Update of the 5 MW Beam-on-Target Requirements for improvement of the materials irradiation performance at IFMIF-DONES

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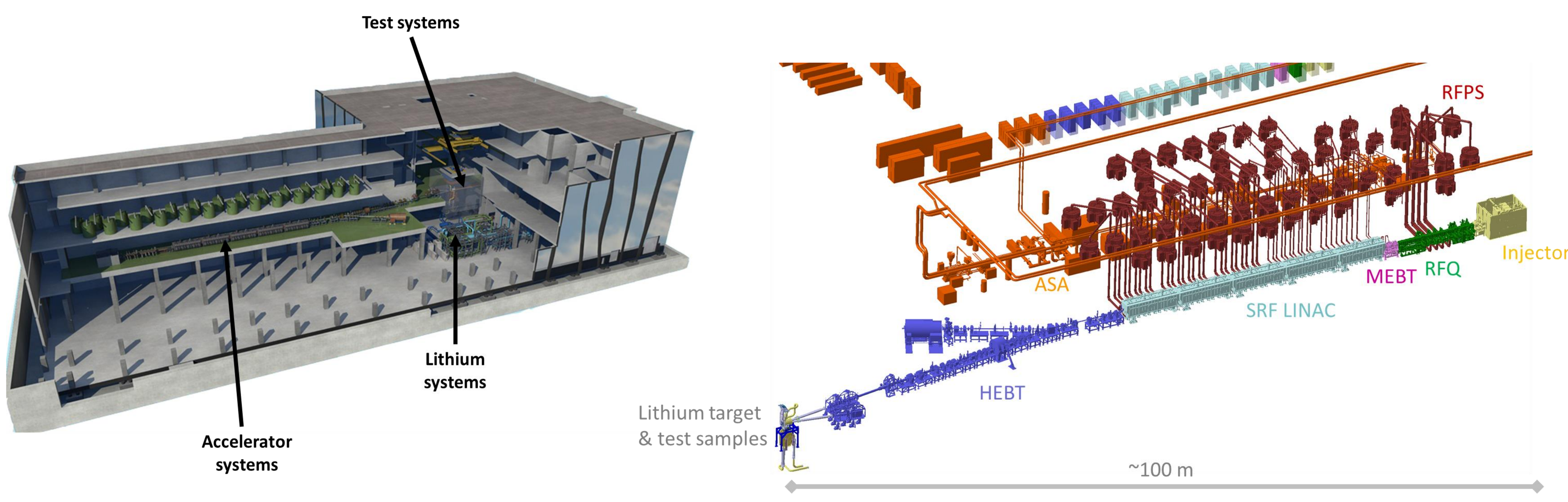
Abstract

IFMIF-DONES is a facility under construction in Granada, whose main goal is the validation and characterization of materials under a fusion prototypic irradiation field. This field is created by the interaction of a high energy intense continuous deuteron beam and a flowing liquid lithium target. The requirements imposed on the beam at the interaction point are a complex trade-off among the scientific experimental needs for the materials irradiation defined at the top-level requirements (20 dpa in a volume of 0.3 dm³ and 50 dpa in 0.1 dm³), and the technical constraints of several systems such as the Accelerator Systems, the Lithium Systems, and the Test Systems. Recent simulations with the initial definition of beam-on-target requirements showed the necessity of redefining them in order to fulfill the irradiation needs.
This contribution will address the main challenges to gather the inputs for the definition and reassessment of the beam-on-target requirements. A comparison detailing the main changes compared to the previous ones will be given, together with a short overview of the studies ongoing by different systems to analyze the impact of each beam-on-target requirements on the performance of the whole facility.

