EUROfusion

Current status of IFMIF DONES project

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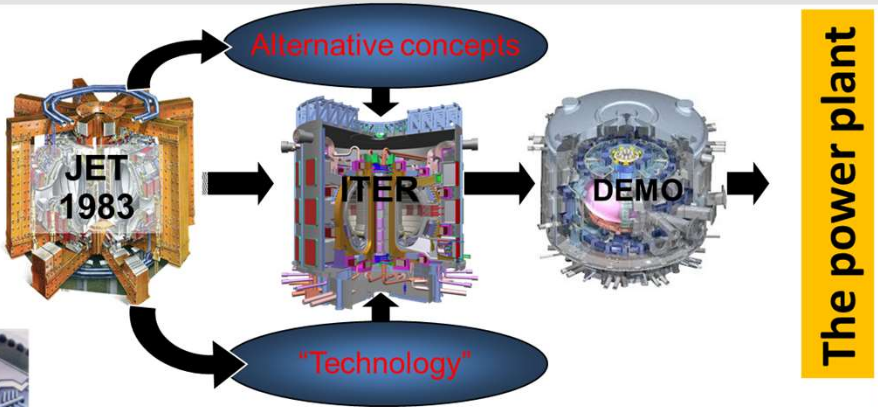
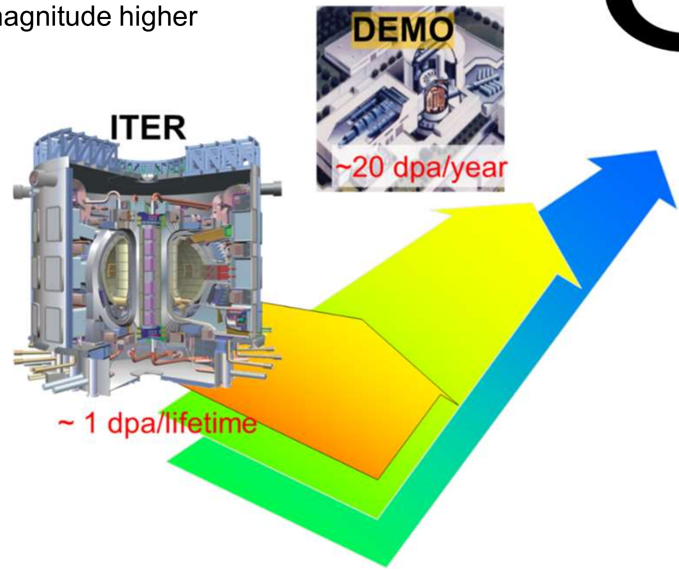
- **Introduction**
- **IFMIF-DONES Facility Description**
- **IFMIF-DONES Experimental Capabilities**
- **IFMIF-DONES Status**
- **Summary**

Why DONES?

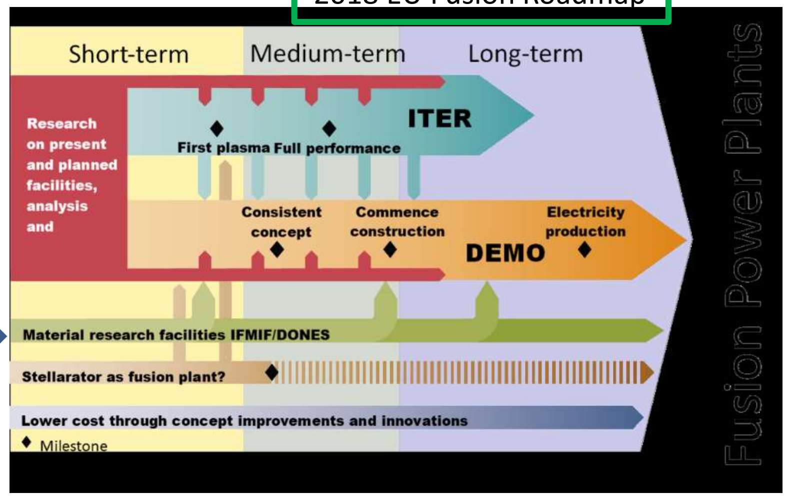


EU strategy towards fusion energy

One of the main differences between ITER and DEMO is the radiation dose: at DEMO more that two orders of magnitude higher



