JANIS Book

of triton-induced cross-sections

Comparison of evaluated and experimental data from

ENDF/B-VIII.0, TENDL-2019 and EXFOR

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Introduction

This document compares evaluated cross-sections with corresponding experimental data from the EXFOR database for a number of evaluated libraries (Table 1), nuclear reactions and associated reaction products (Table 3). This document was produced using tools based on the NEA Java-based nuclear information software (JANIS) and associated databases; up-to-date plots are available from online JANIS Books [1].

Caveat: When studying plots, please take into account that the energy resolution of experimental data is not always comparable with the resolution of the evaluated data.

Graphical comparison of nuclear data

Experimental data sets are identified by the year and first author of the main reference compiled in EXFOR. The colors give an indication on the publication year, from black/blue for the oldest data to orange/red for the most recent ones (Table 2). All experimental data are plotted on the graph but the legend will ignore all of them if there are more than 20 data sets.

Evaluated data are plotted with full lines for exclusive cross-sections explicitly defined by a MT number, whereas dashed lines indicate residual production cross-sections given in MT5. A star '*' after the name of the library indicates additional operations performed by JANIS, e.g. summation over the ground and metastable yields, reconstruction of residual production cross-sections over the whole energy range.

The data are plotted in log-log scale (on the left hand side) and lin-log scale (on the right hand side). The best representation depends on the Q value of the reaction and/or the magnitude of the variation in the cross-section values.

Table of reactions and Q values

In order to identify individual contributions in residual production cross-sections, reactions leading to the same product are listed along with their associated Q values. The latter are calculated using mass excess from the NUBASE2016 evaluation of nuclear properties [2].

Navigation in this document

The data are sorted by element, then by isotope and finally by reaction. In order to facilitate access to the information, two navigation modes are available in addition to the usual bookmark. At the top of each page, on the first row, the previous (<<) and next (>>) "Isotope links" allow the reader to move from one isotope to another while staying on the same MT reaction. On the second row, the "MT links" allow scanning all reactions of a given isotope. The latter navigation mode is actually similar to the use of the page up and page down keys.

References

[1]   N. Soppera *et al.*, *Nuclear Data Sheets 120* (2014), 294. See also www.oecd-nea.org/janis.

[2]   G. Audi *et al.*, *Chinese Physics C, 41* (3), 030001, 2017.

Table 1: list of databases used in the inter-comparison

Library	Release date
ENDF/B-VIII.0	February 2018
TENDL-2019	December 2019
EXFOR	September 2020

Table 2: experimental data sets color code

Color	Publication year
red	2005 ≤ year
orange	2000 ≤ year < 2005
light orange	1995 ≤ year < 2000
khaki	1990 ≤ year < 1995
light green	1985 ≤ year < 1990
green	1980 ≤ year < 1985
light blue	1970 ≤ year < 1980
dark blue	1960 ≤ year < 1970
black	year < 1960

Table 3: list of exclusive reactions used in the inter-comparison

MT	Reaction	MT	Reaction	MT	Reaction	MT	Reaction
4	N	102	gamma	159	2n+p+a	181	3n+p+a
11	2n+d	103	p	160	7n	182	d+t
16	2n	104	d	161	8n	183	n+p+d
17	3n	105	t	162	5n+p	184	n+p+t
18	fission	106	h	163	6n+p	185	n+d+t
22	n+a	107	a	164	7n+p	186	n+p+h
23	n+3a	108	2a	165	4n+a	187	n+d+h
24	2n+a	109	3a	166	5n+a	188	n+t+h
25	3n+a	111	2p	167	6n+a	189	n+t+a
28	n+p	112	p+a	168	7n+a	190	2n+2p
29	n+2a	113	t+2a	169	4n+d	191	p+h
30	2n+2a	114	d+2a	170	5n+d	192	d+h
32	n+d	115	p+d	171	6n+d	193	h+a
33	n+t	116	p+t	172	3n+t	194	4n+2p
34	n+h	117	d+a	173	4n+t	195	4n+2a
35	n+d+2a	152	5n	174	5n+t	196	4n+p+a
36	n+t+2a	153	6n	175	6n+t	197	3p
37	4n	154	2n+t	176	2n+h	198	n+3p
41	2n+p	155	t+a	177	3n+h	199	3n+2p+a
42	3n+p	156	4n+p	178	4n+h	200	5n+2p
44	n+2p	157	3n+d	179	3n+2p		
45	n+p+a	158	n+d+a	180	3n+2a		

1-H-3	
MT16 (t,2n) or MT5 (He4 production)	2-He-3 MT28 (t,n+p) >>

H3 (t,2n) or He4 production log-log

H3 (t,2n) or He4 production lin-log
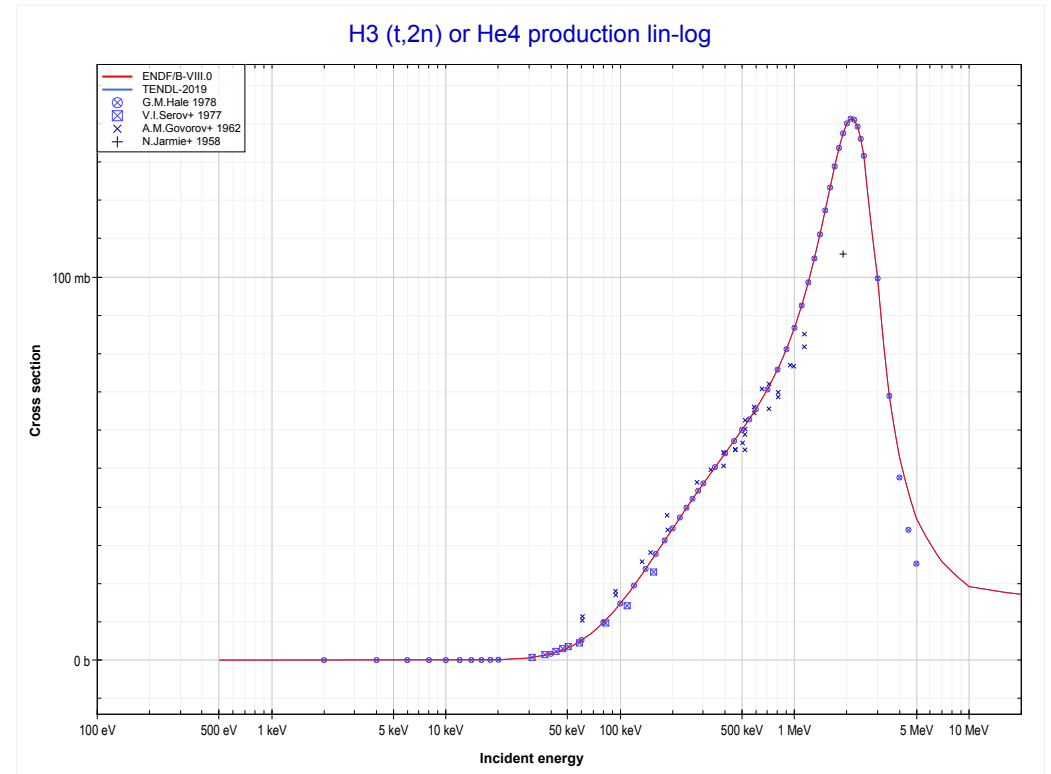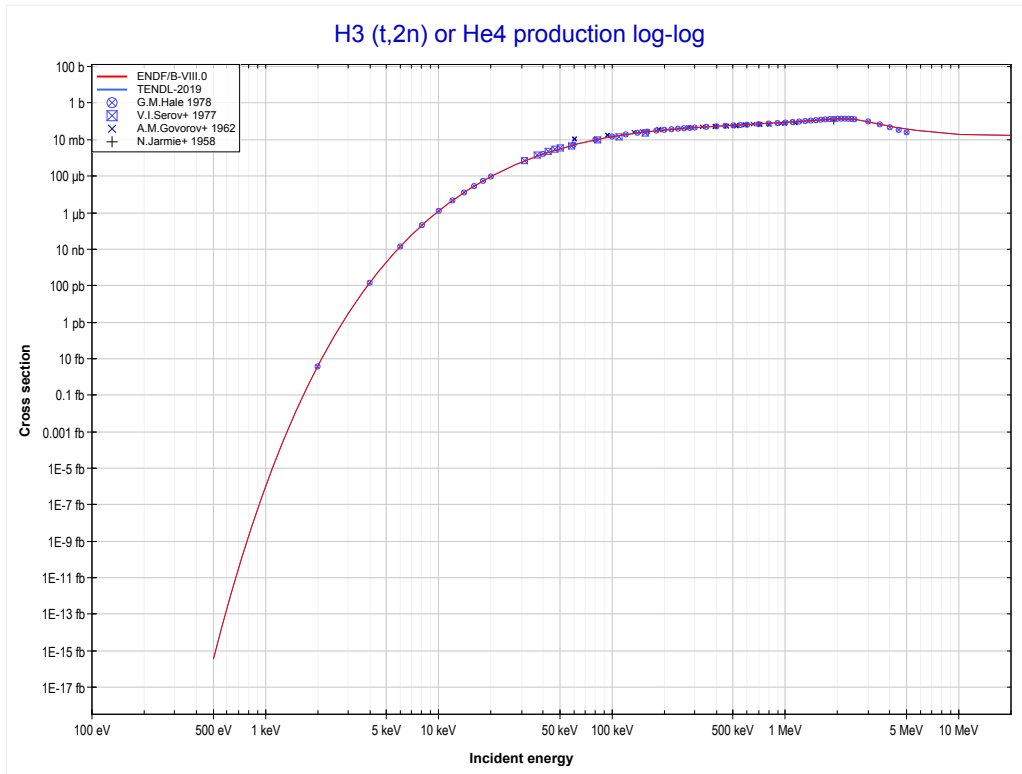
Reaction	Q-Value
H3(t,2n)He4	11332.07 keV

	2-He-3	
<< 1-H-3 MT16 (t,2n)	MT28 (t,n+p) or MT5 (He4 production)	3-Li-7 MT29 (t,n+2α) >>

He3 (t,n+p) or He4 production log-log

He3 (t,n+p) or He4 production lin-log
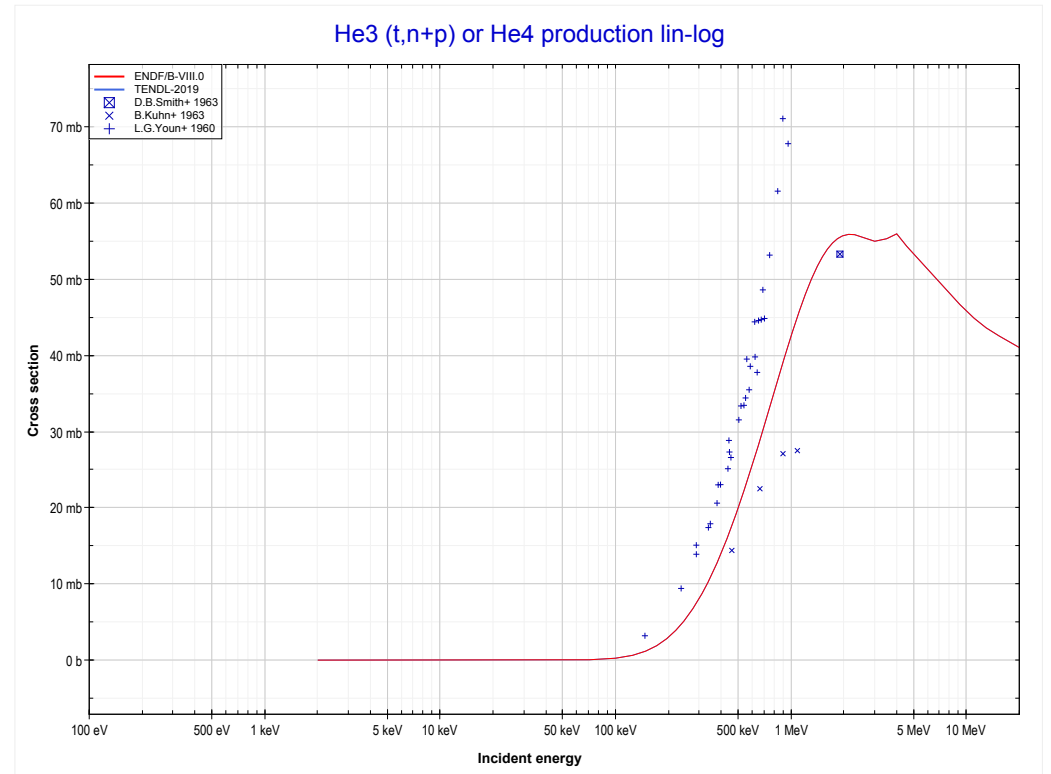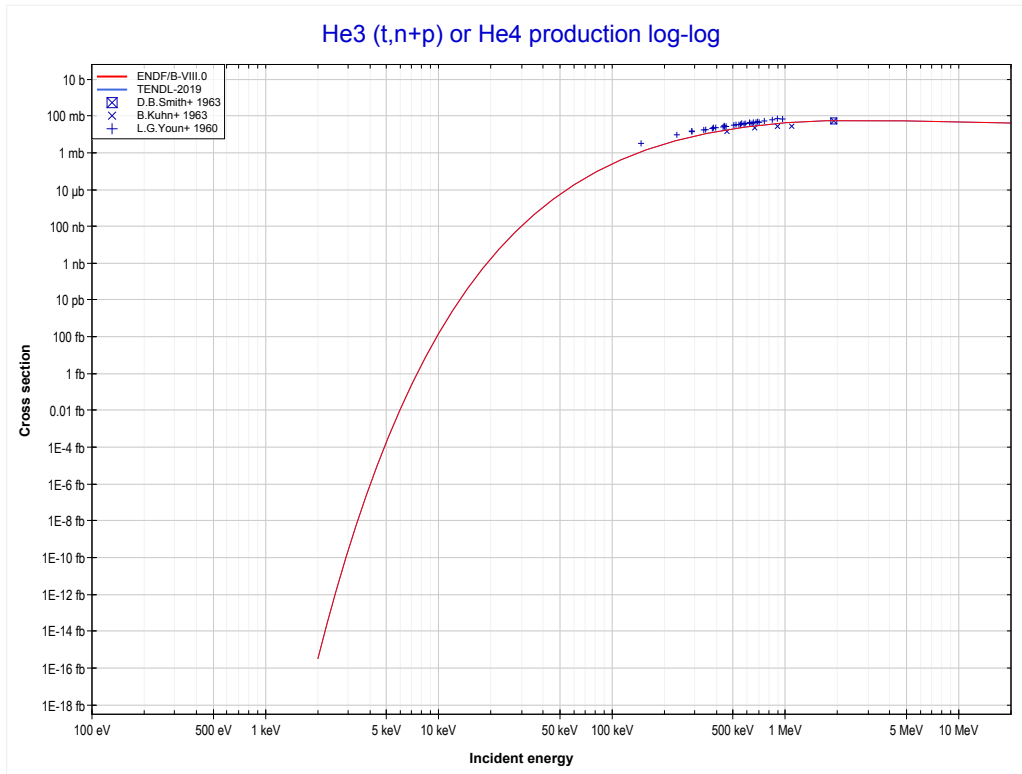
Reaction	Q-Value
He3(t,d)He4	14320.39 keV
He3(t,n+p)He4	12095.82 keV

	3-Li-7	
<< 2-He-3 MT28 (t,n+p)	**MT29 (t,n+2α) or MT5 (n production)**	MT103 (t,p) >>

