Quantification of the uncertainties in the determination of the final dose of the High Flux Test Module (HFTM) samples in IFMIF-DONES

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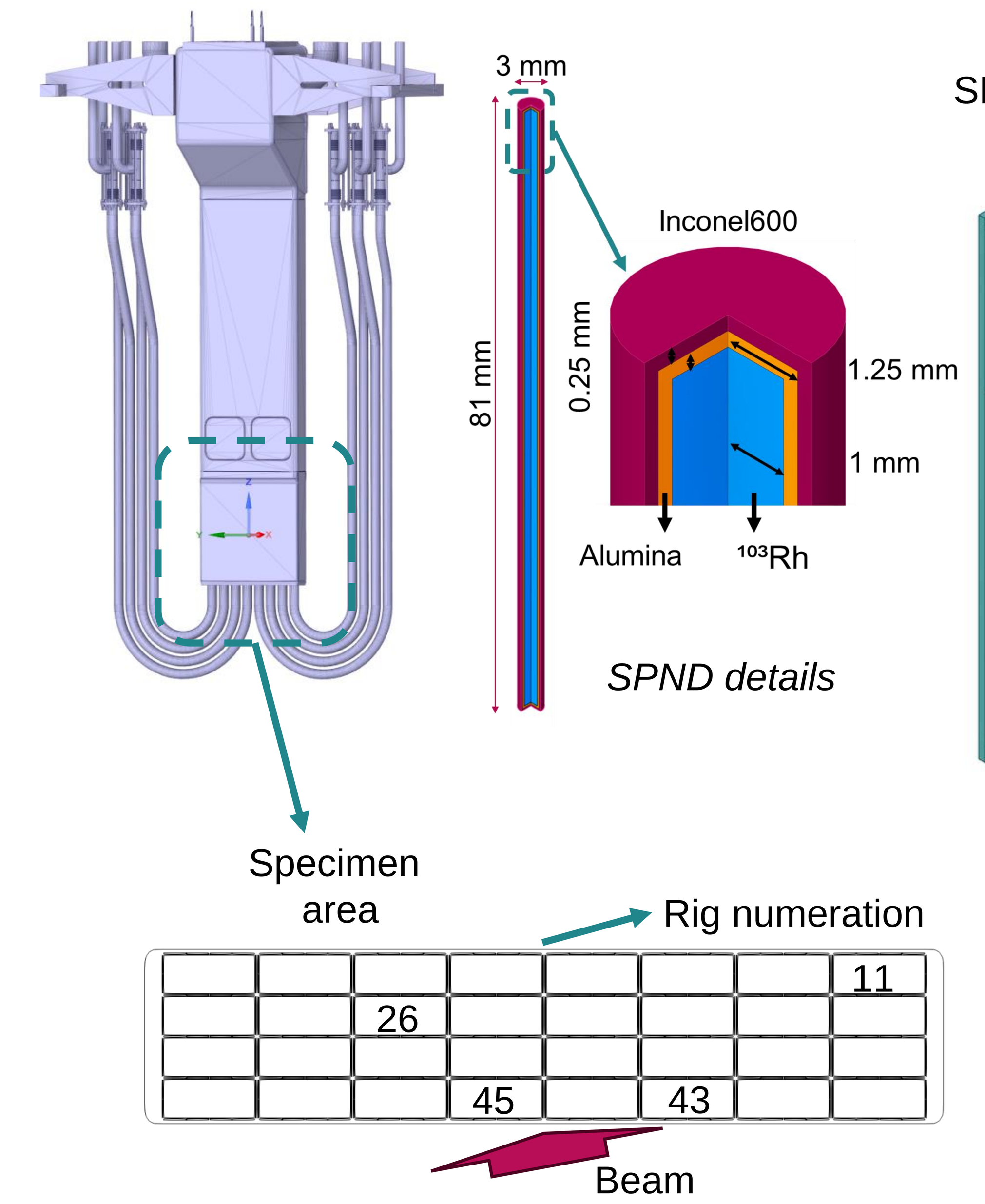
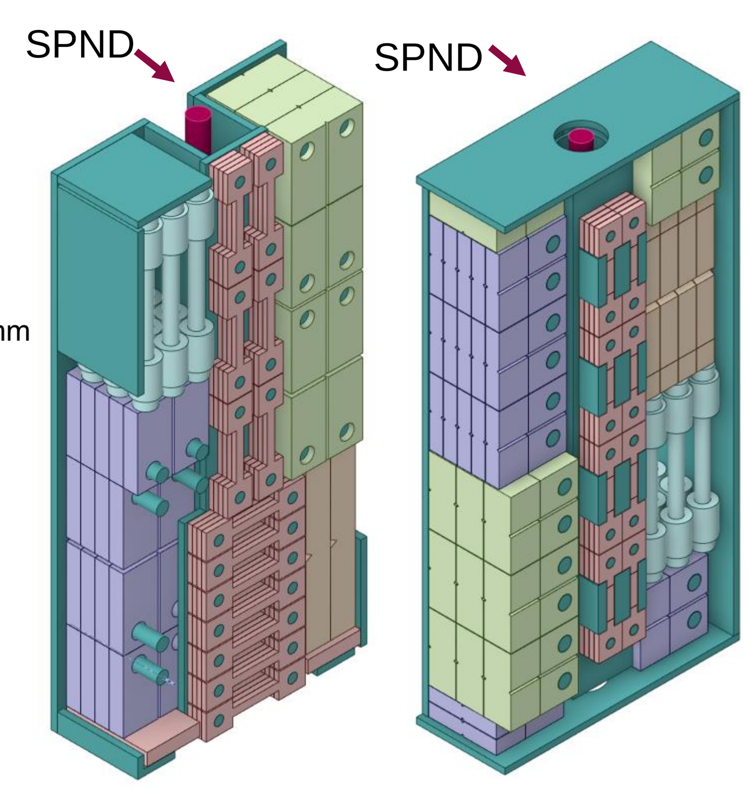
IFMIF-DONES Specimens