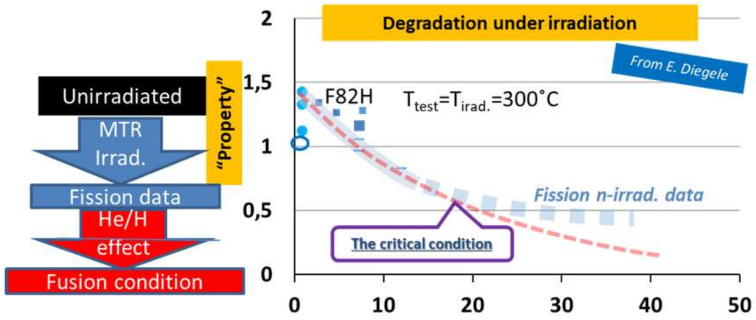
2018 EU Fusion Roadmap



EU Strategy for Material n-Irradiation

Fission irradiations

- **Intensive and broad use of MTR (Material Test Reactors) fission irradiation:** EU plans for 50M€ in the next decade
- **Complementary irradiation modelling and verification (multi-ion beams)**



To establish 1st step "best estimate" to perform engineering design

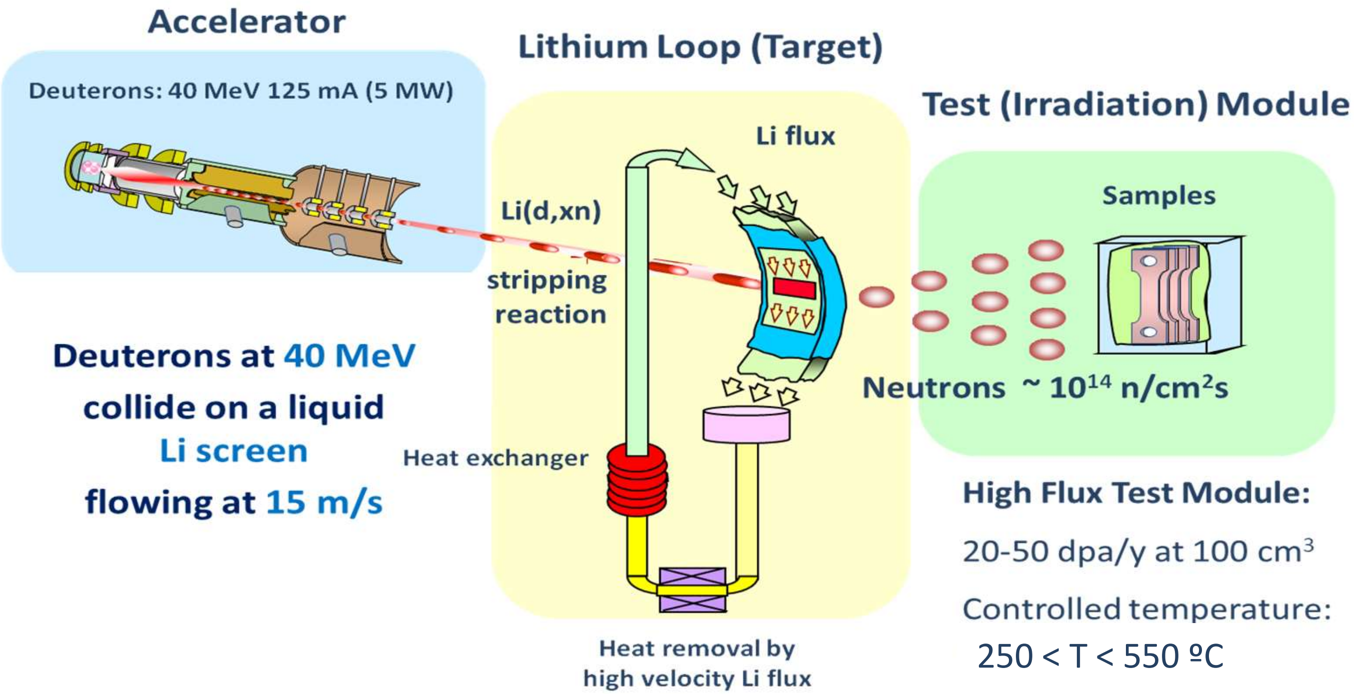
Fusion-like irradiations

- Mandatory: a dedicated facility for material qualification that best mimics 14Mev neutrons with reasonable irradiation volume, fluence, and optimized homogeneity in T with the objective to (finally) validate in-vessel materials