Li7 (t,n+2α) or n production log-log

Li7 (t,n+2α) or n production lin-log

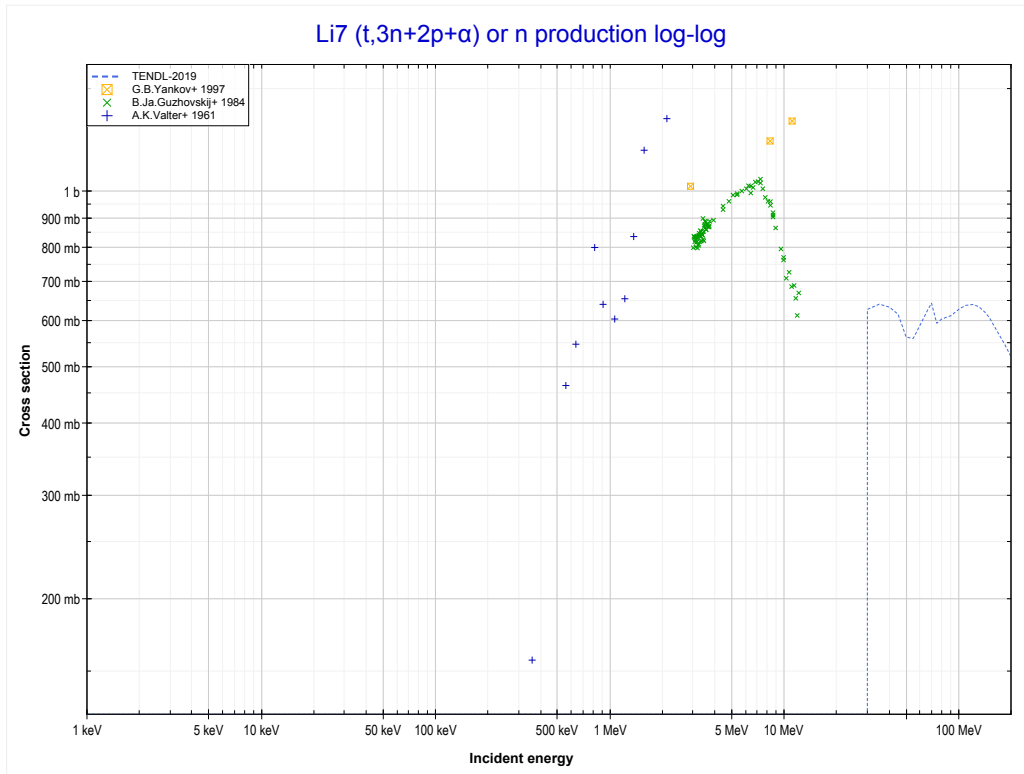| Reaction	Q-Value	Reaction	Q-Value
Li7(t,n+2α)n	8864.45 keV	Li7(t,p+d+2t)n	-28538.71 keV
Li7(t,d+t+α)n	-8724.85 keV	Li7(t,n+d+t+He3)n	-29302.47 keV
Li7(t,n+p+t+α)n	-10949.42 keV	Li7(t,n+2p+2t)n	-30763.28 keV
Li7(t,2n+He3+α)n	-11713.17 keV	Li7(t,2n+p+t+He3)n	-31527.03 keV
Li7(t,n+2d+α)n	-14982.08 keV	Li7(t,3n+2He3)n	-32290.79 keV
Li7(t,2n+p+d+α)n	-17206.64 keV	Li7(t,3d+t)n	-32571.38 keV
Li7(t,3n+2p+α)n	-19431.21 keV	Li7(t,n+p+2d+t)n	-34795.94 keV
Li7(t,2t+He3)n	-23045.24 keV	Li7(t,2n+2d+He3)n	-35559.70 keV

	3-Li-7	5-B-11 >>
<< MT29 (t,n+2α)	**MT103 (t,p) or MT5 (Li9 production)**	MT104 (t,d) >>

Li7 (t,p) or Li9 production log-log

Li7 (t,p) or Li9 production lin-log
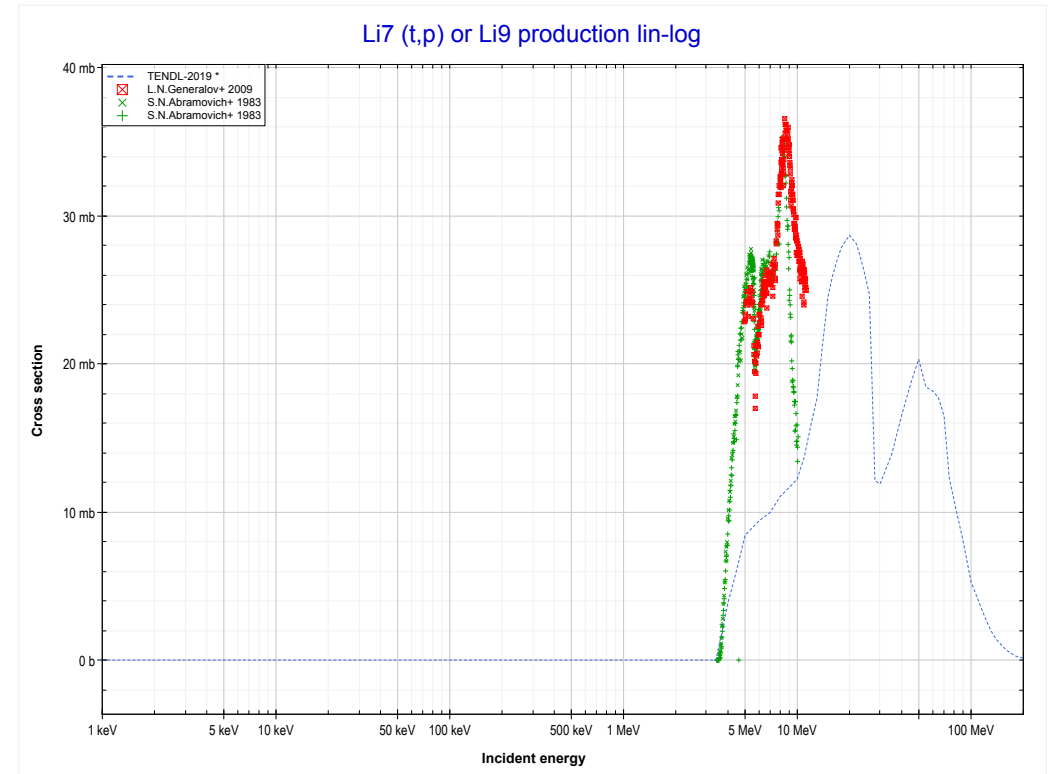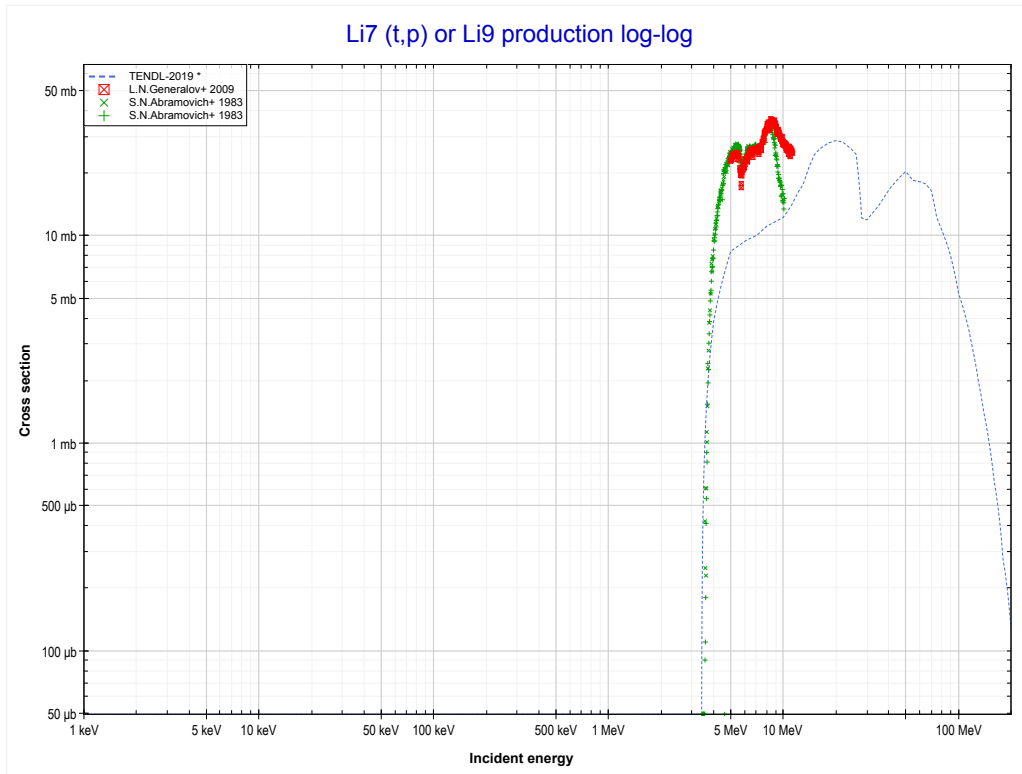
Reaction	Q-Value
Li7(t,p)Li9	-2386.96 keV

3-Li-7		79-Au-197 >>
<< MT103 (t,p)	**MT104 (t,d) or MT5 (Li8 production)**	MT199 (t,3n+2p+α) >>

Li7 (t,d) or Li8 production log-log

Li7 (t,d) or Li8 production lin-log
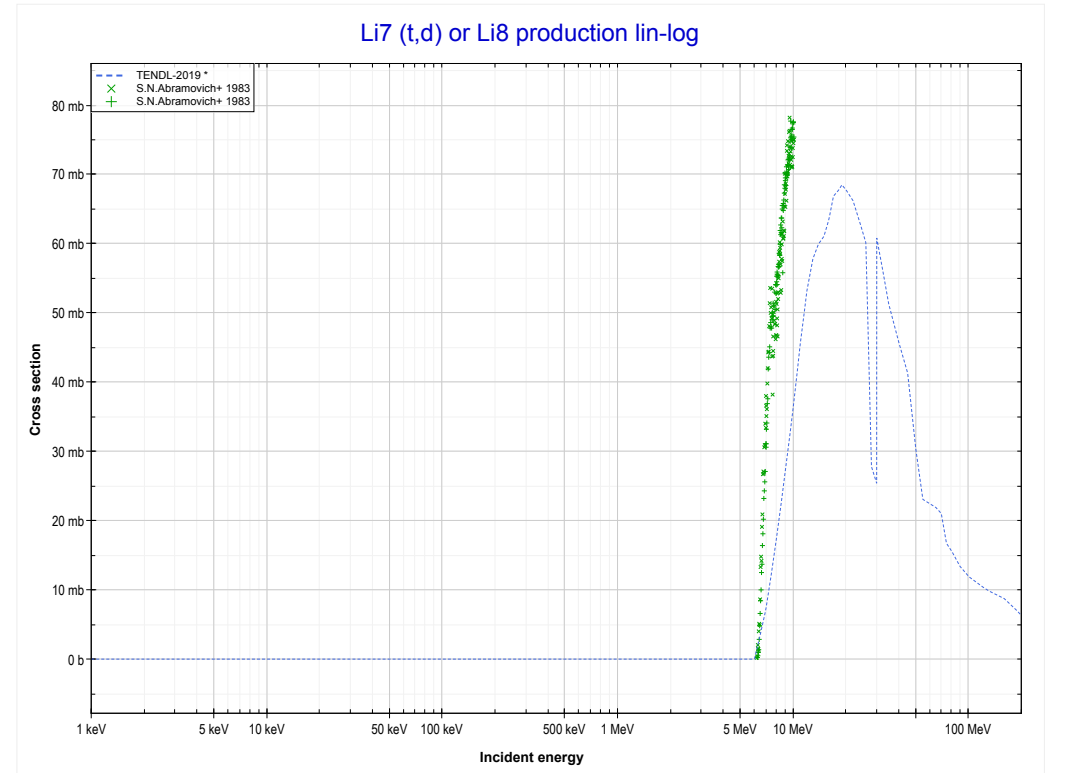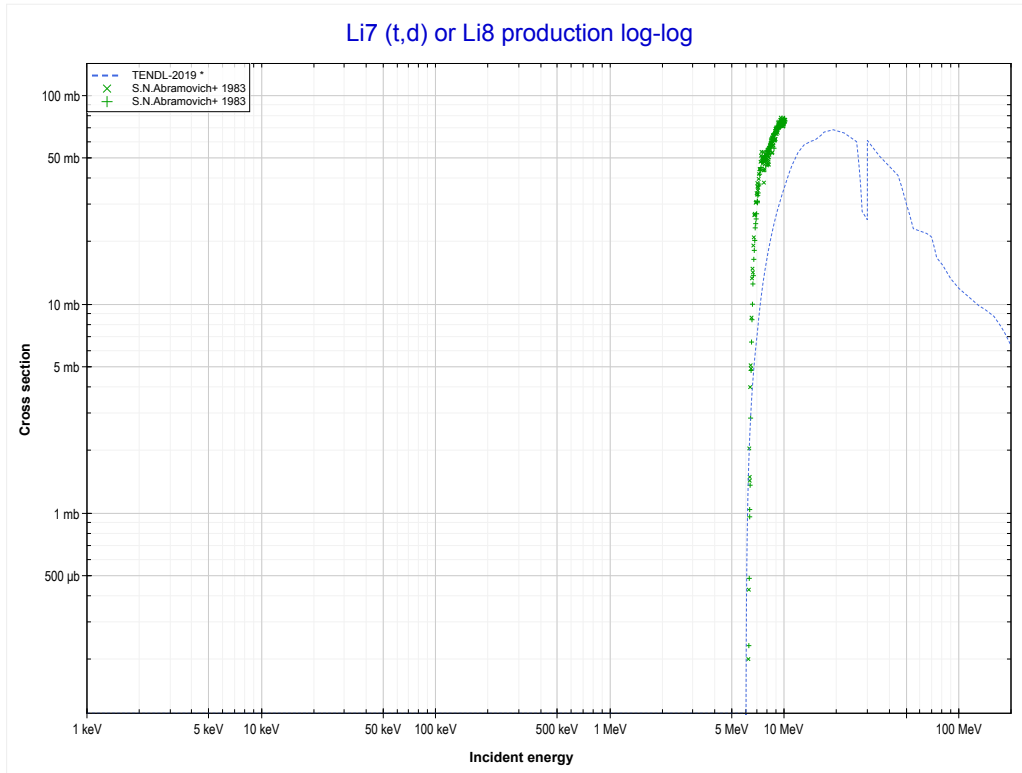
Reaction	Q-Value
Li7(t,d)Li8	-4224.61 keV
Li7(t,n+p)Li8	-6449.17 keV

	3-Li-7	
<< MT104 (t,d)	MT199 (t,3n+2p+α) or MT5 (n production)	4-Be-9 MT4 (t,n) >>

Li7 (t,3n+2p+α) or n production log-log

Li7 (t,3n+2p+α) or n production lin-log

Reaction	Q-Value	Reaction	Q-Value
Li7(t,n+2α)n	8864.45 keV	Li7(t,p+d+2t)n	-28538.71 keV
Li7(t,d+t+α)n	-8724.85 keV	Li7(t,n+d+t+He3)n	-29302.47 keV
Li7(t,n+p+t+α)n	-10949.42 keV	Li7(t,n+2p+2t)n	-30763.28 keV
Li7(t,2n+He3+α)n	-11713.17 keV	Li7(t,2n+p+t+He3)n	-31527.03 keV
Li7(t,n+2d+α)n	-14982.08 keV	Li7(t,3n+2He3)n	-32290.79 keV
Li7(t,2n+p+d+α)n	-17206.64 keV	Li7(t,3d+t)n	-32571.38 keV
Li7(t,3n+2p+α)n	-19431.21 keV	Li7(t,n+p+2d+t)n	-34795.94 keV
Li7(t,2t+He3)n	-23045.24 keV	Li7(t,2n+2d+He3)n	-35559.70 keV

4-Be-9		6-C-12 >>
<< 3-Li-7 MT199 (t,3n+2p+α)	**MT4 (t,n) or MT5 (B11 production)**	MT35 (t,n+d+2α) >>

