Testing JEFF-3.3T3 in TOF Shielding Benchmarks

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I. Objectives

- TOF Shielding Benchmarks for Nuclear Data validation

- Testing JEFF-3.3T2/T3 (and other evaluations) in TOF Shielding Benchmarks
  - FNS
  - MCNP6 shielding suite
  - Oktavian

- Searching/verifying MCNP inputs in open literature, databases, …

References:

1. *SINBAD, DVD, 2016*
2. *F. Maekawa et al., "Collection of Experimental Data for Fusion Neutronics Benchmark", JAERI, 1994.*
3. *F. Maekawa et al., "Compilation of Benchmark Results for Fusion Related Nuclear Data", JAERI, 1998.*
4. *IAEA, "FENDEL-2 Benchmarks Sublibrary" [https://www-nds.iaea.org/fendl2/validation/benchmarks/jaerim94014/fns-tof/] (Accessed on 2017/April/19)*
5. *U. Fischer et al., "Benchmarking of the FENDL-3 Neutron Cross-Section Data Library for Fusion Applications", IAEA, 2014.*
6. *Russell D. Mosteller, "Validation Suites for MCNP", American Nuclear Society, for presentation at its 12th Biennial RPSD Topical Meeting (Santa Fe, April 14-17, 2002)*

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II. TOF Benchmarks and materials

Z	Material	FNS_TOF	MCNP6 Shielding Suite	Oktavian
3	Li		X	
4	Be	X	X	
6	Graphite	X	X	
7	N2	X	X	
8	O2	X		
13	Al			X
14	Si			X
22	Ti			X
24	Cr			X
25	Mn			X
26	Fe	X	X	
27	Co			X
29	Cu			X
33	As			X
34	Se			X
40	Zr			X
41	Nb			X
42	Mo			X
74	W			X
82	Pb	X	X	
92	U235, U238		X	
94	Pu239		X	

(23 elements and/or isotopes)

Compounds	FNS_TOF	MCNP6 Shielding Suite	Oktavian
Li2O	X		
Iron duct		X	
Iron duct+SS304		X	
Iron duct+SS304+PE		x	
Concrete		X	
Water		x	
LiF			X
Teflon (CF2)			X

(8 compounds/media)

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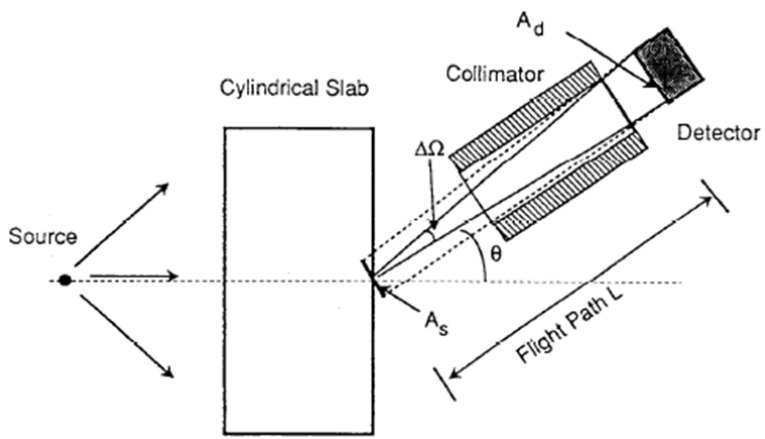
III.1 FNS-TOF Benchmarks (17 cases x 5 angles)

1. TOF



Detector was located to observe leakage neutrons from cylindrical slabs at several angles.

2. In-situ

Detector was located inside of the slabs.

Geometry, materials		Detector Position
Beryllium	FNS-TOF/31.4 CM(R)*15.24 CM(Z)	Angle= 0.0 deg
	FNS-TOF/31.4 CM(R)*5.06 CM(Z)	Angle= 12.20 deg
Graphite	FNS-TOF/31.4 CM(R)*20.24CM(Z)	Angle= 24.90 deg
	FNS-TOF/31.4 CM(R)*40.48CM(Z)	Angle= 41.80 deg
	FNS-TOF/31.4 CM(R)*5.06CM(Z)	Angle= 66.80 deg
Iron	FNS-TOF/50.0 CM(R)*20.0 CM(Z)-Iron	
	FNS-TOF/50.0 CM(R)*40.0 CM(Z)-Iron	
	FNS-TOF/50.0 CM(R)*5.0 CM(Z)-Iron	
	FNS-TOF/50.0 CM(R)*60.0 CM(Z)-Iron	
Li2O	FNS-TOF/31.4 CM(R)*20.0 CM(Z)-Li2O	
	FNS-TOF/31.4 CM(R)*40.0 CM(Z)-Li2O	
	FNS-TOF/31.4 CM(R)*4.8 CM(Z)-Li2O	
N2	FNS-TOF/ N2 SLAB-TOF	
O2	FNS-TOF/ LO2 SLAB-TOF	
Lead	FNS-TOF/31.4 CM(R)*20.32CM(Z)-Lead	
	FNS-TOF/31.4 CM(R)*40.64CM(Z)-Lead	
	FNS-TOF/31.4 CM(R)*5.06CM(Z)-Lead	

F. Maekawa et al., "Collection of Experimental Data for Fusion Neutronics Benchmark", JAERI, 1994.

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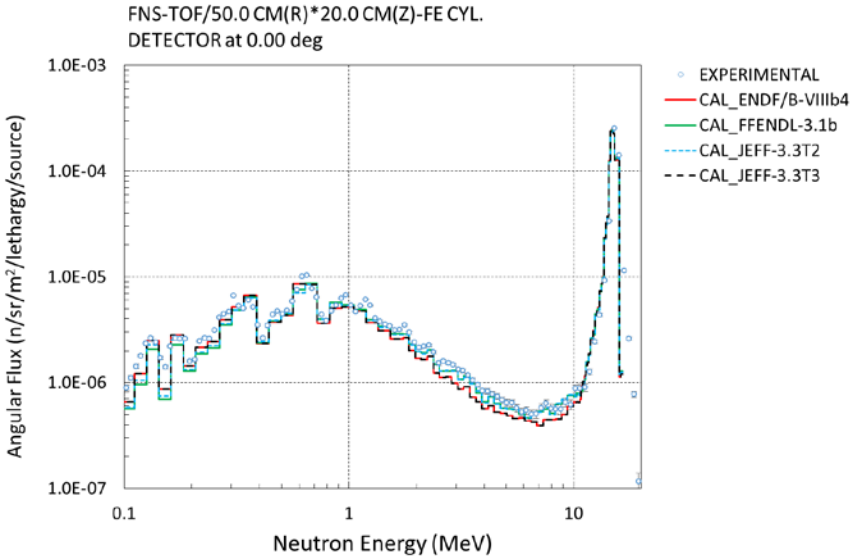
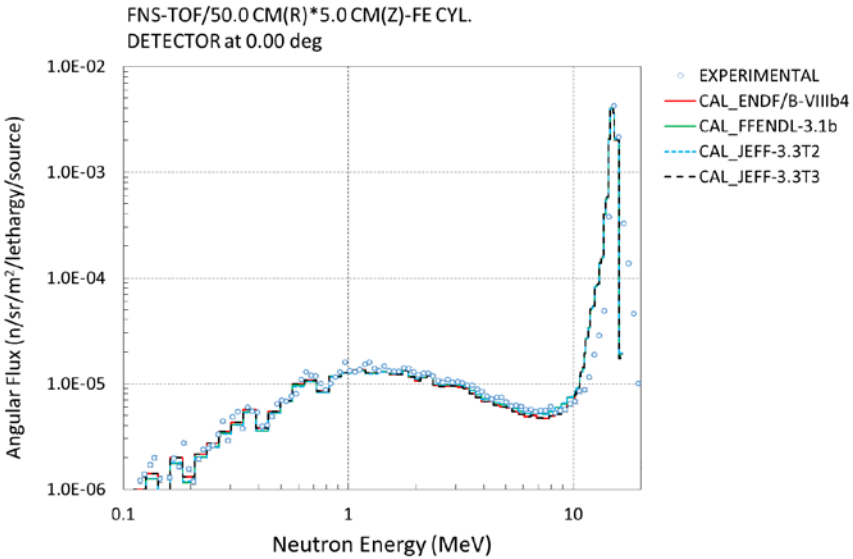
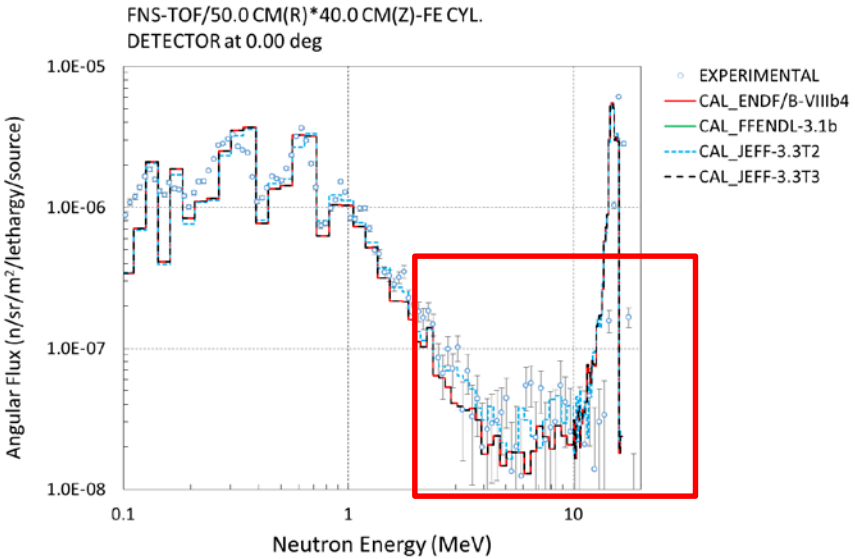
Figures. Results obtained for the **<u>Fe (iron)</u>** ToF-experiment at FNS showing angular neutron leakage spectra for thick slabs <u>at 0 degrees</u>

- Fe, slightly better agreement in JEFF-3.3T2







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FNS-TOF/50.0 CM(R)*5.0 CM(Z)-Iron				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.95	0.95	**0.95**	0.95
5 MeV < E < 10 MeV	0.93	1.01	**1.02**	0.93
1 MeV < E < 5 MeV	0.95	0.96	**0.96**	0.95
0.5 MeV < E < 1 MeV	0.96	0.94	**0.93**	0.96
0.1 MeV < E < 0.5 MeV	1.06	1.00	**1.00**	1.06
Angle= 24.90 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.20	1.26	1.27	1.20
5 MeV < E < 10 MeV	0.95	0.98	1.00	0.95
1 MeV < E < 5 MeV	0.92	0.95	0.95	0.92
0.5 MeV < E < 1 MeV	1.03	0.99	1.00	1.03
0.1 MeV < E < 0.5 MeV	1.23	1.09	1.12	1.23
Angle= 41.80 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.77	0.83	0.82	0.77
5 MeV < E < 10 MeV	0.84	0.85	0.86	0.84
1 MeV < E < 5 MeV	0.89	0.91	0.91	0.89
0.5 MeV < E < 1 MeV	1.02	0.98	0.99	1.02
0.1 MeV < E < 0.5 MeV	1.20	1.07	1.09	1.20
Angle= 66.80 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.62	0.59	0.58	0.62
5 MeV < E < 10 MeV	0.74	0.74	0.75	0.74
1 MeV < E < 5 MeV	0.87	0.90	0.89	0.87
0.5 MeV < E < 1 MeV	0.95	0.91	0.91	0.95
0.1 MeV < E < 0.5 MeV	1.00	0.90	0.91	1.00

FNS-TOF/50.0 CM(R)*40.0 CM(Z)-Iron				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.95	0.96	**0.94**	0.95
5 MeV < E < 10 MeV	0.65	0.97	**0.93**	0.65
1 MeV < E < 5 MeV	0.96	1.15	**1.08**	0.96
0.5 MeV < E < 1 MeV	1.01	1.10	**1.02**	1.01
0.1 MeV < E < 0.5 MeV	0.96	0.94	**0.93**	0.96
Angle= 24.90 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.93	0.92	0.95	0.93
5 MeV < E < 10 MeV	0.80	0.97	0.94	0.80
1 MeV < E < 5 MeV	0.95	1.15	1.11	0.95
0.5 MeV < E < 1 MeV	0.98	1.07	1.01	0.98
0.1 MeV < E < 0.5 MeV	0.97	0.96	0.96	0.97
Angle= 41.80 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.86	0.81	0.87	0.86
5 MeV < E < 10 MeV	0.42	0.46	0.46	0.42
1 MeV < E < 5 MeV	0.86	1.07	1.02	0.86
0.5 MeV < E < 1 MeV	0.93	1.02	0.97	0.93
0.1 MeV < E < 0.5 MeV	0.91	0.90	0.91	0.91
Angle= 66.80 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.67	0.63	0.63	0.67
5 MeV < E < 10 MeV	0.00	0.00	0.00	0.00
1 MeV < E < 5 MeV	0.74	0.94	0.88	0.74
0.5 MeV < E < 1 MeV	0.87	0.97	0.92	0.87
0.1 MeV < E < 0.5 MeV	0.84	0.82	0.85	0.84

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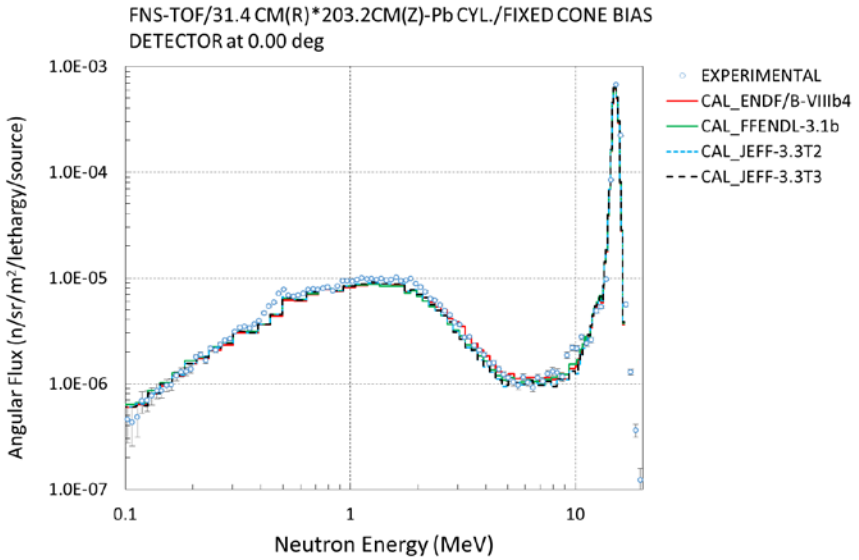
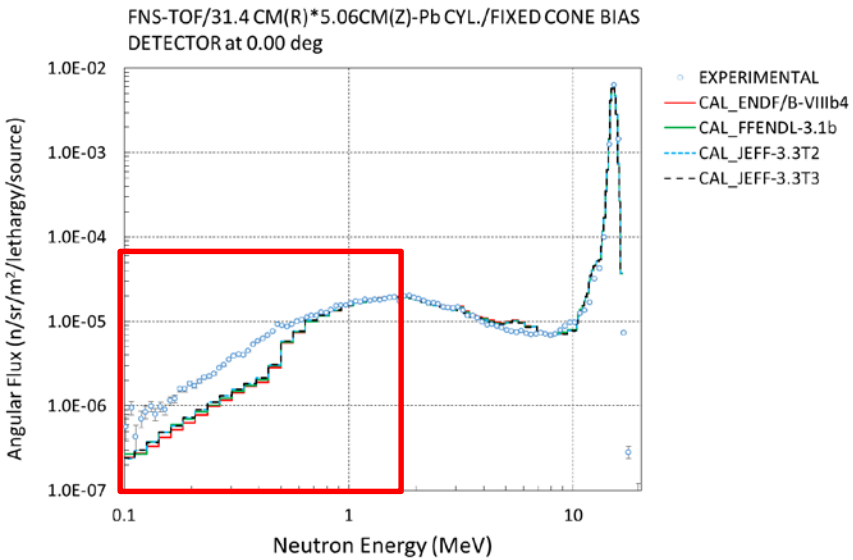
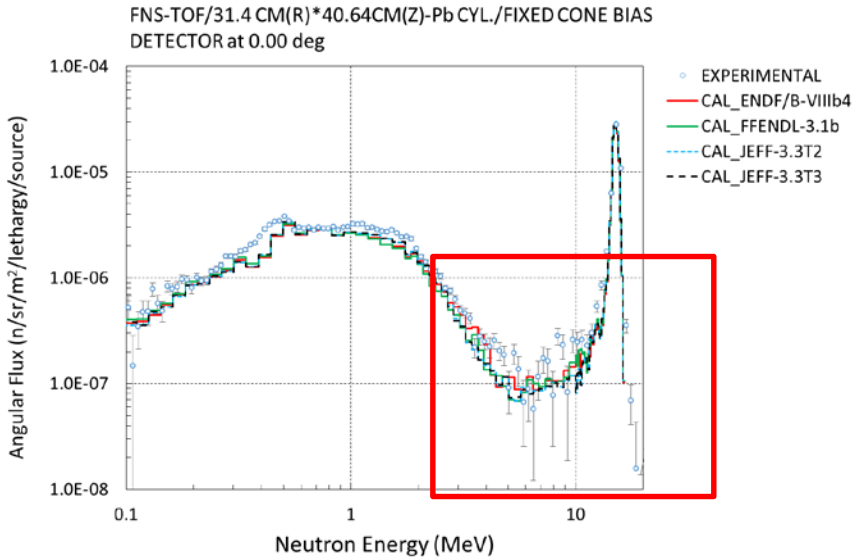
Figures. Results obtained for the **Pb (lead)** ToF-experiment at FNS showing angular neutron leakage spectra for thick slabs at 0 degrees

- Pb, slightly better JEFF-3.3T2/T3







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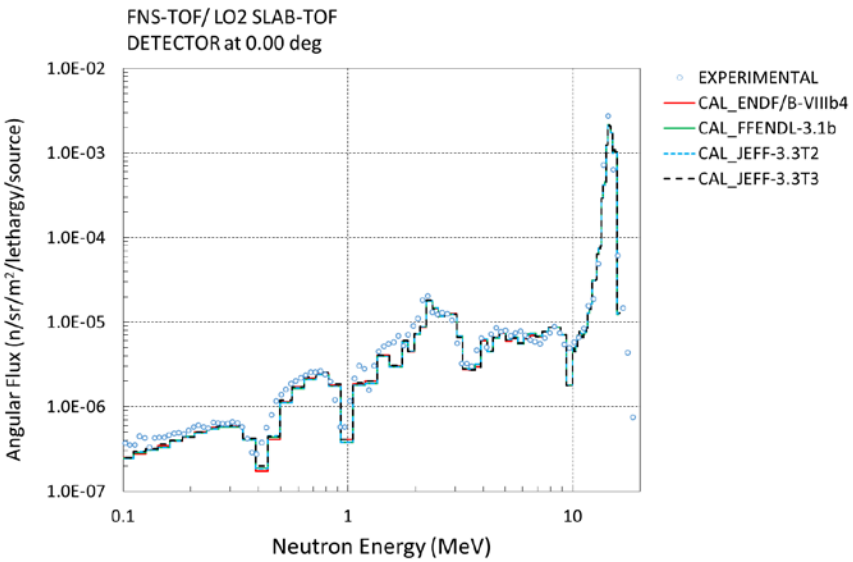
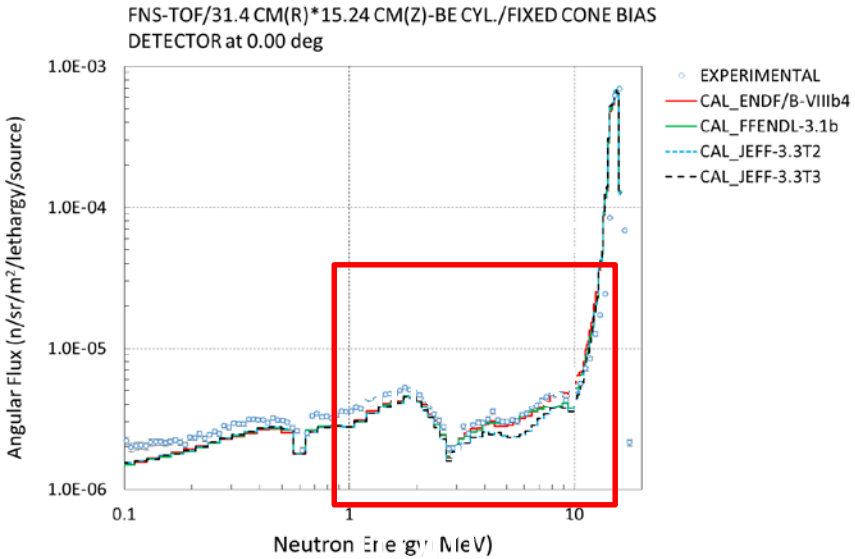
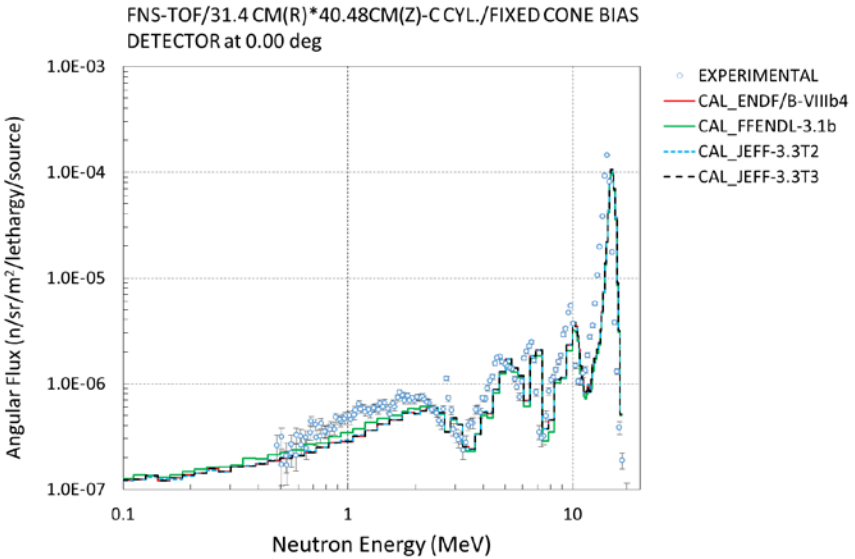
- O2, slightly better agreement in T3