Based on the assumption that fusion-related effects will appear only at high dose (>10-20 dpa)

What is IFMIF-DONES?

A fusion-like neutron source required for the qualification of the materials to be used in the EU DEMO



Deuterons at 40 MeV collide on a liquid Li screen flowing at 15 m/s

High Flux Test Module:

20-50 dpa/y at 100 cm^3

Controlled temperature:

250 < T < 550 ºC

Identified as high priority in the EU Fusion Roadmap
Included in the ESFRI Roadmap as a EU strategic facility

European Strategy Forum Research Infrastructures

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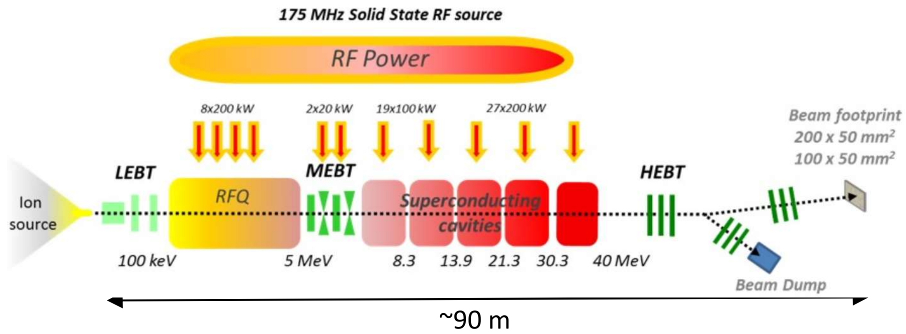
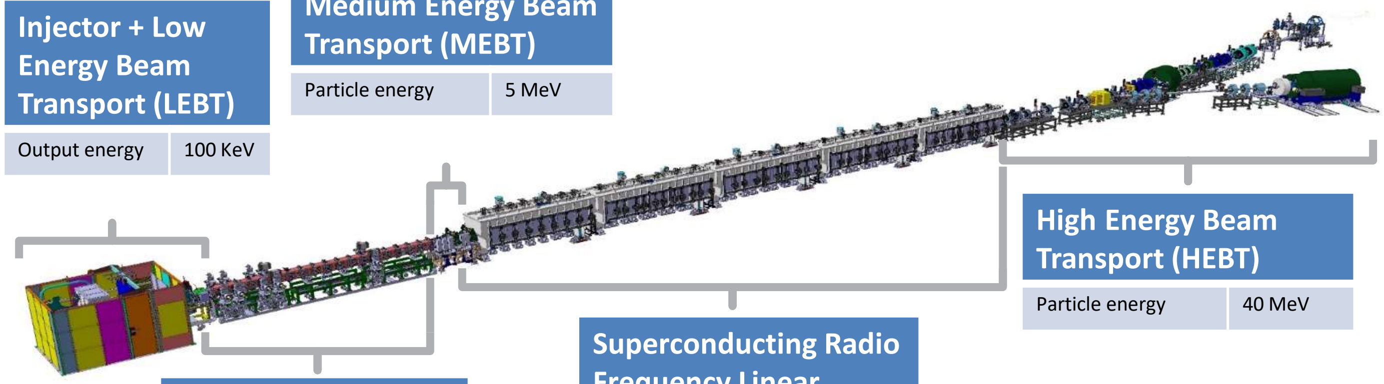
Accelerator systems summary