Be9 (t,n) or B11 production log-log
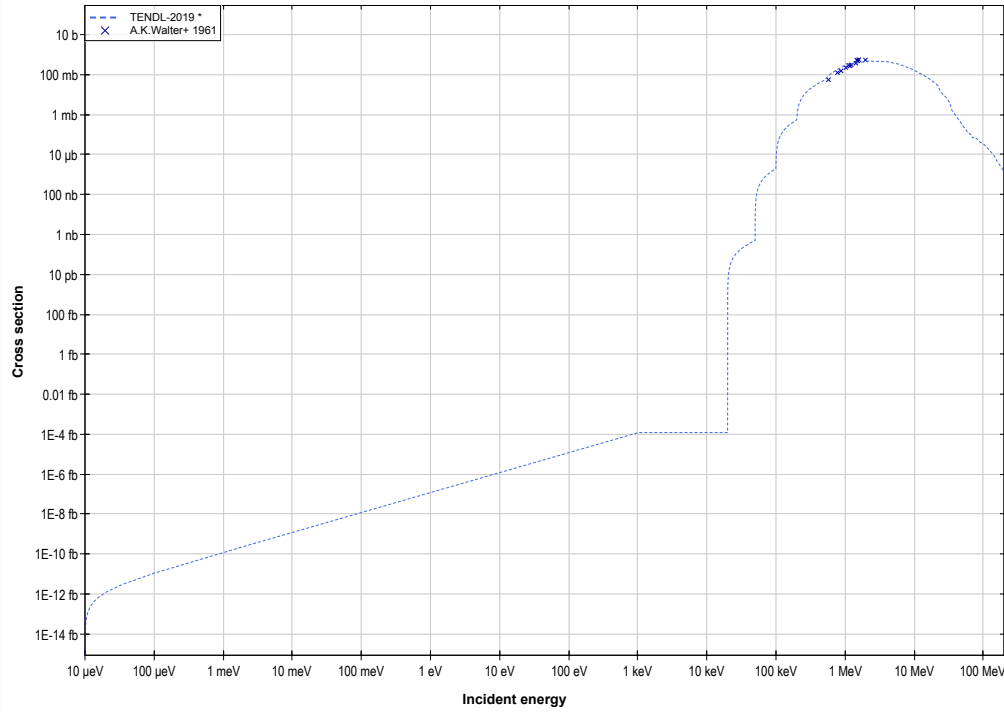
Be9 (t,n) or B11 production lin-log
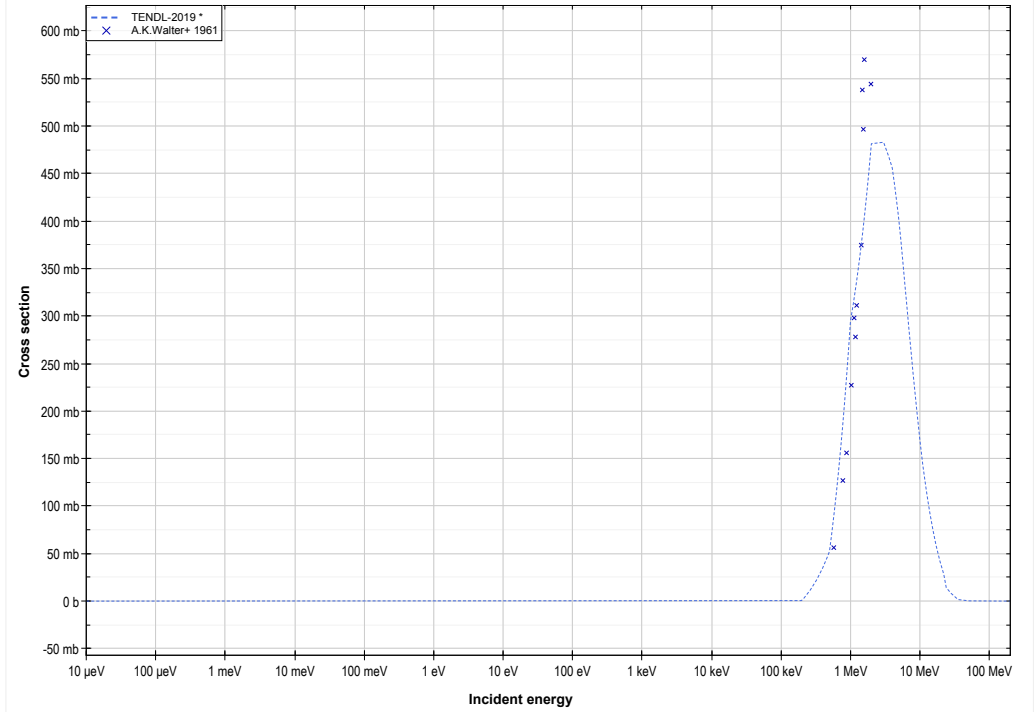
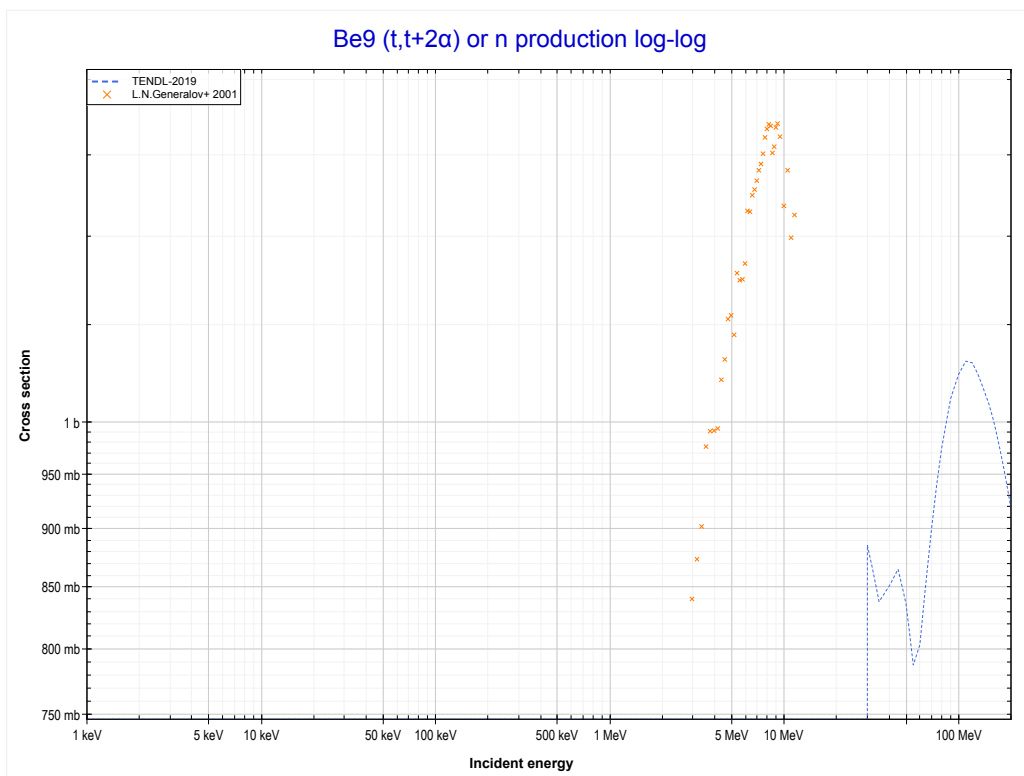| Reaction	Q-Value
Be9(t,n)B11	9559.24 keV

	4-Be-9	
<< MT4 (t,n)	MT35 (t,n+d+2α) or MT5 (n production)	MT113 (t,t+2α) >>

Be9 (t,n+d+2α) or n production log-log

Be9 (t,n+d+2α) or n production lin-log

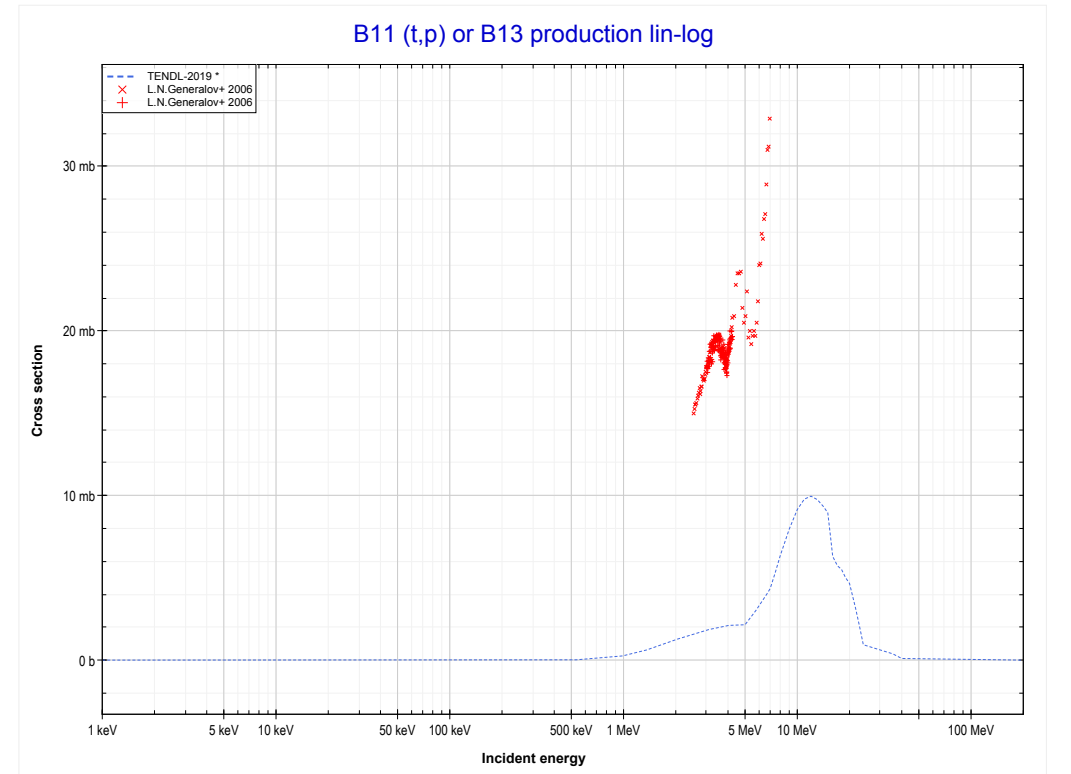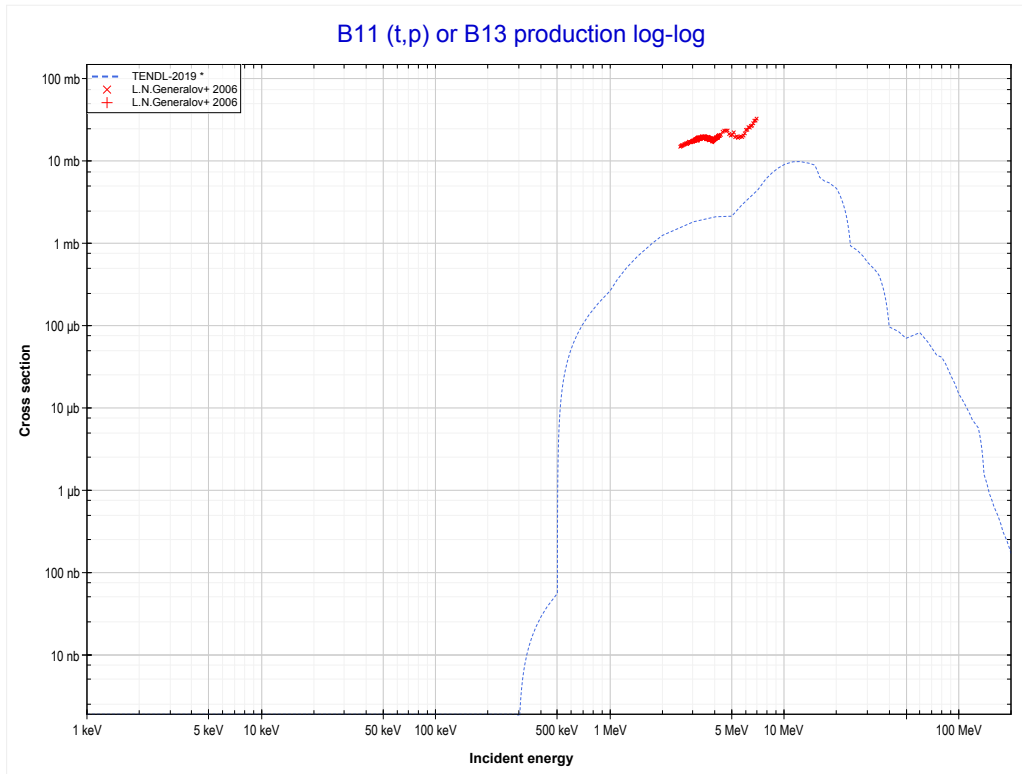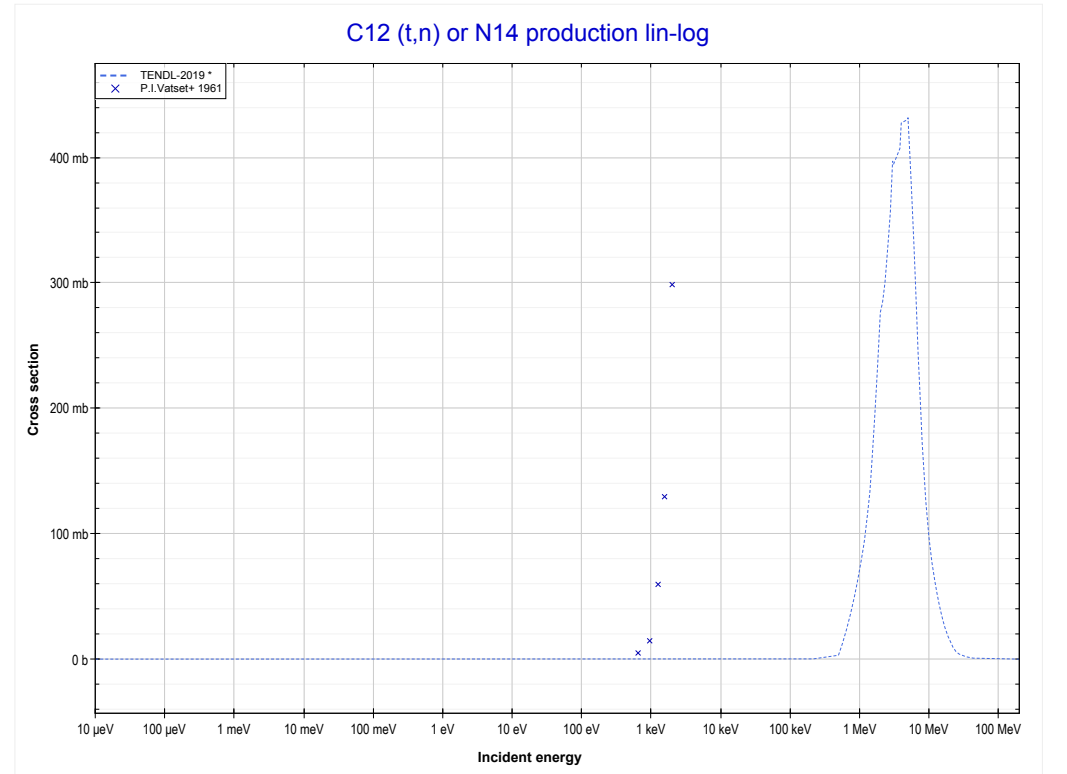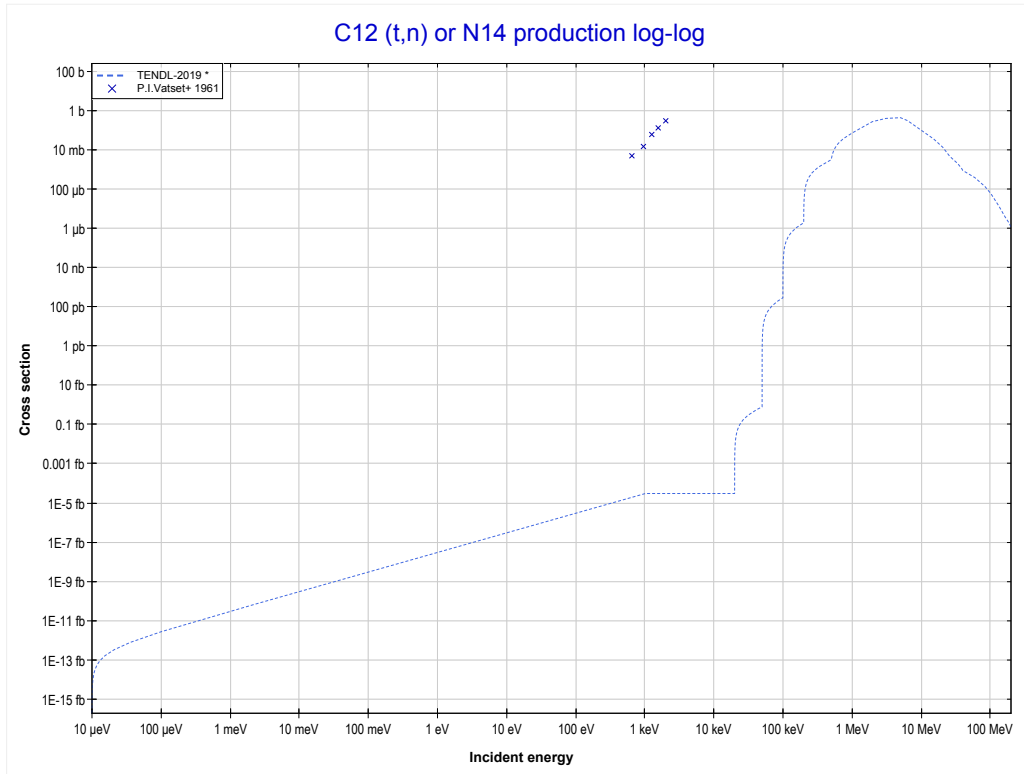| Reaction	Q-Value	Reaction	Q-Value
Be9(t,t+2α)n	-1572.70 keV	Be9(t,2n+2p+t+α)n	-29868.36 keV
Be9(t,n+d+2α)n	-7829.93 keV	Be9(t,3n+p+He3+α)n	-30632.11 keV
Be9(t,2n+p+2α)n	-10054.49 keV	Be9(t,n+3d+α)n	-31676.46 keV
Be9(t,p+2t+α)n	-21386.56 keV	Be9(t,2n+p+2d+α)n	-33901.02 keV
Be9(t,n+t+He3+α)n	-22150.32 keV	Be9(t,3n+2p+d+α)n	-36125.59 keV
Be9(t,2d+t+α)n	-25419.23 keV	Be9(t,4n+3p+α)n	-38350.15 keV
Be9(t,n+p+d+t+α)n	-27643.79 keV	Be9(t,d+2t+He3)n	-39739.62 keV
Be9(t,2n+d+He3+α)n	-28407.55 keV	Be9(t,2p+3t)n	-41200.43 keV

