Assessment of the IFMIF-DONES irradiation capabilities

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On behalf of the DONES integrated programme team





Fourth DONES Users Workshop
13 October 2026

Overview

- Introduction
- Test Cell analyses
  - Primary displacement damage rate
    - Material specimens region
  - Neutron fluence rate
    - Test Cell
      - One- and two-accelerator setups
      - Different irradiation modules in TC
    - Complementary Experimental Room
      - One- and two-accelerator setups
      - Different irradiation modules in TC
- Conclusions

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Introduction

- The main objective of IFMIF-DONES is to test structural material for fusion reactors.

- Beyond this, it offers potential for a wide range of applications, including experiments for other technological and scientific purposes, both fusion and non-fusion related.

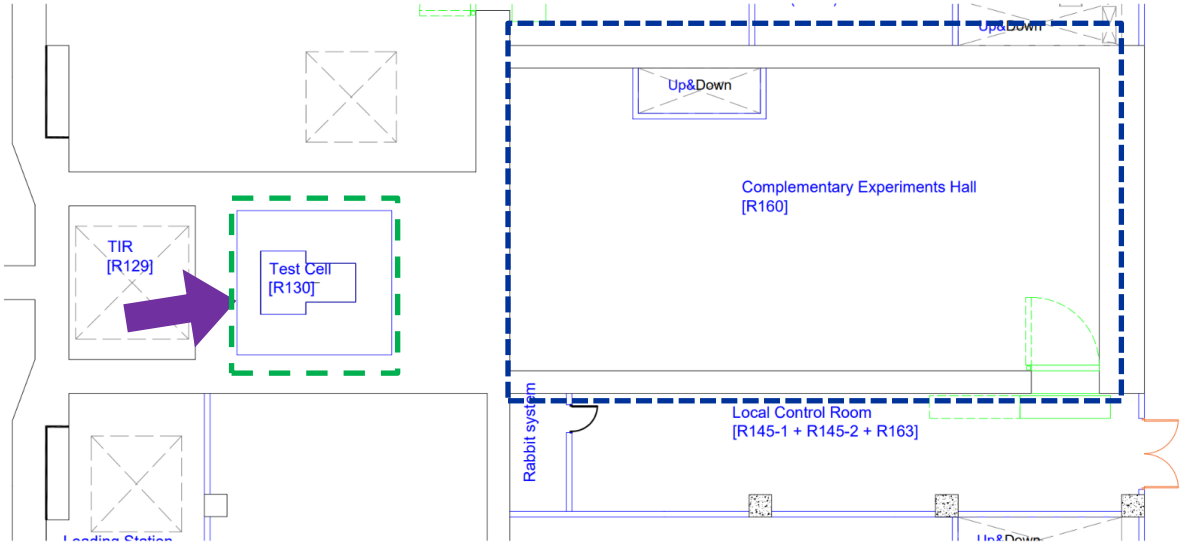
Introduction

- The objective of this presentation is to show the capabilities of the IFMIF-DONES facility.

- Among the possible upgrades, we have considered the installation of a second accelerator [1].

[1] A. Ibarra et al., Nuclear Fusion 2025

Introduction



Deuteron beam

Test Cell (TC):
- High Flux Test Module (HFTM)
- Medium Flux Test Module (MFTM)

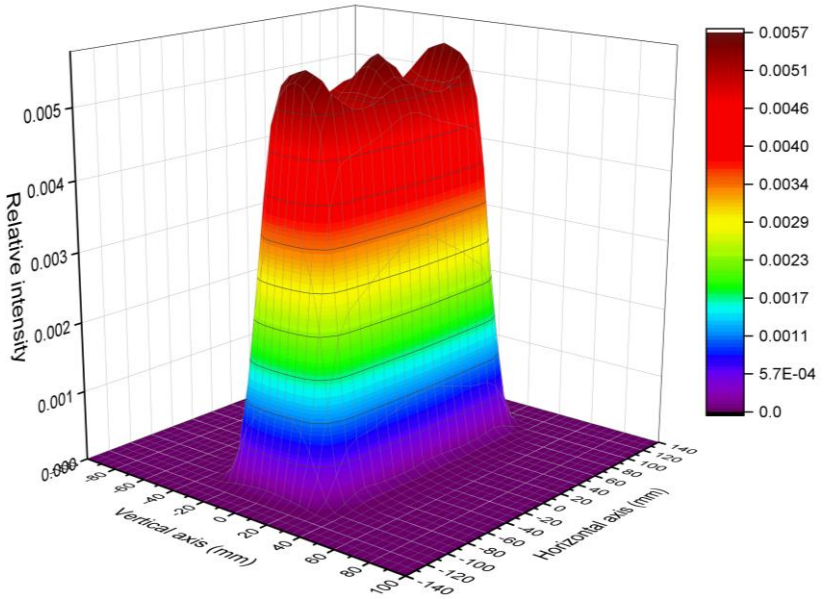
Complementary experimental room (CER)

