Detailed irradiation parameters assessment of the IFMIF-DONES HFTM irradiation capsules

I. Álvarez, M. Anguiano, F. Mota, R. Hernández, Y. Qiu, F. Arbeiter, J. Park

UNIVERSIDAD DE GRANADA

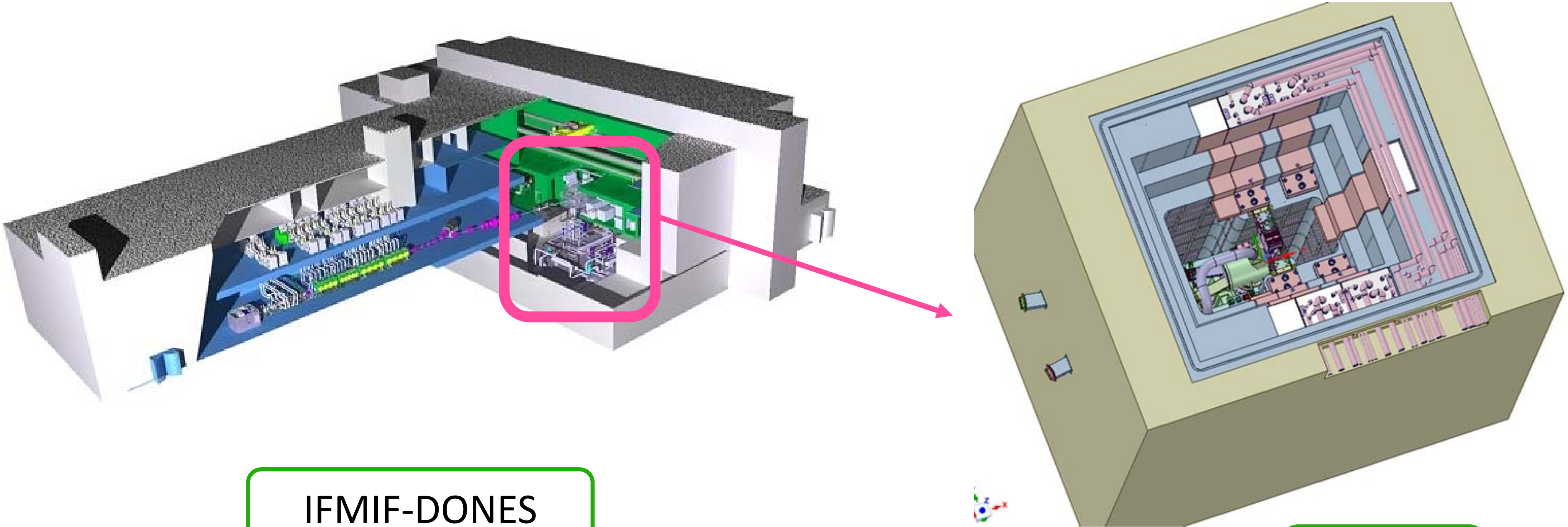
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