4-Be-9		
<< MT35 (t,n+d+2α)	**MT113 (t,t+2α) or MT5 (n production)**	5-B-10 MT112 (t,p+α) >>

Be9 (t,t+2α) or n production log-log

Be9 (t,t+2α) or n production lin-log

Reaction	Q-Value	Reaction	Q-Value
Be9(t,t+2α)n	-1572.70 keV	Be9(t,2n+2p+t+α)n	-29868.36 keV
Be9(t,n+d+2α)n	-7829.93 keV	Be9(t,3n+p+He3+α)n	-30632.11 keV
Be9(t,2n+p+2α)n	-10054.49 keV	Be9(t,n+3d+α)n	-31676.46 keV
Be9(t,p+2t+α)n	-21386.56 keV	Be9(t,2n+p+2d+α)n	-33901.02 keV
Be9(t,n+t+He3+α)n	-22150.32 keV	Be9(t,3n+2p+d+α)n	-36125.59 keV
Be9(t,2d+t+α)n	-25419.23 keV	Be9(t,4n+3p+α)n	-38350.15 keV
Be9(t,n+p+d+t+α)n	-27643.79 keV	Be9(t,d+2t+He3)n	-39739.62 keV
Be9(t,2n+d+He3+α)n	-28407.55 keV	Be9(t,2p+3t)n	-41200.43 keV

	5-B-10	
<< 4-Be-9 MT113 (t,t+2α)	MT112 (t,p+α) or MT5 (Li8 production)	5-B-11 MT103 (t,p) >>

B10 (t,p+α) or Li8 production log-log

B10 (t,p+α) or Li8 production lin-log
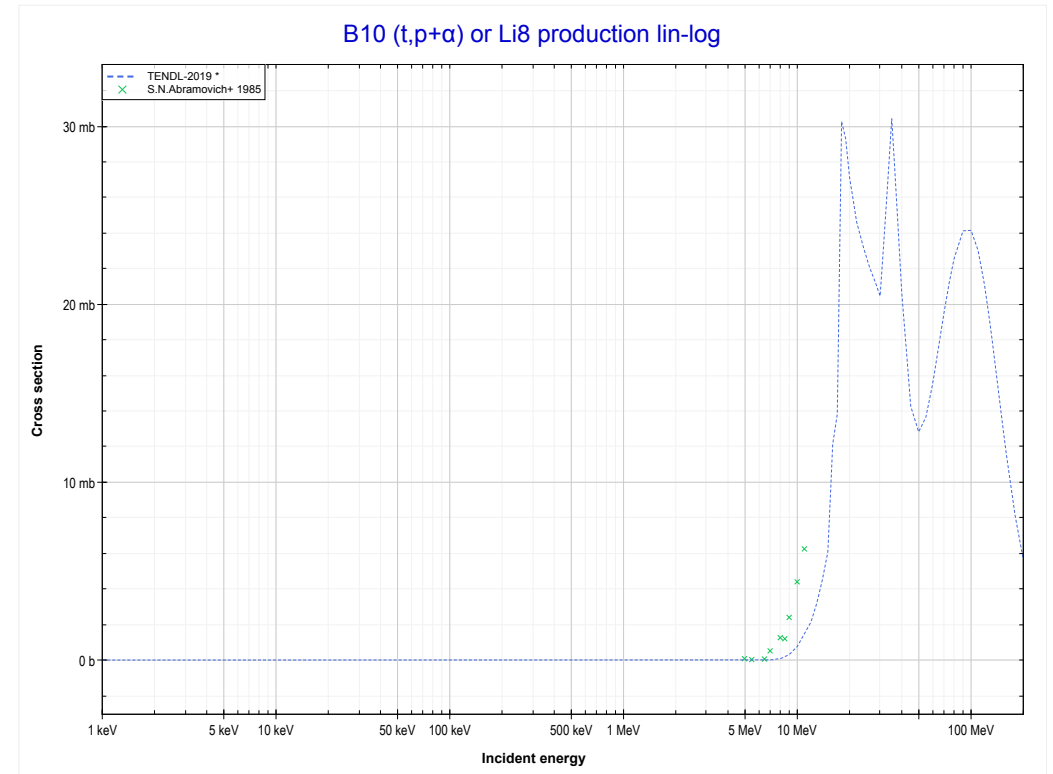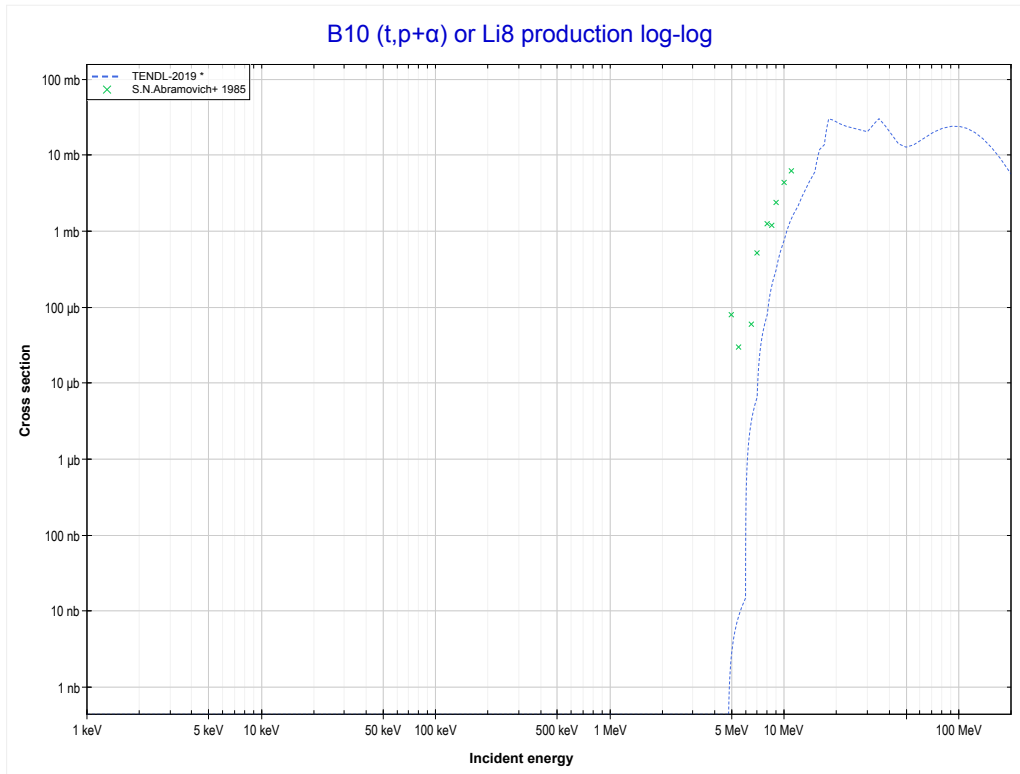
Reaction	Q-Value
B10(t,p+α)Li8	-3659.27 keV
B10(t,d+He3)Li8	-22012.32 keV
B10(t,2p+t)Li8	-23473.13 keV
B10(t,n+p+He3)Li8	-24236.89 keV
B10(t,p+2d)Li8	-27505.80 keV
B10(t,n+2p+d)Li8	-29730.36 keV
B10(t,2n+3p)Li8	-31954.93 keV

<< 3-Li-7	5-B-11	6-C-12 >>
<< 5-B-10 MT112 (t,p+α)	MT103 (t,p) or MT5 (B13 production)	6-C-12 MT4 (t,n) >>

B11 (t,p) or B13 production log-log

B11 (t,p) or B13 production lin-log

Reaction	Q-Value
B11(t,p)B13	-233.35 keV

<< 4-Be-9	6-C-12	8-O-16 >>
<< 5-B-11 MT103 (t,p)	MT4 (t,n) or MT5 (N14 production)	MT103 (t,p) >>

C12 (t,n) or N14 production log-log

C12 (t,n) or N14 production lin-log

Reaction	Q-Value
C12(t,n)N14	4015.08 keV

<< 5-B-11	6-C-12	8-O-17 >>
<< MT4 (t,n)	**MT103 (t,p) or MT5 (C14 production)**	MT107 (t,α) >>

C12 (t,p) or C14 production log-log
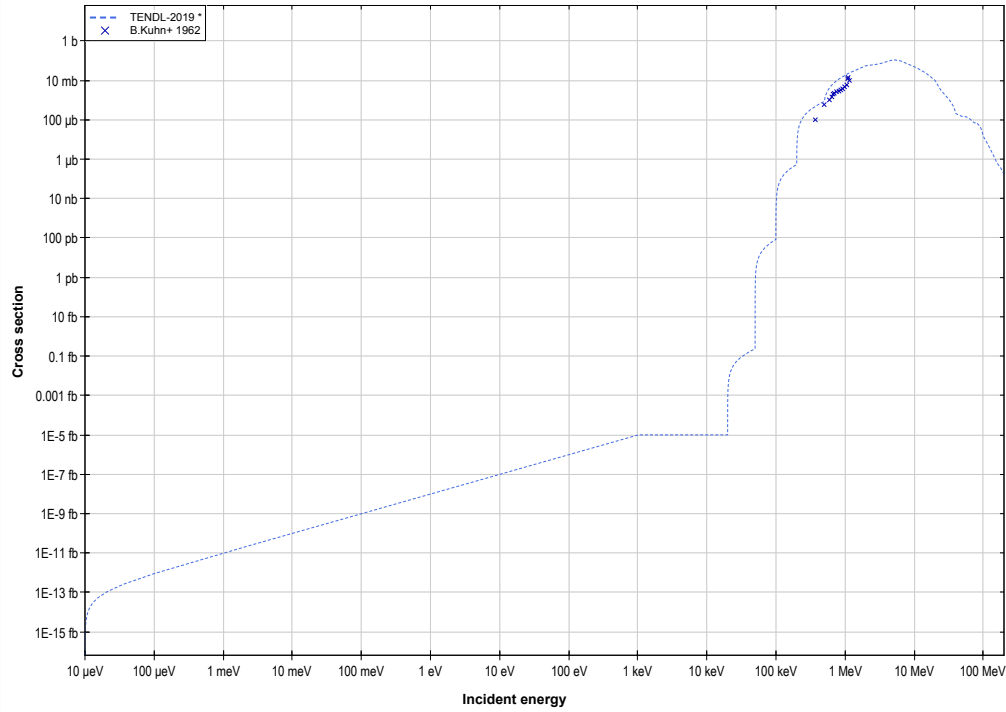
C12 (t,p) or C14 production lin-log
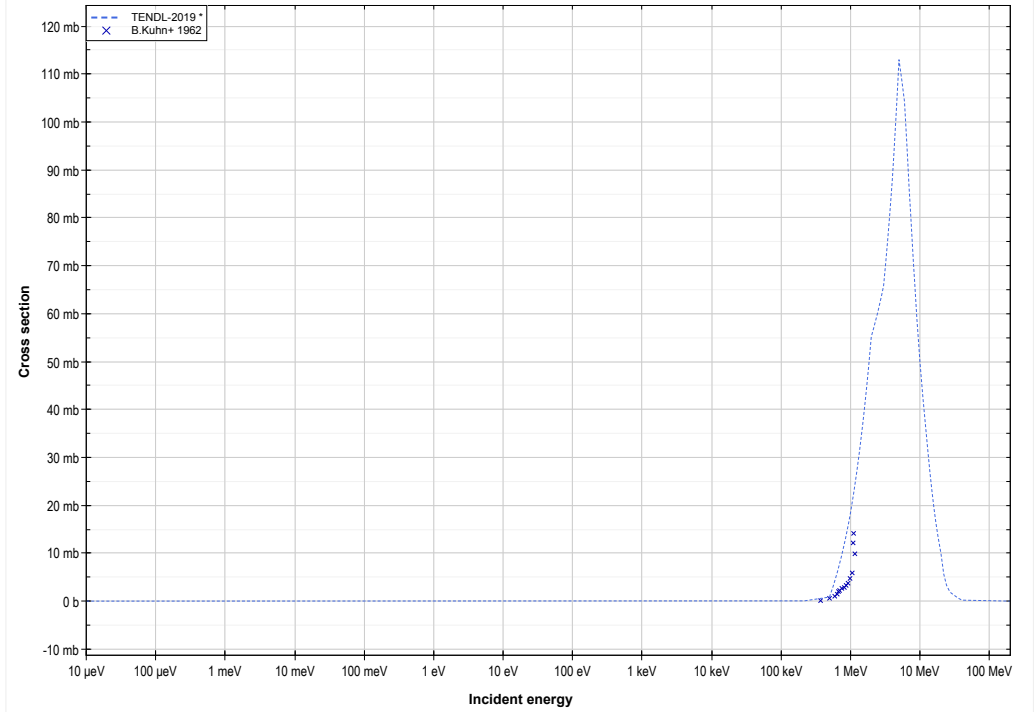
Reaction	Q-Value
C12(t,p)C14	4640.95 keV

	6-C-12	22-Ti-48 >>
<< MT103 (t,p)	**MT107 (t,α) or MT5 (B11 production)**	8-O-16 MT4 (t,n) >>

C12 (t,α) or B11 production log-log

C12 (t,α) or B11 production lin-log
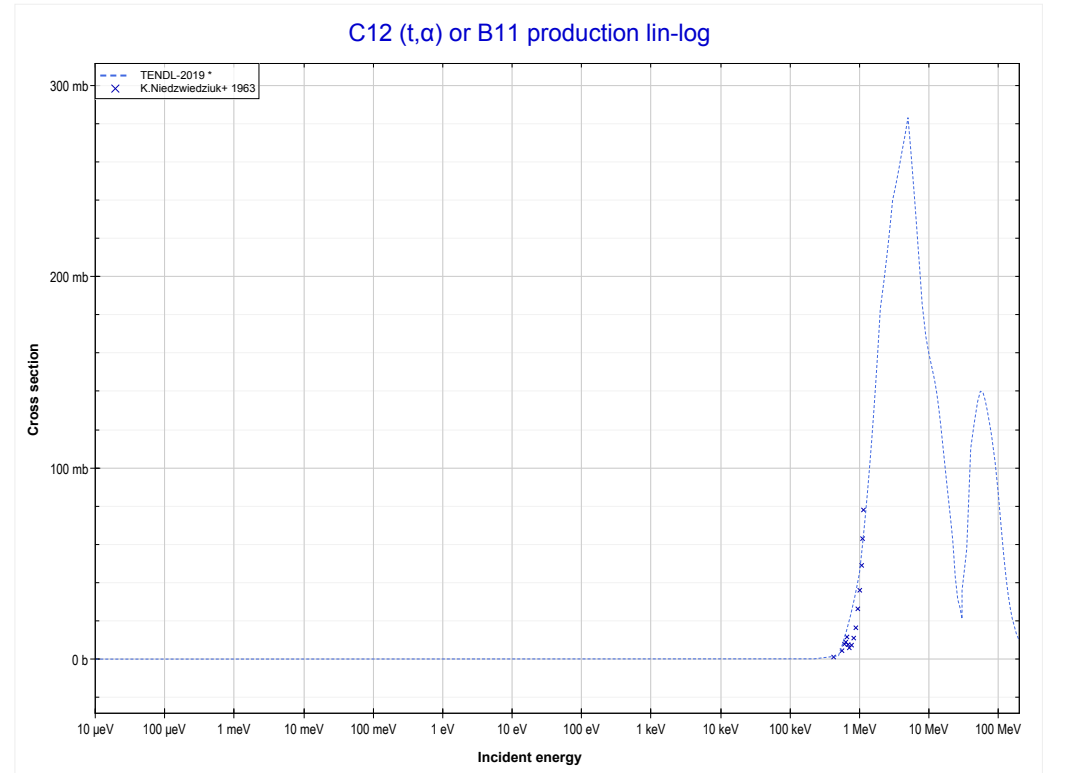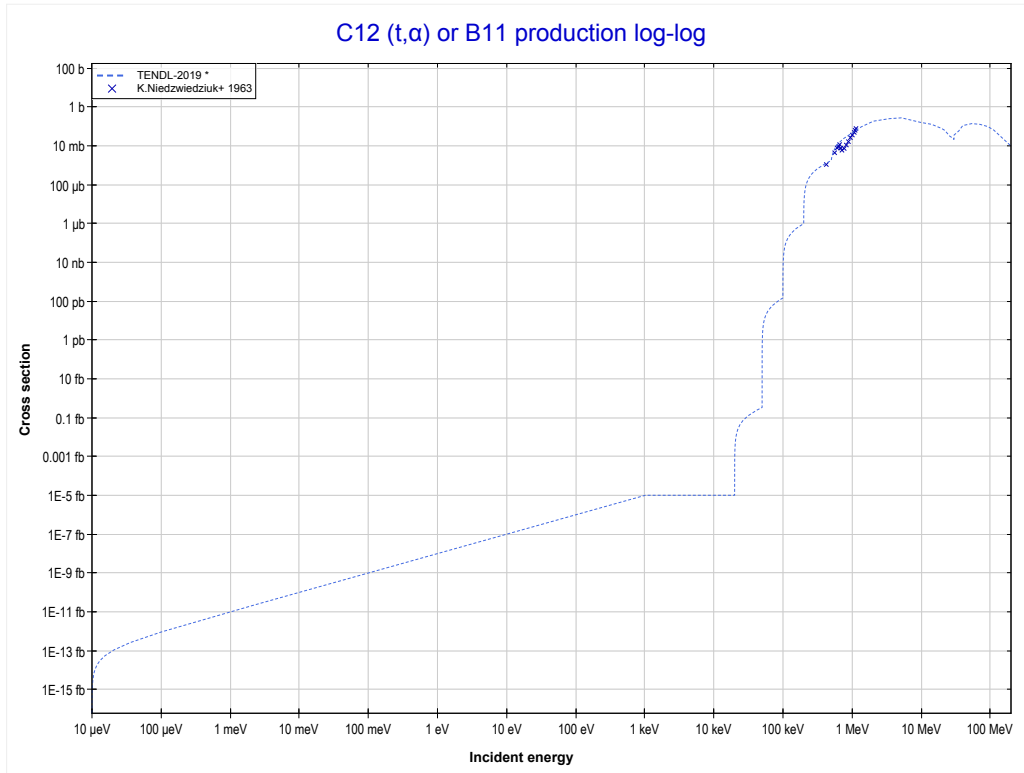
Reaction	Q-Value
C12(t,α)B11	3857.19 keV
C12(t,p+t)B11	-15956.68 keV
C12(t,n+He3)B11	-16720.43 keV
C12(t,2d)B11	-19989.34 keV
C12(t,n+p+d)B11	-22213.91 keV
C12(t,2n+2p)B11	-24438.47 keV