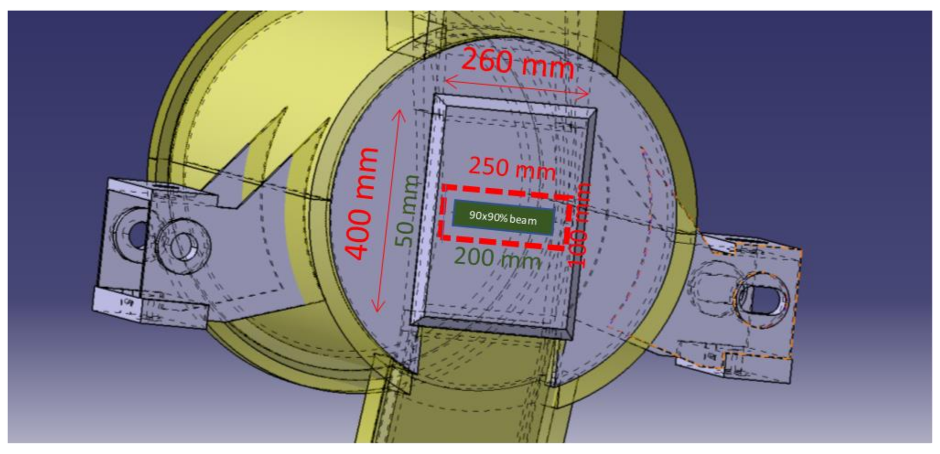
IFMIF-DONES Facility

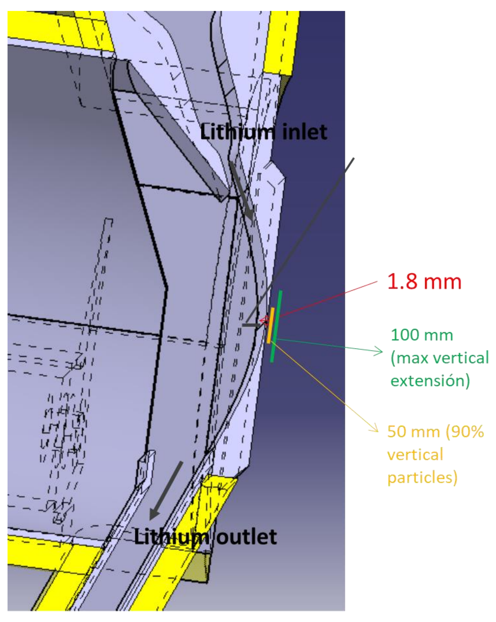
IFMIF-DONES is a facility to produce fusion relevant neutrons to test materials based on **Li(d,xn)** stripping reactions of **40 MeV D+**



Interaction D+-Li

Mechanical interface





Neutronics requirement

- **20 dpaNRT** in <2.5 years applicable to 0.3 litre overall volume
- **50 dpaNRT** in <3 years applicable to 0.1 litre overall volume
- Gradient **<15%** and temperature **<+/-3%** inside a SSTT

Lithium requirement

Thermomechanical needs of the 25 mm liquid Lithium target flowing at 15 m/s

Updated Beam On-Target Requirements

Beam Energy	40 MeV
Beam current	125 mA
Beam energy spread	±0.5 MeV FWHM
Beam horizontal size (90% beam)	10-20 cm (16.6 cm reference)
Beam vertical size (90% beam)	5 cm
Average power density in beam size (90% beam)	480 W/mm²
Maximum beam power density	<700 W/mm² for Li flow of 15 m/s
Angle incidence	9°
Beam position	± 5 mm
Beam tails	< 0.2 W/mm² beyond ± 11 cm in horizontal
Edge side peaks	feasible in horizontal profile current density <30% of average density
Maximum beam extension	25 cm in horizontal direction 10 cm in vertical direction

