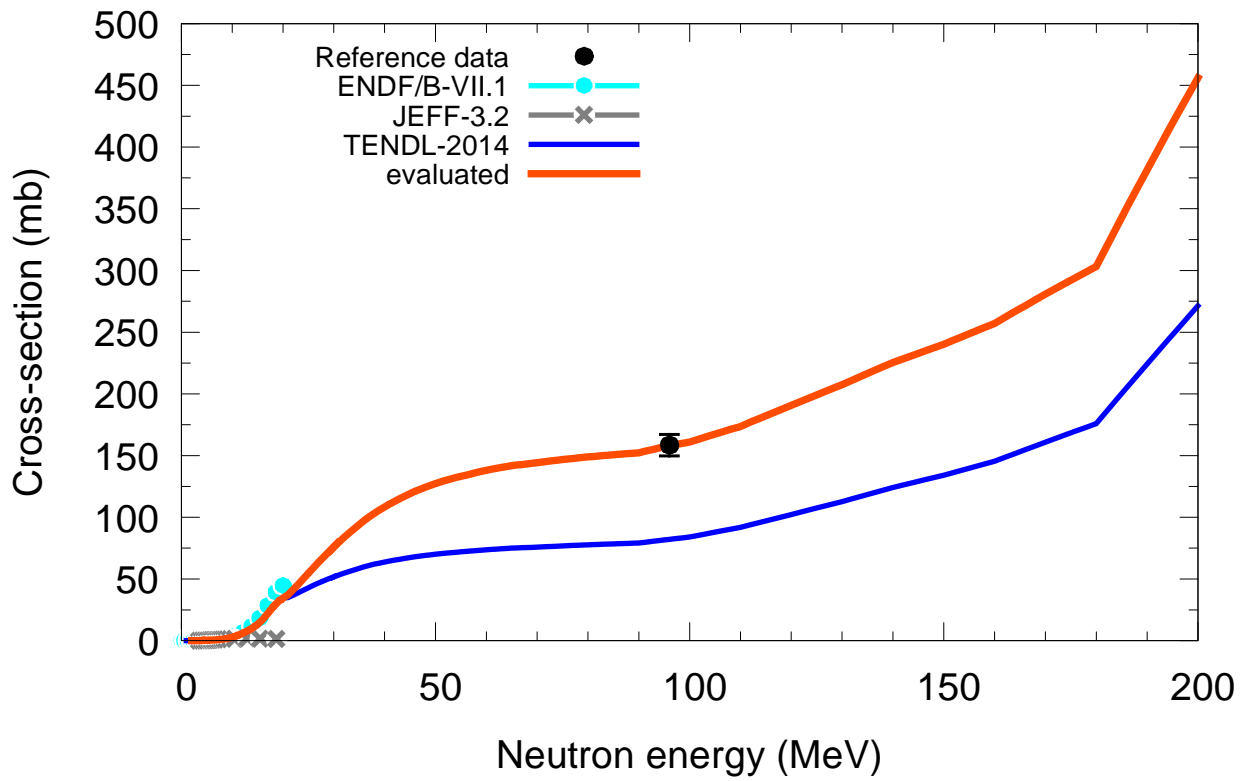


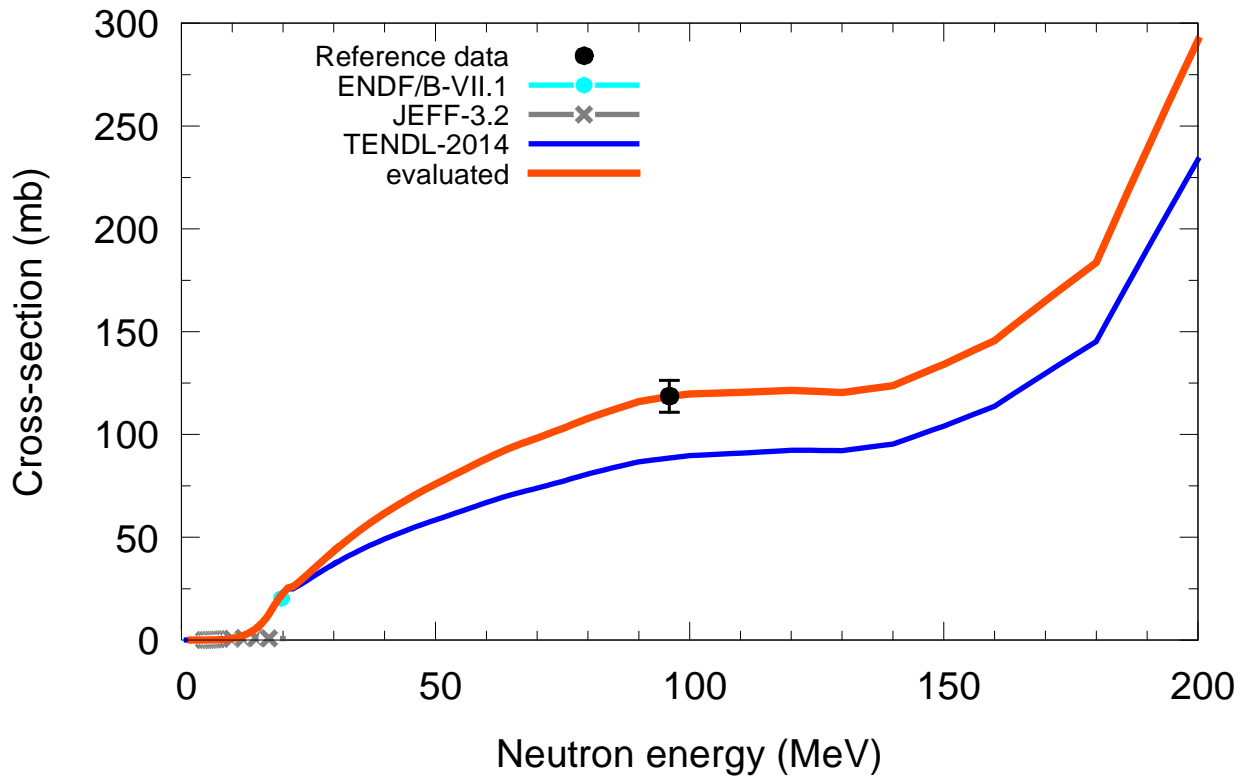
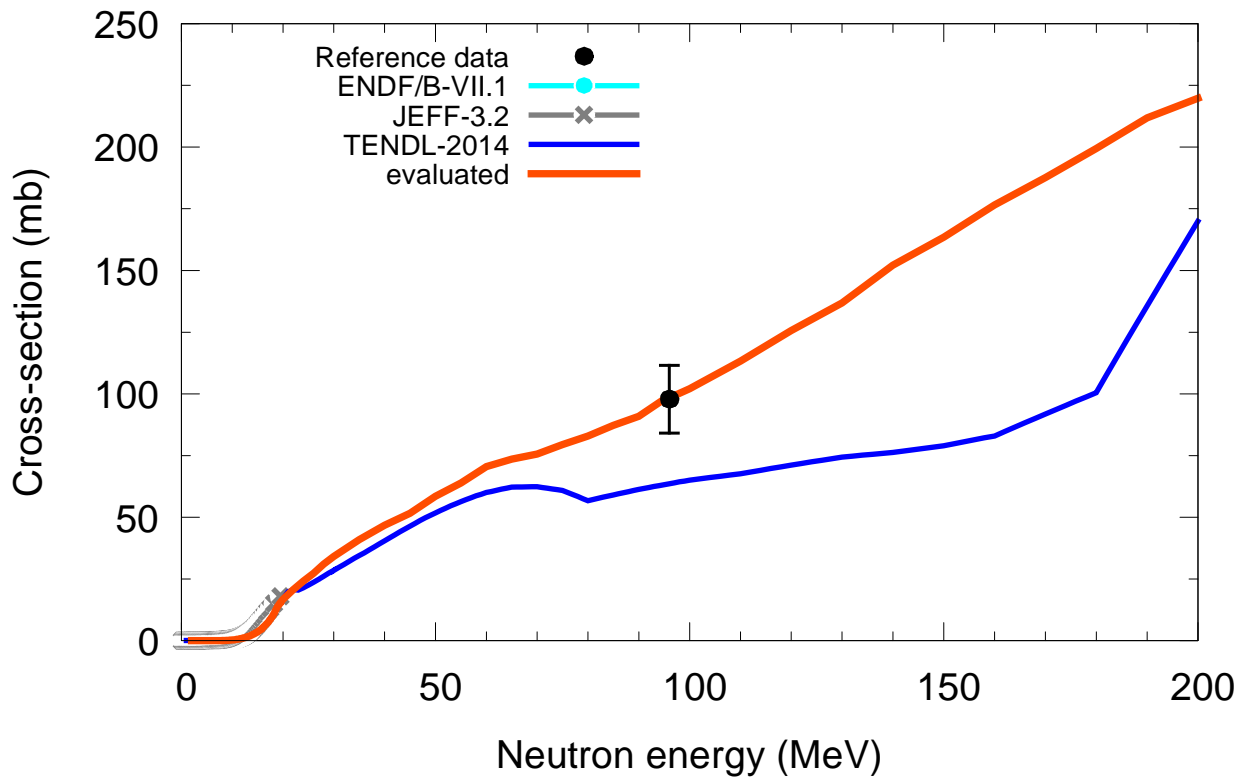
$^{128}\text{Te}(n,x)^4\text{He}$  $^{130}\text{Te}(n,x)^4\text{He}$ 

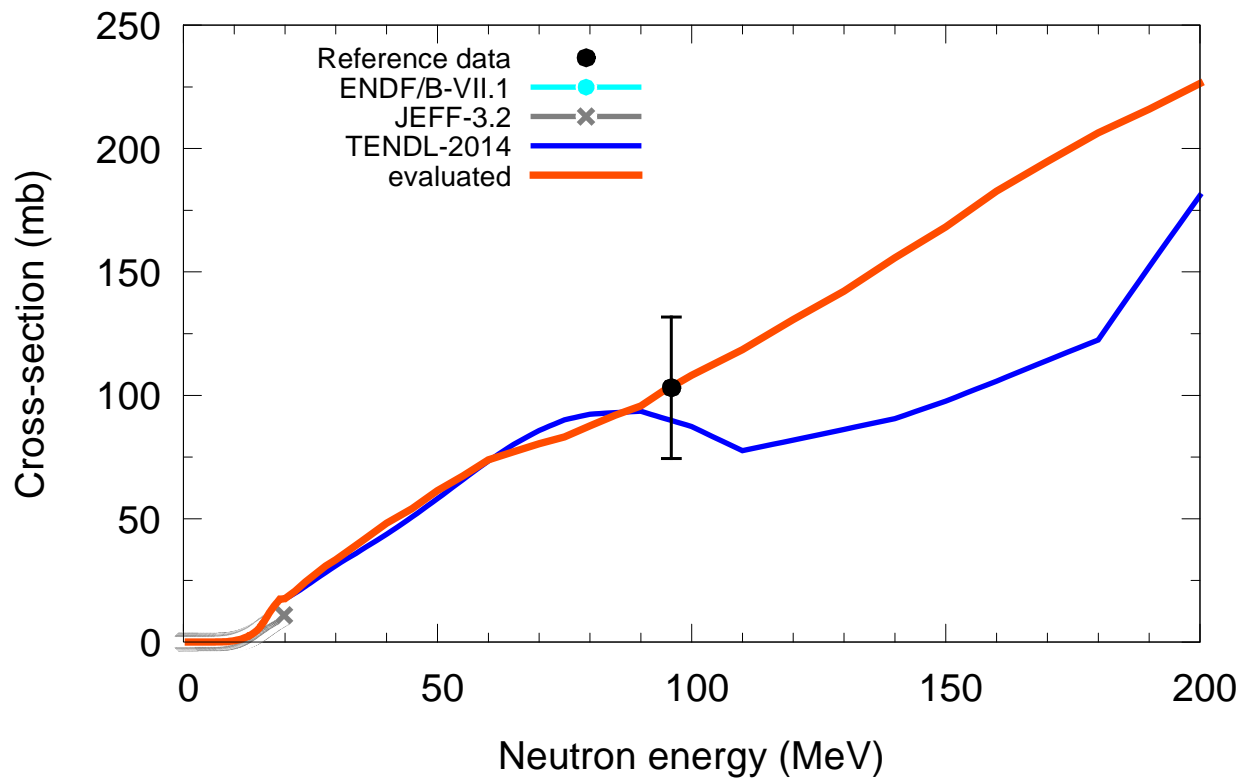
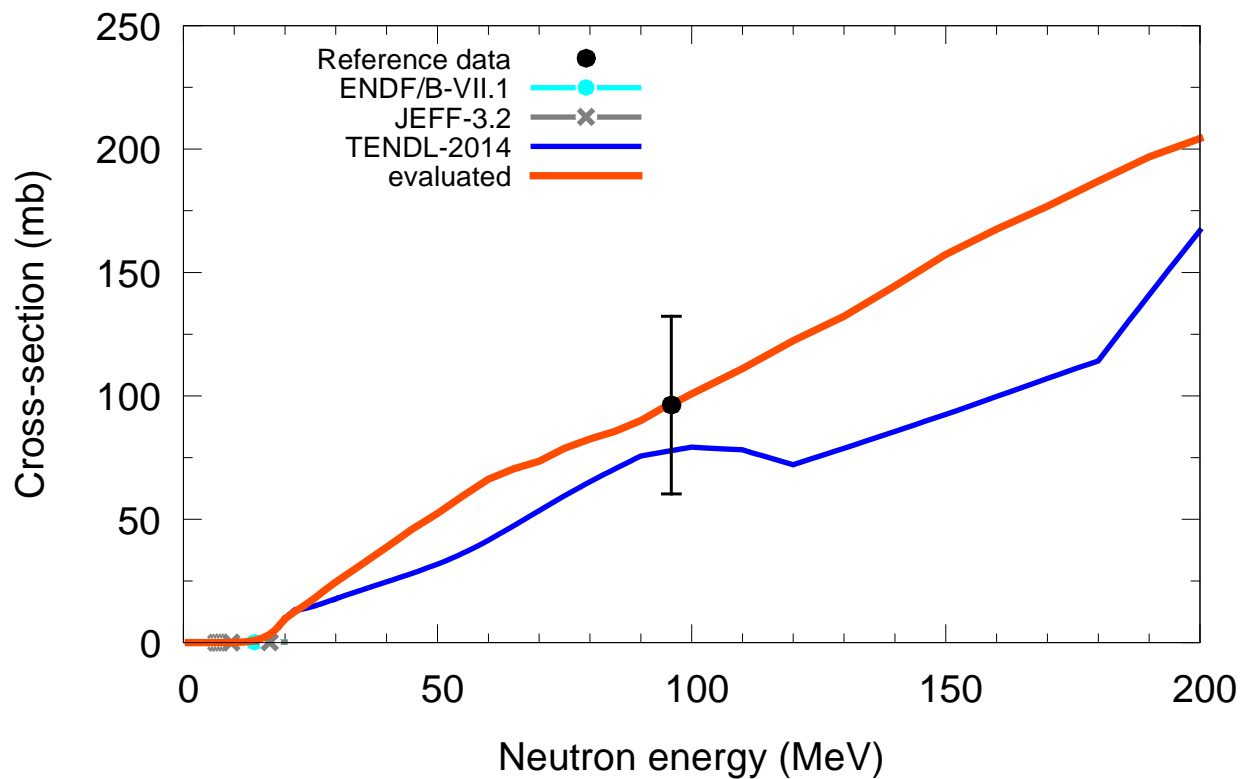
$^{127}\text{I}(n,x)^4\text{He}$

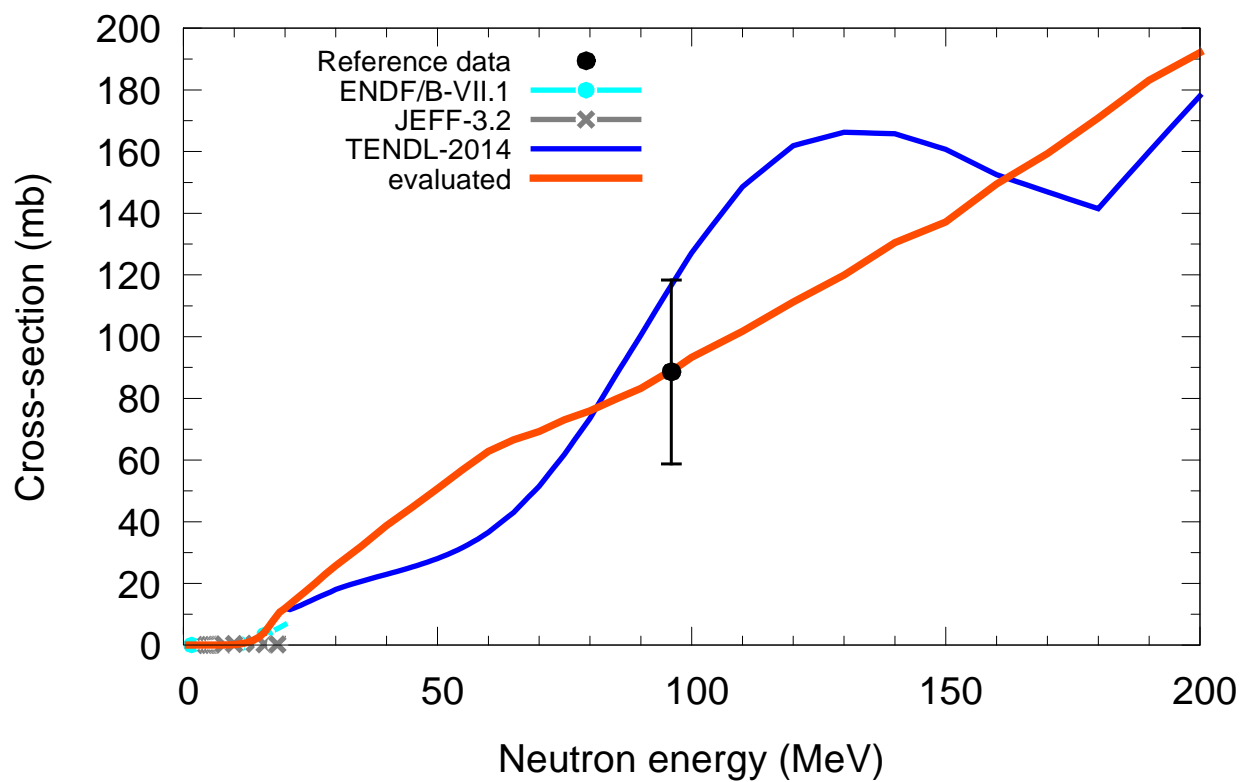
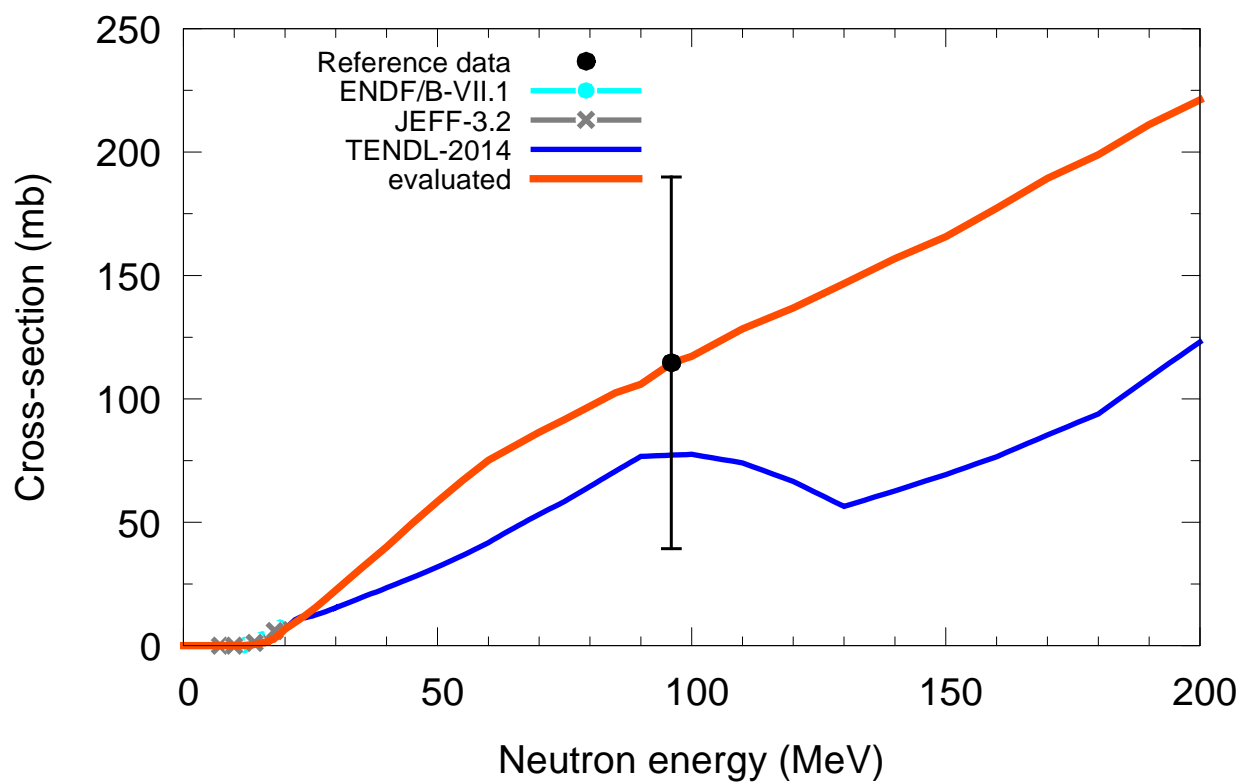


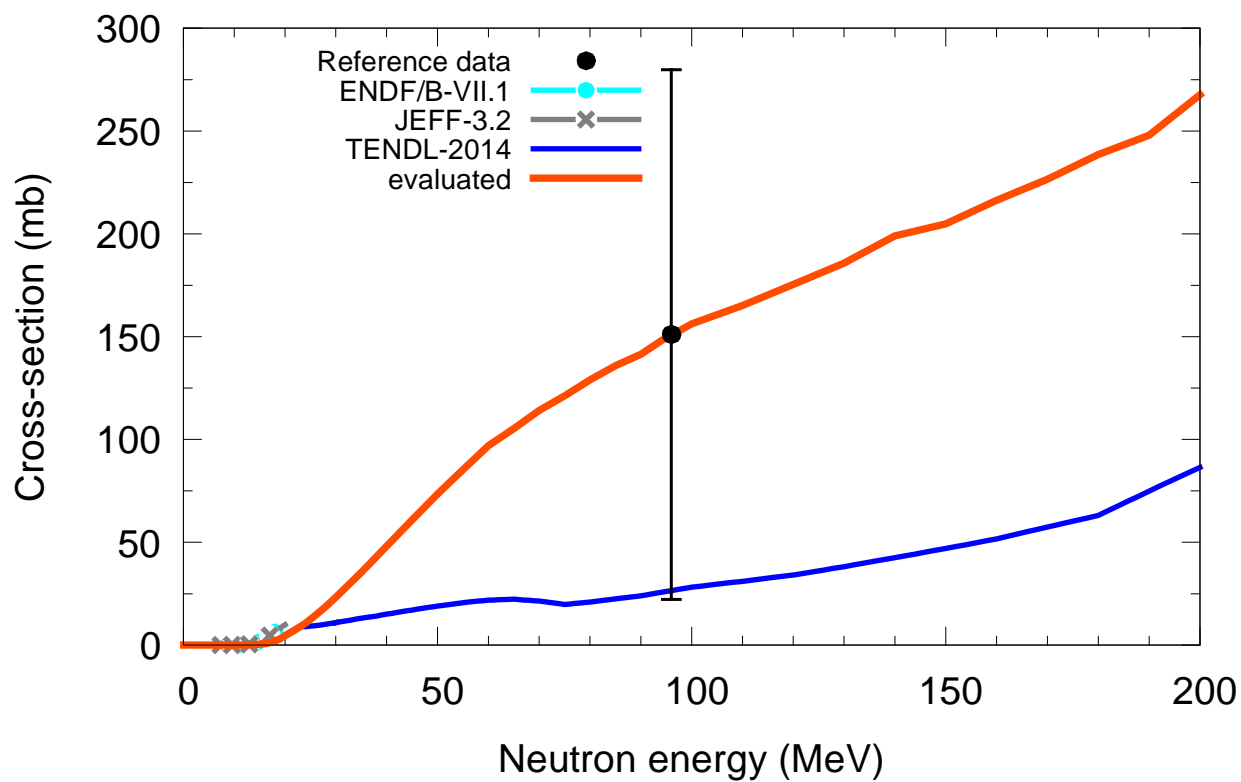
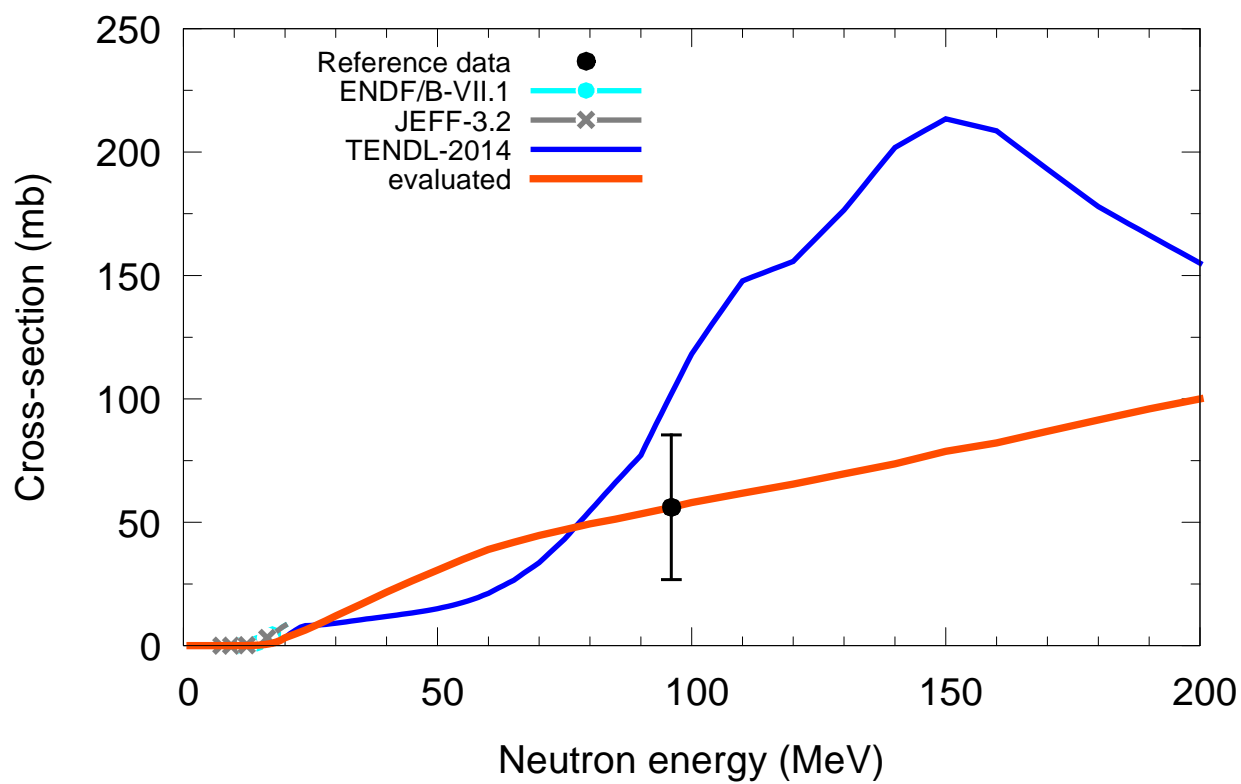
$^{124}\text{Xe}(n,x)^4\text{He}$

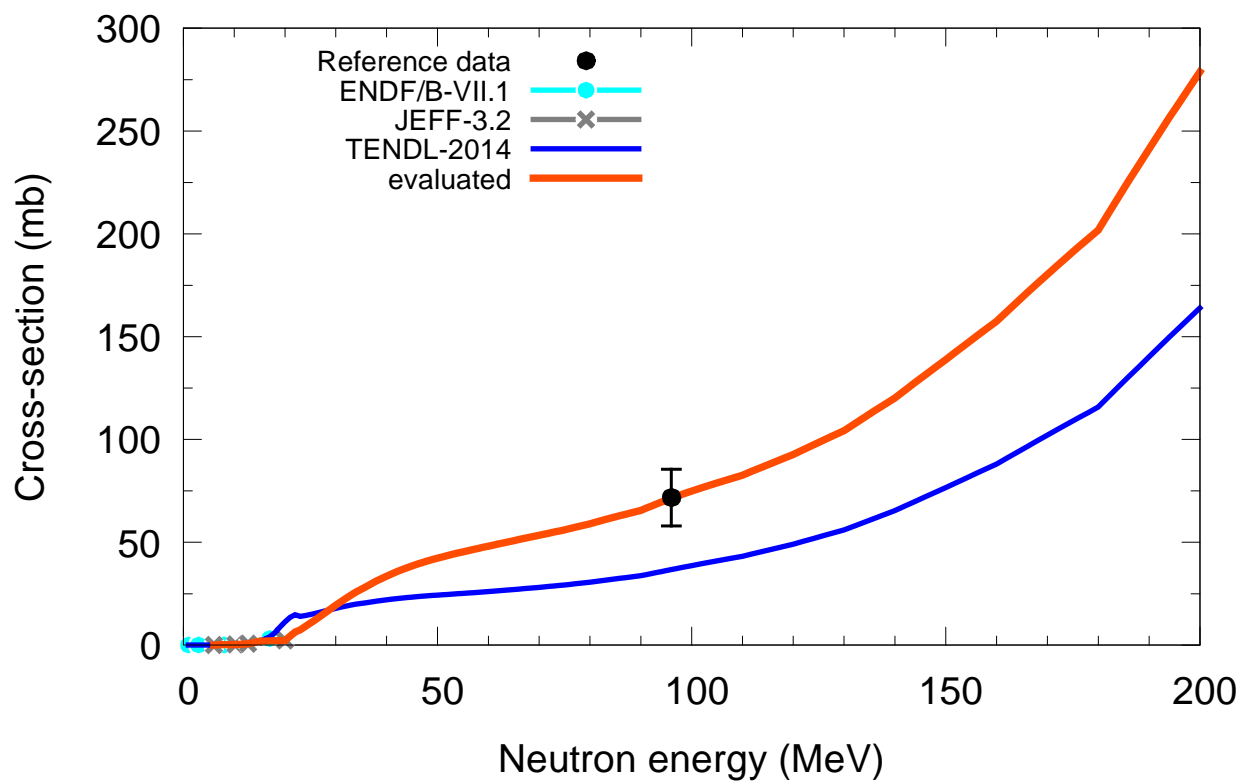
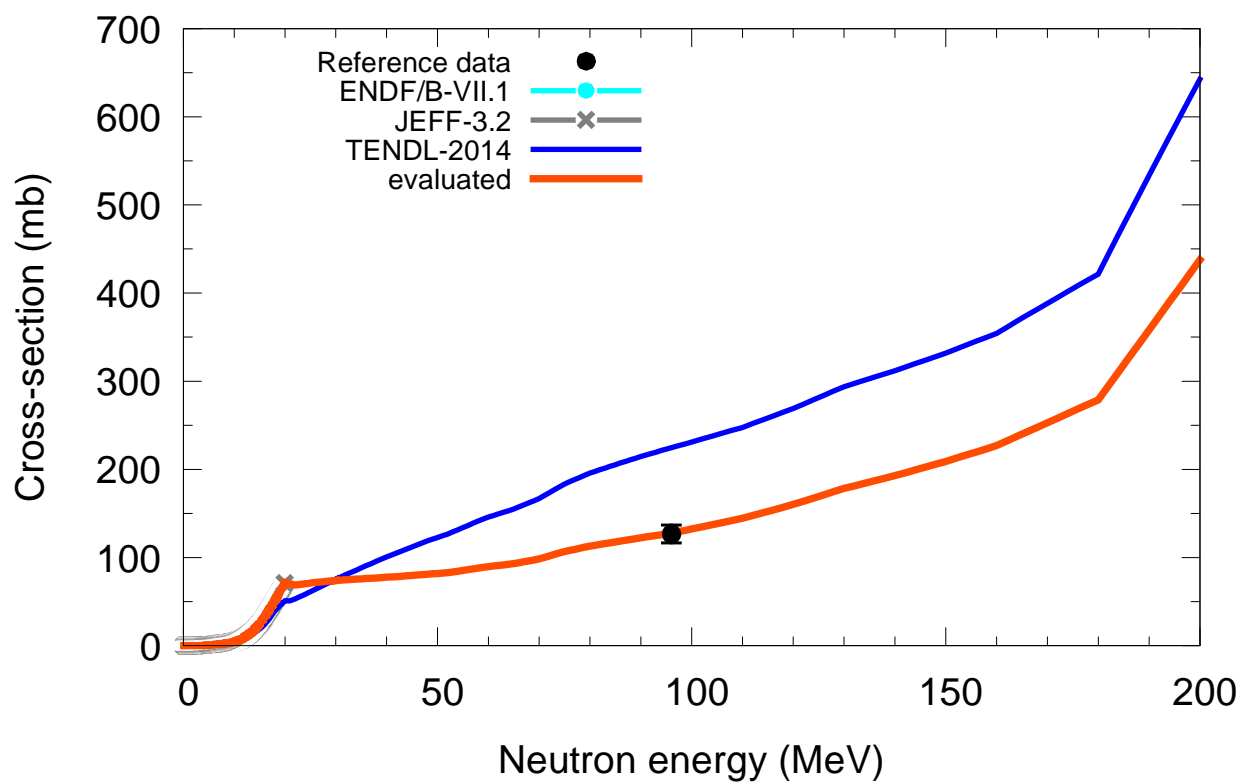


$^{126}\text{Xe}(n,x)^4\text{He}$  $^{128}\text{Xe}(n,x)^4\text{He}$ 

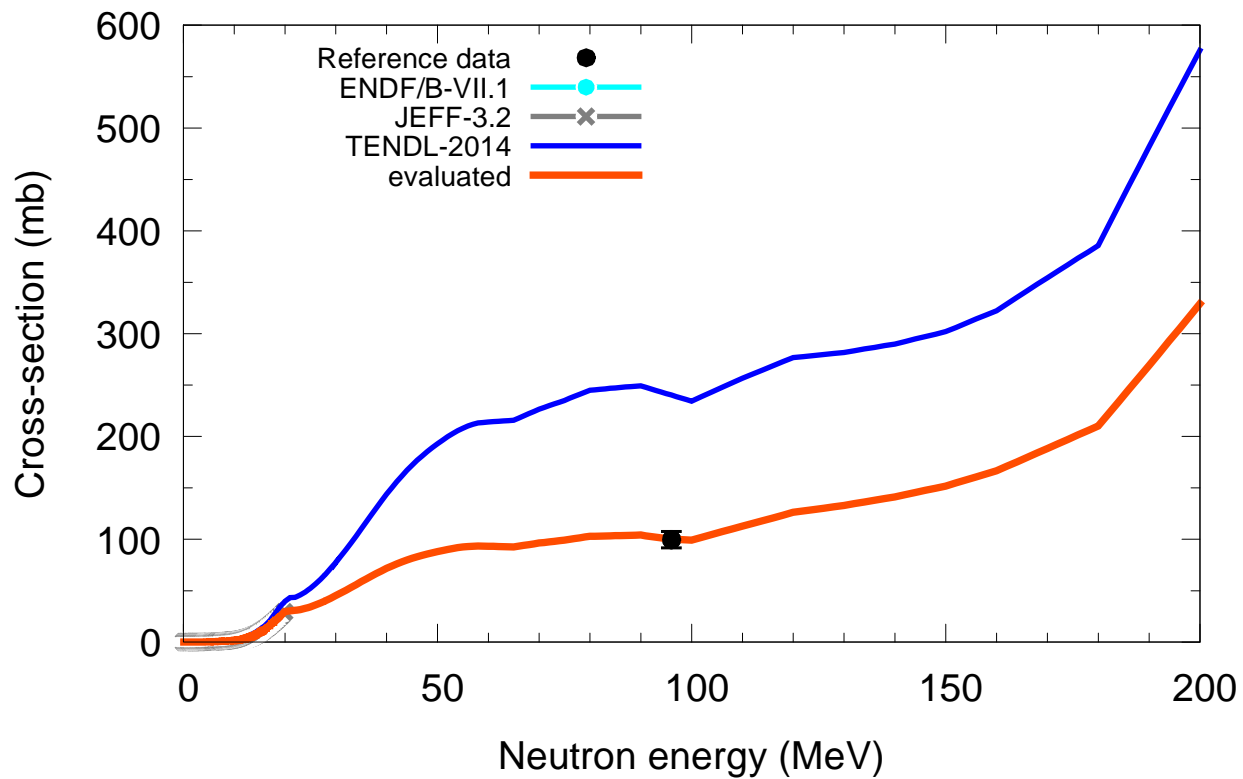
$^{129}\text{Xe}(n,x)^4\text{He}$  $^{130}\text{Xe}(n,x)^4\text{He}$ 

$^{131}\text{Xe}(n,x)^4\text{He}$  $^{132}\text{Xe}(n,x)^4\text{He}$ 

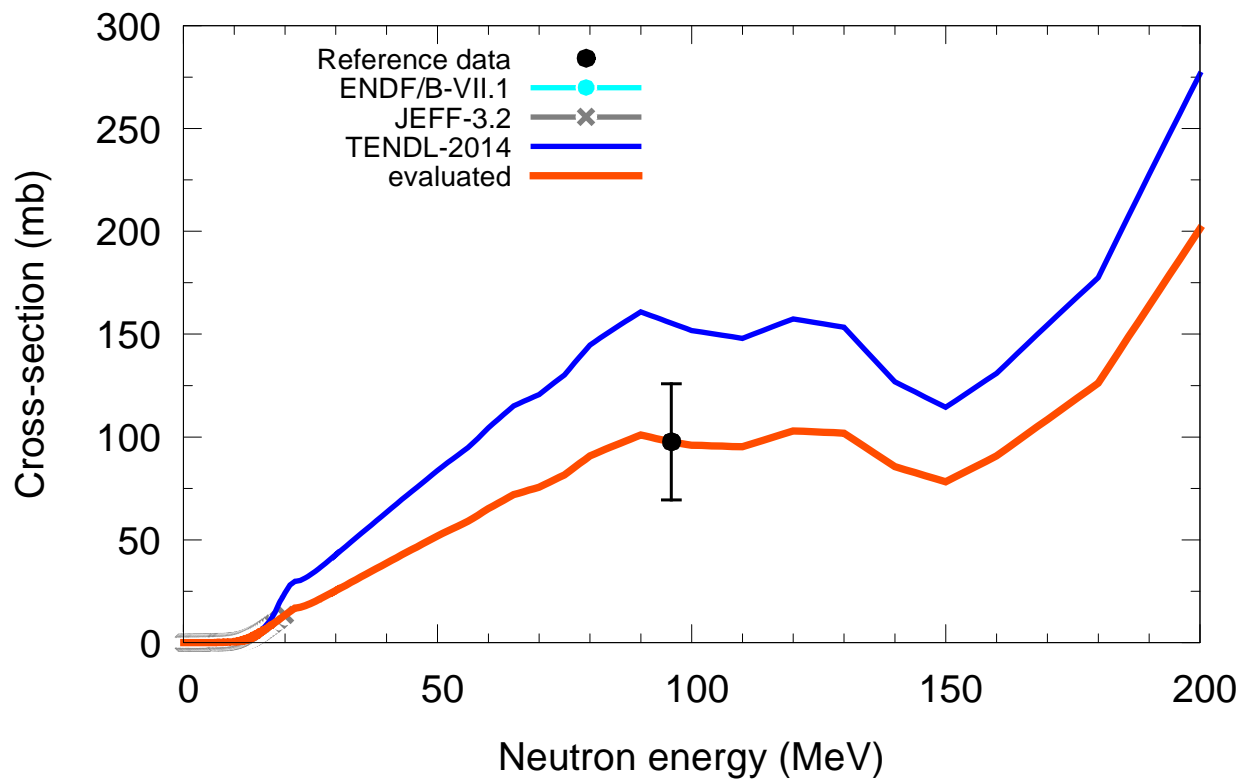
$^{134}\text{Xe}(n,x)^4\text{He}$  $^{136}\text{Xe}(n,x)^4\text{He}$ 

$^{133}\text{Cs}(n,x)^4\text{He}$  $^{130}\text{Ba}(n,x)^4\text{He}$ 

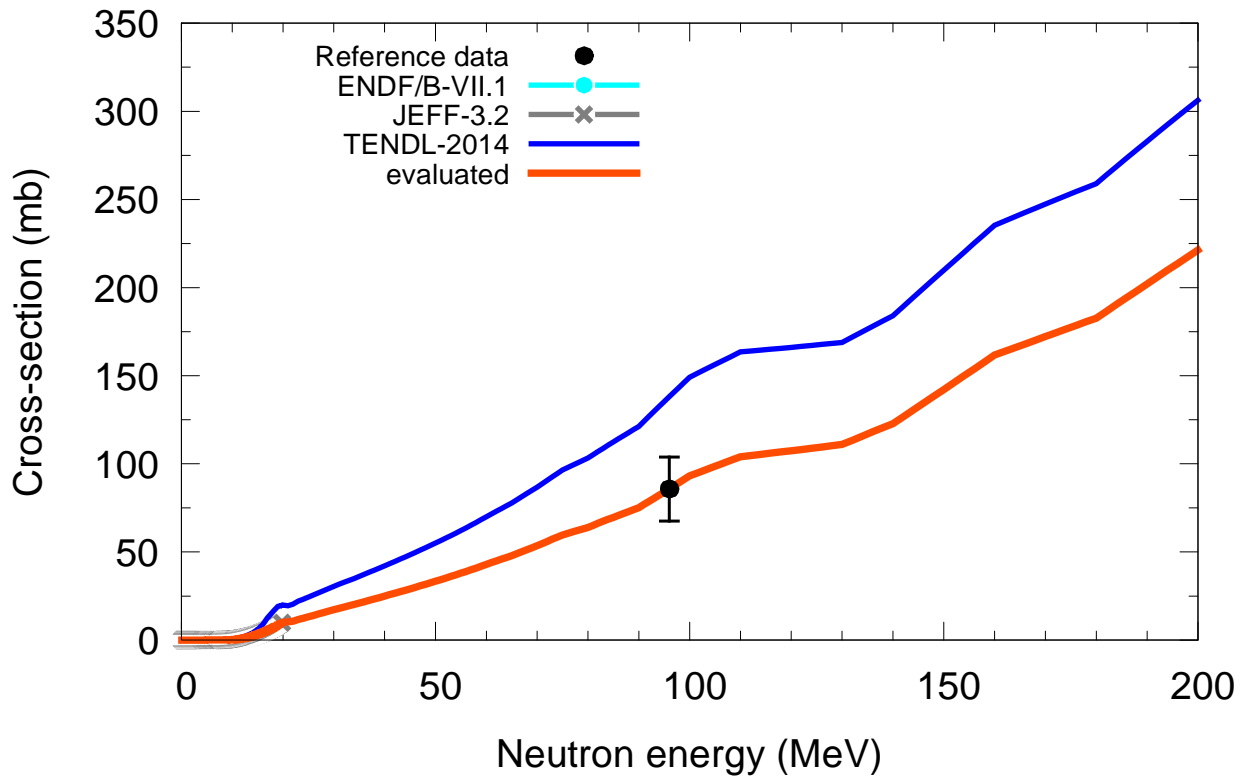
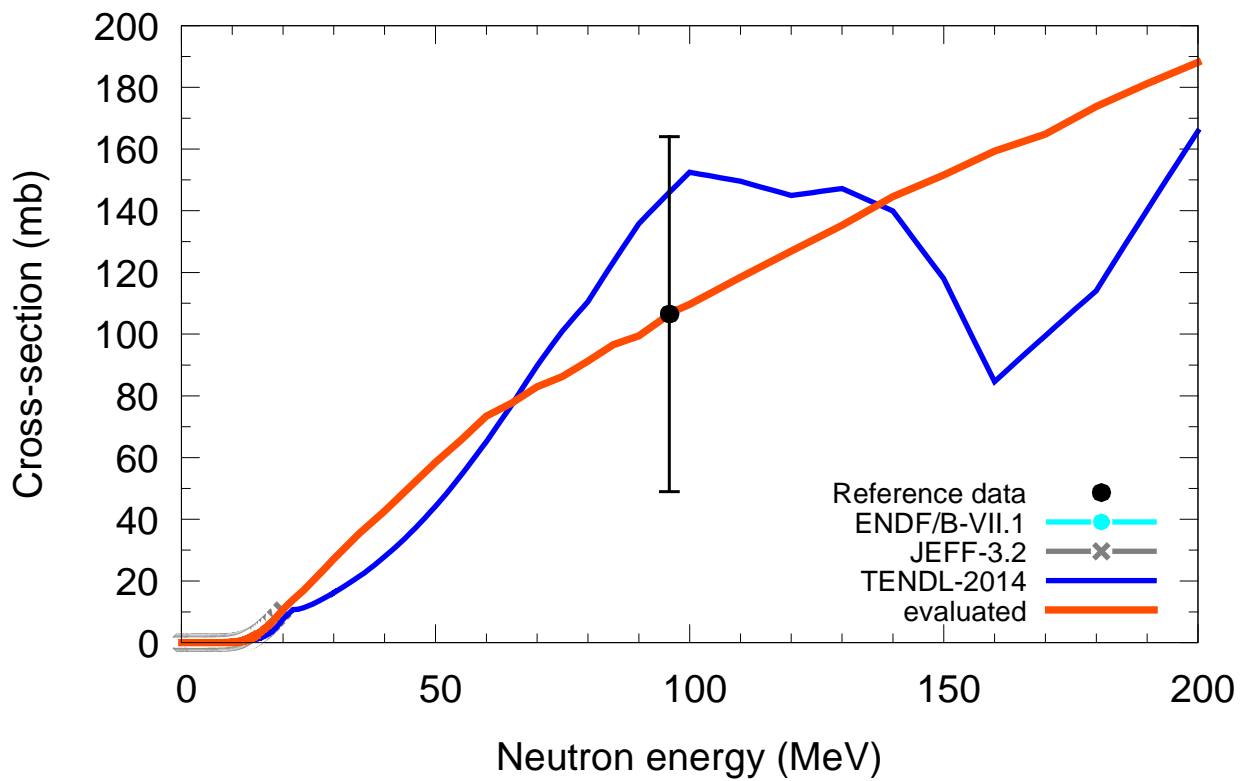
### $^{132}\text{Ba}(n,x)^4\text{He}$