<< 6-C-12	**8-O-16**	
<< 6-C-12 MT107 (t,α)	**MT4 (t,n) or MT5 (F18 production)**	8-O-17 MT103 (t,p) >>

O16 (t,n) or F18 production log-log

O16 (t,n) or F18 production lin-log
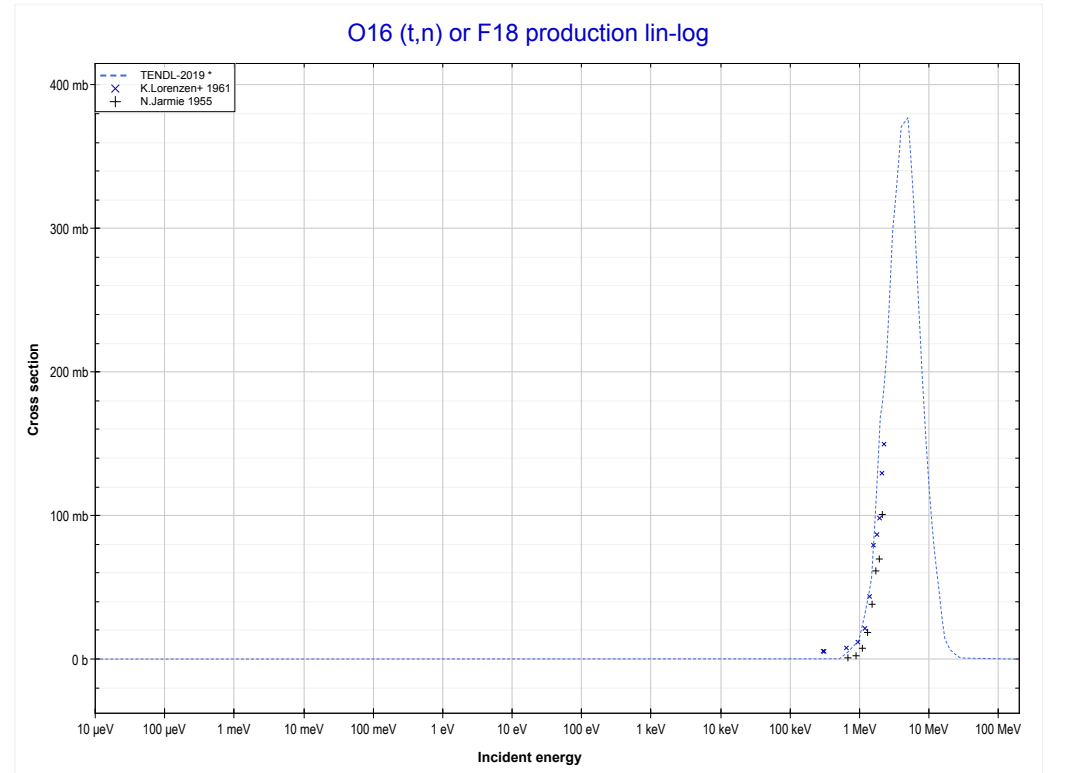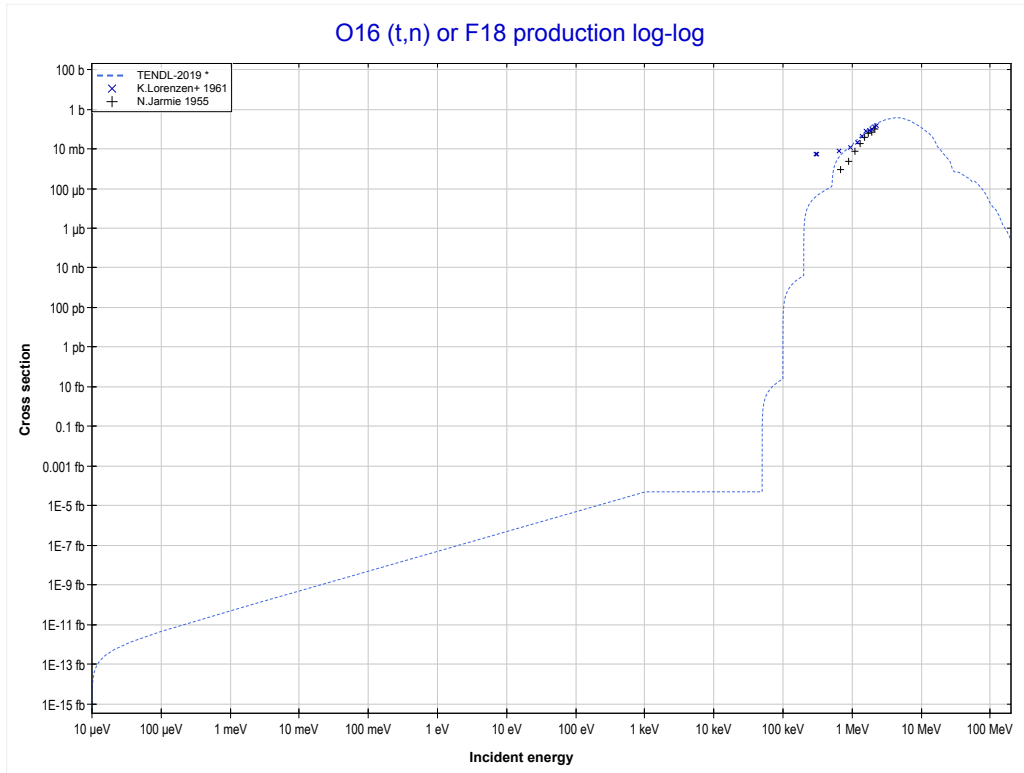
Reaction	Q-Value
O16(t,n)F18	1268.39 keV

<< 6-C-12	**8-O-17**	
<< 8-O-16 MT4 (t,n)	**MT103 (t,p) or MT5 (O19 production)**	13-Al-27 MT45 (t,n+p+α) >>

O17 (t,p) or O19 production log-log

O17 (t,p) or O19 production lin-log
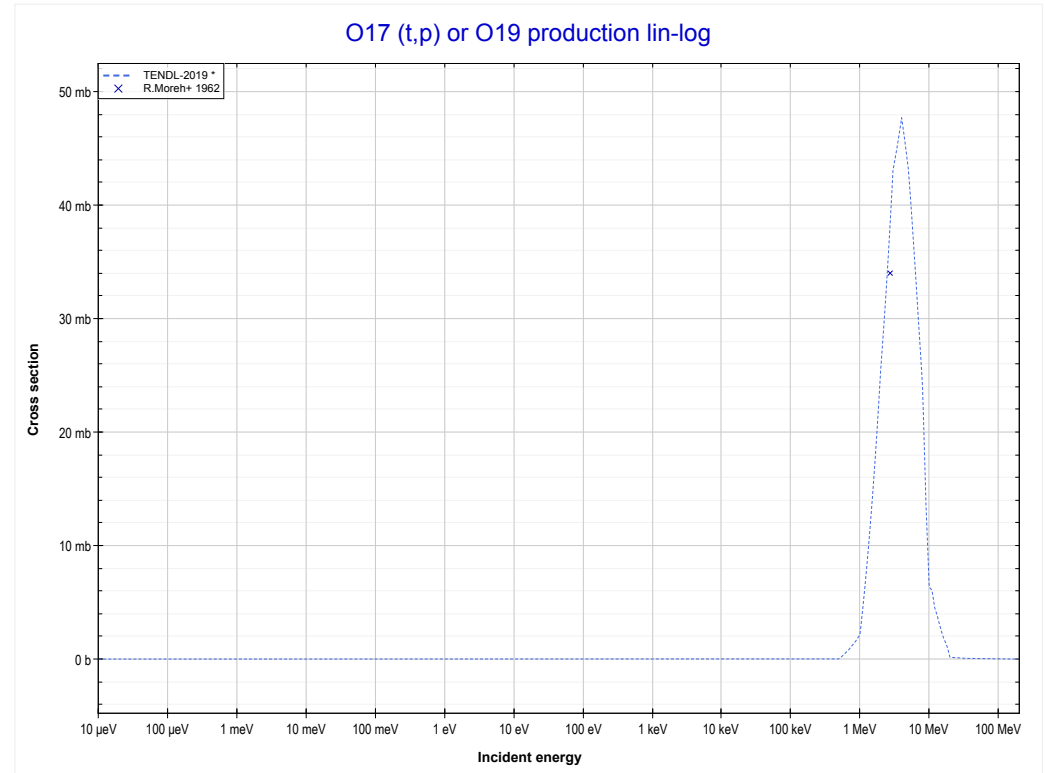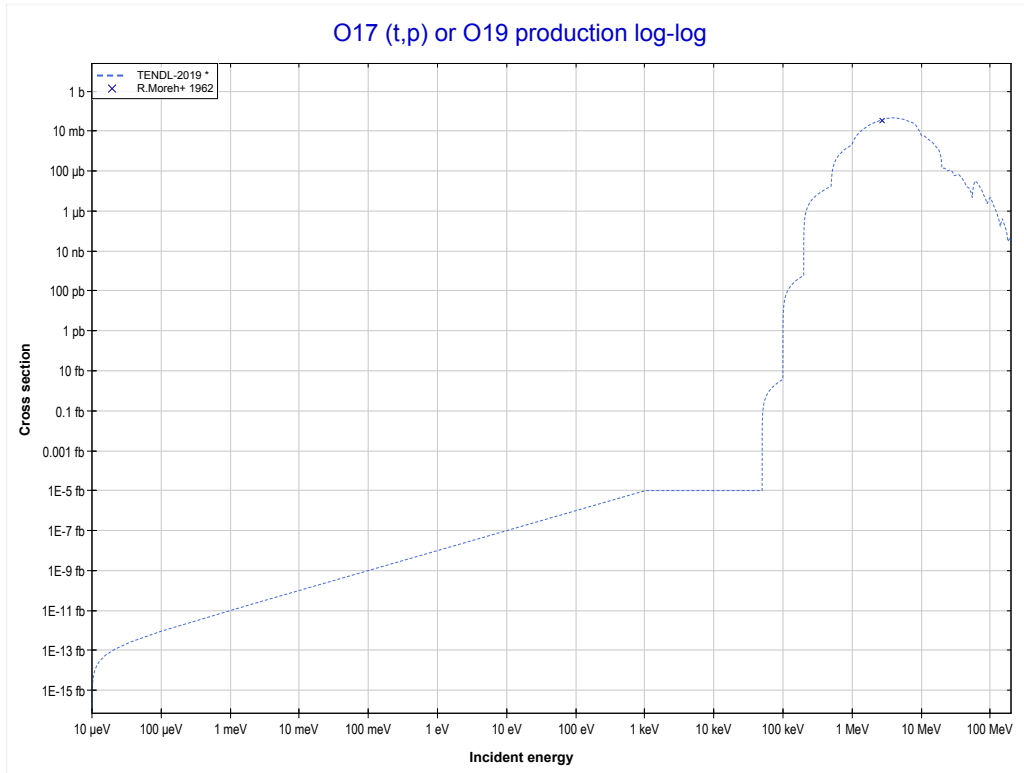
Reaction	Q-Value
O17(t,p)O19	3519.18 keV

	13-Al-27	
<< 8-O-17 MT103 (t,p)	**MT45 (t,n+p+α) or MT5 (Na24 production)**	MT111 (t,2p) >>

Al27 (t,n+p+α) or Na24 production log-log

Al27 (t,n+p+α) or Na24 production lin-log

Reaction	Q-Value	Reaction	Q-Value
Al27(t,d+α)Na24	-9389.79 keV	Al27(t,n+p+2d)Na24	-35460.88 keV
Al27(t,n+p+α)Na24	-11614.35 keV	Al27(t,2n+2p+d)Na24	-37685.45 keV
Al27(t,t+He3)Na24	-23710.18 keV	Al27(t,3n+3p)Na24	-39910.01 keV
Al27(t,p+d+t)Na24	-29203.65 keV		
Al27(t,n+d+He3)Na24	-29967.41 keV		
Al27(t,n+2p+t)Na24	-31428.22 keV		
Al27(t,2n+p+He3)Na24	-32191.97 keV		
Al27(t,3d)Na24	-33236.31 keV		

	13-AI-27	
<< MT45 (t,n+p+α)	MT111 (t,2p) or MT5 (Mg28 production)	MT117 (t,d+α) >>