Flat top requirement has been exchanged by maximum beam power density

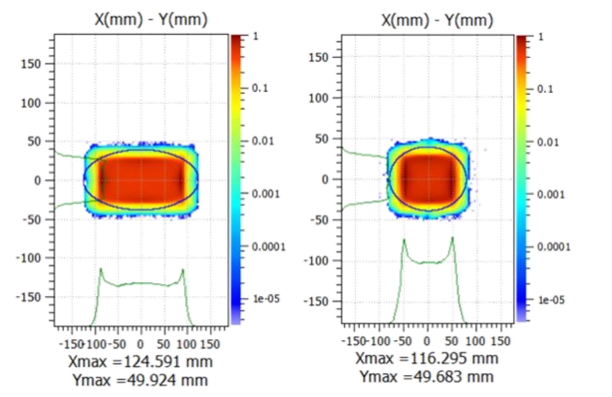
The 5 MW Deuteron Accelerator

100 m long, 175 MHz, D+ 5 MW CW scLINAC

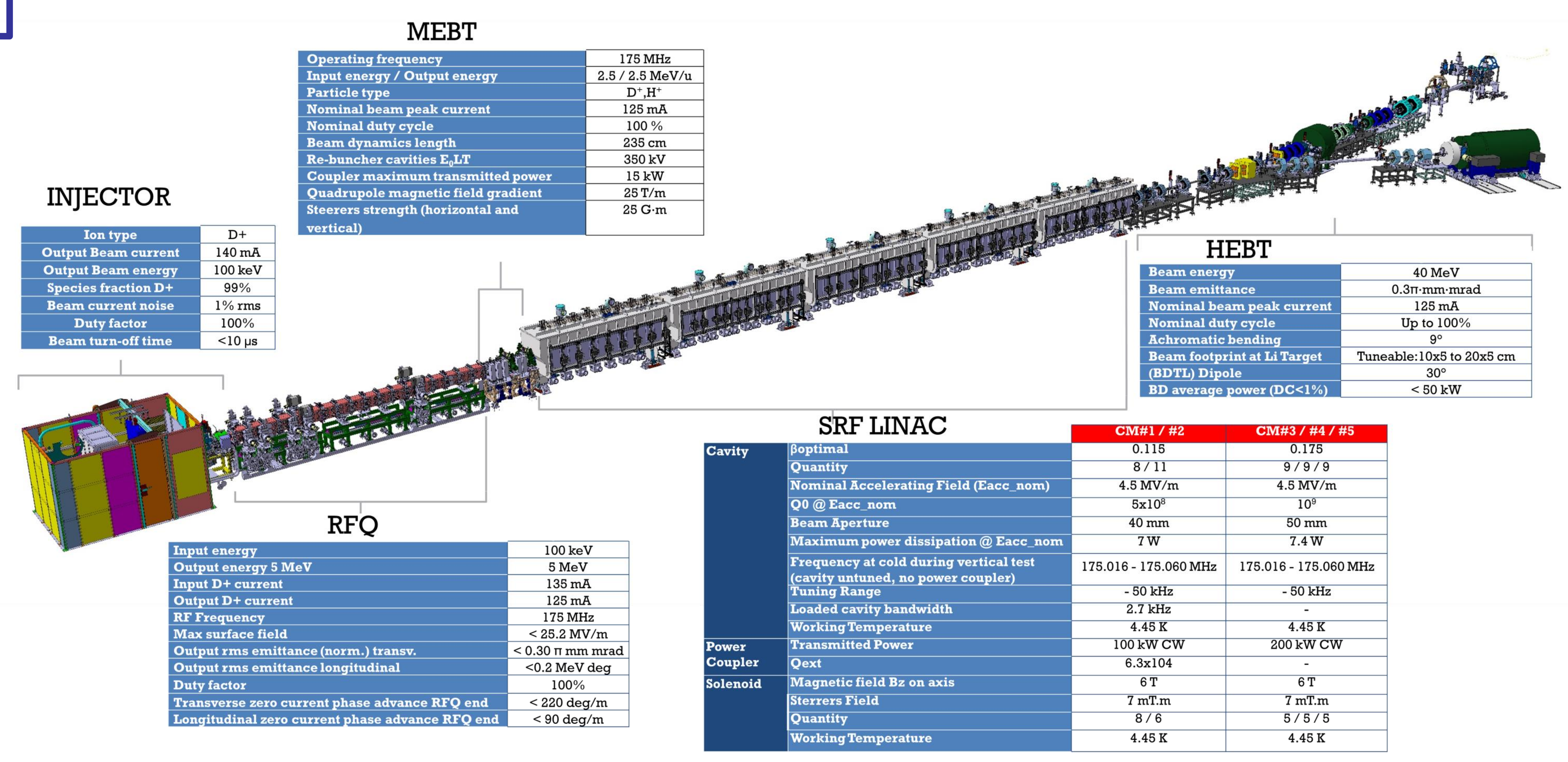
The **Accelerator Systems**: Injector, RFQ, MEBT, SRF LINAC, HEBT, RFPS and AS Ancillaries (ASA)

Main AS Challenges:

- High availability (>87%) over lifespan,
- Remote Handling,
- Materials damage and activation,
- High CW beam control and monitoring,
- Control of the Rectangular beam shaping for dpa volume and gradient optimization
- Machine, safety protection and diagnose at extreme environmental and beam conditions

