

Deterministic 3D Analysis of HCPB Breeder Blanket Mock-up Experiment

I. Kodeli

*IAEA representative at OECD/NEA
Ivo.kodeli@oecd.org*

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Calculational tools

Nuclear Data

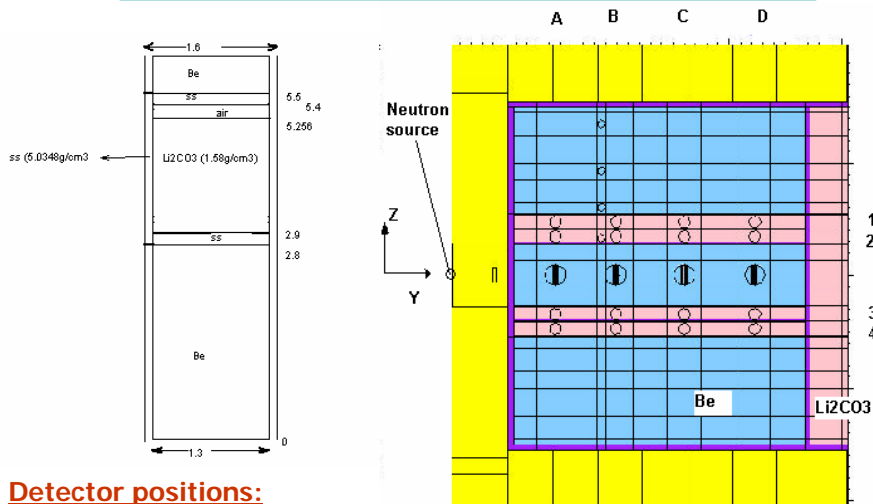
- Cross-sections: FENDL-2 & -2.1, Be-9 from EFF-3.0; 175-group self-shielded cross sections produced by NJOY/TRANSX
- Covariance matrices: taken from ZZ-VITAMIN-J/COVA libraries, ERROR-J code package and NJOY processing:
 - Be-9: EFF-3 & ENDF/B-V
 - Li-6: IRDF-90
 - Li-7: ENDF/B-VI.8
 - C-12: EFF-2.2
 - O-16: JENDL-3.3
- Response functions: IRDF-2002 for $\text{Li6}(n,t)$, $\text{Nb93}(n,2n)$, $\text{Al27}(n,\alpha)$, $\text{Ni58}(n,p)$, $\text{Au197}(n,\gamma)$
JEF-2.2 for $\text{Li-7}(n,t)$

Calculational tools

Discrete ordinates transport computer codes:

- First collision source code GRTUNCL-3D: neutron transport in air
- TORT (S-8 & 16, P-5, 3D X-Y-Z geometry)
- SUS3D sensitivity & uncertainty package

FNG TBM Benchmark



Detector positions:

- A:** y= 4.2 cm **B:** y= 10.5 cm
C: y= 16.8 cm **D:** y= 23.1 cm

TORT comparison with measured RR

TORT/FENDL-2.1: S-16, P-5

RR [I/(n s)] - TORT - FENDL-2.1				
Posit. [cm]	²⁷ Al(n,α)	⁵⁸ Ni(n,p)	⁹³ Nb(n,2n)	¹⁹⁷ Au(n,γ)
4.2 (A)	8.71E-5	3.58E-4	3.27E-4	1.51E-2
10.5 (B)	2.28E-5	1.21E-4	7.94E-5	2.18E-2
16.8(C)	7.60E-6	4.83E-5	2.48E-5	1.87E-2
23.1 (D)	2.85E-6	2.08E-5	8.83E-6	1.15E-2

RR [I/(n s)] - EXPERIMENT				
Posit. [cm]	²⁷ Al(n,α)	⁵⁸ Ni(n,p)	⁹³ Nb(n,2n)	¹⁹⁷ Au(n,γ)
~4.2 (A)	8.42E-5	3.50E-4	3.37E-4	1.23E-2
~10.5 (B)	2.20E-5	1.18E-4	8.30E-5	1.82E-2
~16.8 (C)	7.48E-6	4.98E-5	2.60E-5	1.52E-2
~23.1 (D)	2.88E-6	2.05E-5	9.04E-6	9.02E-3

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TORT comparison with measured RR

