

# Fornax and Activation Source Generator (ASG)

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# ACTIVATION AND DEPLETION

Attila has a GUI driven activation capability that tracks the population of isotopes created through neutron activation and decay processes.

Compatible with both SMP (attilasolver) and DMP (severian)

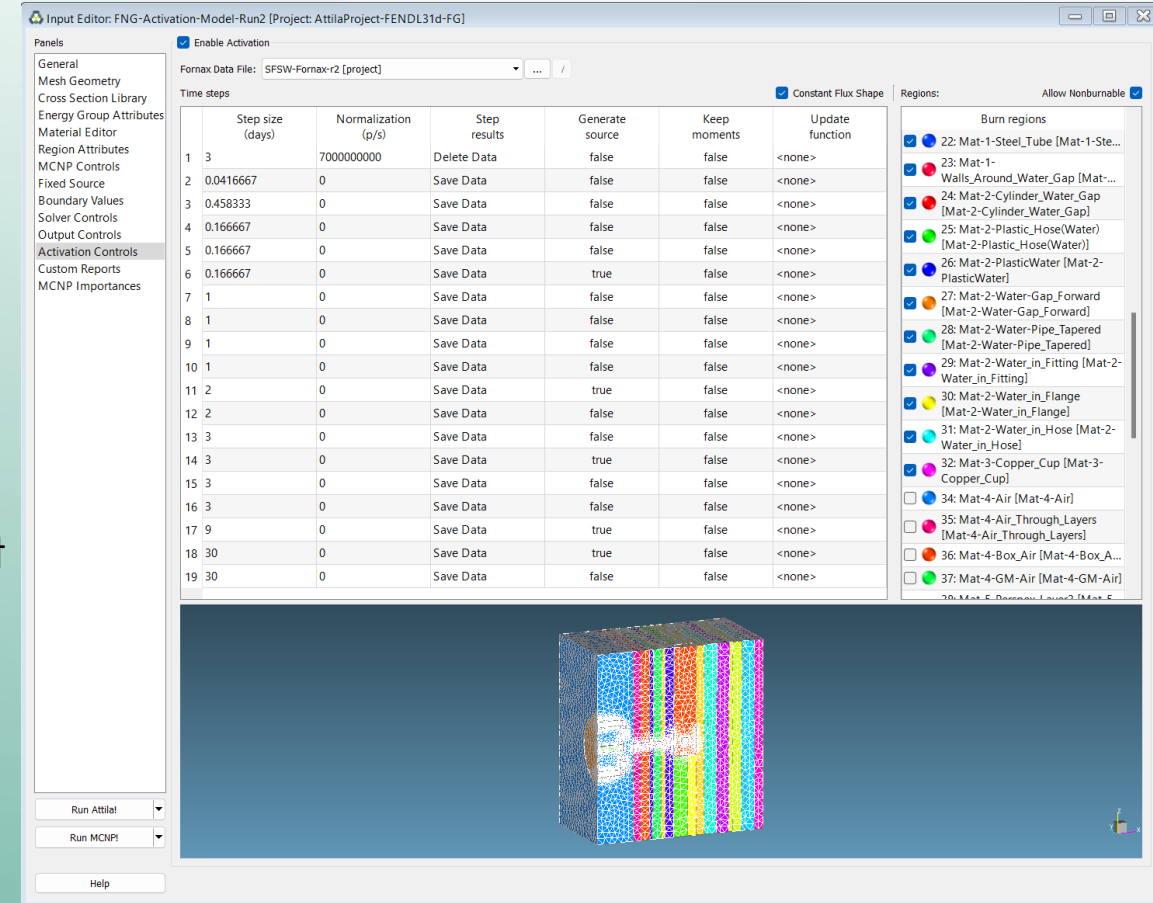
Performed as a 2-step process (R2S)

Step 1: Calculate neutron flux field and activation source at desired timesteps

- ▶ Run through regular Attila neutron calculation and Fornax/ASG. Activation gamma source can be created at every timestep.