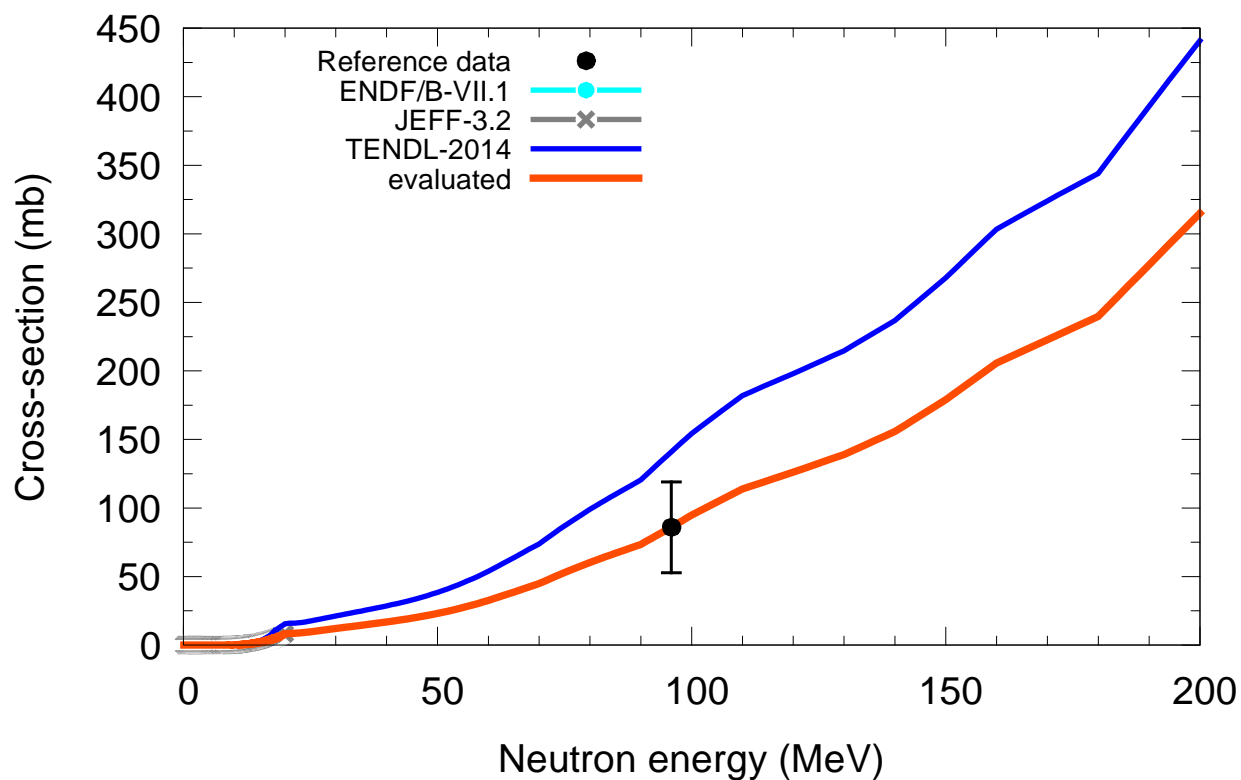
### $^{134}\text{Ba}(n,x)^4\text{He}$



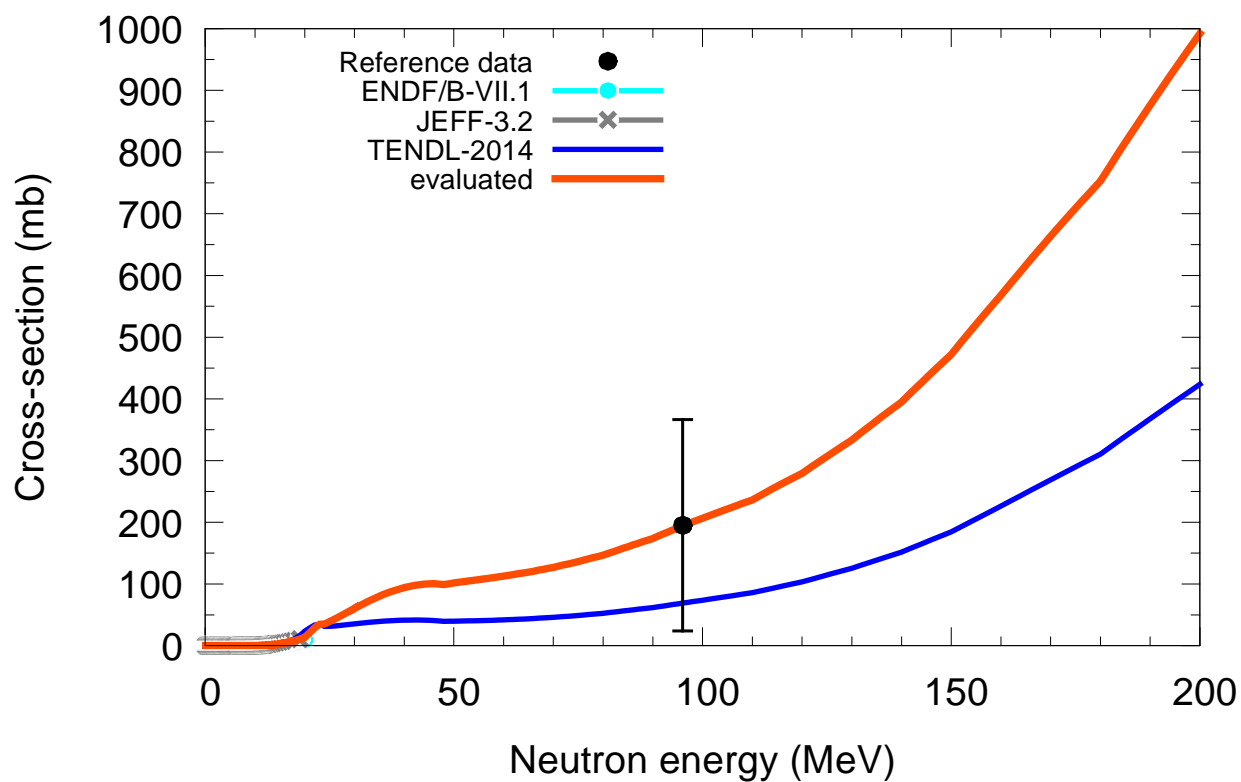


$^{135}\text{Ba}(n,x)^4\text{He}$  $^{136}\text{Ba}(n,x)^4\text{He}$ 

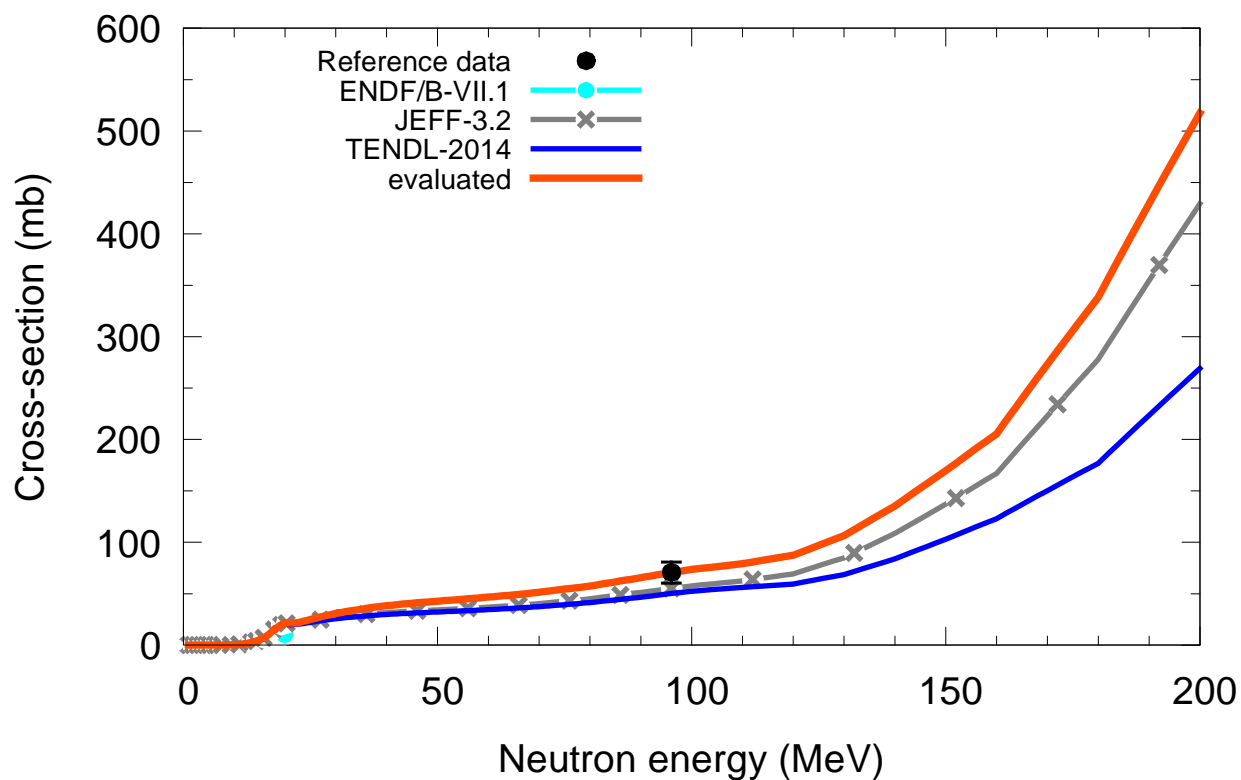
$^{137}\text{Ba}(n,x)^4\text{He}$



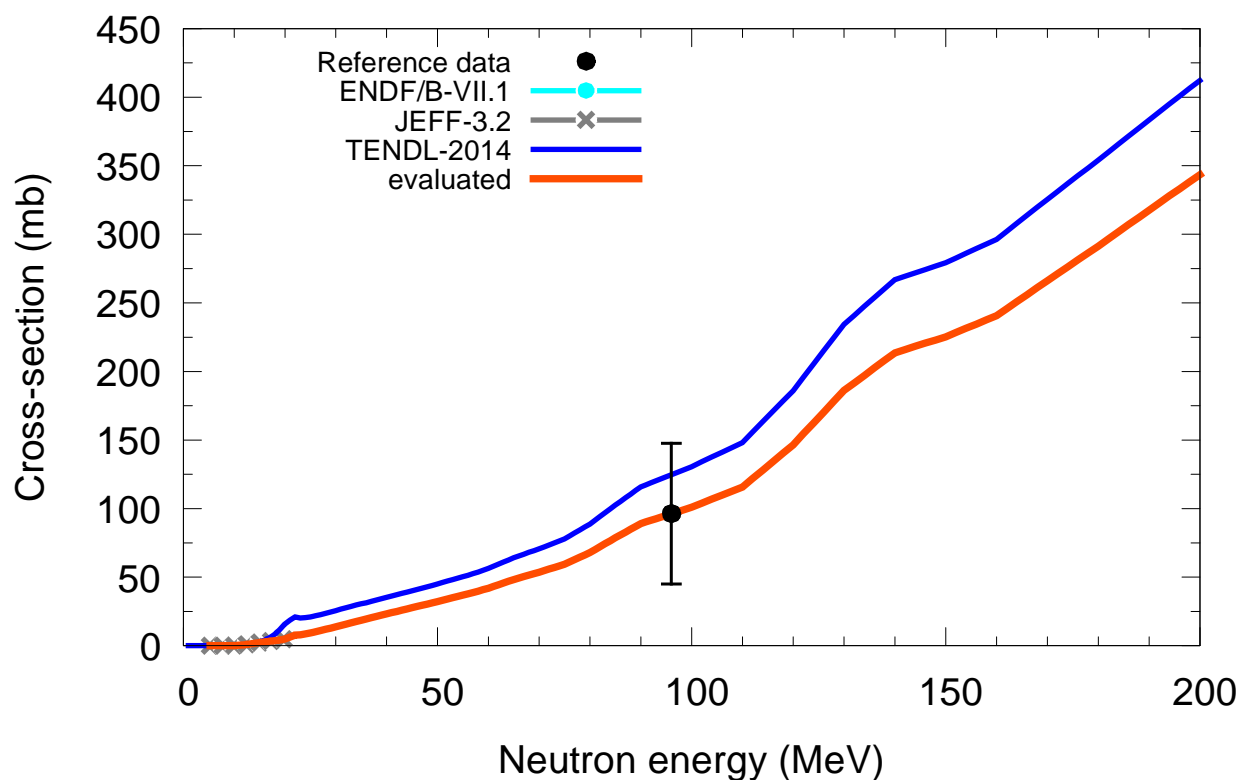
$^{138}\text{Ba}(n,x)^4\text{He}$

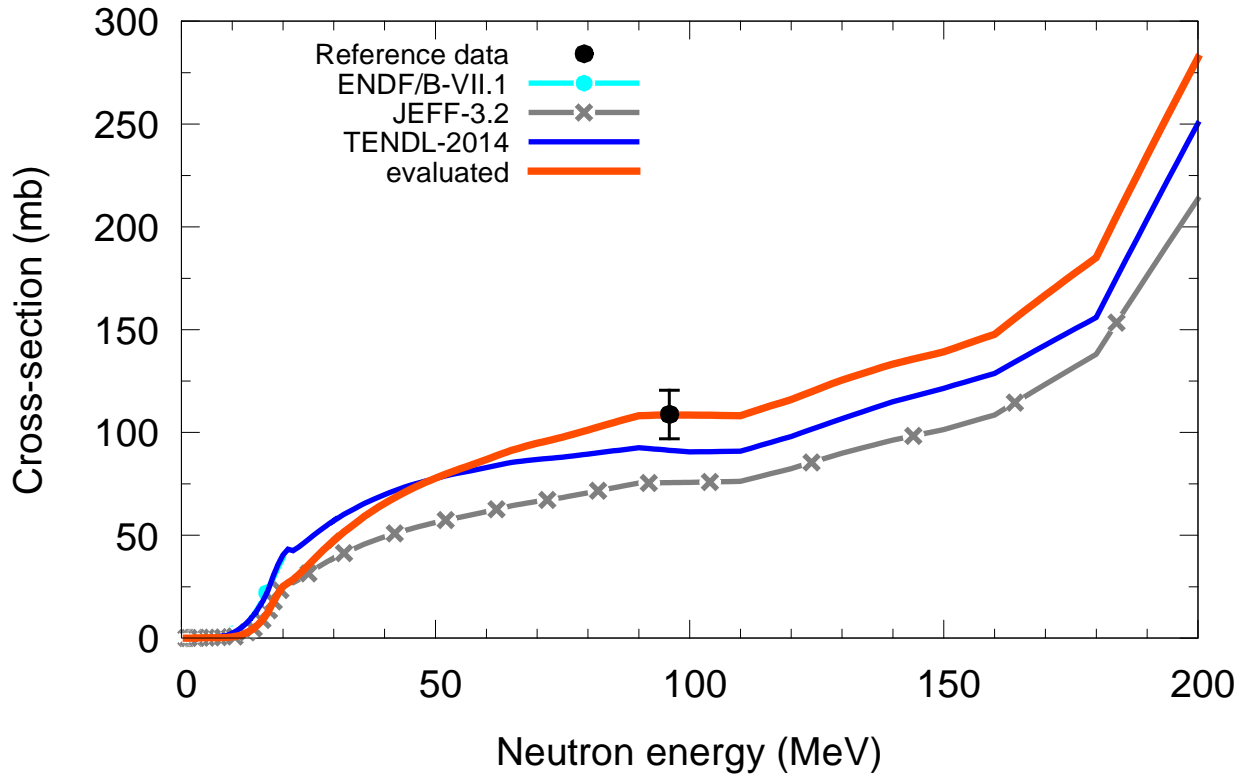
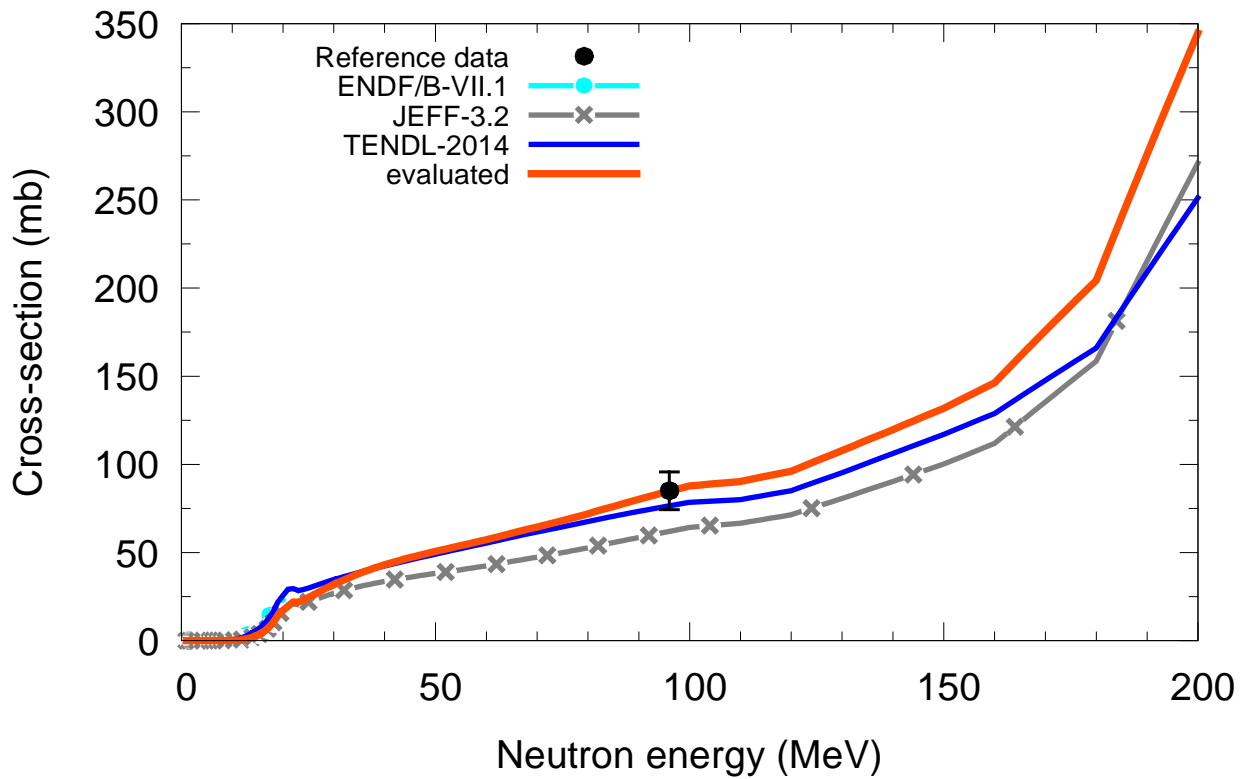


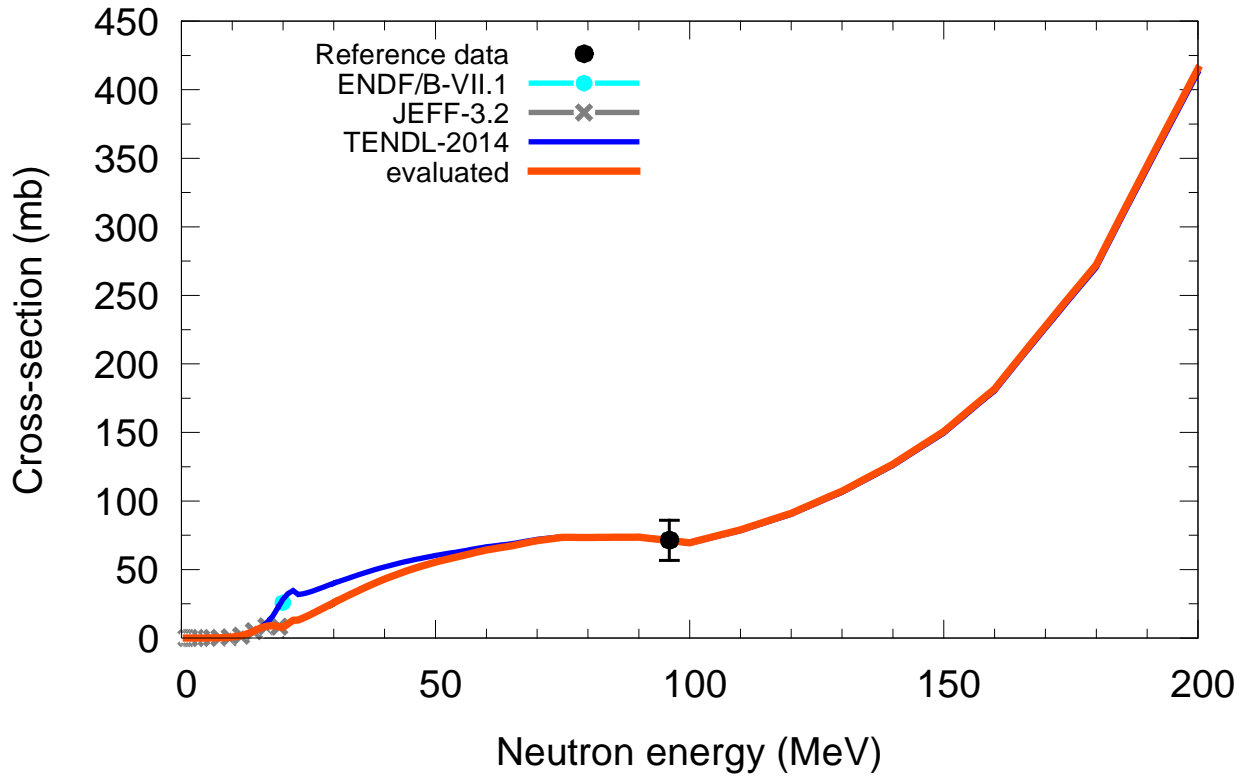
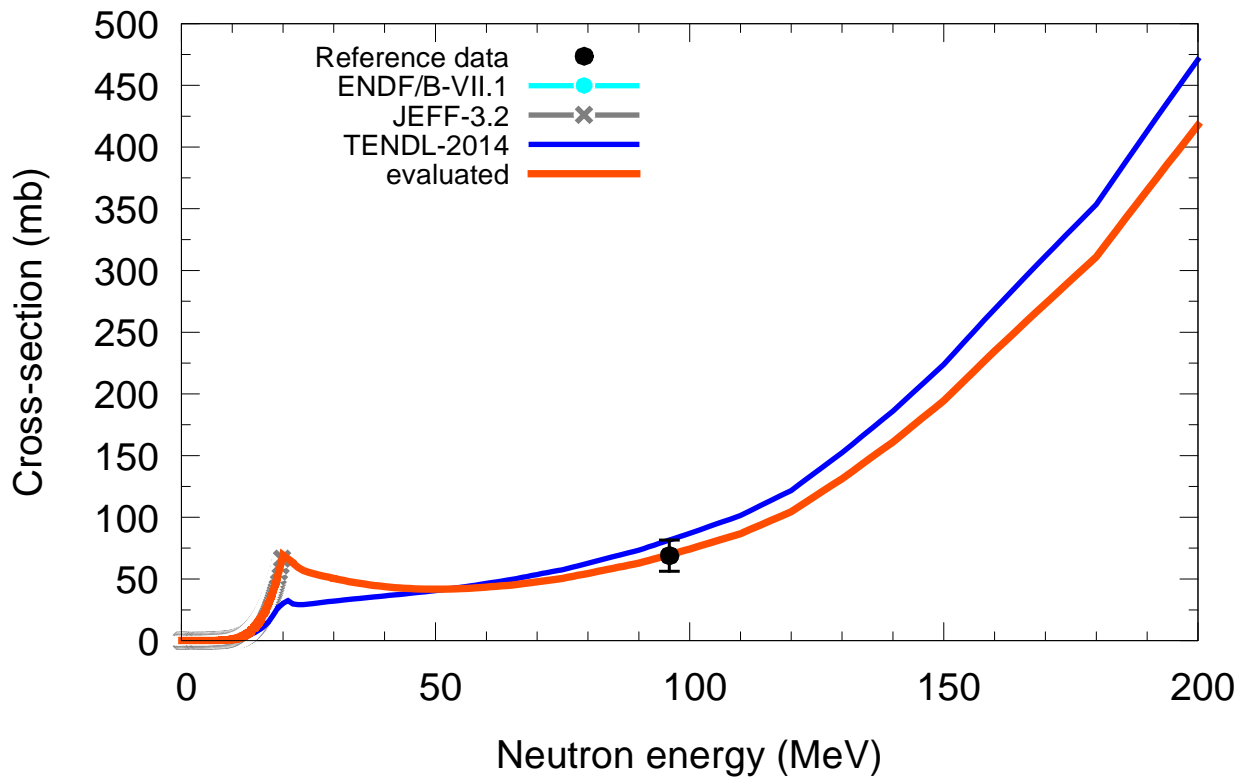
$^{138}\text{La}(n,x)^4\text{He}$



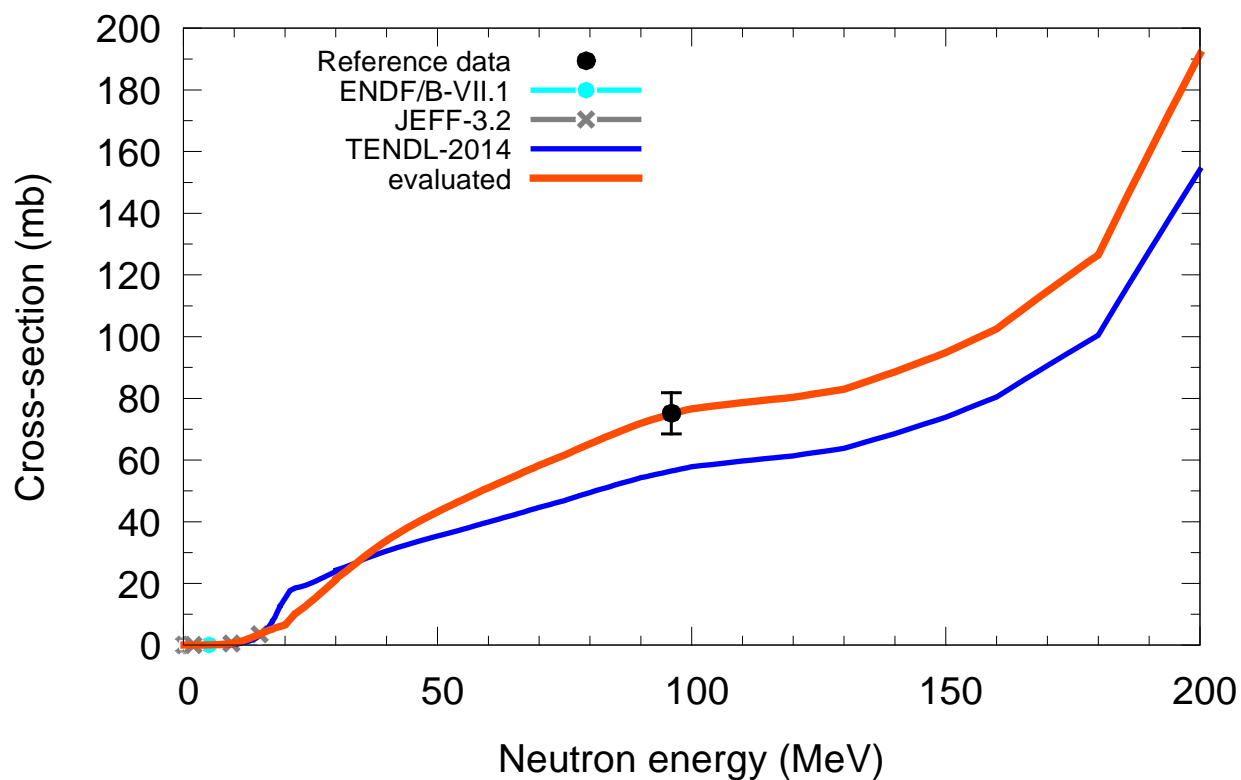
$^{139}\text{La}(n,x)^4\text{He}$



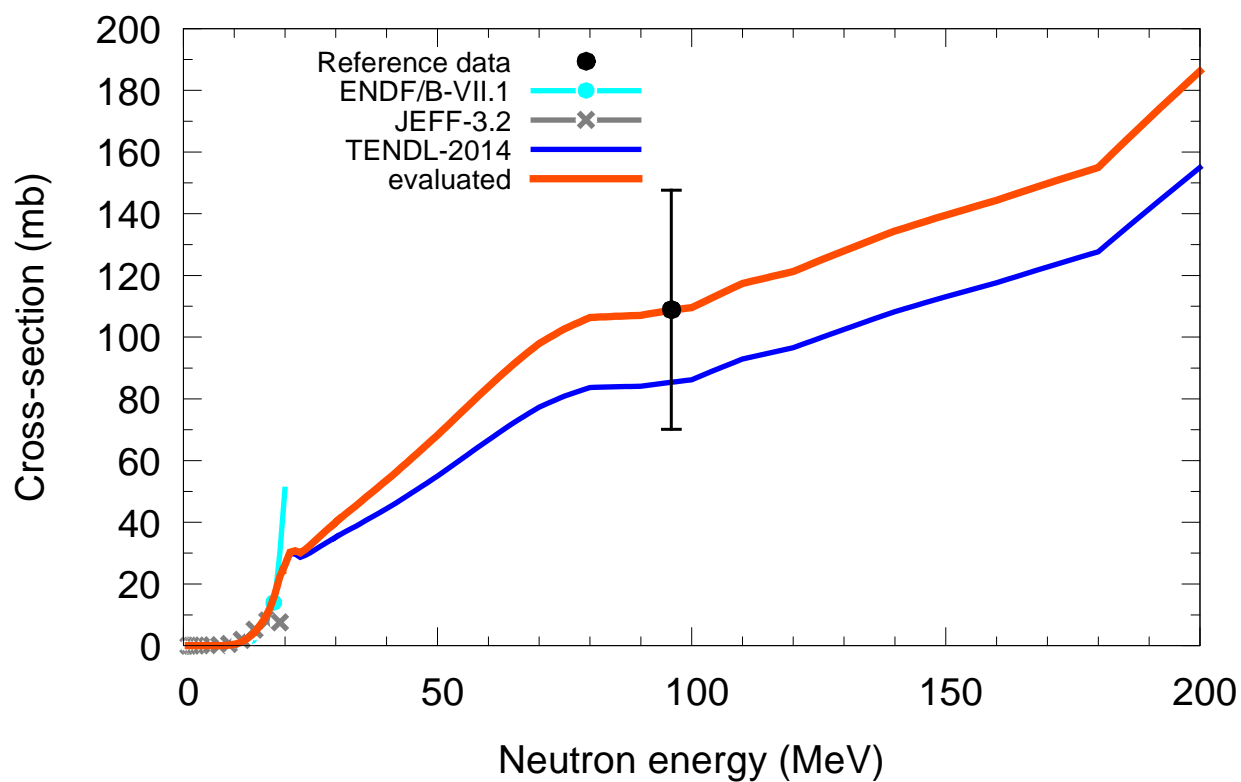
$^{136}\text{Ce}(n,x)^4\text{He}$  $^{138}\text{Ce}(n,x)^4\text{He}$ 

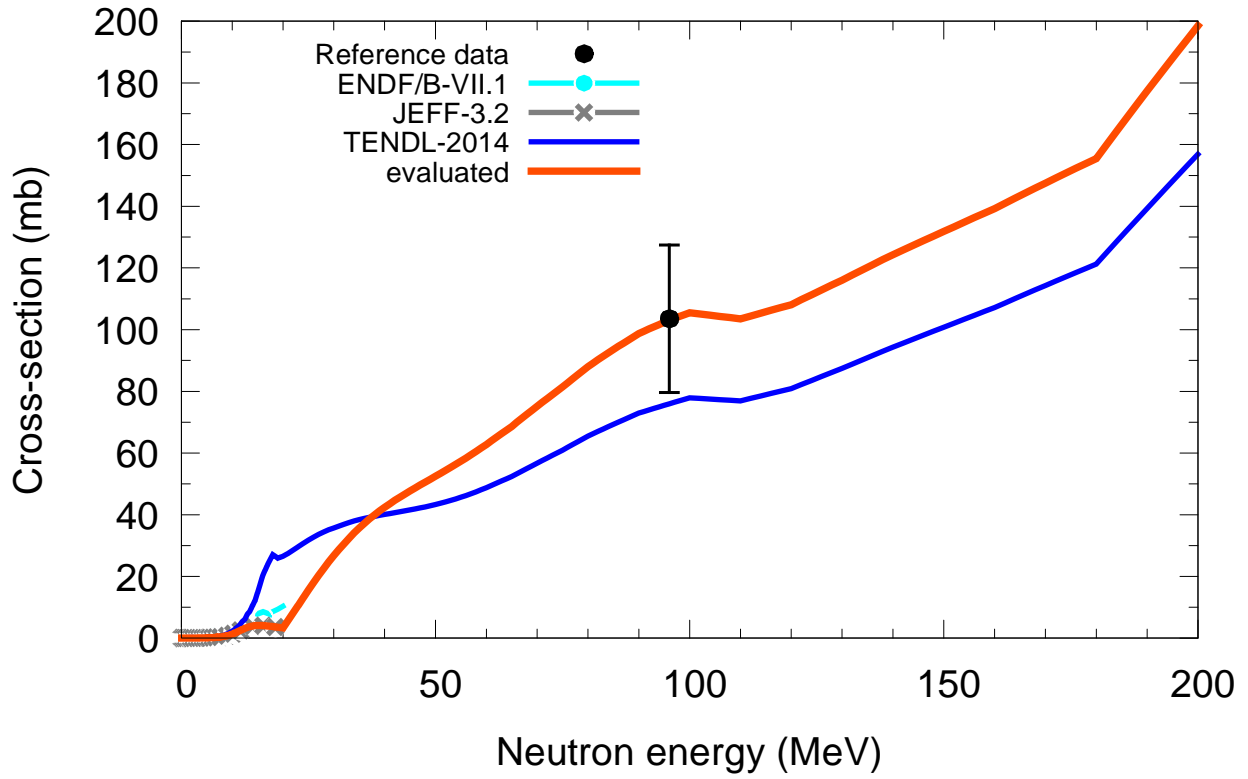
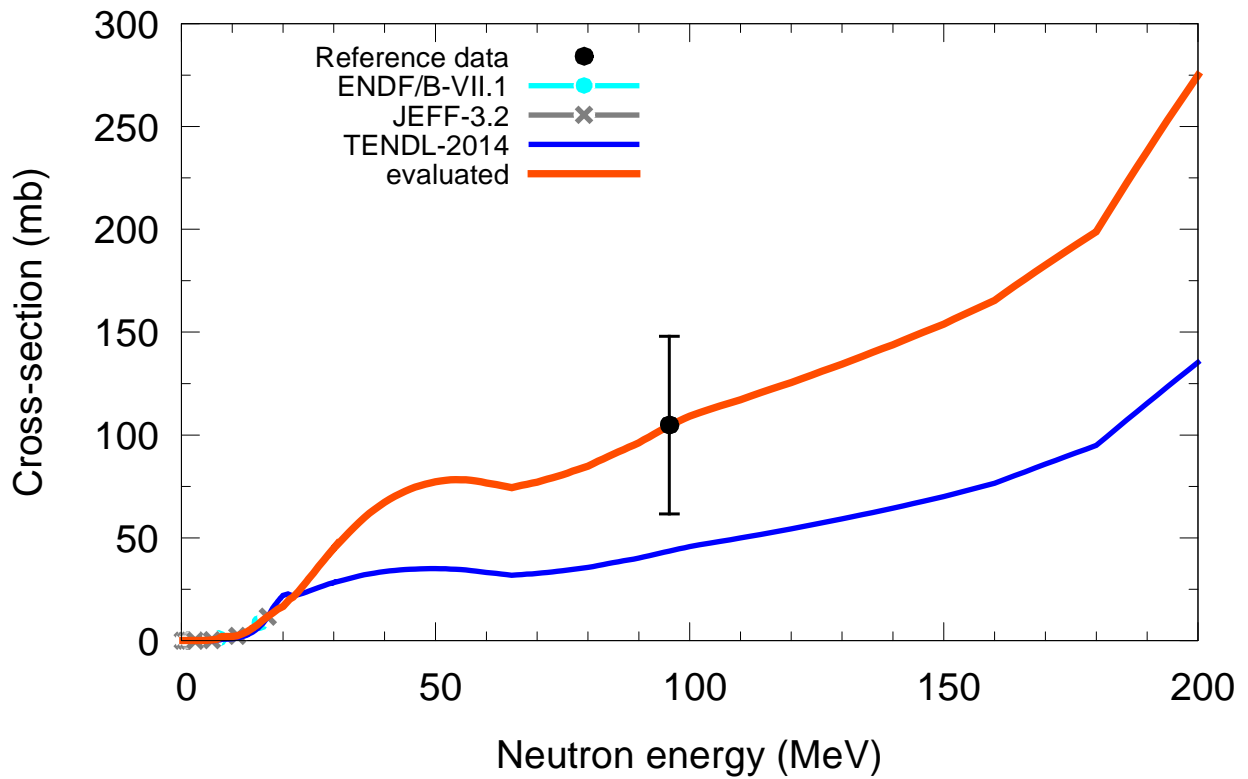
$^{140}\text{Ce}(n,x)^4\text{He}$  $^{142}\text{Ce}(n,x)^4\text{He}$ 

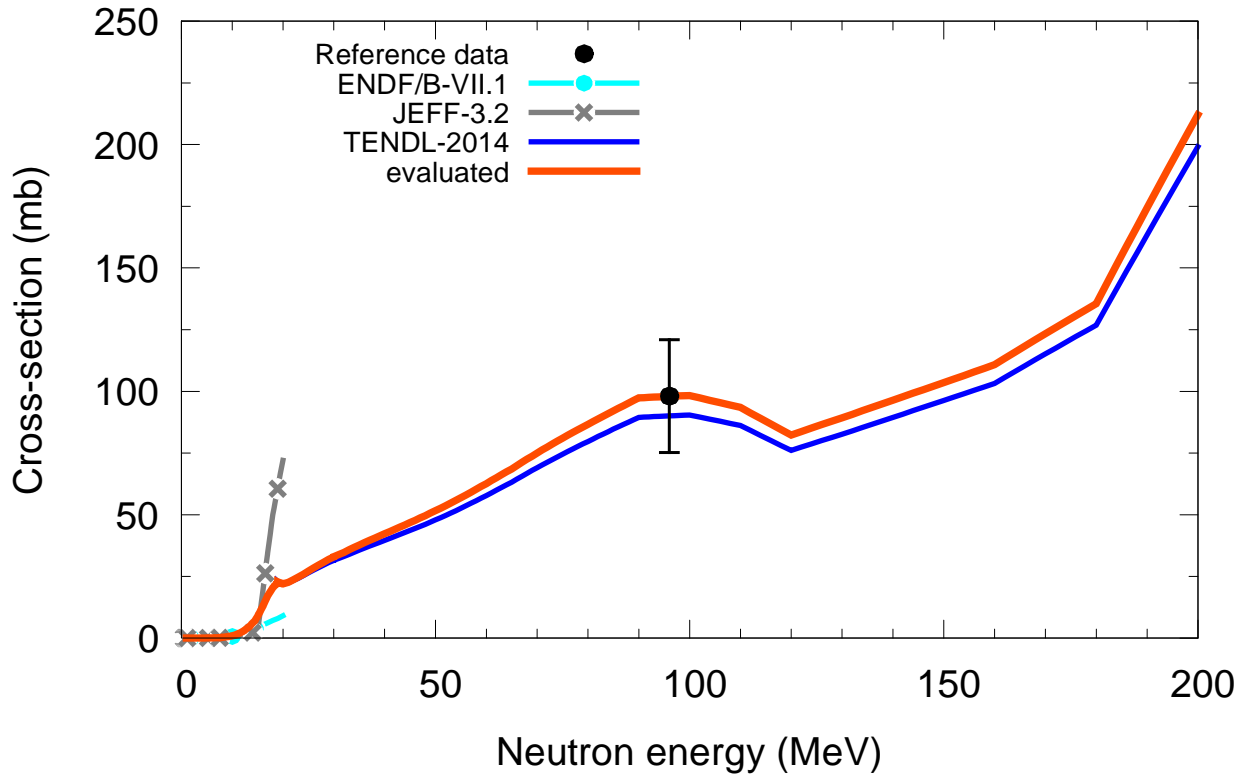
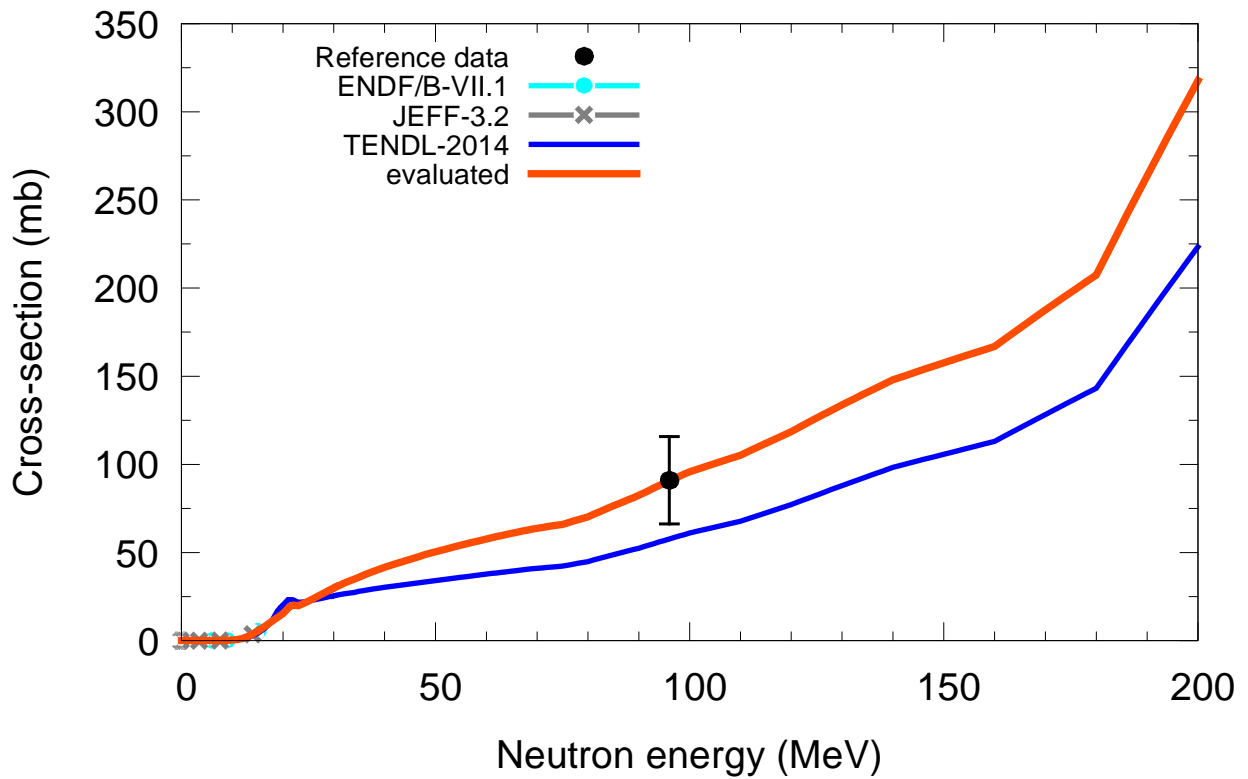
### $^{141}\text{Pr}(n,x)^4\text{He}$