KIT Karlsruher Institut für Technologie

EUROfusion

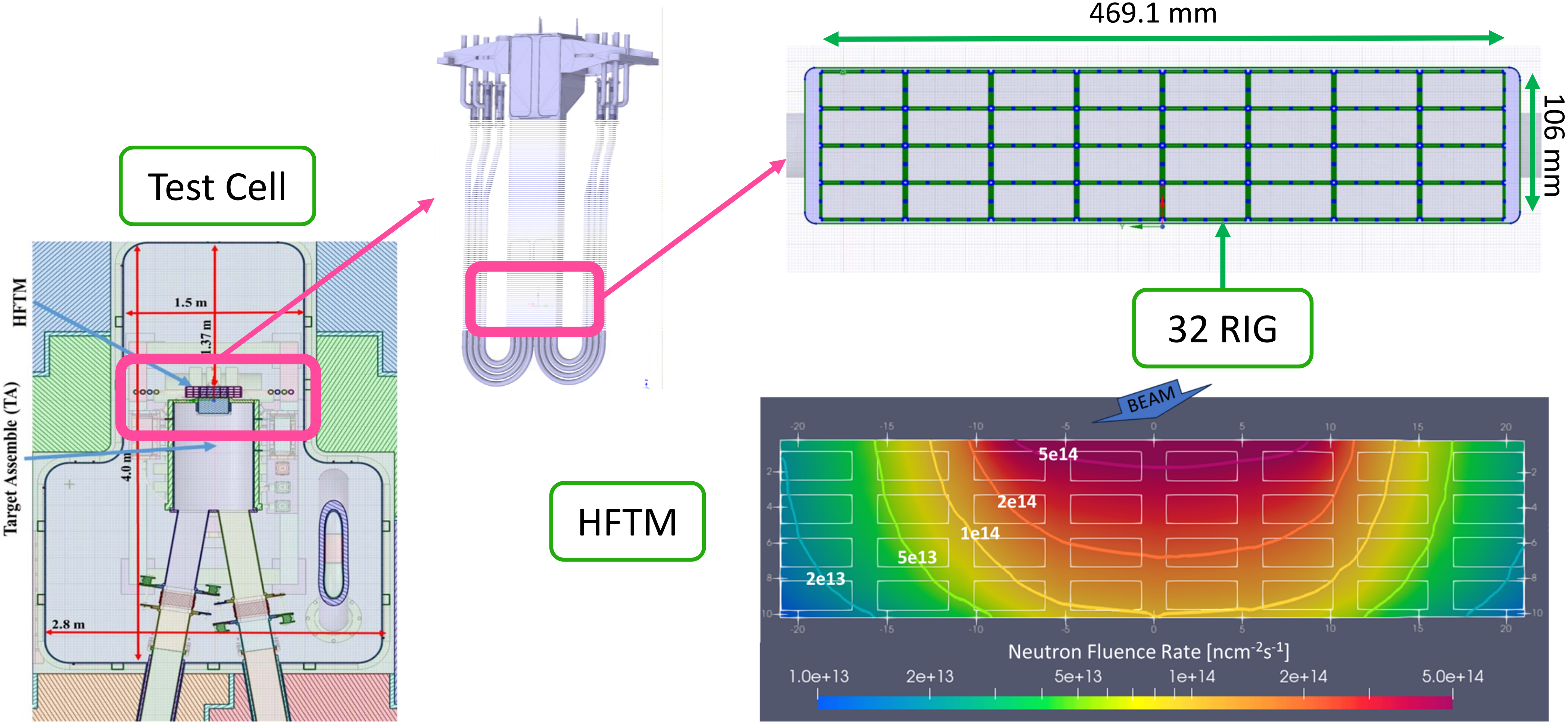
Introduction



IFMIF-DONES

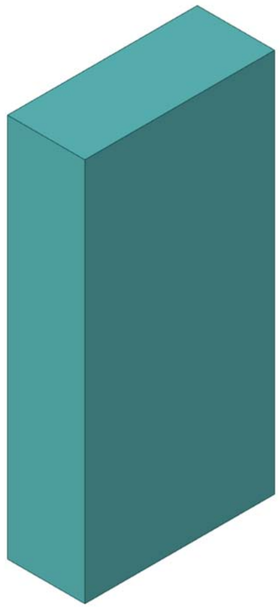
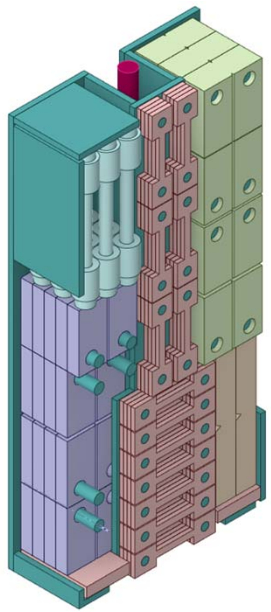
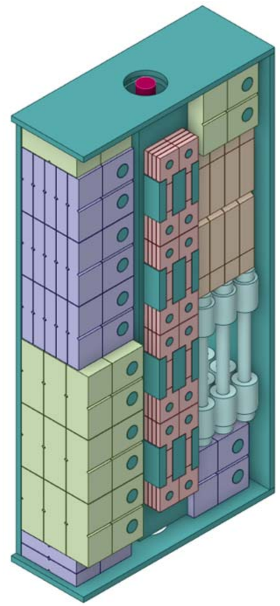
Test Cell

High Flux Test Module



Considerations

- The neutron fluence rate is very different from one capsule to another and also within the same capsule
- Objective of this work: estimate dose uncertainties in specimen evaluation
- To study how the specimens distribution influences the dose and its uncertainty
- To study the different configurations available for the rigs, analysing the neutron fluence rate, the NRT_dpa and the gas production

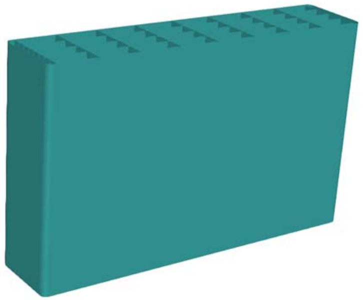
Characteristics of specimen distribution			
	Homogeneous	CLC.v1.0	CLC.v2.0
STACK MODELS			
Eurofer volume [%]	75	48.16	84.77
Liquid metal (Na) [%]	25	21.86	12.92
Specimens per rig	Not defined	101	120