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Primary displacement damage rate in HFTM

- Raw data: Calculation performed in the WPENS framework [1]
- Conditions
  - IFMIF-EVEDA beam profile



IFMIF/EVEDA profile [2]

[1] I. Álvarez et al., Fusion Engineering and Design 2025
[2] BA_D_22NJX9 v1.4

Primary displacement damage rate in HFTM

- Raw data: Calculation performed in the WPENS framework [1]
- Conditions
  - IFMIF-EVEDA beam profile
  - 20×5 cm^2 beam footprint size
  - 1 Operational Accelerator
  - High Flux Test Module (HFTM) with homogeneous model in the capsules 75% EUROFER97 25% Na
  - DPA calculated for the EUROFER97 equivalent material

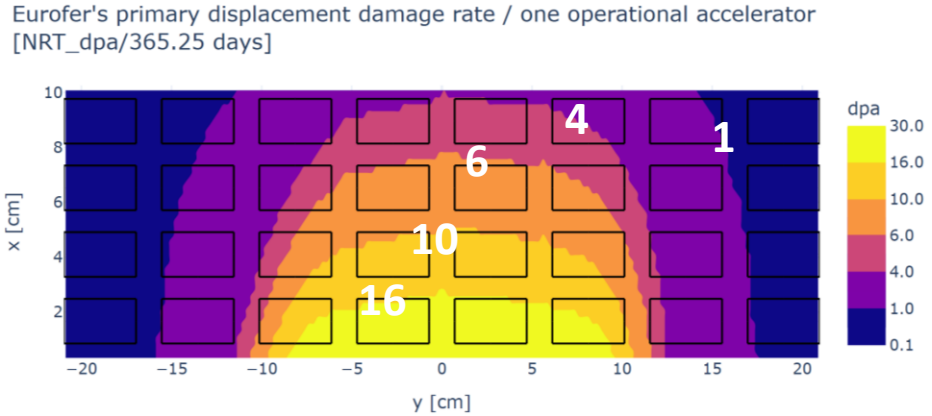
[1] I. Álvarez et al., Fusion Engineering and Design 2025

Primary displacement damage rate in HFTM

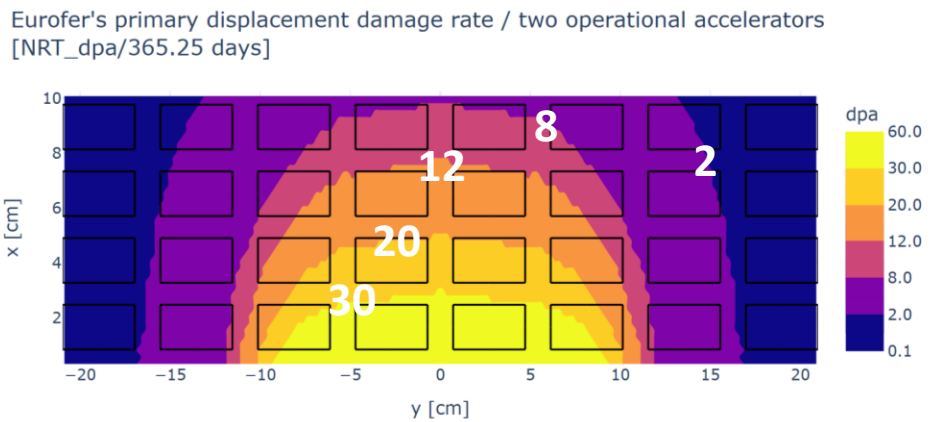
Primary displacement damage rate in HFTM [NRT_dpa/fpy]

- Cut at plane z = 0

1 Operational accelerator

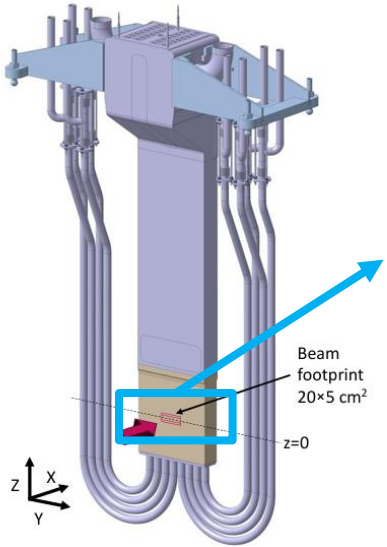


2 Operational accelerators

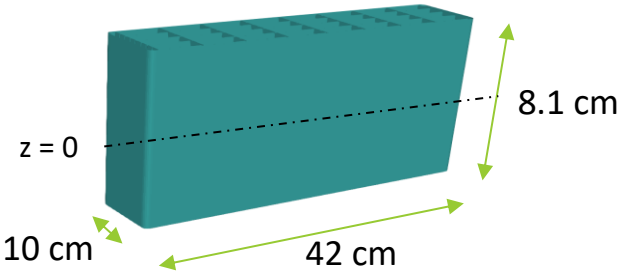


Primary displacement damage rate in HFTM

- Specimen region within the HFTM volume



High Flux Test Module

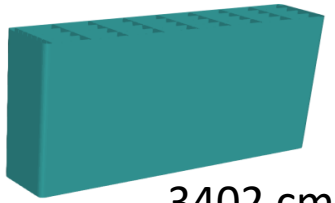


Total volume of 3402 cm^3

The DPA distribution within the HFTM specimen region is analysed to provide a comprehensive overview of the achievable damage levels, as the irradiation module configuration may change in future studies.