Al27 (t,2p) or Mg28 production log-log

Al27 (t,2p) or Mg28 production lin-log
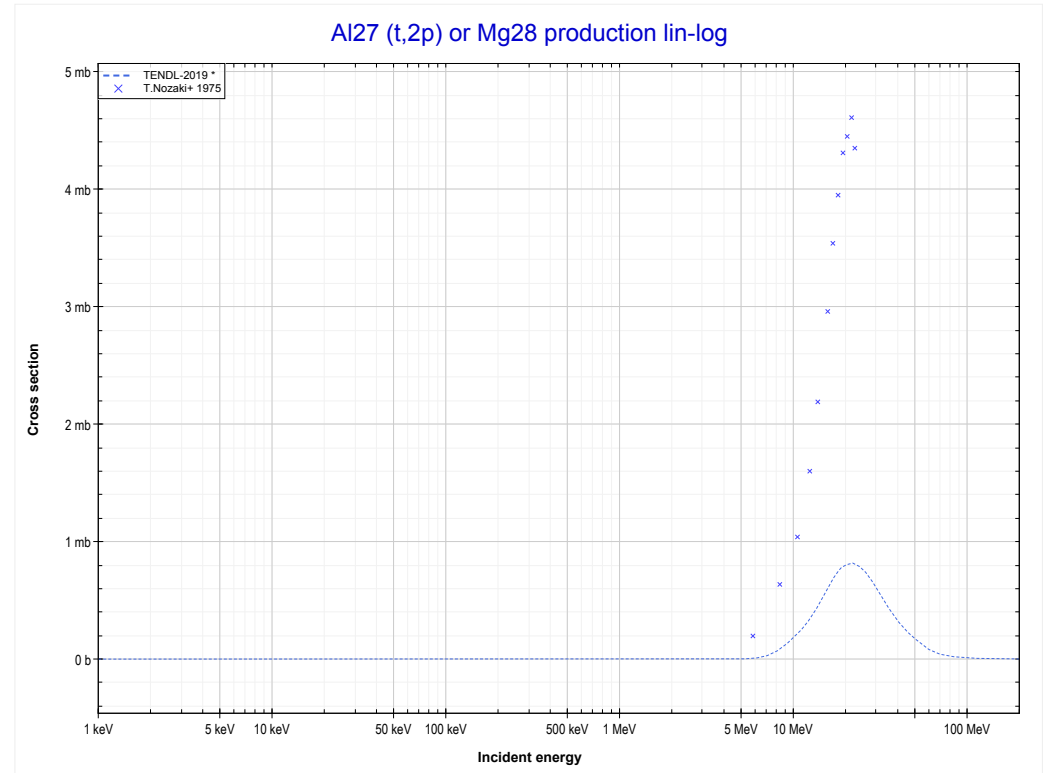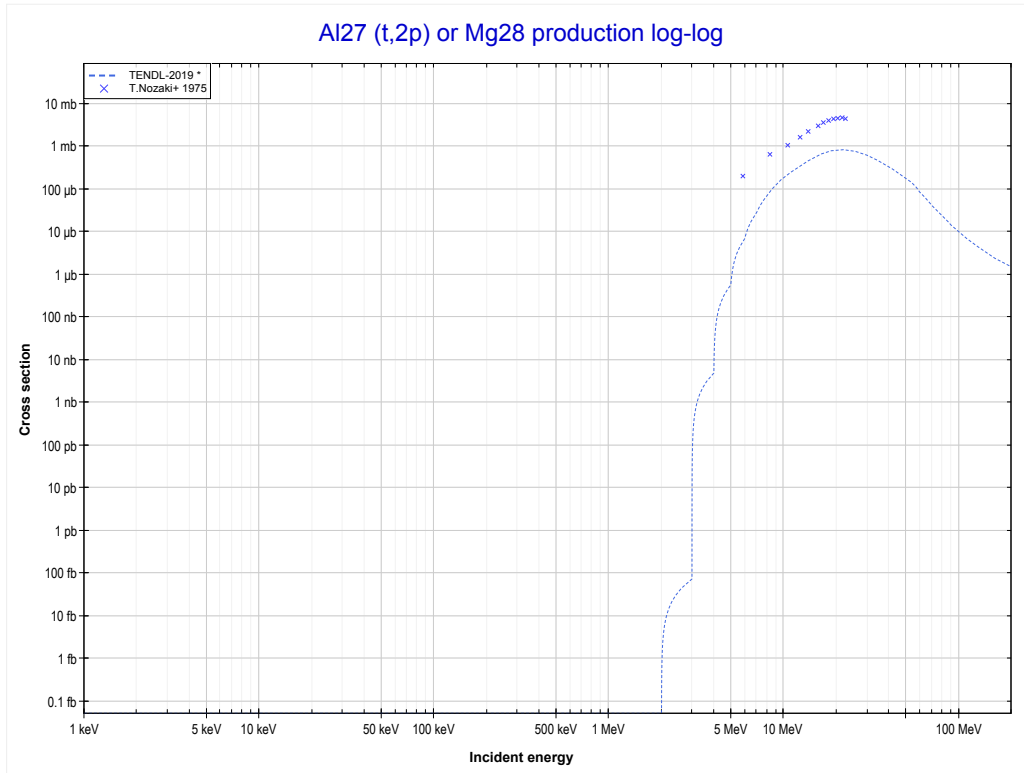
Reaction	Q-Value
Al27(t,2p)Mg28	-1806.19 keV

	13-Al-27	
<< MT111 (t,2p)	**MT117 (t,d+α) or MT5 (Na24 production)**	MT187 (t,n+d+³He) >>

Al27 (t,d+α) or Na24 production log-log

Al27 (t,d+α) or Na24 production lin-log

Reaction	Q-Value	Reaction	Q-Value
Al27(t,d+α)Na24	-9389.79 keV	Al27(t,n+p+2d)Na24	-35460.88 keV
Al27(t,n+p+α)Na24	-11614.35 keV	Al27(t,2n+2p+d)Na24	-37685.45 keV
Al27(t,t+He3)Na24	-23710.18 keV	Al27(t,3n+3p)Na24	-39910.01 keV
Al27(t,p+d+t)Na24	-29203.65 keV		
Al27(t,n+d+He3)Na24	-29967.41 keV		
Al27(t,n+2p+t)Na24	-31428.22 keV		
Al27(t,2n+p+He3)Na24	-32191.97 keV		
Al27(t,3d)Na24	-33236.31 keV		

13-AI-27		
<< MT117 (t,d+α)	**MT187 (t,n+d+³He) or MT5 (Na24 production)**	22-Ti-48 MT107 (t,α) >>

Al27 (t,n+d+³He) or Na24 production log-log

Al27 (t,n+d+³He) or Na24 production lin-log

Reaction	Q-Value	Reaction	Q-Value
Al27(t,d+α)Na24	-9389.79 keV	Al27(t,n+p+2d)Na24	-35460.88 keV
Al27(t,n+p+α)Na24	-11614.35 keV	Al27(t,2n+2p+d)Na24	-37685.45 keV
Al27(t,t+He3)Na24	-23710.18 keV	Al27(t,3n+3p)Na24	-39910.01 keV
Al27(t,p+d+t)Na24	-29203.65 keV		
Al27(t,n+d+He3)Na24	-29967.41 keV		
Al27(t,n+2p+t)Na24	-31428.22 keV		
Al27(t,2n+p+He3)Na24	-32191.97 keV		
Al27(t,3d)Na24	-33236.31 keV		

<< 6-C-12	22-Ti-48	
<< 13-Al-27 MT187 (t,n+d+³He)	MT107 (t,α) or MT5 (Sc47 production)	56-Ba-138 MT102 (t,γ) >>

Ti48 (t,α) or Sc47 production log-log

Ti48 (t,α) or Sc47 production lin-log
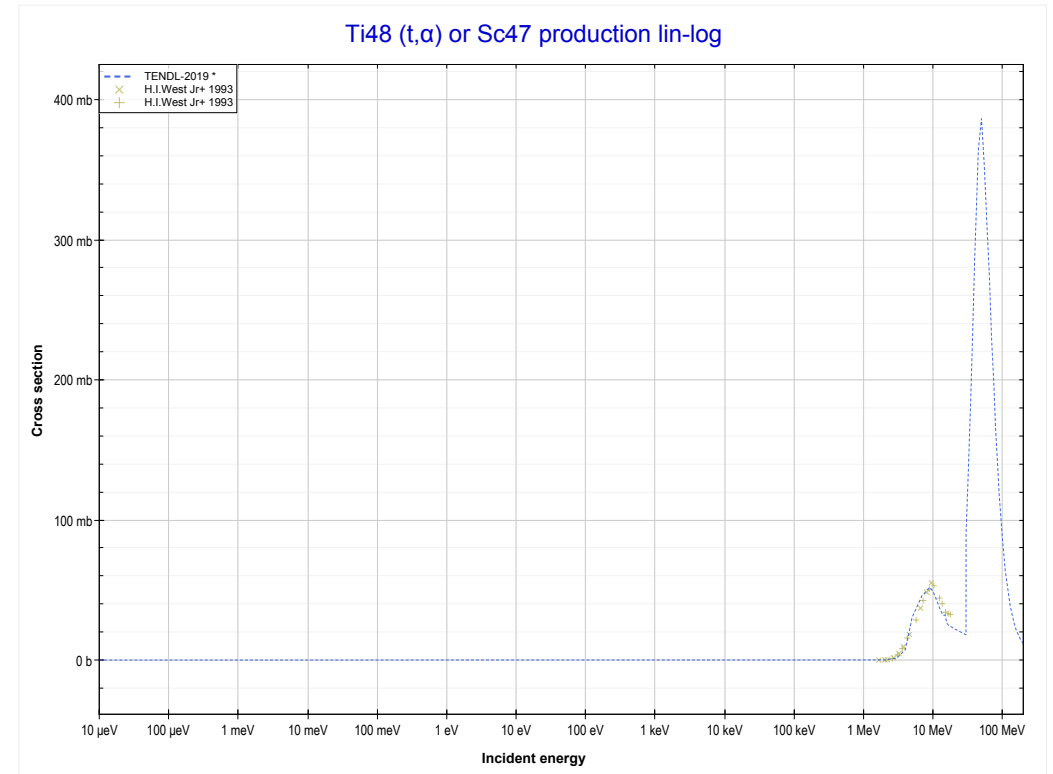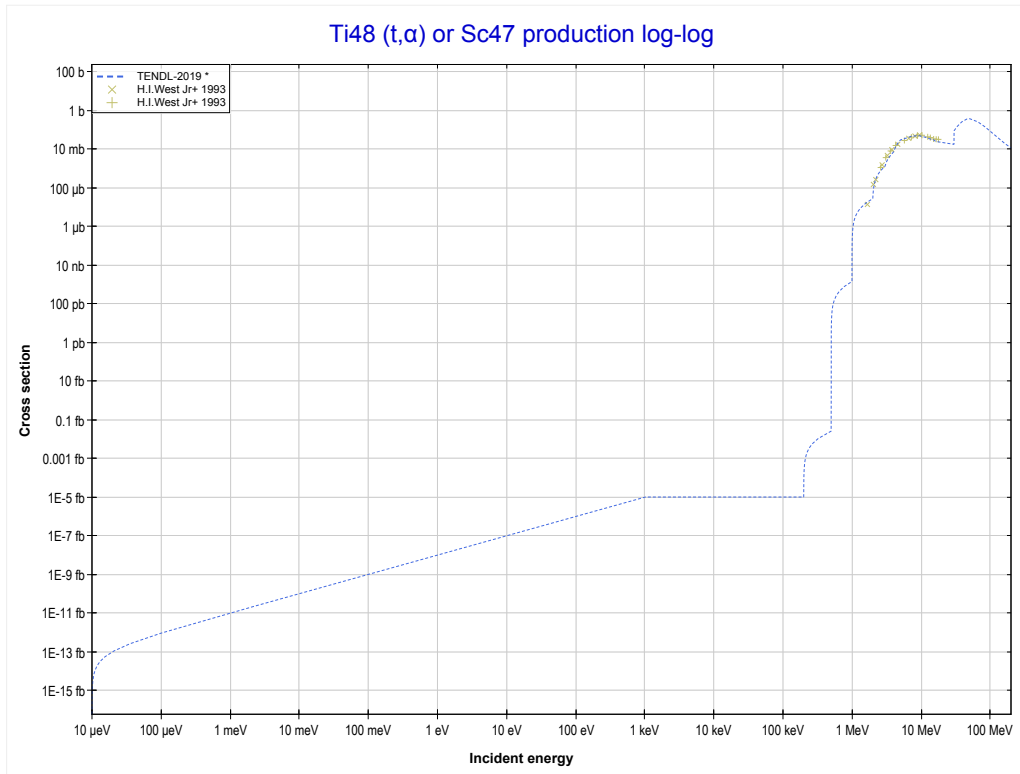
Reaction	Q-Value
Ti48(t,α)Sc47	8368.78 keV
Ti48(t,p+t)Sc47	-11445.08 keV
Ti48(t,n+He3)Sc47	-12208.84 keV
Ti48(t,2d)Sc47	-15477.74 keV
Ti48(t,n+p+d)Sc47	-17702.31 keV
Ti48(t,2n+2p)Sc47	-19926.88 keV

	56-Ba-138	
<< 22-Ti-48 MT107 (t,α)	MT102 (t,γ) or MT5 (La141 production)	79-Au-197 MT104 (t,d) >>

Ba138 (t,γ) or La141 production log-log

Ba138 (t,γ) or La141 production lin-log
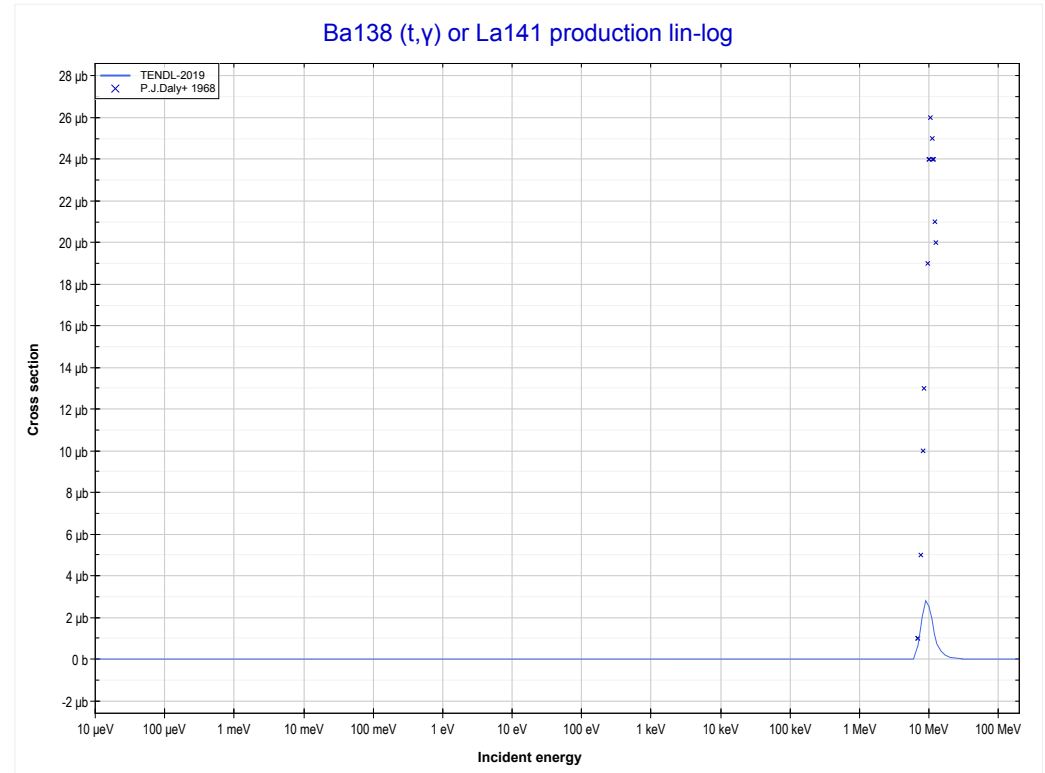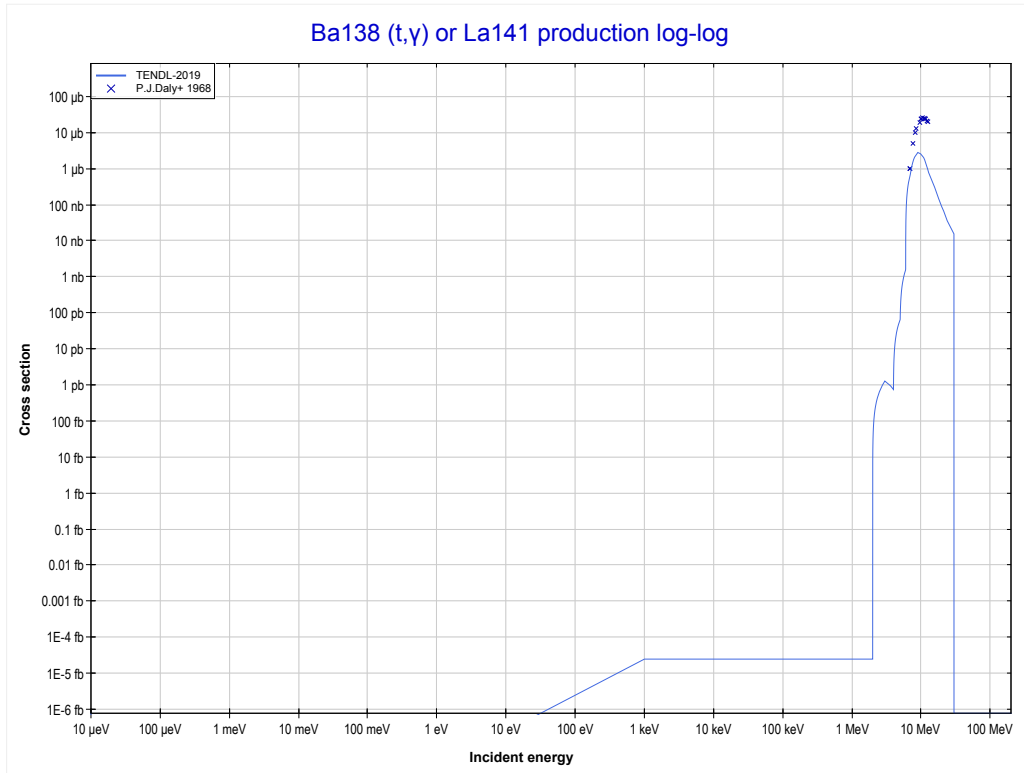
Reaction	Q-Value
Ba138(t,γ)La141	9620.21 keV