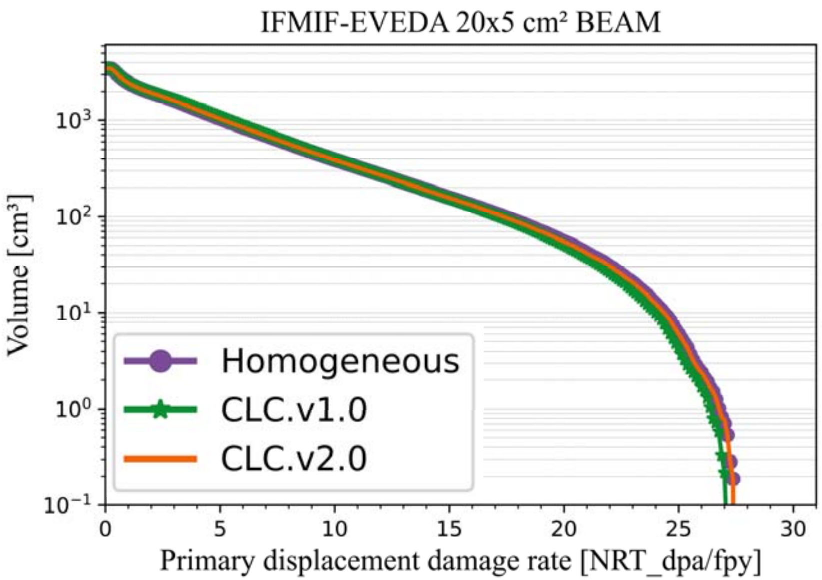
Methodology

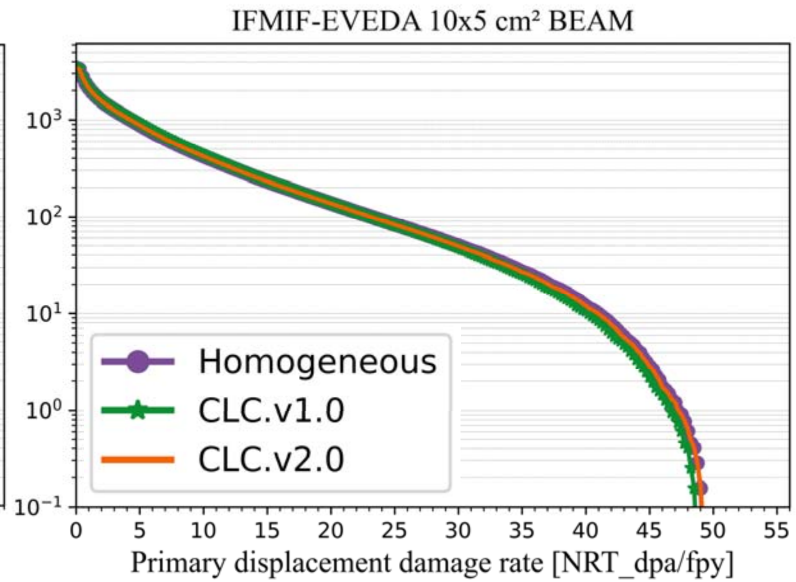
- IFMIF-DONES TC MCNP model version used: mdl9.2.0 (2020) and mdl9.2.8 (2023), KIT/INR
- McDelicious 2017
- Nuclear Data libraries used:
  - FENDL3.1d nuclear data libraries for neutron transport calculations
  - JEFF3.3DPAarc nuclear data libraries for primary displacement damage calculations in eurofer. (26001.32y)
- The statistic relative error has been lower than 0.05 for all bins.
- Deuteron IFMIF-EVEDA E= 40 MeV, 125 mA, footprint size 20x5 and 10x5 cm^2
- Fpy = 365.25 days

Primary displacement damage rate

Integrated HFTM volumen in specimens region



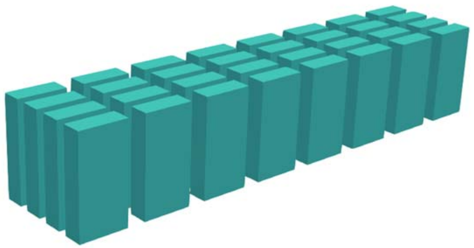


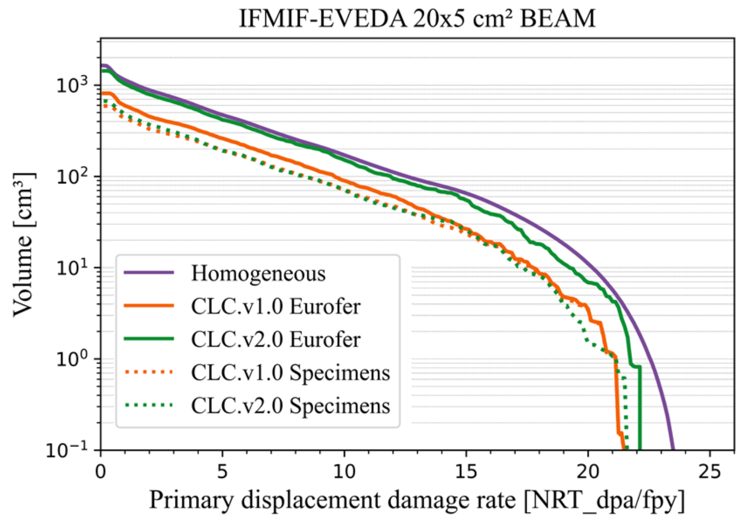


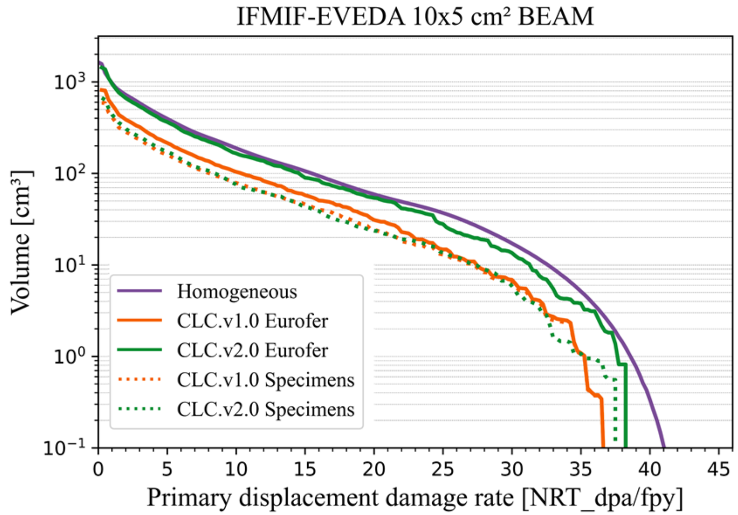
Volume DPA requirements [litres]				
		Target value	Homogeneous/CLC.v1.0/CLC.v2.0	
	Beam		10x5	20x5
R-1	8-12 NRT_dpa/fpy	0.3	0.2	0.3
R-2	>16.7 NRT_dpa/fpy	0.1	0.2	0.1