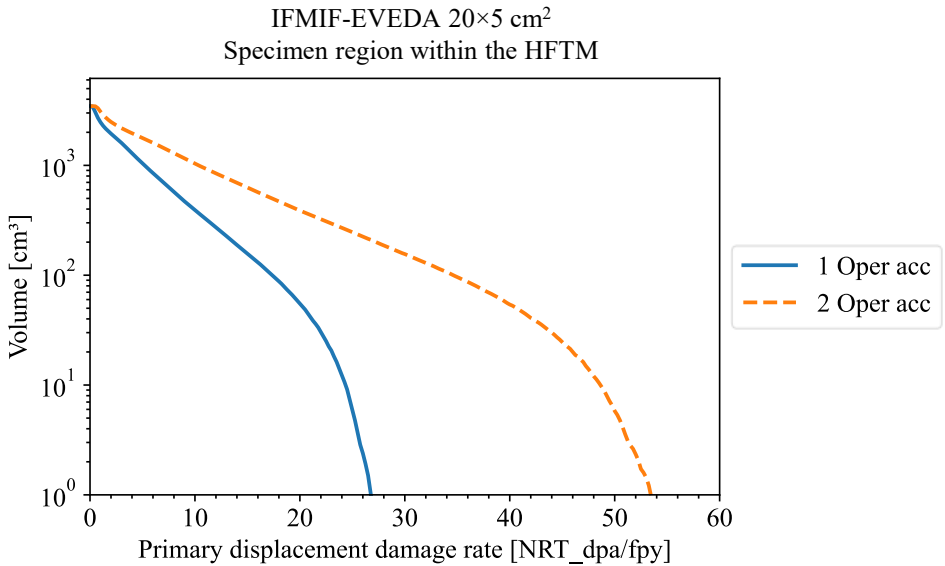
Primary displacement damage rate in HFTM

- Specimen region within the HFTM volume



3402 cm^3

Integrated volume vs Eurofer's primary displacement damage rate [NRT_dpa/365.25 days]



When two operational accelerators are considered, the DPA values reached are approximately doubled.

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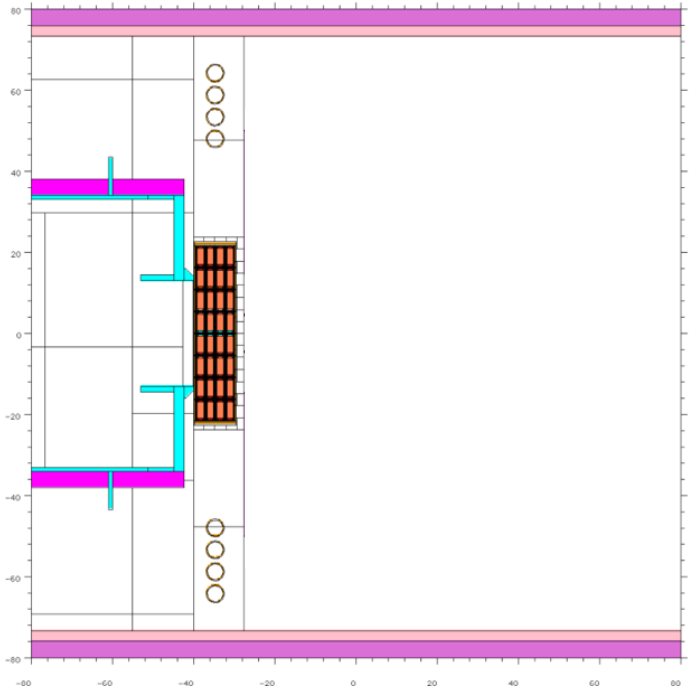
Neutron fluence rate – Test Cell

- Raw data: Calculation performed in the WPENS framework [1]
- Conditions
  - IFMIF-EVEDA beam profile
  - 20×5 cm^2 beam footprint size
  - 1 Operational Accelerator
  - High Flux Test Module (HFTM) with homogeneous model in the capsules 75% EU97 25% Na
  - Medium Flux Test Module (MFTM) module considered is BLUME-7 with Pb reflectors [2] to test the tritium production