- Be, JEFF-3.3/T2-T3 underestimate from 5 MeV - 10 MeV



- C, higher differences E< 2 MeV



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Conclusion for FNS-TOF Benchmarks

Material	Conclusion FENDL report	Our conclusion
Be	*"All calculations reproduce very well"*	JEFF-3.3 T2 and T3 underestimate from 5-10 MeV
Graphite	*"All calculations reproduce very well"*	Large differences between FENDL-31b and JEFF-3.3 T2/T3 at high angles for 50 mm and 200mm below 1 MeV
Fe	*"50 and 200 mm assemblies: all calculations very well above 0.1 MeV, 400 and 600 mm assemblies: less good agreement below 1 MeV"*	*Slightly better agreement in T2*
Li_2O	*"All calculations reproduce very well"*	T2 and T3 similar to FENDL/3.1b
N_2	*""All calculations reproduce very well except for the angle 66.6 deg"*	T2 and T3 similar to FENDL/3.1b
O_2	*"All calculations underestimate at larger angles"*	*Slightly better agreement in T3*
Pb	*"All calculations reproduce very well except for JENDL-4.0 which, at the neutron energy around 10 MeV, produces a smaller peak than the measured one"*	Better T2/T3

U. Fischer et al., "Benchmarking of the FENDL-3 Neutron Cross-Section Data Library for Fusion Applications", IAEA, 2014.

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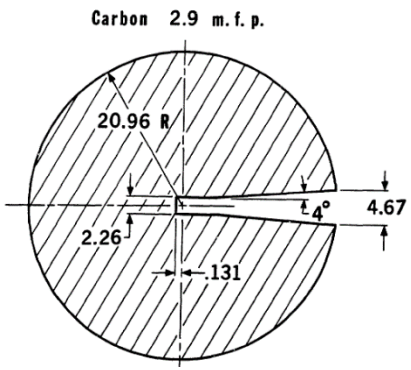
III.2 MCNP6-TOF Suite (14 cases)

Leakage neutrons from

- FNS: Cylindrical slab Configuration
  1: Iron duct
  3: Duct + SS-304
  7: Duct + SS-304 + Polyethylene

- LLNL: Pulsed sphere



Geometry, FNS	
Fusion Spectra Problem Configuration 1 On Axis	
Fusion Spectra Problem Configuration 3 Off Axis	
Fusion Spectra Problem Configuration 7 On Axis	
LLNL pulsed spheres	
Beryllium	: 0.8 mfp, fwhm=4.0 ns, Pilot-B bias=1.6, FP=765.20 cm, 30-deg
Carbon	: 2.9 mfp, fwhm=4.0 ns, NE213-A bias=1.6, FP=766.00 cm, 30-deg
Concrete	: 2.0 mfp, fwhm=3.0 ns, NE213-A bias=1.6, FP=975.40 cm, 120-deg
Iron	: 0.9 mfp, fwhm=3.0 ns, NE213-A bias=1.6, FP=766.00 cm, 30-deg
Lead	: 1.4 mfp, fwhm=3.0 ns, NE213-A bias=1.6, FP=766.00 cm, 30-deg
Lithium	: 1.6 mfp, fwhm=4.0 ns, Pilot-B bias=1.6, FP=765.20 cm, 30-deg
Nitrogen	: 3.1 mfp, fwhm=4.0 ns, Pilot-B bias=1.6, FP=765.20 cm, 30-deg
Pu-239	: 0.7 mfp, fwhm=3.0 ns, NE213-A bias=1.6, FP=766.00 cm, 30-deg
U-235	: 0.7 mfp, fwhm=3.0 ns, NE213-A bias=1.6, FP=766.00 cm, 30-deg
U-238	: 0.8 mfp, fwhm=4.0 ns, Pilot-B bias=1.6, FP=765.20 cm, 30-deg
Water	: 1.9 mfp, fwhm=5.0 ns, Pilot-B bias=1.6, FP=754.00 cm, 30-deg

Ref. MCNP6 Benchmark suite

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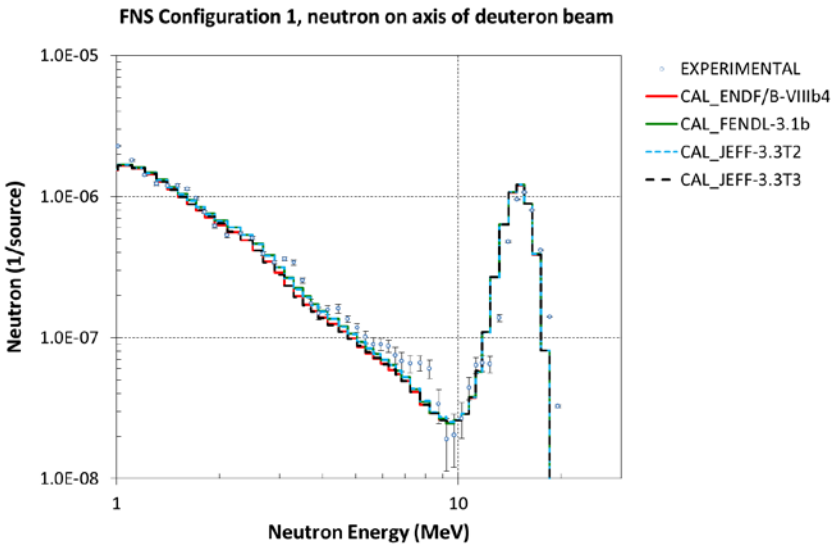
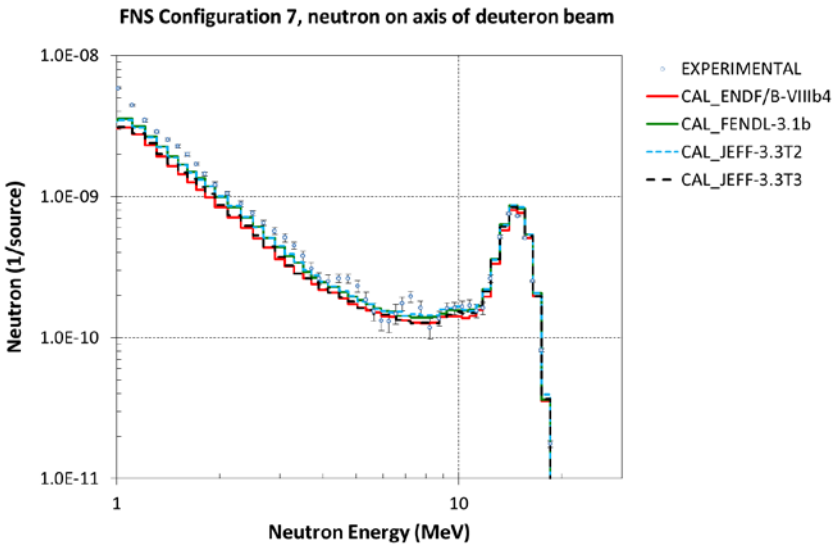
Figure. Fusion Spectra Problem Configuration 1/3/7 - On/Off Axis

- FNS, FENDL-3.1b and JEFF-3.3T2 show slightly better agreement than ENDF/B-VIIIb4 and JEFF-3.3T3 (1 – 10 MeV)





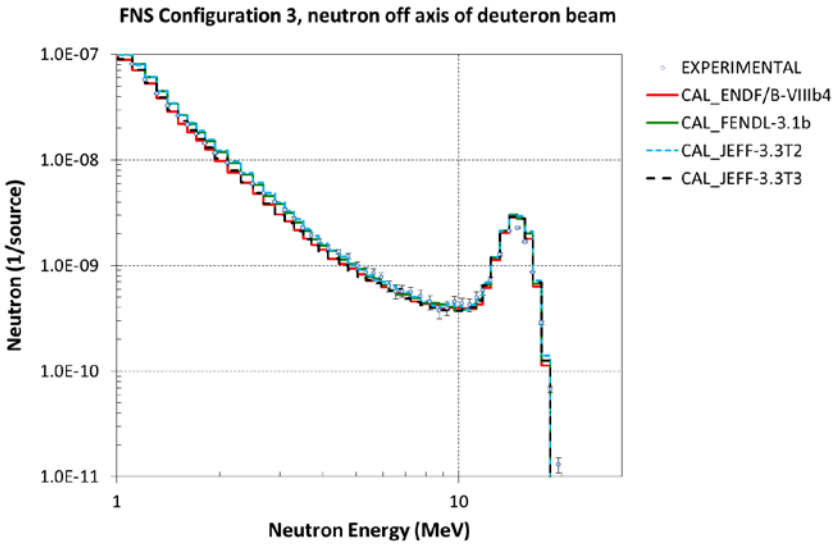


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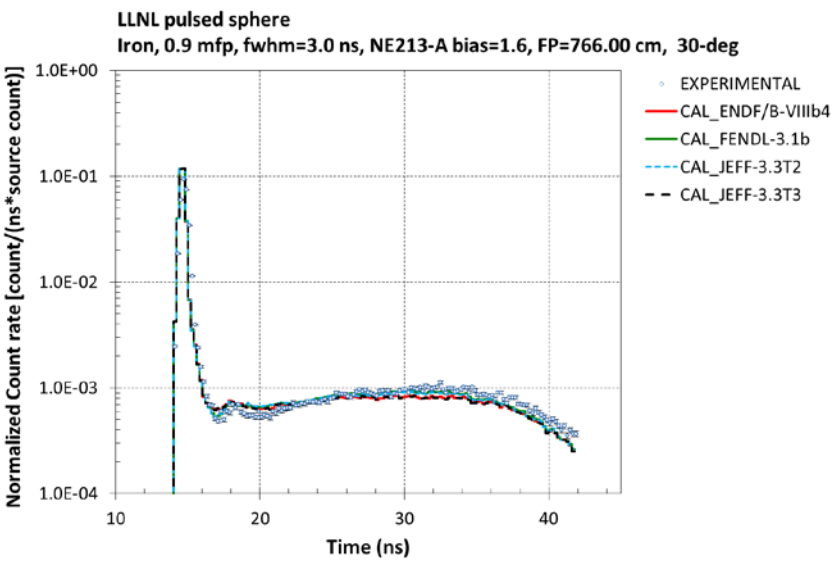
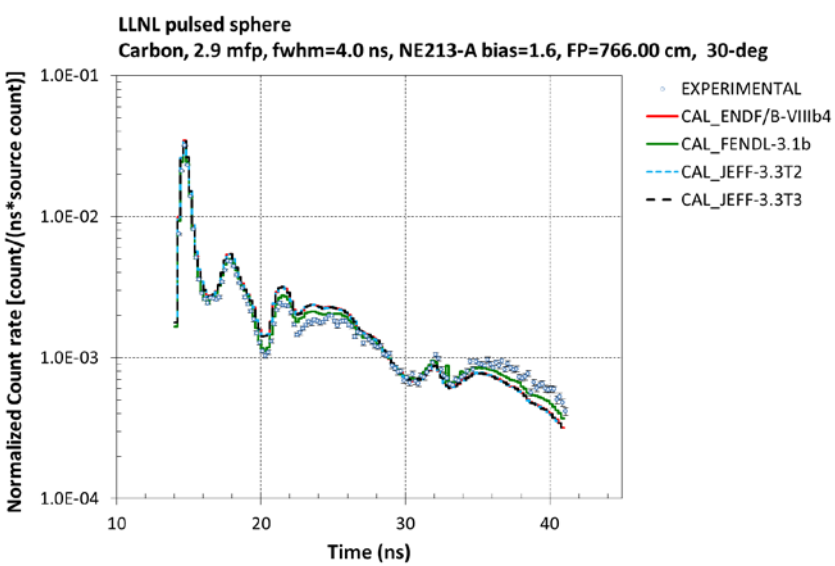
Figure. LLNL pulsed spheres

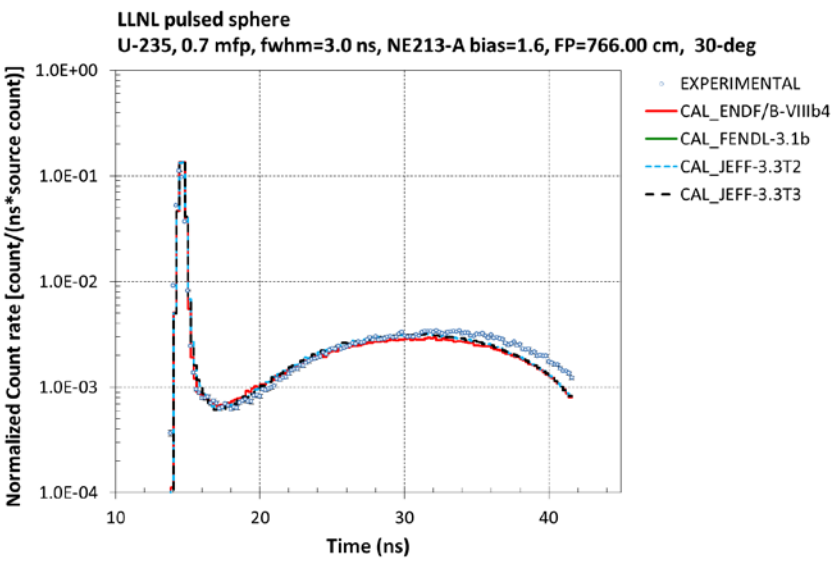
- Fe, FENDL-3.1 and JEFF-3.3T2 show better agreement



- C, FENDL-3.1b shows better agreement than others



- U235, underestimation above 25 ns (normalization problem?)



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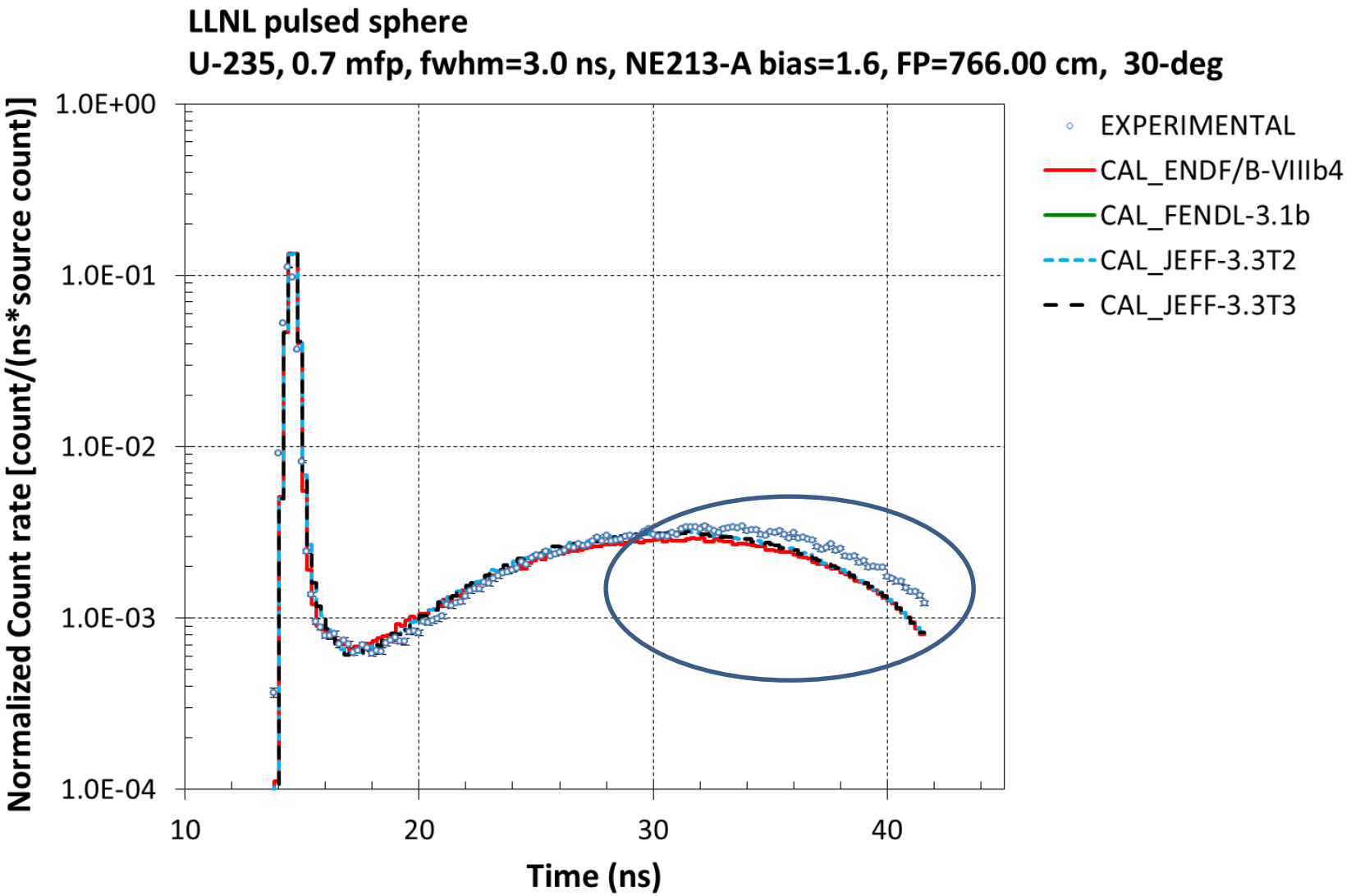
- U235, underestimation above 25 ns (normalization problem?)



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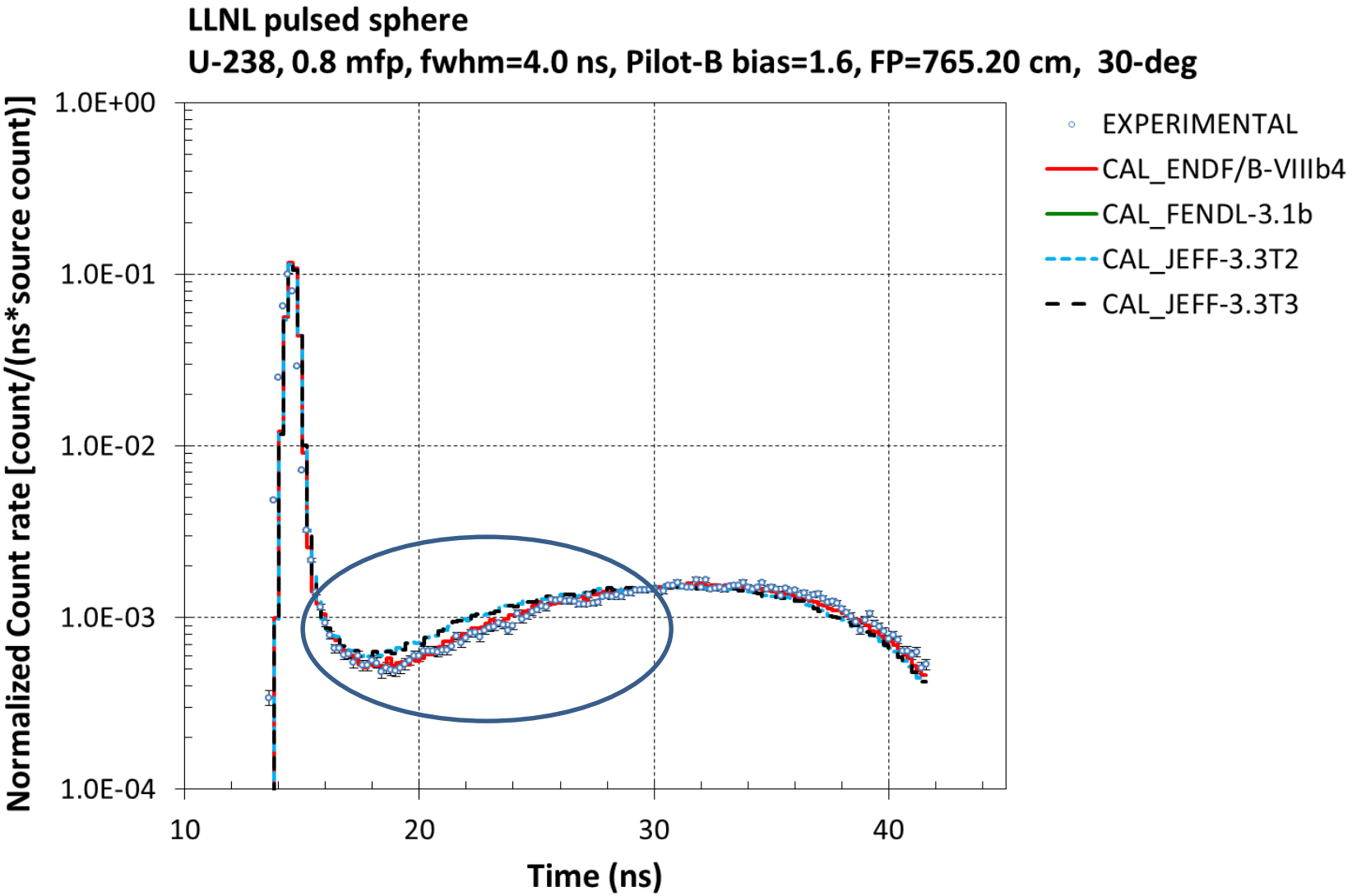
- U238, overestimation 18-26 ns



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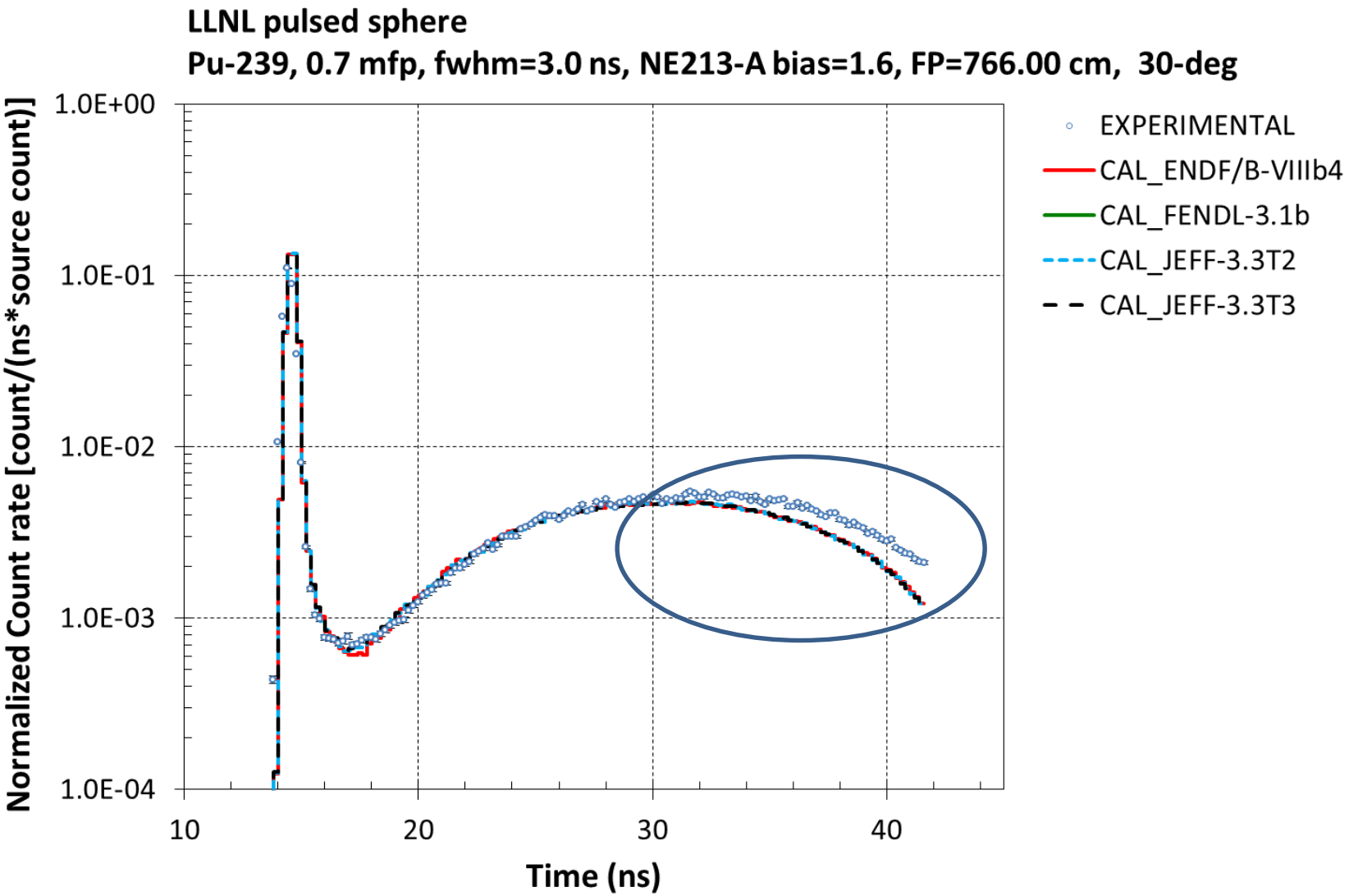
- Pu239 (normalization problem?)