Primary displacement damage rate

Integrated stack and specimens in HFTM volumen



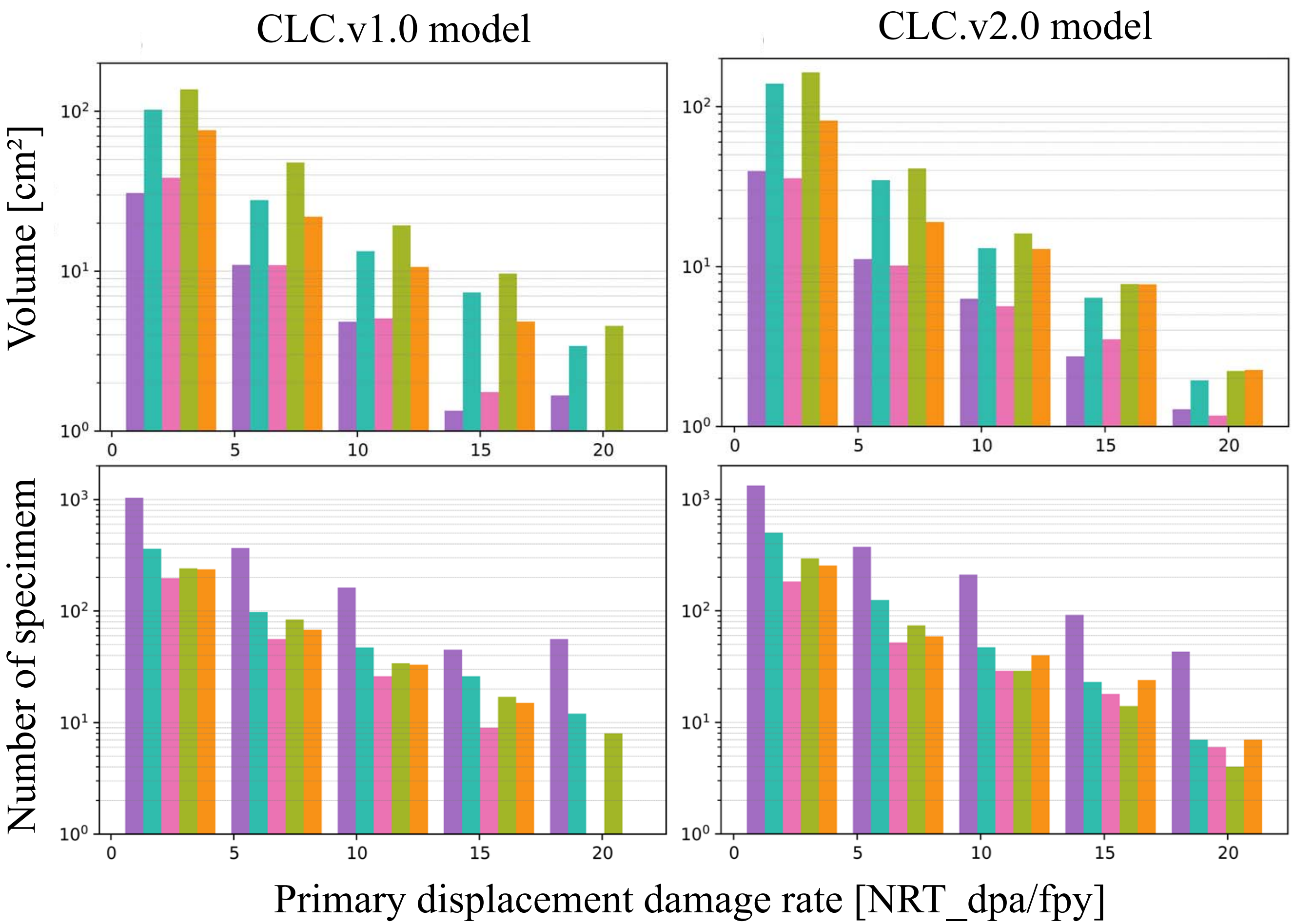


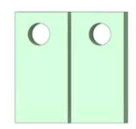
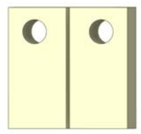


Volume DPA requirements [litre]							
				CLC.v1.0		CLC.v2.0	
Beam footprint		[NRT_dpa/fpy]	Target volume	Specimens	Eurofer	Specimens	Eurofer
20x5 cm²	R-1	8-12	0.3	0.06	0.08	0.06	0.13
	R-2	>16.7	0.1	0.014	0.015	0.013	0.03
10x5 cm²	R-1	8-12	0.3	0.04	0.05	0.04	0.09
	R-2	>16.7	0.1	0.04	0.05	0.03	0.07