High Flux Test Module (HFTM)



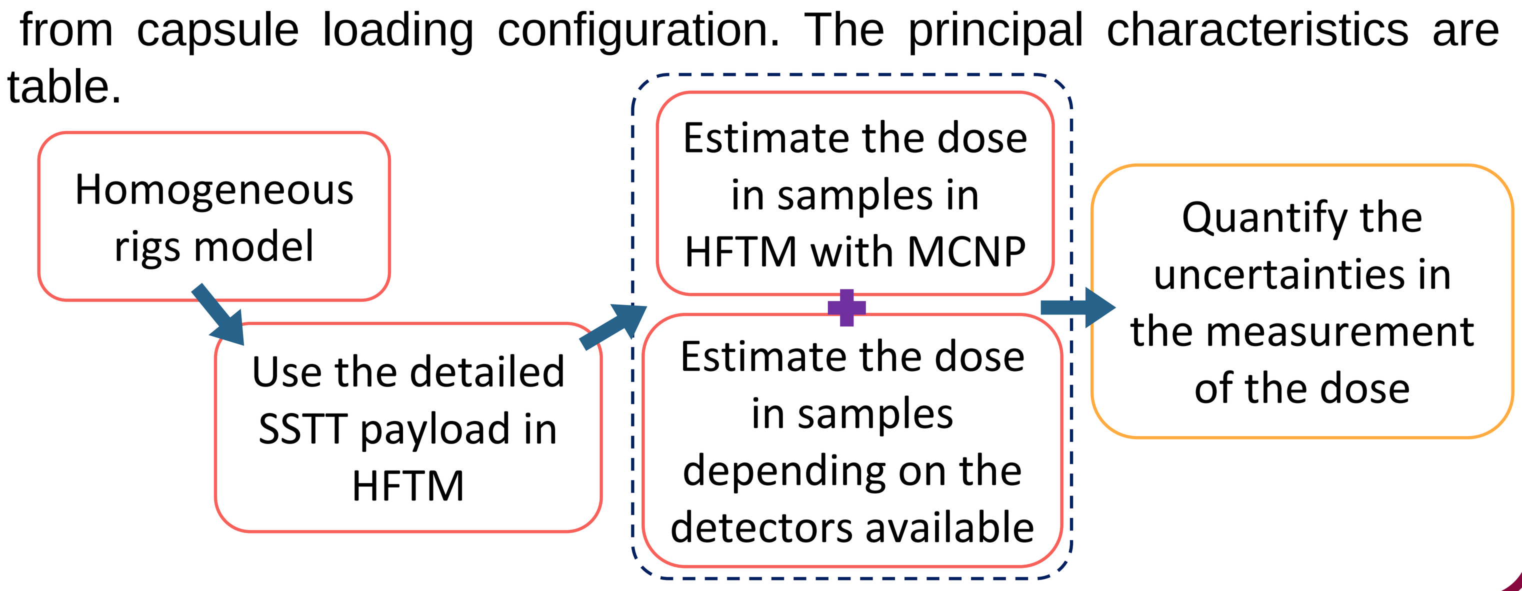
Horizontal cut-plane of specimen capsules