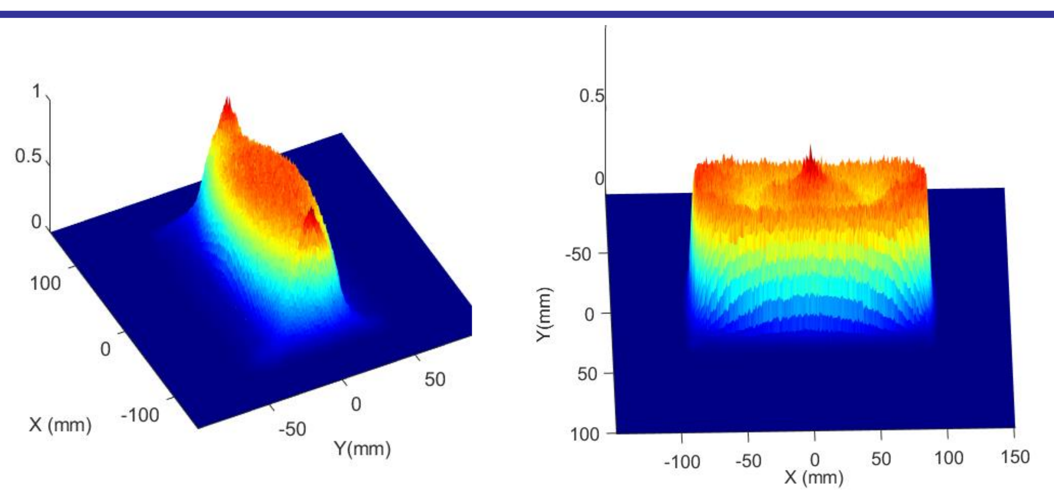


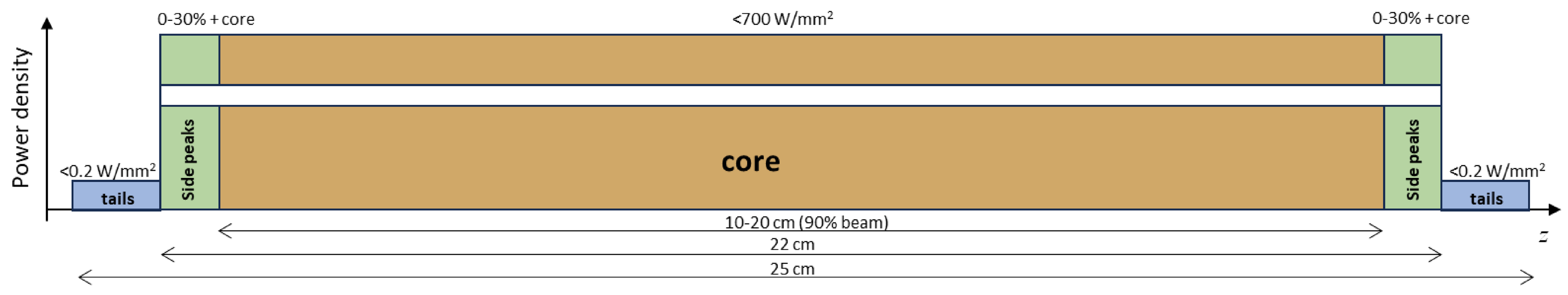
20x5 cm²   10x5 cm²

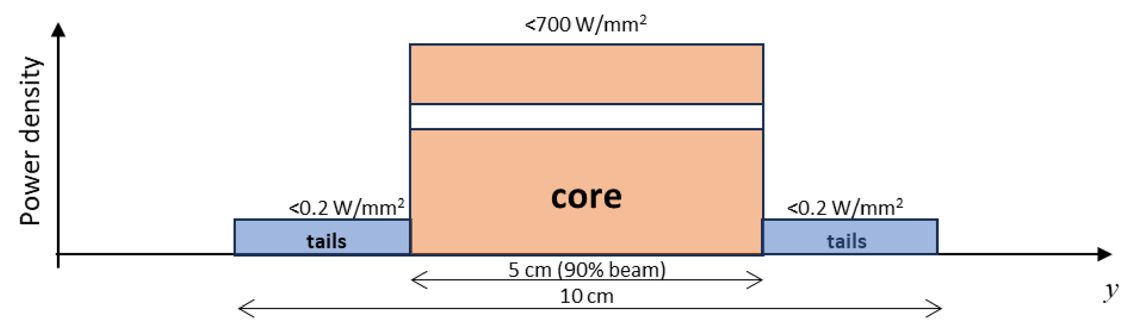


Target footprint

Beam-on Target examples







Next steps

1) Study the **influence of each parameter of the beam profile on the quality of the materials irradiation and in the target behaviour** (central, side peaks...) → requirements HEBT electromagnets and collimators.
2) Study of **alternative beam profiles for optimizing the material irradiation** → simulation tool is being developed together between accelerator and neutronics teams to provide optimized beams for irradiation [1]
3) Study the **damage dose measurement techniques** → answer to the users the measurement value of DPA and the uncertainties expected for the individual specimens with a reference payload, using the current diagnostics systems [2]
4) Consider **upgrade to IFMIF** (second accelerator) → 10 MW overlapping beams in the target.

References

[1] I. Alvarez, Quantification of the uncertainties in the determination of the final dose of the HFTM samples in IFMIF-DONES, Proc. Of ISFNT-15, 2023

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.