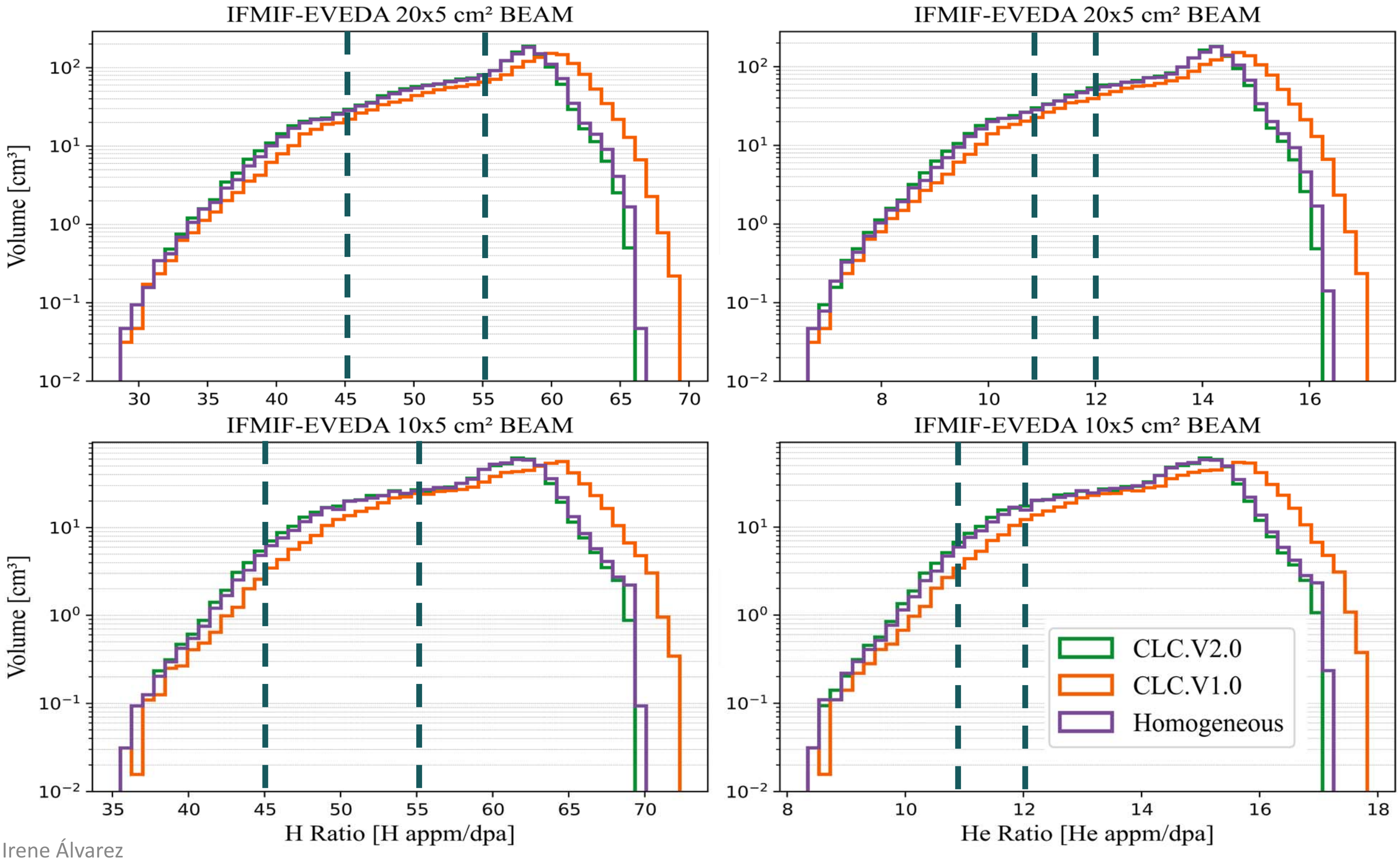
Primary displacement damage rate

DPA variation by specimen type in 20x5 cm² beam footprint

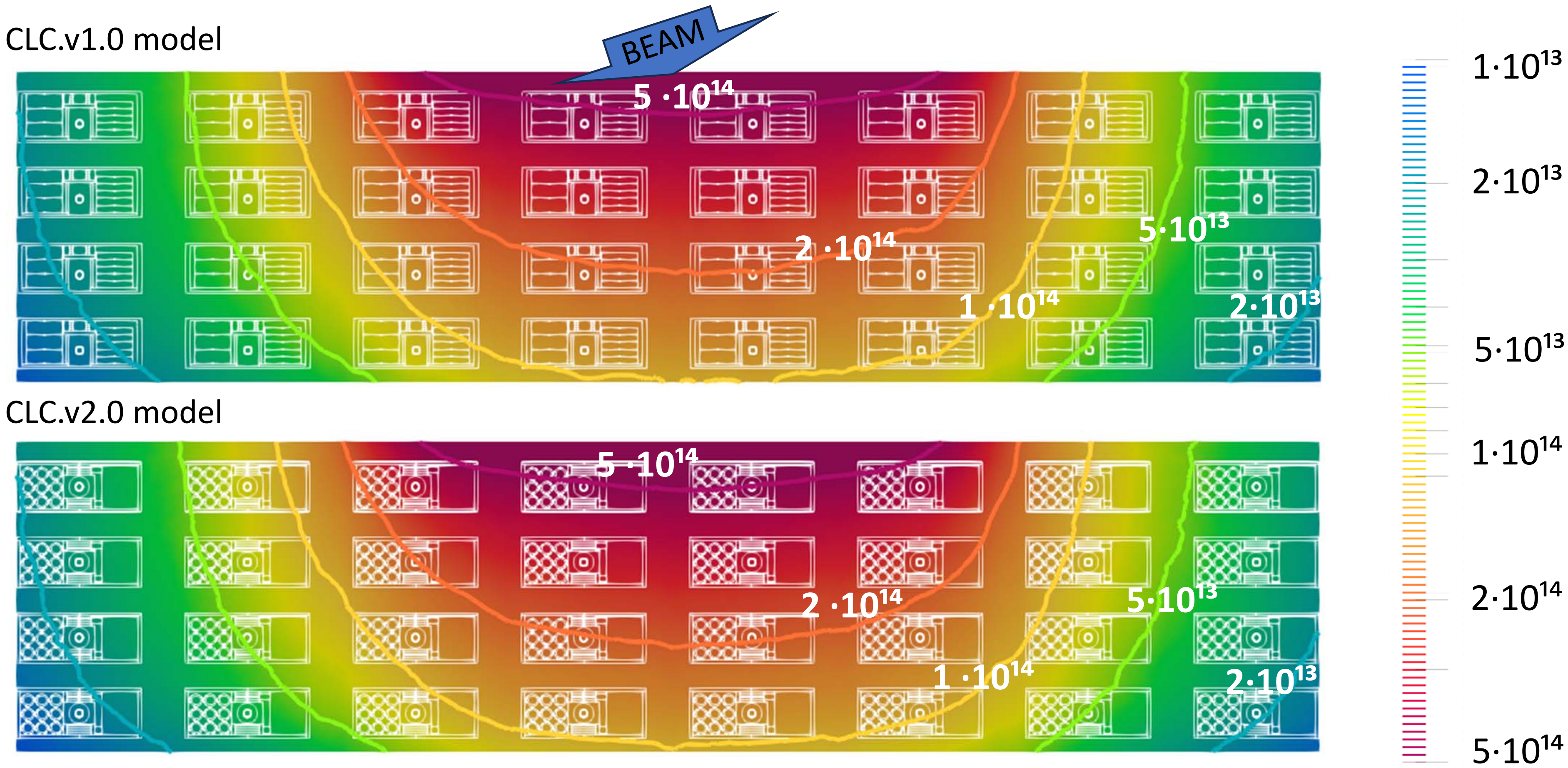


	Units/rig		
	Type	CLC.v1.0	CLC.v2.0
Tensile		52	64
FCG		17	22
Fatigue		9	9
FT		11	13
KLST		12	12