<< 3-Li-7	**79-Au-197**	
<< 56-Ba-138 MT102 (t,γ)	**MT104 (t,d) or MT5 (Au198 production)**	90-Th-232 MT18 (t,fission) >>

Au197 (t,d) or Au198 production log-log

Au197 (t,d) or Au198 production lin-log
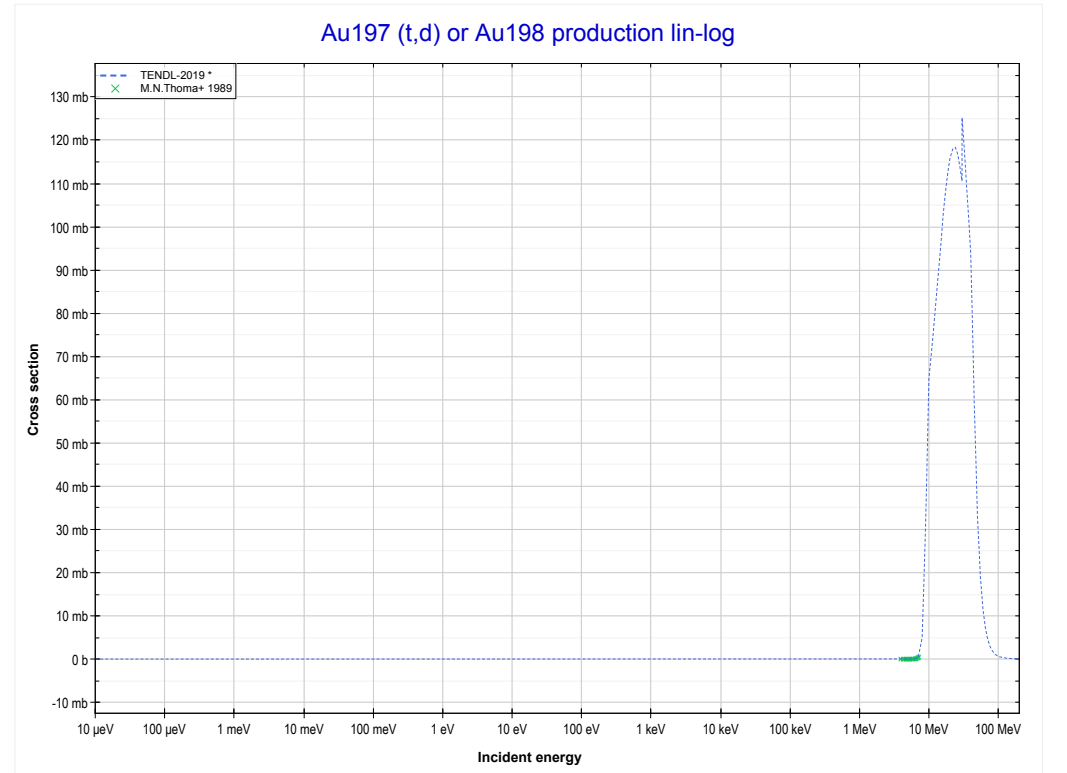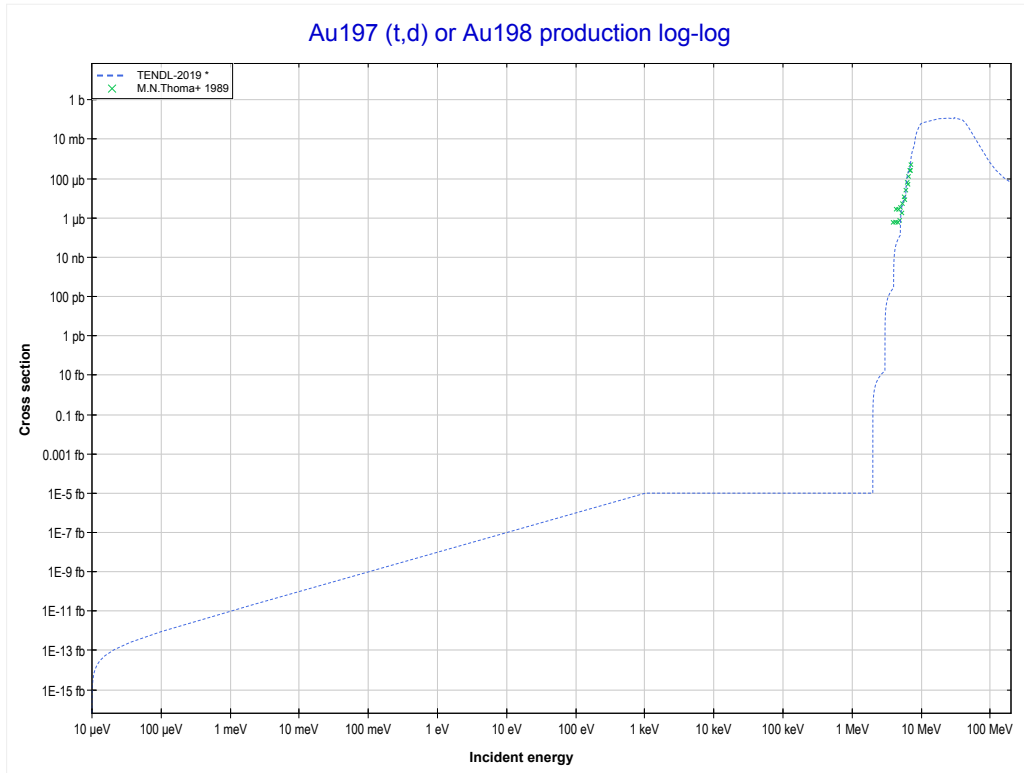
Reaction	Q-Value
Au197(t,d)Au198	255.19 keV
Au197(t,n+p)Au198	-1969.38 keV

>> 90-Th-232 >>		92-U-233 >>
<< 79-Au-197 MT104 (t,d)	**MT18 (t,fission)**	92-U-233 MT18 (t,fission) >>

Th232 (t,fission) log-log

Th232 (t,fission) lin-log
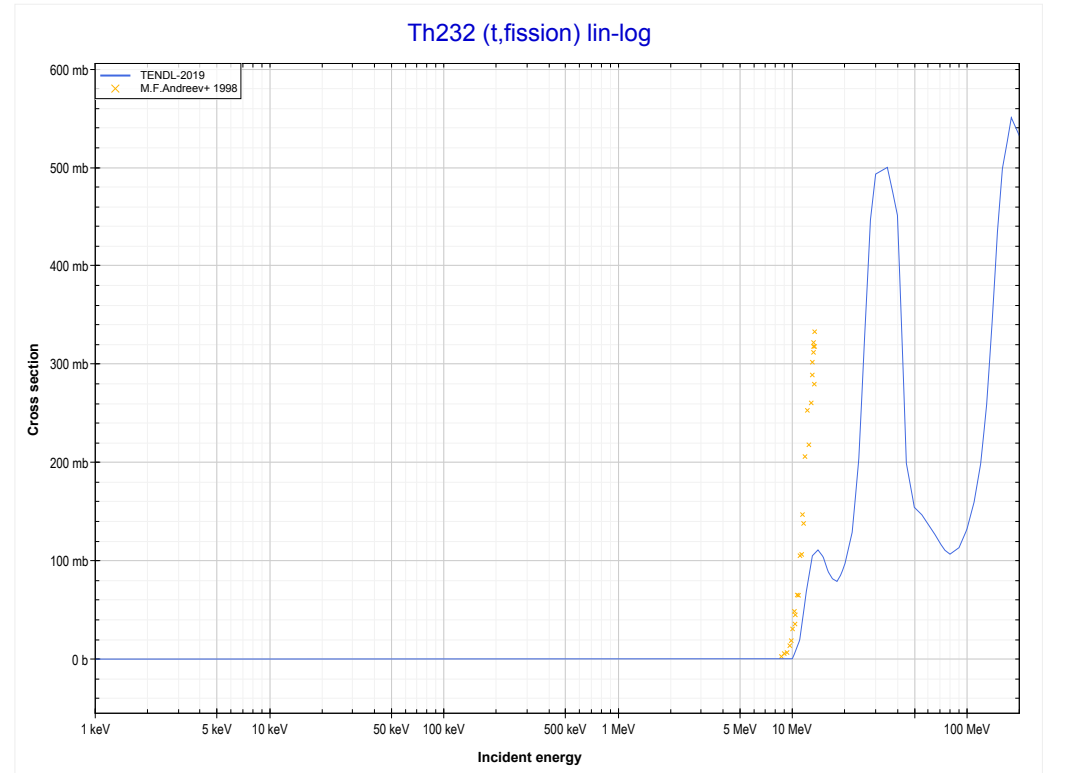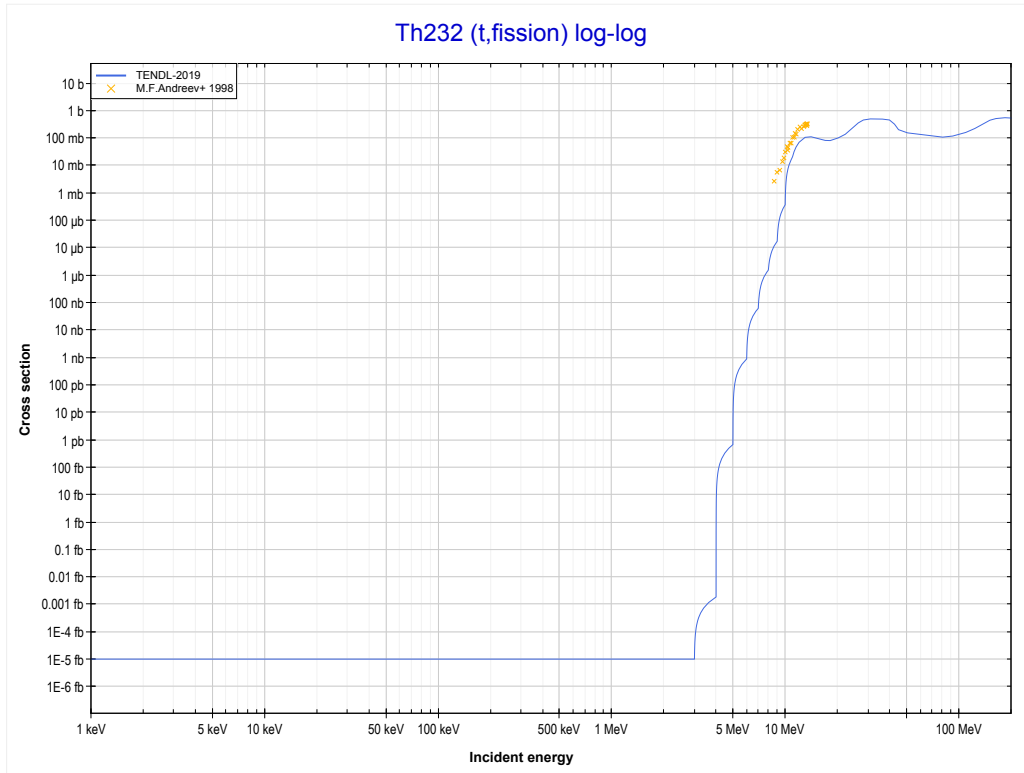
<< 90-Th-232	**92-U-233**	92-U-235 >>
<< 90-Th-232 MT18 (t,fission)	**MT18 (t,fission)**	92-U-235 MT18 (t,fission) >>