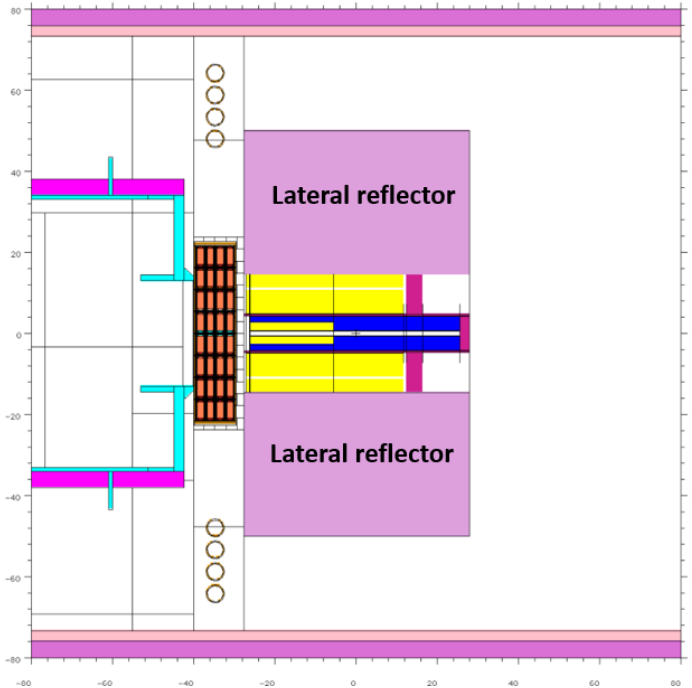
[1] A. Serikov et al., DONES User's Workshop, 2024
[2] G. Zhou et al., Conf. on Radiation Applications, 2024

Neutron fluence rate – Test Cell

- Test Cell cut at plane z=0
  - HFTM in TC



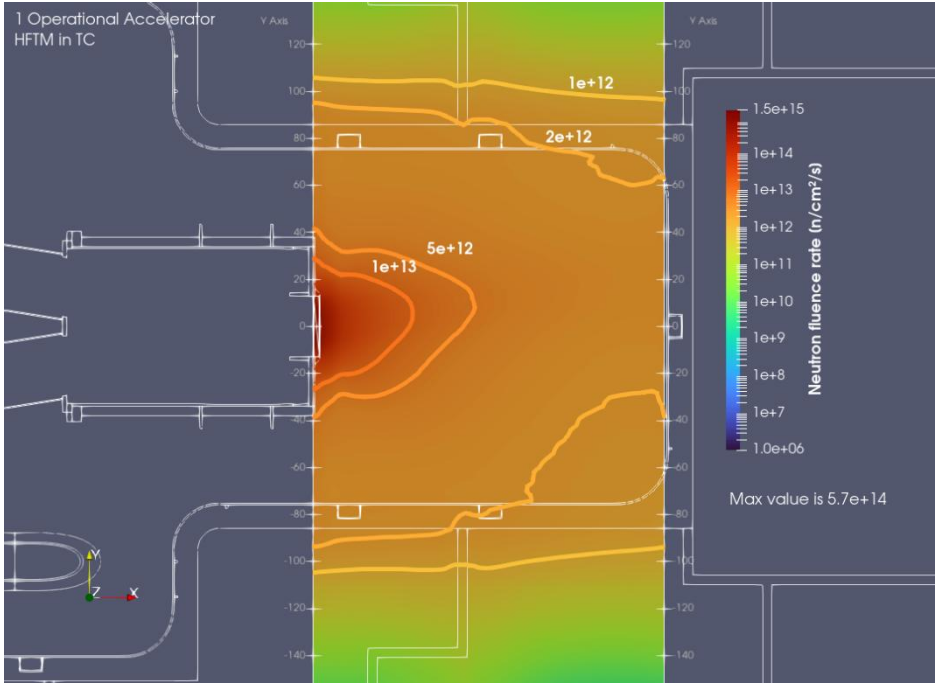
- HFTM and MFTM (BLUME with Pb reflectors) in TC