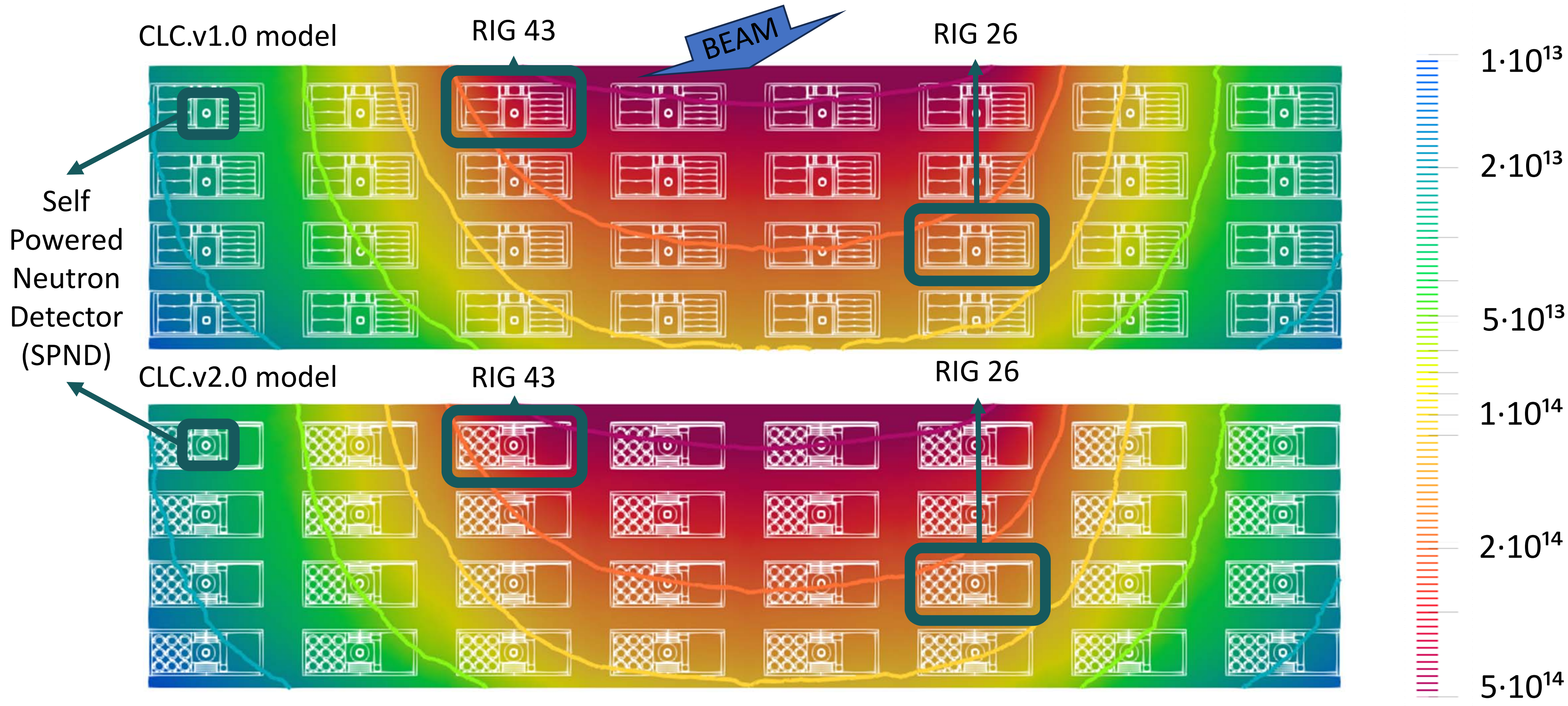
Gas –production



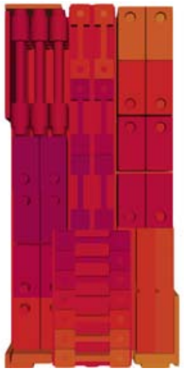
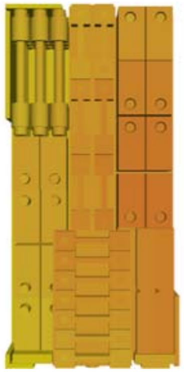
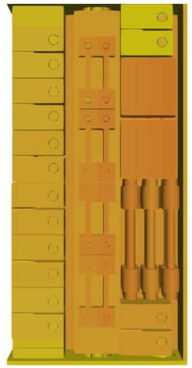
Neutron fluence rate [n/cm²s]

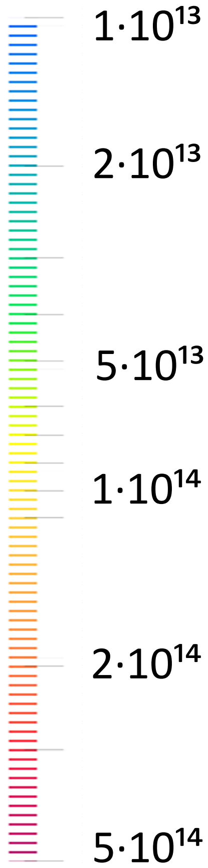