Step 2: Compute activation dose rate field

- ▶ Regular Attila gamma calculation using activation gamma source file.



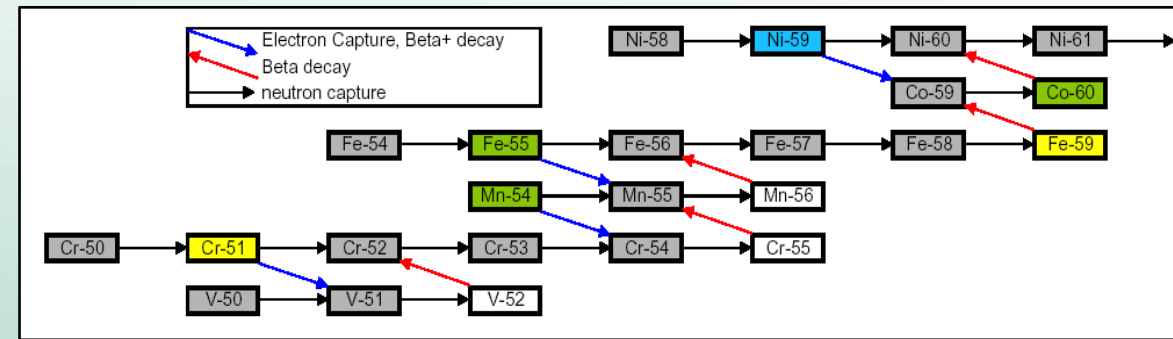
Activation controls panel in Attila GUI



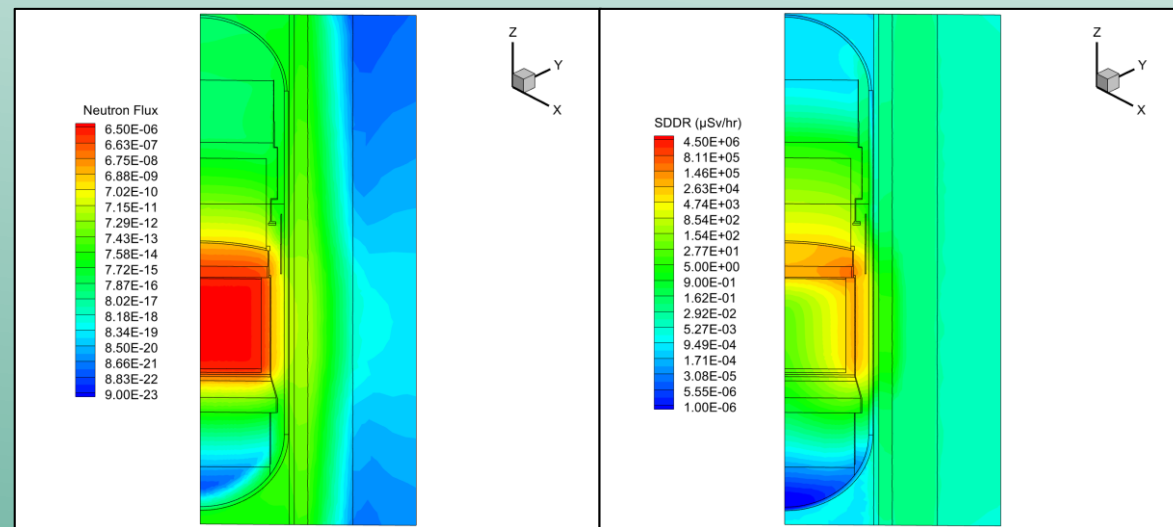
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# ACTIVATION AND DEPLETION

- ▶ Decay chains specified in a single XML file
- ▶ Users can modify or add decay chain data for their applications
- ▶ User specifies which CAD/mesh regions to activate
- ▶ Creates a unique activation source in each tetrahedral element, providing a high spatial resolution
- ▶ Eliminates the need for a user defined activation "grid"
- ▶ Provides unrivaled solution precision
- ▶ Fine resolution, body-fitted activation mesh
- ▶ No spatial homogenization
- ▶ Intuitive post processing visualization of calculated inventories
- ▶ Optional output of region-wise activities for waste categorization