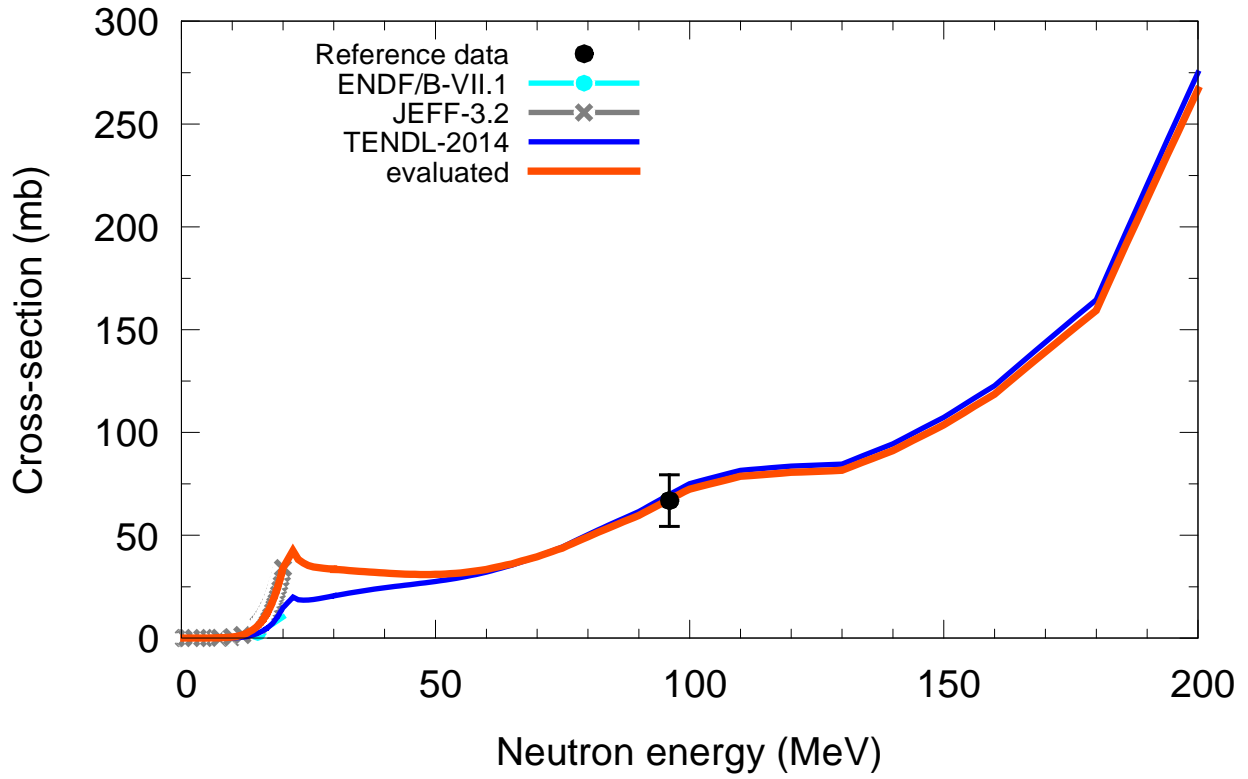
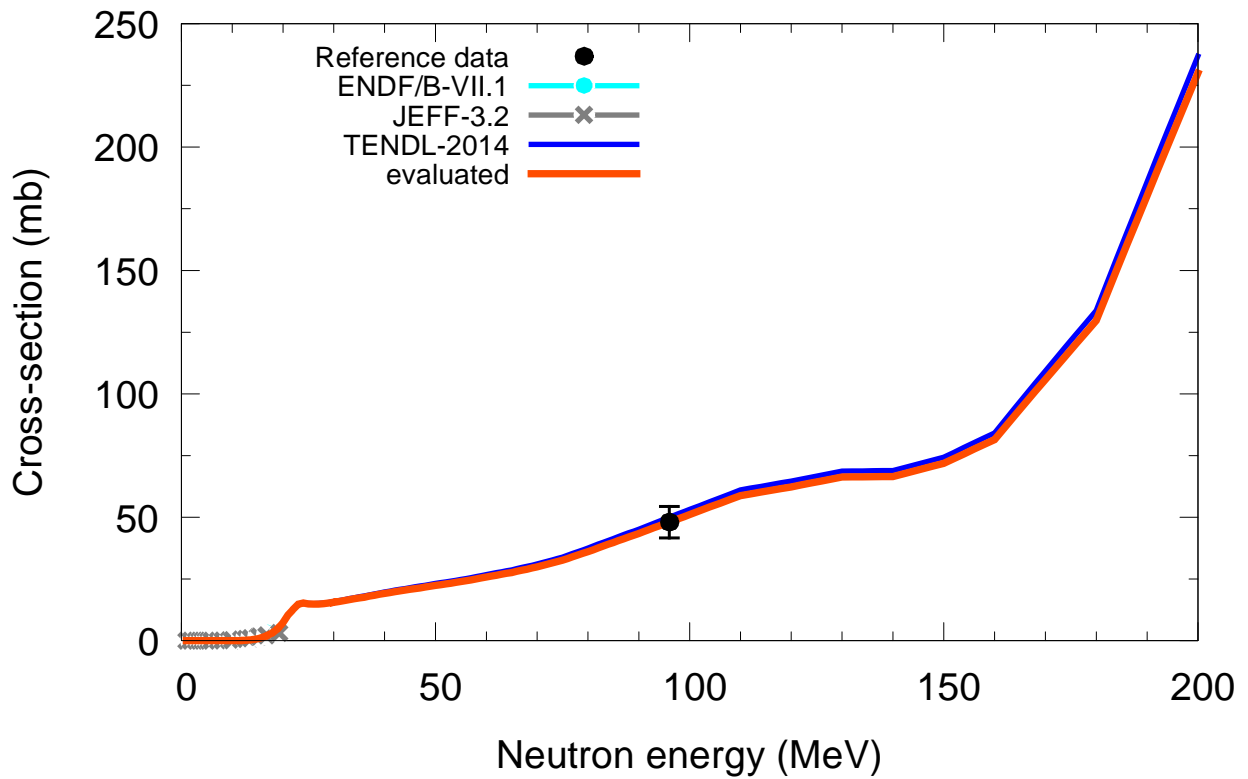
### $^{142}\text{Nd}(n,x)^4\text{He}$



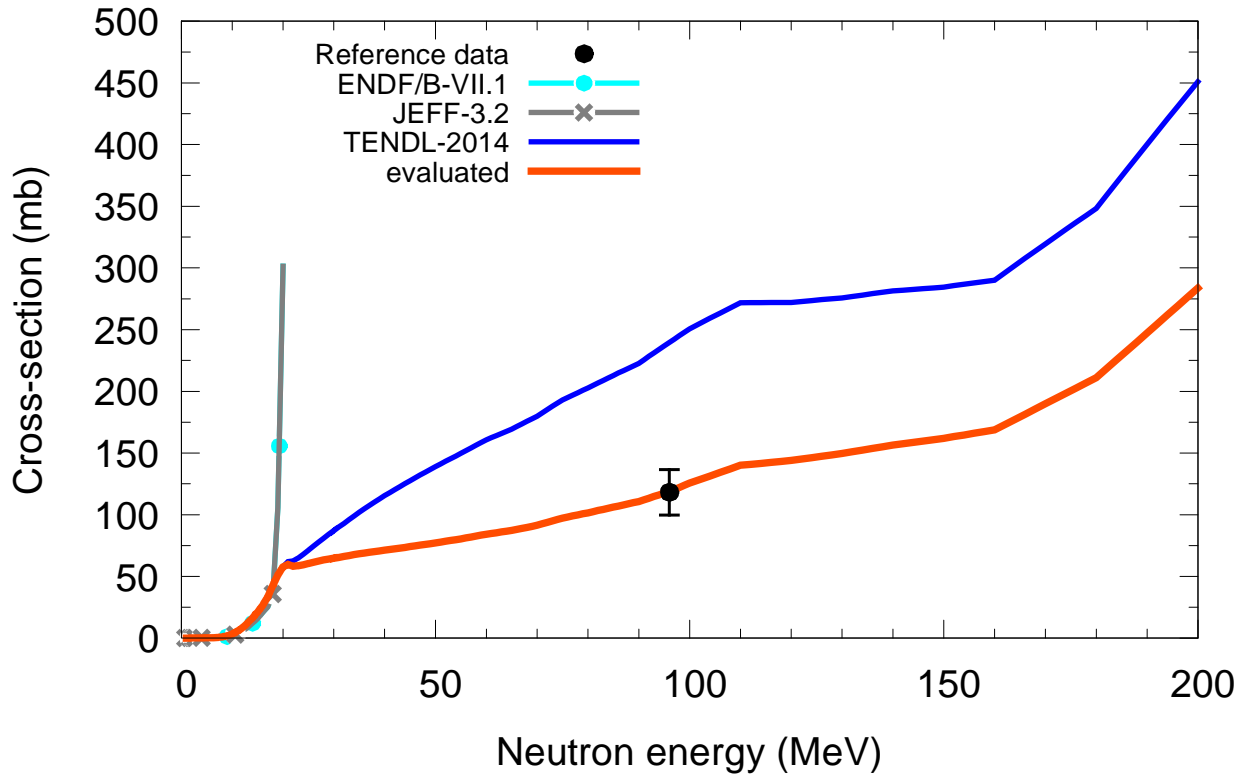
$^{143}\text{Nd}(n,x)^4\text{He}$  $^{144}\text{Nd}(n,x)^4\text{He}$ 