175 MHz, 5MW, 125 mA, CW, high availability: One of the more powerful accelerators in the world

Obtaining validation results from IFMIF-EVEDA: LIPAc Prototype (Rokkasho)





Injector + Low Energy Beam Transport (LEBT)

Output energy	100 KeV

Medium Energy Beam Transport (MEBT)

Particle energy	5 MeV

Radio Frequency Quadrupole (RFQ)

Output energy	5 MeV

Superconducting Radio Frequency Linear Accelerator (SRF-Linac)

Output energy	40 MeV

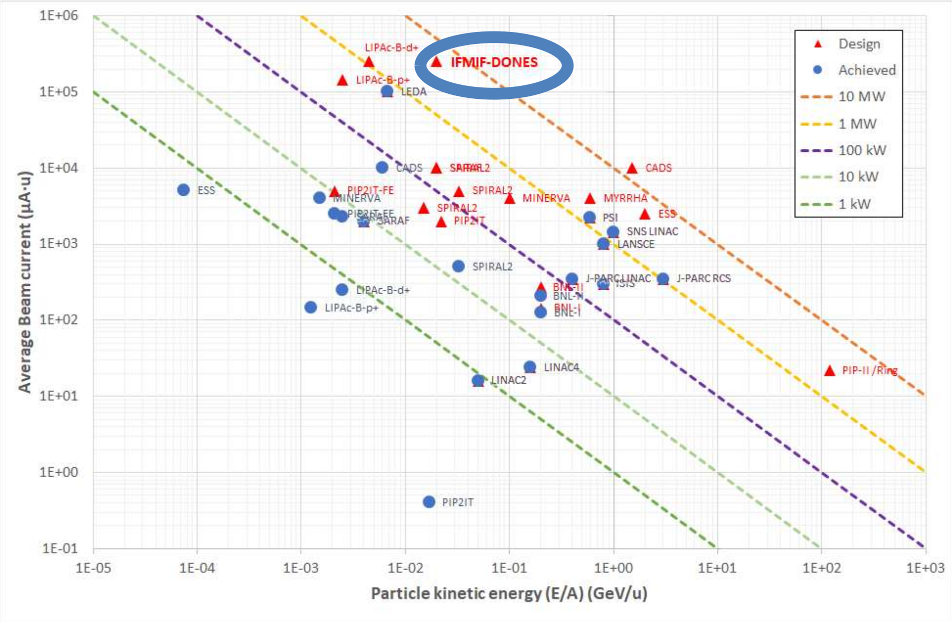
High Energy Beam Transport (HEBT)

Particle energy	40 MeV

Main involved technologies

- RF
- Cavities
- Magnets
- Mecatronics (Cu, Nb, Al,…)
- Criogenics
- Vacuum
- Power supplies
- Cooling technologies
- Sensors and diagnostics
- Control (hardware and software)