## Generic PWR Activation Study



Neutron Flux

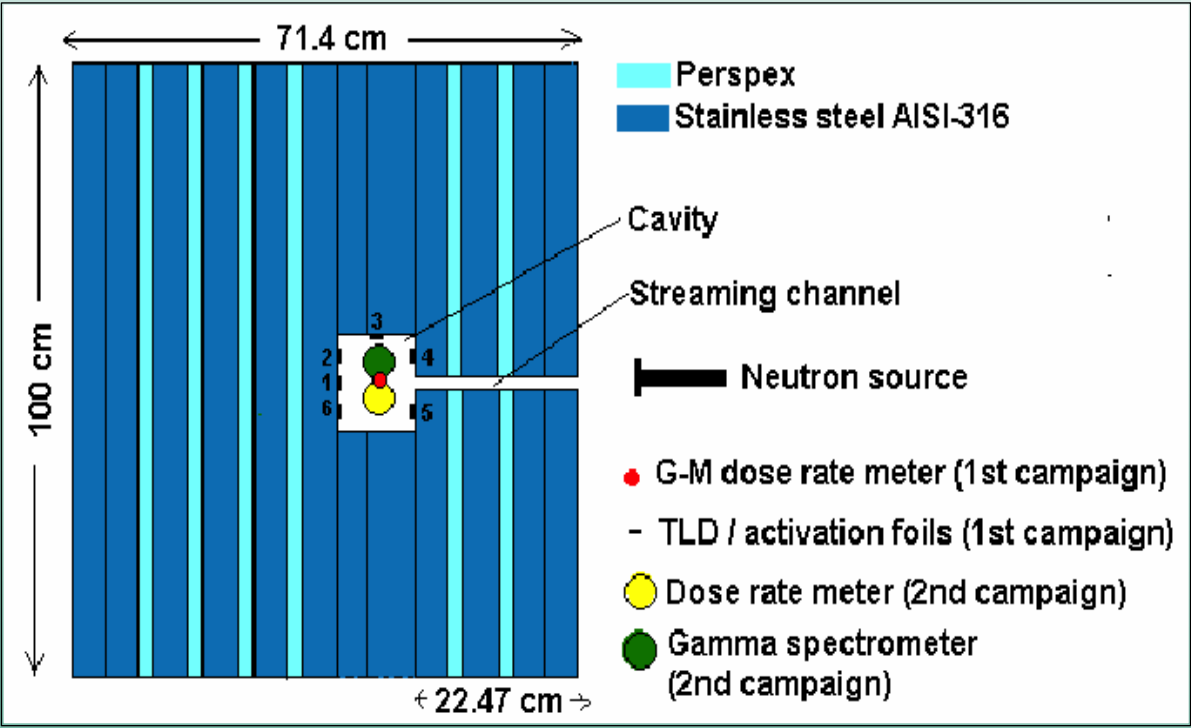
Activation gamma dose rate



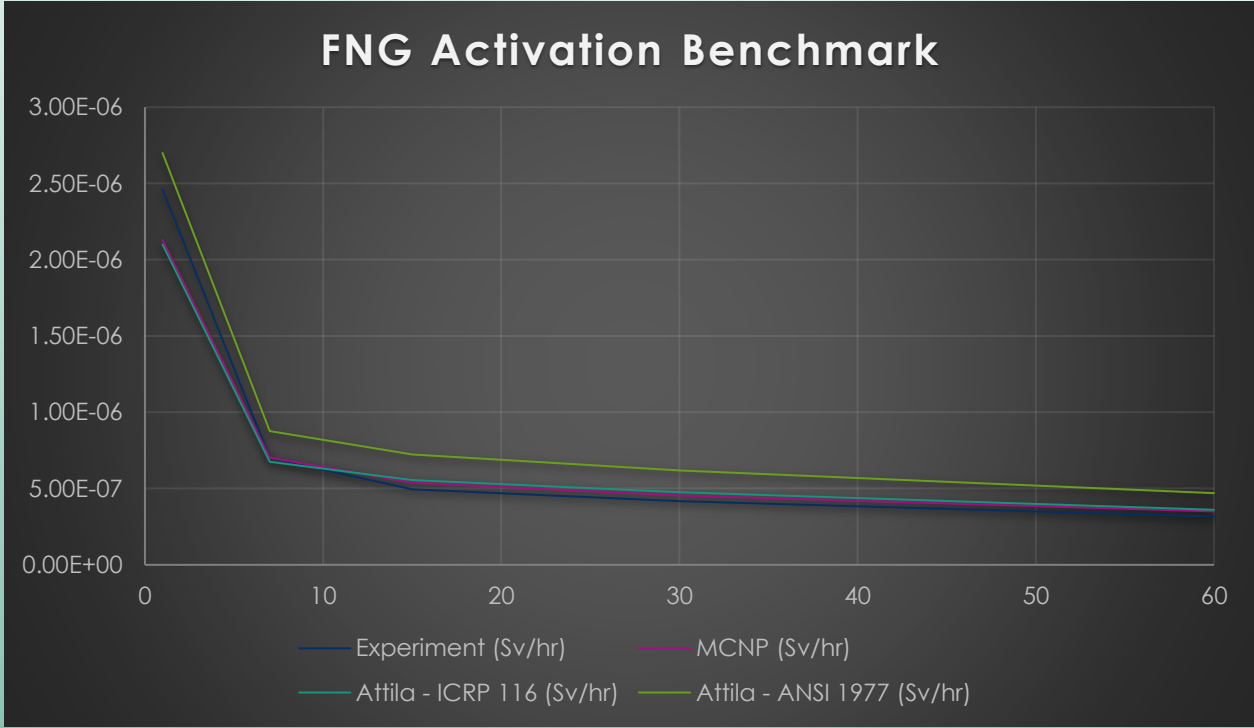
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# FNG ACTIVATION BENCHMARK

Benchmark<sup>1</sup> to validate accuracy of dose-rate calculations after shut-down in representative ITER shielding conditions (ITER Task T-426).