$^{145}\text{Nd}(n,x)^4\text{He}$  $^{146}\text{Nd}(n,x)^4\text{He}$ 

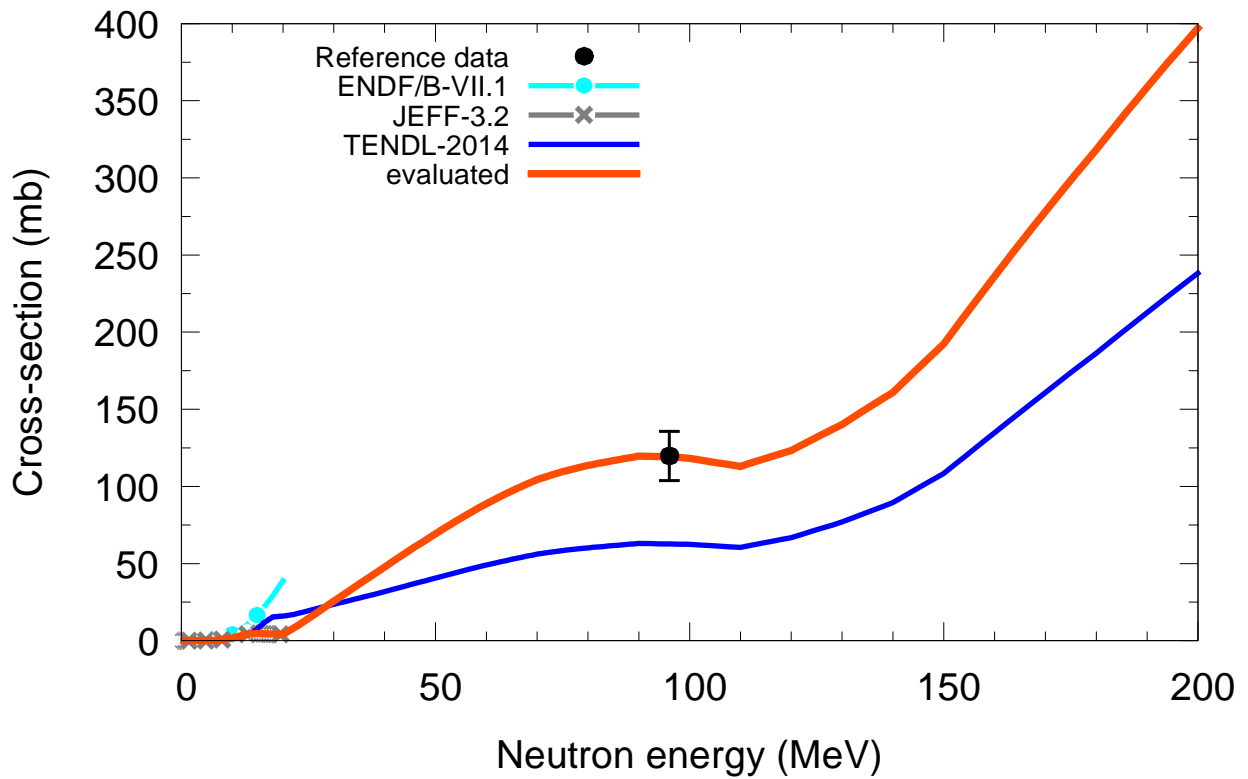


$^{148}\text{Nd}(n,x)^4\text{He}$  $^{150}\text{Nd}(n,x)^4\text{He}$ 

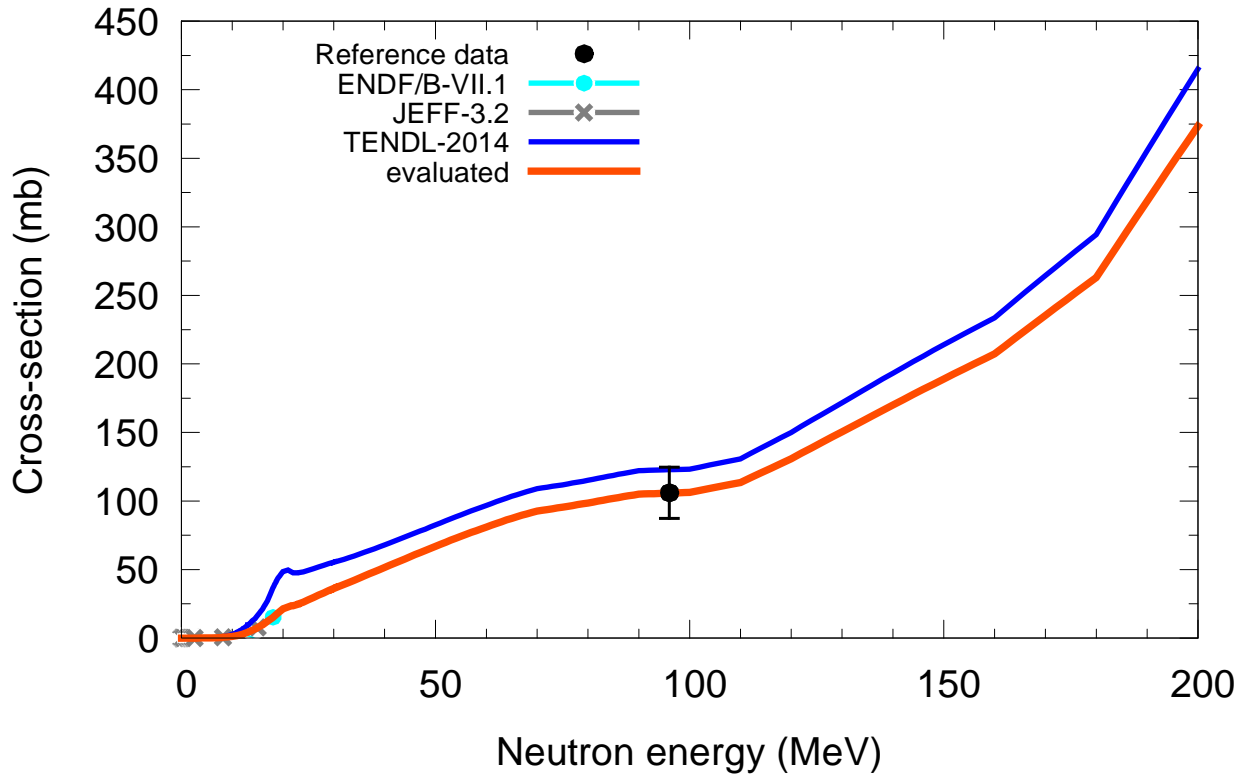
### $^{144}\text{Sm}(n,x)^4\text{He}$



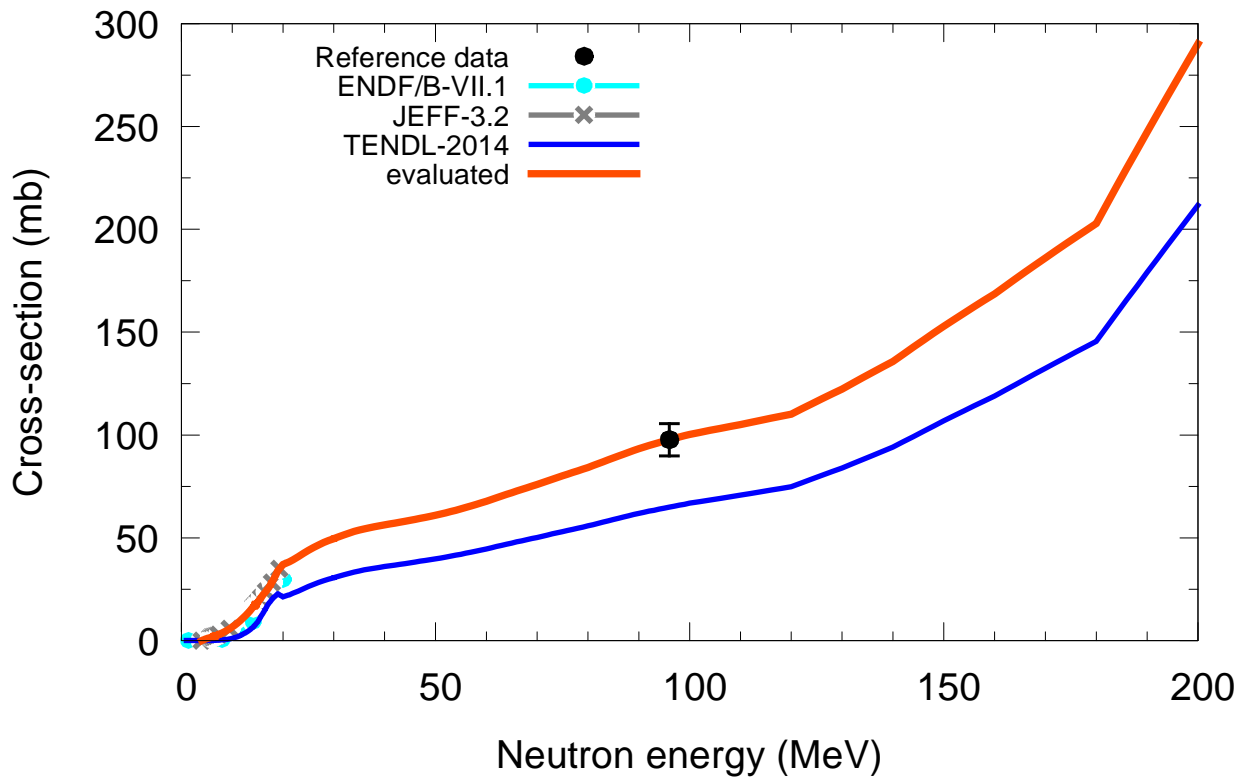
### $^{147}\text{Sm}(n,x)^4\text{He}$



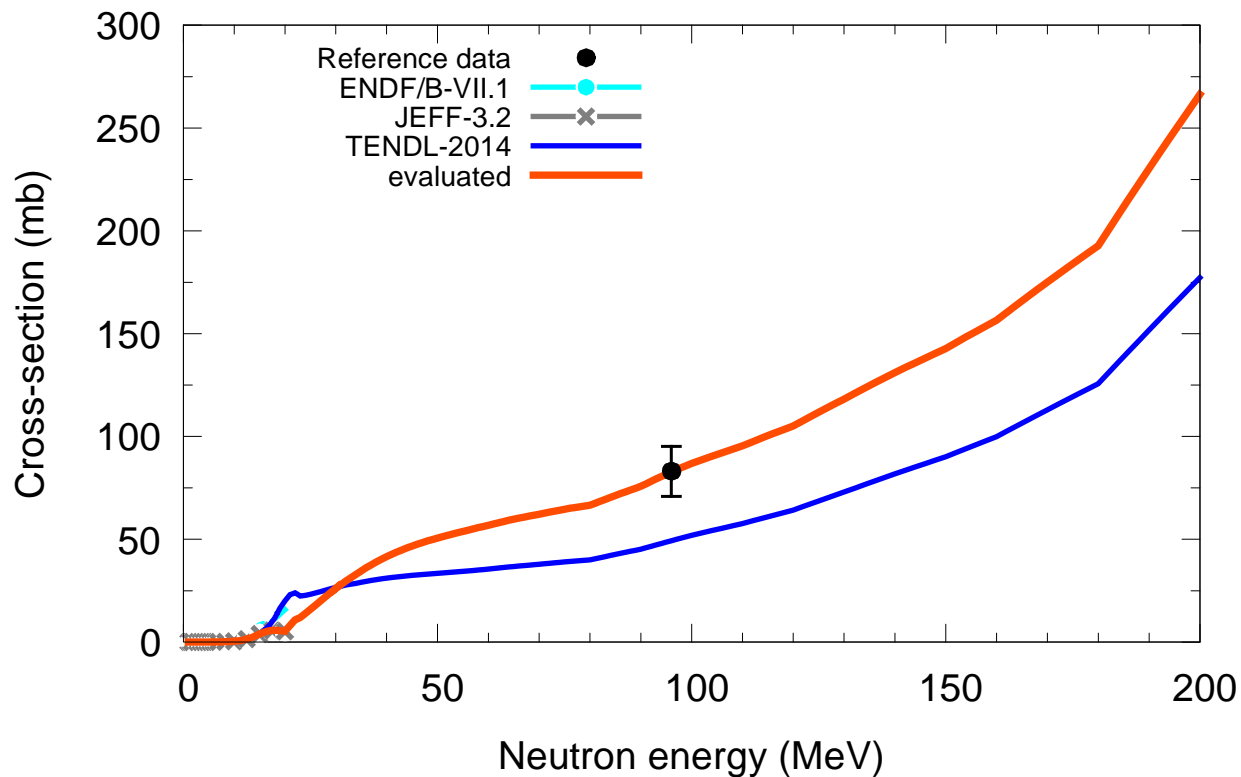
### $^{148}\text{Sm}(n,x)^4\text{He}$



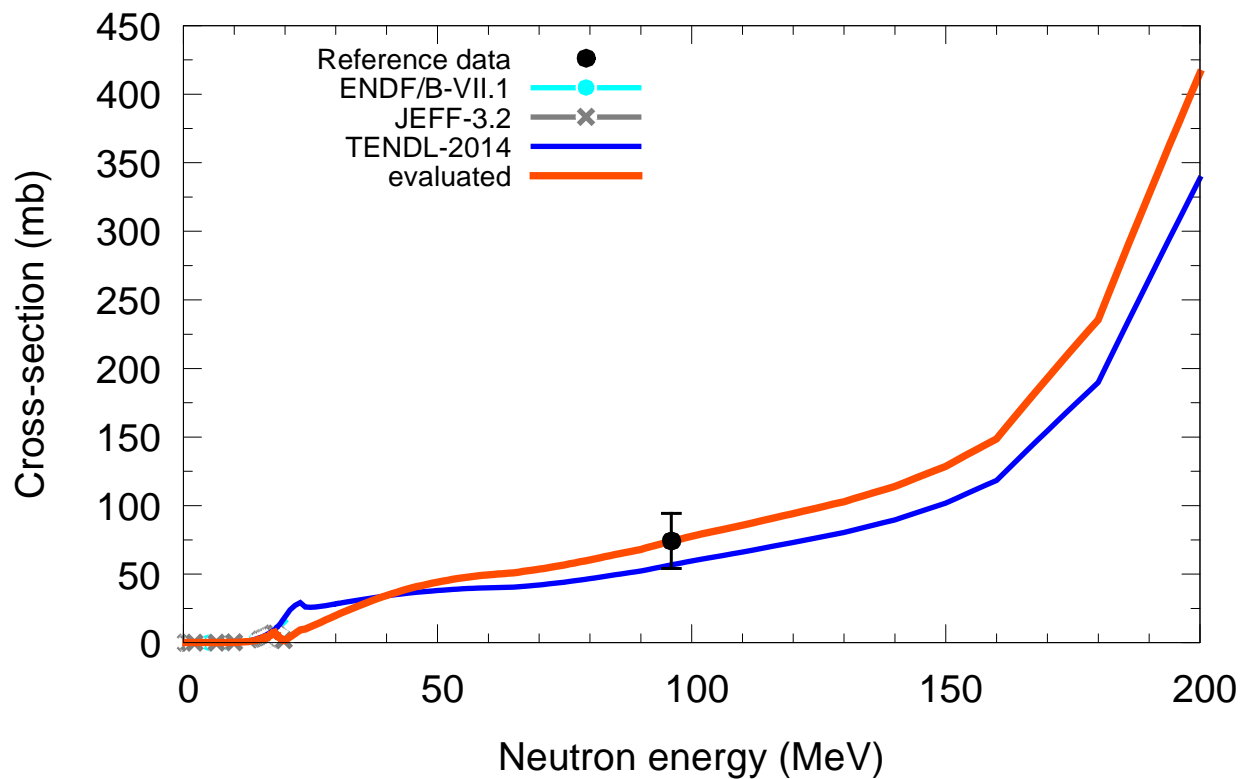
### $^{149}\text{Sm}(n,x)^4\text{He}$



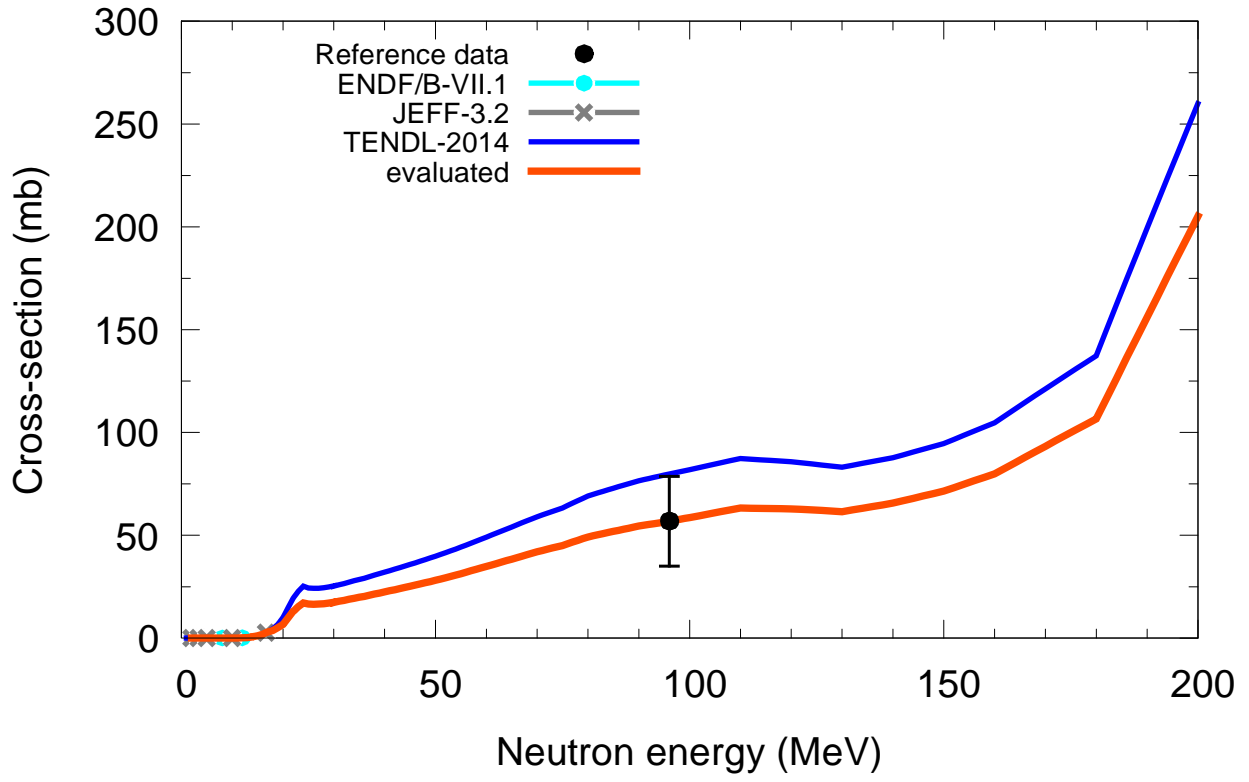
### $^{150}\text{Sm}(n,x)^4\text{He}$



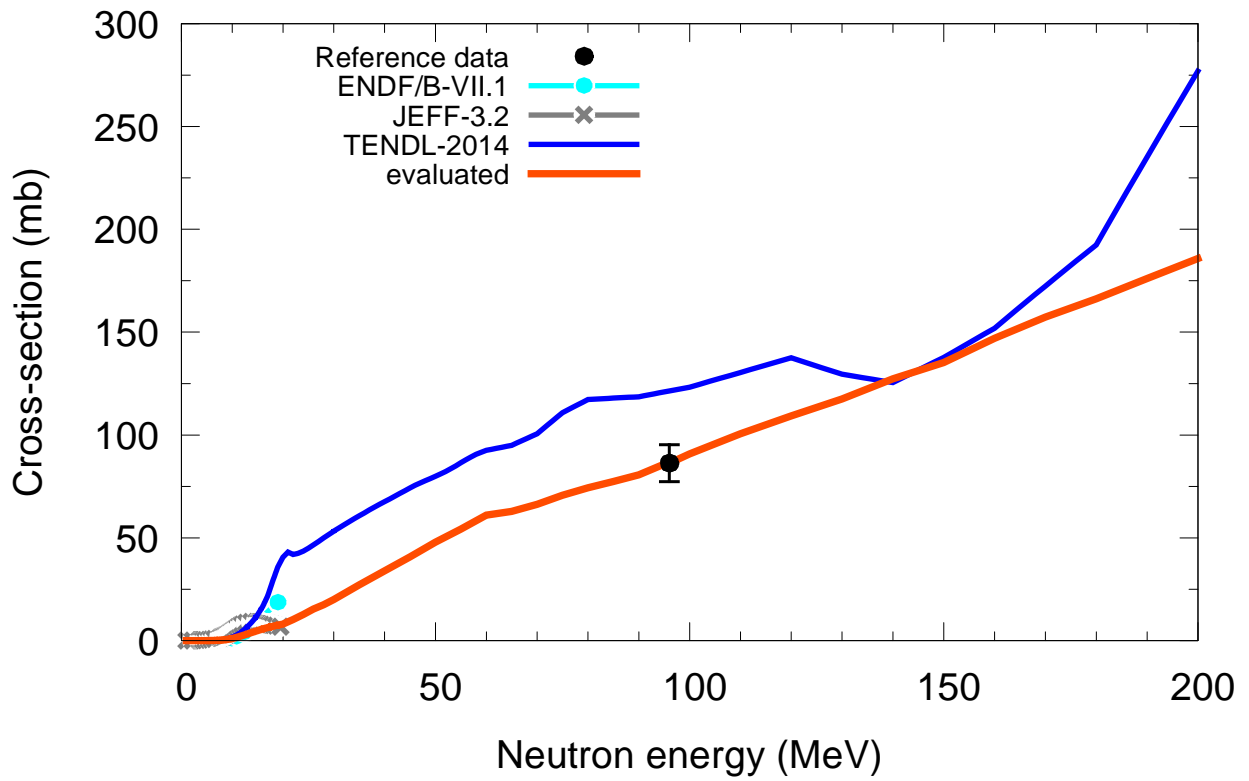
### $^{152}\text{Sm}(n,x)^4\text{He}$



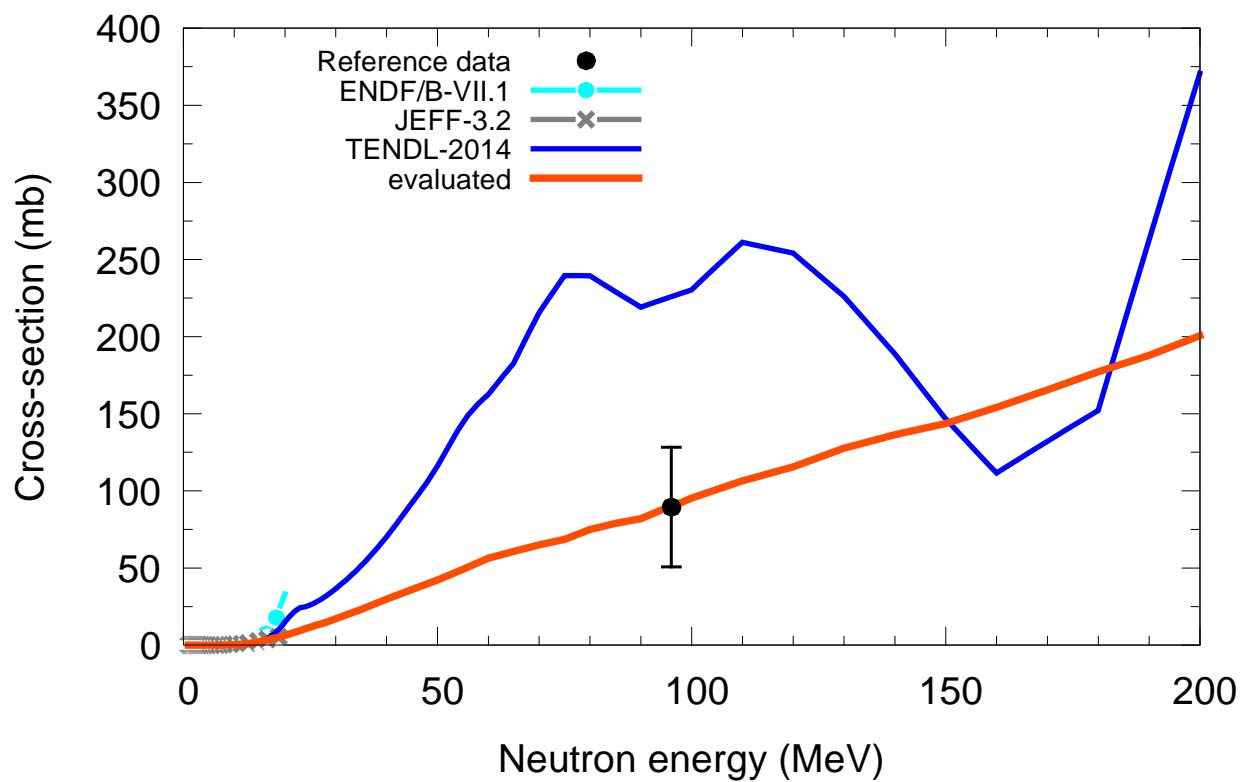
### $^{154}\text{Sm}(n,x)^4\text{He}$



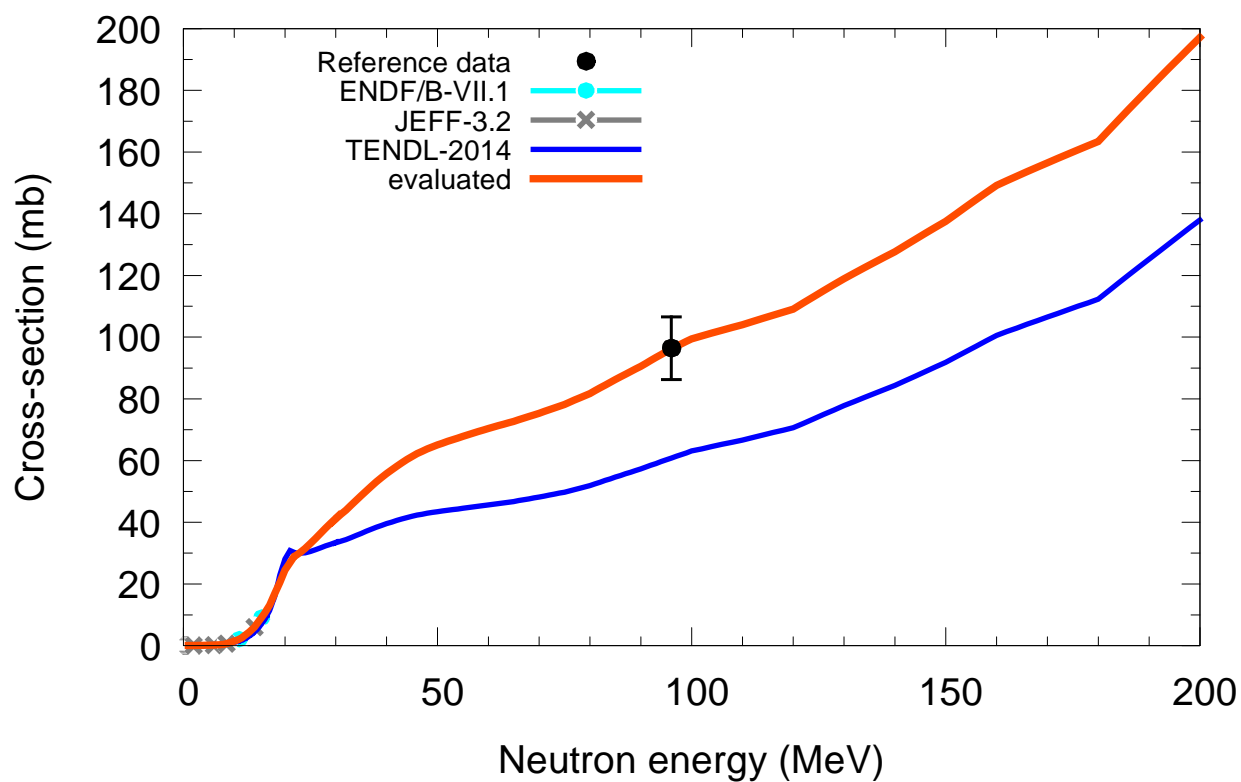
### $^{151}\text{Eu}(n,x)^4\text{He}$



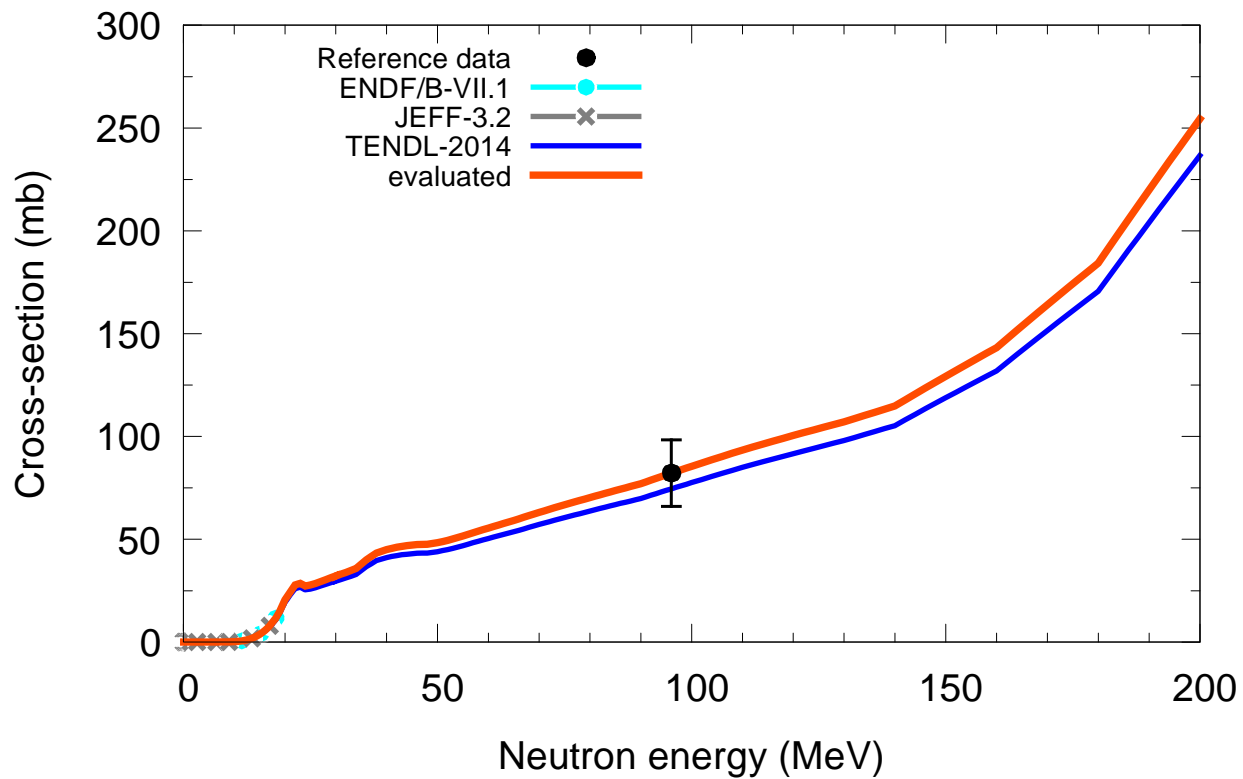
$^{153}\text{Eu}(n,x)^4\text{He}$



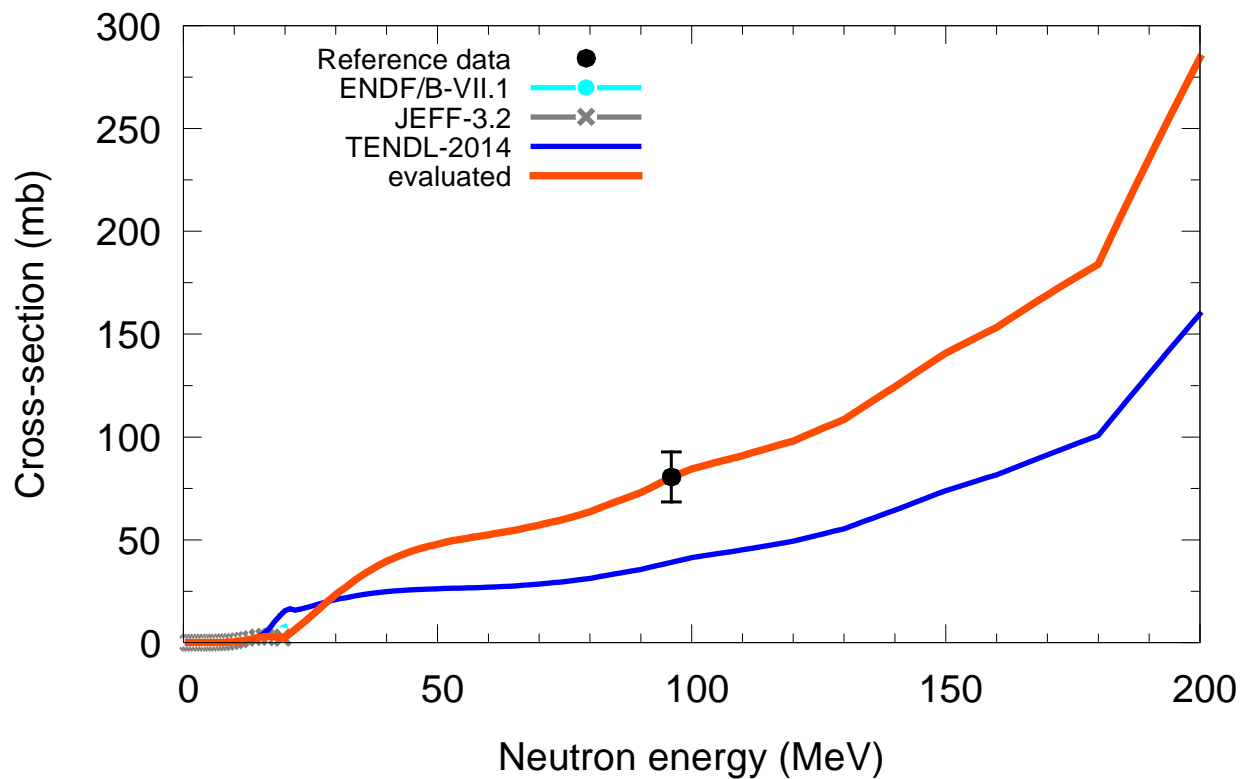
$^{152}\text{Gd}(n,x)^4\text{He}$



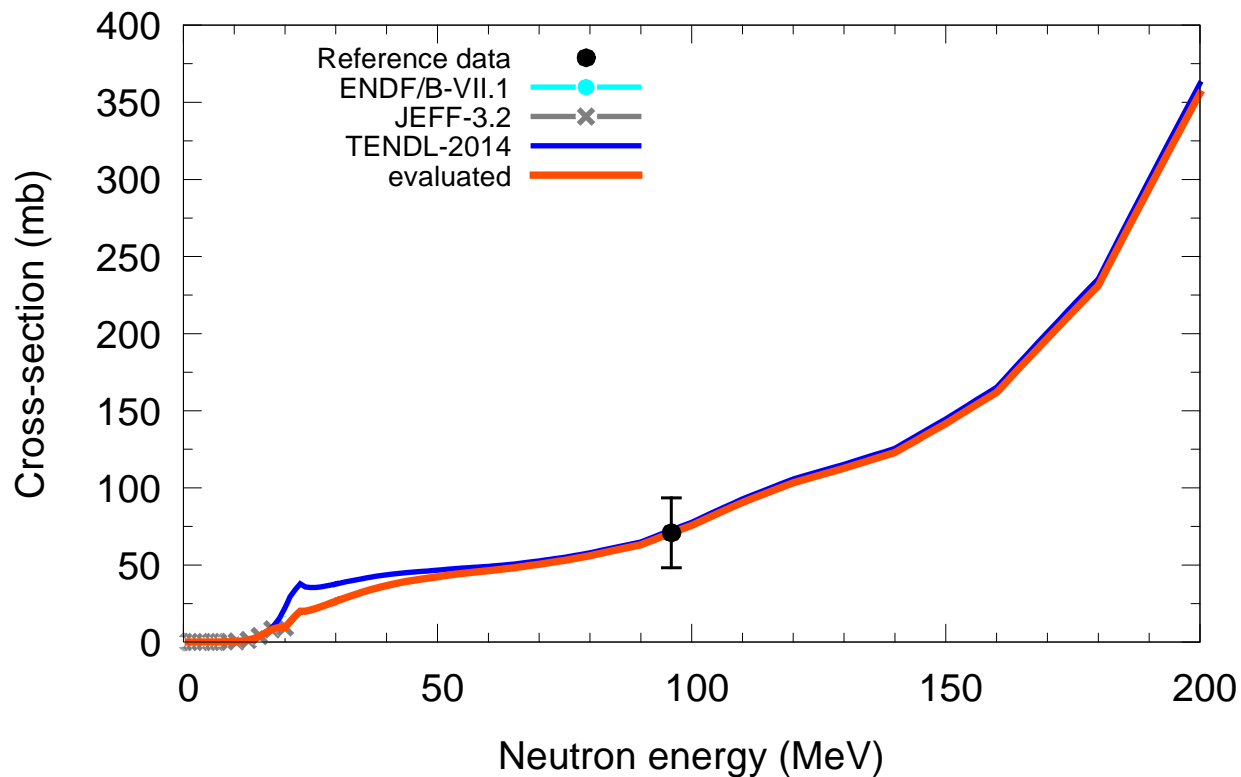
$^{154}\text{Gd}(n,x)^4\text{He}$



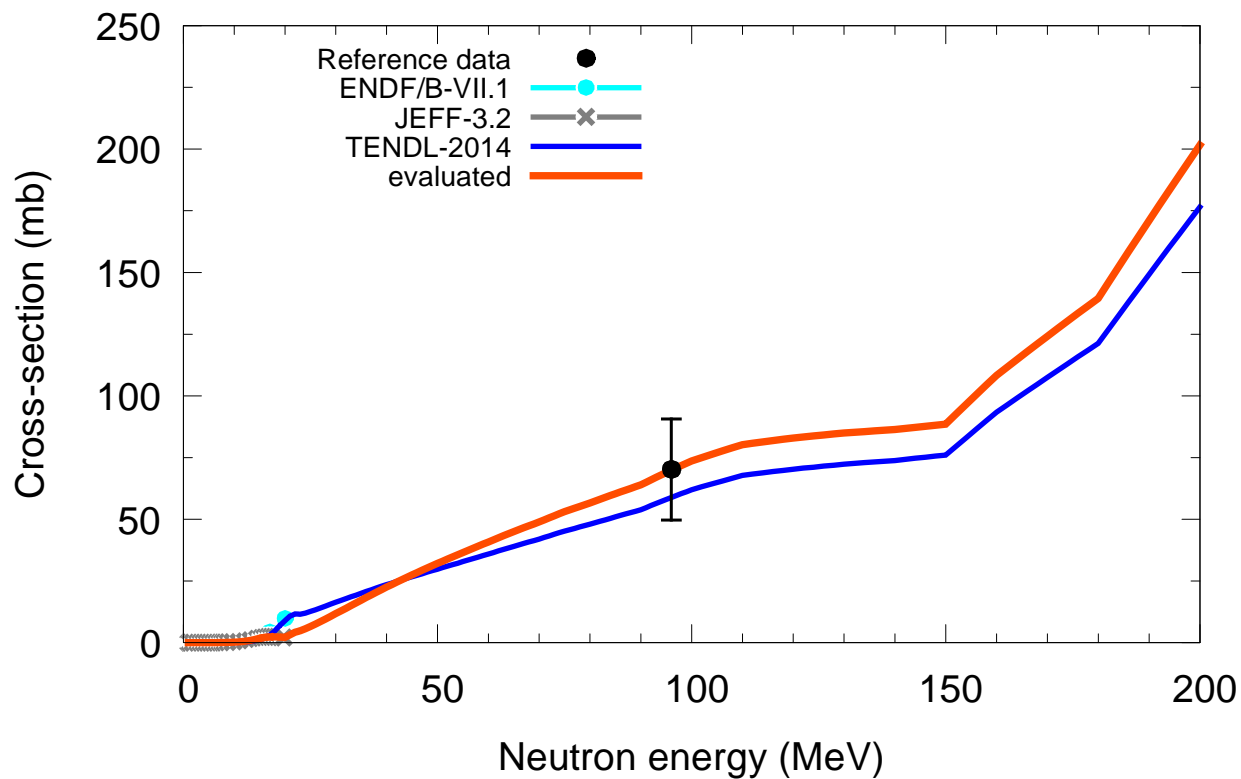
$^{155}\text{Gd}(n,x)^4\text{He}$



$^{156}\text{Gd}(n,x)^4\text{He}$

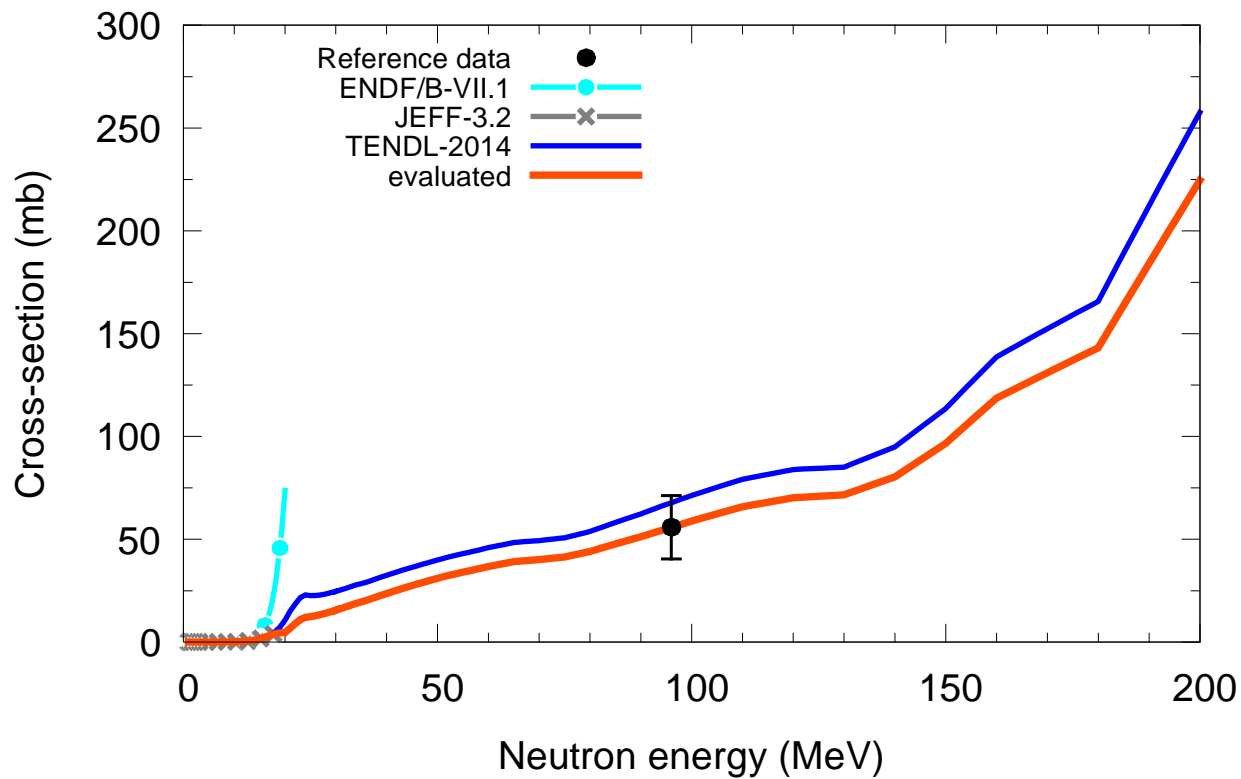


$^{157}\text{Gd}(n,x)^4\text{He}$

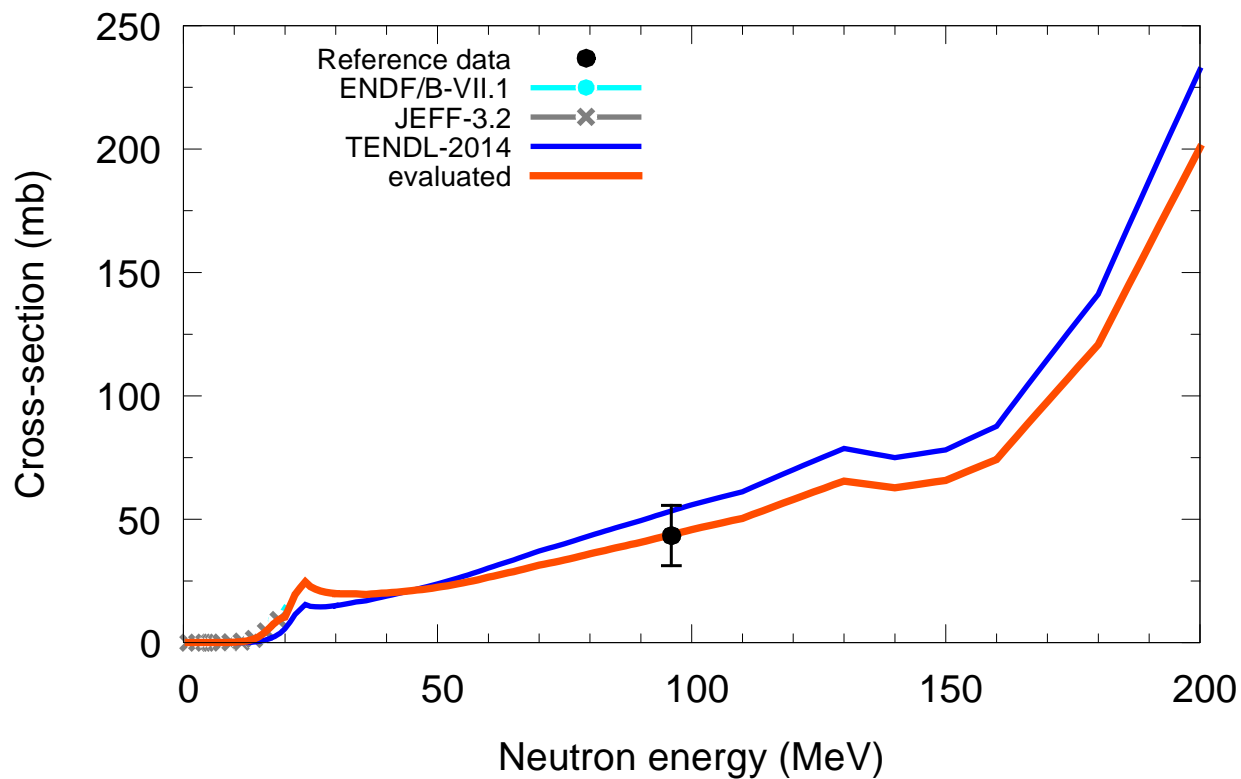




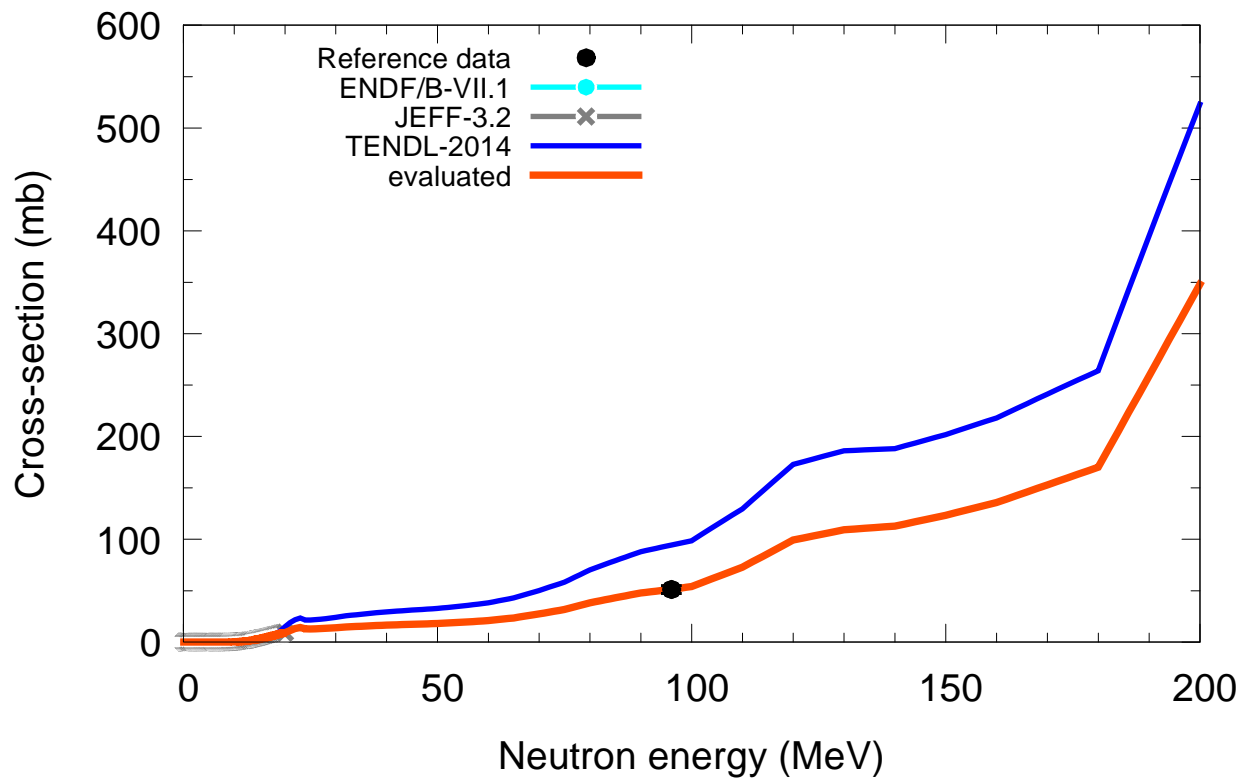
$^{158}\text{Gd}(n,x)^4\text{He}$



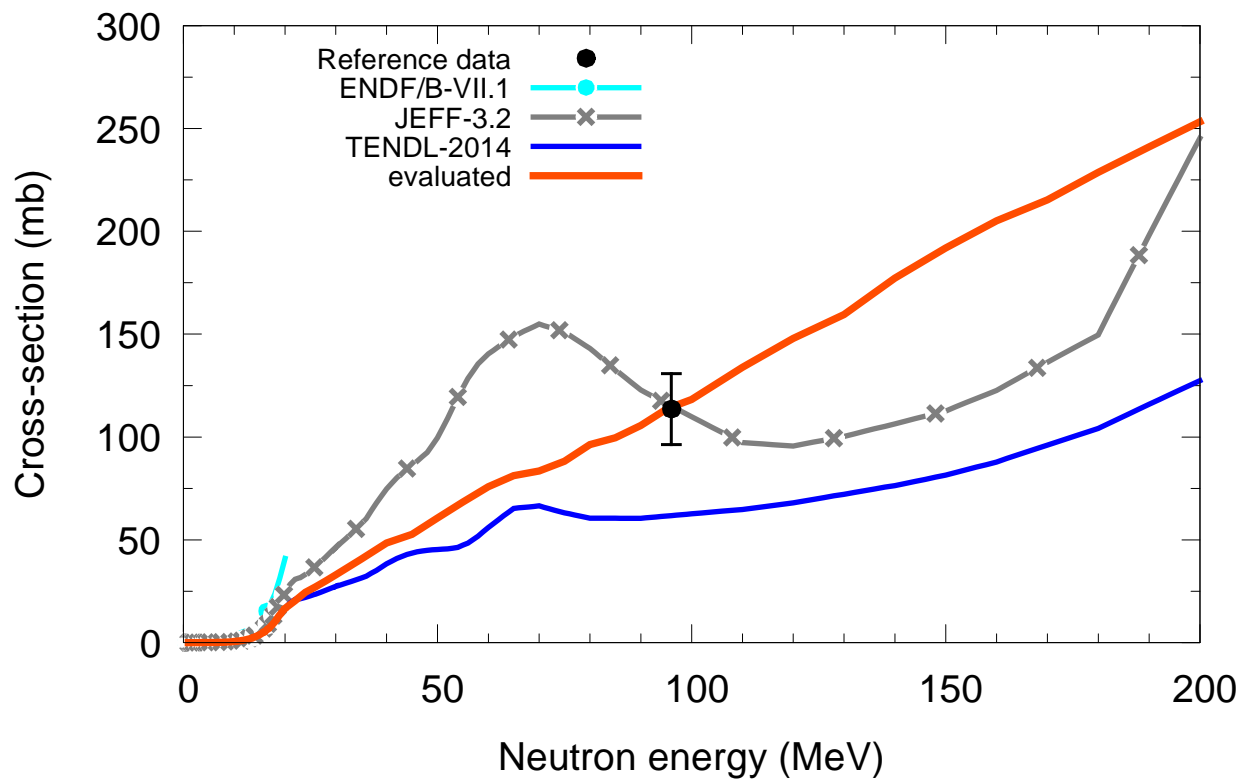
$^{160}\text{Gd}(n,x)^4\text{He}$

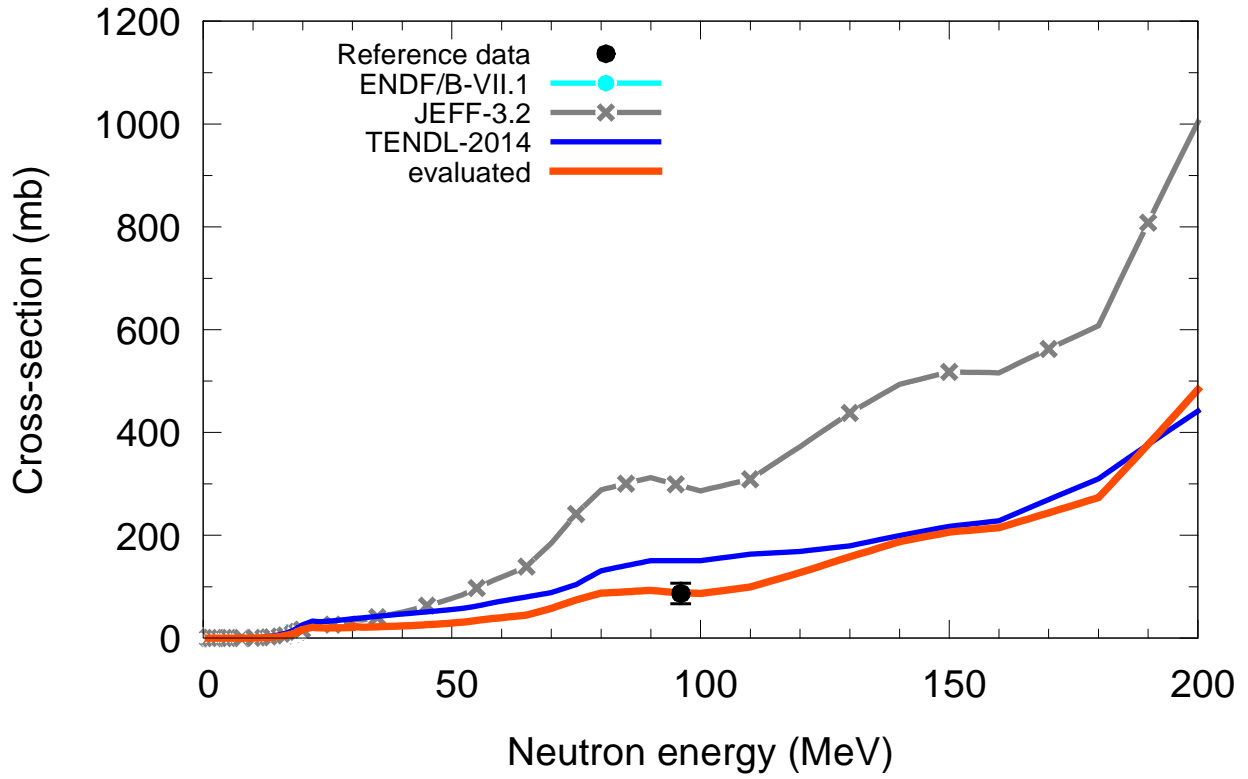
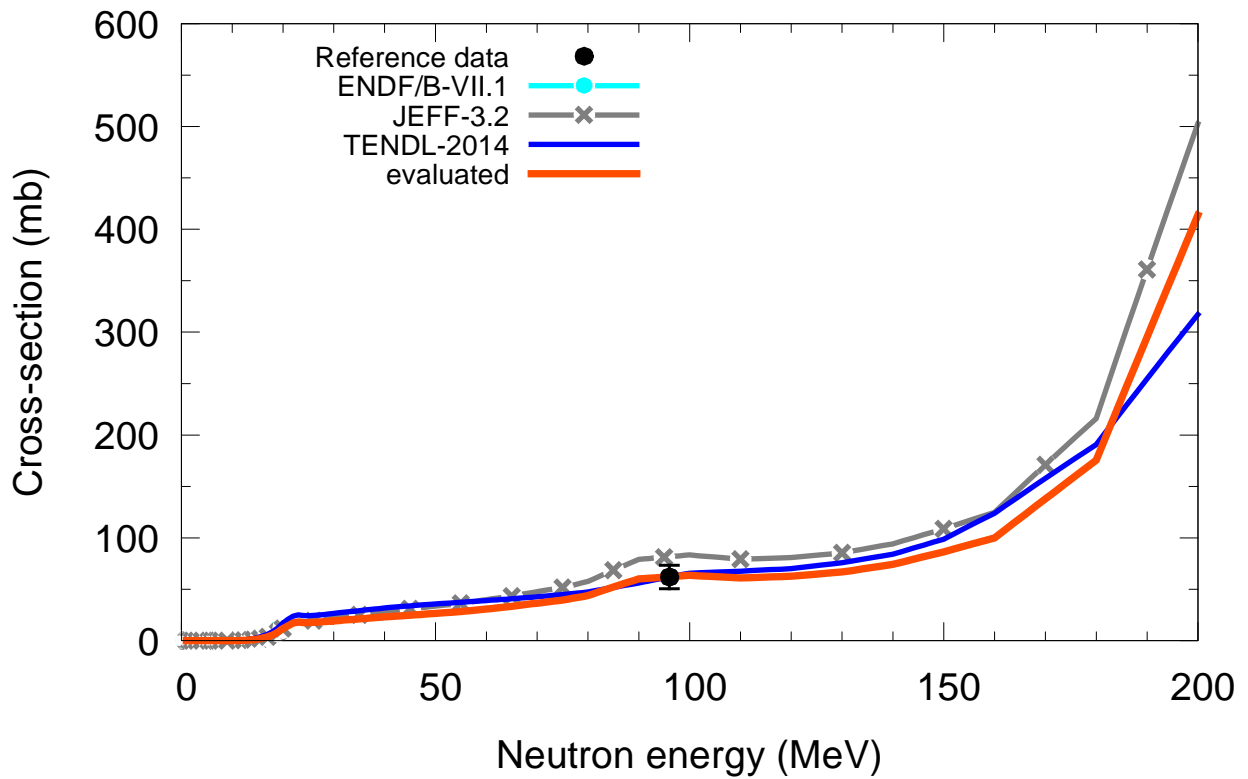


$^{159}\text{Tb}(n,x)^4\text{He}$

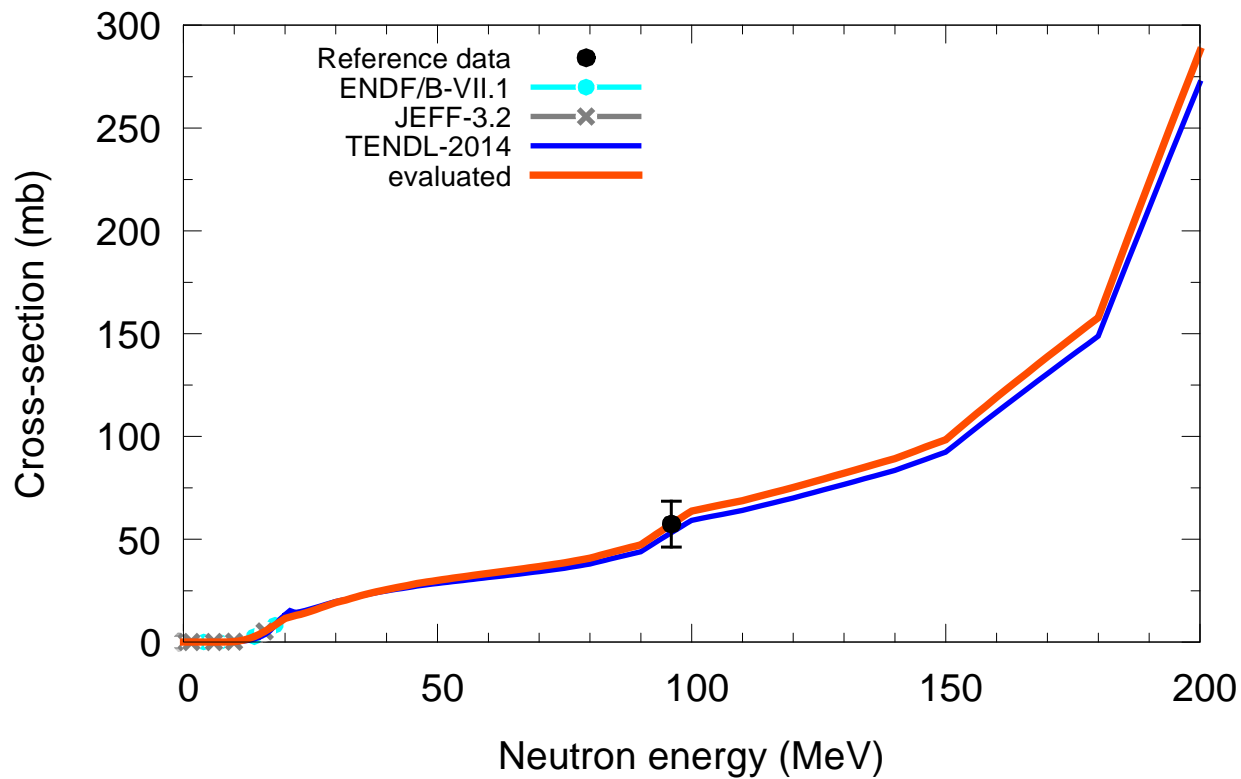


$^{156}\text{Dy}(n,x)^4\text{He}$

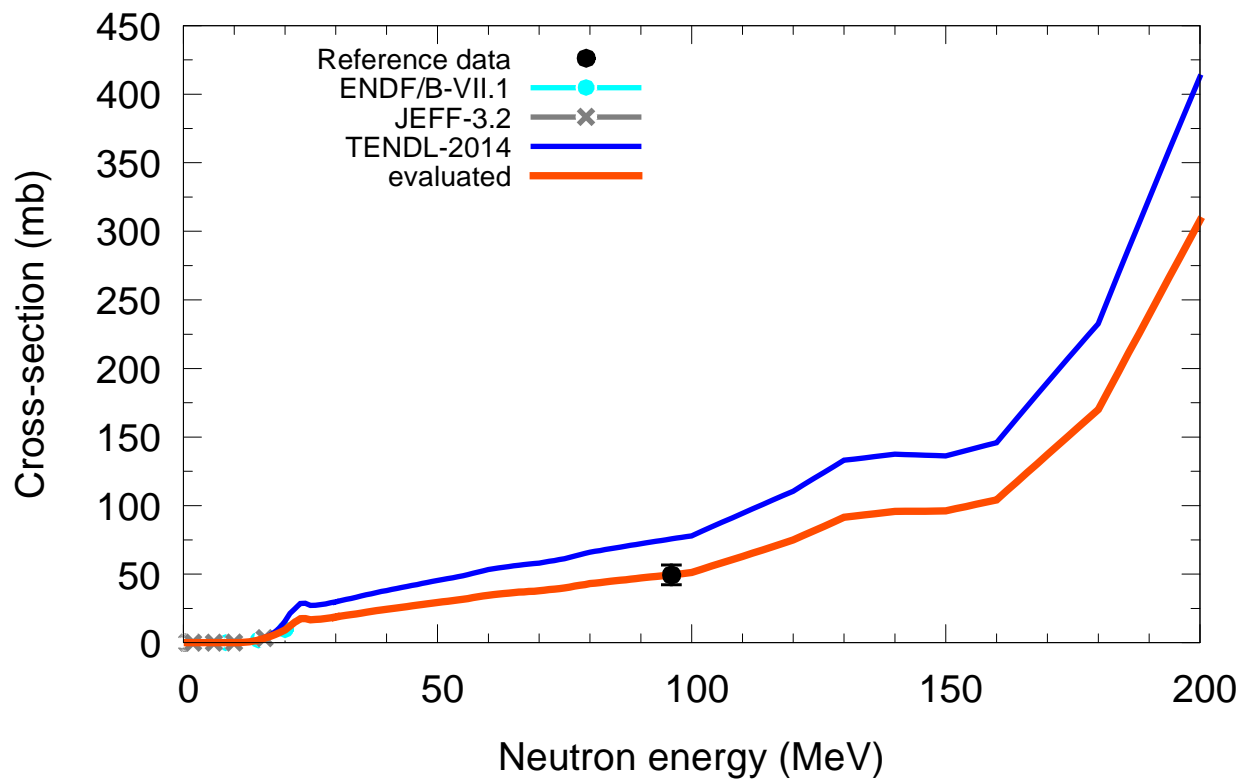


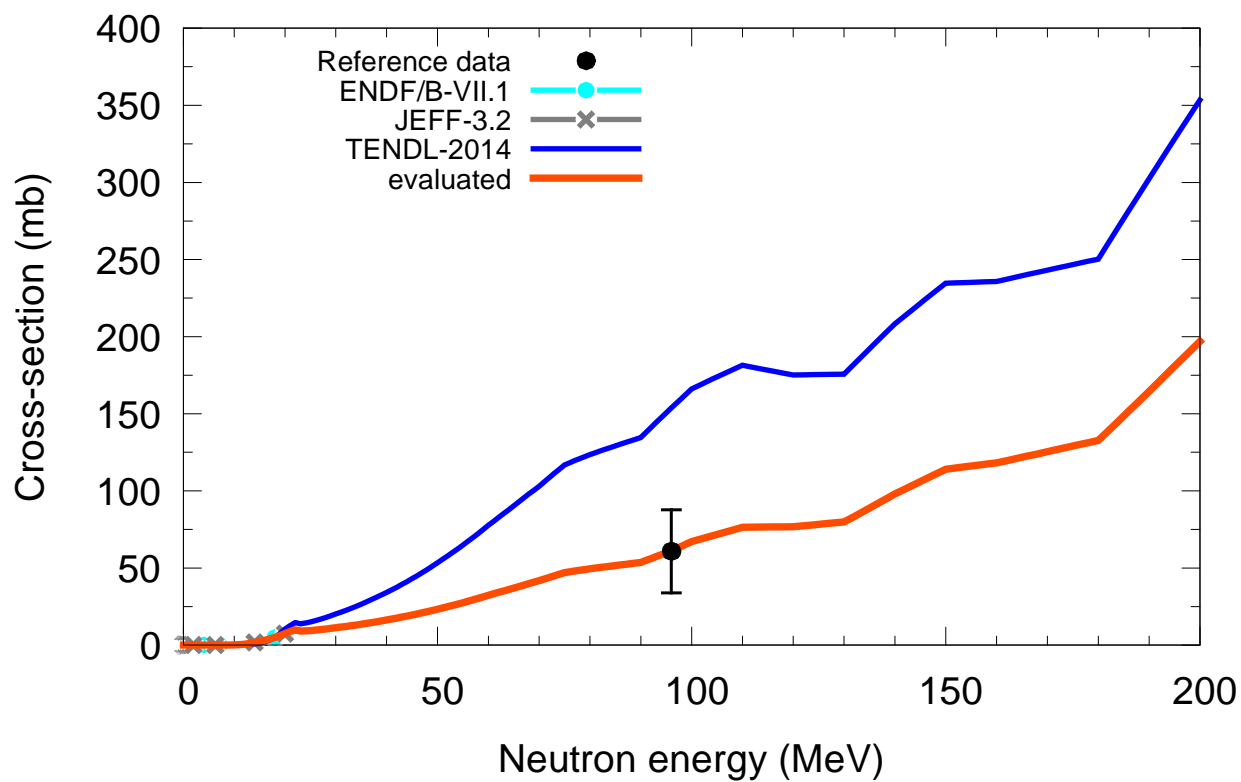
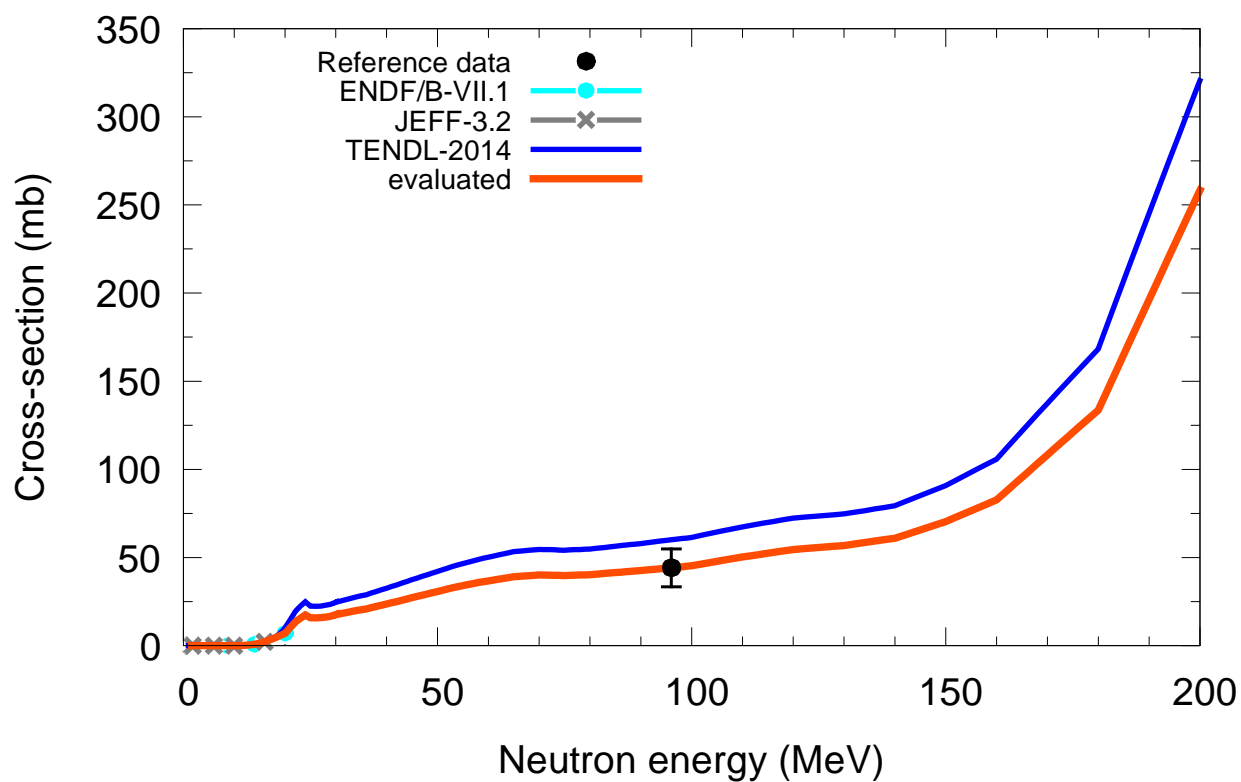
$^{158}\text{Dy}(n,x)^4\text{He}$  $^{160}\text{Dy}(n,x)^4\text{He}$ 