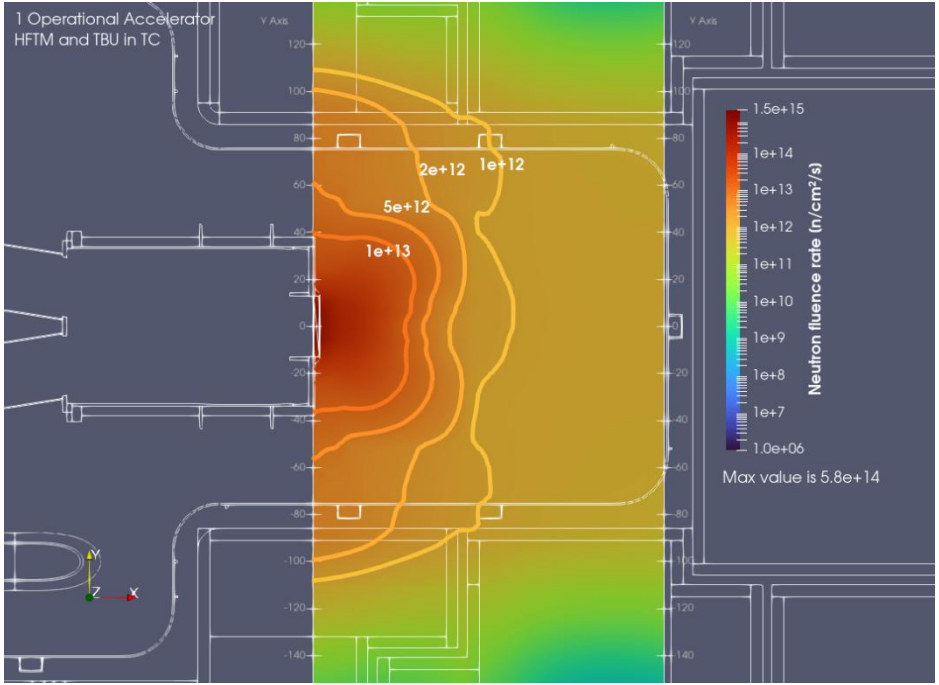
Neutron fluence rate – Test Cell

Neutron fluence rate maps for 1 Operational Accelerator z=0 (raw Data)

- HFTM in TC



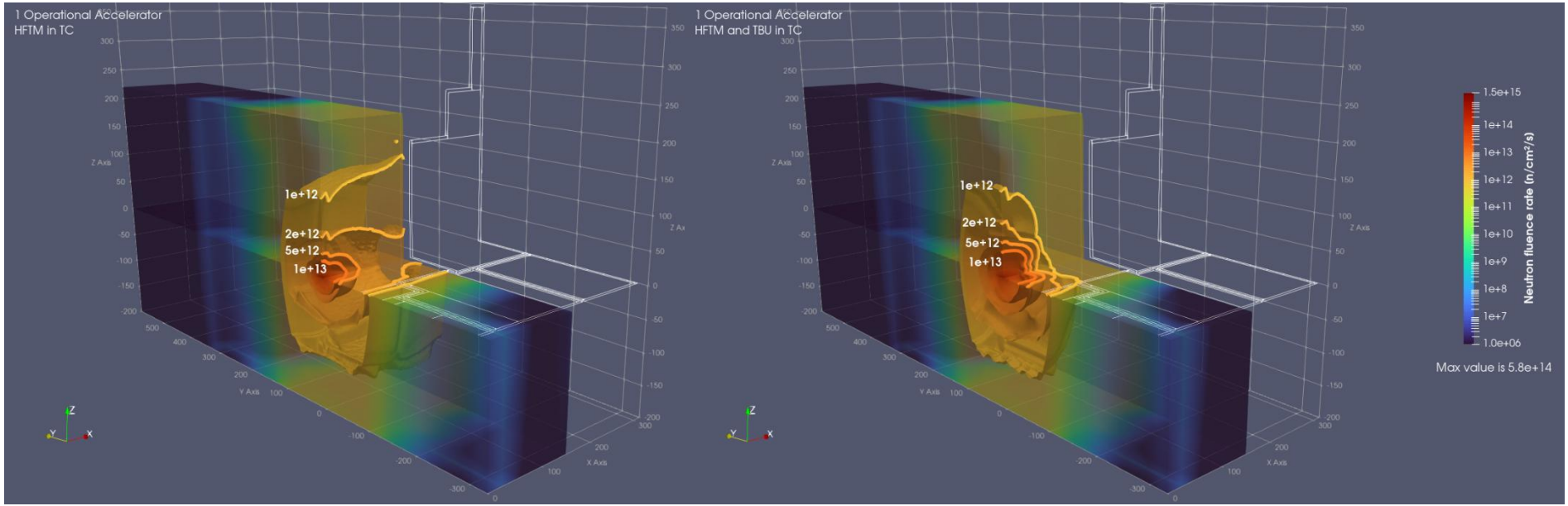
- HFTM and MFTM in TC



Neutron fluence rate – Test Cell

Neutron fluence rate maps for 1 Operational Accelerator z=0 (raw Data)