Experimental Setup



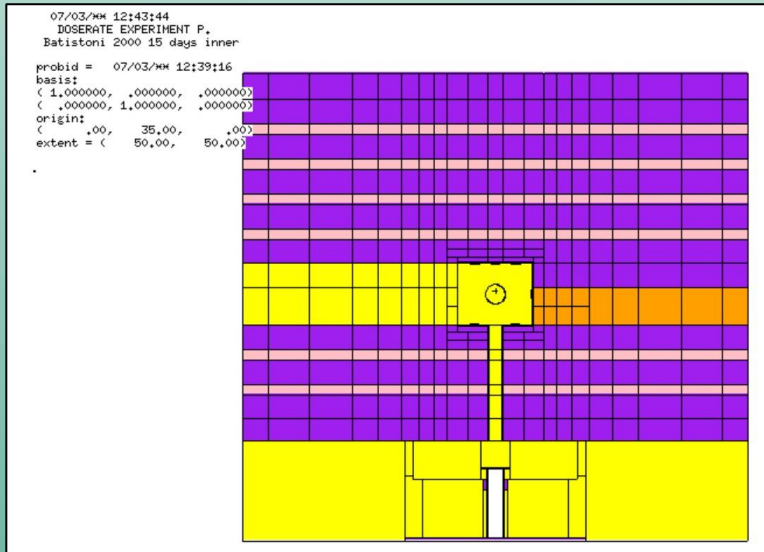
G-M Shut down dose rate results



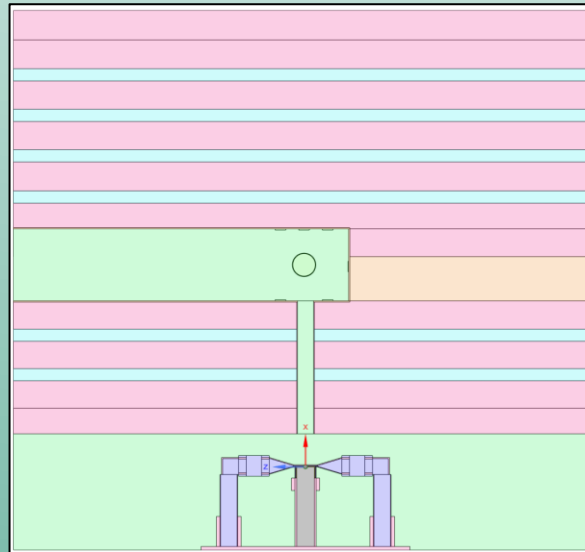
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# FNG ACTIVATION BENCHMARK

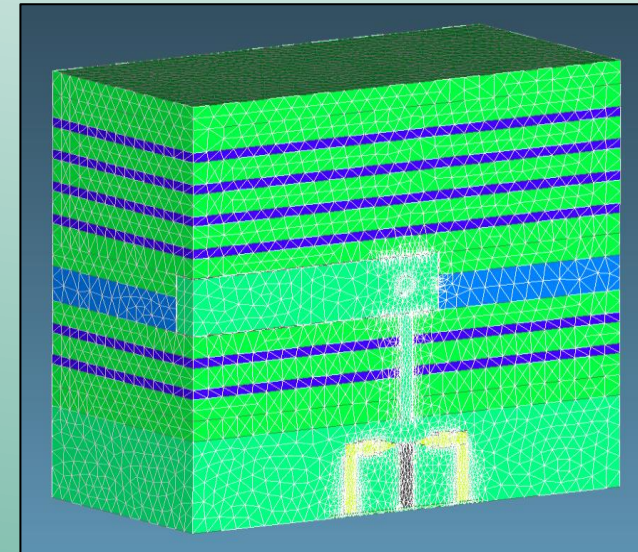
- ▶ Neutron flux and activation calculations performed using SFSW-FENDL31 d-FG cross sections and SFSW-Fornax-r2 dataset
- ▶ ~220k tetrahedral mesh elements, 3.5 cm mesh for fine spatial resolution
- ▶ Neutron calculation performed with 175 neutron groups, calculation time ~5 hrs
- ▶ Activation calculation time 13 minutes
- ▶ Shut down gamma calculations performed with Transpire94g cross section, 20-30 minutes depending on timestep.