U233 (t,fission) log-log

U233 (t,fission) lin-log
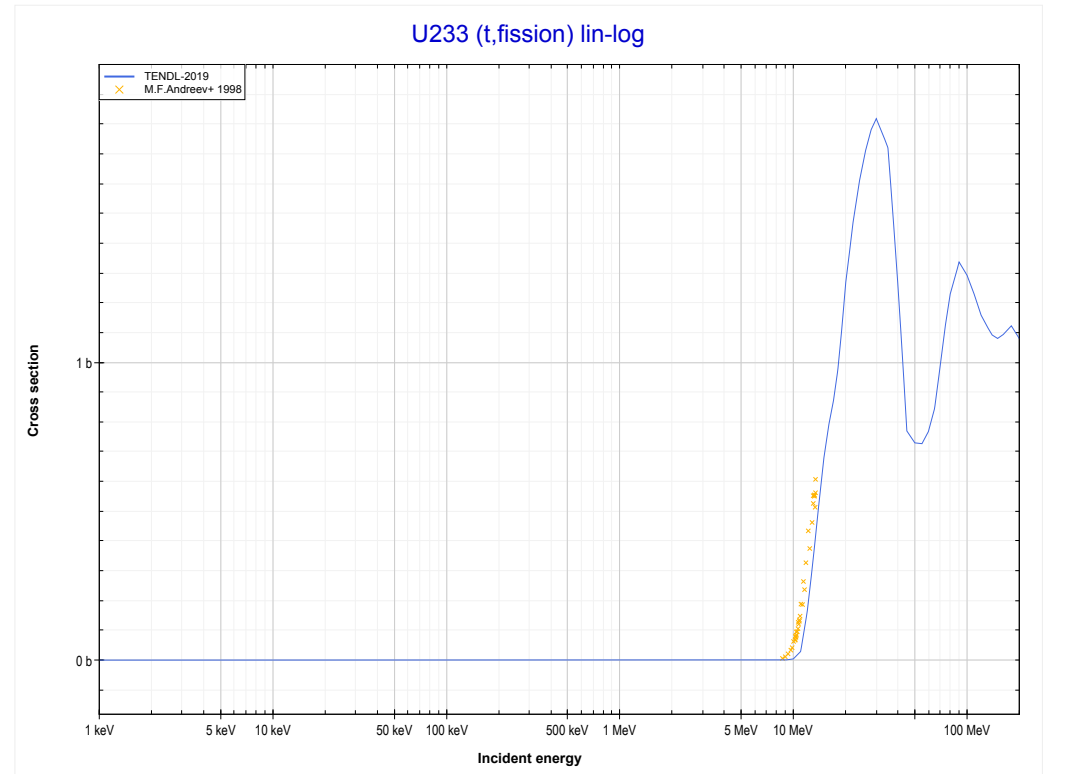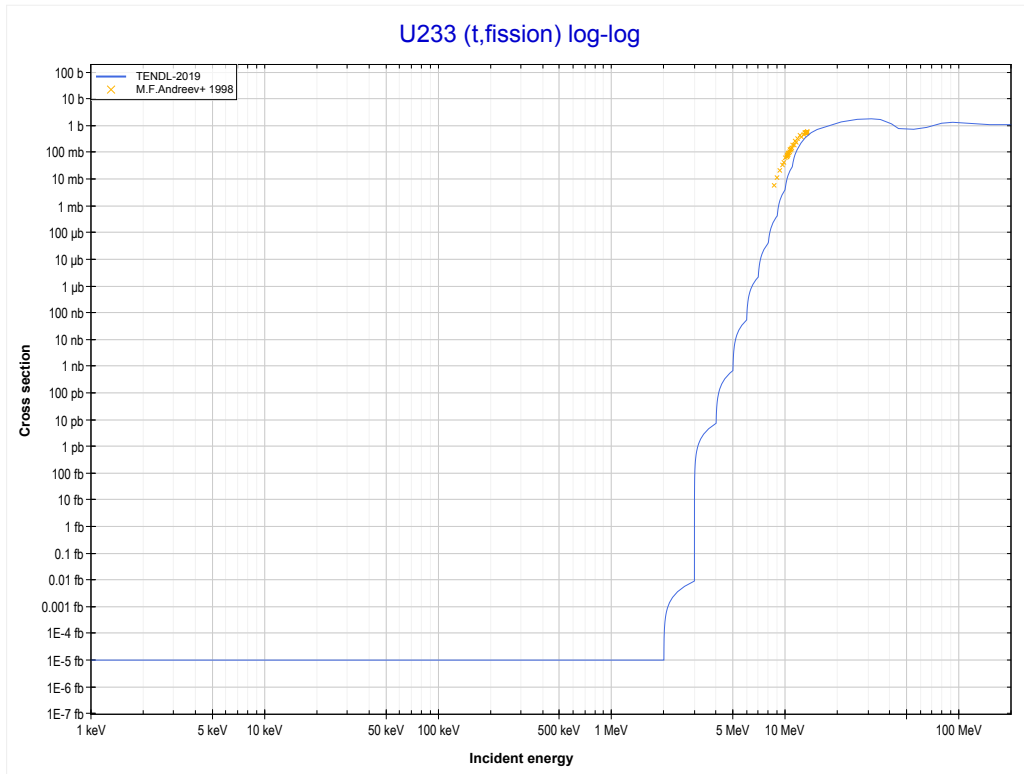
<< 92-U-233	**92-U-235**	92-U-238 >>
<< 92-U-233 MT18 (t,fission)	**MT18 (t,fission)**	92-U-238 MT18 (t,fission) >>
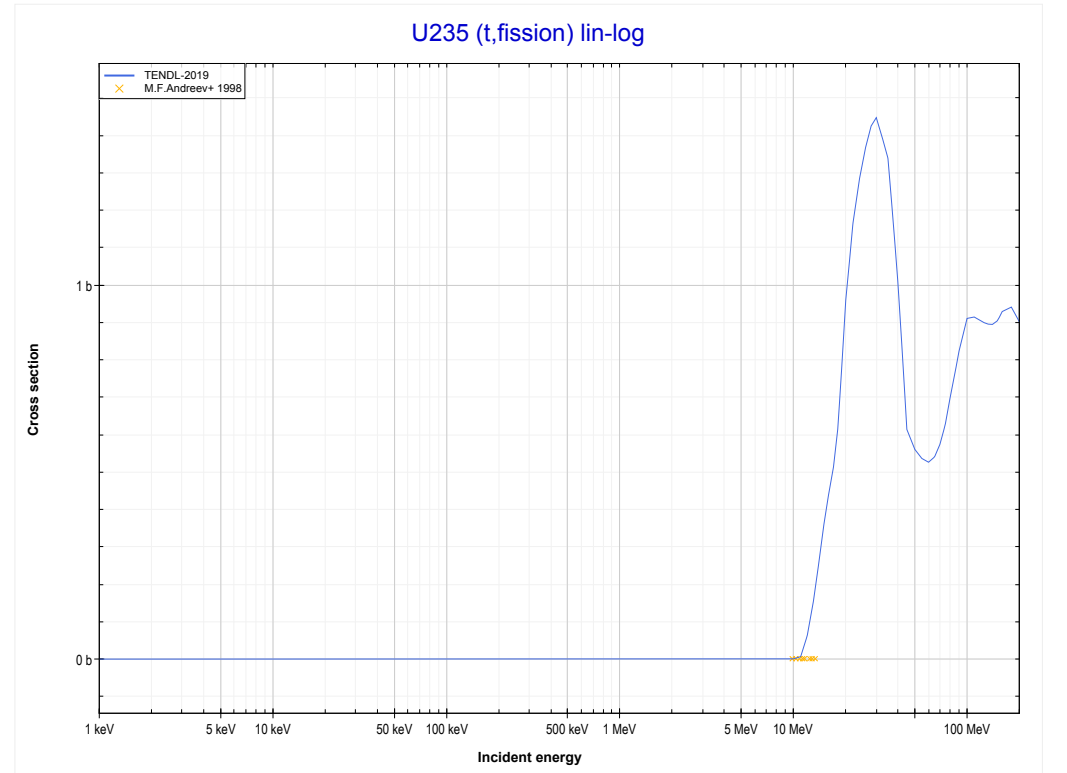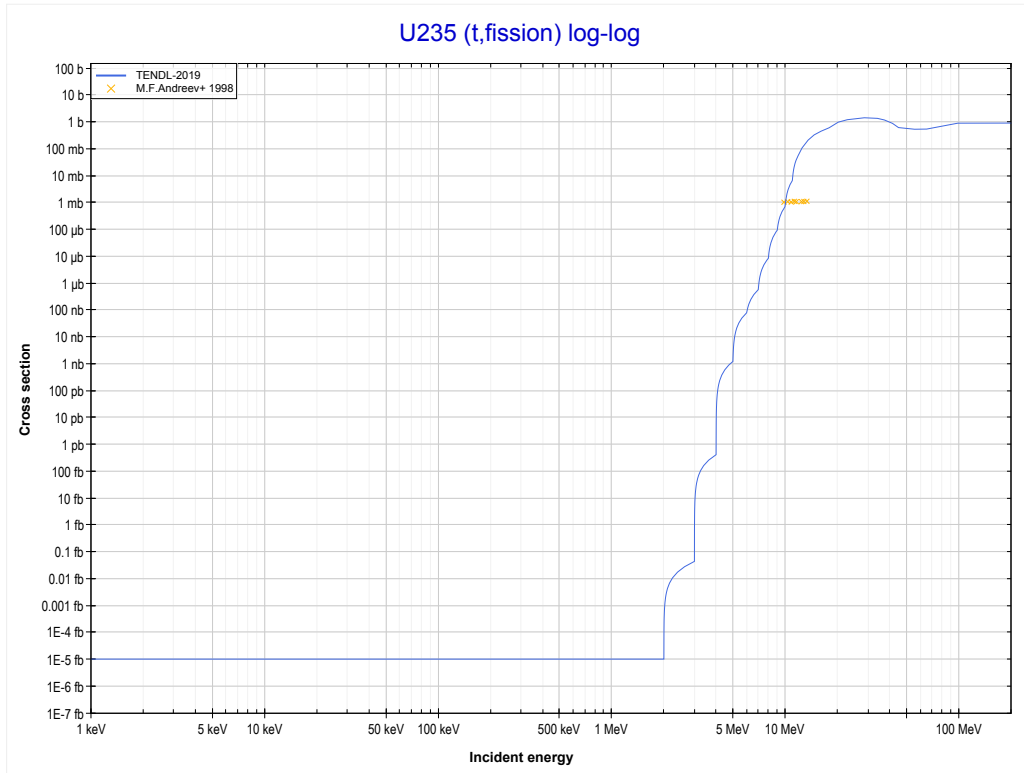
U235 (t,fission) log-log

U235 (t,fission) lin-log

U238 (t,fission) log-log

U238 (t,fission) lin-log
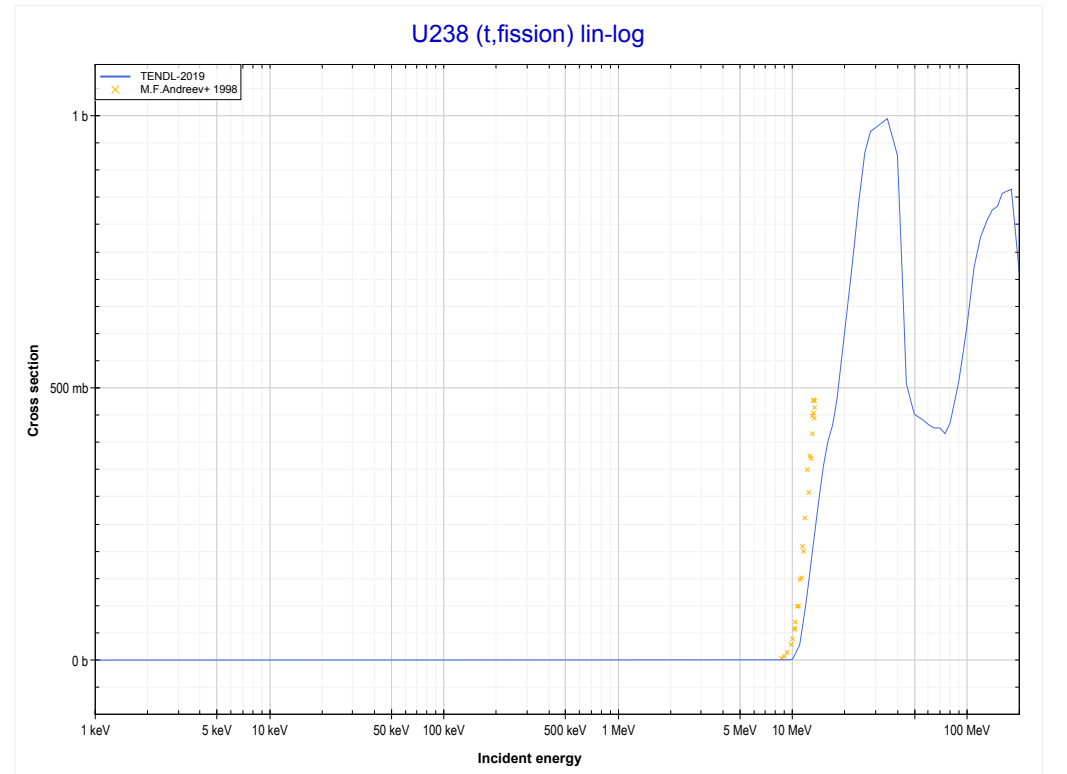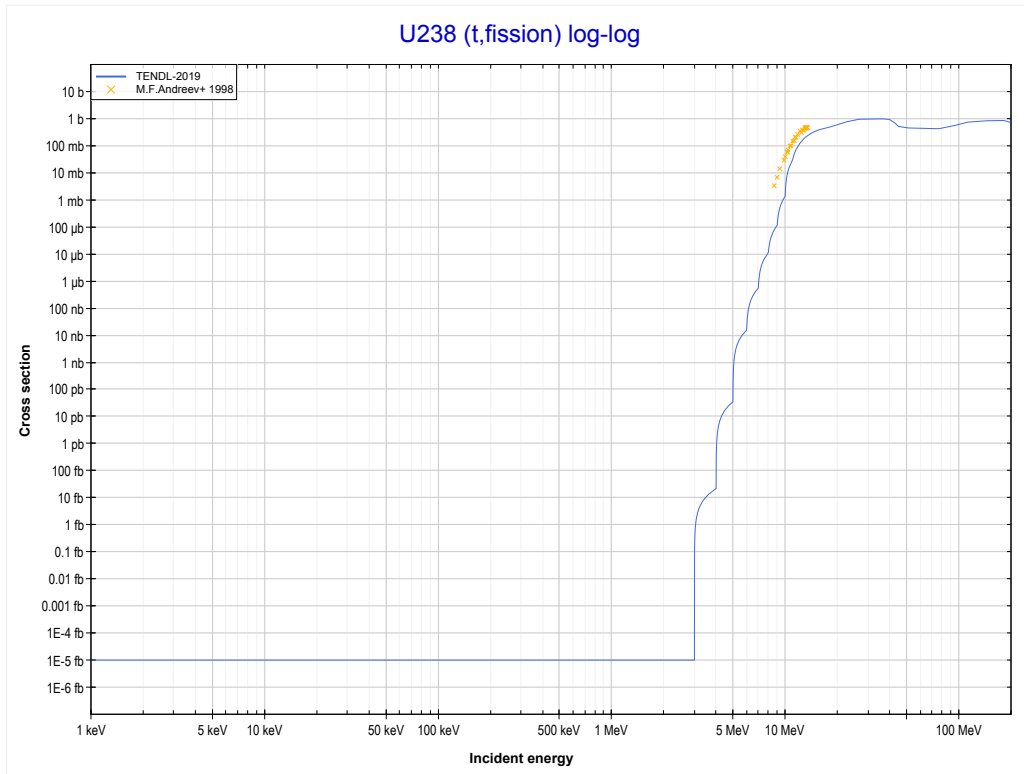
<< 92-U-238	**93-Np-237**	95-Am-243 >>
<< 92-U-238 MT18 (t,fission)	**MT18 (t,fission)**	95-Am-243 MT18 (t,fission) >>

Np237 (t,fission) log-log

Np237 (t,fission) lin-log
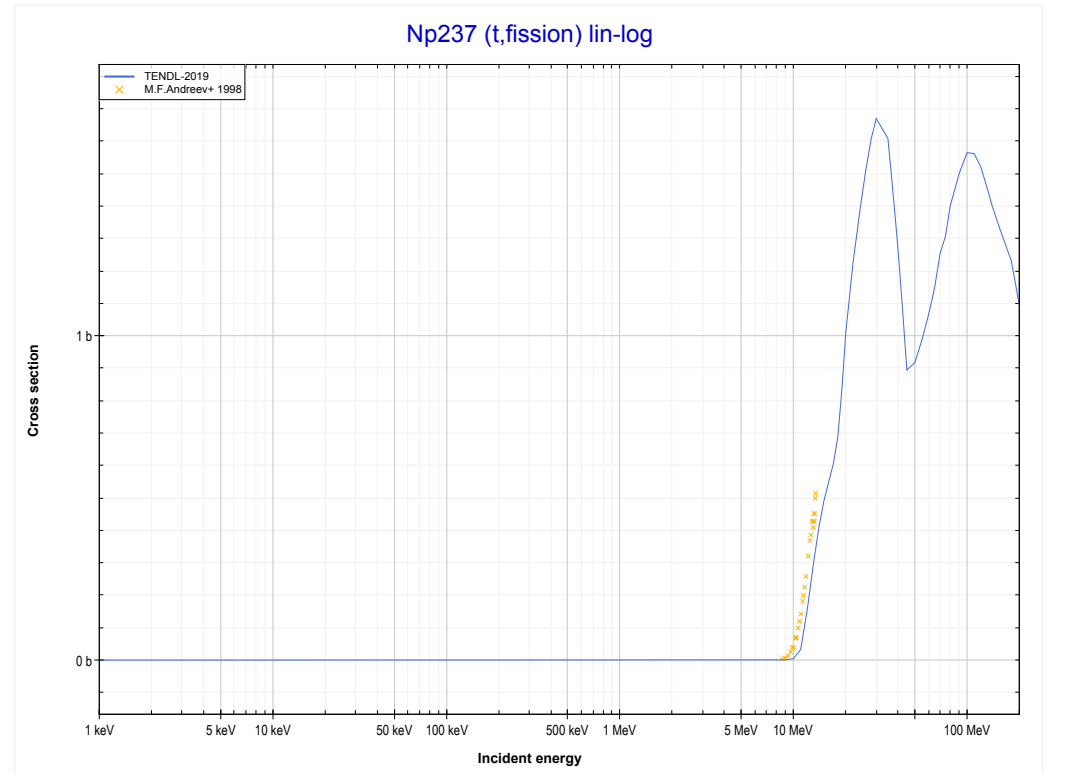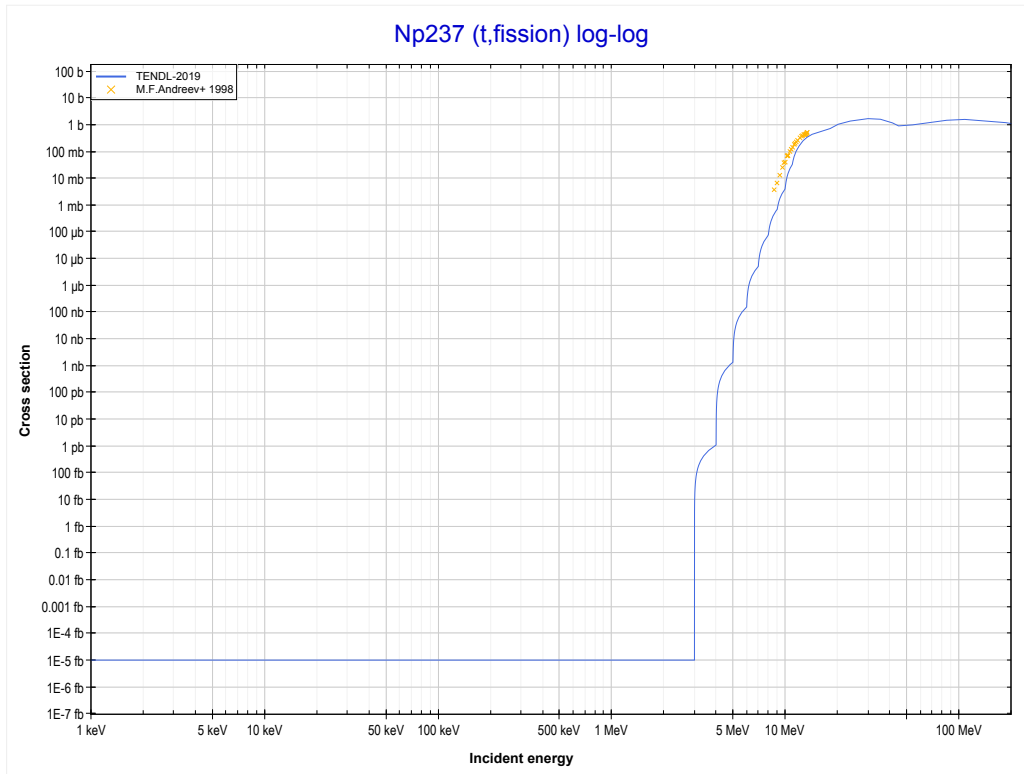
<< 93-Np-237	**95-Am-243**	
<< 93-Np-237 MT18 (t,fission)	**MT18 (t,fission)**	

Am243 (t,fission) log-log

Am243 (t,fission) lin-log