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Conclusion for MCNP6-TOF Suite

Material	Our conclusion
Configuration 1	All libraries underestimation (3 – 9 MeV)
Configuration 3	All libraries showed good agreement. ENDF/B-VIIIb4 and JEFF-3.3T3 slight underestimation, FENDL-3.1 and JEFF-3.3T2 slight over estimation
Configuration 7	FENDL-3.1b and JEFF-3.3T2 showed better agreement than ENDF/B-VIIIb4 and JEFF-3.3T3 (1 – 10 MeV).
Be	JEFF-3.3T2/T3 showed much better agreement than ENDF/B-VIIIb4 and FENDL-3.1b
Carbon	FENDL-3.1b showed better agreement than others
Concrete	ENDF/B-VIIIb4 and JEFF-3.3T3 slightly better than FENDL-3.1b and JEFF-3.3T2
Fe	**FENDL-3.1 and JEFF-3.3T2 showed better agreement** than ENDF/B-VIIIb4 and JEFF-3.3T3 (lower energy range, 26 – 36 ns of flight-time).
Pb	ENDF/B-VIIIb4 overestimation 20-32 ns
Li	All libraries showed similar calculated values and overestimated 20-35ns
Nitrogen	All libraries overestimate above 8ns, FENDL-3.1b big change at 28ns?
Pu-239	All libraries showed good agreement in higher energy range. Small deep of ENDF/B-VIIIb at 17 ns. Underestimation in the lower energy range.
U-235	All libraries showed good agreement in higher energy rangy. Underestimation above 25 ns
U-238	Overestimation for JEFF-3.3T2 and T3 in the range of 17 – 26 ns.
Water	All libraries slightly overestimate measured ones

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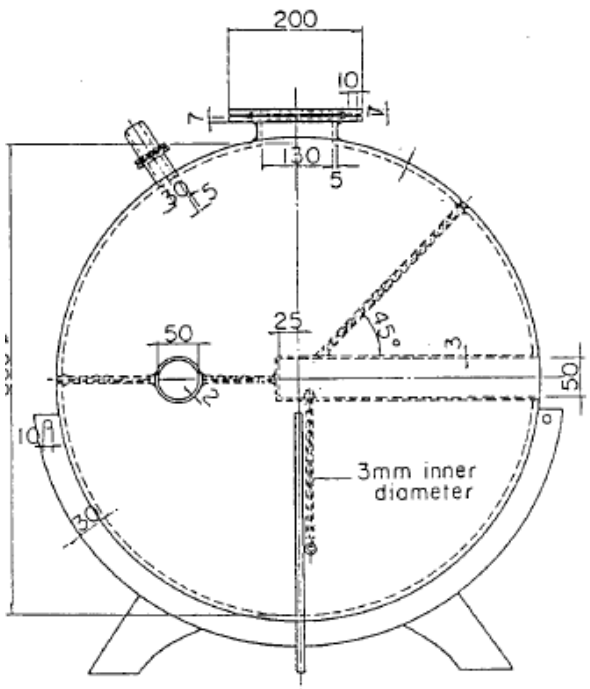
III.3 OKTAVIAN TOF Benchmarks (15 cases)

Neutron leakage from OKTAVIAN pulsed sphere
Ex) 61 cm sphere: Type I



Geometry	Type-I 61 cm diameter vessel	Type-II 40 cm diameter vessel	Type-III 60 cm diameter vessel	Type –IV 28 cm diameter vessel
	Cu	Al	Si	Nb
	LiF	As		
	Mn	Co		
	Mo	Cr		
	Zr	Se		
		Teflon		
		Ti		
		W		

Neutron source spectra	
CASE 1 (Table 4.2)	LiF, Mn , Cu, Mo, W
CASE 2 (Table 4.3)	Teflon, Si, Co
CASE 3 (Table 4.4)	Al
CASE 4 (Table 4.5)	Ti, As, Se, Zr
CASE 5 (Table 4.6)	Cr, Nb

F. Maekawa et al., "Collection of Experimental Data for Fusion Neutronics Benchmark", JAERI, 1994.

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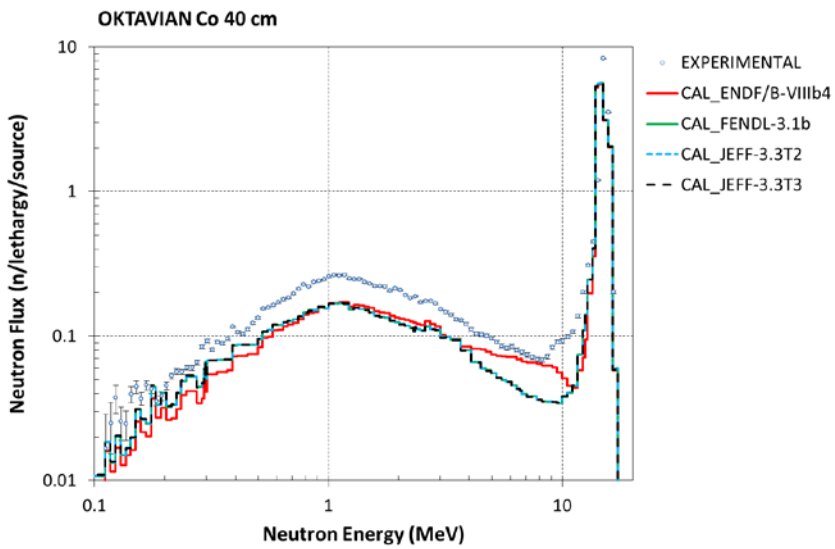
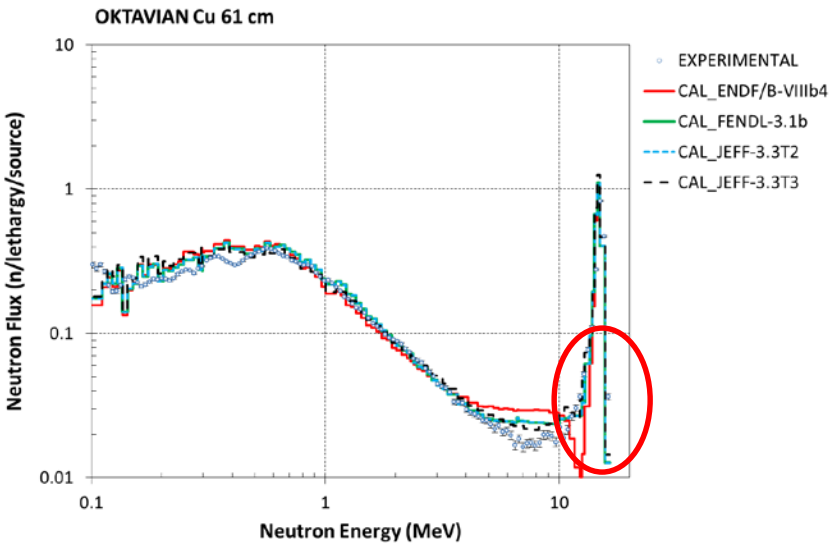
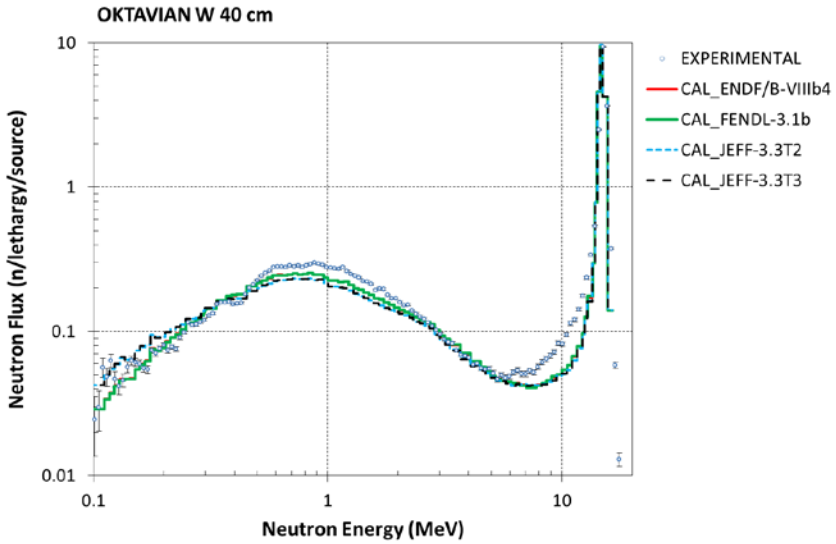
- Co, all libraries high underestimation



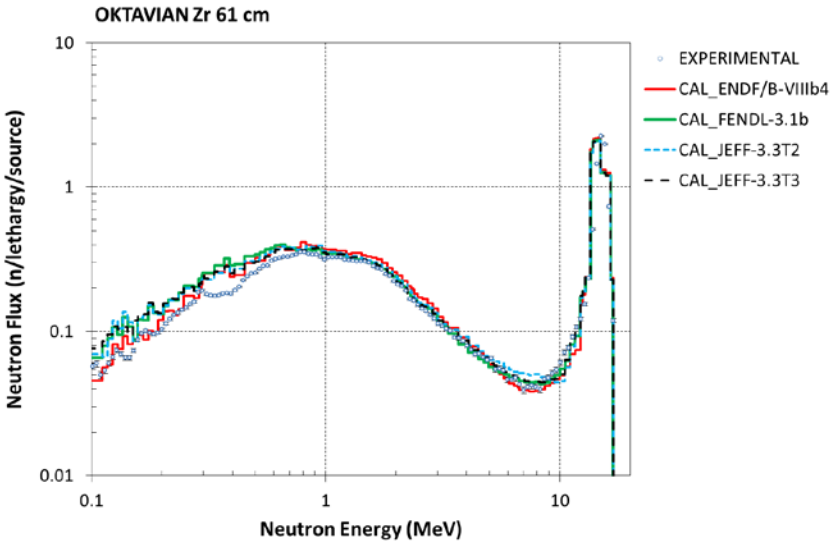
- Cu, slightly better T2=FENDL-3.1b



- W, T2/T3 lower values below 1 MeV



- Zr, JEFF/3.3T3 better agreement



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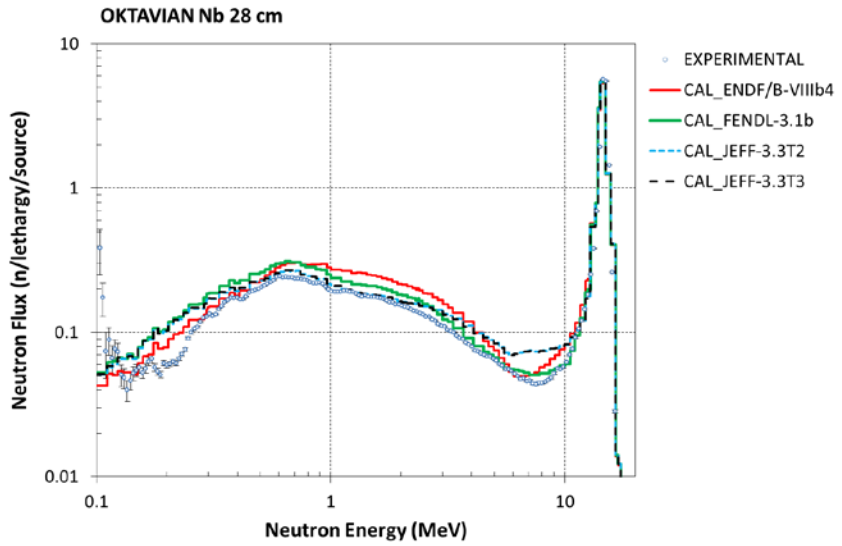
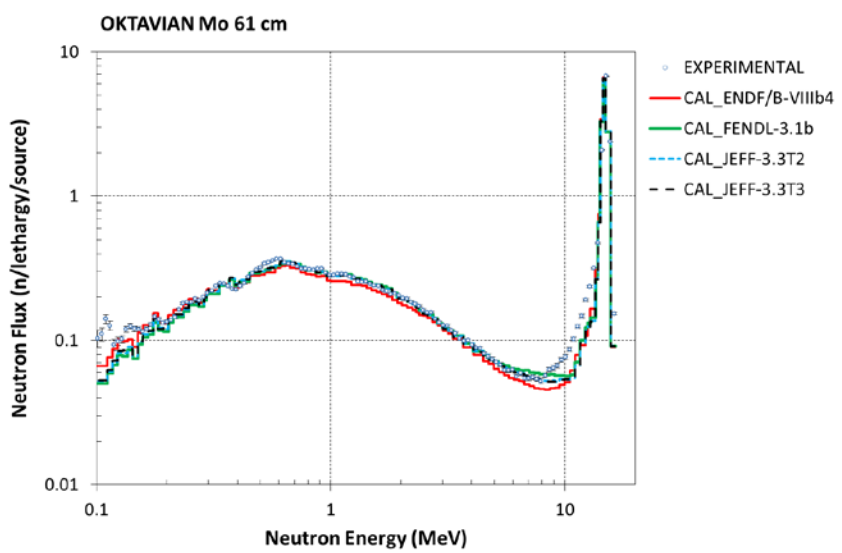


- Nb, JEFF-3.3T2/T3 high overestimation from 5 MeV– 10 MeV

- Mo, T2/T3 good agreement



- Mn, JEFF-3.3T2/T3 overestimation 1MeV to 5 MeV

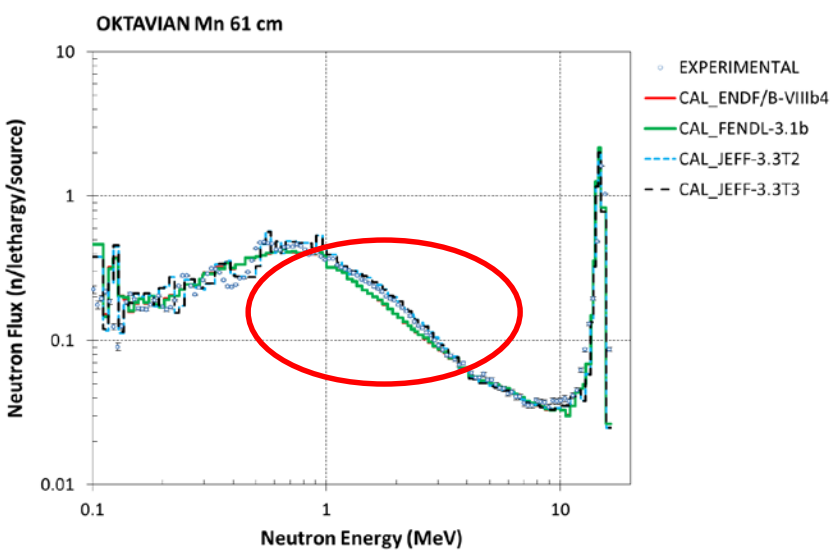


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Table. <C>/<E> values

	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3		ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
	Oktavian Al-40 cm					**Oktavian As-40 cm**			
10 MeV < E < 16 MeV	1.01	1.01	1.01	1.01		0.82	-	0.83	0.83
5 MeV < E < 10 MeV	0.91	0.90	0.90	0.90		0.88	-	0.92	0.92
1 MeV < E < 5 MeV	0.91	0.91	0.91	0.91		1.22	-	1.14	1.14
0.5 MeV < E < 1 MeV	0.93	0.93	0.93	0.94		1.12	-	1.08	1.08
0.1 MeV < E < 0.5 MeV	1.41	1.38	1.38	1.41		1.23	-	1.27	1.27
	Oktavian Co-40 cm					**Oktavian Cr-40cm**			
10 MeV < E < 16 MeV	0.81	0.83	0.83	0.83		0.92	0.93	0.93	0.93
5 MeV < E < 10 MeV	0.89	0.55	0.55	0.55		1.18	1.06	1.07	1.07
1 MeV < E < 5 MeV	0.69	0.64	0.64	0.64		1.17	1.12	1.14	1.14
0.5 MeV < E < 1 MeV	0.58	0.61	0.61	0.62		1.15	1.25	1.23	1.23
0.1 MeV < E < 0.5 MeV	0.64	0.77	0.77	0.78		1.16	1.07	1.05	1.05
	Oktavian Cu-61cm					**Oktavian LiF-61 cm**			
10 MeV < E < 16 MeV	0.91	1.02	1.02	1.15		1.05	1.05	1.05	1.05
5 MeV < E < 10 MeV	1.58	1.31	1.31	1.28		0.87	0.88	0.88	0.87
1 MeV < E < 5 MeV	1.01	1.12	1.12	1.07		0.88	0.88	0.88	0.88
0.5 MeV < E < 1 MeV	0.99	1.01	1.01	0.93		0.67	0.65	0.67	0.67
0.1 MeV < E < 0.5 MeV	1.15	1.11	1.11	1.16		0.85	0.82	0.85	0.85

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Table. <C>/<E> values

	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3		ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
	Oktavian Mn-61cm					**Oktavian Mo-61 cm**			
10 MeV < E < 16 MeV	0.98	0.98	0.92	0.92		0.85	0.83	0.83	0.83
5 MeV < E < 10 MeV	1.02	1.02	1.00	1.00		0.86	1.04	0.97	0.97
1 MeV < E < 5 MeV	0.95	0.96	1.13	1.13		0.96	1.05	1.04	1.04
0.5 MeV < E < 1 MeV	0.87	0.87	1.00	1.00		0.84	0.90	0.90	0.90
0.1 MeV < E < 0.5 MeV	1.25	1.24	1.15	1.16		0.98	0.92	0.94	0.95
	Oktavian Nb-61 cm					**Oktavian Se-40cm**			
10 MeV < E < 16 MeV	0.98	0.98	0.98	0.98		0.97	-	0.94	0.94
5 MeV < E < 10 MeV	1.23	1.13	1.53	1.52		0.74	-	1.28	1.28
1 MeV < E < 5 MeV	1.46	1.22	1.16	1.16		1.25	-	1.21	1.21
0.5 MeV < E < 1 MeV	1.23	1.23	1.07	1.07		1.21	-	1.11	1.12
0.1 MeV < E < 0.5 MeV	1.14	1.40	1.29	1.30		1.50	-	1.53	1.54
	Oktavian Si-60cm					**Oktavian Teflon-40cm**			
10 MeV < E < 16 MeV	0.87	0.87	0.90	0.90		0.66	0.65	0.66	0.66
5 MeV < E < 10 MeV	1.03	1.03	0.96	0.96		0.66	0.64	0.66	0.66
1 MeV < E < 5 MeV	1.05	1.06	0.99	0.99		0.61	0.63	0.61	0.61
0.5 MeV < E < 1 MeV	1.18	1.18	1.12	1.13		0.61	0.58	0.61	0.61
0.1 MeV < E < 0.5 MeV	1.26	1.24	1.16	1.18		0.79	0.68	0.78	0.80

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Table. <C>/<E> values

	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3		ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
	Oktavian Ti-40cm					**Oktavian W-40cm**			
10 MeV < E < 16 MeV	0.93	0.93	0.93	0.93		0.87	0.87	0.88	0.88
5 MeV < E < 10 MeV	1.26	1.25	1.18	1.18		0.81	0.81	0.80	0.80
1 MeV < E < 5 MeV	1.28	1.28	1.26	1.26		0.94	0.94	0.87	0.87
0.5 MeV < E < 1 MeV	1.24	1.25	1.22	1.22		0.81	0.81	0.74	0.74
0.1 MeV < E < 0.5 MeV	1.69	1.67	1.66	1.68		1.07	1.06	1.13	1.13
	Oktavian Zr-40cm								
10 MeV < E < 16 MeV	0.97	0.94	0.93	0.94					
5 MeV < E < 10 MeV	0.96	1.03	1.12	1.05					
1 MeV < E < 5 MeV	1.19	1.09	1.13	1.10					
0.5 MeV < E < 1 MeV	1.07	1.06	1.06	1.03					
0.1 MeV < E < 0.5 MeV	1.23	1.44	1.37	1.38					