VisEd slice of MCNP Model



CAD Model



Attila tetrahedral mesh



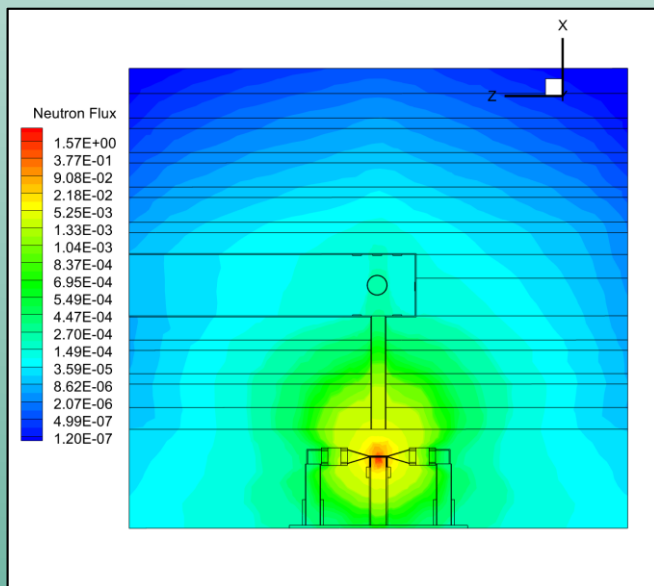


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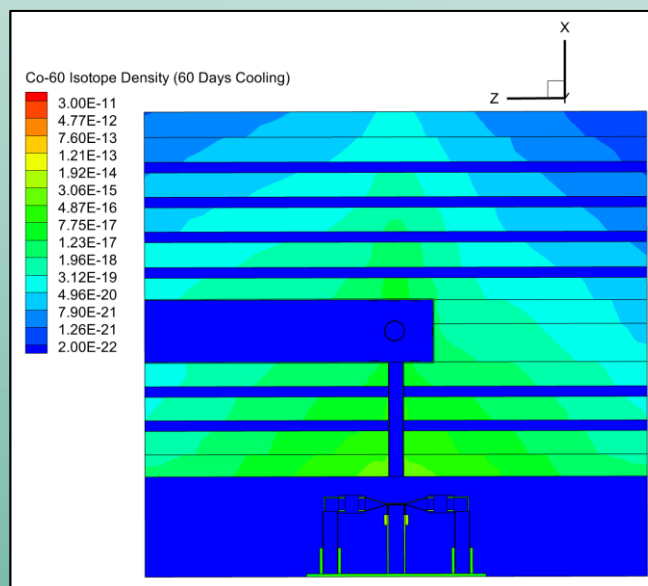
# FNG ACTIVATION BENCHMARK

## ► Results Summary Reactions and Plots

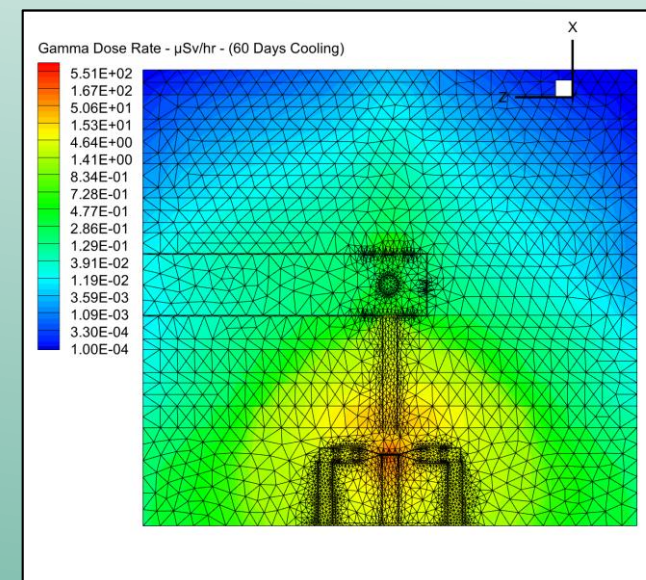
Ni58-(n,p)Co-58							Ni58-(n,2n)						
Foil	E	MCNP-Fispact	Attila	A/E	A/M	E/M	Foil	E	MCNP-Fispact	Attila	A/E	A/M	E/M
1	2.15E-05	2.20E-05	1.94E-05	9.00E-01	8.81E-01	9.79E-01	1	2.84E-06	2.60E-06	2.19E-06	7.70E-01	8.42E-01	1.09E+00
2	5.19E-06	5.51E-06	5.10E-06	9.83E-01	9.26E-01	9.42E-01	2	3.94E-07	3.95E-07	3.54E-07	9.00E-01	8.98E-01	9.98E-01
3	4.13E-06	4.56E-06	4.10E-06	9.94E-01	9.00E-01	9.06E-01	3	2.07E-07	1.91E-07	1.99E-07	9.61E-01	1.04E+00	1.08E+00
4	8.48E-06	9.30E-06	8.42E-06	9.93E-01	9.06E-01	9.12E-01	4	4.92E-07	4.99E-07	4.87E-07	9.89E-01	9.75E-01	9.86E-01
5	7.86E-06	8.31E-06	7.59E-06	9.65E-01	9.13E-01	9.46E-01	5	4.71E-07	4.28E-07	4.13E-07	8.77E-01	9.65E-01	1.10E+00
6	5.15E-06	5.35E-06	4.73E-06	9.18E-01	8.84E-01	9.64E-01	6	3.64E-07	3.27E-07	3.08E-07	8.46E-01	9.41E-01	1.11E+00