### $^{161}\text{Dy}(n,x)^4\text{He}$

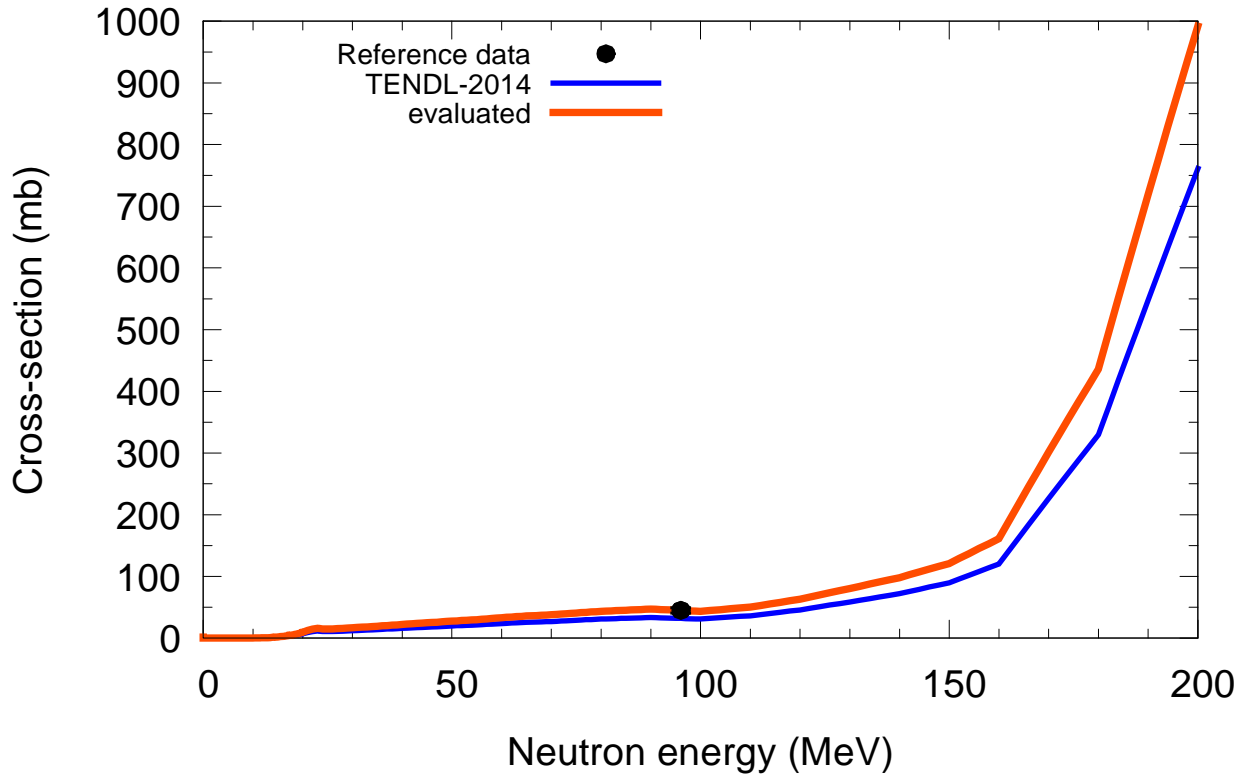


### $^{162}\text{Dy}(n,x)^4\text{He}$

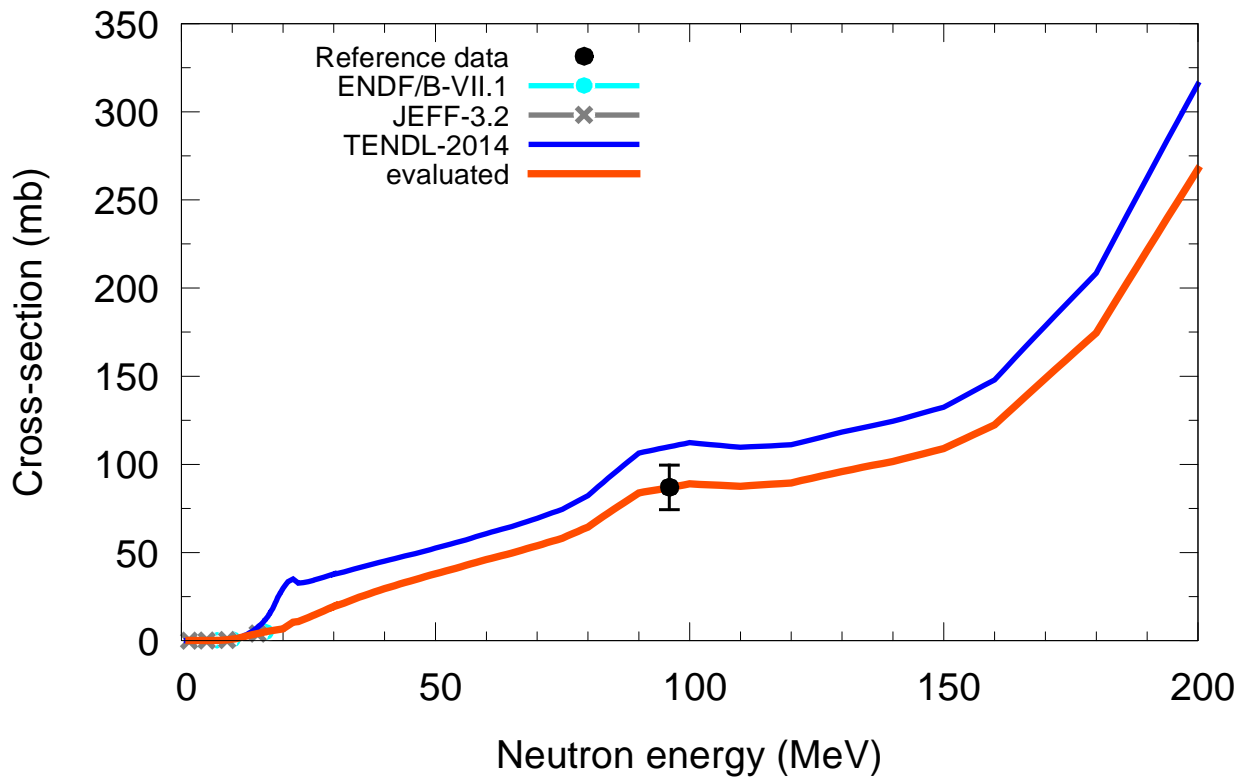


$^{163}\text{Dy}(n,x)^4\text{He}$  $^{164}\text{Dy}(n,x)^4\text{He}$ 

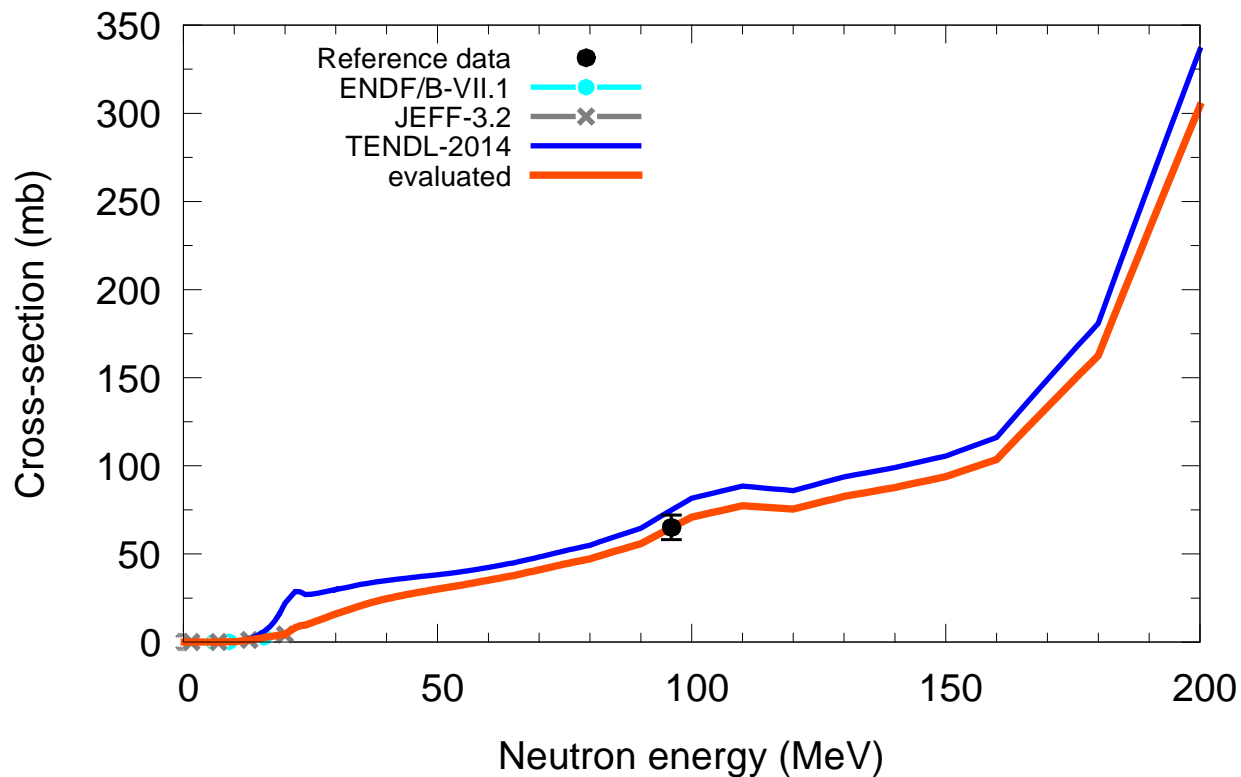
$^{165}\text{Ho}(n,x)^4\text{He}$



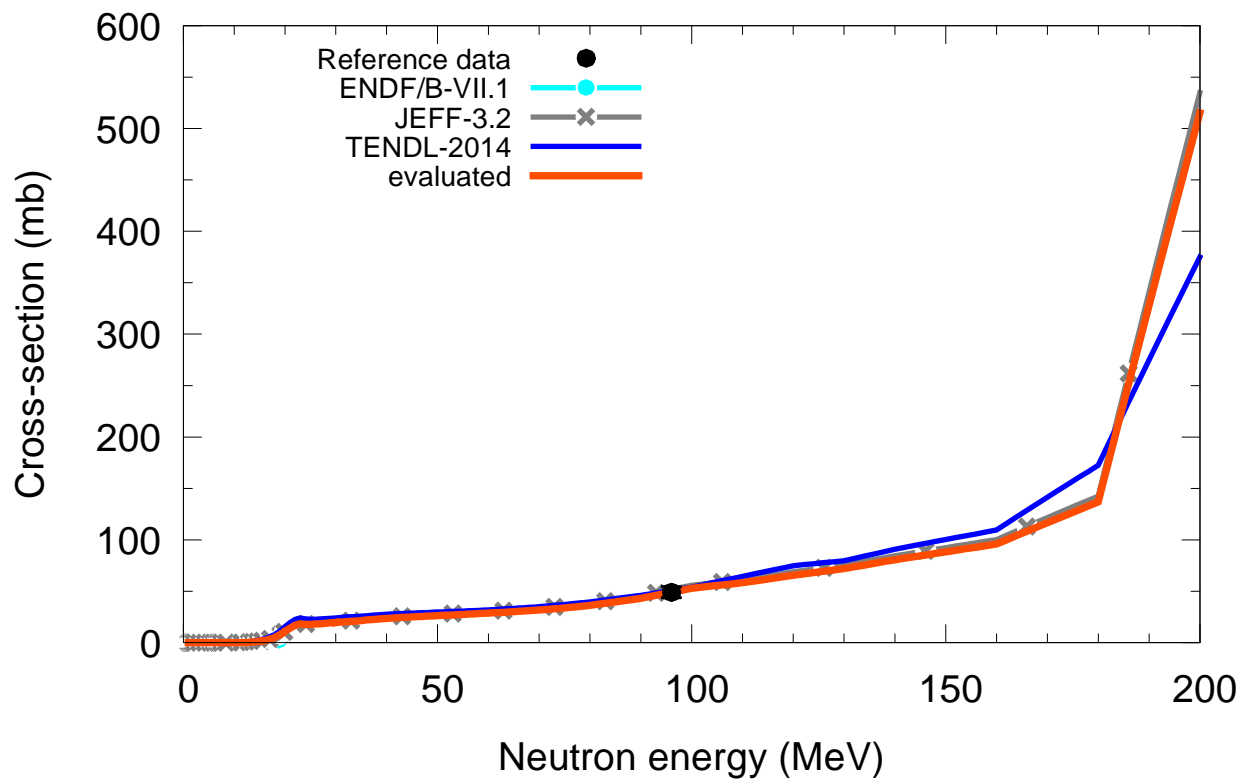
$^{162}\text{Er}(n,x)^4\text{He}$



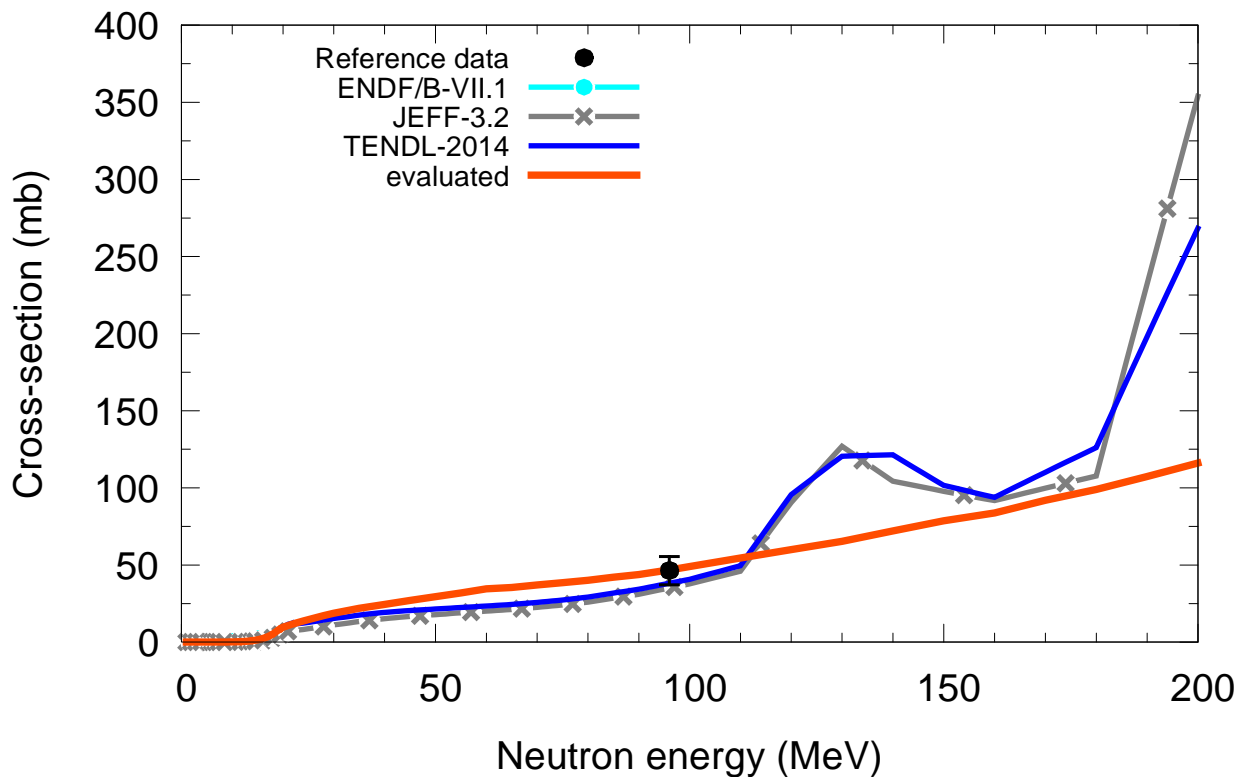
$^{164}\text{Er}(n,x)^4\text{He}$



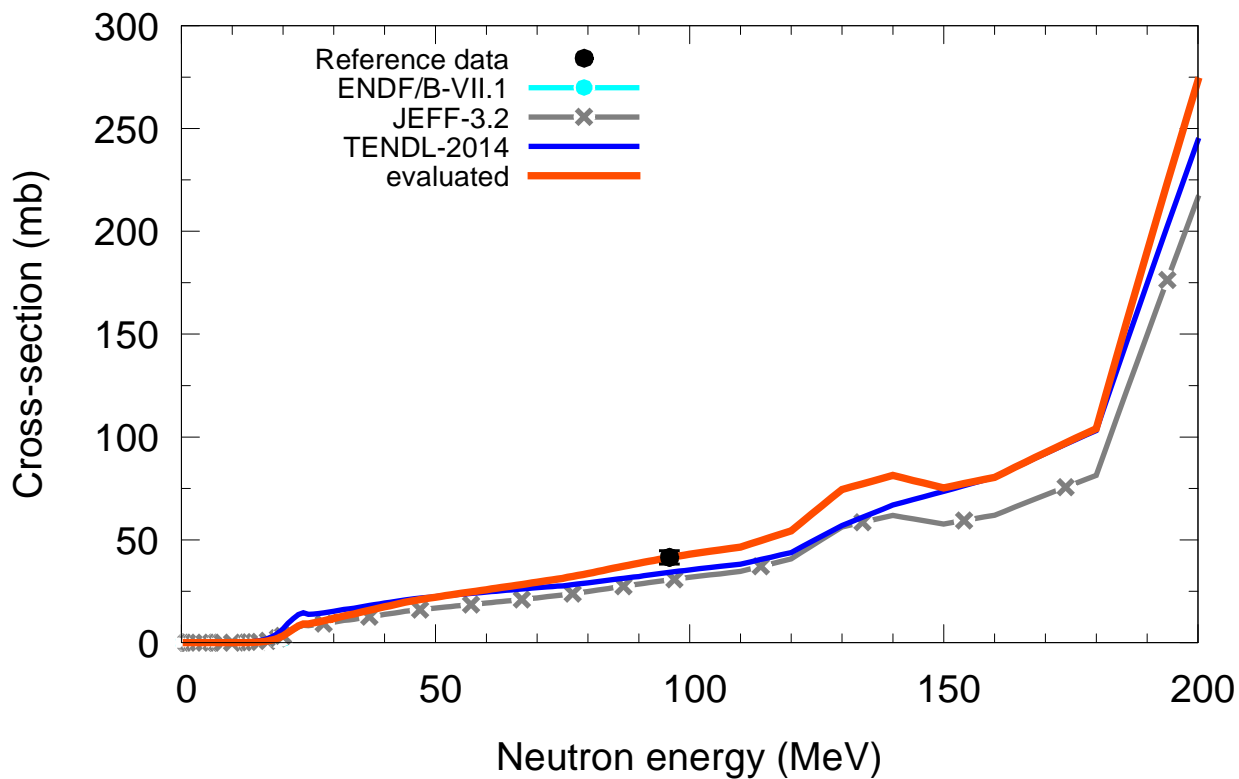
$^{166}\text{Er}(n,x)^4\text{He}$



### $^{167}\text{Er}(n,x)^4\text{He}$

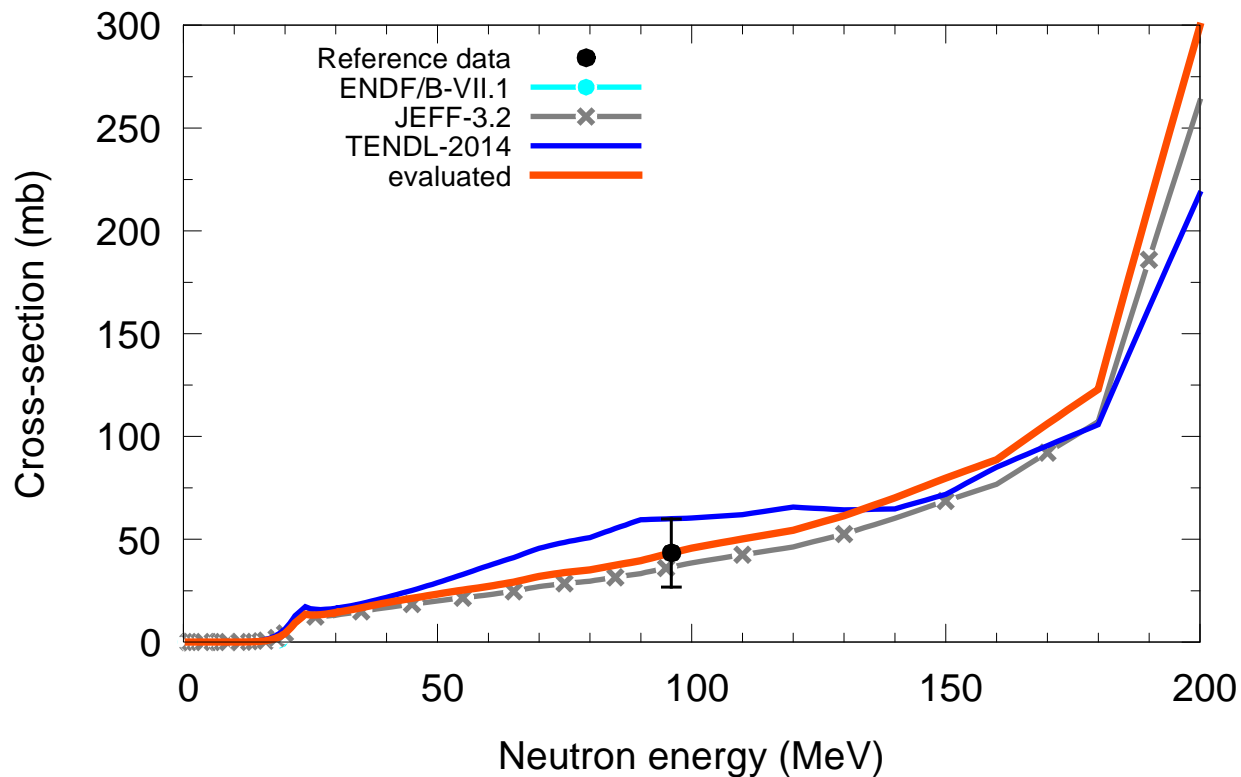


### $^{168}\text{Er}(n,x)^4\text{He}$

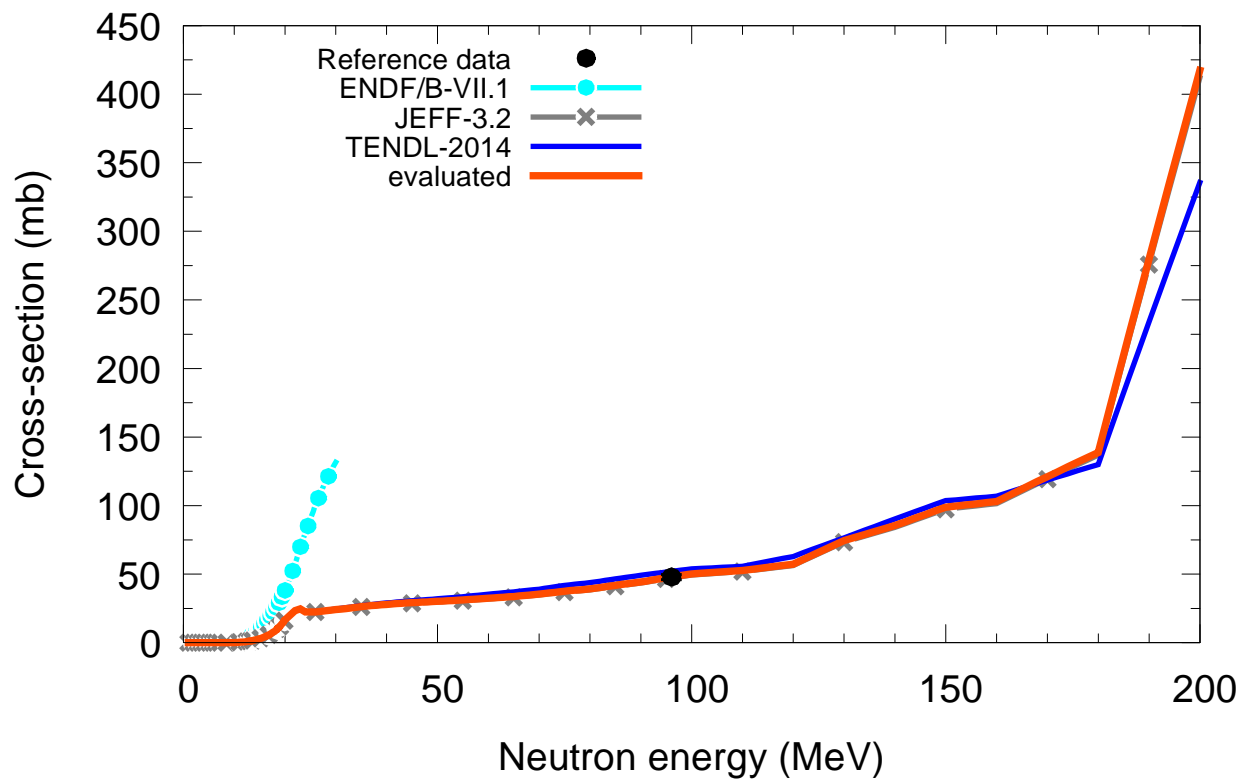




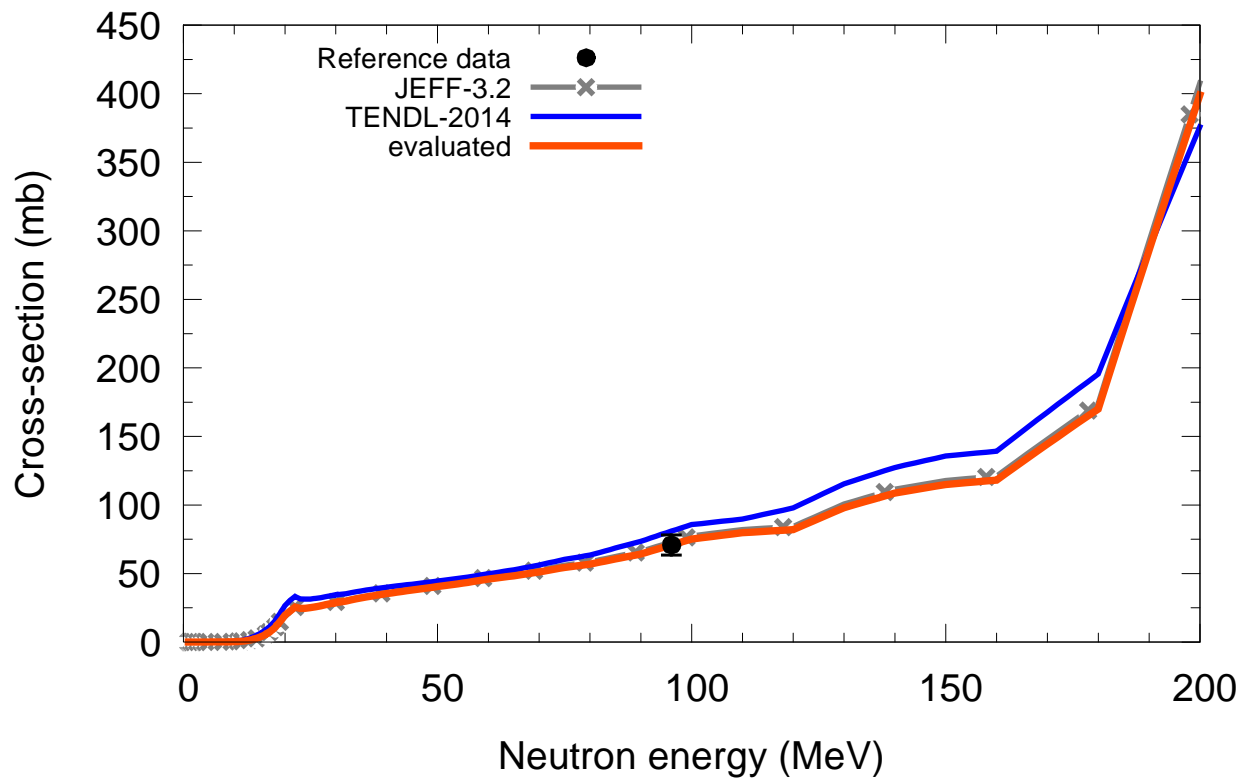
$^{170}\text{Er}(n,x)^4\text{He}$



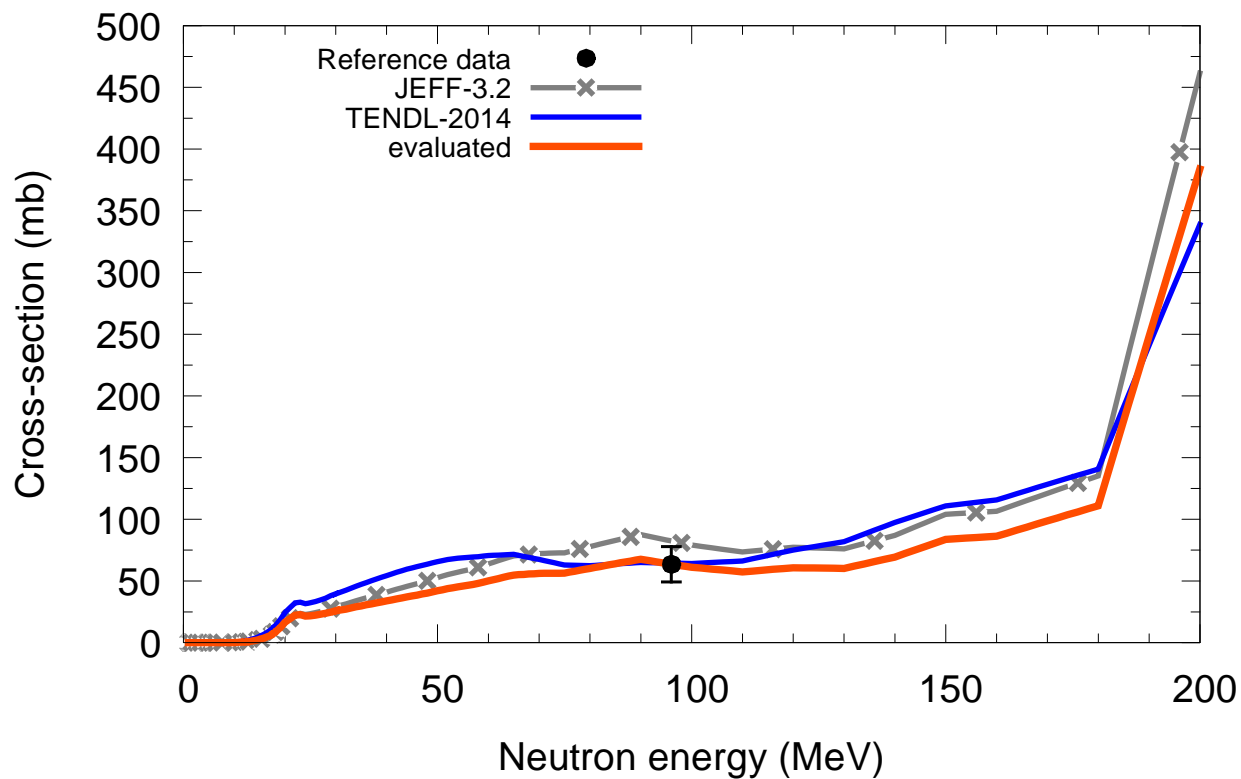
$^{169}\text{Tm}(n,x)^4\text{He}$



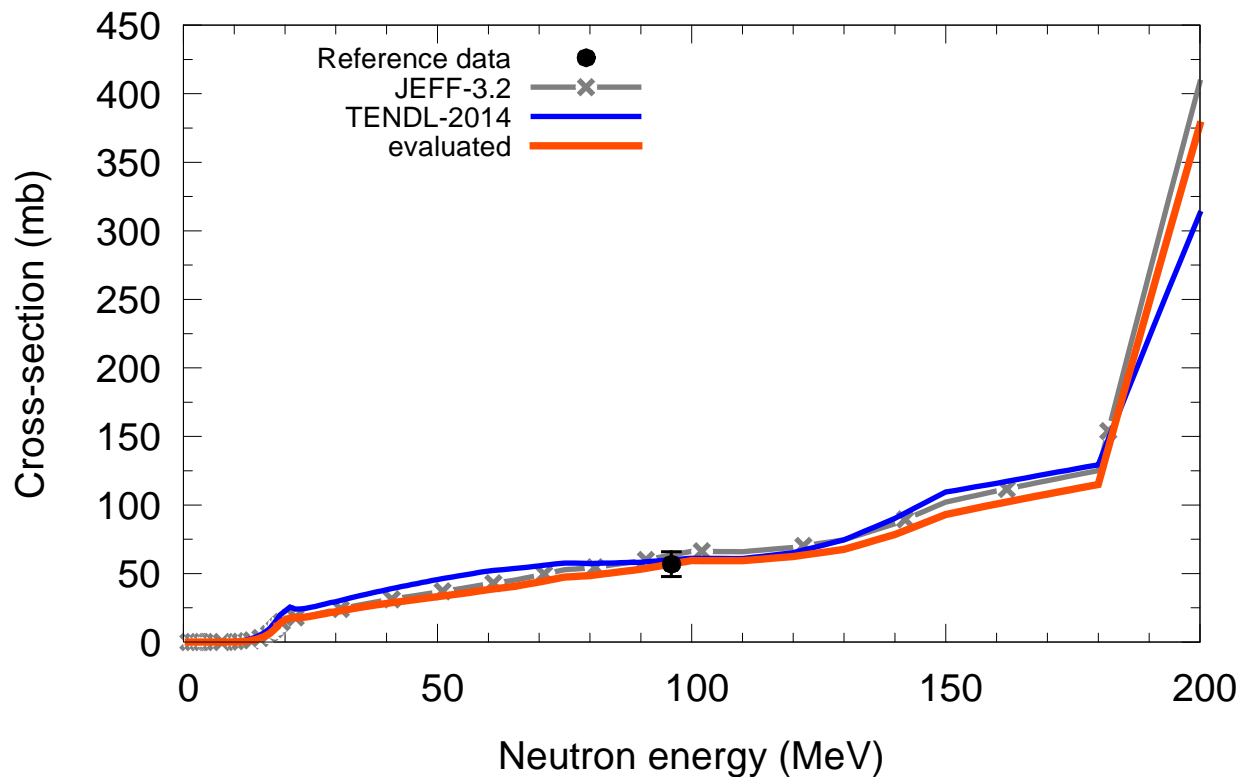
$^{168}\text{Yb}(n,x)^4\text{He}$



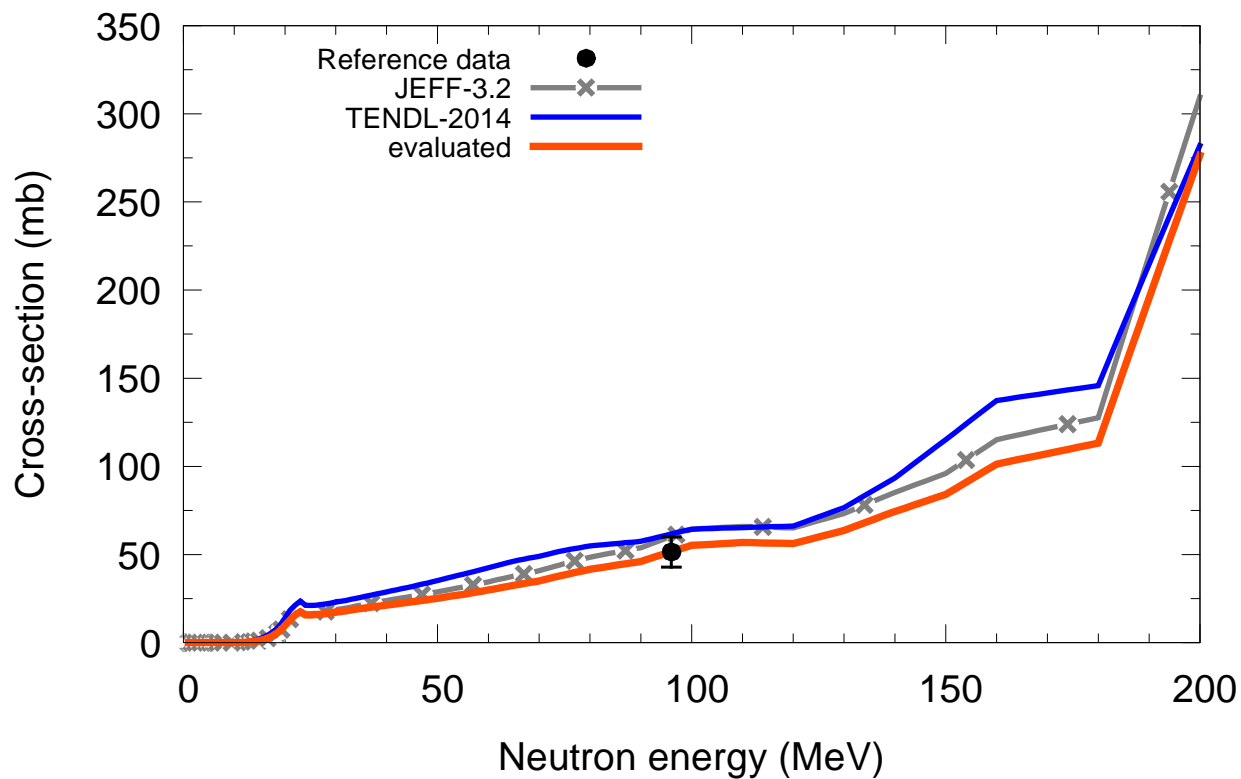
$^{170}\text{Yb}(n,x)^4\text{He}$

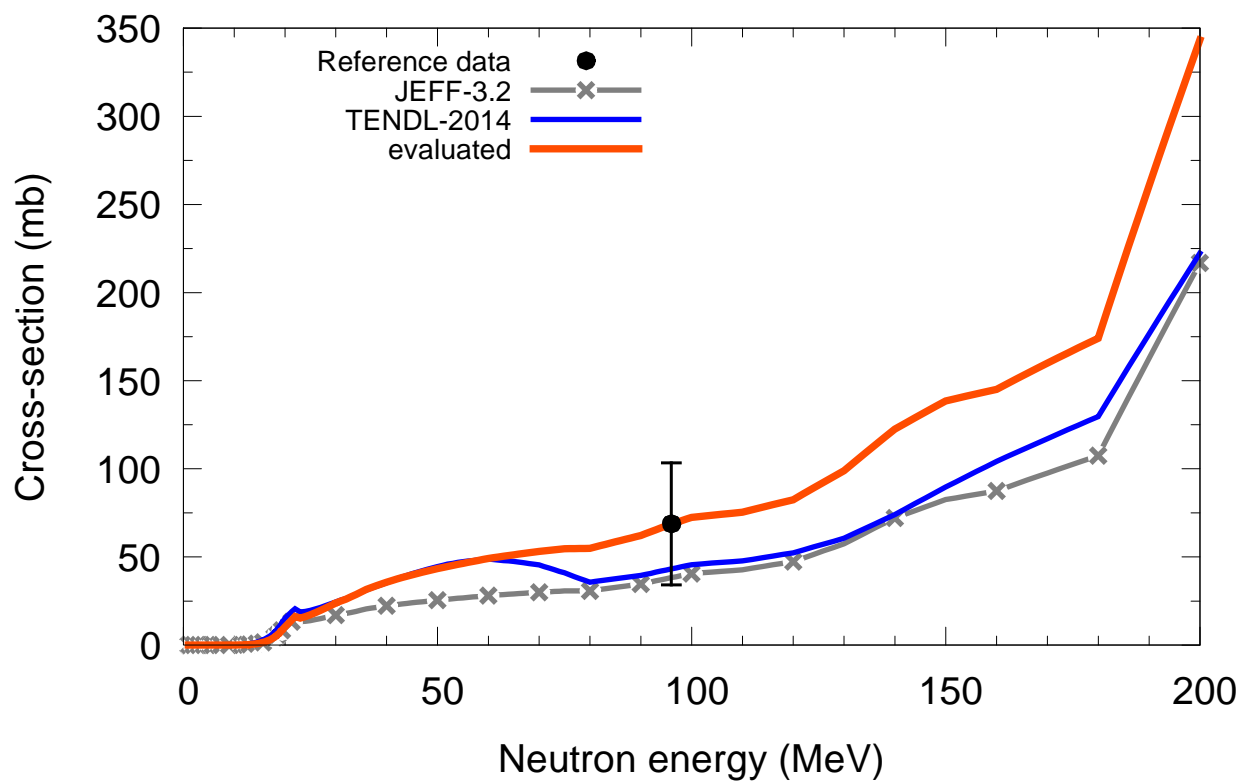
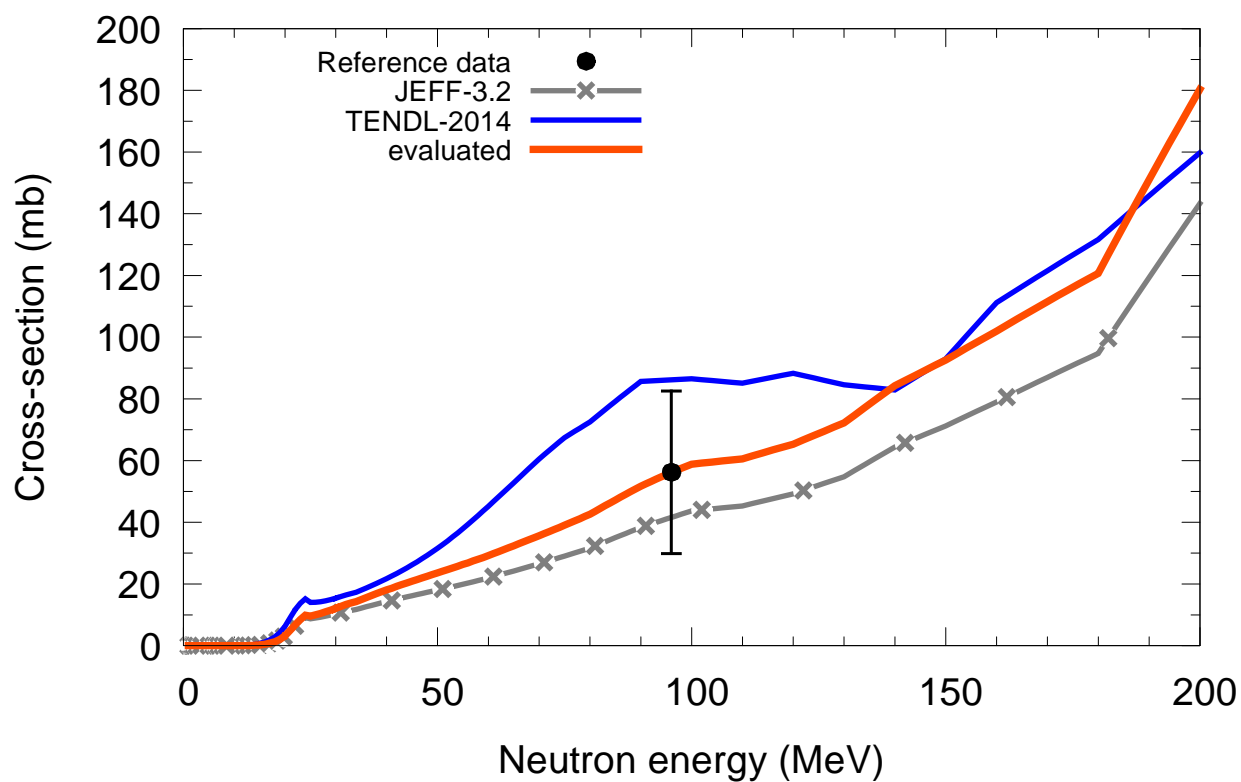