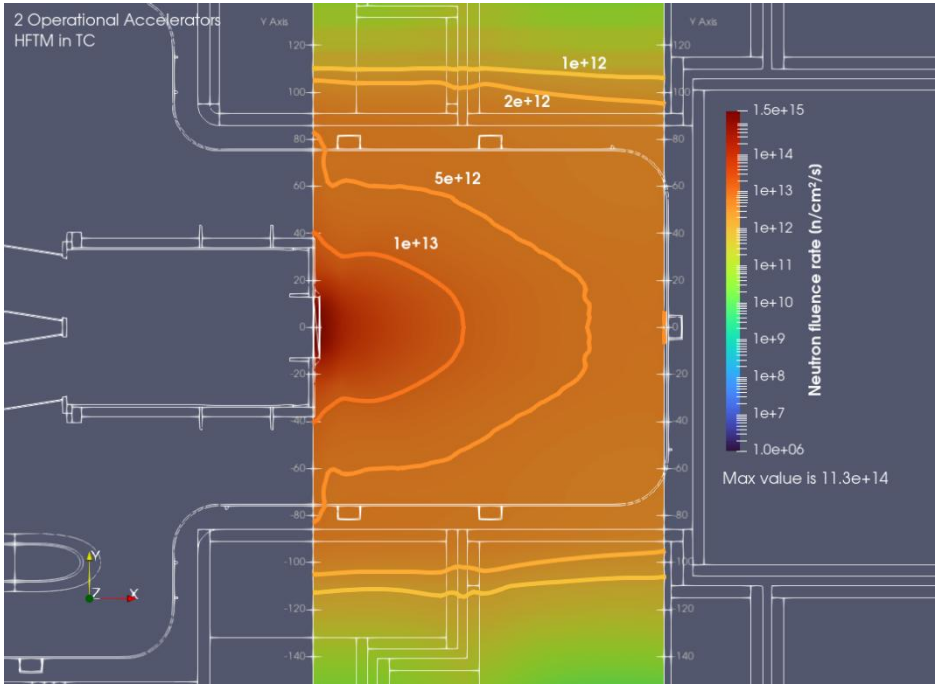
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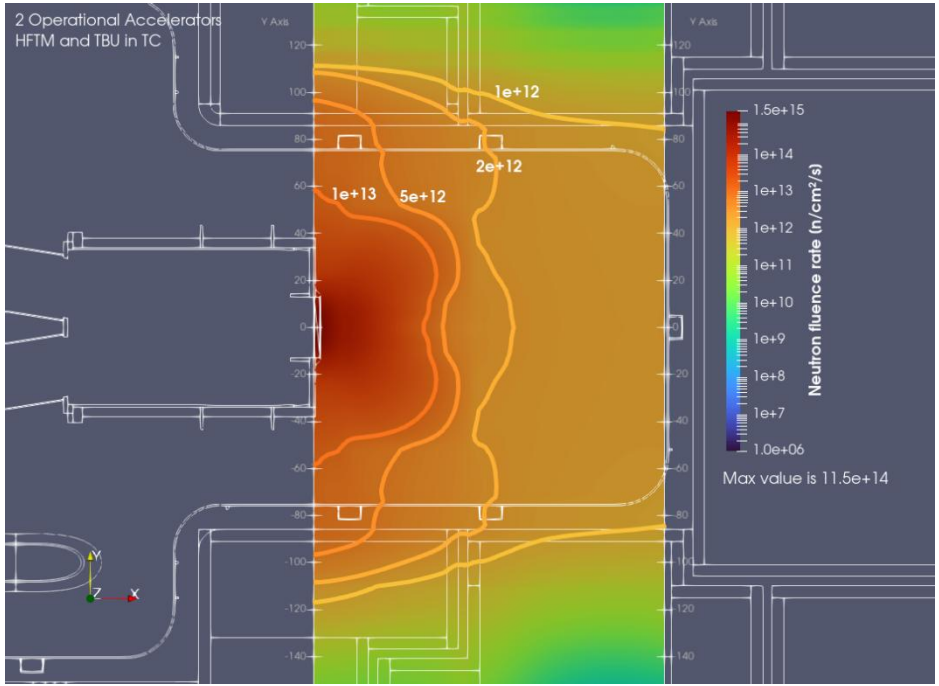
Neutron fluence rate – Test Cell