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Conclusion for Oktavian

Material	Conclusion FENDL report	Our conclusion
Al	*"FENDL-3 is slightly better than FENDL-2.1 and JENDL-4"*	All libraries showed similar results (0.5 – 10 MeV). Overestimation below 0.5 MeV
As	-	JEFF-3.3T2/T3 slightly better than ENDF/B-VIIIb4
Co	"FENDL-3 is the same as FENDL-2.1. The JENDL-4 is better than FENDL-3 (4 - 11 MeV)"	All libraries high underestimation
Cr	"FENDL-3 is better than FENDL-2.1 and JENDL-4 except for neutrons from 0.5 to 1 MeV for which FENDL-3 gives a larger overestimation"	All similar results. Overestimation from 0.5 to 1 MeV for ENDF/B-VIIIb4
Cu	"*FENDL-3 is the same as FENDL-2.1. JENDL-4 is better than FENDL-3 (1 to 11 MeV)*"	Slightly better T2=FENDL-3.1b. From 1 to 5 MeV overestimation, and large overestimation for ENDF/B-VIIIb4
LiF	-	All same results.
Mn	"FENDL-3 is better than FENDL-2.1 for neutrons above 1 MeV. Worse agreement is obtained for neutrons below 1 MeV"	JEFF-3.3T2/T3 overestimation 1MeV to 5 MeV
Mo	"FENDL-3 is better than FENDL-2.1 for neutrons from 0.5 to 10 MeV"	T2/T3 good agreement

U. Fischer et al., "Benchmarking of the FENDL-3 Neutron Cross-Section Data Library for Fusion Applications", IAEA, 2014.

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Conclusion for Oktavian

Material	Conclusion FENDL report	Our conclusion
Nb	"FENDL-3 is better than FENDL-2.1 for neutrons below 1 MeV. Worse agreement is obtained for neutrons from 1 to 10 MeV"	JEFF-3.3T2/T3 high overestimation from 5 MeV– 10 MeV
Se	-	All libraries overestimation 0.1 – 10 MeV ENDF/B-VIIIb4 underestimates 5 – 10MeV
Si	"FENDL-3 is the same as FENDL-2.1. JENDL-4 is better than FENDL-3 below 10 MeV"	All libraries great agreement (1 – 16 MeV)
Teflon	*"All the calculation results underestimate the measured ones. The measured data might include some errors"*	All, underestimation
Ti	"FENDL-3 is better than FENDL-2.1 and JENDL-4 for neutrons below 1 MeV. Worse or the same agreement is obtained for neutrons above 1 MeV"	All libraries overestimation (0.1 – 10 MeV) Better T2/T3 in 5-10 MeV
W	"FENDL-3 is almost the same as FENDL-2.1 and JENDL-4"	All libraries underestimation 0.5 – 16 MeV T2/T3 lower values below 1 MeV
Zr	All the calculation results are the same. They overestimate neutrons below 1 MeV.	JEFF/3.3T3 better agreement

U. Fischer et al., "Benchmarking of the FENDL-3 Neutron Cross-Section Data Library for Fusion Applications", IAEA, 2014.

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IV. Conclusion

- Testing JEFF-3.3T3/T2, FENDL-3.1b and ENDF/B-VIIIb4 in TOF Shielding Benchmarks
  - FNS, MCNP6 shielding suite and Oktavian
  - Main elements:
    - **Fe:** Good agreement for JEFF-3.3T2 and JEFF-3.3T3, slightly better T2
    - **Cu:** JEFF-3.3T3 better from 1Mev to 10 MeV
      JEFF-3.3T2 better above 10 MeV, and below 1 MeV
    - **Pb:** JEFF-3.3 libraries showed good agreement
- Collection of MCNP inputs/exp.data
  - Some references have problems in inputs
    - MCNP4 → MCNP6
    - Neutron source spectra
  - Inputs and experimental data
    - Experimental data normalization

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Annex I. FNS TOF

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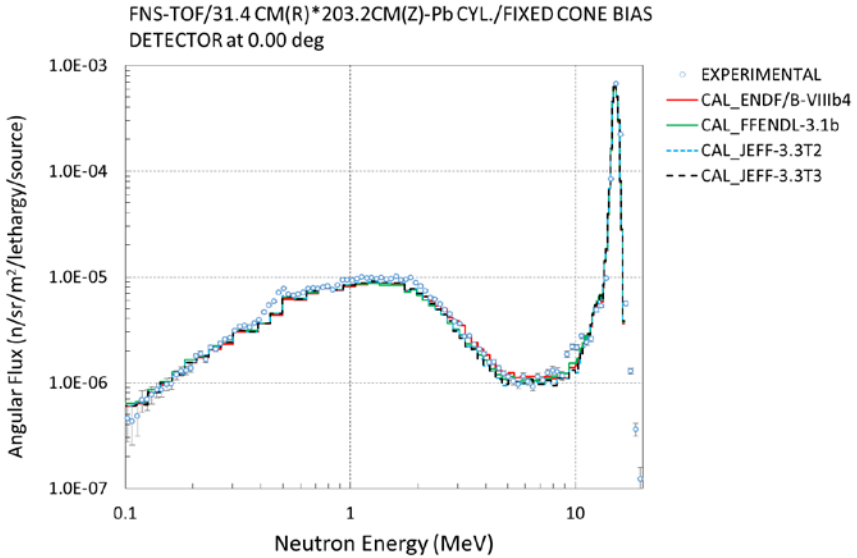
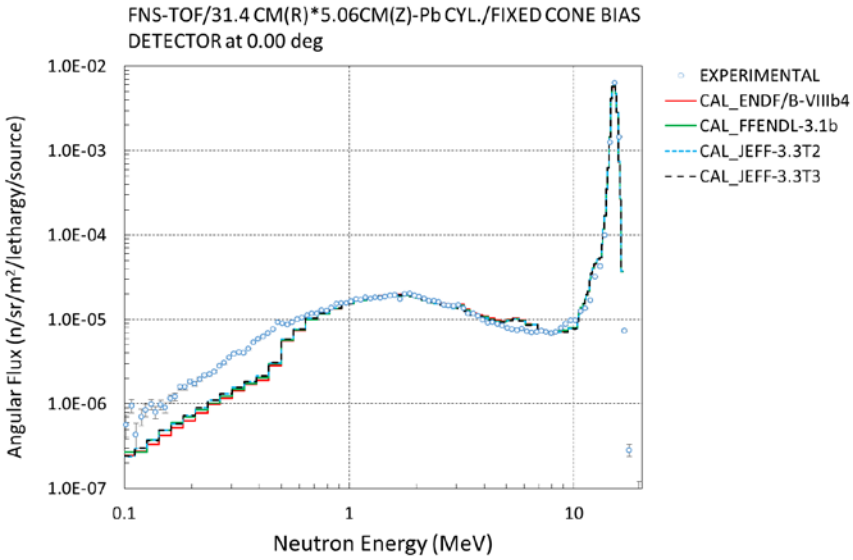
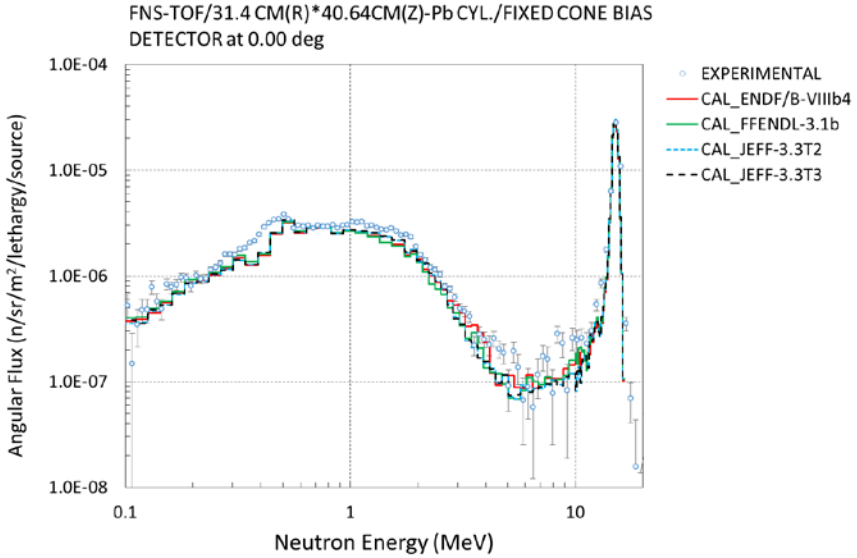
FNS TOF : Lead







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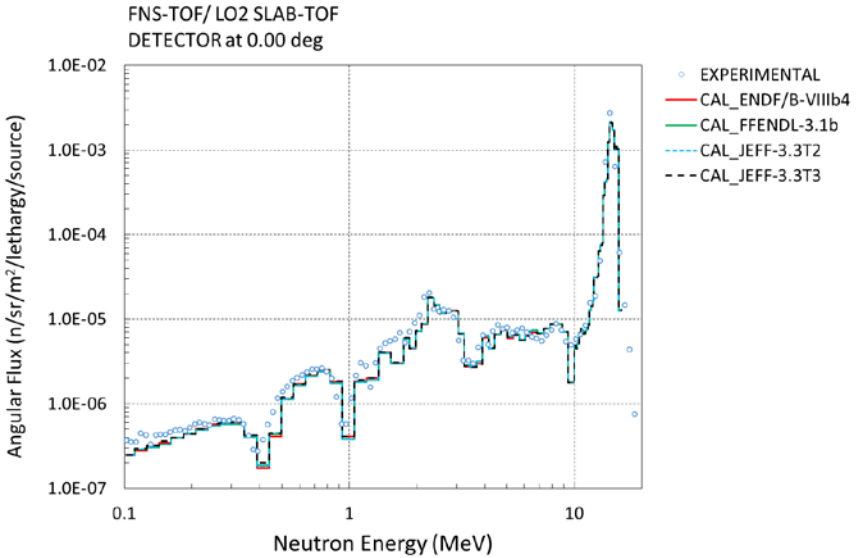
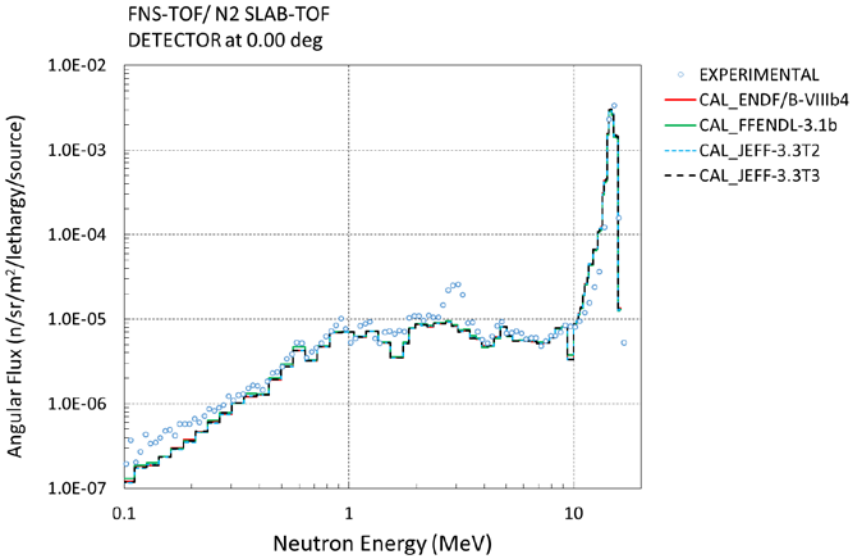
Appendix. FNS TOF: Oxygen



Appendix. FNS TOF: Nitrogen



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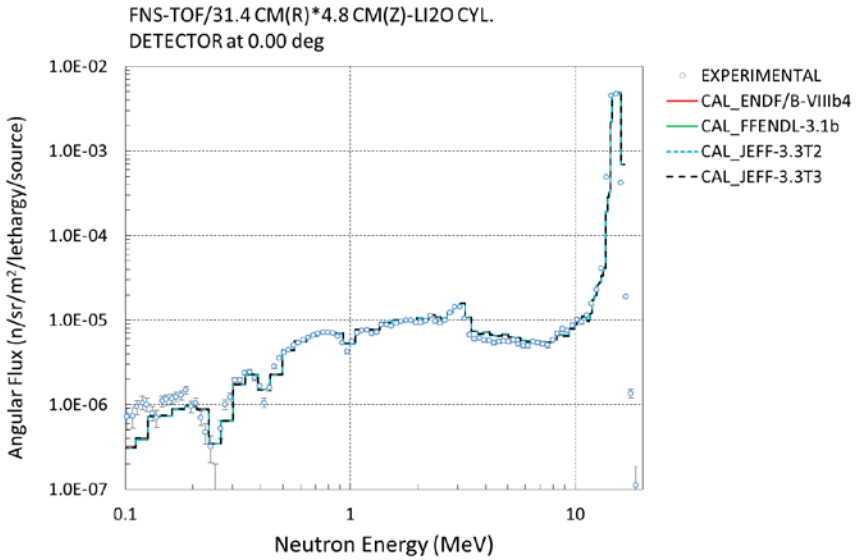
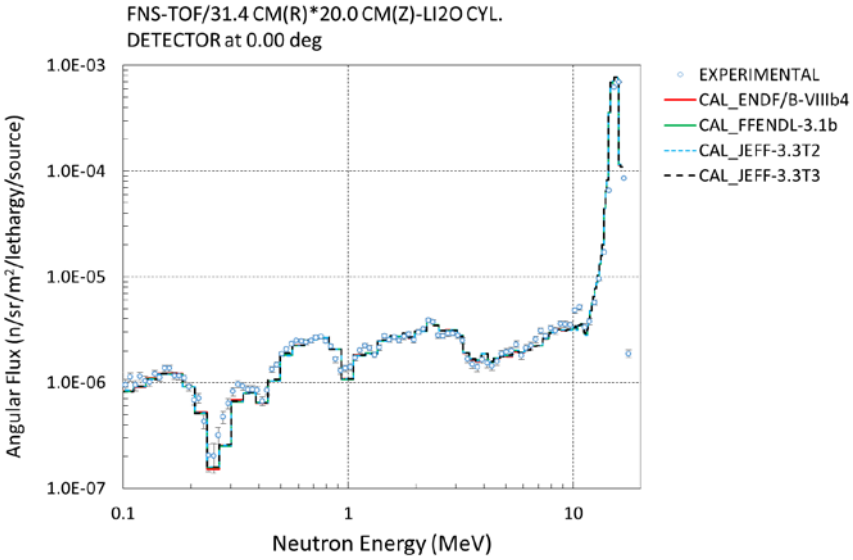
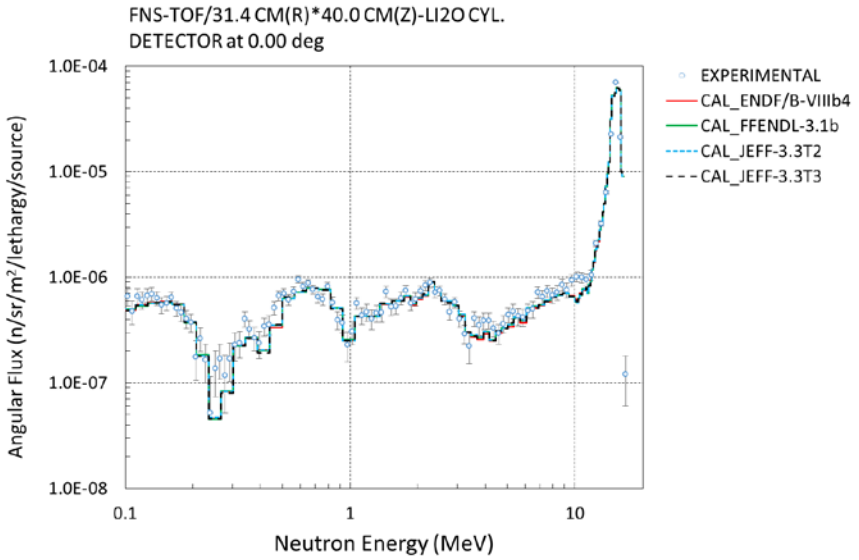
Appendix. FNS TOF: Li2O







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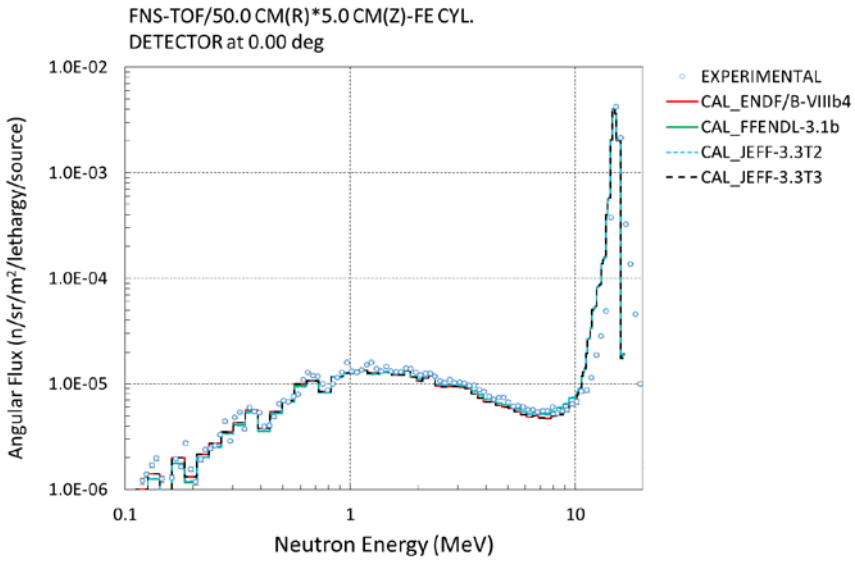
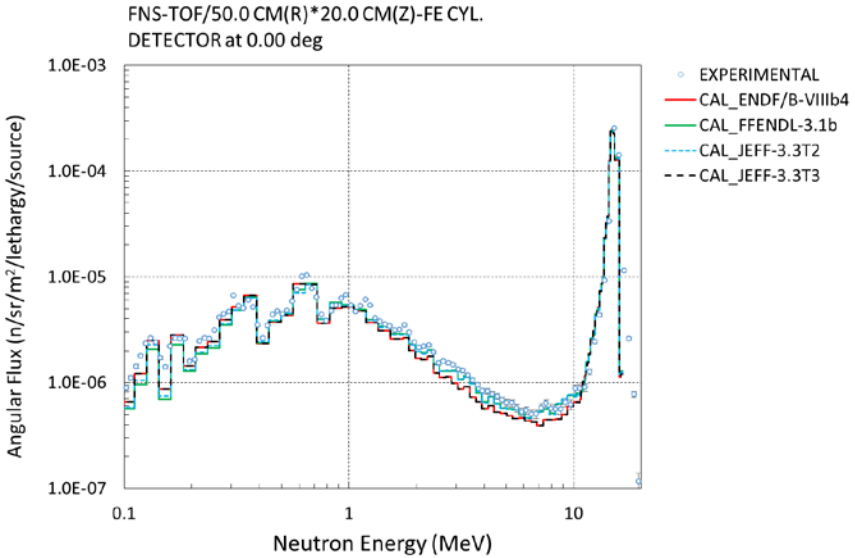
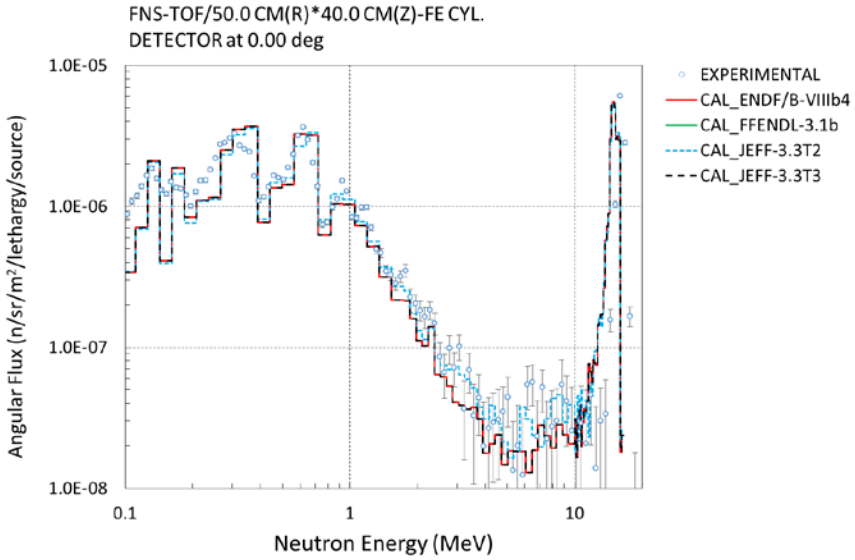
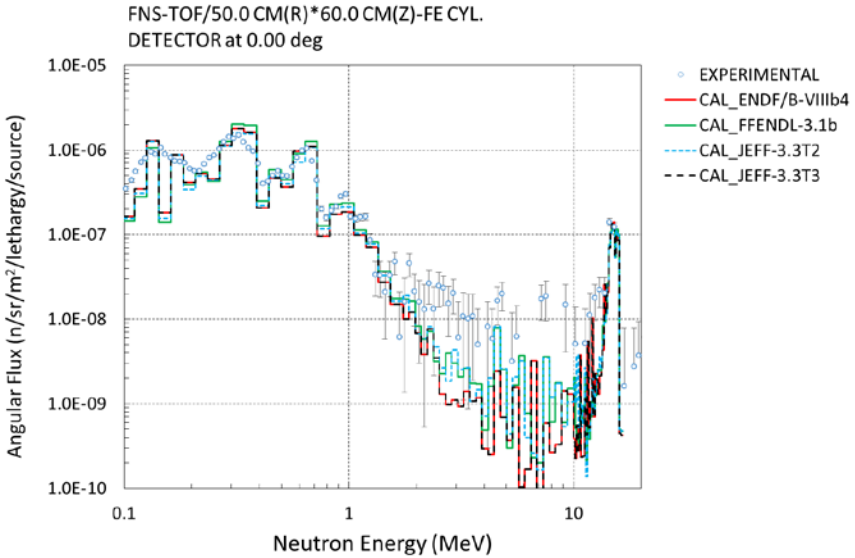
Appendix. FNS TOF: Iron