Neutron fluence rate [n/cm²s]



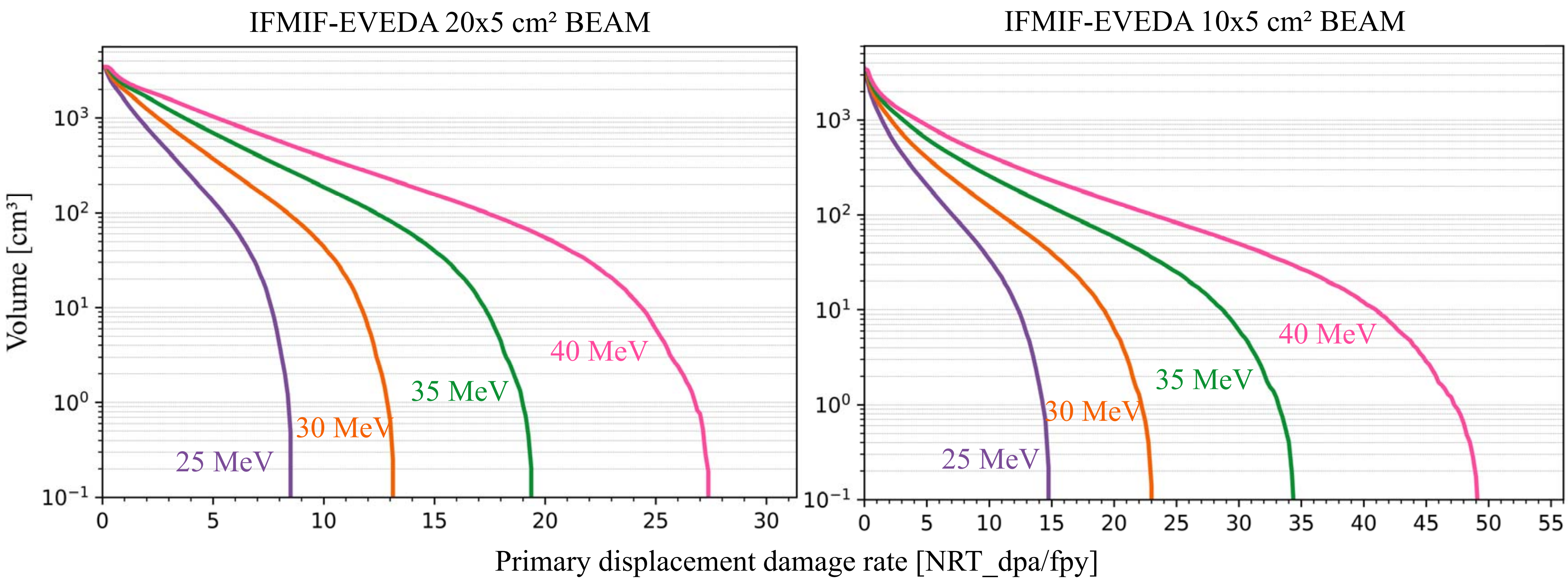
Neutron fluence rate

Neutron fluence rate 20x5 cm² beam footprint [10^{14} n/cm²s]								
Model	CLC.v1.0				CLC.v2.0			
RIG	43		26		43		26	
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	