$^{171}\text{Yb}(n,x)^4\text{He}$

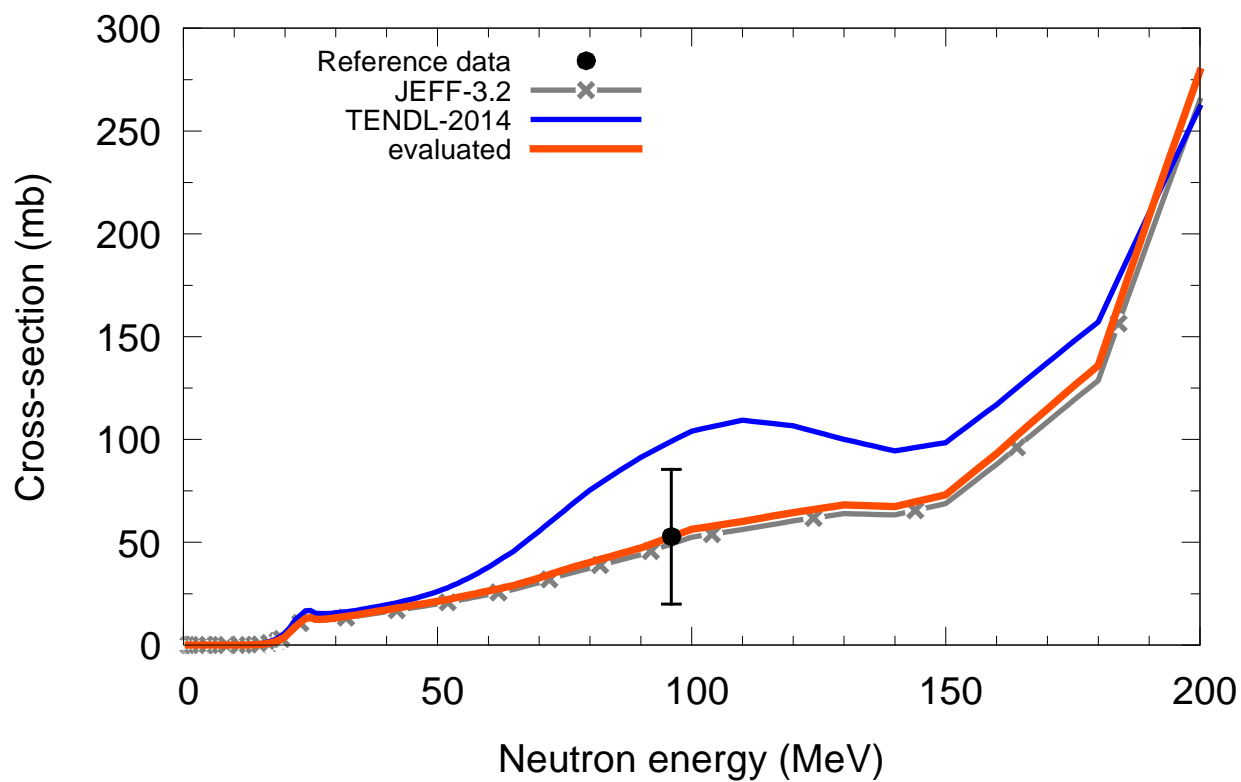


$^{172}\text{Yb}(n,x)^4\text{He}$

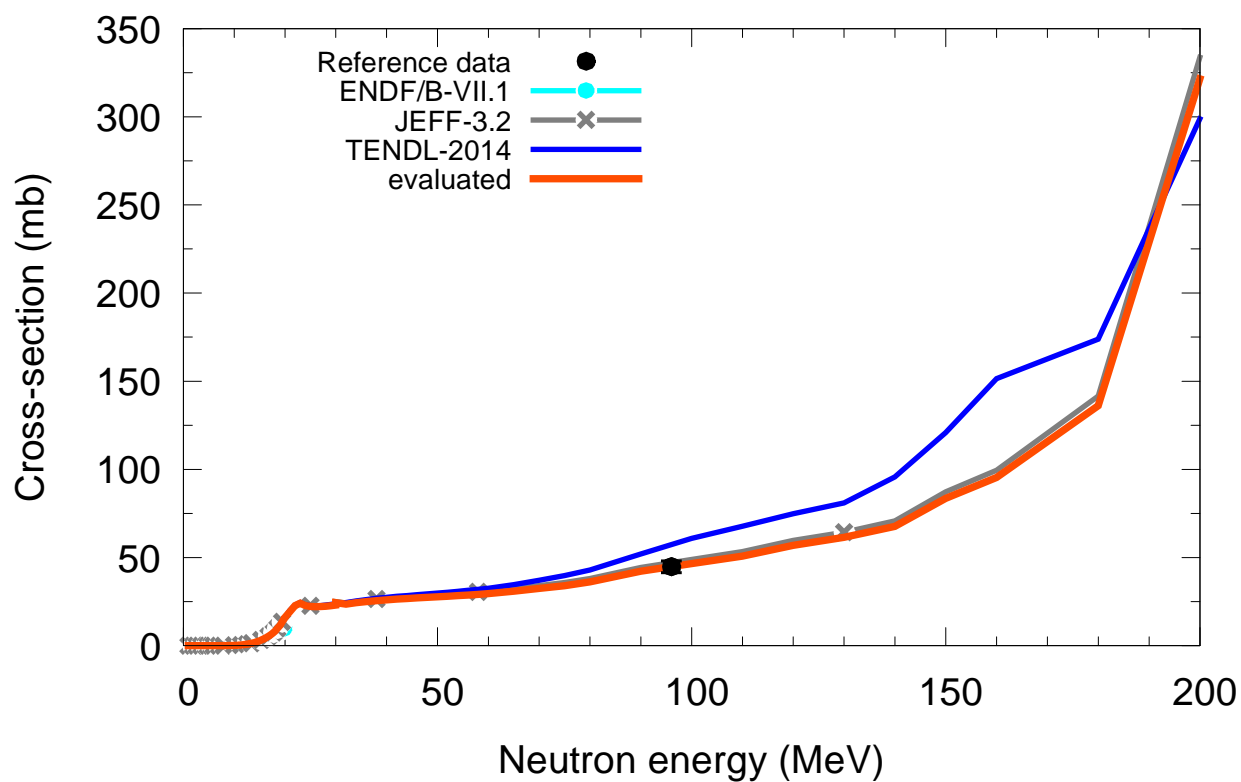


$^{173}\text{Yb}(n,x)^4\text{He}$  $^{174}\text{Yb}(n,x)^4\text{He}$ 

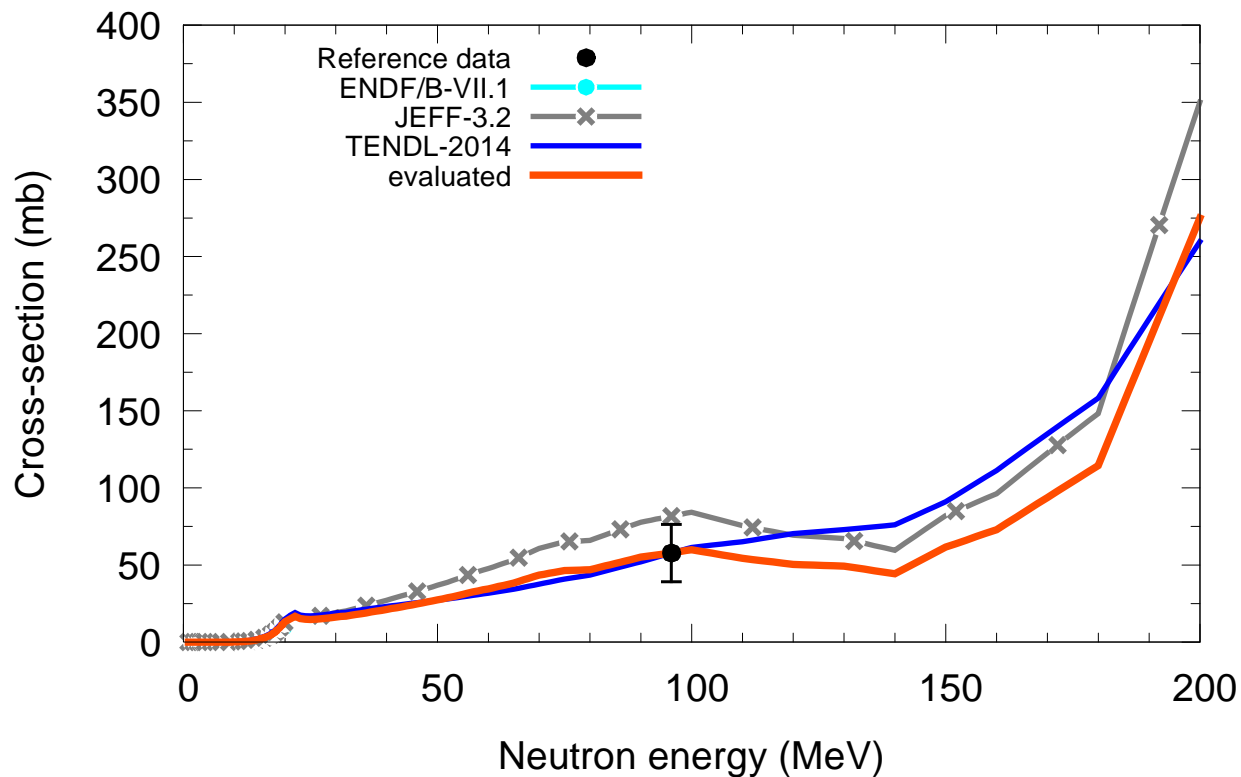
$^{176}\text{Yb}(n,x)^4\text{He}$



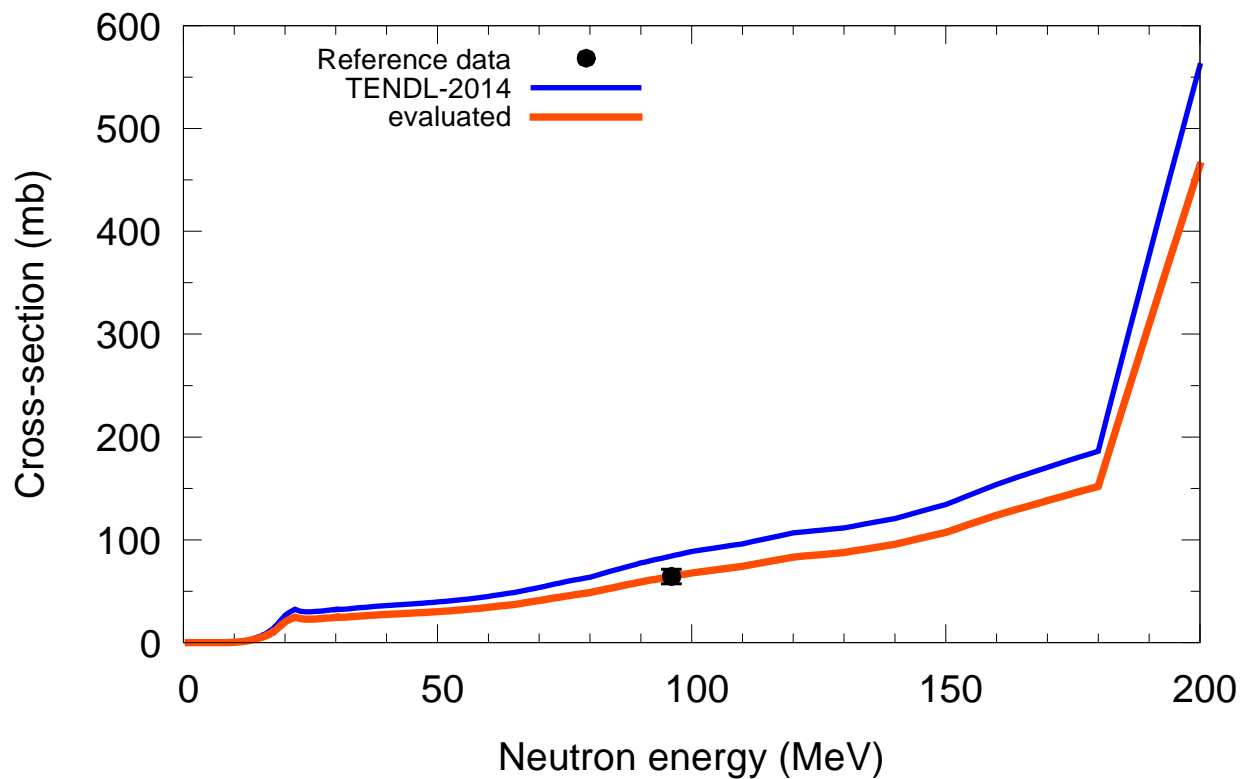
$^{175}\text{Lu}(n,x)^4\text{He}$



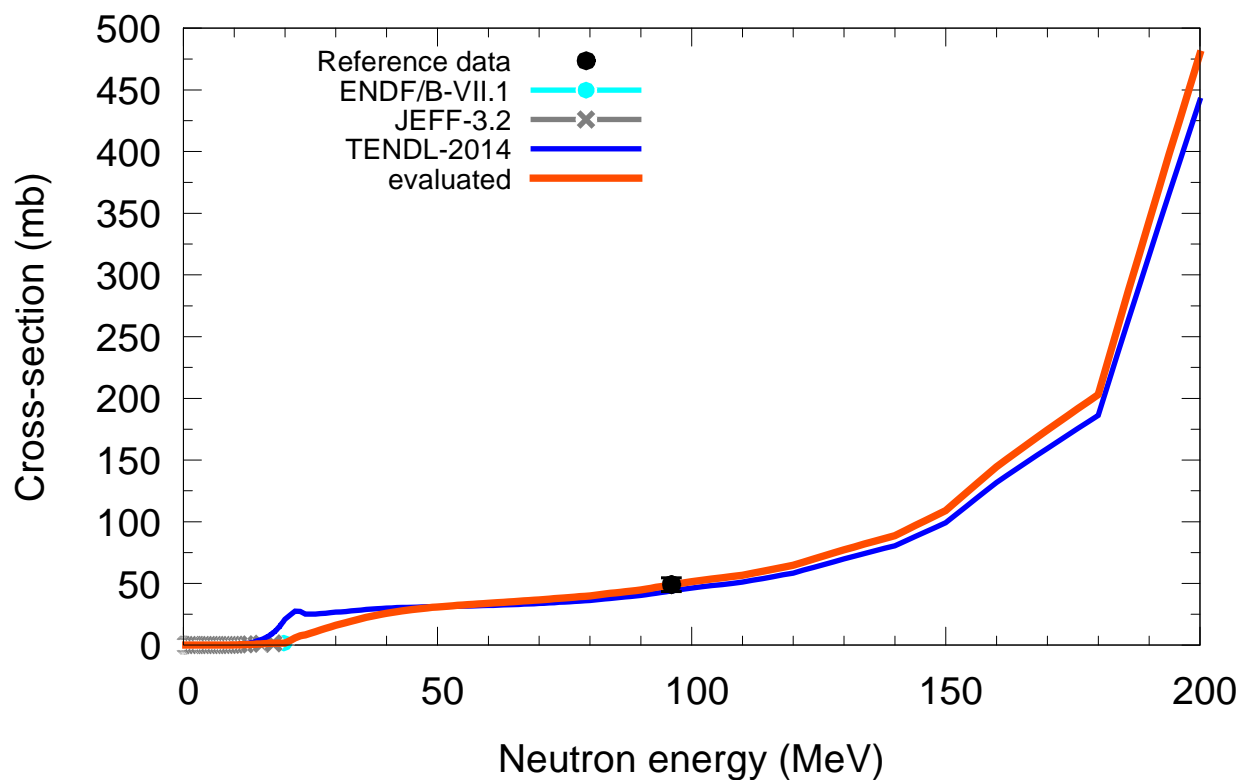
$^{176}\text{Lu}(n,x)^4\text{He}$



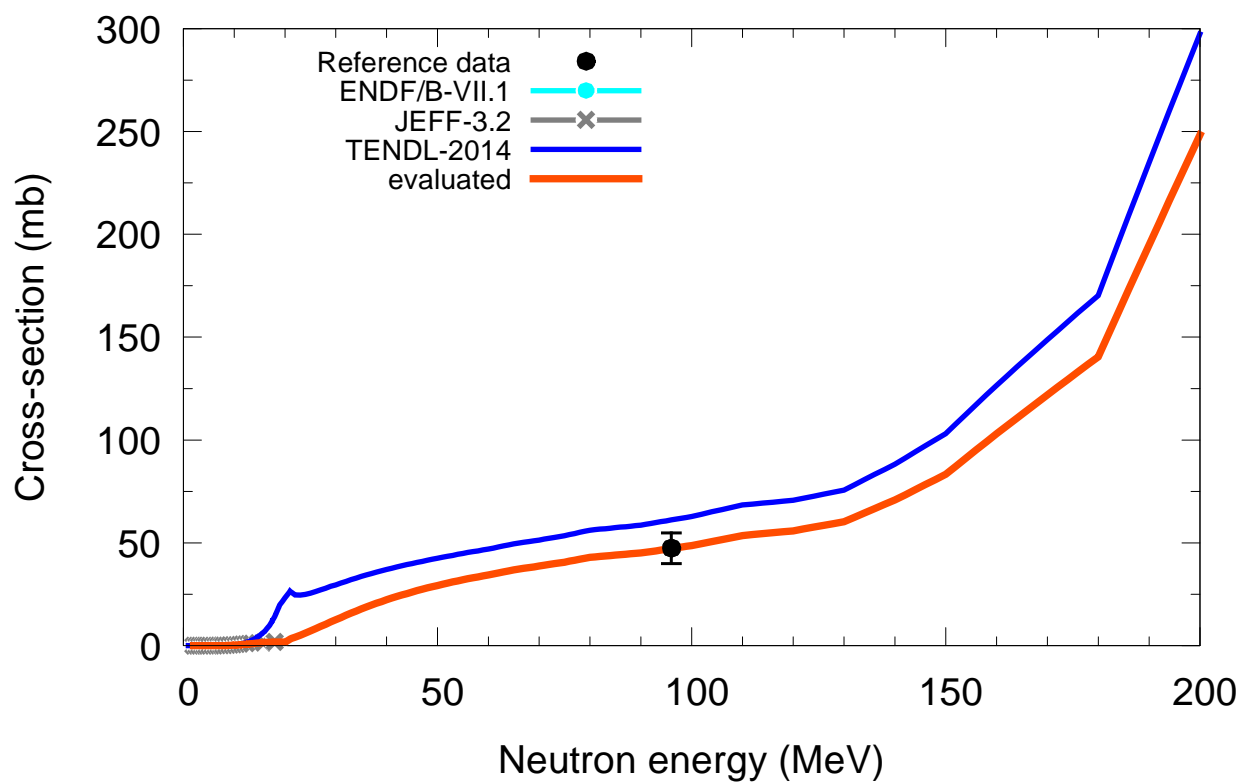
$^{174}\text{Hf}(n,x)^4\text{He}$



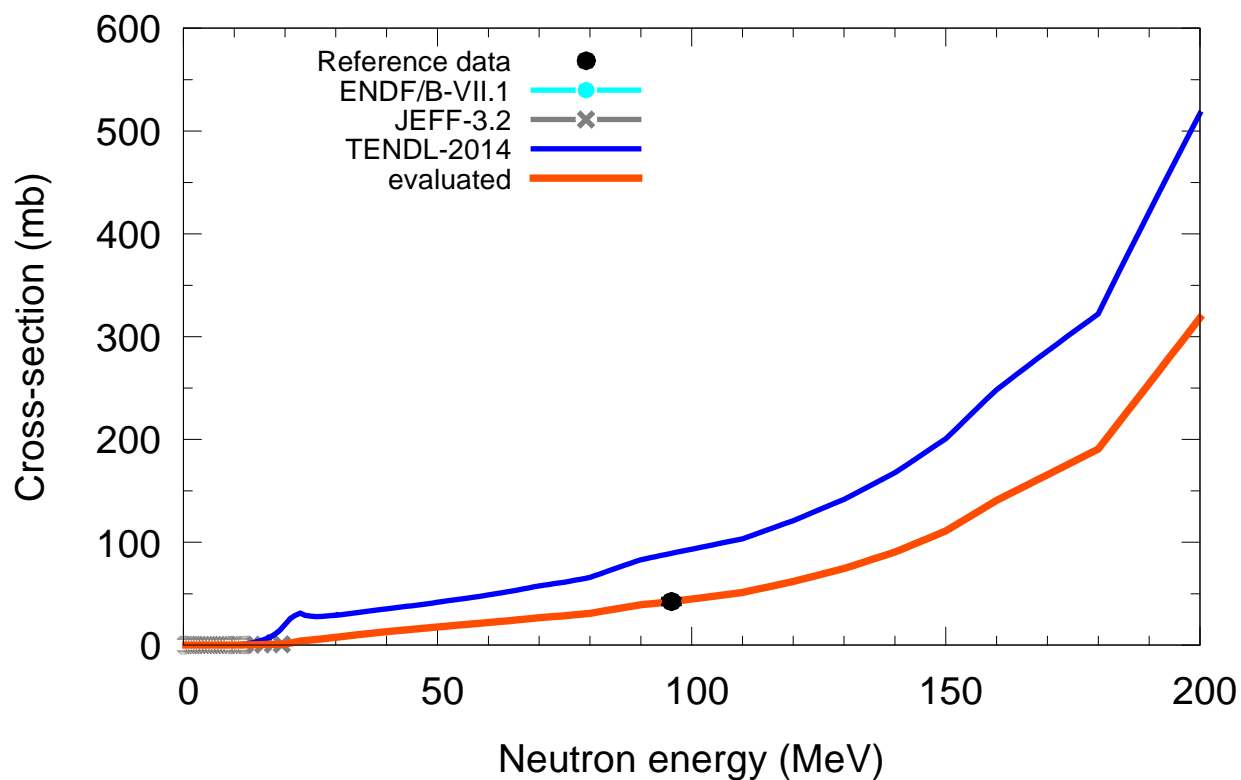
### $^{176}\text{Hf}(n,x)^4\text{He}$



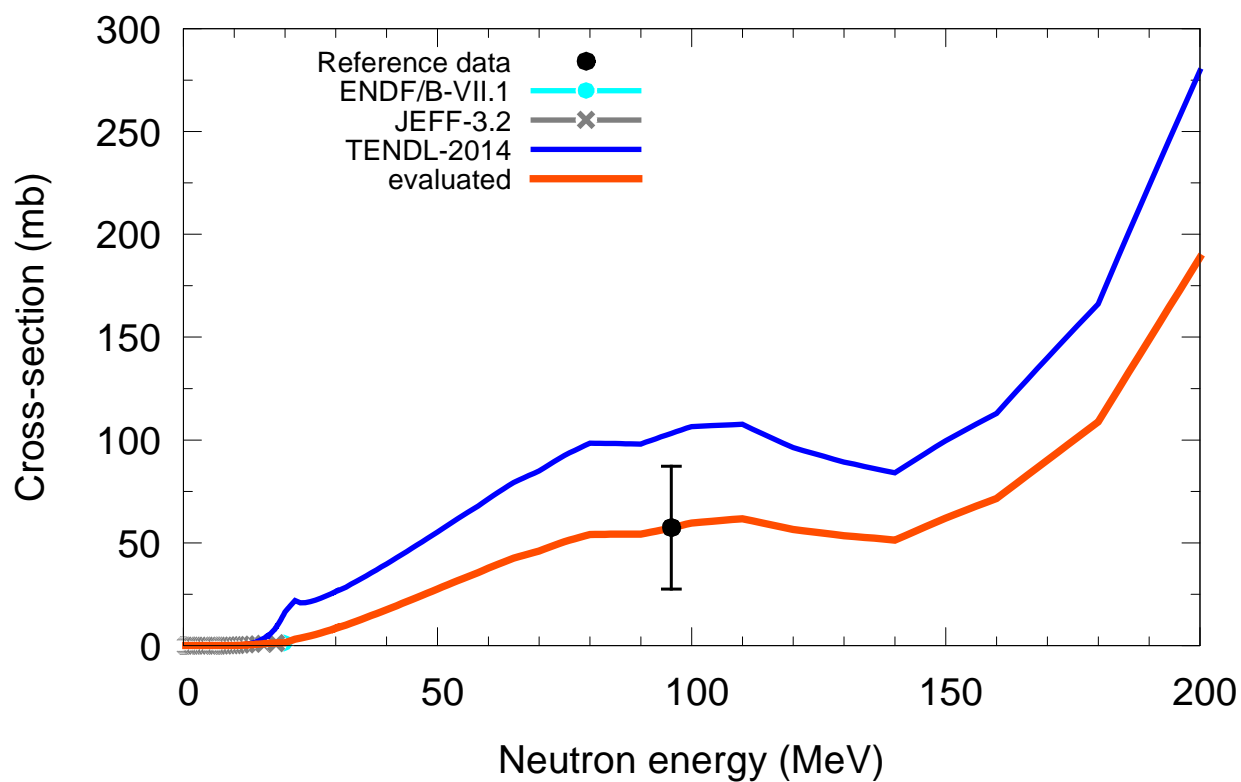
### $^{177}\text{Hf}(n,x)^4\text{He}$



$^{178}\text{Hf}(n,x)^4\text{He}$

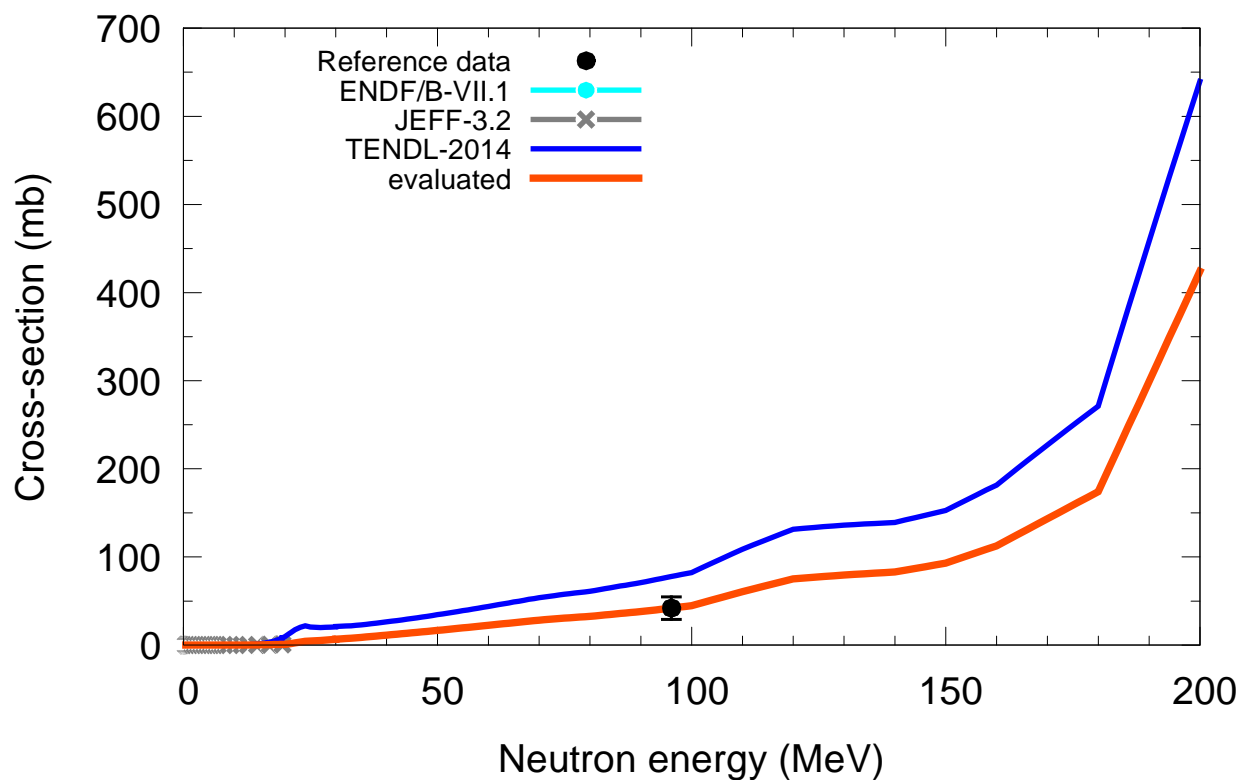


$^{179}\text{Hf}(n,x)^4\text{He}$

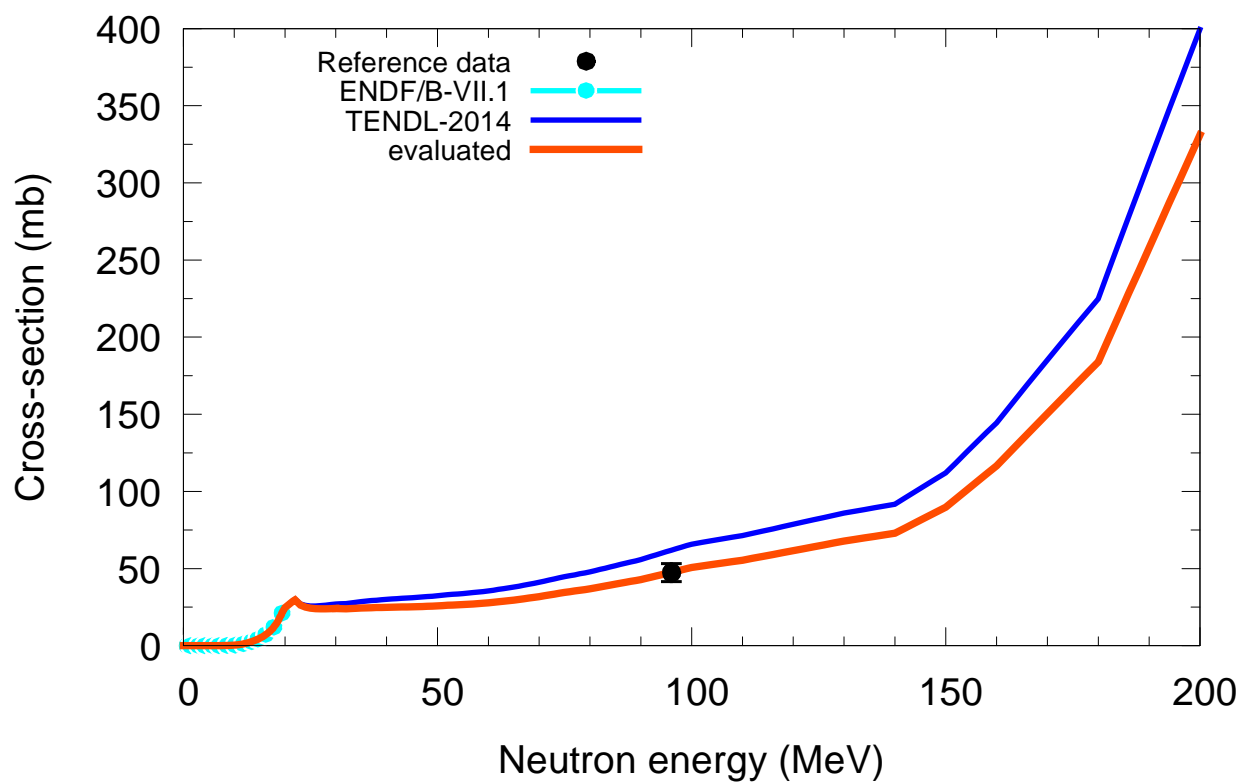


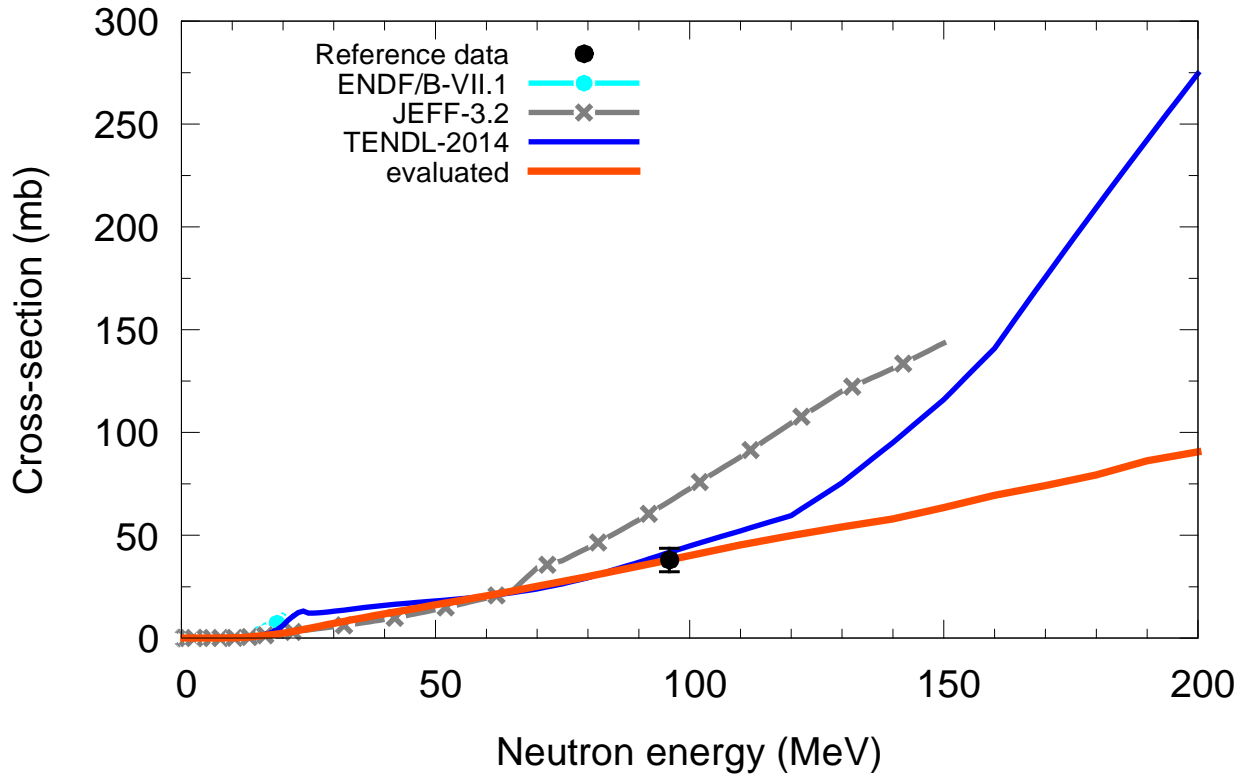
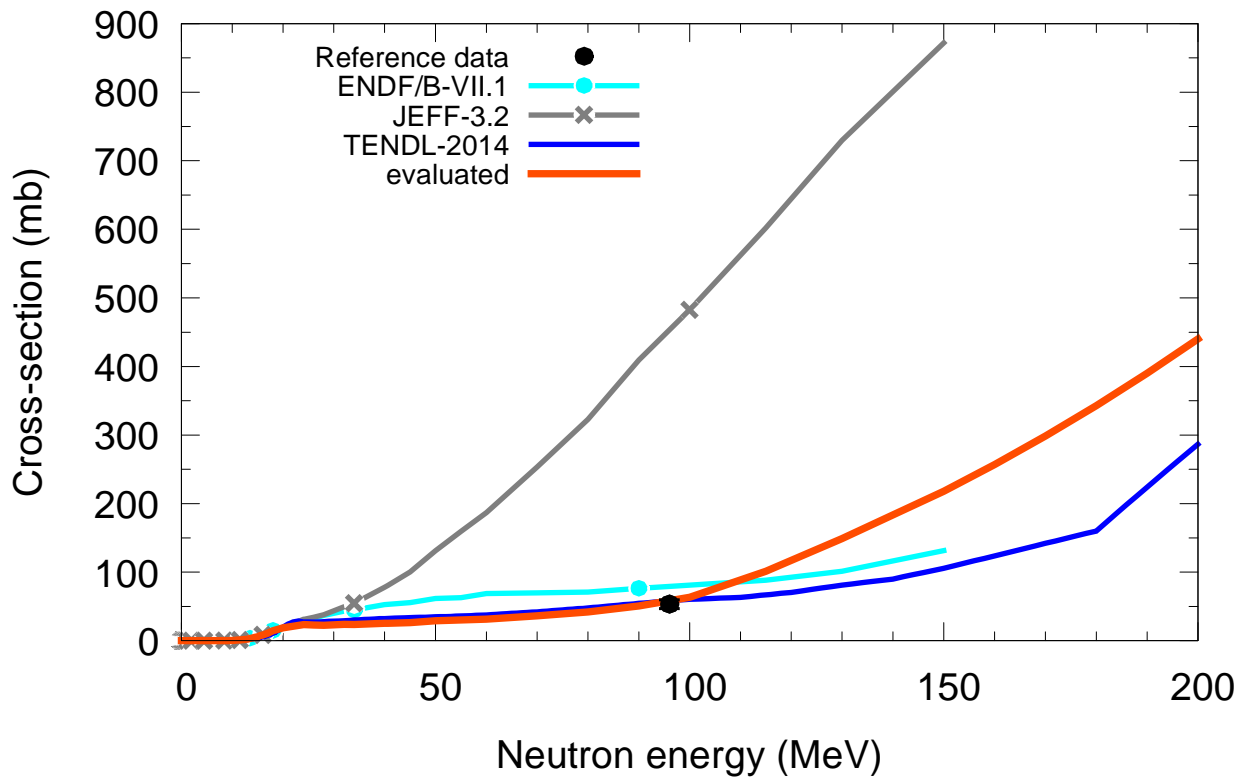


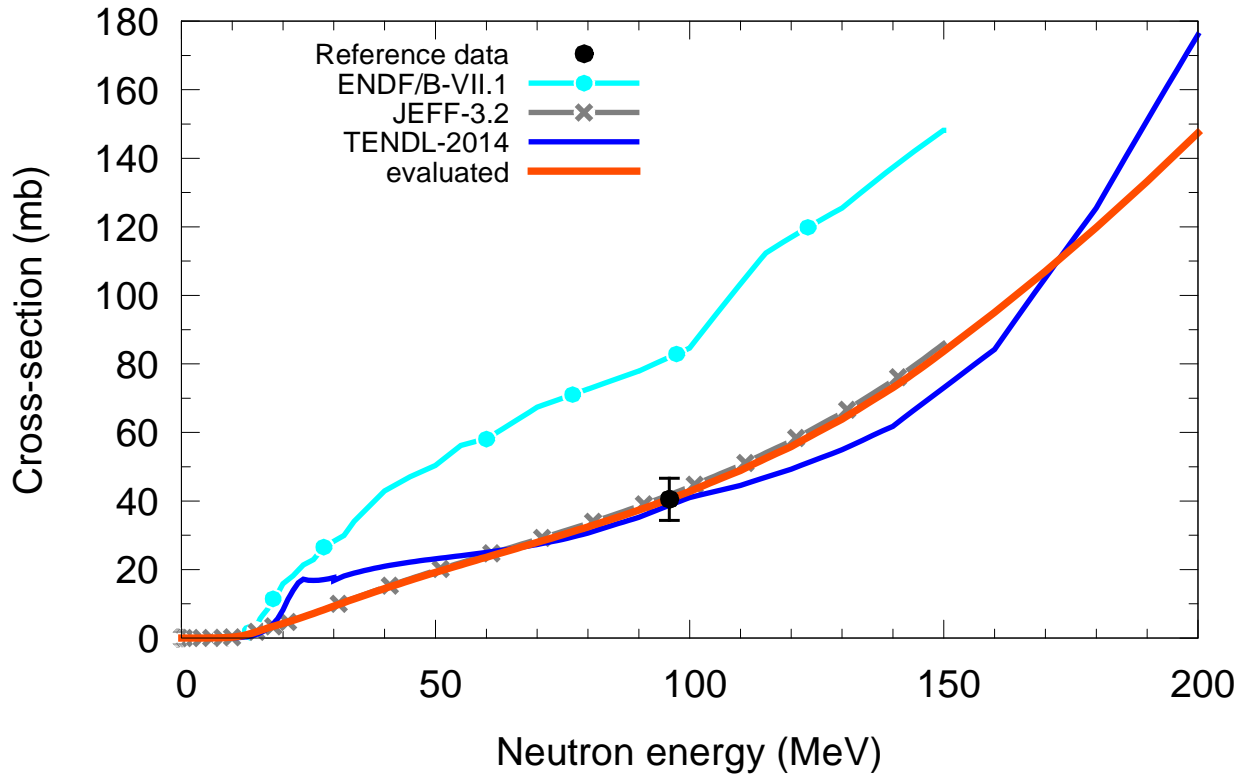
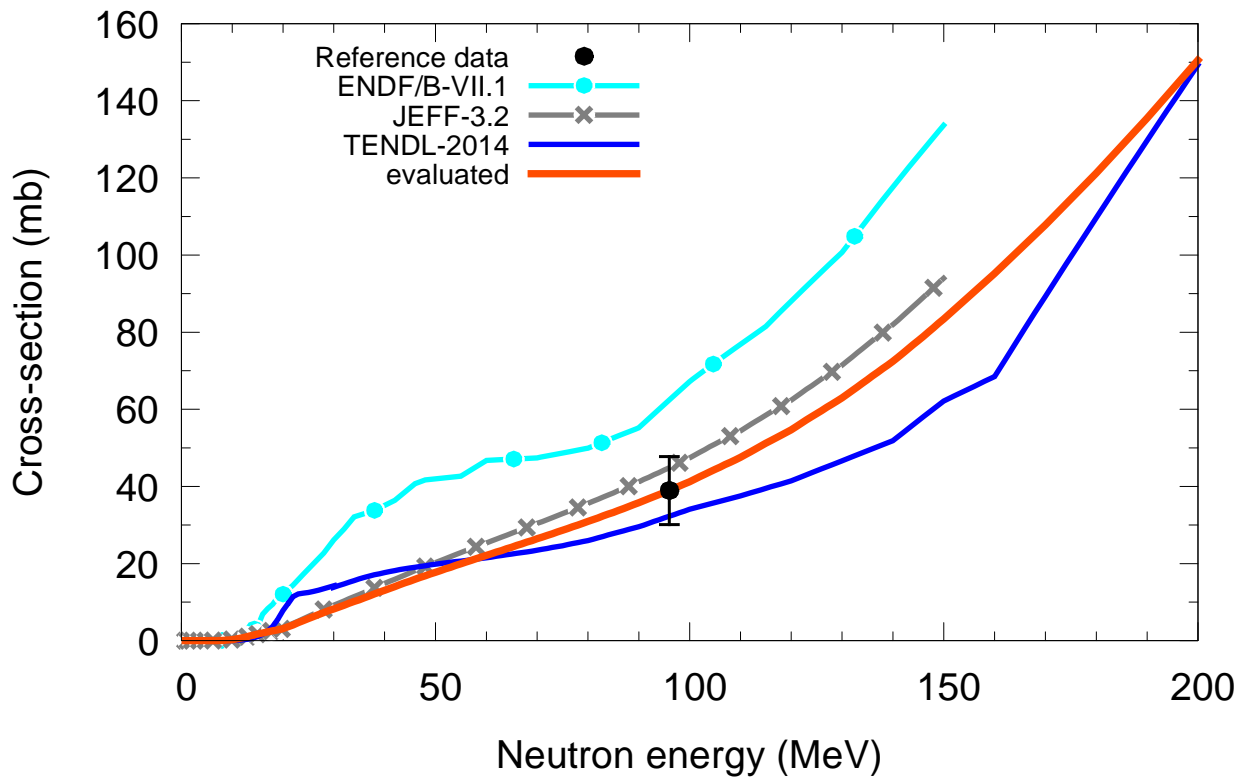
$^{180}\text{Hf}(n,x)^4\text{He}$

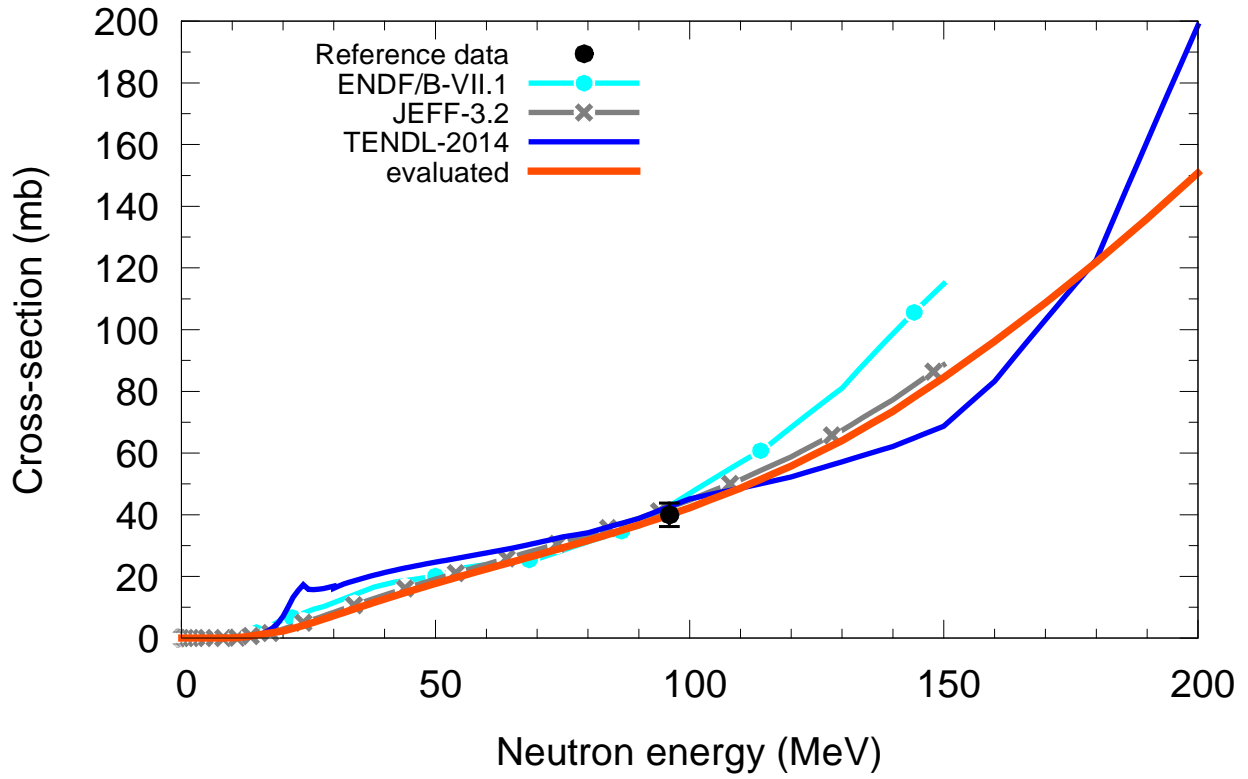
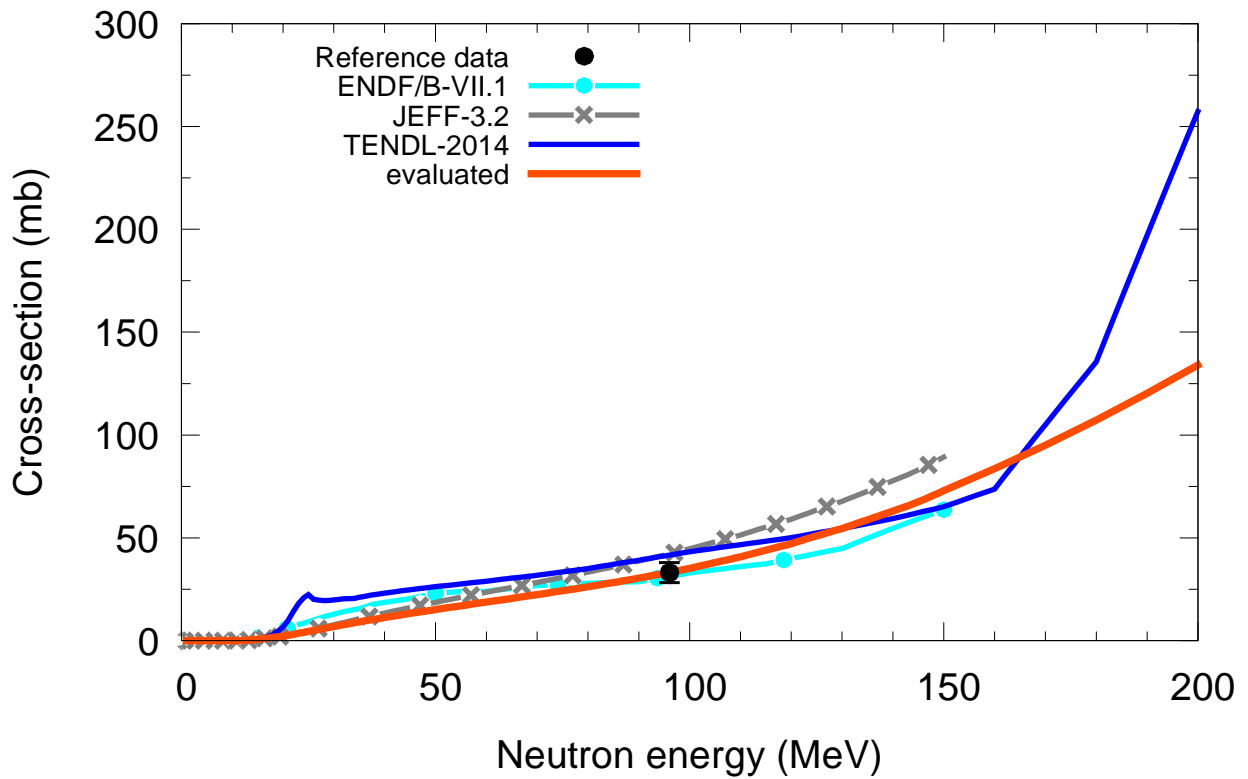


$^{180}\text{Ta}(n,x)^4\text{He}$

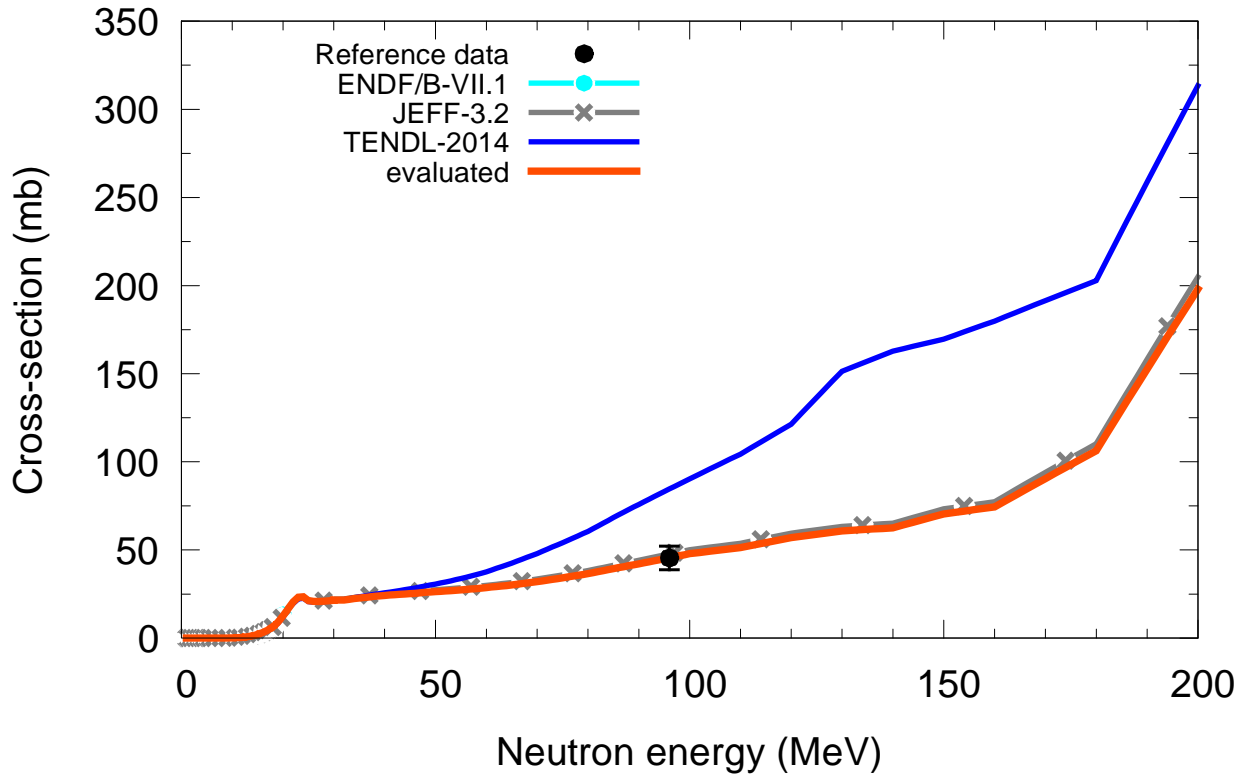


$^{181}\text{Ta}(n,x)^4\text{He}$  $^{180}\text{W}(n,x)^4\text{He}$ 

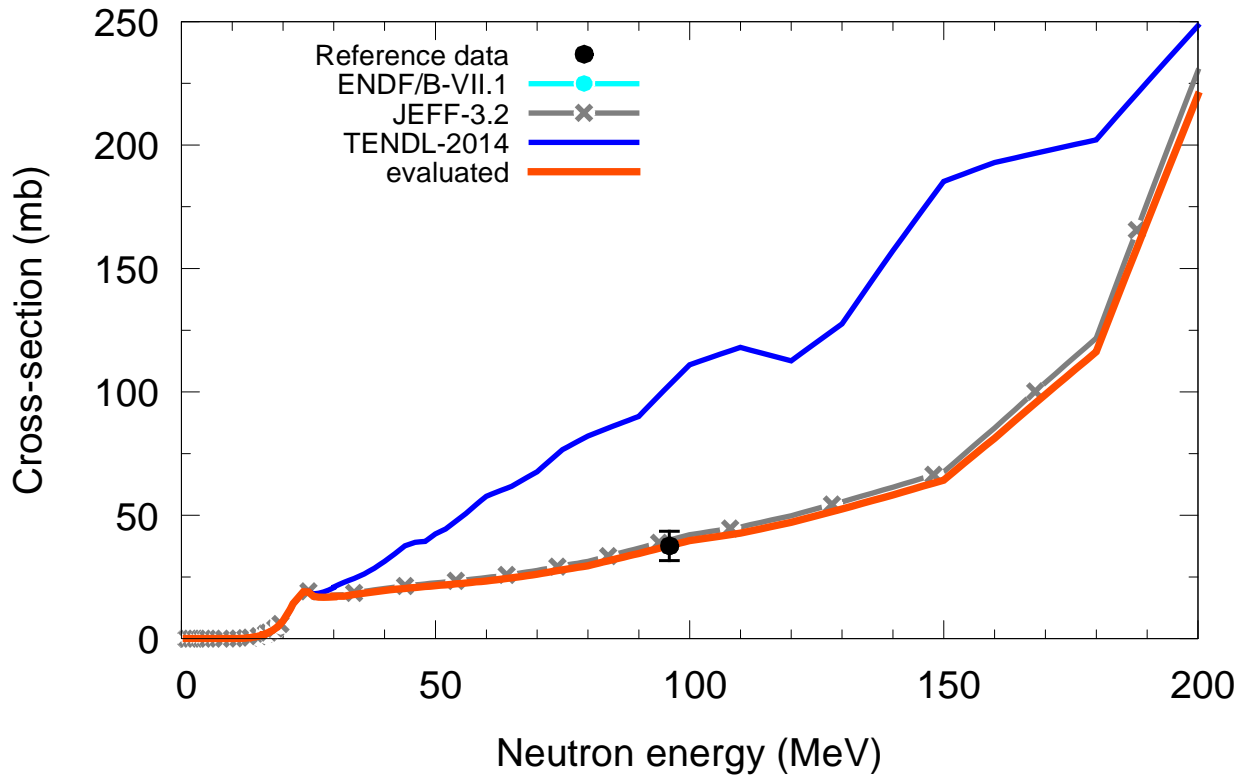
$^{182}\text{W}(n,x)^4\text{He}$  $^{183}\text{W}(n,x)^4\text{He}$ 