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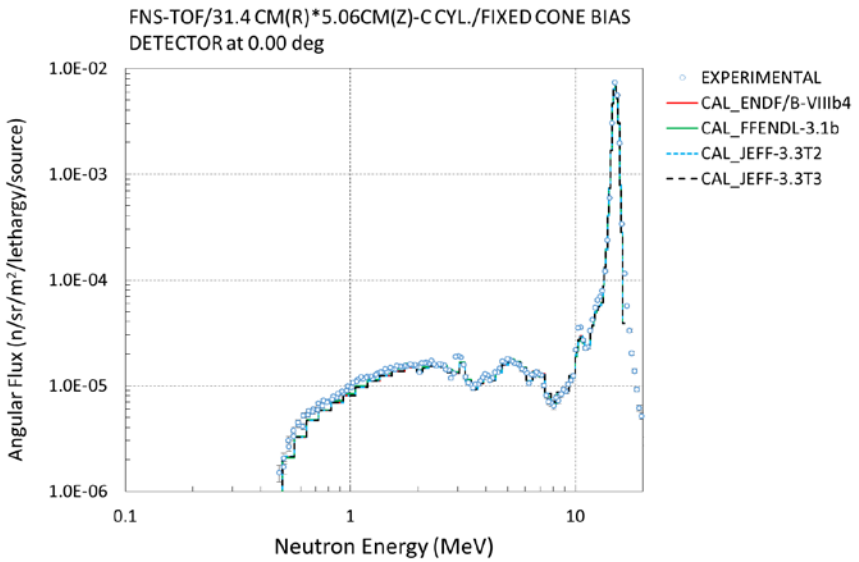
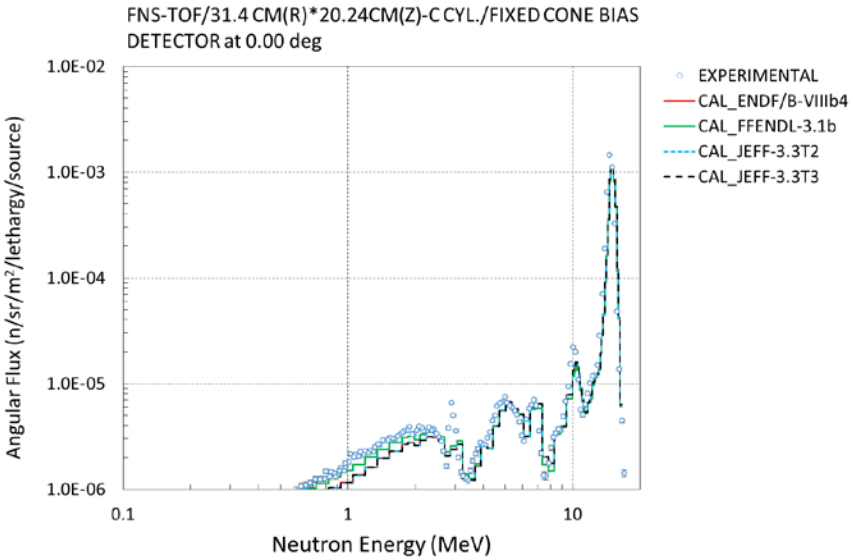
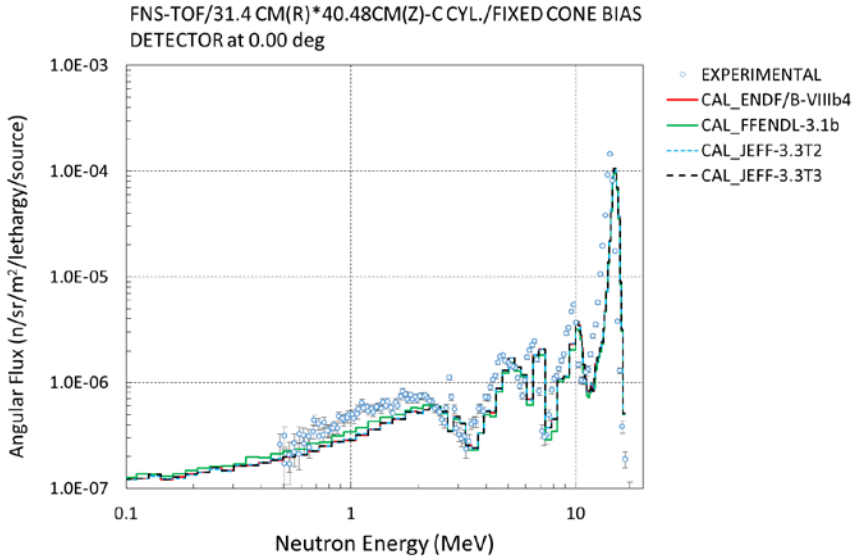
Appendix. FNS TOF: Graphite







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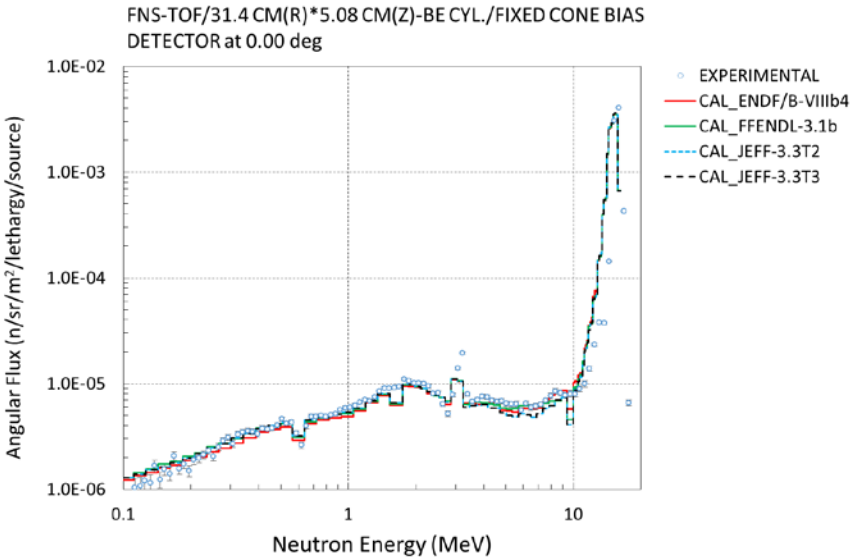
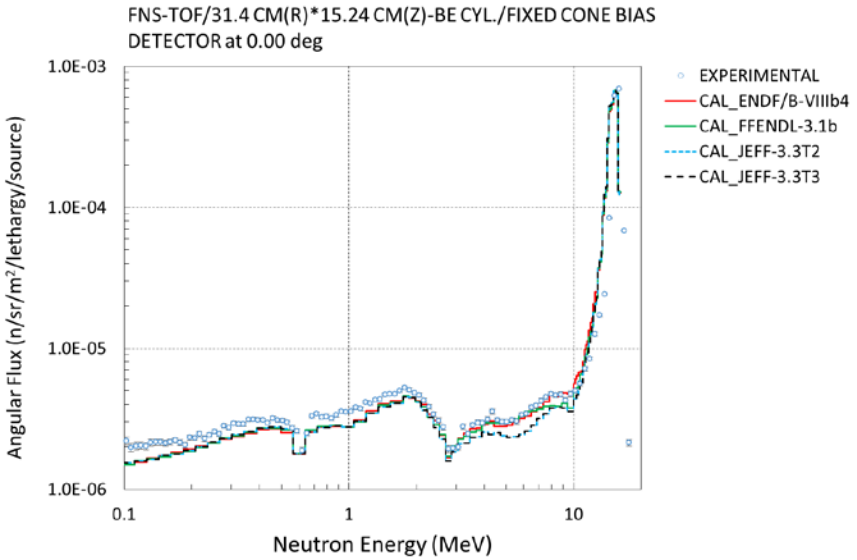
Appendix. FNS TOF: Beryllium





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FNS-TOF/31.4 CM(R)*15.24 CM(Z)-Beryllium				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.92	0.93	0.95	0.95
5 MeV < E < 10 MeV	0.97	0.91	0.78	0.78
1 MeV < E < 5 MeV	0.91	0.89	0.85	0.85
0.5 MeV < E < 1 MeV	0.82	0.84	0.83	0.83
0.1 MeV < E < 0.5 MeV	0.88	0.88	0.89	0.89
E < 0.1 MeV	0.23	0.23	0.23	0.23
FNS-TOF/31.4 CM(R)*15.24 CM(Z)-Beryllium				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.75	0.77	0.77	0.77
5 MeV < E < 10 MeV	1.05	0.99	0.83	0.83
1 MeV < E < 5 MeV	0.97	0.96	0.90	0.90
0.5 MeV < E < 1 MeV	0.90	0.91	0.91	0.91
0.1 MeV < E < 0.5 MeV	1.03	1.03	1.04	1.04
E < 0.1 MeV	1.38	1.39	1.43	1.43
FNS-TOF/31.4 CM(R)*15.24 CM(Z)-Beryllium				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.96	0.95	0.95	0.95
5 MeV < E < 10 MeV	1.07	1.00	0.86	0.86
1 MeV < E < 5 MeV	0.97	0.95	0.90	0.90
0.5 MeV < E < 1 MeV	0.89	0.90	0.90	0.90
0.1 MeV < E < 0.5 MeV	1.02	1.02	1.03	1.03
E < 0.1 MeV	0.74	0.74	0.76	0.76
FNS-TOF/31.4 CM(R)*15.24 CM(Z)-Beryllium				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.79	0.76	0.76	0.76
5 MeV < E < 10 MeV	1.03	0.96	0.85	0.85
1 MeV < E < 5 MeV	0.94	0.91	0.86	0.86
0.5 MeV < E < 1 MeV	0.87	0.88	0.88	0.88
0.1 MeV < E < 0.5 MeV	1.02	1.01	1.03	1.03
E < 0.1 MeV	1.11	1.12	1.15	1.15
FNS-TOF/31.4 CM(R)*15.24 CM(Z)-Beryllium				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.71	0.67	0.67	0.67
5 MeV < E < 10 MeV	0.98	0.90	0.83	0.83
1 MeV < E < 5 MeV	0.94	0.89	0.84	0.84
0.5 MeV < E < 1 MeV	0.85	0.86	0.86	0.86
0.1 MeV < E < 0.5 MeV	0.97	0.96	0.97	0.97
E < 0.1 MeV	0.95	0.95	0.98	0.98

FNS-TOF/31.4 CM(R)*5.06 CM(Z)-Beryllium				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.92	0.93	0.94	0.94
5 MeV < E < 10 MeV	0.95	0.91	0.81	0.81
1 MeV < E < 5 MeV	0.87	0.89	0.88	0.88
0.5 MeV < E < 1 MeV	0.89	0.95	0.97	0.97
0.1 MeV < E < 0.5 MeV	1.07	1.16	1.16	1.16
E < 0.1 MeV	-	-	-	-
FNS-TOF/31.4 CM(R)*5.06 CM(Z)-Beryllium				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	-	-	-	-
1 MeV < E < 5 MeV	-	-	-	-
0.5 MeV < E < 1 MeV	-	-	-	-
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-
FNS-TOF/31.4 CM(R)*5.06 CM(Z)-Beryllium				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.96	0.95	0.95	0.95
5 MeV < E < 10 MeV	1.02	0.97	0.81	0.81
1 MeV < E < 5 MeV	0.92	0.96	0.93	0.93
0.5 MeV < E < 1 MeV	0.85	0.92	0.95	0.95
0.1 MeV < E < 0.5 MeV	0.95	1.04	1.04	1.04
E < 0.1 MeV	0.81	0.86	0.85	0.85
FNS-TOF/31.4 CM(R)*5.06 CM(Z)-Beryllium				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.97	0.93	0.92	0.92
5 MeV < E < 10 MeV	1.03	0.96	0.84	0.84
1 MeV < E < 5 MeV	0.94	0.95	0.92	0.92
0.5 MeV < E < 1 MeV	0.84	0.90	0.94	0.94
0.1 MeV < E < 0.5 MeV	0.99	1.06	1.08	1.08
E < 0.1 MeV	3.40	3.58	3.55	3.55
FNS-TOF/31.4 CM(R)*5.06 CM(Z)-Beryllium				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.65	0.61	0.62	0.62
5 MeV < E < 10 MeV	1.00	0.90	0.85	0.85
1 MeV < E < 5 MeV	0.90	0.88	0.84	0.84
0.5 MeV < E < 1 MeV	0.79	0.84	0.88	0.88
0.1 MeV < E < 0.5 MeV	0.89	0.95	0.98	0.98
E < 0.1 MeV	0.66	0.69	0.69	0.69

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FNS-TOF/31.4 CM(R)*5.06CM(Z)-Graphite				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.96	0.96	0.96	0.96
5 MeV < E < 10 MeV	1.08	1.07	1.08	1.08
1 MeV < E < 5 MeV	0.94	0.97	0.94	0.94
0.5 MeV < E < 1 MeV	0.88	0.90	0.87	0.88
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Graphite				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.56	1.55	1.56	1.56
5 MeV < E < 10 MeV	1.67	1.66	1.67	1.67
1 MeV < E < 5 MeV	1.48	1.54	1.48	1.48
0.5 MeV < E < 1 MeV	1.36	1.39	1.36	1.36
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Graphite				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.30	1.18	1.30	1.30
5 MeV < E < 10 MeV	1.16	1.11	1.16	1.16
1 MeV < E < 5 MeV	0.82	1.13	0.82	0.82
0.5 MeV < E < 1 MeV	0.95	1.12	0.95	0.95
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Graphite				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.46	1.31	1.46	1.46
5 MeV < E < 10 MeV	1.22	1.17	1.22	1.22
1 MeV < E < 5 MeV	0.88	1.21	0.88	0.88
0.5 MeV < E < 1 MeV	0.94	1.10	0.94	0.94
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Graphite				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.05	0.94	1.05	1.05
5 MeV < E < 10 MeV	1.08	1.01	1.08	1.08
1 MeV < E < 5 MeV	0.83	1.13	0.83	0.83
0.5 MeV < E < 1 MeV	0.86	0.99	0.86	0.86
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*20.24CM(Z)-Graphite				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.85	0.82	0.85	0.85
5 MeV < E < 10 MeV	0.94	0.89	0.94	0.94
1 MeV < E < 5 MeV	0.76	0.85	0.76	0.76
0.5 MeV < E < 1 MeV	0.79	0.99	0.79	0.79
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*20.24CM(Z)-Graphite				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.99	0.88	1.00	0.99
5 MeV < E < 10 MeV	1.16	1.06	1.16	1.16
1 MeV < E < 5 MeV	0.87	1.04	0.87	0.87
0.5 MeV < E < 1 MeV	0.90	1.15	0.90	0.90
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*20.24CM(Z)-Graphite				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.11	0.98	1.11	1.11
5 MeV < E < 10 MeV	1.06	0.96	1.06	1.06
1 MeV < E < 5 MeV	0.88	1.04	0.87	0.88
0.5 MeV < E < 1 MeV	0.84	1.07	0.84	0.84
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*20.24CM(Z)-Graphite				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.17	1.00	1.17	1.17
5 MeV < E < 10 MeV	1.11	0.99	1.11	1.11
1 MeV < E < 5 MeV	0.90	1.06	0.90	0.90
0.5 MeV < E < 1 MeV	0.81	1.05	0.81	0.81
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*20.24CM(Z)-Graphite				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.00	0.85	1.00	1.00
5 MeV < E < 10 MeV	1.05	0.92	1.05	1.05
1 MeV < E < 5 MeV	0.88	1.01	0.88	0.88
0.5 MeV < E < 1 MeV	0.80	1.03	0.80	0.80
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

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FNS-TOF/31.4 CM(R)*40.48CM(Z)-Graphite				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.77	0.73	0.77	0.77
5 MeV < E < 10 MeV	0.82	0.75	0.82	0.82
1 MeV < E < 5 MeV	0.71	0.74	0.71	0.71
0.5 MeV < E < 1 MeV	0.70	0.80	0.71	0.70
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-
FNS-TOF/31.4 CM(R)*40.48CM(Z)-Graphite				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.85	0.73	0.85	0.85
5 MeV < E < 10 MeV	1.04	0.90	1.04	1.04
1 MeV < E < 5 MeV	0.82	0.85	0.82	0.82
0.5 MeV < E < 1 MeV	0.71	0.82	0.71	0.71
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-
FNS-TOF/31.4 CM(R)*40.48CM(Z)-Graphite				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.89	0.75	0.89	0.89
5 MeV < E < 10 MeV	1.01	0.86	1.01	1.01
1 MeV < E < 5 MeV	0.83	0.85	0.83	0.83
0.5 MeV < E < 1 MeV	0.82	0.94	0.82	0.82
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-
FNS-TOF/31.4 CM(R)*40.48CM(Z)-Graphite				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.98	0.81	0.98	0.98
5 MeV < E < 10 MeV	1.02	0.86	1.02	1.02
1 MeV < E < 5 MeV	0.78	0.79	0.79	0.78
0.5 MeV < E < 1 MeV	0.59	0.69	0.60	0.59
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-
FNS-TOF/31.4 CM(R)*40.48CM(Z)-Graphite				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.79	0.64	0.78	0.79
5 MeV < E < 10 MeV	1.05	0.85	1.04	1.05
1 MeV < E < 5 MeV	0.86	0.84	0.87	0.86
0.5 MeV < E < 1 MeV	0.89	1.03	0.89	0.89
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

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FNS-TOF/50.0 CM(R)*5.0 CM(Z)-Iron				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.95	0.95	0.95	0.95
5 MeV < E < 10 MeV	0.93	1.01	1.02	0.93
1 MeV < E < 5 MeV	0.95	0.96	0.96	0.95
0.5 MeV < E < 1 MeV	0.96	0.94	0.93	0.96
0.1 MeV < E < 0.5 MeV	1.06	1.00	1.00	1.06
E < 0.1 MeV	0.00	0.00	0.00	0.00

FNS-TOF/50.0 CM(R)*5.0 CM(Z)-Iron				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	-	-	-	-
1 MeV < E < 5 MeV	-	-	-	-
0.5 MeV < E < 1 MeV	-	-	-	-
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/50.0 CM(R)*5.0 CM(Z)-Iron				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.20	1.26	1.27	1.20
5 MeV < E < 10 MeV	0.95	0.98	1.00	0.95
1 MeV < E < 5 MeV	0.92	0.95	0.95	0.92
0.5 MeV < E < 1 MeV	1.03	0.99	1.00	1.03
0.1 MeV < E < 0.5 MeV	1.23	1.09	1.12	1.23
E < 0.1 MeV	1.07	0.81	0.84	1.07

FNS-TOF/50.0 CM(R)*5.0 CM(Z)-Iron				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.77	0.83	0.82	0.77
5 MeV < E < 10 MeV	0.84	0.85	0.86	0.84
1 MeV < E < 5 MeV	0.89	0.91	0.91	0.89
0.5 MeV < E < 1 MeV	1.02	0.98	0.99	1.02
0.1 MeV < E < 0.5 MeV	1.20	1.07	1.09	1.20
E < 0.1 MeV	0.84	0.63	0.65	0.84

FNS-TOF/50.0 CM(R)*5.0 CM(Z)-Iron				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.62	0.59	0.58	0.62
5 MeV < E < 10 MeV	0.74	0.74	0.75	0.74
1 MeV < E < 5 MeV	0.87	0.90	0.89	0.87
0.5 MeV < E < 1 MeV	0.95	0.91	0.91	0.95
0.1 MeV < E < 0.5 MeV	1.00	0.90	0.91	1.00
E < 0.1 MeV	0.00	7.71	7.94	0.00

FNS-TOF/50.0 CM(R)*20.0 CM(Z)-Iron				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.93	0.93	0.92	0.93
5 MeV < E < 10 MeV	0.80	0.98	0.98	0.80
1 MeV < E < 5 MeV	0.89	0.98	0.97	0.89
0.5 MeV < E < 1 MeV	0.94	0.95	0.93	0.94
0.1 MeV < E < 0.5 MeV	0.96	0.89	0.92	0.96
E < 0.1 MeV	0.77	0.65	0.67	0.77

FNS-TOF/50.0 CM(R)*20.0 CM(Z)-Iron				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.96	0.98	0.98	0.96
5 MeV < E < 10 MeV	0.88	1.01	1.02	0.88
1 MeV < E < 5 MeV	0.89	0.99	0.98	0.89
0.5 MeV < E < 1 MeV	1.00	1.02	1.00	1.00
0.1 MeV < E < 0.5 MeV	1.08	0.99	1.03	1.08
E < 0.1 MeV	1.10	0.92	0.94	1.10

FNS-TOF/50.0 CM(R)*20.0 CM(Z)-Iron				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.99	1.04	1.04	0.99
5 MeV < E < 10 MeV	0.81	0.91	0.92	0.81
1 MeV < E < 5 MeV	0.88	0.98	0.97	0.88
0.5 MeV < E < 1 MeV	0.99	1.01	0.99	0.99
0.1 MeV < E < 0.5 MeV	1.08	1.00	1.04	1.08
E < 0.1 MeV	1.58	1.32	1.36	1.58

FNS-TOF/50.0 CM(R)*20.0 CM(Z)-Iron				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.92	0.93	0.92	0.92
5 MeV < E < 10 MeV	0.83	0.91	0.92	0.83
1 MeV < E < 5 MeV	0.88	0.98	0.96	0.88
0.5 MeV < E < 1 MeV	0.98	0.99	0.98	0.98
0.1 MeV < E < 0.5 MeV	1.01	0.94	0.96	1.01
E < 0.1 MeV	1.01	0.84	0.87	1.01