RR [I/(n s)] - C/E				
Posit. [cm]	²⁷ Al(n,α)	⁵⁸ Ni(n,p)	⁹³ Nb(n,2n)	¹⁹⁷ Au(n,γ)
~4.2 (A)	1.03	1.02	0.97	1.22
~10.5 (B)	1.04	1.03	0.96	1.20
~16.8(C)	1.02	0.97	0.95	1.23
~23.1 (D)	0.99	1.01	0.98	1.27

TORT/FENDL-2.1: S-16, P-5

Au-197: 0.03mm, N=0.058952674 at/cm3

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TORT comparison with measured RR

TORT/FENDL-2.1 & EFF-3.0 (Be-9):

RR [/ (n s)] - C/E				
Posit. [cm]	²⁷ Al(n,α)	⁵⁸ Ni(n,p)	⁹³ Nb(n,2n)	¹⁹⁷ Au(n,γ)
4.2 (A)	1.03	1.03	0.97	1.22
10.5 (B)	1.03	1.03	0.95	1.19
16.8(C)	0.93	0.92	0.87	1.22
23.1 (D)	0.88	0.94	0.86	1.27

S-8/P-5

RR [/ (n s)] - EFF-3.0 / FENDL-2.1				
Posit. [cm]	²⁷ Al(n,α)	⁵⁸ Ni(n,p)	⁹³ Nb(n,2n)	¹⁹⁷ Au(n,γ)
4.2 (A)	1.00	0.97	1.00	0.99
10.5 (B)	0.99	0.94	1.01	0.98
16.8(C)	0.99	0.93	1.01	0.98
23.1 (D)	0.99	0.92	1.02	0.98

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TORT Tritium Production Rate

TORT/FENDL-2:

Y -locat. (cm)	TPR [t/(n cm ³ s)]					
	FENDL 2.1		FENDL-2.0 / FENDL-2.1		EFF-3.0* / FENDL2.1	
	⁶ Li(n,t)	⁷ Li(n,t)	⁶ Li(n,t)	⁷ Li(n,t)	⁶ Li(n,t)	⁷ Li(n,t)
4.2 (A)	1.19E-5	5.19E-6	0.99	1.04	0.98	1.05
10.5 (B)	1.68E-5	1.74E-6	0.99	1.04	1.00	0.97
16.8(C)	1.44E-5	7.18E-7	1.00	1.05	0.99	0.96
23.1 (D)	8.86E-6	3.09E-7	1.00	1.05	0.95	0.91

Total TPR:

TPR	FENDL 2.1	FENDL-2.0 / FENDL-2.1	EFF-3.0* / FENDL2.1
4.2 (A)	1.71E-5	1.00	1.00
10.5 (B)	1.85E-5	1.00	1.00
16.8 (C)	1.51E-5	1.00	0.99
23.1 (D)	9.17E-6	1.00	0.95

S-8/P-5

* FENDL2.1 + Be from EFF-3.0

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Li6(n,t): Sensitivity & uncertainty to cross-sections (summary of 2D DORT/SUSD3D analysis)

		Sensit. [%/%]	Δ [%]	Sensit. [%/%]	Δ [%]
Be	Total	1.50	~2	1.78	~2
	Elast	0.73		1.18	
	(n,2n)	0.65	(4.6 - ENDF/B-V)	0.67	(5.1 - ENDF/B-V)
Li-6	(n,t)	-0.89	0.13	-0.95	0.13
Li-7	Total	0.031	0.1	0.025	0.08
C	Total	0.031	~0.1	0.021	~0.1
O	Total	0.052		0.030	

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Conclusions & future work

- TORT/GRTUNCL-3D calculational model refinements (geometry clarifications needed, SN order, space mesh)
- Sensitivity & uncertainty analysis. New version of SUSD3D.f90 and plotting routines will be used.
- According to preliminary 2D SU analysis the **uncertainties in Li6(n,t) are ~2%** using EFF-3 covariances (**~5%** using ENDF/B-V).
- Rather large differences (up to 8%) observed in TPR and Ni-58(n,p) RR calculated using FENDL-2.0 & 2.1 and JEFF-3.1 Be-9 file. JEFF-3.1 gives by up to 5 % lower Li6(n,t) than FENDL-2/-2.1.

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