$^{184}\text{W}(n,x)^4\text{He}$  $^{186}\text{W}(n,x)^4\text{He}$ 

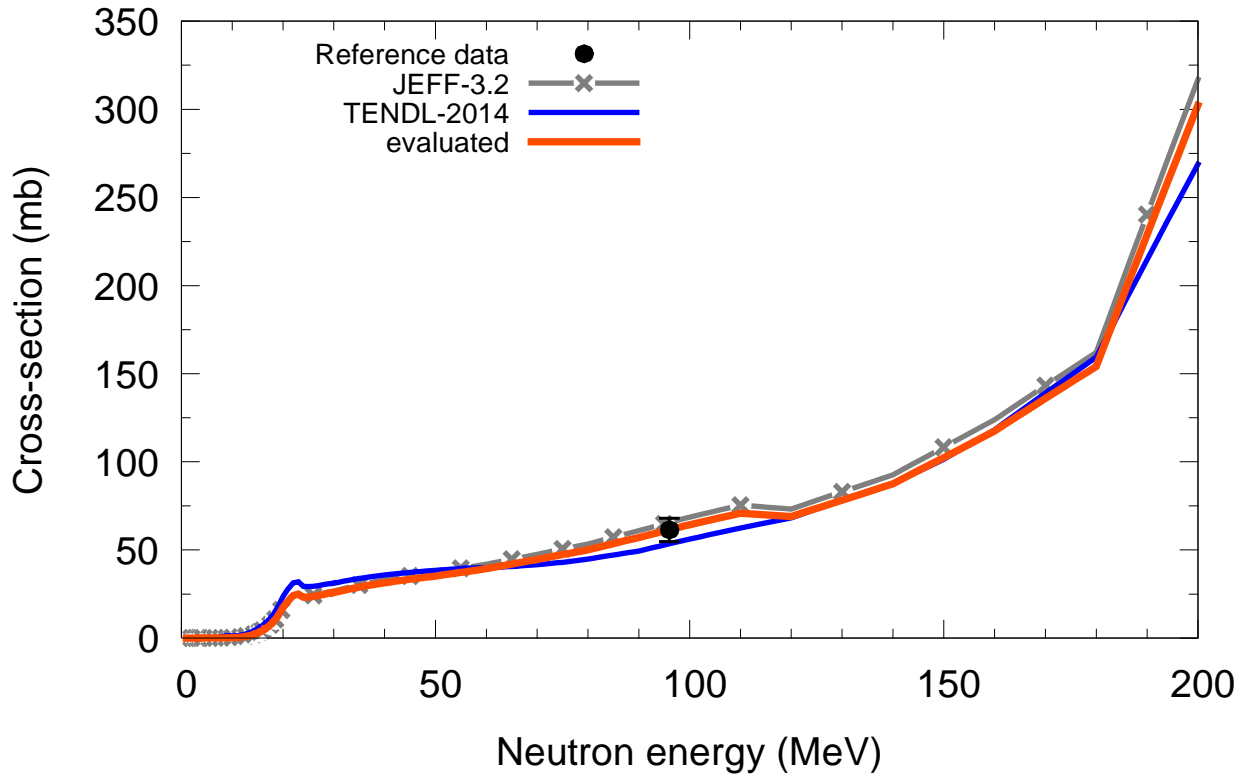
$^{185}\text{Re}(n,x)^4\text{He}$



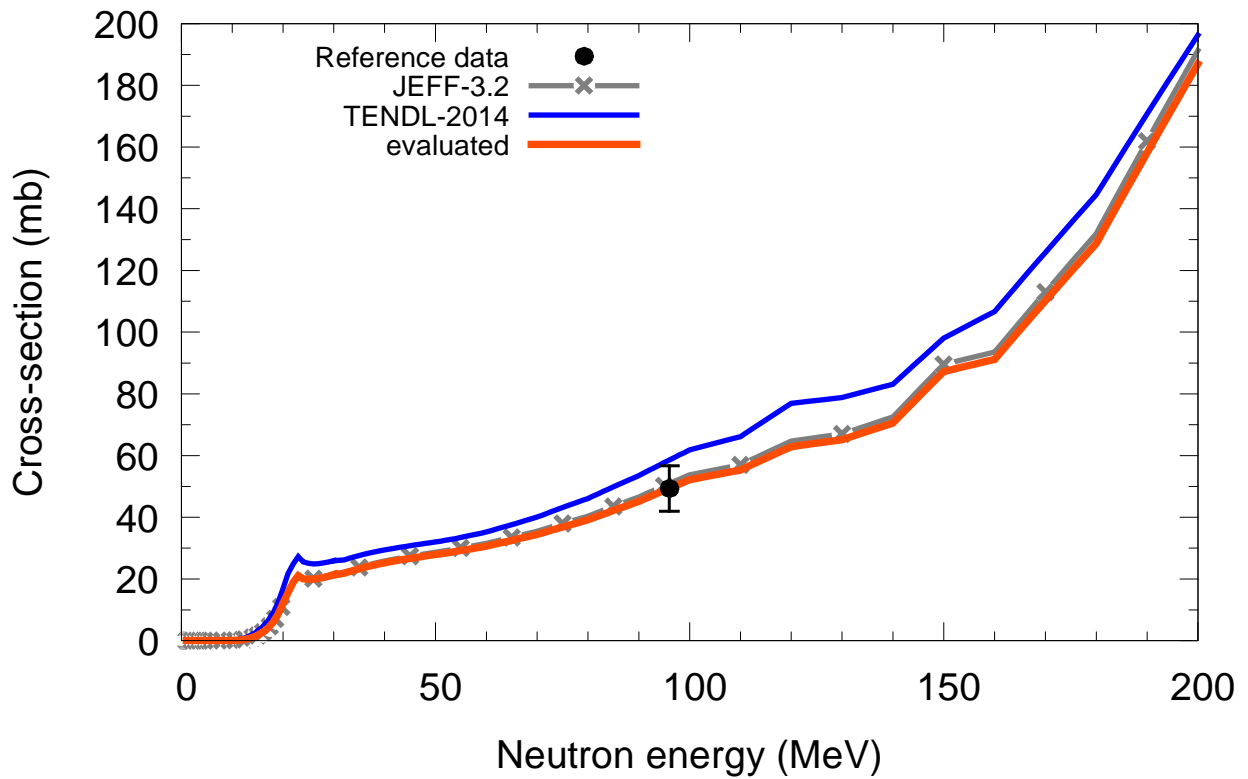
$^{187}\text{Re}(n,x)^4\text{He}$



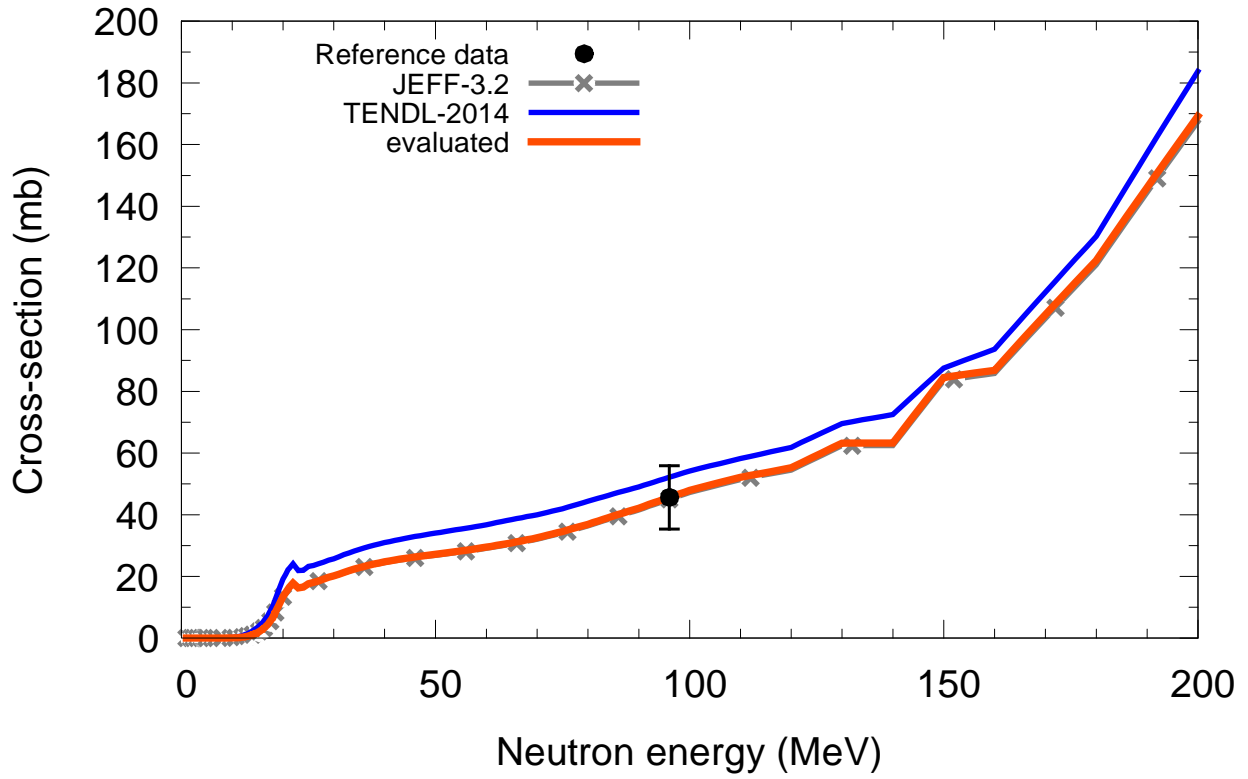
$^{184}\text{Os}(n,x)^4\text{He}$



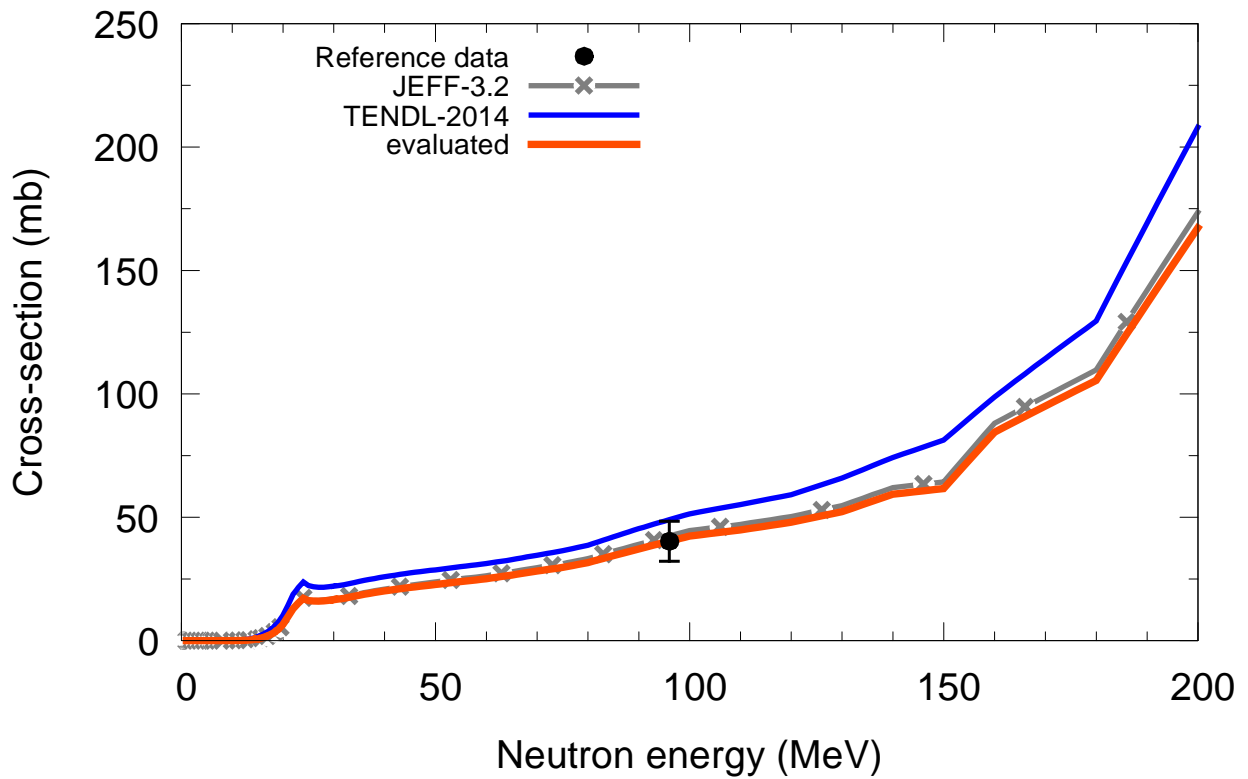
$^{186}\text{Os}(n,x)^4\text{He}$

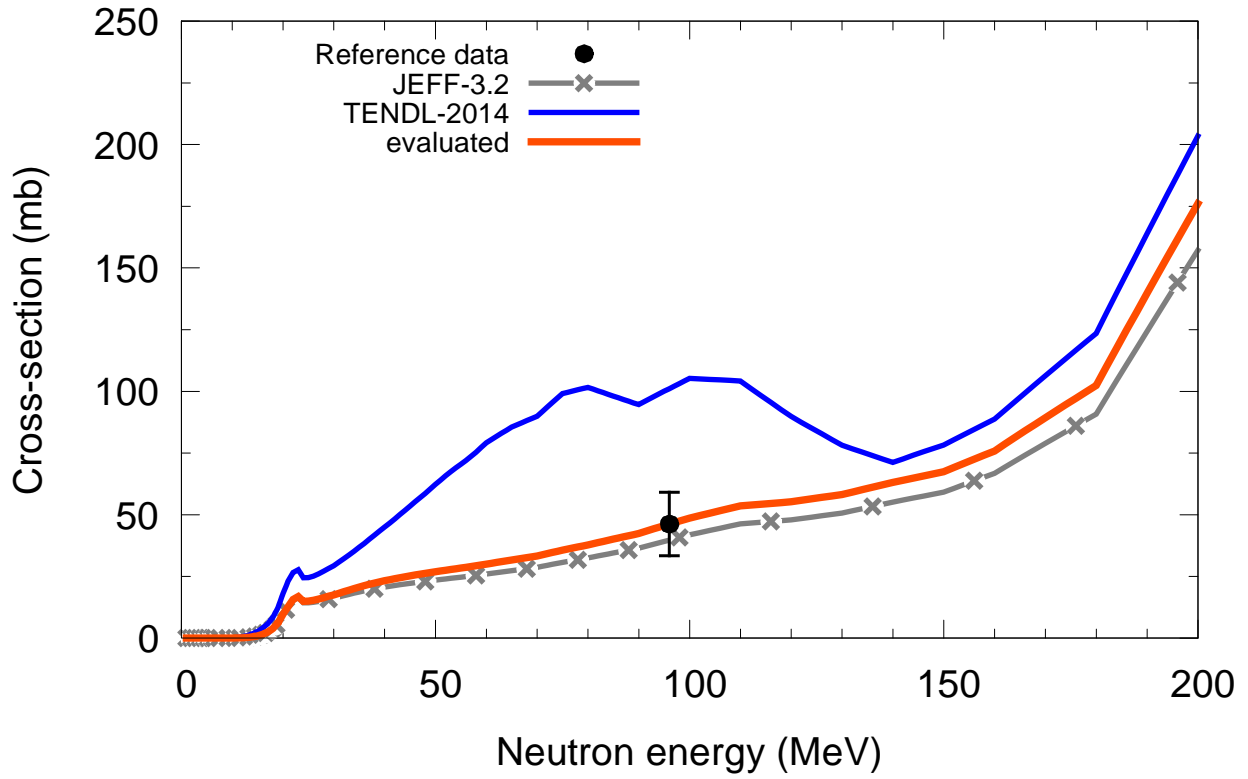
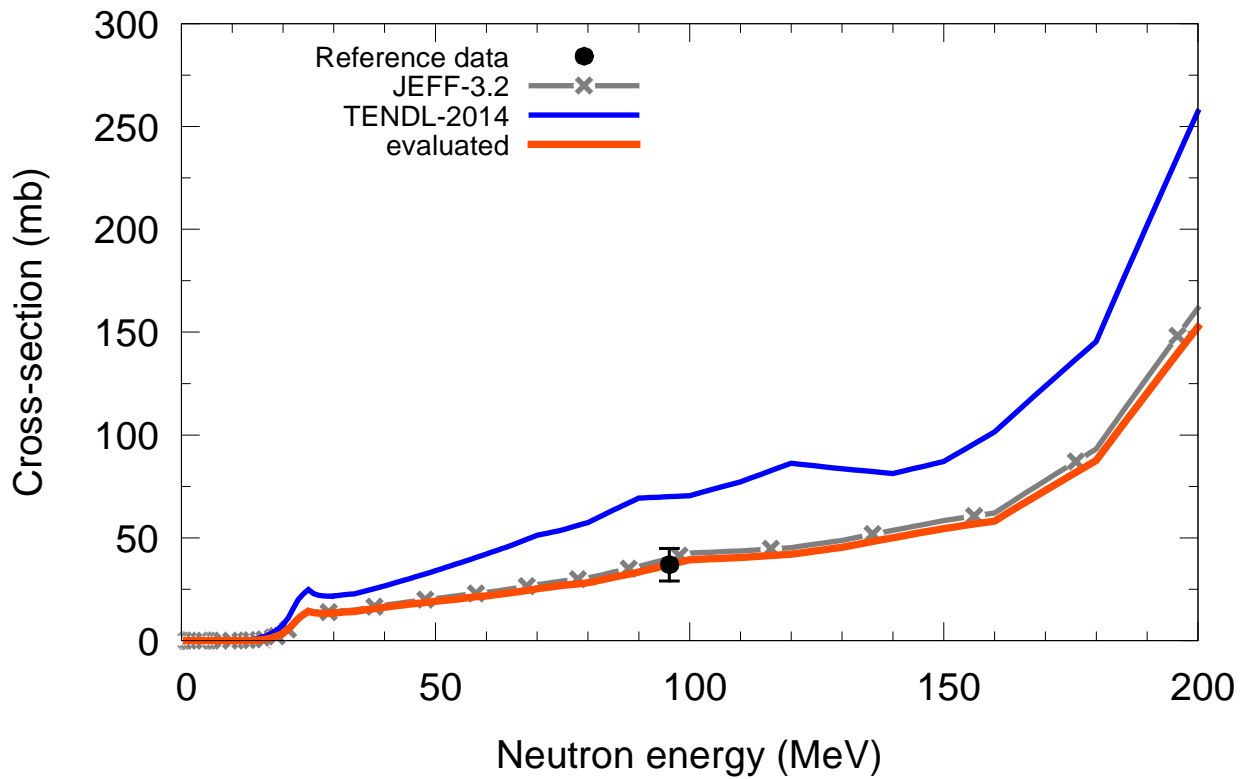


$^{187}\text{Os}(n,x)^4\text{He}$

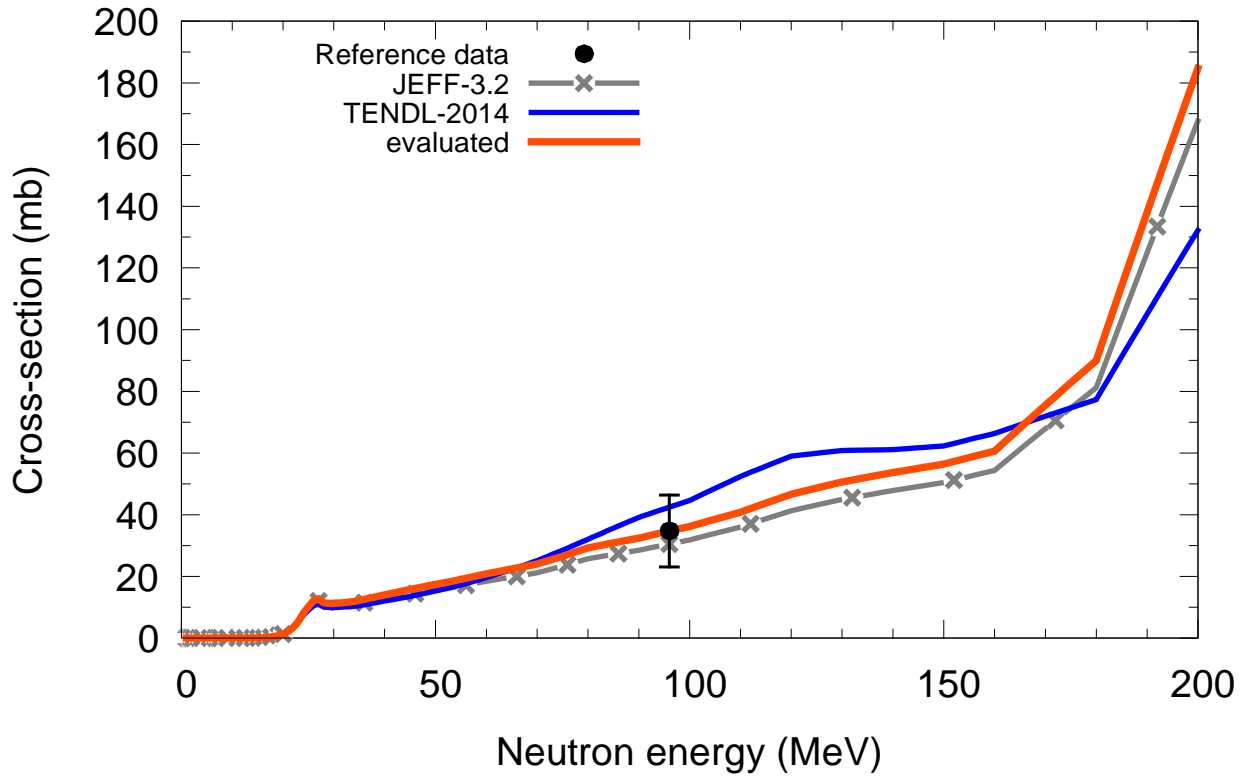
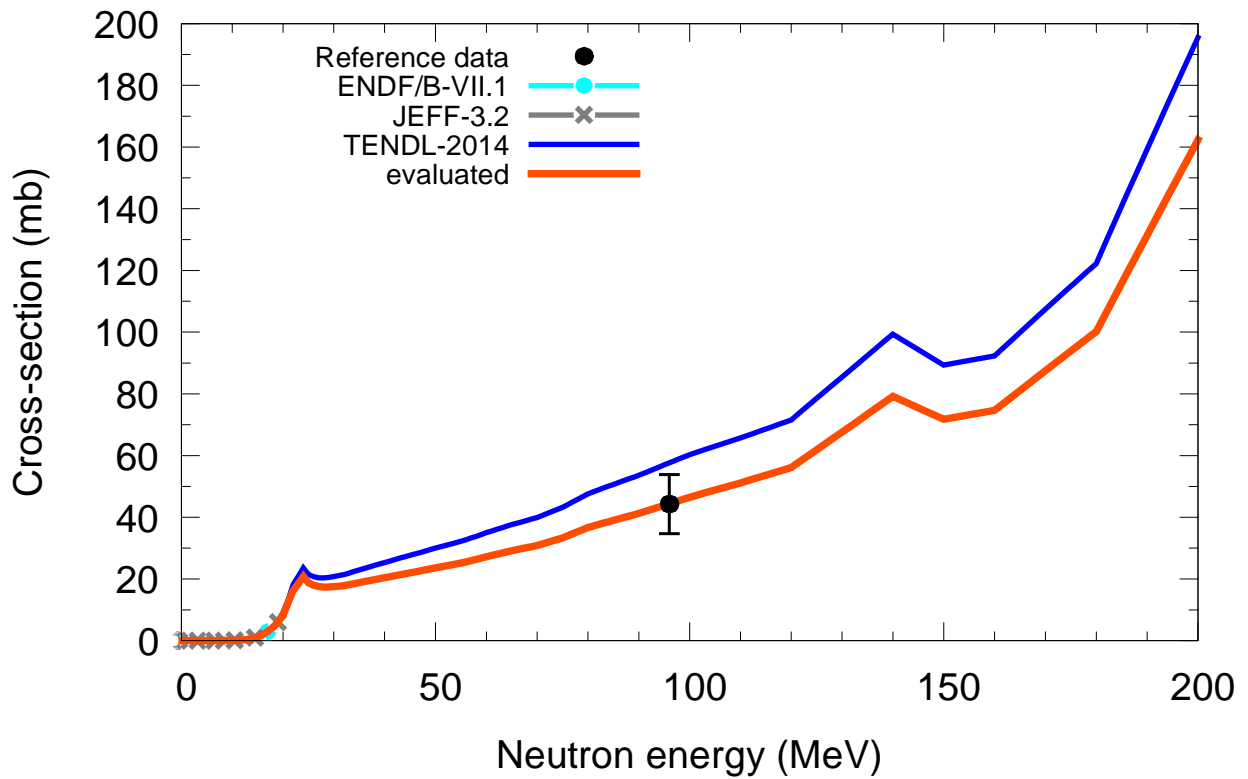


$^{188}\text{Os}(n,x)^4\text{He}$

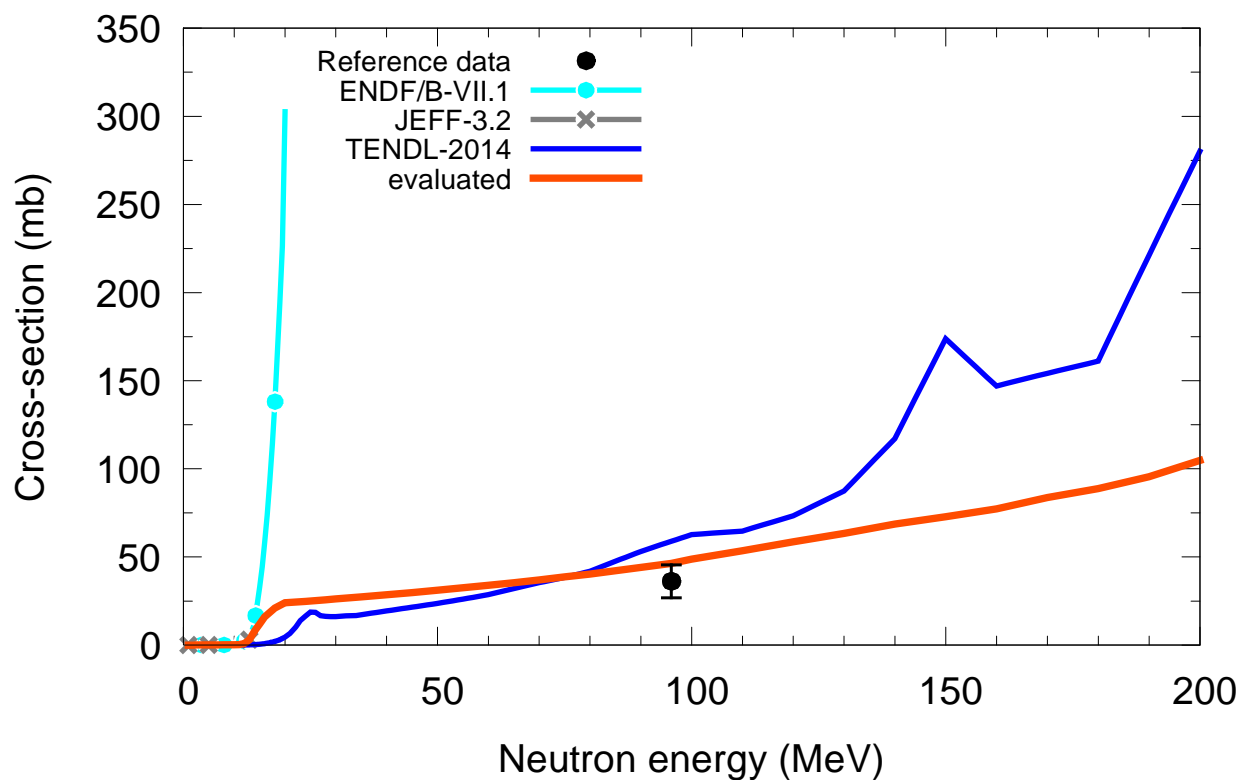


$^{189}\text{Os}(n,x)^4\text{He}$  $^{190}\text{Os}(n,x)^4\text{He}$ 

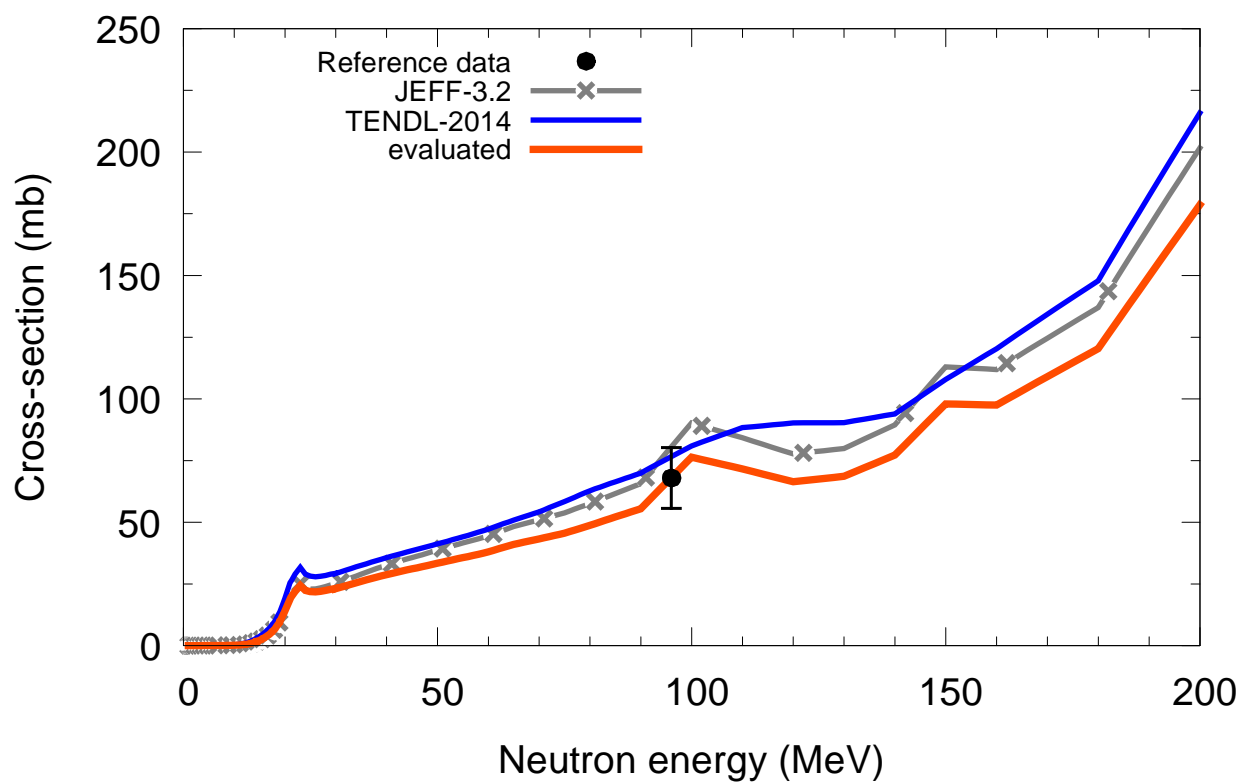


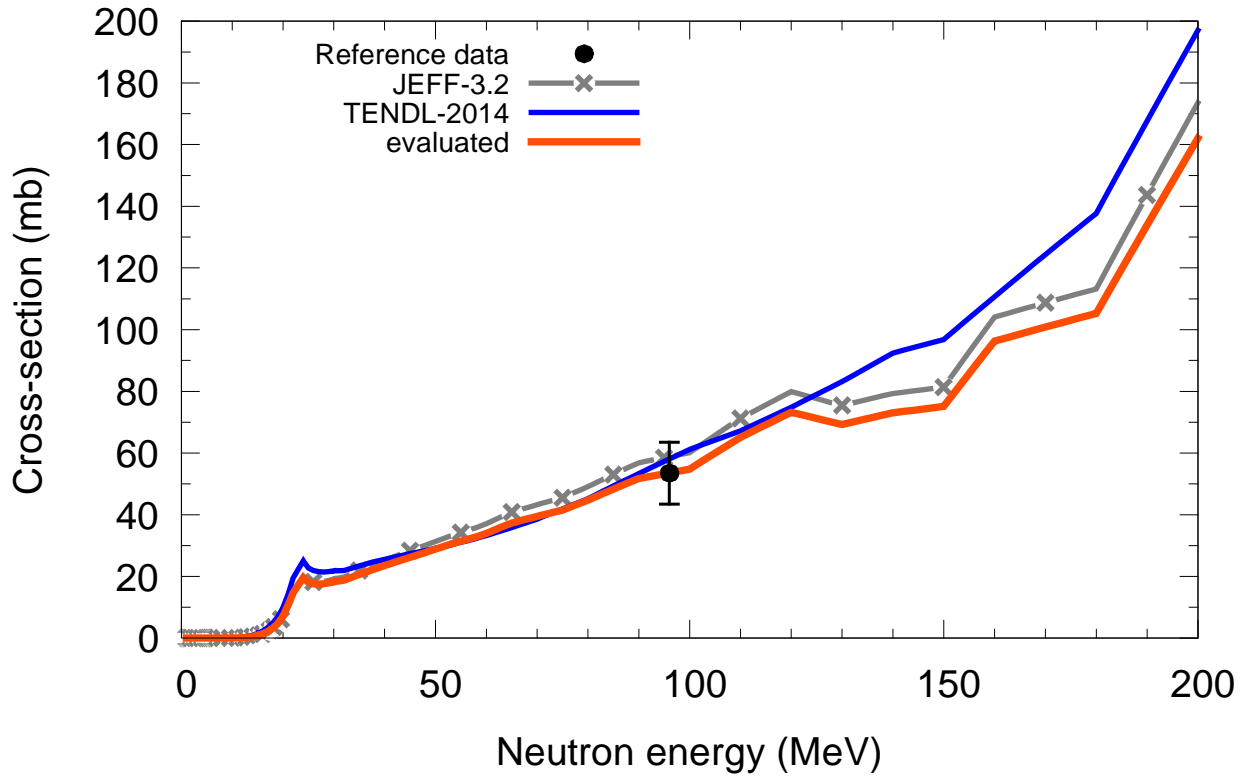
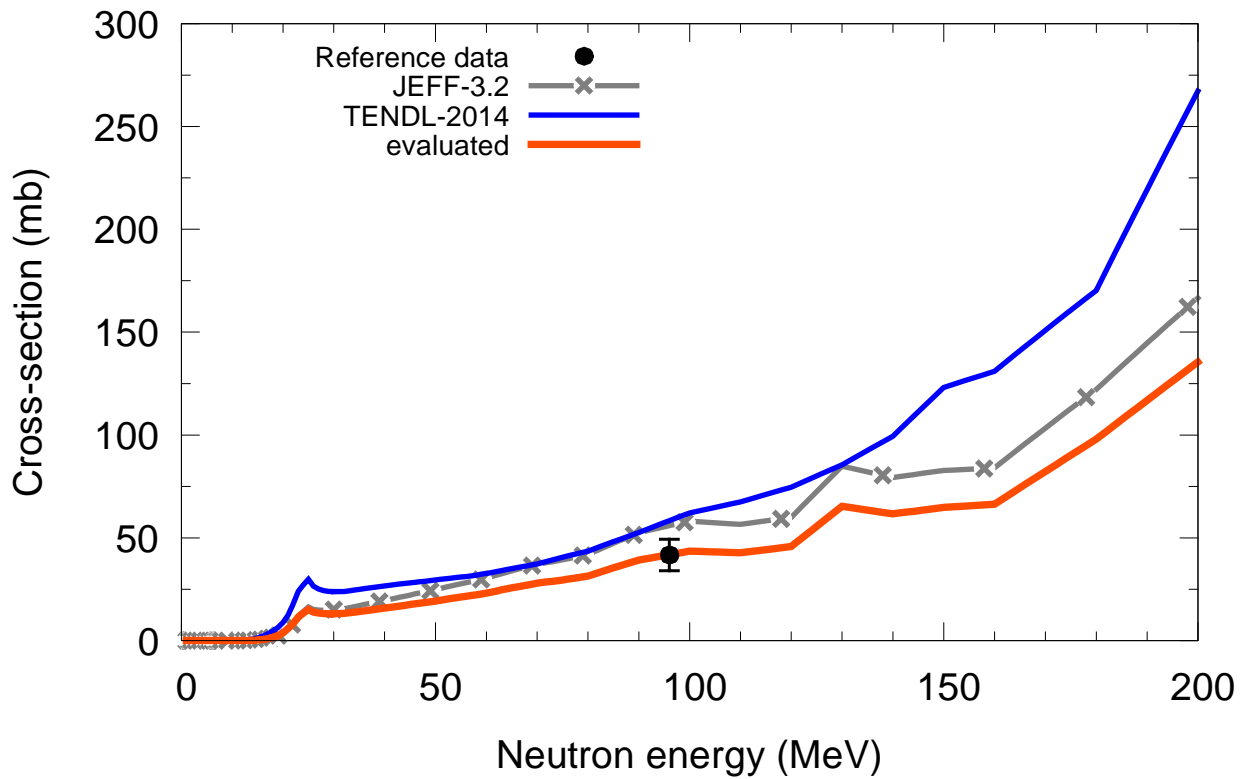
$^{192}\text{Os}(n,x)^4\text{He}$  $^{191}\text{Ir}(n,x)^4\text{He}$ 

$^{193}\text{Ir}(n,x)^4\text{He}$

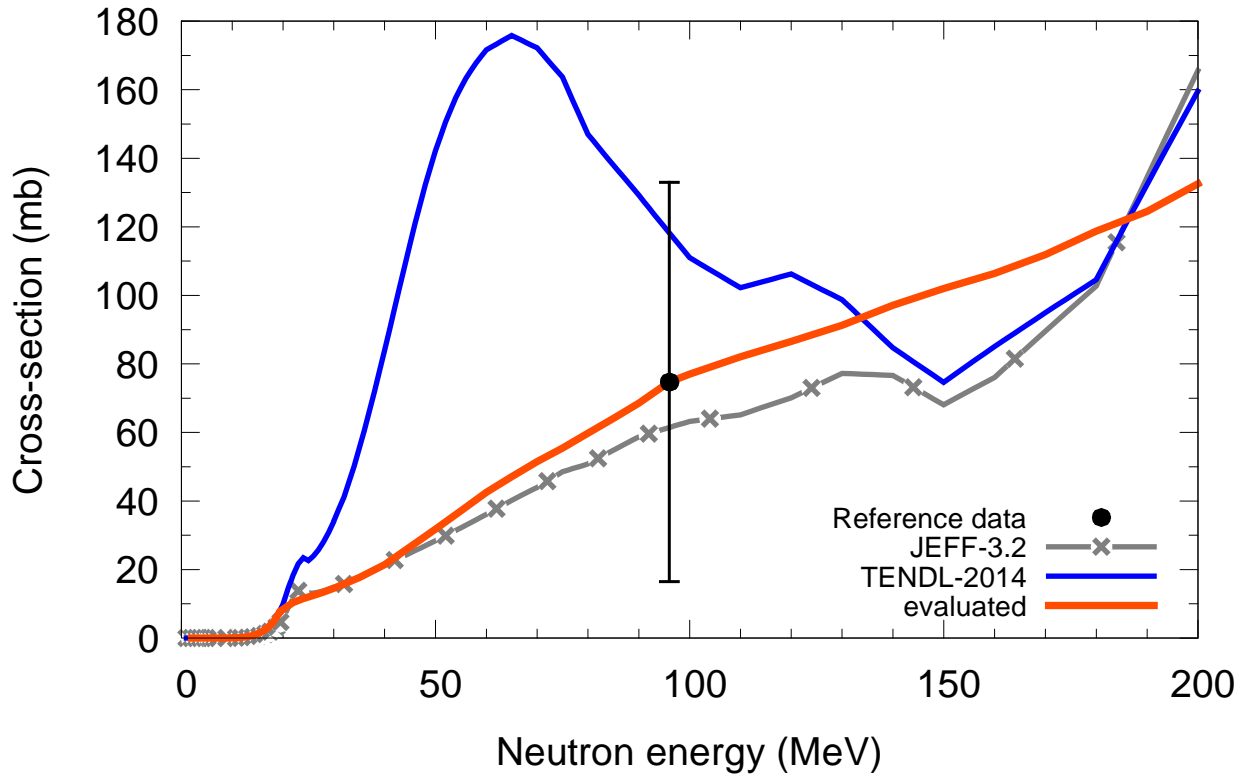


$^{190}\text{Pt}(n,x)^4\text{He}$

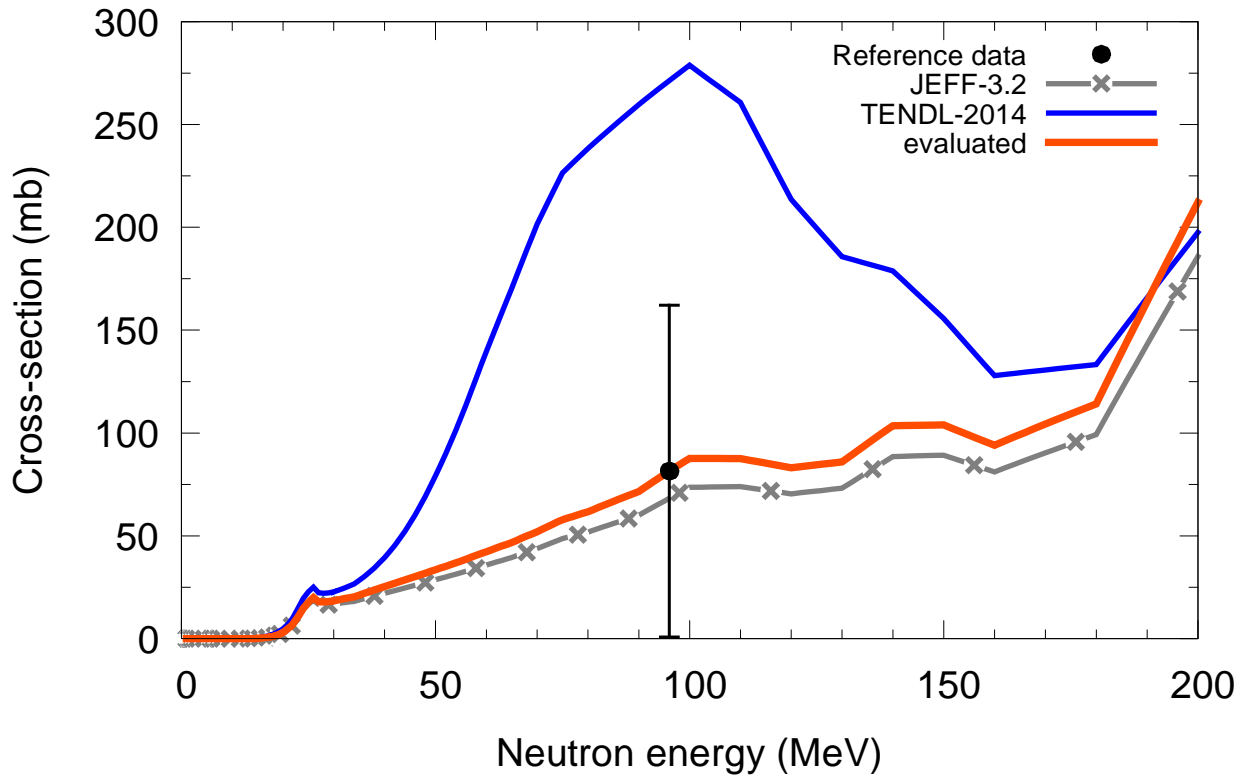


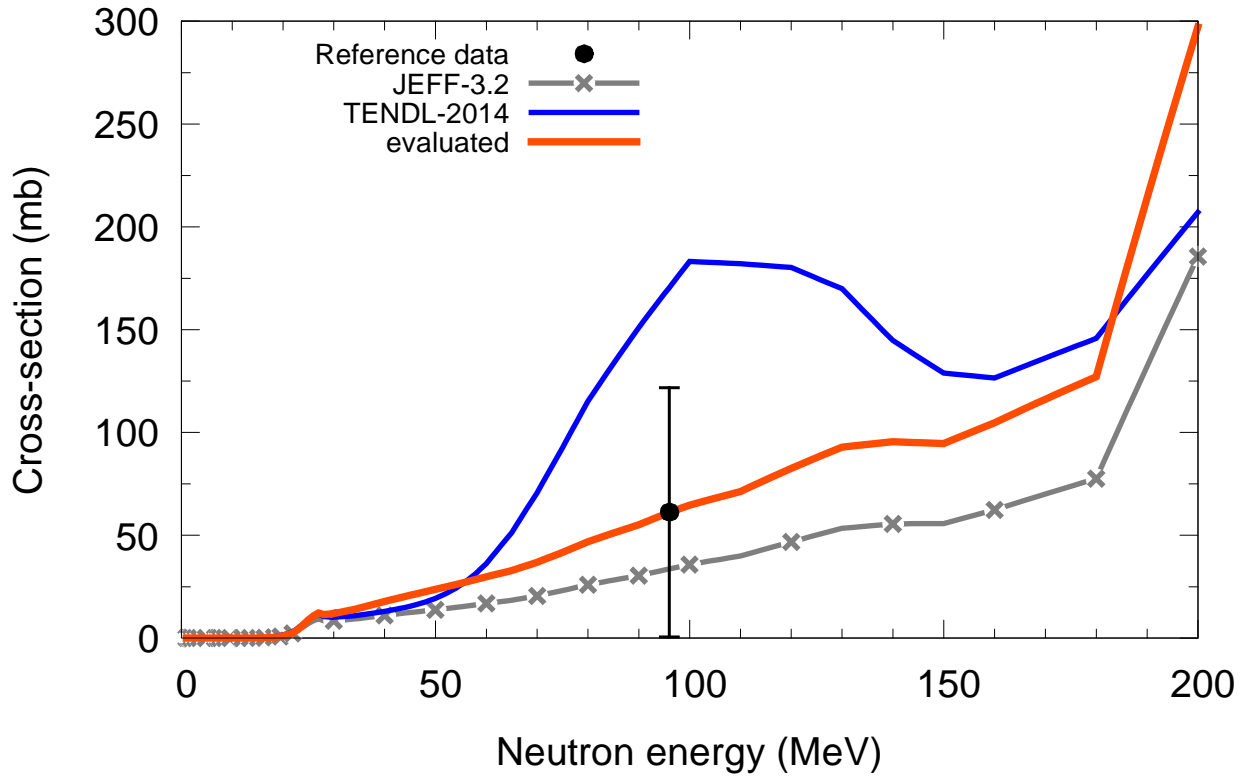
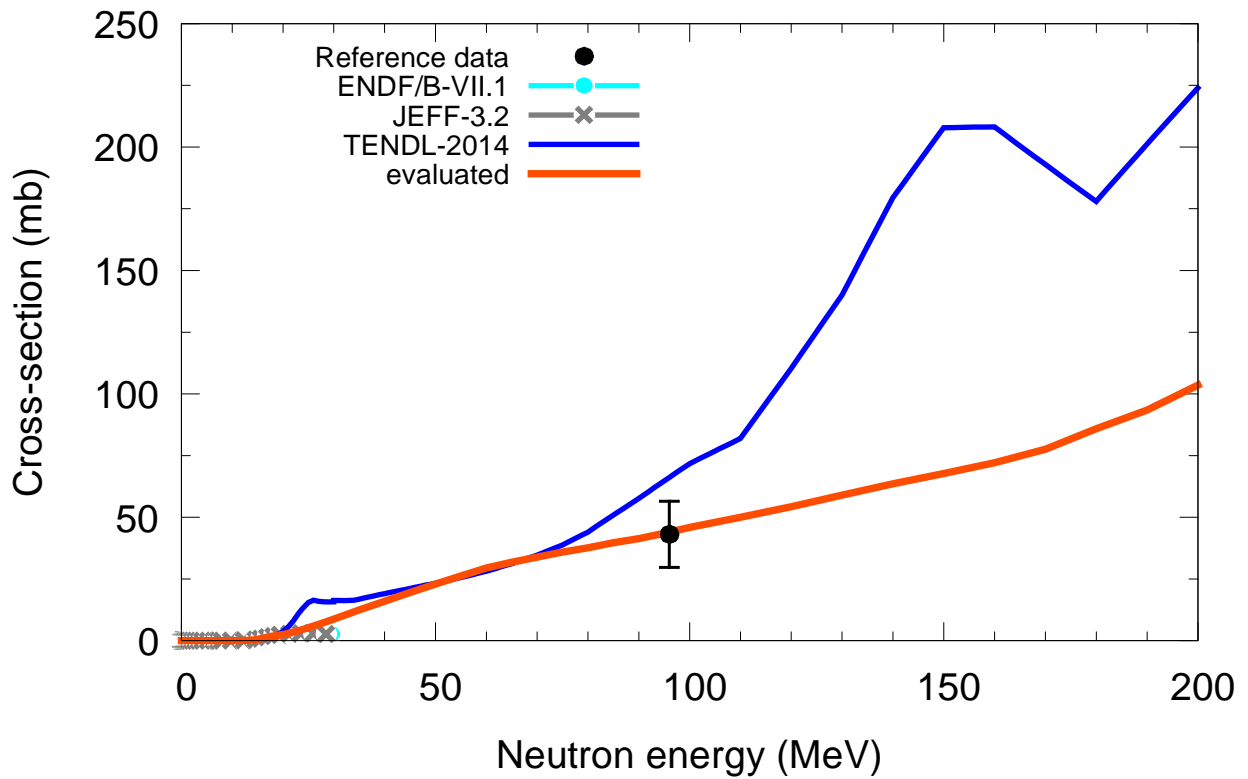
$^{192}\text{Pt}(n,x)^4\text{He}$  $^{194}\text{Pt}(n,x)^4\text{He}$ 