Specimens distribution

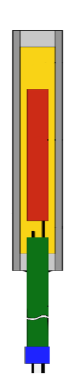


- IFMIF-DONES is a neutron irradiation facility which aims at providing the irradiation materials data required for the construction of future fusion reactors.
- The HFTM is designed to expose material specimens to high neutron flux conditions, generated by a deuteron beam directed at a lithium target.
- The neutron damage will depend on different factors such as the irradiated material, the dose received, the neutron spectra, the dose rate and the temperature. So, the determination of the neutron fluence to which the specimens in the HFTM of DONES are exposed is a fundamental parameter for further specimen analysis.
- Using Self Powered Neutron Detectors (SPNDs) in each rig inside the HFTM is possible to obtain the neutron flux and estimate the dose absorbed by the specimens. The flux will be different in the 32 SPND.
- Two different specimen distribution have been designed: **CLC.V1.0** and **CLC.V2.0**. The acronym comes from capsule loading configuration. The principal characteristics are presented in the table.

Characteristics of specimen distribution		
	CLC.v1.0	CLC.v2.0
Eurofer volume [%]	48.16	84.77
Liquid metal (Na) [%]	21.86	12.92
Specimens per rig	101	120



Self-powered neutron detectors (SPNDs)



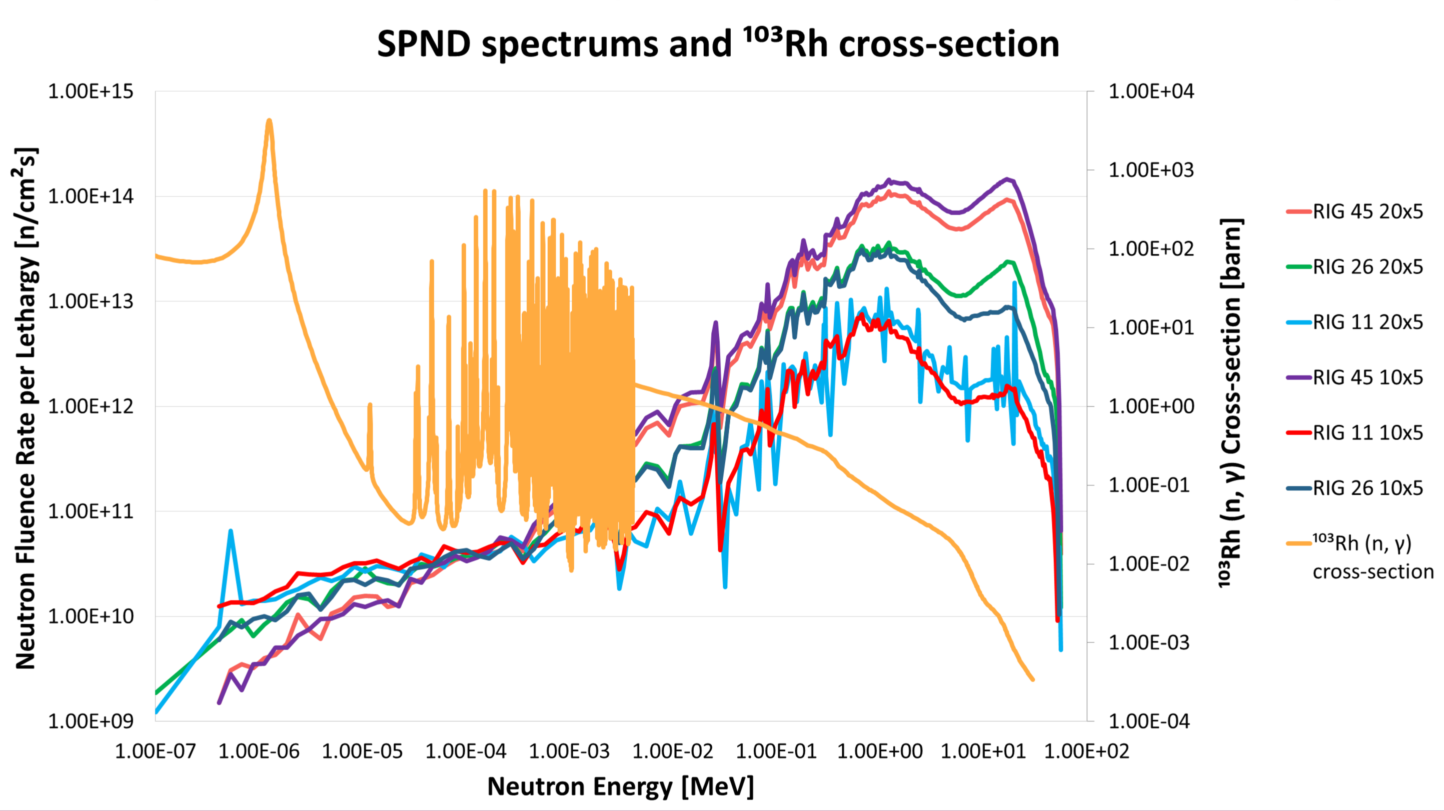
- Online detector which measures neutron and photon flux
- Gives an electrical signal in proportion to the incident fluxes of neutron and/or photon
- Multi-layered design: emitter, insulator and collector
- Main nuclear processes to create current: (n, β-), (n, γ, e-), (γ, e-)

The first estimation of the current in the SPND has been obtained taking only into account the process (n, β-), that means the 95% of the signal for a Rh SPND.

For the calculation, the material are ^{103}Rh, alumina and Inconel600. The spectrum data are for the SPND in **CLC.v1.0** model. As observed in the table, the electrical current values are higher when the SPND is farther from the neutron source.

Electrical current estimation (μA)			
RIG	45	26	11
20x5 cm²	1.79	2.97	9.95
10x5 cm²	1.61	3.66	11.8

The graphic shows the neutron spectrums in different SPND with different beam sizes (left axis) and the neutronic capture for the ^{103}Rh cross-section (right axis).