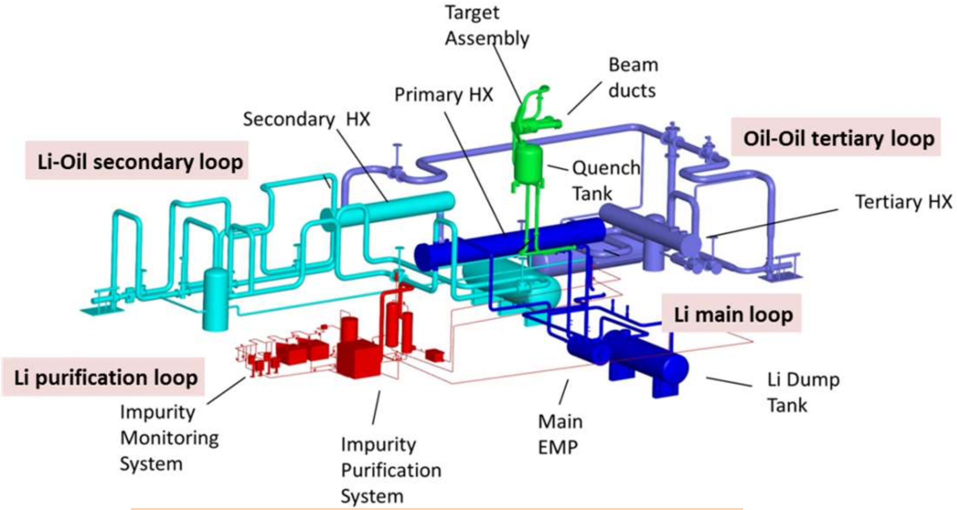
Very challenging due to the high 125 mA beam current and very high 5 MW beam power in the HEBT and on target but also:



- highest current linac D^+ in CW
- top H^+&D^+ injector performance
- longest RFQ
- record of light hadrons current through SC cavities
- highest beam space charge

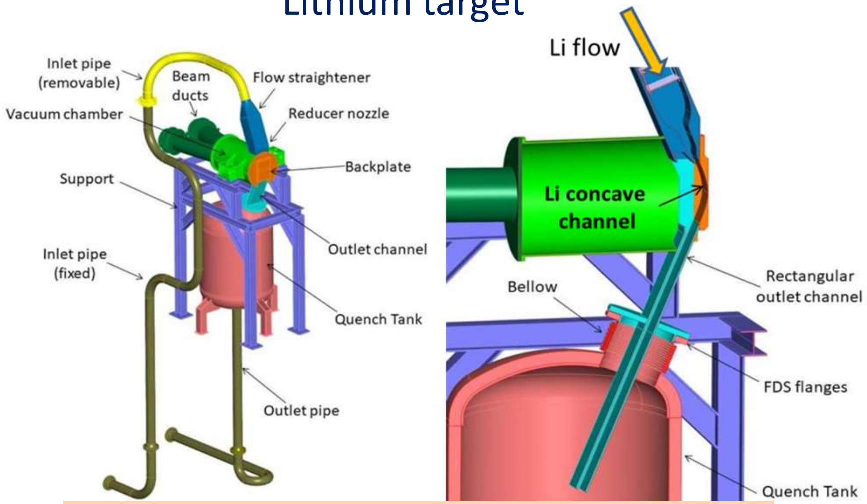
Li systems summary

5 MW power handling, 15 m/s Li speed, remote handling maintenance
Main requirements: Li flow stability and Li impurities control



Li volume ~14 m^3 Li flow rate ~100 l/s
Temperature (inlet Target) ~300 °C

Lithium target



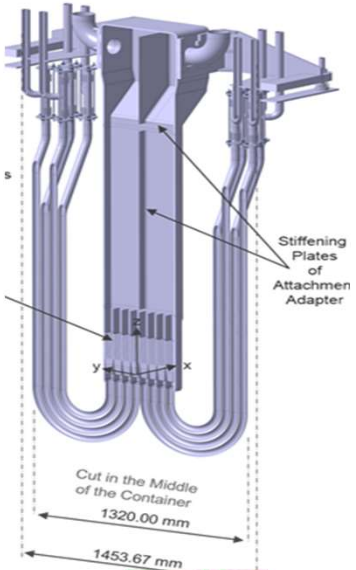
Jet thickness: 25±1 mm Li flow speed: 15 m/s
Chamber pressure: 10^{-3} Pa Heat flux: 500 MW/m^2

