Overview of the DONES Experimental Programme

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The International Fusion Materials Irradiation Facility – DEMO Oriented Neutron Source (IFMIF-DONES) is a cutting-edge research infrastructure designed to test and qualify materials under neutron irradiation conditions similar to those expected in future fusion reactors. Currently under construction in Escúzar, Spain, IFMIF-DONES plays a pivotal role in the European roadmap for fusion energy, aiming to bridge critical gaps in material science, essential for the development of fusion power plants. As a first-of-its-class, high-flux, fusion-like neutron source, IFMIF-DONES features outstanding experimental capabilities, enabling both fusion-oriented and non-fusion-oriented experiments using neutrons and deuterons.

To meet the required experimental capabilities, this infrastructure will feature the most intense continuous-wave linear accelerator in the world, ranking among the most powerful ever built. It will include the largest liquid lithium circuit and a unique experimental target, where a 5 MW (with a possible upgrade to 10 MW), 40 MeV, 125 mA deuteron beam will impinge on a liquid lithium curtain flowing at 15 m/s, embedded within a modularly shielded test cell. The facility will also incorporate two dedicated rooms for complementary deuteron- and neutron-based experiments, requiring advanced technologies such as deuteron beam extraction from the accelerator to expand the range of experimental capabilities. Beyond fusion, the facility is expected to support nuclear physics research, radioisotope production, and broader scientific investigations.

The DONES Programme is primarily dedicated to generating irradiation test data for the design, licensing, construction, and safe operation of the fusion demonstration power plant (DEMO). This involves developing a comprehensive database of fusion-like neutron irradiation effects on materials, facilitating radiation response benchmarking, and advancing computational material science models to validate and enhance predictions of material behaviour. To fulfil these objectives, the programme is focused on providing a high-energy neutron source with sufficient intensity and irradiation volume to simulate the fusion environment. Additionally, testing of tritium breeding blanket concepts will be an integral part of the research activities.

Significant progress has been achieved during the first years of the construction phase, which formally started on 16 March 2023.

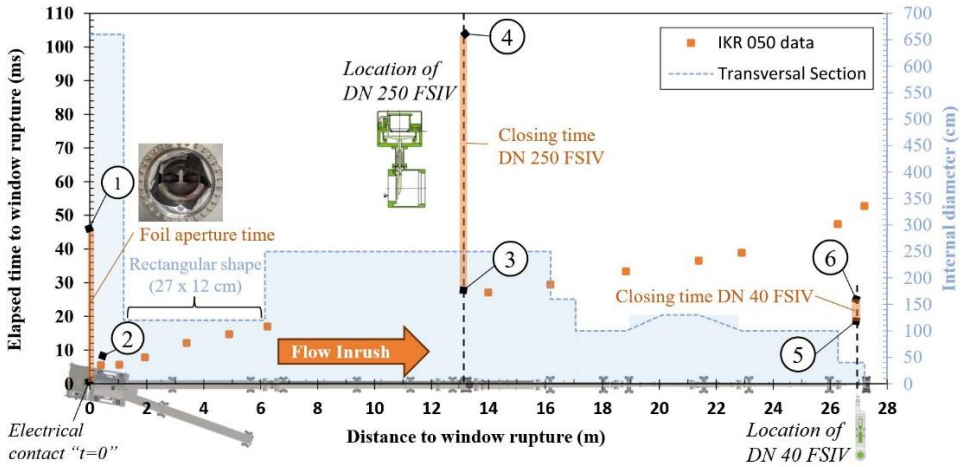

Fig. 1. Experimental data recorded in the MuVacAS setup, at Escúzar, when recreating a sudden air inrush in the vacuum lines

On the one hand DONES Programme Team has been stablished and the DONES Programme management setup based in an innovating organization is already running. On the other hand, several relevant prototypes have been installed in partner laboratories and also at the Escúzar site while, in order to support the licensing, safety, and construction of the first buildings of the IFMIF-DONES facility, major contracts have been awarded for technical and engineering assistance, project integration, safety engineering, and essential accelerator and test cell systems, including the Programme Lifecycle Management implementation. The main building construction contract is expected to be awarded in 2025, with civil works commencing early.

From a programme experimental standpoint, IFMIF-DONES facility is designed to accommodate a wide range of experimental activities, including fusion-related experiments focused on materials characterization with reloading capacity, breeding blankets testing and divertor components evaluation under fusion-relevant conditions, and other irradiation modules for further testing. The test facilities are also ready for complementary research activities encompassing studies in nuclear physics, medical applications, and industrial research, thereby broadening the scientific scope of the infrastructure.

To define the experimental programme, IFMIF-DONES works in close collaboration with the DONES Users Community, an international assembly of scientists and engineers actively involved in the identification and preparation of experiments at the facility, encompassing both fusion and non-fusion applications. DONES Users Workshops are held on yearly basis to discuss experimental needs, propose research applications, and review progress.

A first proposal of the IFMIF-DONES experimental programme is being discussed to address the most relevant needs for fusion materials research. It will be coordinated by the DONES Programme Team in liaise with the different stakeholders and will integrate the proposal of the Users community. It has been established, focusing on defining irradiation priorities, optimizing irradiation matrices, and fostering a robust user community. Initial experiments will focus on irradiation of reduced activation ferritic martensitic (RAFM) steels like EUROFER97 and similar candidates, assessing their performance under high neutron flux to validate their application in fusion reactors. The experimental plan will also include irradiation experiments to investigate tritium behavior in breeding blanket systems to ensure efficient tritium production and recovery.

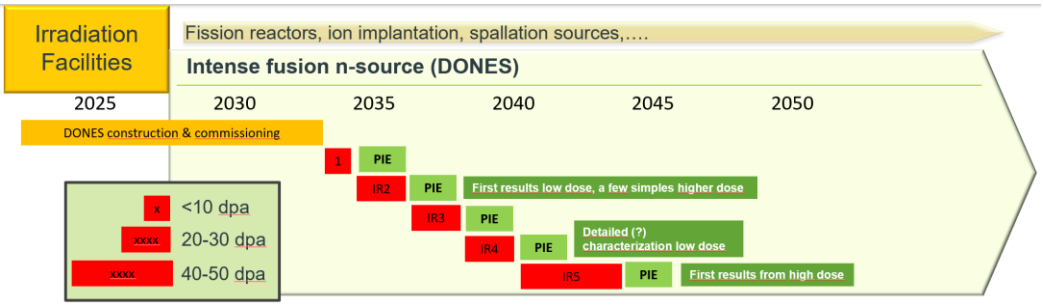

Fig. 2. First approach of the experimental programme

These initial experiments are designed to establish a robust foundation for subsequent research activities, ensuring that IFMIF-DONES fulfils its mission of advancing fusion energy development. Standing at the forefront of fusion materials research, IFMIF-DONES Facility provides unprecedent capabilities to simulate the extreme conditions of future fusion reactors. Planed test and qualification activities will play a crucial role in the licensing of fusion power plants. This work outlines the experimental capabilities of the facility, the current construction status in Escúzar, and the systematic approach taken to structure the experimental programme, define irradiation conditions, and consolidate user engagement.