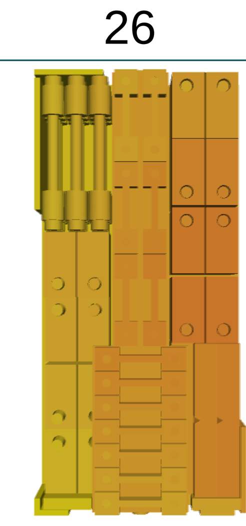
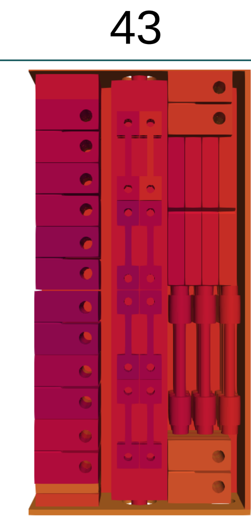
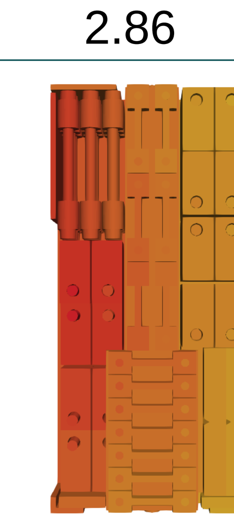
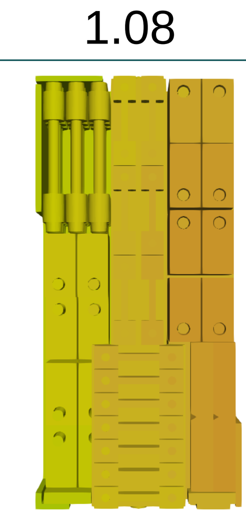
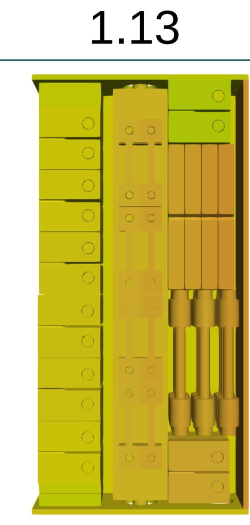


Conclusions and next steps

- The estimated electric current in the SPND is lower when the SPND is closer to the neutron source. This is because there are more fast neutrons than thermal neutrons, and β- generation is more likely in this case.
- This information needs experimental validation in order to enhance the accuracy of the simulation model and the response of different emitter SPND materials will be studied for the IFMIF-DONES neutron spectrum.
- The spread of the fluences within a specimen set is relatively high and the difference vs. the single SPND value of the same capsule can be up to +75%. Additional assumptions or measurements (i.e. activation) are necessary for a meaningful dose assessment of individual specimens. However, the SPND value reflects the average dose in the rig quite well.

Variation of neutron fluence rate [n/cm²s] in specimens and SPNDs

For both sample models, neutron fluence rate have been obtained using two different IFMIF-EVEDA beam sizes, 20x5 cm² and 10x5 cm². Two rigs with a high gradient have been selected to compare the different cases: 43 and 26. For each rig, the maximum, minimum and average neutron fluence rate values received by the specimens inside the rig, as well as the value reaching the SPND, have been obtained. As can be seen, the values vary significantly from one rig to another and also with changing beam size. Relative differences have been calculated with respect to the SPND value, and substantial fluctuations in flux values are observed within the same rig, where a single SPND per capsule is employed as a reference point.

Neutron fluence rate [10^{14} n/cm²s]									
Model		CLC.v1.0				CLC.v2.0			
Beam	RIG	43		26		43		26	
20x5 cm²	Layout								
	Min	1.58	-44.8%	0.76	-29.5%	1.77	-42.7%	0.78	-30.9%
	Max	4.54	58.7%	1.60	48.1%	4.84	56.6%	1.50	38.9%
	Average	3.12	9.1%	1.16	7.4%	3.23	4.5%	1.15	1.8%
	SPND	2.86		1.08		3.09		1.13	
10x5 cm²	Layout								
	Min	1.03	-36.4%	0.62	-23.9%	1.16	-31.4%	0.63	-27.2%
	Max	2.83	74.7%	1.16	42.2%	2.95	74.6%	1.23	41.2%
	Average	1.72	6.2%	0.88	8.6%	1.81	7.1%	0.89	2.3%
	SPND	1.62		0.81		1.69		0.87	

Neutron fluence rate [n/cm²s]

$1\cdot10^{13}$ $2\cdot10^{13}$ $5\cdot10^{13}$ $1\cdot10^{14}$ $2\cdot10^{14}$ $5\cdot10^{14}$

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