FNS-TOF/50.0 CM(R)*20.0 CM(Z)-Iron				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.82	0.77	0.76	0.82
5 MeV < E < 10 MeV	0.81	0.89	0.89	0.81
1 MeV < E < 5 MeV	0.85	0.96	0.94	0.85
0.5 MeV < E < 1 MeV	0.96	0.98	0.96	0.96
0.1 MeV < E < 0.5 MeV	1.02	0.95	0.97	1.02
E < 0.1 MeV	0.76	0.64	0.66	0.76

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FNS-TOF/50.0 CM(R)*40.0 CM(Z)-Iron				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.95	0.96	0.94	0.95
5 MeV < E < 10 MeV	0.65	0.97	0.93	0.65
1 MeV < E < 5 MeV	0.96	1.15	1.08	0.96
0.5 MeV < E < 1 MeV	1.01	1.10	1.02	1.01
0.1 MeV < E < 0.5 MeV	0.96	0.94	0.93	0.96
E < 0.1 MeV	1.68	1.51	1.61	1.68

FNS-TOF/50.0 CM(R)*40.0 CM(Z)-Iron				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.84	0.87	0.86	0.84
5 MeV < E < 10 MeV	0.91	1.21	1.17	0.91
1 MeV < E < 5 MeV	0.95	1.14	1.09	0.95
0.5 MeV < E < 1 MeV	1.02	1.11	1.04	1.02
0.1 MeV < E < 0.5 MeV	1.05	1.03	1.03	1.05
E < 0.1 MeV	1.26	1.11	1.20	1.26

FNS-TOF/50.0 CM(R)*40.0 CM(Z)-Iron				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.93	0.92	0.95	0.93
5 MeV < E < 10 MeV	0.80	0.97	0.94	0.80
1 MeV < E < 5 MeV	0.95	1.15	1.11	0.95
0.5 MeV < E < 1 MeV	0.98	1.07	1.01	0.98
0.1 MeV < E < 0.5 MeV	0.97	0.96	0.96	0.97
E < 0.1 MeV	1.00	0.90	0.96	1.00

FNS-TOF/50.0 CM(R)*40.0 CM(Z)-Iron				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.86	0.81	0.87	0.86
5 MeV < E < 10 MeV	0.42	0.46	0.46	0.42
1 MeV < E < 5 MeV	0.86	1.07	1.02	0.86
0.5 MeV < E < 1 MeV	0.93	1.02	0.97	0.93
0.1 MeV < E < 0.5 MeV	0.91	0.90	0.91	0.91
E < 0.1 MeV	1.02	0.91	0.99	1.02

FNS-TOF/50.0 CM(R)*40.0 CM(Z)-Iron				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.67	0.63	0.63	0.67
5 MeV < E < 10 MeV	0.00	0.00	0.00	0.00
1 MeV < E < 5 MeV	0.74	0.94	0.88	0.74
0.5 MeV < E < 1 MeV	0.87	0.97	0.92	0.87
0.1 MeV < E < 0.5 MeV	0.84	0.82	0.85	0.84
E < 0.1 MeV	0.60	0.56	0.60	0.60

FNS-TOF/50.0 CM(R)*60.0 CM(Z)--Iron				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	-	-	-	-
1 MeV < E < 5 MeV	0.87	1.08	0.99	0.87
0.5 MeV < E < 1 MeV	1.01	1.12	0.96	1.01
0.1 MeV < E < 0.5 MeV	0.92	0.96	0.88	0.92
E < 0.1 MeV	1.41	1.32	1.38	1.41

FNS-TOF/50.0 CM(R)*60.0 CM(Z)--Iron				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.55	0.53	0.51	0.55
5 MeV < E < 10 MeV	0.00	0.00	0.00	0.00
1 MeV < E < 5 MeV	0.97	1.18	1.12	0.97
0.5 MeV < E < 1 MeV	1.09	1.20	1.02	1.09
0.1 MeV < E < 0.5 MeV	1.01	1.04	0.97	1.01
E < 0.1 MeV	4.97	4.58	4.83	4.97

FNS-TOF/50.0 CM(R)*60.0 CM(Z)--Iron				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	-	-	-	-
1 MeV < E < 5 MeV	1.01	1.31	1.27	1.01
0.5 MeV < E < 1 MeV	1.02	1.14	0.98	1.02
0.1 MeV < E < 0.5 MeV	0.93	0.97	0.92	0.93
E < 0.1 MeV	3.64	3.42	3.51	3.64

FNS-TOF/50.0 CM(R)*60.0 CM(Z)--Iron				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	0.14	0.51	0.47	0.14
1 MeV < E < 5 MeV	0.92	1.23	1.20	0.92
0.5 MeV < E < 1 MeV	1.00	1.16	1.00	1.00
0.1 MeV < E < 0.5 MeV	0.95	0.97	0.94	0.95
E < 0.1 MeV	0.48	0.46	0.48	0.48

FNS-TOF/50.0 CM(R)*60.0 CM(Z)--Iron				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	-	-	-	-
1 MeV < E < 5 MeV	-	-	-	-
0.5 MeV < E < 1 MeV	-	-	-	-
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

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FNS-TOF/31.4 CM(R)*4.8 CM(Z)-Li2O				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.98	0.98	0.98	0.98
5 MeV < E < 10 MeV	1.00	1.01	1.01	1.00
1 MeV < E < 5 MeV	1.11	1.11	1.11	1.11
0.5 MeV < E < 1 MeV	1.03	1.02	1.02	1.04
0.1 MeV < E < 0.5 MeV	1.00	0.99	0.99	1.00
E < 0.1 MeV	0.26	0.26	0.26	0.26

FNS-TOF/31.4 CM(R)*4.8 CM(Z)-Li2O				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	-	-	-	-
1 MeV < E < 5 MeV	-	-	-	-
0.5 MeV < E < 1 MeV	-	-	-	-
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*4.8 CM(Z)-Li2O				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.10	1.10	1.10	1.10
5 MeV < E < 10 MeV	0.90	0.91	0.91	0.91
1 MeV < E < 5 MeV	1.26	1.26	1.26	1.26
0.5 MeV < E < 1 MeV	0.99	1.00	1.00	1.01
0.1 MeV < E < 0.5 MeV	1.01	1.00	1.00	1.02
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*4.8 CM(Z)-Li2O				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.90	0.90	0.90	0.90
5 MeV < E < 10 MeV	0.81	0.81	0.81	0.81
1 MeV < E < 5 MeV	1.11	1.11	1.11	1.11
0.5 MeV < E < 1 MeV	0.96	0.97	0.97	0.97
0.1 MeV < E < 0.5 MeV	0.84	0.84	0.84	0.85
E < 0.1 MeV	0.32	0.32	0.32	0.32

FNS-TOF/31.4 CM(R)*4.8 CM(Z)-Li2O				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.87	0.87	0.87	0.87
5 MeV < E < 10 MeV	0.85	0.85	0.86	0.85
1 MeV < E < 5 MeV	1.01	1.01	1.01	1.01
0.5 MeV < E < 1 MeV	0.92	0.92	0.92	0.92
0.1 MeV < E < 0.5 MeV	0.79	0.78	0.78	0.79
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*20.0 CM(Z)-Li2O				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.04	1.04	1.04	1.04
5 MeV < E < 10 MeV	0.87	0.88	0.88	0.88
1 MeV < E < 5 MeV	1.02	1.02	1.02	1.02
0.5 MeV < E < 1 MeV	0.97	0.97	0.97	0.98
0.1 MeV < E < 0.5 MeV	0.98	0.98	0.98	0.99
E < 0.1 MeV	0.38	0.38	0.38	0.37

FNS-TOF/31.4 CM(R)*20.0 CM(Z)-Li2O				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.99	0.99	0.99	0.99
5 MeV < E < 10 MeV	0.87	0.89	0.89	0.88
1 MeV < E < 5 MeV	1.09	1.10	1.10	1.09
0.5 MeV < E < 1 MeV	1.04	1.04	1.04	1.05
0.1 MeV < E < 0.5 MeV	1.14	1.13	1.13	1.15
E < 0.1 MeV	0.72	0.72	0.72	0.72

FNS-TOF/31.4 CM(R)*20.0 CM(Z)-Li2O				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.93	0.93	0.93	0.93
5 MeV < E < 10 MeV	0.85	0.85	0.86	0.85
1 MeV < E < 5 MeV	1.03	1.03	1.03	1.03
0.5 MeV < E < 1 MeV	0.97	0.96	0.96	0.97
0.1 MeV < E < 0.5 MeV	1.04	1.03	1.03	1.05
E < 0.1 MeV	0.66	0.66	0.66	0.66

FNS-TOF/31.4 CM(R)*20.0 CM(Z)-Li2O				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.82	0.83	0.83	0.82
5 MeV < E < 10 MeV	0.79	0.80	0.80	0.79
1 MeV < E < 5 MeV	0.98	0.99	0.99	0.98
0.5 MeV < E < 1 MeV	0.95	0.94	0.95	0.95
0.1 MeV < E < 0.5 MeV	1.02	1.01	1.00	1.02
E < 0.1 MeV	0.62	0.62	0.62	0.62

FNS-TOF/31.4 CM(R)*20.0 CM(Z)-Li2O				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.74	0.74	0.74	0.74
5 MeV < E < 10 MeV	0.76	0.77	0.77	0.76
1 MeV < E < 5 MeV	0.91	0.91	0.91	0.91
0.5 MeV < E < 1 MeV	0.87	0.86	0.87	0.87
0.1 MeV < E < 0.5 MeV	0.94	0.93	0.93	0.93
E < 0.1 MeV	0.52	0.53	0.53	0.52

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FNS-TOF/31.4 CM(R)*40.0 CM(Z)-Li2O				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.05	1.06	1.05	1.05
5 MeV < E < 10 MeV	0.82	0.83	0.83	0.82
1 MeV < E < 5 MeV	0.94	0.96	0.96	0.95
0.5 MeV < E < 1 MeV	0.97	0.97	0.97	0.98
0.1 MeV < E < 0.5 MeV	0.95	0.94	0.95	0.94
E < 0.1 MeV	0.47	0.46	0.47	0.47
FNS-TOF/31.4 CM(R)*40.0 CM(Z)-Li2O				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.97	0.97	0.97	0.97
5 MeV < E < 10 MeV	0.84	0.86	0.86	0.85
1 MeV < E < 5 MeV	1.02	1.03	1.03	1.03
0.5 MeV < E < 1 MeV	1.04	1.04	1.04	1.04
0.1 MeV < E < 0.5 MeV	1.13	1.11	1.12	1.12
E < 0.1 MeV	0.82	0.82	0.82	0.83
FNS-TOF/31.4 CM(R)*40.0 CM(Z)-Li2O				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.90	0.90	0.90	0.90
5 MeV < E < 10 MeV	0.82	0.83	0.83	0.82
1 MeV < E < 5 MeV	0.94	0.96	0.96	0.95
0.5 MeV < E < 1 MeV	0.93	0.93	0.93	0.93
0.1 MeV < E < 0.5 MeV	0.97	0.97	0.97	0.97
E < 0.1 MeV	0.42	0.41	0.41	0.42
FNS-TOF/31.4 CM(R)*40.0 CM(Z)-Li2O				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.83	0.83	0.83	0.83
5 MeV < E < 10 MeV	0.73	0.74	0.74	0.73
1 MeV < E < 5 MeV	0.87	0.88	0.88	0.88
0.5 MeV < E < 1 MeV	0.92	0.92	0.92	0.92
0.1 MeV < E < 0.5 MeV	0.97	0.97	0.98	0.98
E < 0.1 MeV	0.52	0.52	0.51	0.52
FNS-TOF/31.4 CM(R)*40.0 CM(Z)-Li2O				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.75	0.75	0.76	0.76
5 MeV < E < 10 MeV	0.70	0.71	0.71	0.70
1 MeV < E < 5 MeV	0.84	0.85	0.85	0.84
0.5 MeV < E < 1 MeV	0.85	0.85	0.85	0.85
0.1 MeV < E < 0.5 MeV	0.90	0.91	0.91	0.91
E < 0.1 MeV	0.53	0.53	0.53	0.54

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FNS-TOF/ N2 SLAB-TOF				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.87	0.83	0.87	0.87
5 MeV < E < 10 MeV	0.94	0.95	0.94	0.93
1 MeV < E < 5 MeV	0.69	0.70	0.69	0.69
0.5 MeV < E < 1 MeV	0.88	0.91	0.88	0.88
0.1 MeV < E < 0.5 MeV	0.91	0.94	0.91	0.91
E < 0.1 MeV	0.11	0.10	0.11	0.11
FNS-TOF/ N2 SLAB-TOF				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.77	0.74	0.77	0.77
5 MeV < E < 10 MeV	0.94	1.00	0.94	0.94
1 MeV < E < 5 MeV	0.77	0.85	0.77	0.77
0.5 MeV < E < 1 MeV	0.83	0.82	0.84	0.84
0.1 MeV < E < 0.5 MeV	0.78	0.74	0.77	0.79
E < 0.1 MeV	0.72	0.70	0.70	0.74
FNS-TOF/ N2 SLAB-TOF				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.57	0.56	0.57	0.57
5 MeV < E < 10 MeV	0.86	0.87	0.85	0.85
1 MeV < E < 5 MeV	0.74	0.83	0.74	0.74
0.5 MeV < E < 1 MeV	0.76	0.74	0.76	0.76
0.1 MeV < E < 0.5 MeV	0.79	0.75	0.78	0.80
E < 0.1 MeV	0.28	0.28	0.28	0.30
FNS-TOF/ N2 SLAB-TOF				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.51	0.52	0.51	0.51
5 MeV < E < 10 MeV	0.79	0.81	0.78	0.78
1 MeV < E < 5 MeV	0.77	0.86	0.77	0.77
0.5 MeV < E < 1 MeV	0.81	0.81	0.82	0.82
0.1 MeV < E < 0.5 MeV	0.76	0.72	0.75	0.78
E < 0.1 MeV	0.29	0.29	0.28	0.30
FNS-TOF/ N2 SLAB-TOF				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.42	0.44	0.42	0.42
5 MeV < E < 10 MeV	0.60	0.63	0.59	0.59
1 MeV < E < 5 MeV	0.64	0.71	0.63	0.64
0.5 MeV < E < 1 MeV	0.61	0.61	0.60	0.63
0.1 MeV < E < 0.5 MeV	0.66	0.62	0.64	0.67
E < 0.1 MeV	0.00	0.00	0.00	0.00

FNS-TOF/ LO2 SLAB-TOF				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.88	0.88	0.88	0.88
5 MeV < E < 10 MeV	1.00	1.03	1.03	1.01
1 MeV < E < 5 MeV	0.84	0.84	0.84	0.84
0.5 MeV < E < 1 MeV	0.90	0.87	0.87	0.92
0.1 MeV < E < 0.5 MeV	0.89	0.88	0.89	0.92
E < 0.1 MeV	3.54	3.36	3.31	3.55
FNS-TOF/ LO2 SLAB-TOF				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.81	0.82	0.82	0.81
5 MeV < E < 10 MeV	1.22	1.26	1.26	1.24
1 MeV < E < 5 MeV	1.05	1.05	1.05	1.05
0.5 MeV < E < 1 MeV	0.97	0.94	0.94	0.97
0.1 MeV < E < 0.5 MeV	0.99	1.00	1.01	1.02
E < 0.1 MeV	1.04	1.00	0.99	1.04
FNS-TOF/ LO2 SLAB-TOF				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.54	0.54	0.54	0.54
5 MeV < E < 10 MeV	0.89	0.91	0.91	0.90
1 MeV < E < 5 MeV	0.93	0.94	0.94	0.92
0.5 MeV < E < 1 MeV	0.85	0.83	0.83	0.84
0.1 MeV < E < 0.5 MeV	0.87	0.87	0.87	0.89
E < 0.1 MeV	0.51	0.48	0.48	0.50
FNS-TOF/ LO2 SLAB-TOF				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.50	0.50	0.50	0.50
5 MeV < E < 10 MeV	0.70	0.72	0.72	0.71
1 MeV < E < 5 MeV	0.79	0.80	0.80	0.79
0.5 MeV < E < 1 MeV	0.75	0.75	0.75	0.76
0.1 MeV < E < 0.5 MeV	0.79	0.79	0.79	0.80
E < 0.1 MeV	0.58	0.54	0.53	0.57
FNS-TOF/ LO2 SLAB-TOF				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.39	0.39	0.39	0.39
5 MeV < E < 10 MeV	0.52	0.54	0.54	0.53
1 MeV < E < 5 MeV	0.59	0.59	0.59	0.59
0.5 MeV < E < 1 MeV	0.66	0.66	0.66	0.66
0.1 MeV < E < 0.5 MeV	0.73	0.71	0.72	0.74
E < 0.1 MeV	0.56	0.53	0.52	0.52

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FNS-TOF/31.4 CM(R)*5.06CM(Z)-Lead				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.93	0.94	0.94	0.94
5 MeV < E < 10 MeV	1.10	1.10	1.08	1.08
1 MeV < E < 5 MeV	1.05	1.03	1.03	1.03
0.5 MeV < E < 1 MeV	0.86	0.87	0.88	0.88
0.1 MeV < E < 0.5 MeV	0.46	0.49	0.51	0.51
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Lead				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	-	-	-	-
5 MeV < E < 10 MeV	-	-	-	-
1 MeV < E < 5 MeV	-	-	-	-
0.5 MeV < E < 1 MeV	-	-	-	-
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Lead				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	1.19	1.23	1.24	1.24
5 MeV < E < 10 MeV	1.10	1.06	0.96	0.96
1 MeV < E < 5 MeV	1.04	1.00	0.98	0.98
0.5 MeV < E < 1 MeV	0.98	1.00	1.04	1.04
0.1 MeV < E < 0.5 MeV	1.13	1.19	1.25	1.25
E < 0.1 MeV	0.00	0.00	0.00	0.00

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Lead				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.80	0.80	0.77	0.77
5 MeV < E < 10 MeV	0.94	0.91	0.79	0.79
1 MeV < E < 5 MeV	0.95	0.92	0.92	0.92
0.5 MeV < E < 1 MeV	0.93	0.96	1.00	1.00
0.1 MeV < E < 0.5 MeV	1.13	1.20	1.26	1.26
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*5.06CM(Z)-Lead				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.66	0.64	0.59	0.60
5 MeV < E < 10 MeV	1.00	0.94	0.80	0.80
1 MeV < E < 5 MeV	0.92	0.88	0.89	0.89
0.5 MeV < E < 1 MeV	0.86	0.89	0.93	0.93
0.1 MeV < E < 0.5 MeV	-	-	-	-
E < 0.1 MeV	-	-	-	-

FNS-TOF/31.4 CM(R)*20.32CM(Z)-Lead				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.91	0.93	0.94	0.94
5 MeV < E < 10 MeV	0.92	0.89	0.82	0.82
1 MeV < E < 5 MeV	0.95	0.91	0.93	0.93
0.5 MeV < E < 1 MeV	0.90	0.92	0.93	0.93
0.1 MeV < E < 0.5 MeV	0.99	1.03	1.02	1.02
E < 0.1 MeV	0.00	0.00	0.00	0.00

FNS-TOF/31.4 CM(R)*203.2CM(Z)-Lead				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.82	0.87	0.89	0.89
5 MeV < E < 10 MeV	1.00	0.96	0.84	0.85
1 MeV < E < 5 MeV	1.01	0.96	0.98	0.98
0.5 MeV < E < 1 MeV	0.98	1.01	1.01	1.01
0.1 MeV < E < 0.5 MeV	1.09	1.13	1.12	1.12
E < 0.1 MeV	0.15	0.16	0.15	0.15

FNS-TOF/31.4 CM(R)*203.2CM(Z)-Lead				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.79	0.84	0.83	0.84
5 MeV < E < 10 MeV	0.98	0.92	0.79	0.80
1 MeV < E < 5 MeV	0.97	0.93	0.95	0.95
0.5 MeV < E < 1 MeV	0.94	0.96	0.97	0.97
0.1 MeV < E < 0.5 MeV	1.09	1.14	1.12	1.12
E < 0.1 MeV	1.81	1.96	1.84	1.83

FNS-TOF/31.4 CM(R)*203.2CM(Z)-Lead				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.67	0.67	0.65	0.65
5 MeV < E < 10 MeV	0.88	0.83	0.70	0.71
1 MeV < E < 5 MeV	0.90	0.87	0.89	0.89
0.5 MeV < E < 1 MeV	0.89	0.91	0.92	0.91
0.1 MeV < E < 0.5 MeV	1.00	1.04	1.03	1.03
E < 0.1 MeV	0.77	0.84	0.78	0.78

FNS-TOF/31.4 CM(R)*203.2CM(Z)-Lead				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.61	0.60	0.57	0.57
5 MeV < E < 10 MeV	0.78	0.72	0.63	0.62
1 MeV < E < 5 MeV	0.86	0.84	0.85	0.85
0.5 MeV < E < 1 MeV	0.84	0.86	0.87	0.87
0.1 MeV < E < 0.5 MeV	0.96	1.01	0.99	0.99
E < 0.1 MeV	0.19	0.20	0.18	0.18