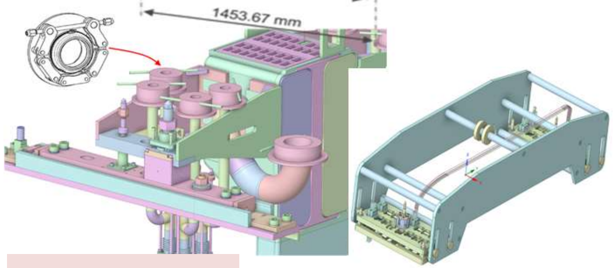
Main involved technologies

- **Liquid metals (fluids, monitoring and purification)**
- **Complex cooling loops**
- **Diagnostics**
- **Remote handling maintenance**
- **Control (hardware and software)**

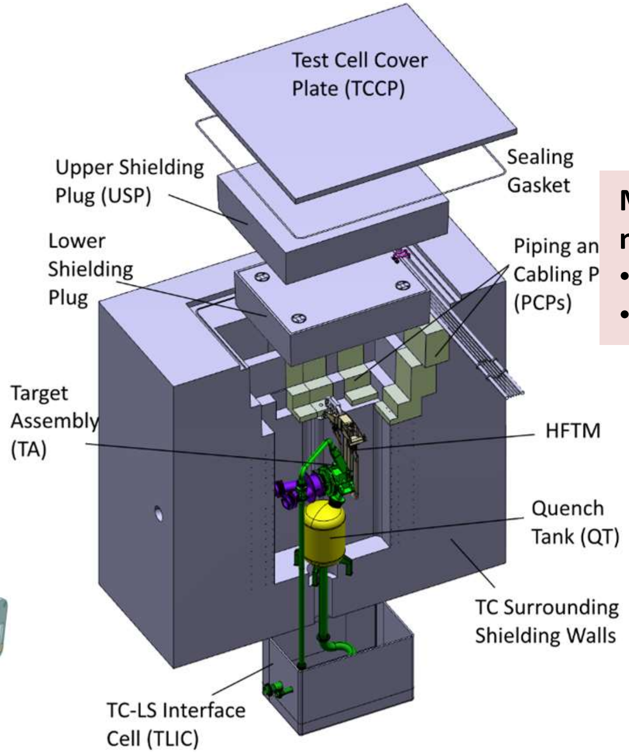
Test Systems summary

Irradiation module

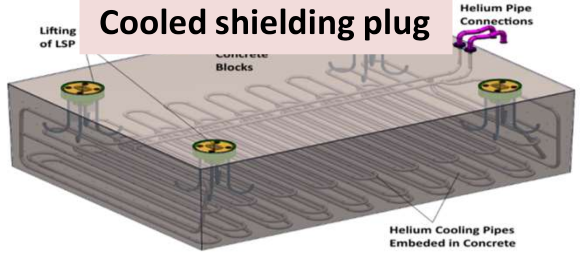




Connections



Cooled shielding plug



Main characteristics driven by the presence of neutrons and Li

- **Internal components cooling by He**
- **Remote Handling Maintenance required**

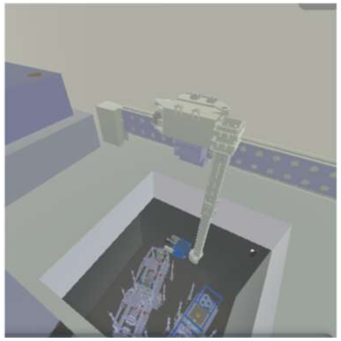
Main involved technologies

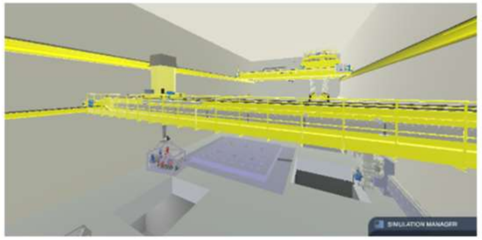
- **Mecatronics**
- **He and water cooling**
- **He, Ar and water systems**
- **Shielding materials and technologies**
- **Remote maintenance**
- **Vacuum**
- **Diagnostics**
- **Control (hardware and sofware)**