Attila neutron flux



Co-60 isotope density at 60 days cooling



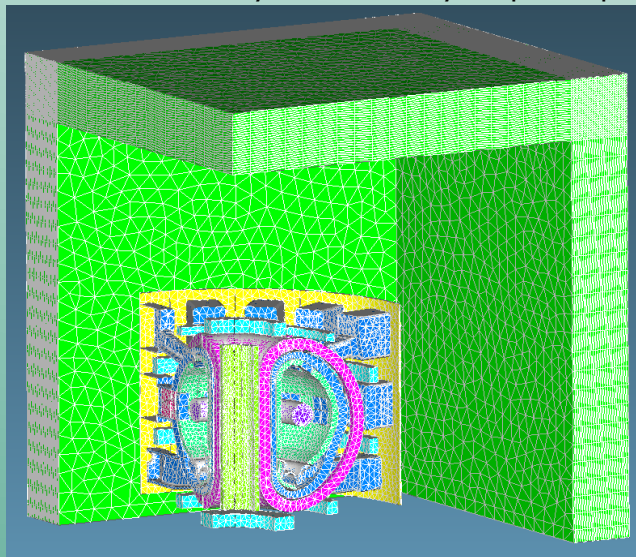
Activation gamma dose rate and Attila mesh



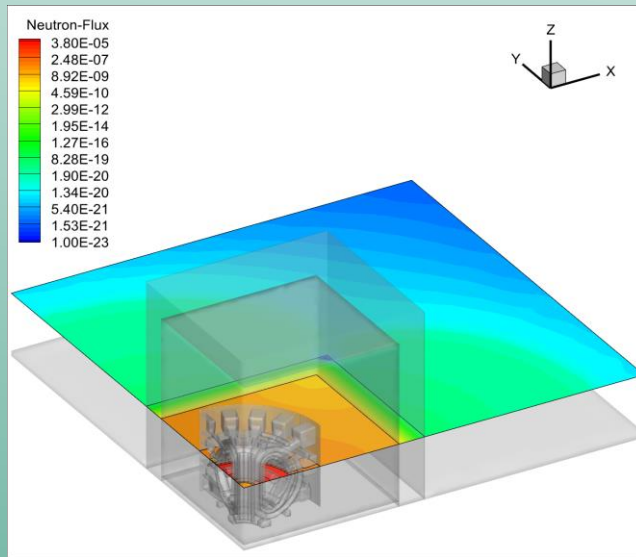
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# GENERIC TOKAMAK CASE STUDY

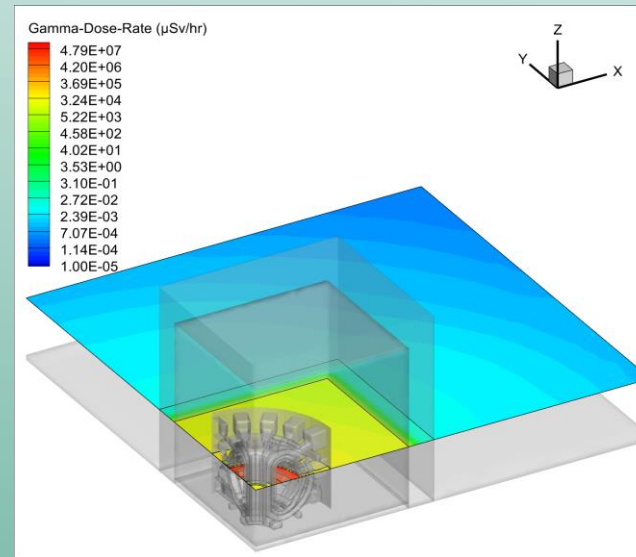
- ▶ Attila calculations performed using SFSW-FENDL31d-FG cross sections and SFSW-Fornax-r2 dataset
- ▶ ~1.2 million tetrahedral mesh elements
- ▶ Neutron flux calculation performed with 53 neutron groups
- ▶  $2.0E+20$  n/s over 1 day, and cooling time of 30 days after final “shot”
- ▶ Activation calculation time 20 minutes
- ▶ Gamma shut down dose rate (SDDR) calculation performed with 42 gamma groups, 1 hr 20 minutes run time
- ▶ Activity inventory report produced for concrete walls.