Neutron fluence rate maps for 2 Operational Accelerator z=0

- HFTM in TC



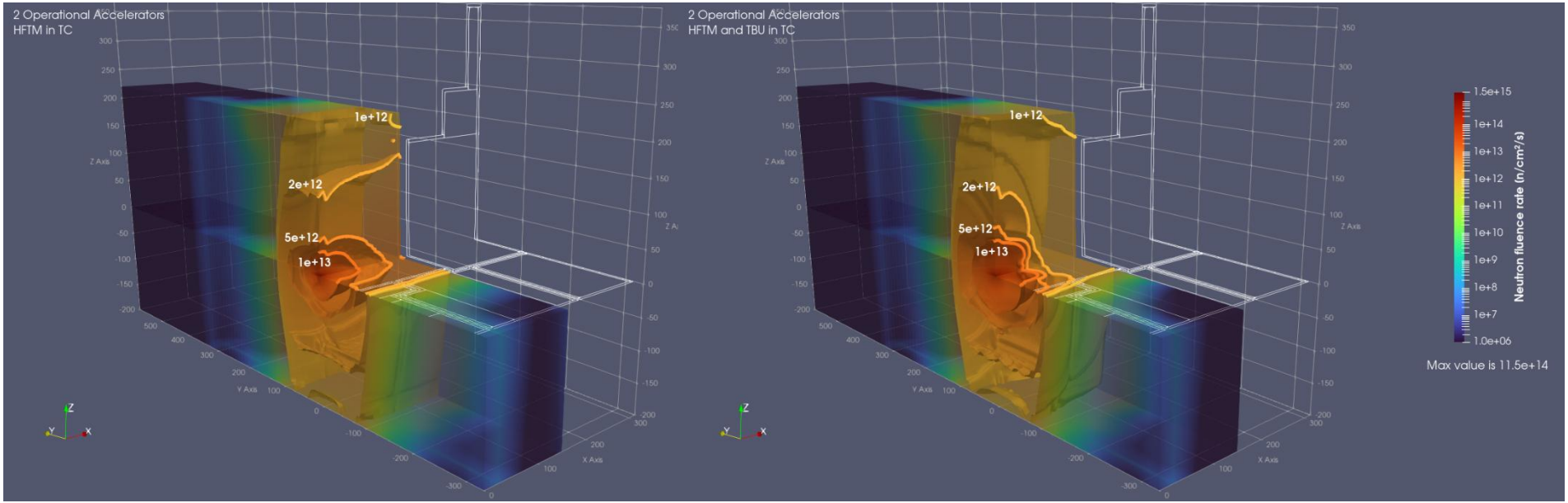
- HFTM and MFTM in TC



Neutron fluence rate – Test Cell

Neutron fluence rate maps for 2 Operational Accelerator z=0

- HFTM in TC
- HFTM and MFTM in TC



Neutron fluence rate – Test Cell

- The neutron fluence rate in the TC is nearly doubled when two accelerators are in operation.
- When a MFTM is considered, the neutron fluence rate distribution shows significant changes in its spatial distribution.
- The neutron flux distribution evolves from being highly dependent on the accelerator location to a much more homogeneous profile across the entire TC.
- Furthermore, the addition of MFTM slightly increases neutron flux at the HFTM location.

Overview

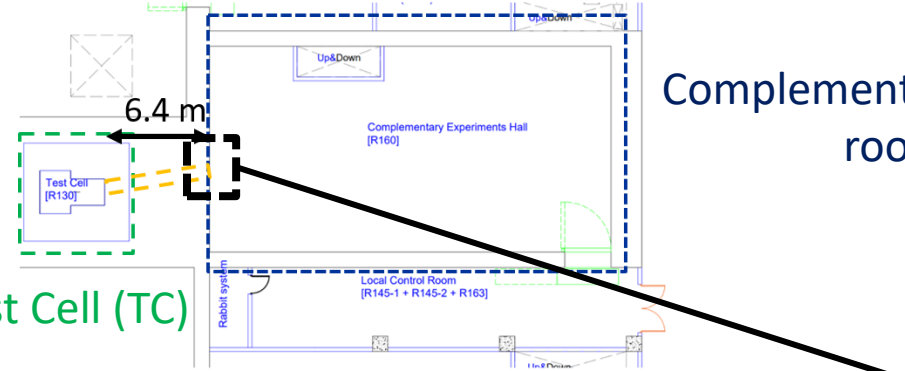
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Neutron fluence rate – CER

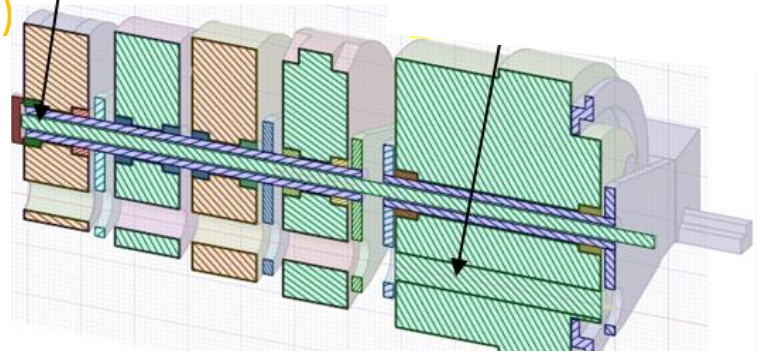


Complementary experimental room (CER)

Test Cell (TC)

Neutron Beam Tube (NBT)

+



Neutron Beam Shutter Open (NBS) [1]

NBS
- 15 cm diameter
- 9º angle

at the entrance of CER

[1] G. Wojtania, et al., DONES User's Workshop, 2024

Neutron fluence rate – CER

Neutron spectra at entrance of CER

- The total neutron fluence rate for 1 operational accelerator:
  - With the HFTM is 1.8e10 n/cm^2/s
  - With the HFTM and the TBU is 2e8 n/cm^2/s

The installation of a MFTM causes 90% times reduction of total neutron fluence rate

Neutron fluence rate – CER

Neutron spectra at entrance with 1 operational accelerator of CER with 9º in percentage by neutron energy group.