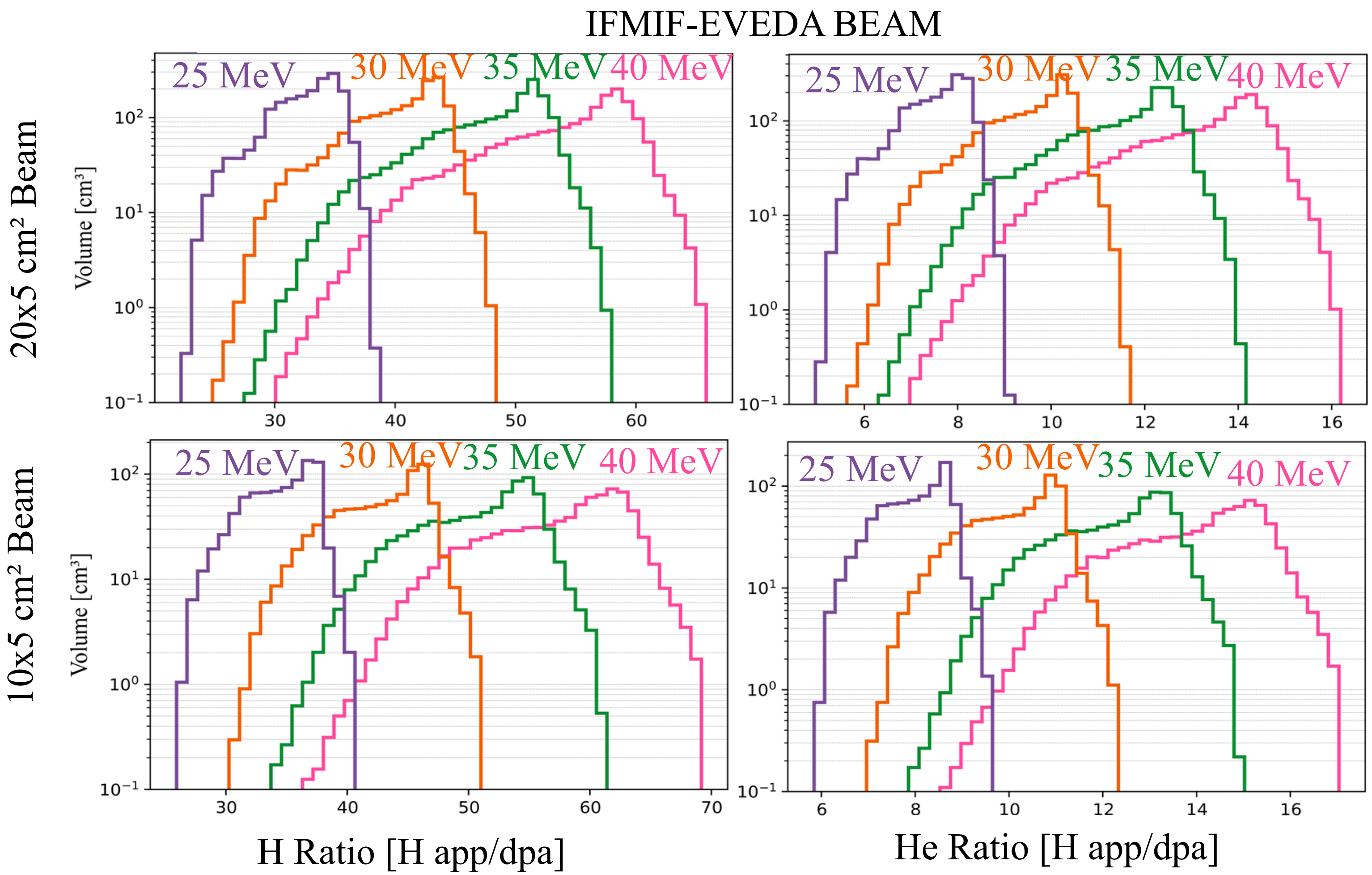


Primary displacement damage rate

Different deuterom beam energy for the CLC.v2.0 model



Gas-production



Different deuterom beam energy for the CLC.v2.0 model

Conclusions

Considering the whole volume of the HFTM, R-1 and R-2 criteria of dpa are fulfilled, but if we only look at the volume of the specimens, these values are significantly reduced, being even lower for the CLC.v1.0 model

NRT_dpa histograms by specimen type show the versatility of this facility, because depending on the specimens distribution design, it is possible to obtain different values. The gradient inside a rig must be also considered

The gas production ratios cover the expected values for DEMO

By changing the beam energy, the desired dpa ranges can be changed, as well as the gas production

Future work

- Results will be obtained for different materials such as W or CuCrZ
- The isotopic composition of these materials and eurofer will be obtained, because they will also affect the macroscopic properties of the material
- Estimation the signal in the SPND

Thank you very much for your attention

Irene Álvarez Castro (iac@ugr.es)

PhD Student

Department of Atomic, Molecular and Nuclear Physics

University of Granada