Attila computational mesh



Neutron flux



Gamma SDDR

Total volume found in edit is: 1.77650E+09

Rank	FornaxID	IsoName	Atoms (1.e-24)	Radioactivity (Bq*1.e-24)	%Total	%Cum
1	02004500	Ca45	2.46993E-04	1.21857E-11	71.078	71.078
2	02605500	Fe55	4.38330E-04	3.50950E-12	20.471	91.549
3	02605900	Fe59	7.81248E-06	1.40876E-12	8.217	99.766
4	02104700	Sc47	6.77652E-09	1.62322E-14	0.095	99.861
5	01803700	Ar37	6.66495E-08	1.52723E-14	0.089	99.950
6	02004700	Ca47	2.89653E-09	5.12291E-15	0.030	99.980
7	01904000	K40	9.57379E+01	1.68496E-15	0.010	99.990
8	02004100	Ca41	6.14803E-03	1.35854E-15	0.008	99.998
9	02104501	Sc45-01	1.06220E-16	2.31528E-16	0.001	99.999
10	02505400	Mn54	4.37589E-09	1.12446E-16	0.001	100.000
11	01803900	Ar39	4.37122E-07	3.58205E-17	0.000	100.000
12	01703600	Cl36	1.94133E-05	1.41663E-18	0.000	100.000
13	01503200	F32	6.98066E-13	3.92505E-19	0.000	100.000
14	02104600	Sc46	2.28391E-12	2.18675E-19	0.000	100.000
15	00601400	C14	1.72069E-08	6.63056E-20	0.000	100.000
16	02706000	Co60	6.59953E-13	2.74999E-21	0.000	100.000
17	00100300	H3	9.14827E-13	1.63094E-21	0.000	100.000
18	01503300	F33	3.24167E-16	1.02589E-22	0.000	100.000
19	01102400	Na24	3.12869E-18	4.01691E-23	0.000	100.000
20	01403200	S132	1.04841E-13	1.50464E-23	0.000	100.000
21	02004800	Ca48	5.05158E+03	3.82605E-24	0.000	100.000
22	02104800	Sc48	3.99423E-19	1.75944E-24	0.000	100.000
23	01904200	K42	1.89582E-22	2.95445E-27	0.000	100.000
24	01904300	K43	1.16579E-22	1.00656E-27	0.000	100.000
25	01804200	Ar42	2.52864E-22	1.69051E-31	0.000	100.000
26	01302800	Al28	1.04470E-30	5.37589E-33	0.000	100.000
27	01202800	Mg28	5.82917E-28	5.36626E-33	0.000	100.000
28	01603500	S35	2.30696E-31	2.11833E-38	0.000	100.000
29	02606000	Fe60	1.48806E-26	1.24750E-40	0.000	100.000
30	02806300	Ni63	1.69460E-33	3.67830E-43	0.000	100.000
31	03006500	Zn65	1.12736E-53	3.70775E-61	0.000	100.000
32	02906600	Cu66	9.62438E-61	2.17159E-63	0.000	100.000
33	02806600	Ni66	3.14848E-58	2.16819E-63	0.000	100.000
34	02906400	Cu64	1.73290E-62	2.62707E-67	0.000	100.000

Concrete activity inventory