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FNS-TOF/31.4 CM(R)*40.64CM(Z)-Lead				
Angle= 0 deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.82	0.86	0.87	0.87
5 MeV < E < 10 MeV	0.74	0.69	0.63	0.63
1 MeV < E < 5 MeV	0.87	0.83	0.90	0.90
0.5 MeV < E < 1 MeV	0.91	0.92	0.92	0.93
0.1 MeV < E < 0.5 MeV	0.86	0.90	0.87	0.88
E < 0.1 MeV	0.00	0.00	0.00	0.00
FNS-TOF/31.4 CM(R)*40.64CM(Z)-Lead				
Angle12.20= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.69	0.74	0.76	0.76
5 MeV < E < 10 MeV	1.01	0.91	0.83	0.83
1 MeV < E < 5 MeV	0.97	0.92	0.99	1.00
0.5 MeV < E < 1 MeV	0.98	1.00	1.00	1.00
0.1 MeV < E < 0.5 MeV	0.93	0.96	0.94	0.94
E < 0.1 MeV	0.65	0.68	0.62	0.61
FNS-TOF/31.4 CM(R)*40.64CM(Z)-Lead				
Angle24.90= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.58	0.65	0.68	0.68
5 MeV < E < 10 MeV	0.77	0.69	0.64	0.60
1 MeV < E < 5 MeV	0.89	0.85	0.91	0.92
0.5 MeV < E < 1 MeV	0.90	0.92	0.92	0.92
0.1 MeV < E < 0.5 MeV	0.80	0.83	0.81	0.81
E < 0.1 MeV	0.17	0.18	0.17	0.16
FNS-TOF/31.4 CM(R)*40.64CM(Z)-Lead				
Angle41.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.61	0.65	0.67	0.67
5 MeV < E < 10 MeV	0.87	0.77	0.68	0.63
1 MeV < E < 5 MeV	0.88	0.85	0.90	0.91
0.5 MeV < E < 1 MeV	0.88	0.89	0.89	0.89
0.1 MeV < E < 0.5 MeV	0.81	0.85	0.82	0.82
E < 0.1 MeV	0.00	0.00	0.00	0.00
FNS-TOF/31.4 CM(R)*40.64CM(Z)-Lead				
Angle66.80= deg	ENDF/B-VIIIb4	FENDL-3.1b	JEFF-3.3T2	JEFF-3.3T3
10 MeV < E < 16 MeV	0.12	0.17	0.13	0.14
5 MeV < E < 10 MeV	0.12	0.10	0.08	0.08
1 MeV < E < 5 MeV	0.83	0.79	0.85	0.85
0.5 MeV < E < 1 MeV	0.87	0.87	0.87	0.87
0.1 MeV < E < 0.5 MeV	0.95	0.99	0.96	0.96
E < 0.1 MeV	-	-	-	-

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Annex II. MCNP6 Shielding Suite

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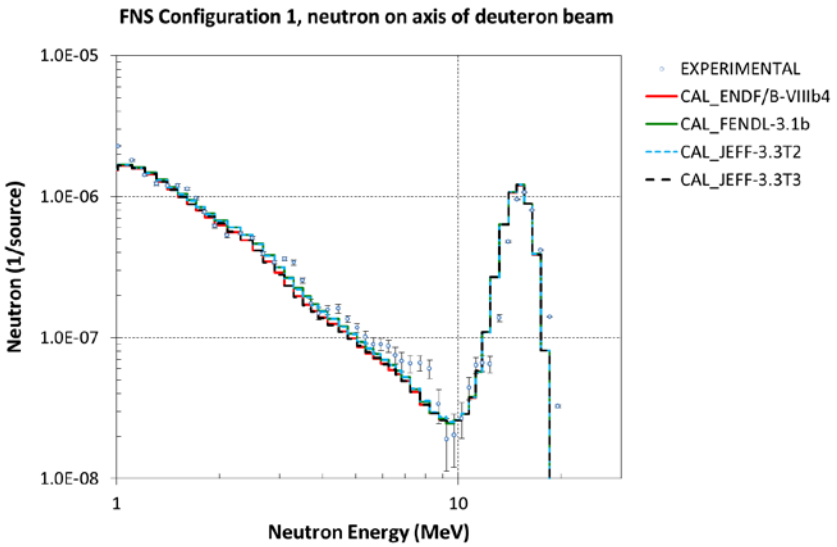
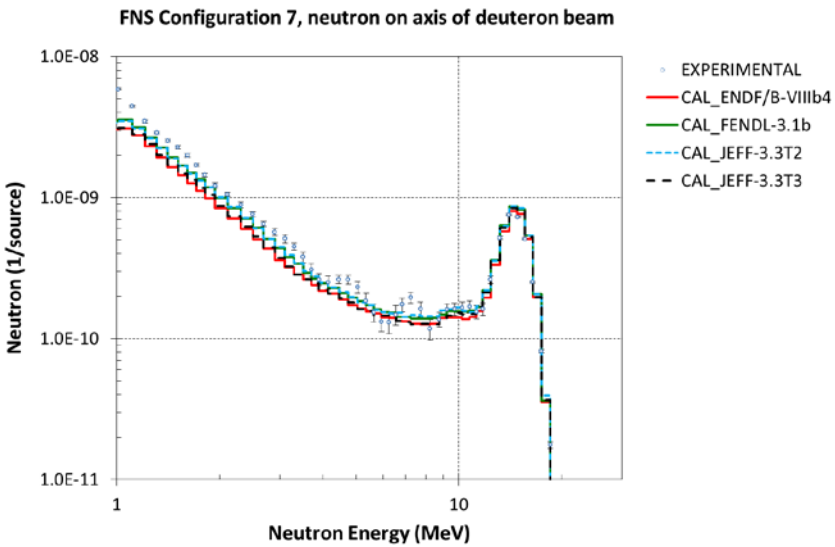
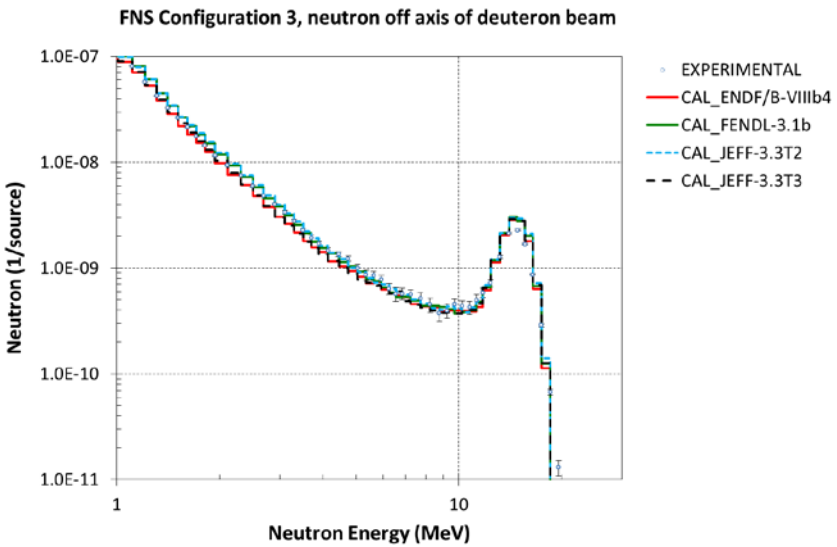
Appendix. MCNP6 suite TOF

Fusion Spectra Problem
Configuration 1/3/7 - On/Off Axis







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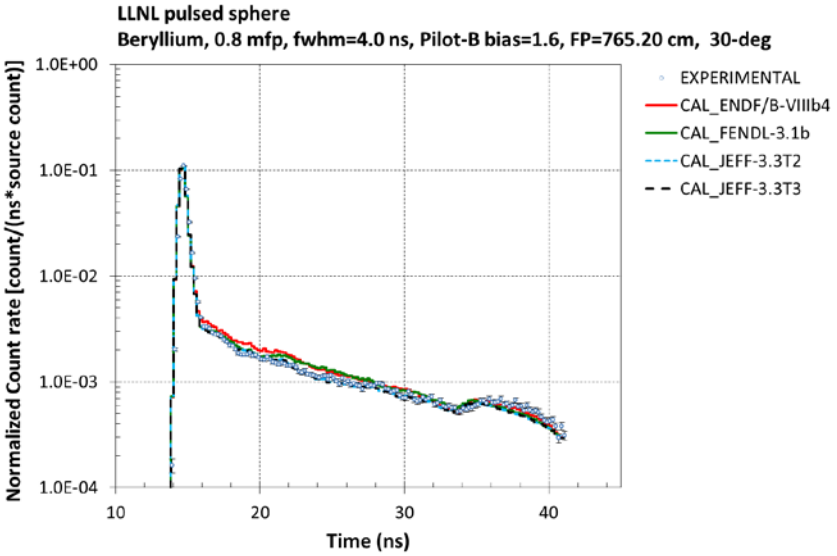
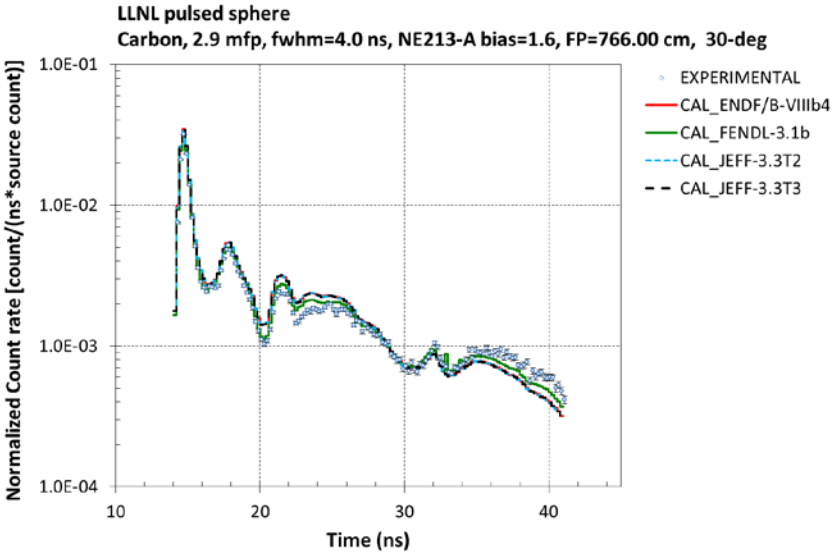
Appendix. MCNP6 suite TOF

LLNL pulsed spheres





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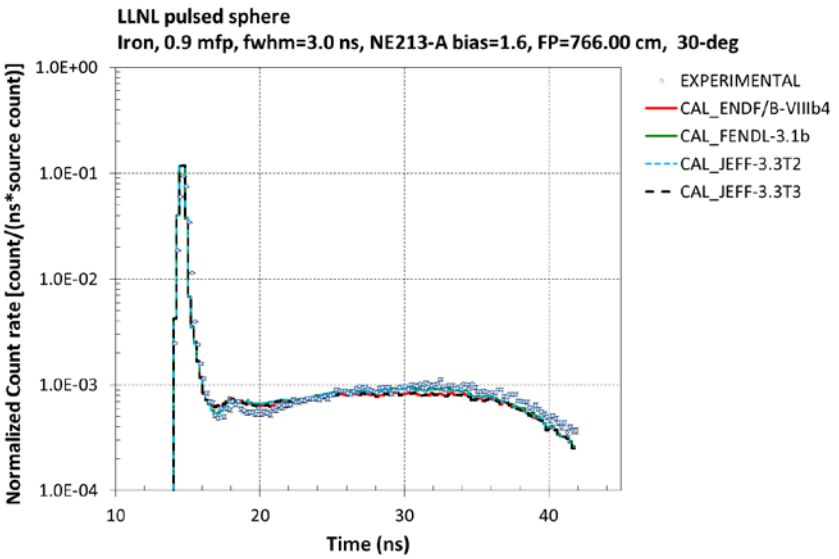
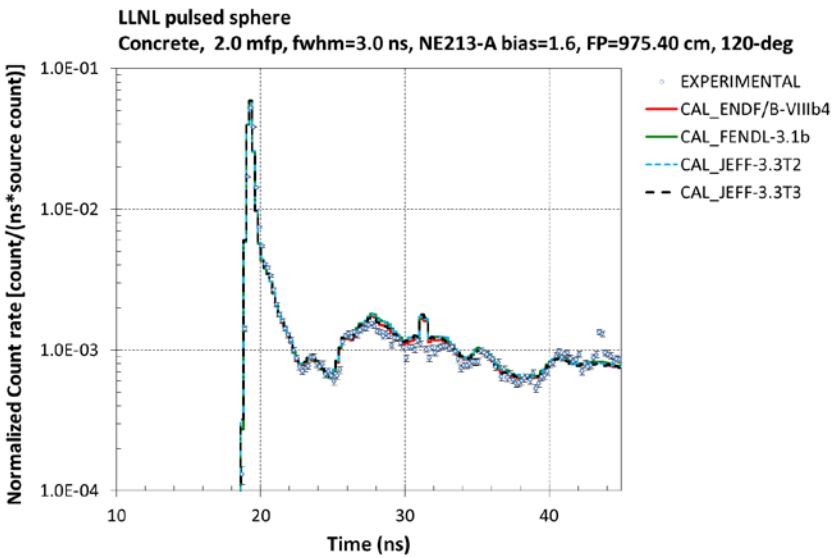
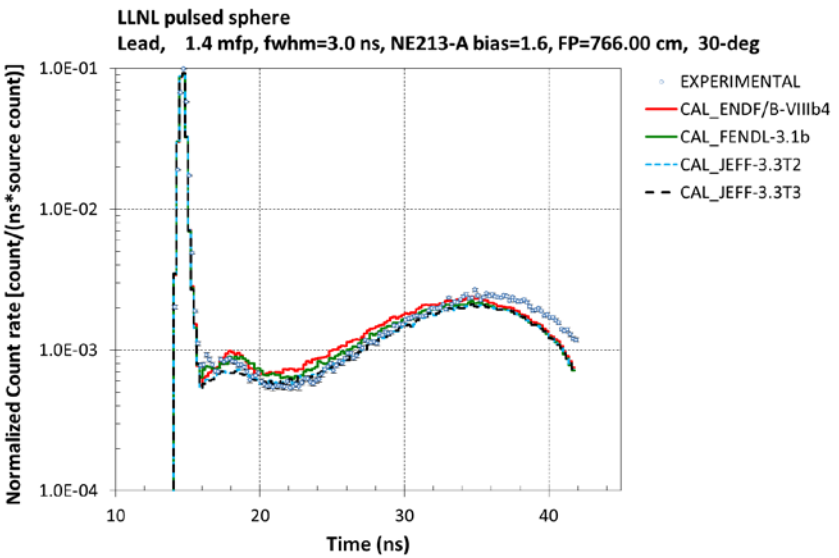
Appendix. MCNP6 suite TOF

LLNL pulsed spheres







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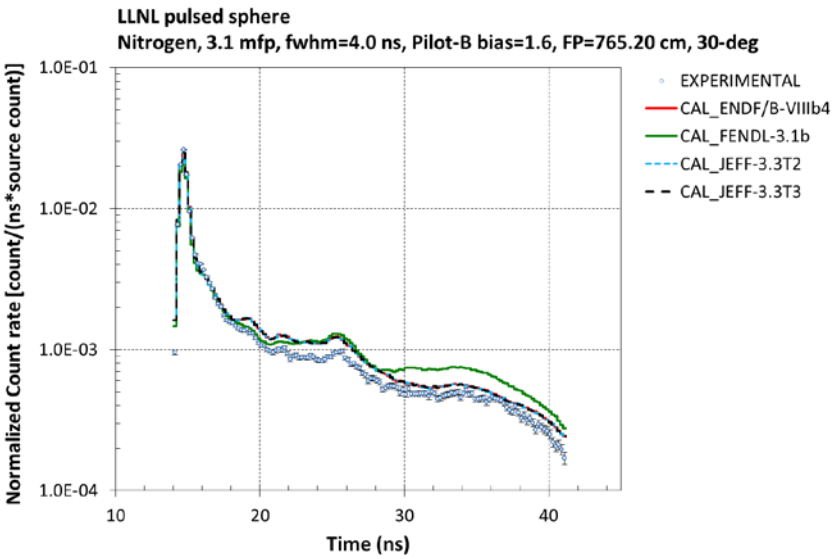
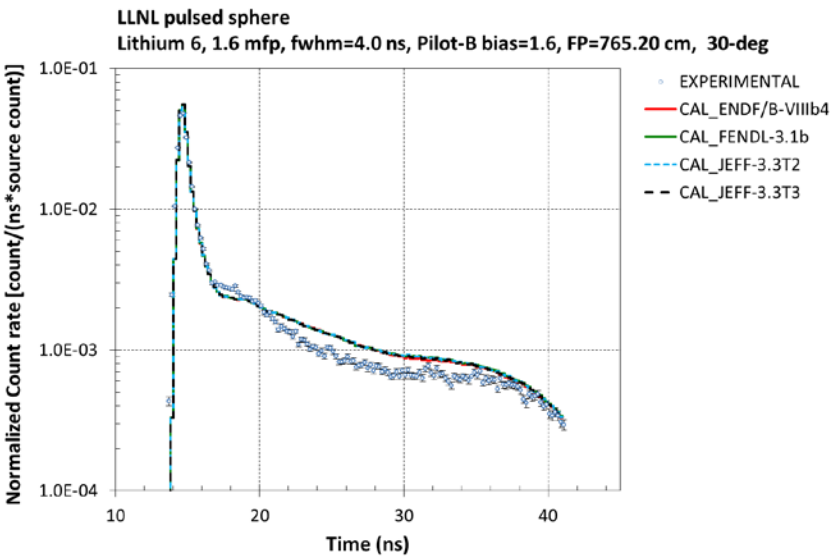
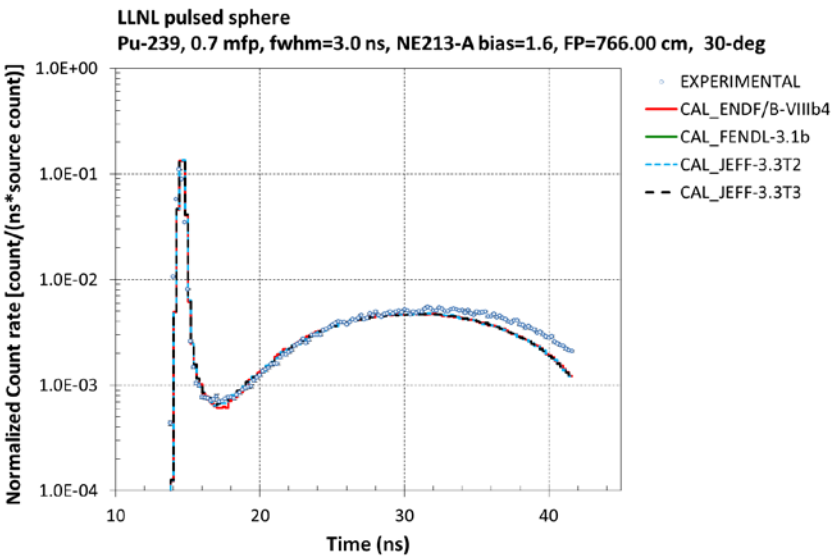
Appendix. MCNP6 suite TOF

LLNL pulsed spheres







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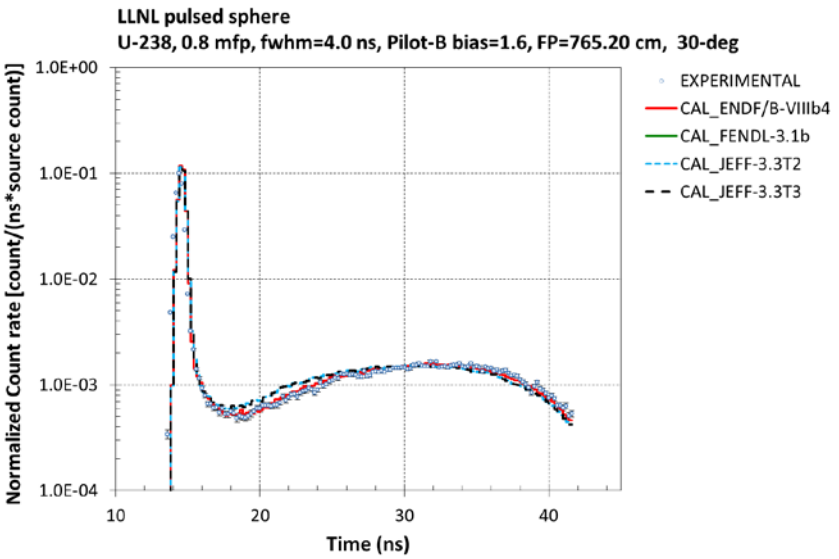
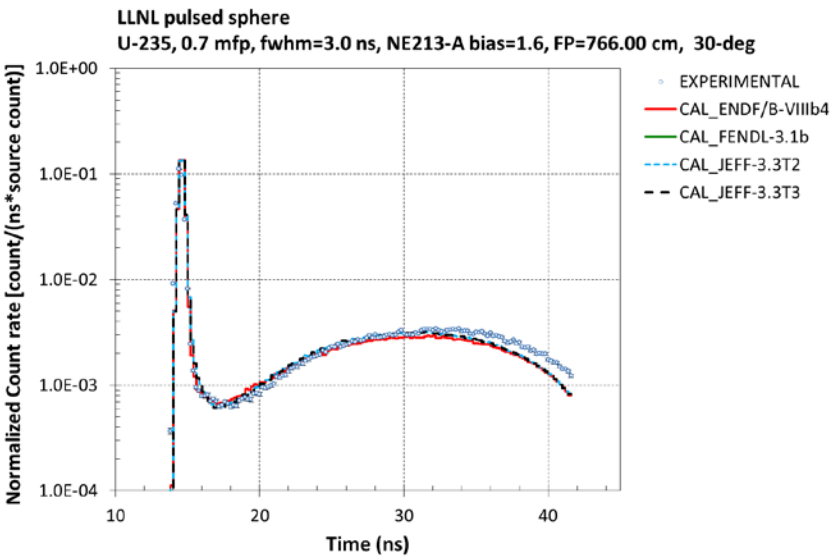
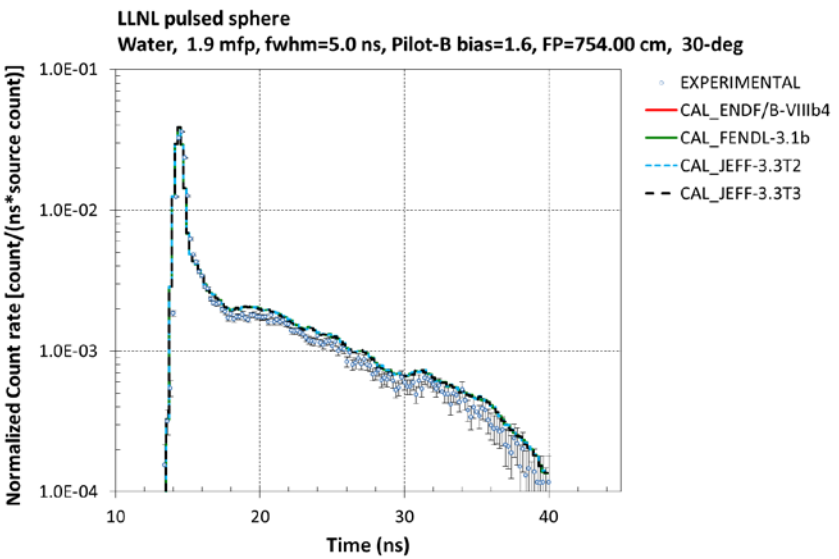
Appendix. MCNP6 suite TOF