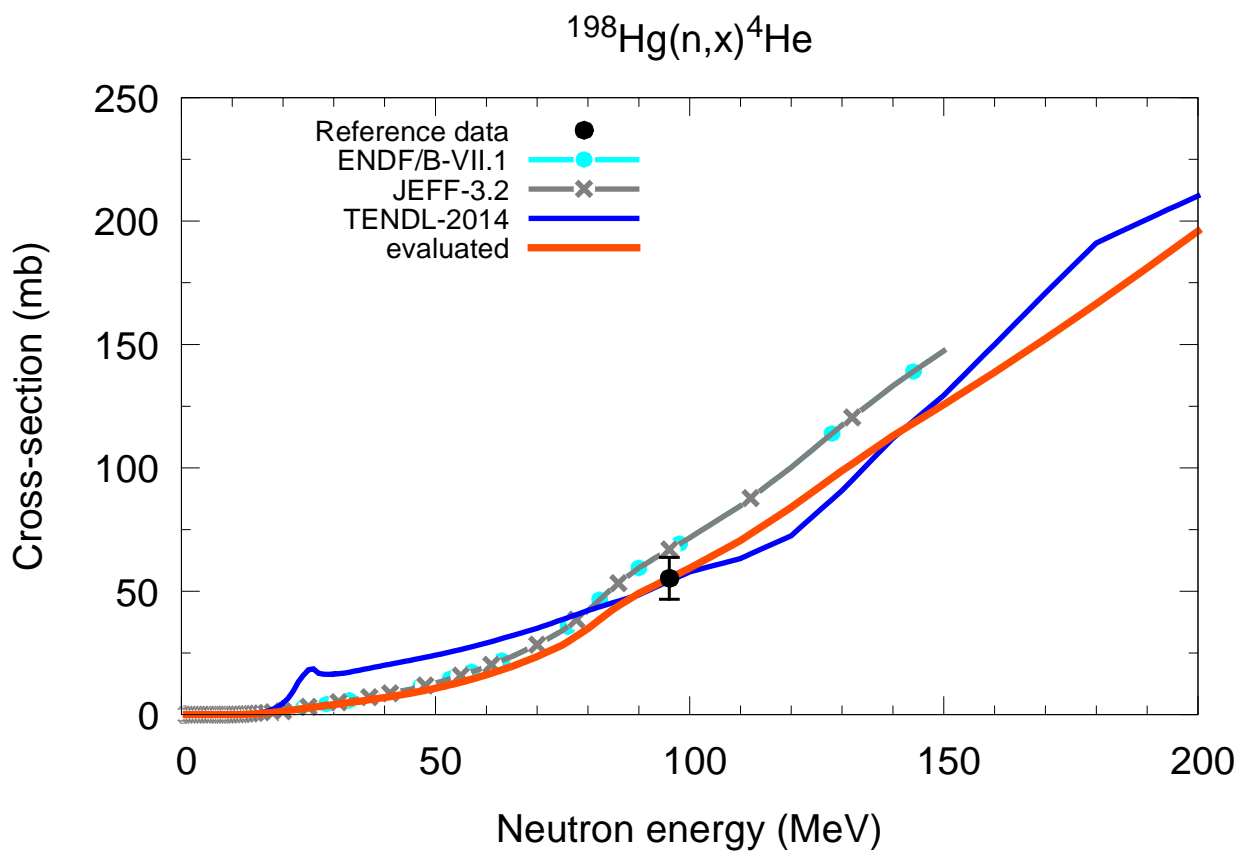
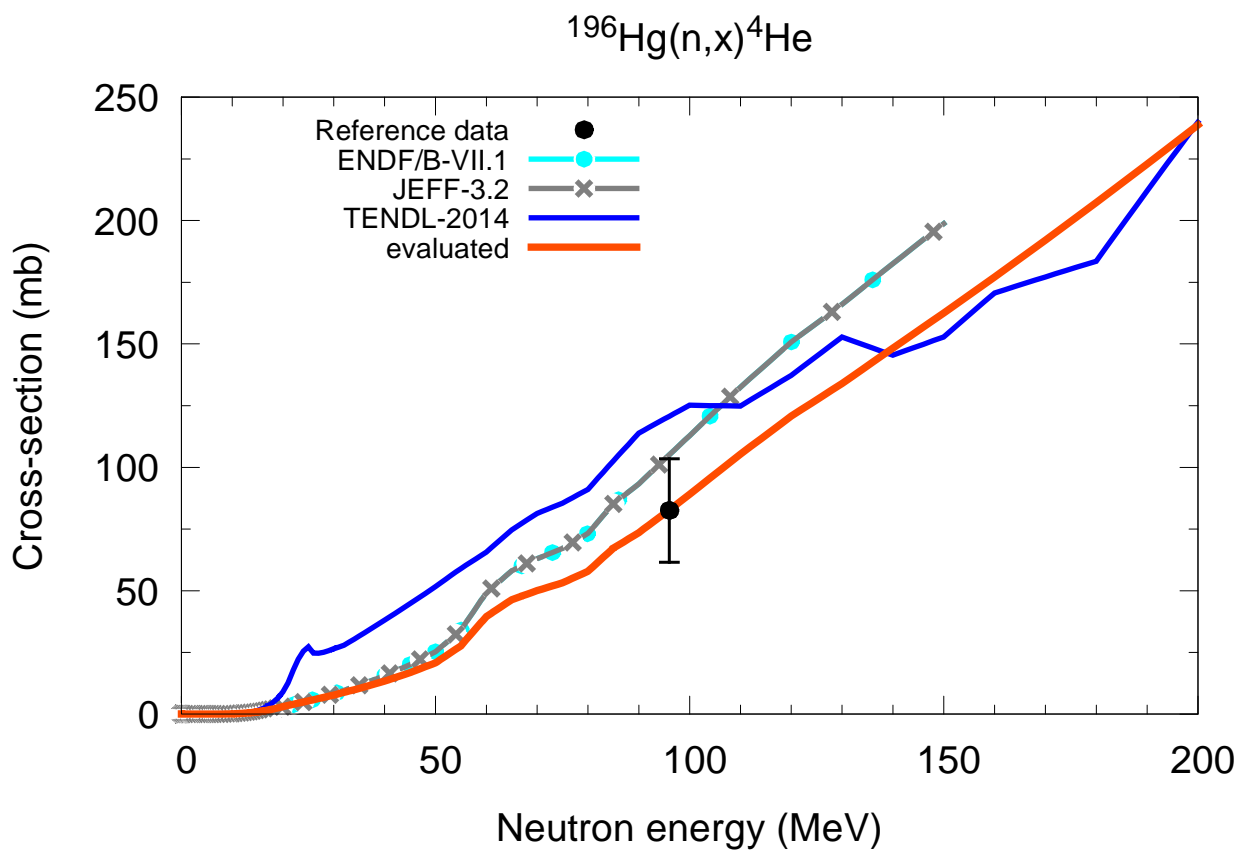
$^{195}\text{Pt}(n,x)^4\text{He}$

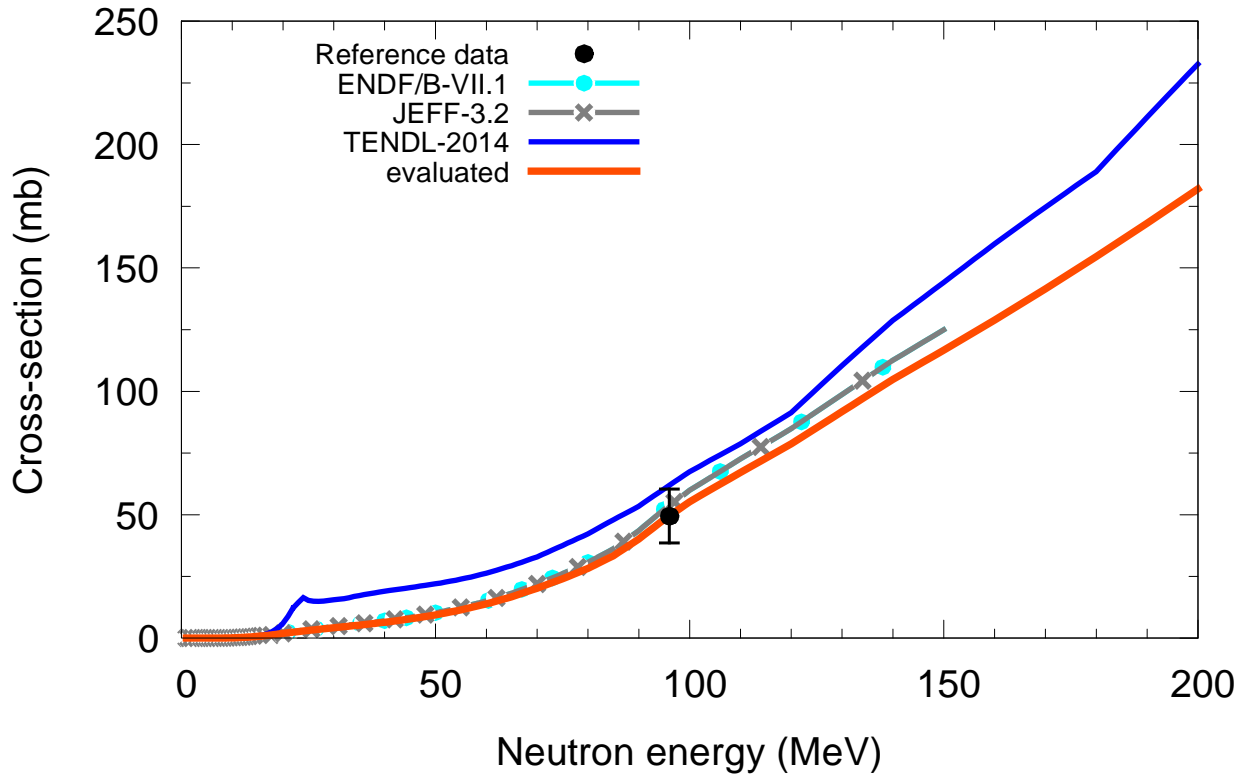
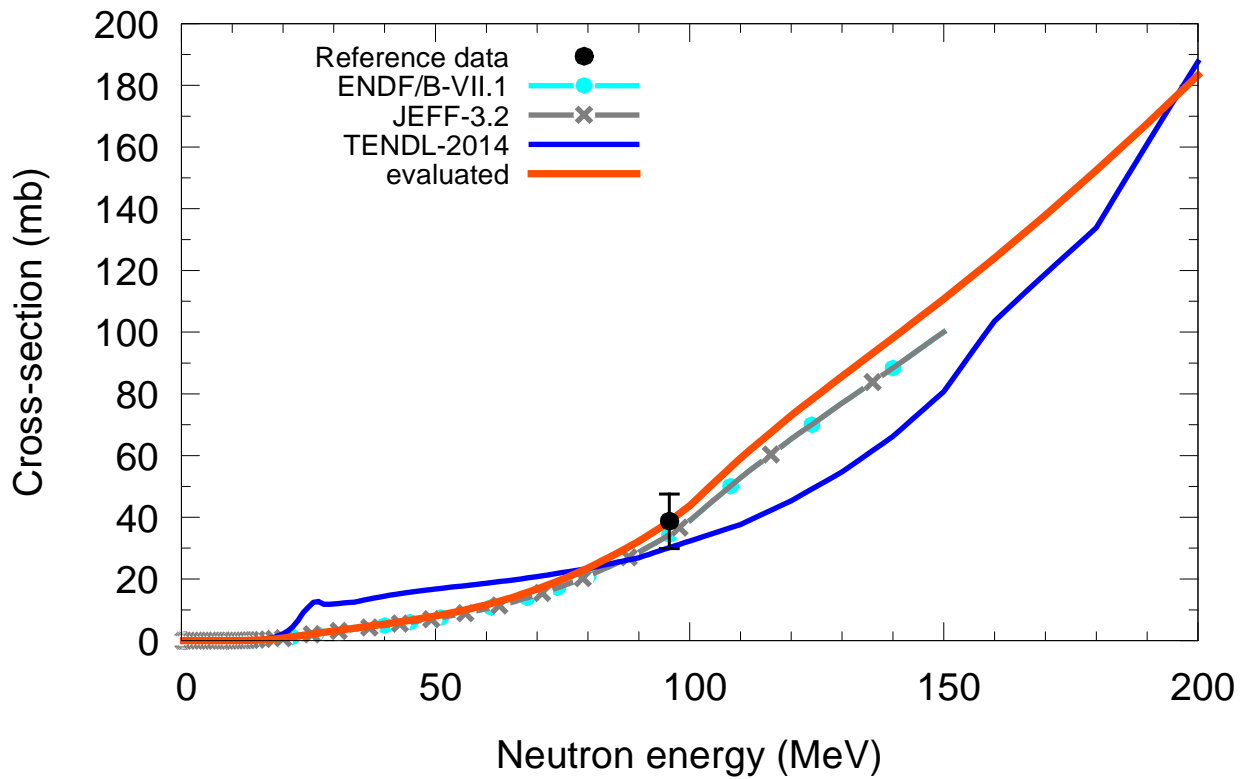


$^{196}\text{Pt}(n,x)^4\text{He}$

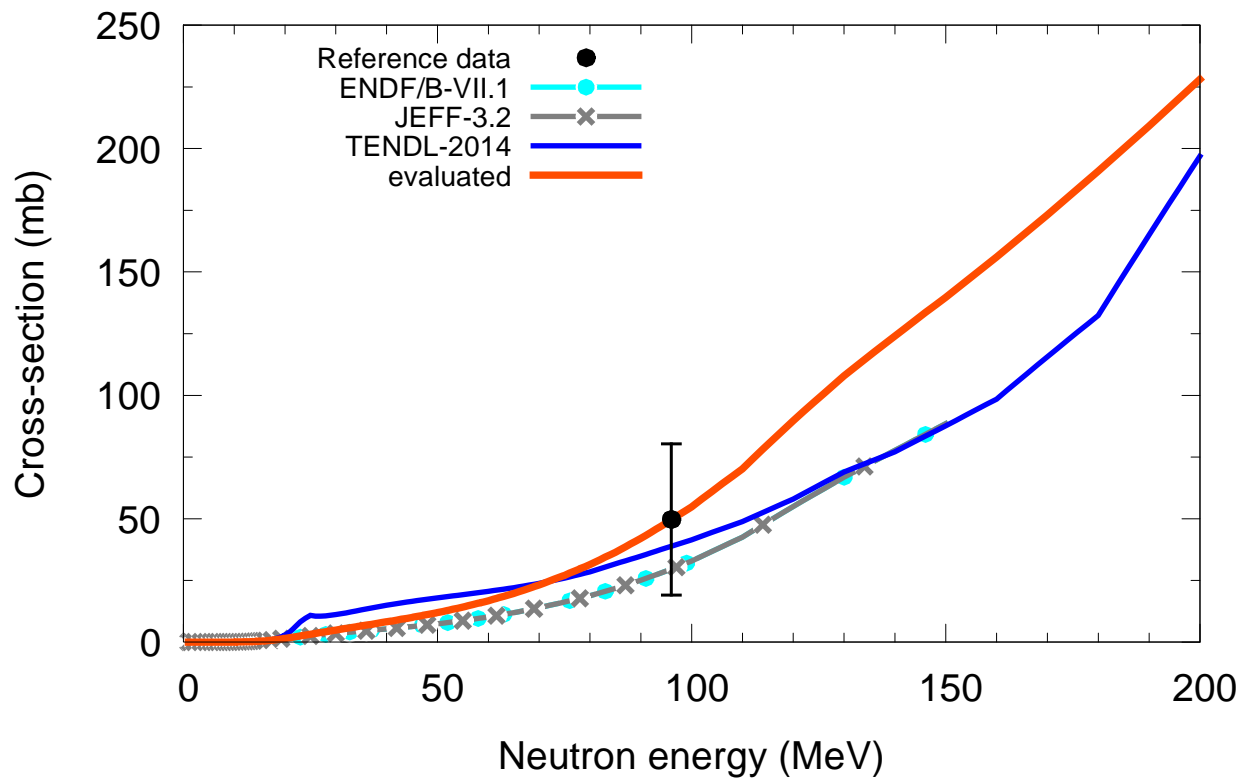


$^{198}\text{Pt}(n,x)^4\text{He}$  $^{197}\text{Au}(n,x)^4\text{He}$ 

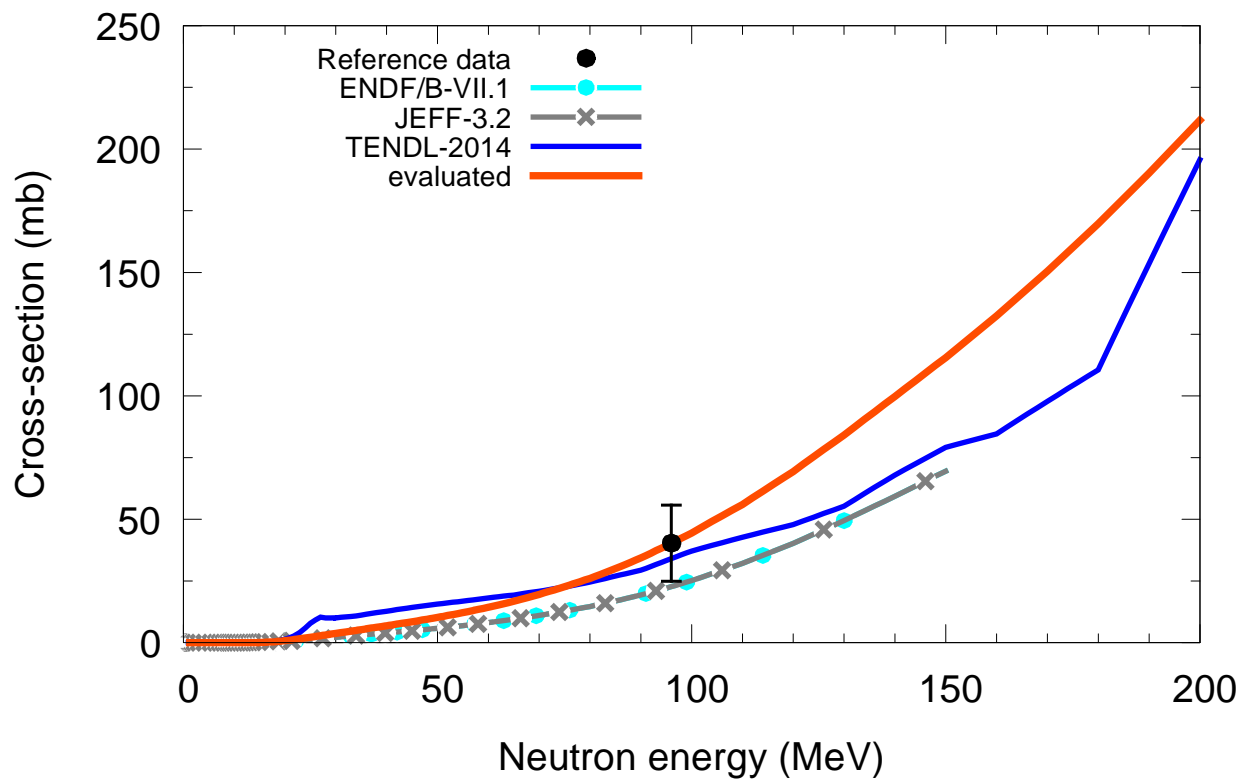


$^{199}\text{Hg}(n,x)^4\text{He}$  $^{200}\text{Hg}(n,x)^4\text{He}$ 

$^{201}\text{Hg}(n,x)^4\text{He}$

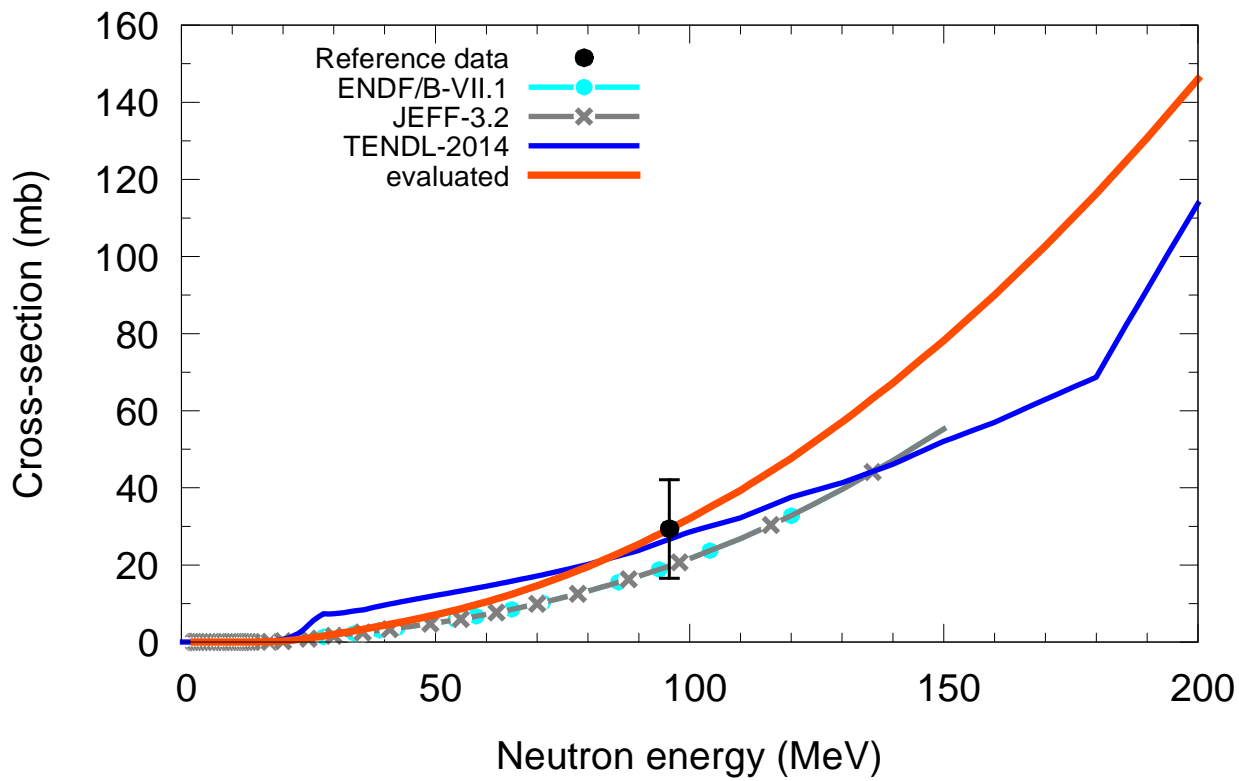


$^{202}\text{Hg}(n,x)^4\text{He}$

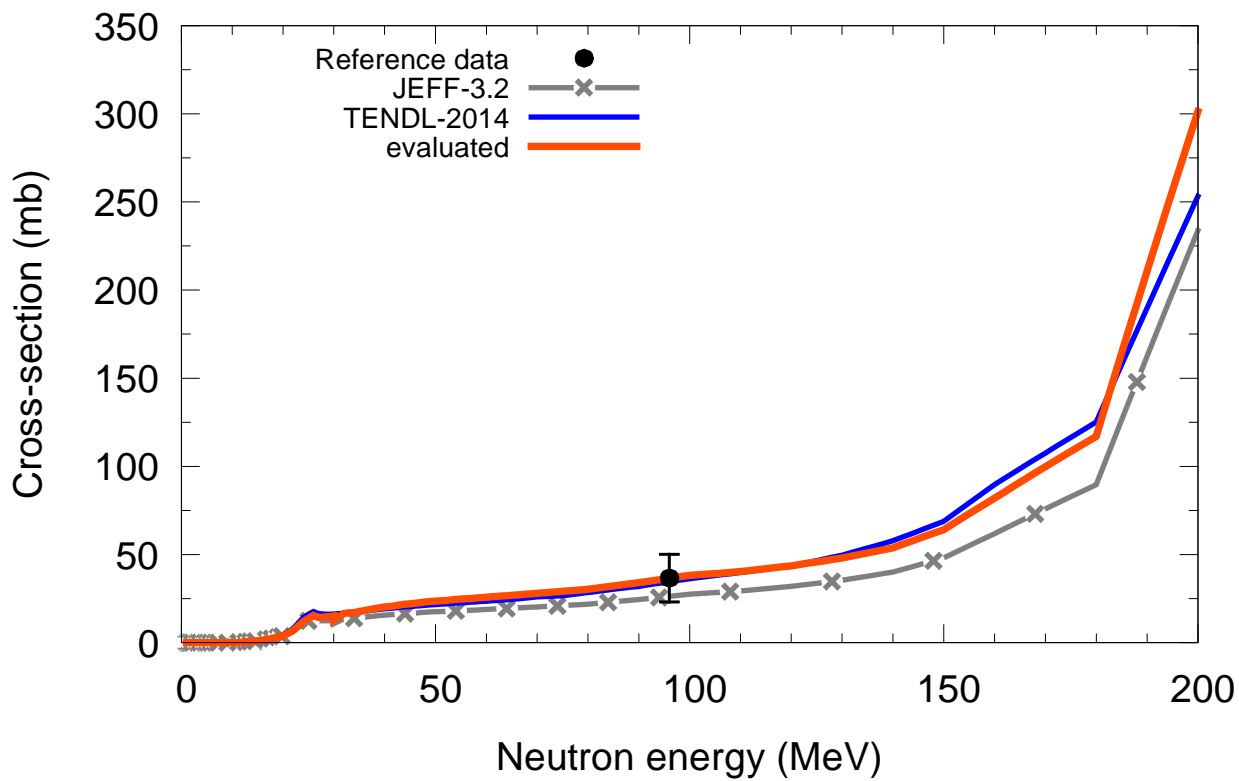


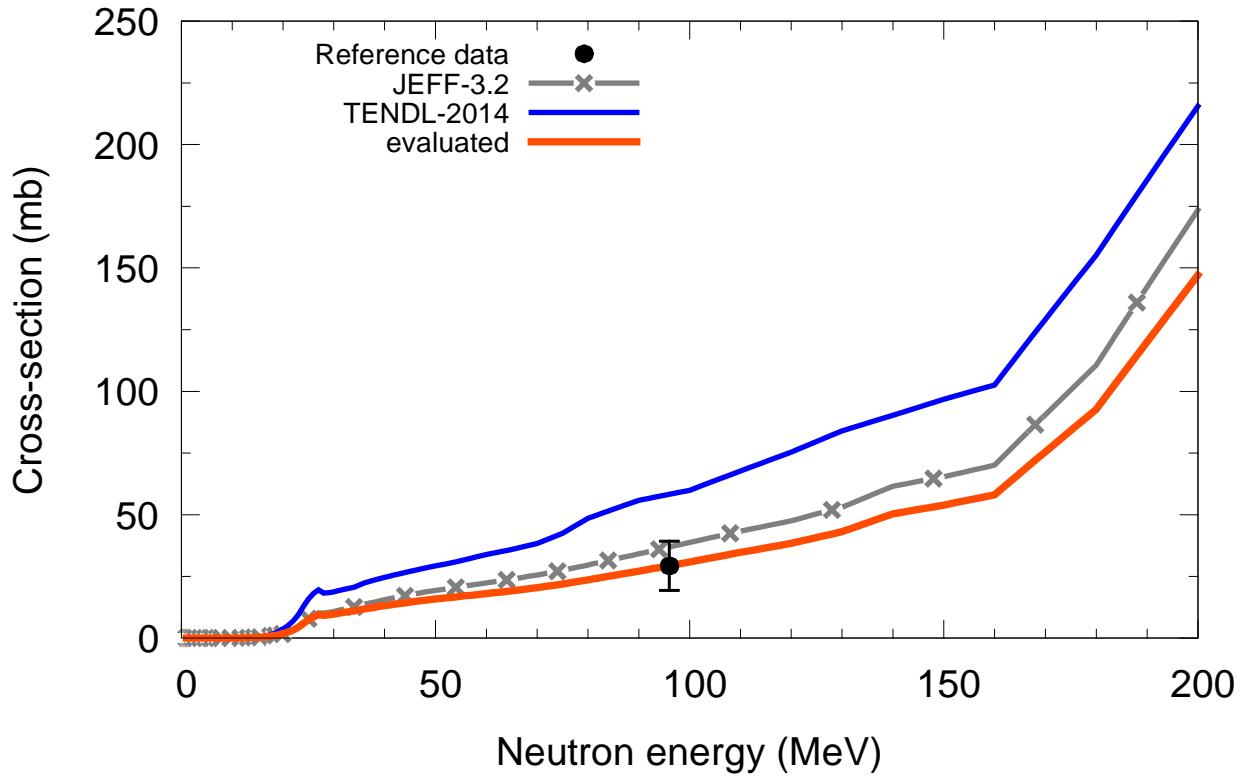
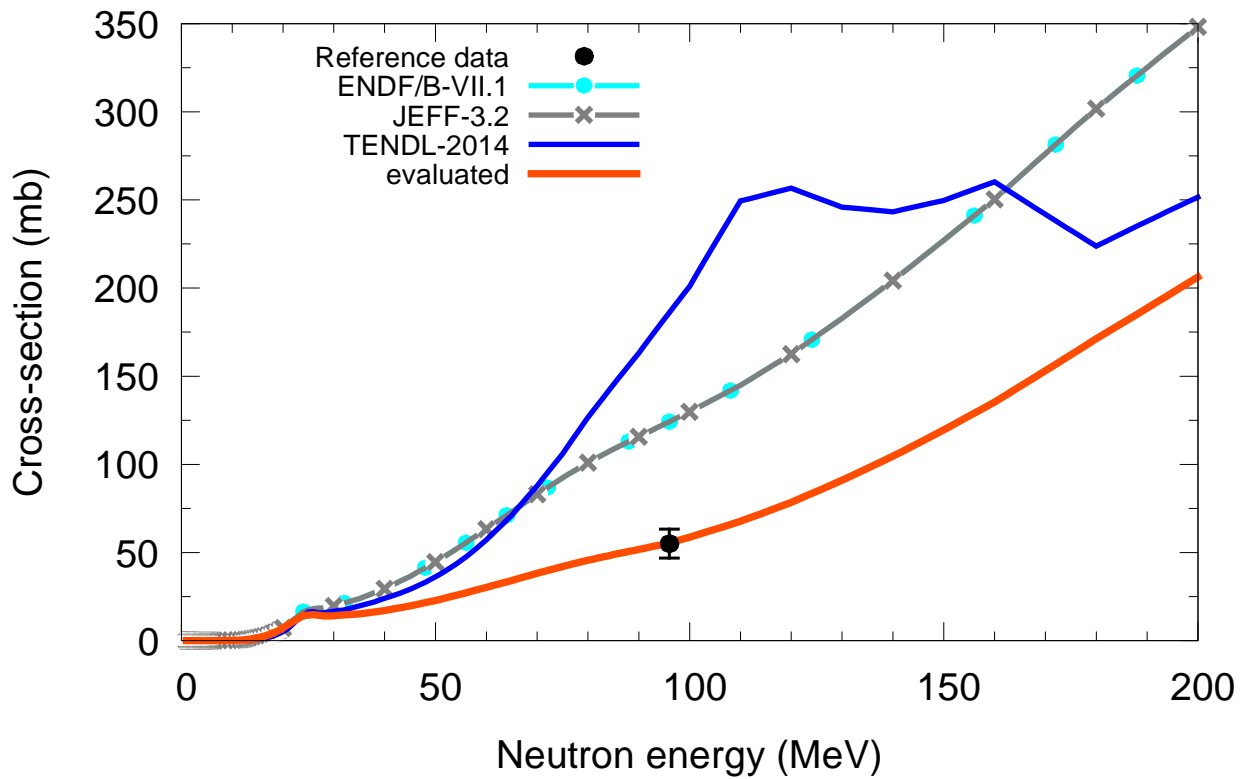


$^{204}\text{Hg}(n,x)^4\text{He}$

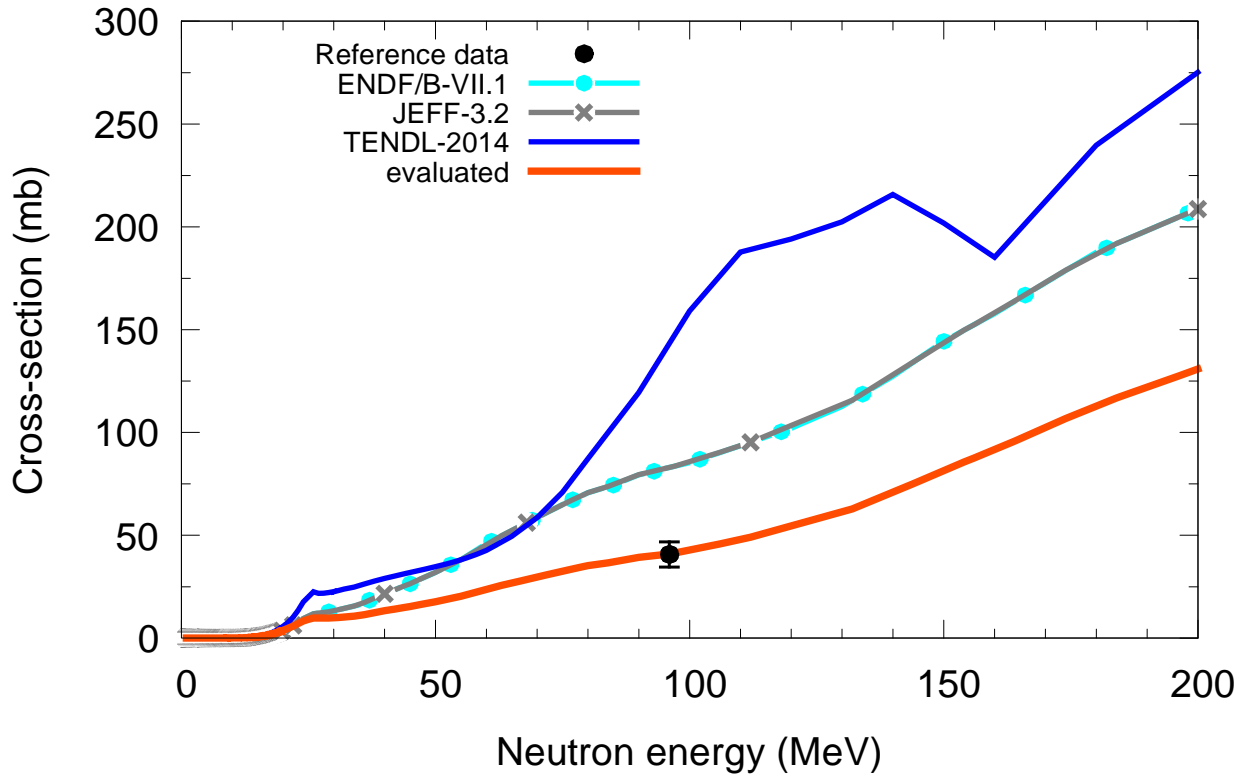


$^{203}\text{Tl}(n,x)^4\text{He}$

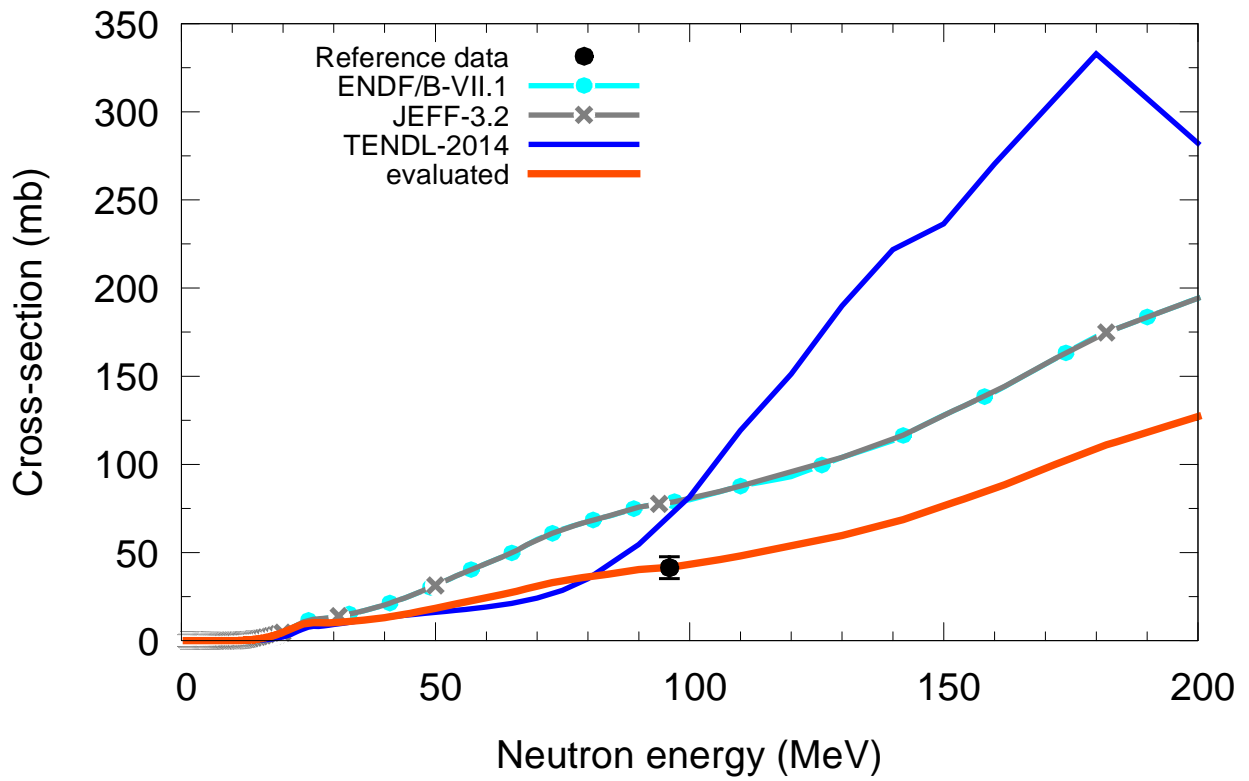


$^{205}\text{Tl}(n,x)^4\text{He}$  $^{204}\text{Pb}(n,x)^4\text{He}$ 

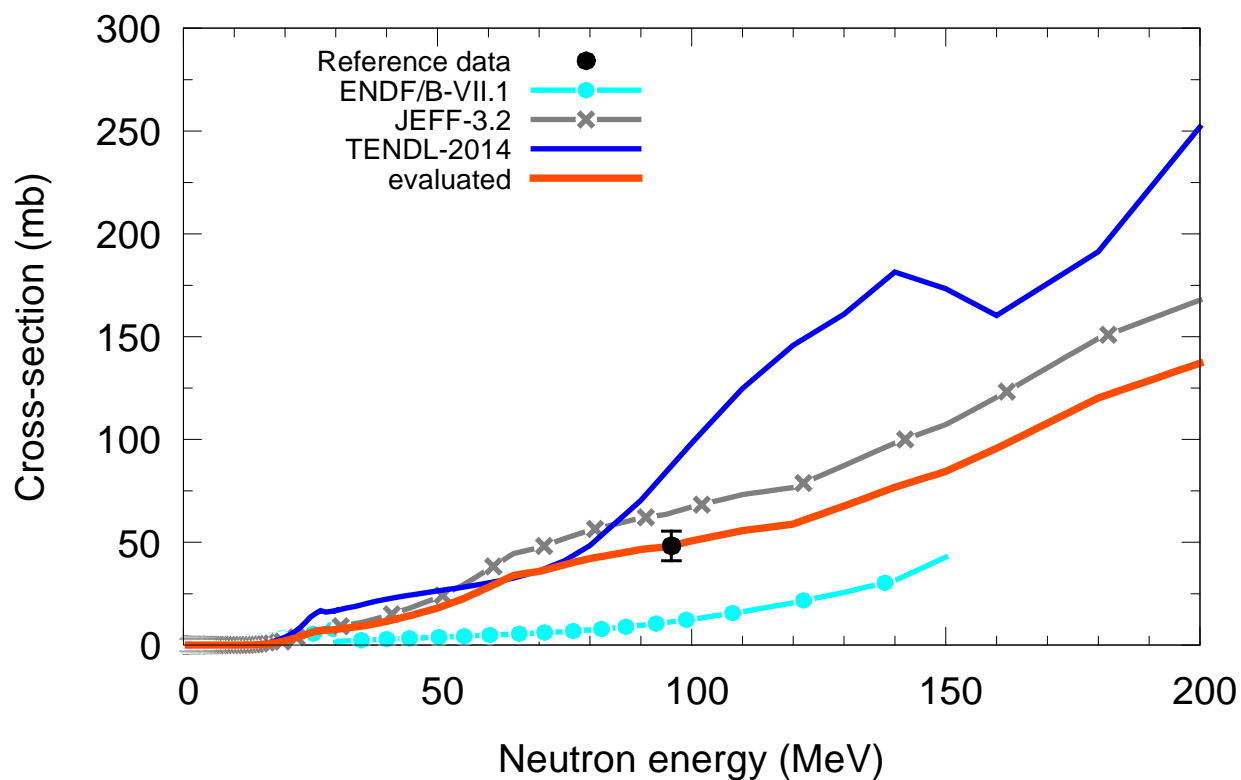
### $^{206}\text{Pb}(n,x)^4\text{He}$



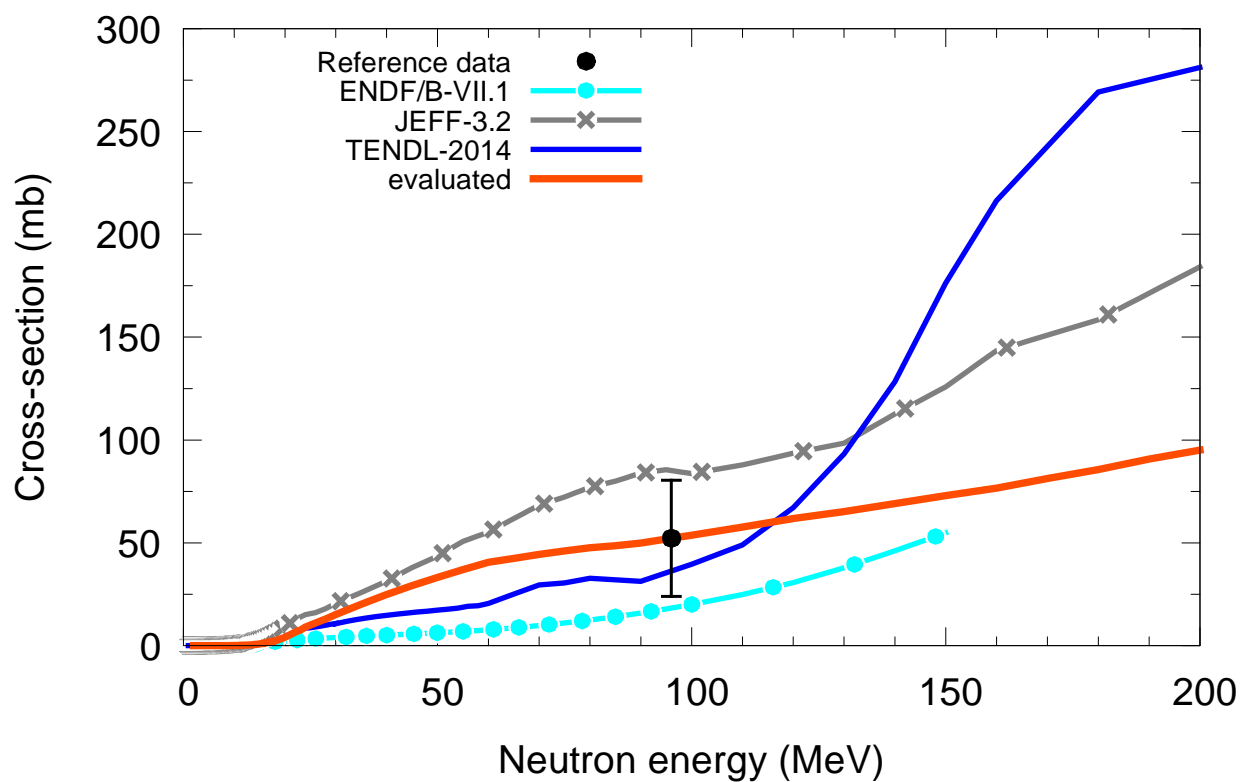
### $^{207}\text{Pb}(n,x)^4\text{He}$



$^{208}\text{Pb}(n,x)^4\text{He}$



$^{209}\text{Bi}(n,x)^4\text{He}$



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