Neutron spectra	Percentage [%]	
Modules in TC	HFTM [1]	HFTM and TBU [2]
Thermal neutron flux ($E < 0.625\times10^{-6}$ MeV)	0.03	10.9
Epithermal neutron flux (0.625×10^{-6} MeV $< E <$ 0.5 MeV)	5	66.1
Fast neutron (0.5 MeV $< E <$ 100 MeV)	94.9	23
Total	100	100

[1] A. Serikov et al., Fusion Neutronic Meeting, 2026
[2] A. Serikov et al., DONES User's Workshop, 2024

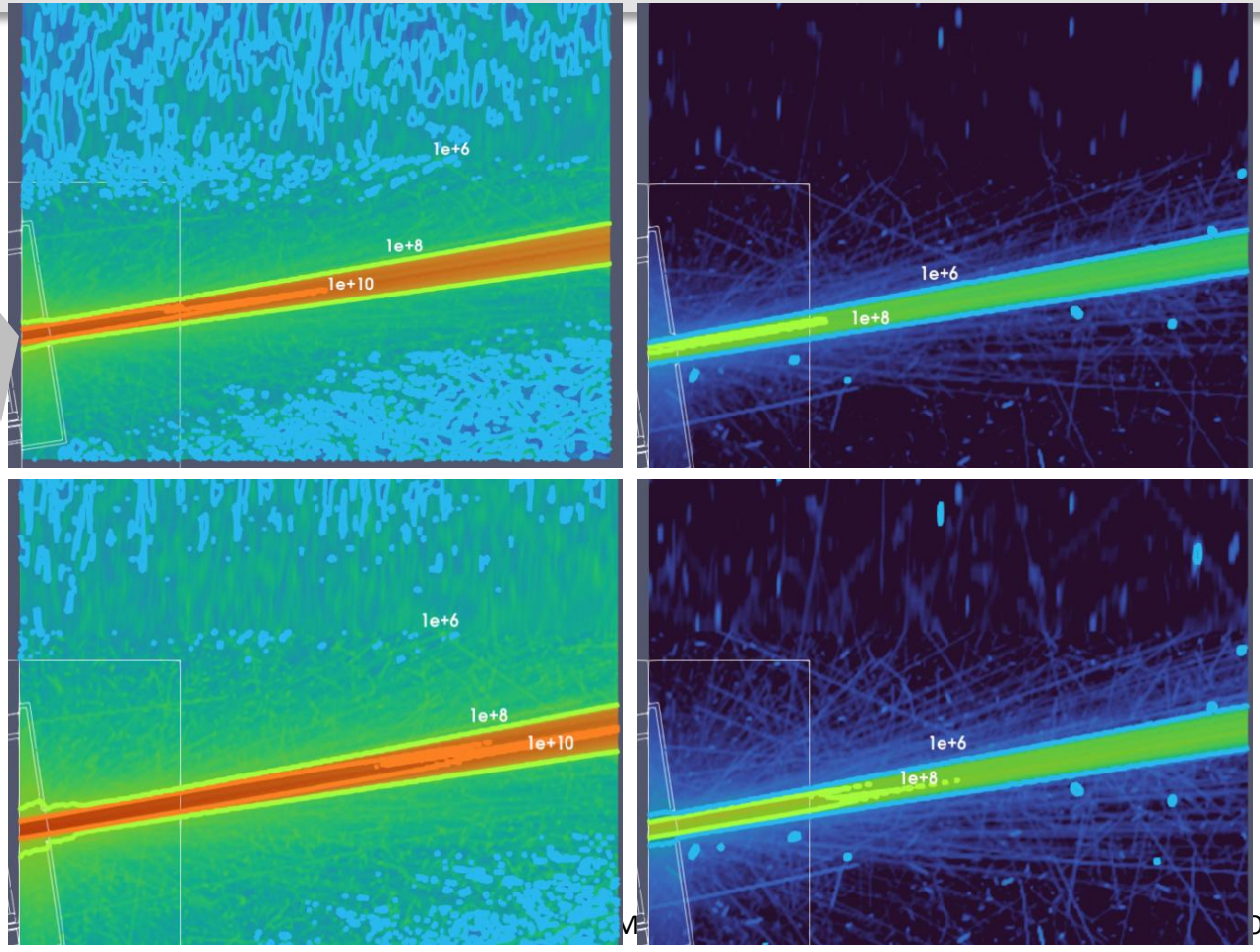
HFTM in TC

HFTM and MFTM in TC

1 Operational Accelerator

CER input
9º angle

2 Operational Accelerator



Neutron fluence rate – CER

- The neutron flux in the CER decreases when the MFTM modules are installed, significantly altering the neutron energy spectrum.
- When two operational accelerators are considered, the neutron flux in this region increases up to a factor of two.

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Conclusions

In the HFTM

- The use of two operational accelerators approximately doubles the Primary displacement damage rates in the HFTM.

In the TC

- The installation of the MFTM modify the neutron fluence in special distribution.
- The use of two operational accelerators nearly doubles the neutron fluence rate in the TC.

In the CER

- The installation of the MFTM reduces the total neutron fluence rate in the CER by about a factor of 90, while also significantly changing the neutron energy spectrum.
- With two operational accelerators, the neutron flux in the CER increases slightly.

Therefore, the IFMIF-DONES facility offers a wide range of operational capabilities

DONES

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