LLNL pulsed spheres







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Annex III. Oktavian

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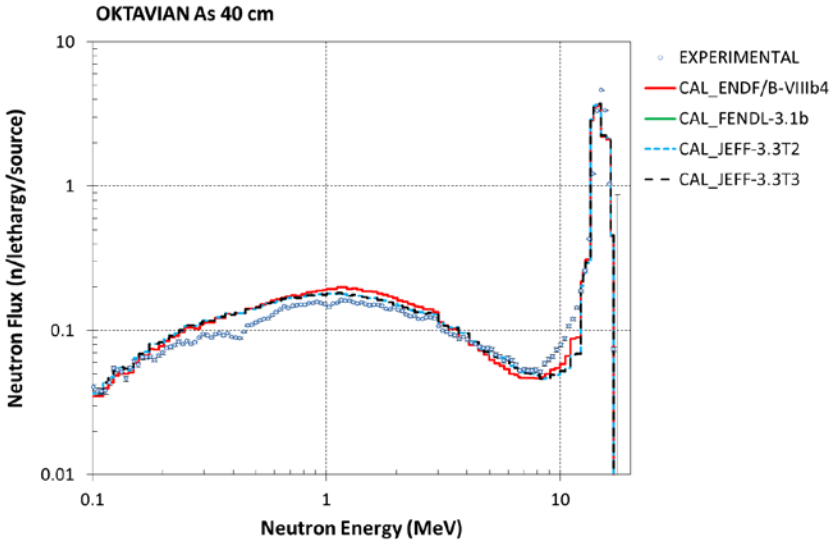
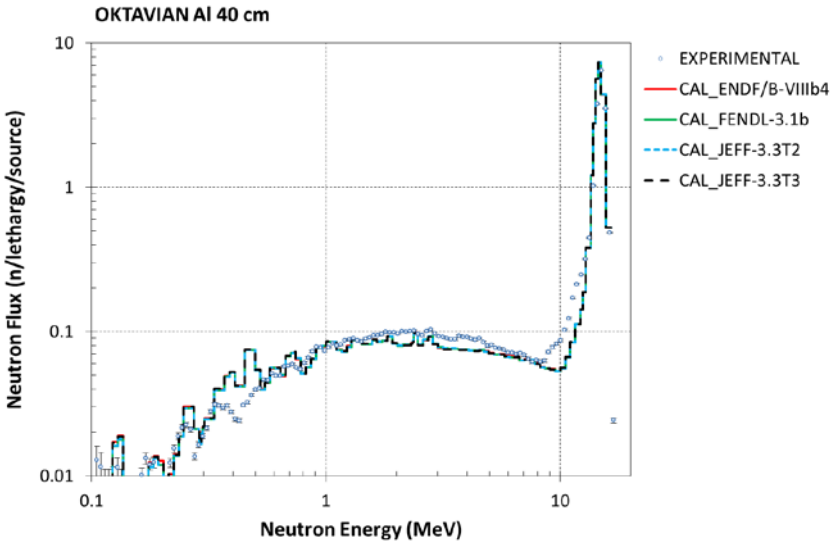
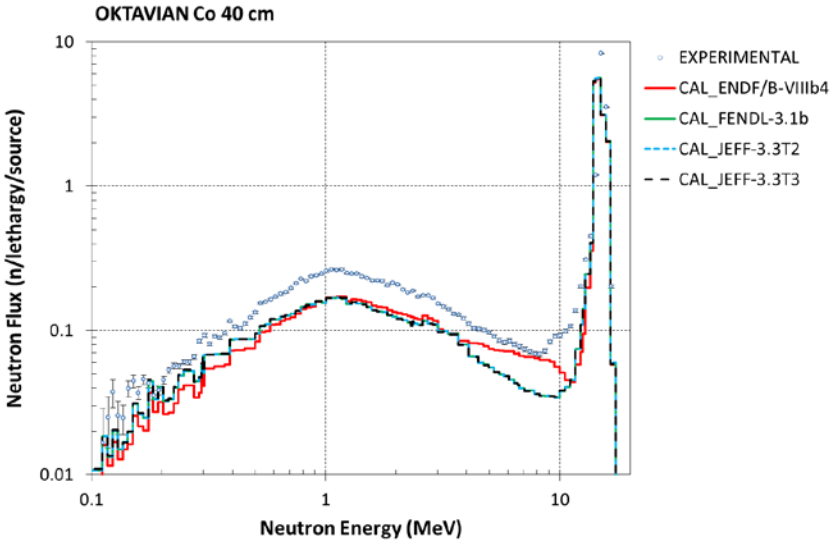
Appendix. Oktavian TOF







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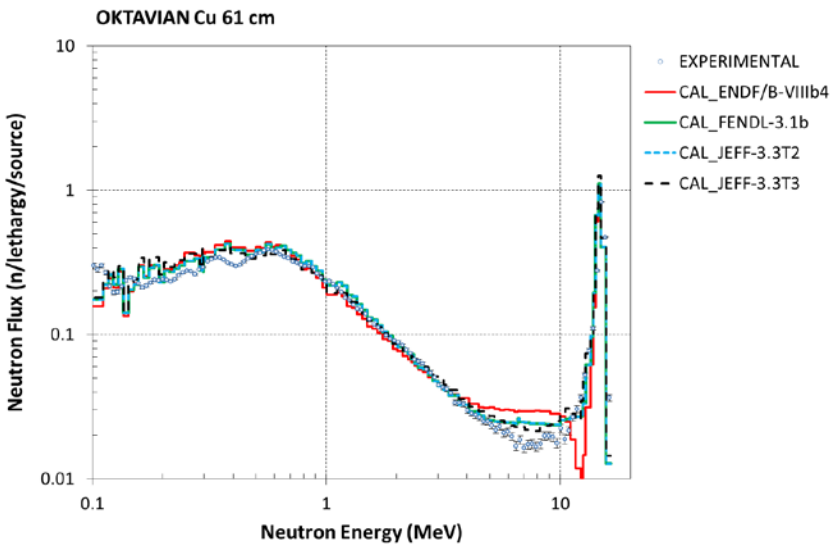
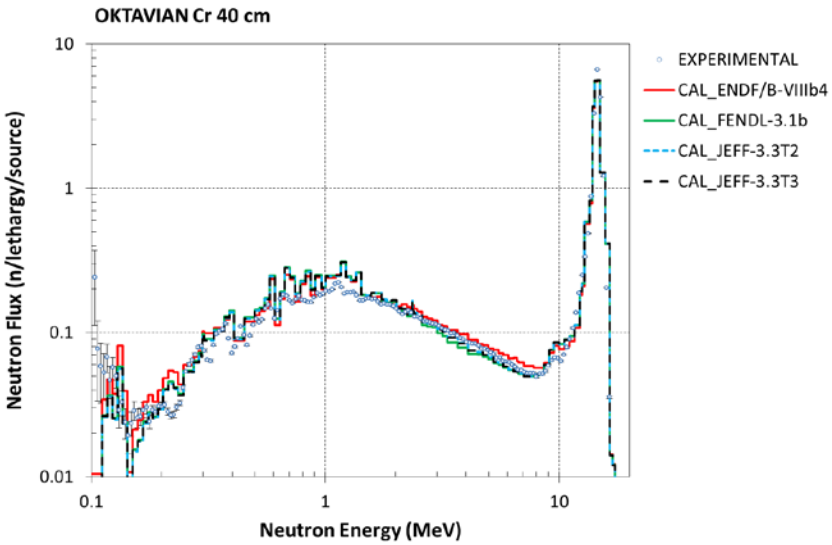
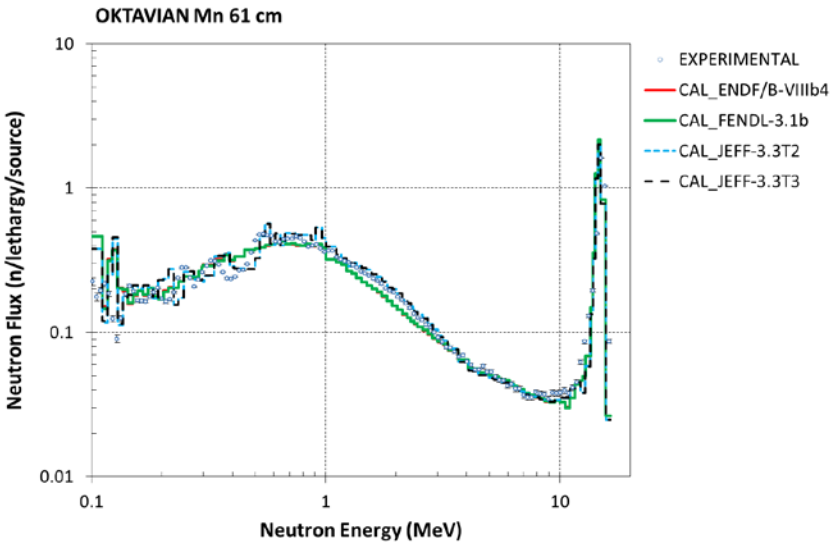
Appendix. Oktavian TOF







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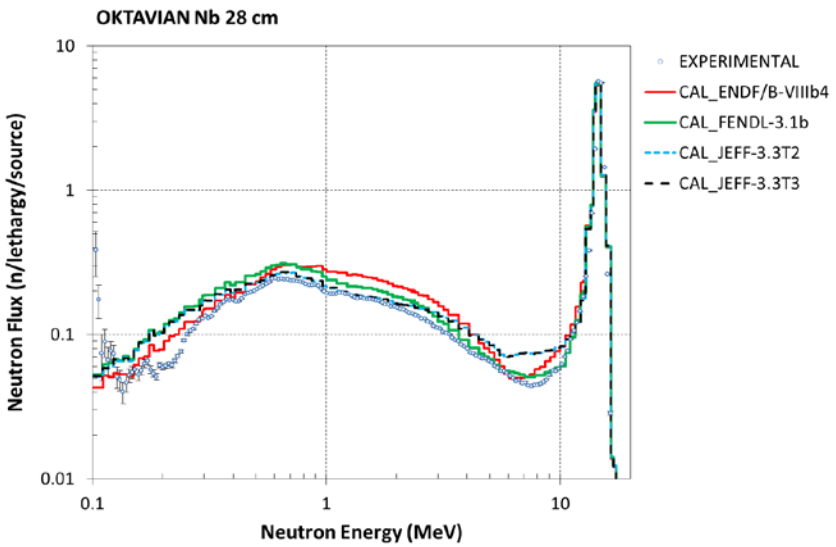
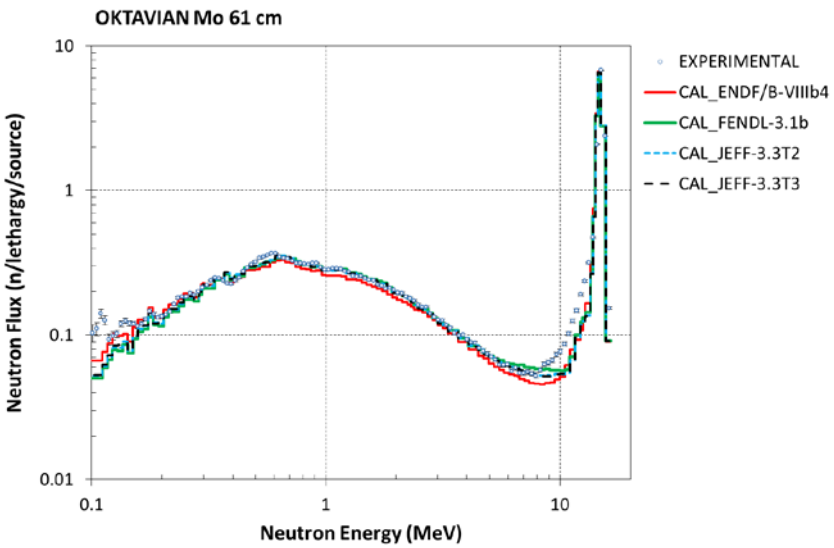
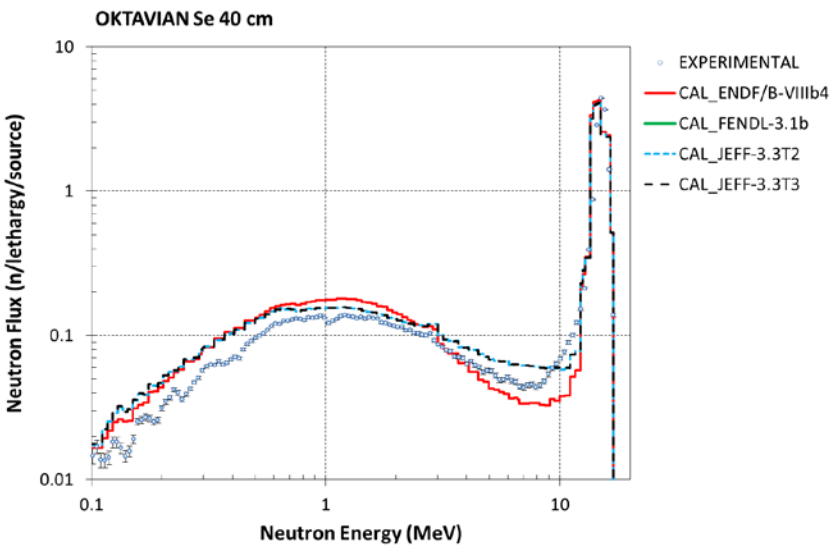
Appendix. Oktavian TOF







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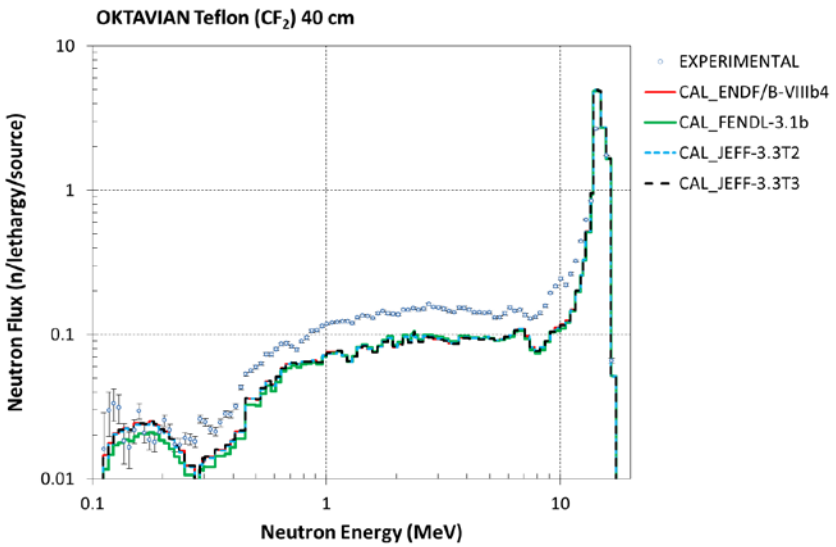
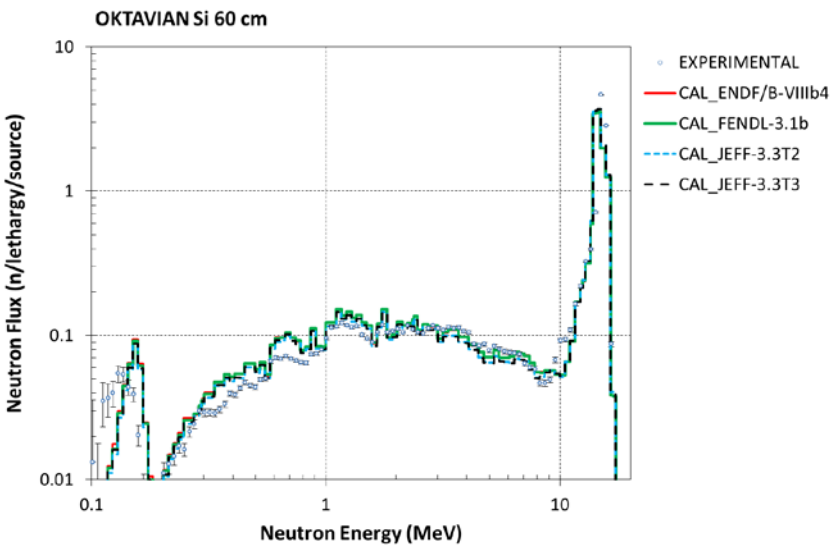
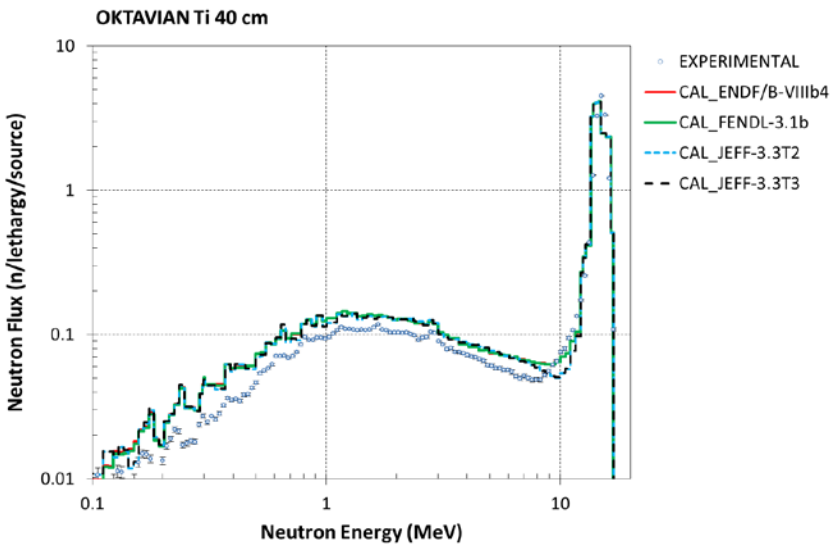
Appendix. Oktavian TOF







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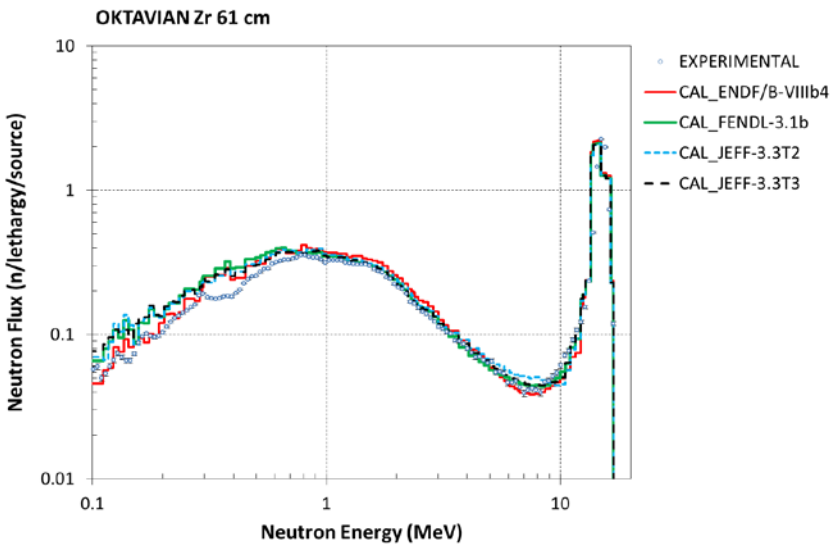
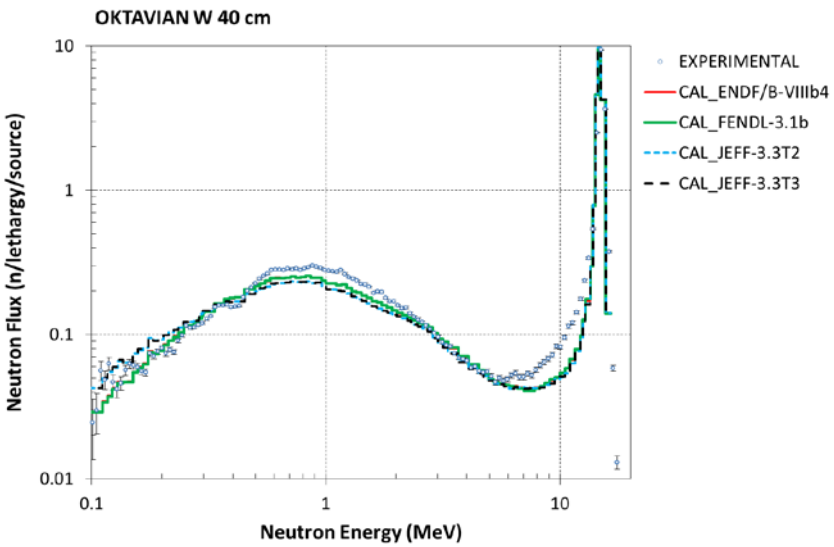
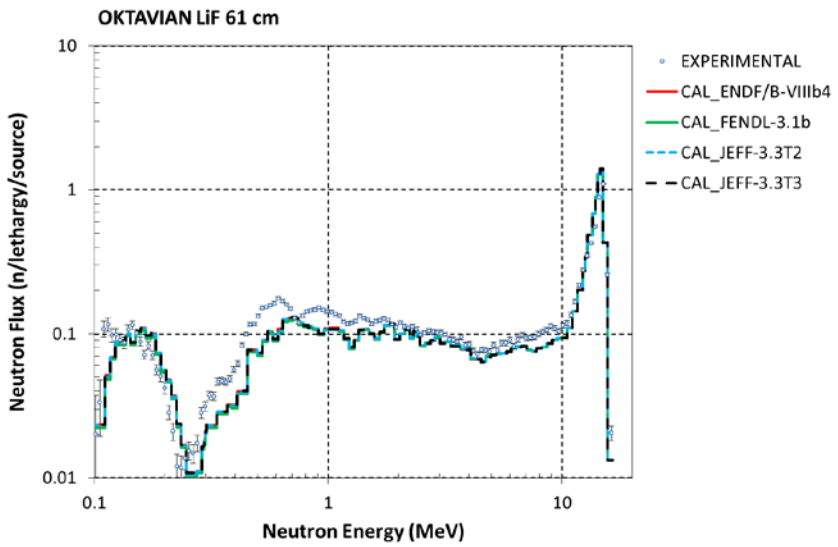
Appendix. Oktavian TOF







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