Remote Handling system

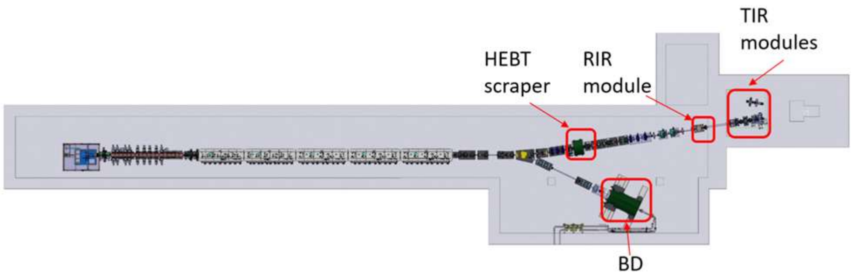
- ❑ **Activated and contaminated equipment requires Remote Handling Maintenance**

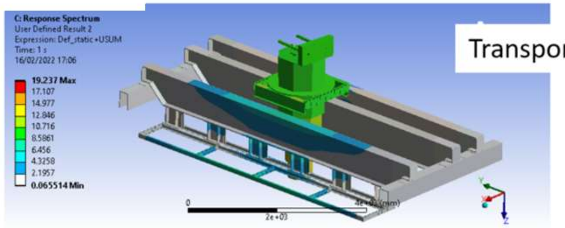
Access Cell: TIR & TC

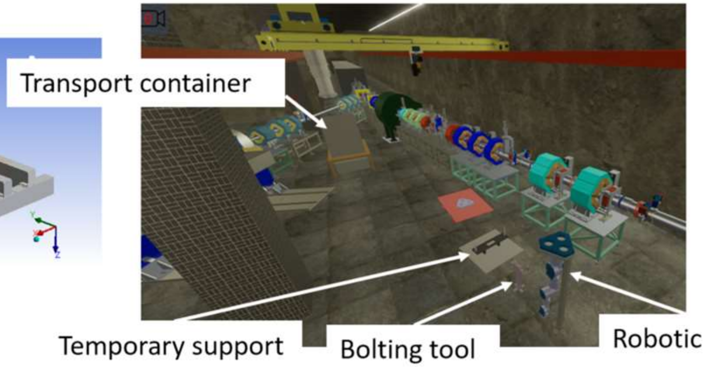




Accelerator







Main involved technologies

- Special cranes
- Telemanipulators
- RH tools
- Radiation monitoring

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Summary of IFMIF-DONES experimental capabilities

- **Materials qualification**

Experiments to be developed in the irradiation area with the highest neutron flux are managed by specific irradiation modules that can be replaced (and modified) after each irradiation campaign

Present baseline design activities focuses on the High Flux Test Module (HFTM) for high-priority structural materials irradiation

Steel irradiation

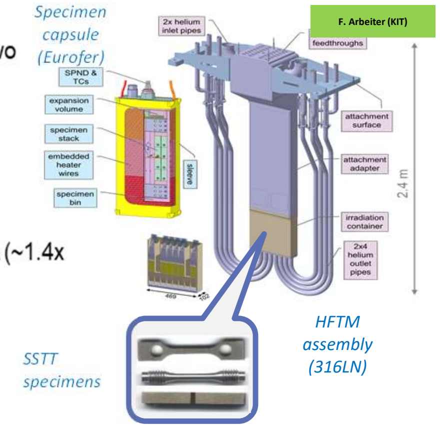
- 13-35 dpa/fpy up to 300 cm³ (22-50 dpa/fpy with two accelerators)
- 10-15 appmHe/dpa, 45-55 appmH/dpa.
- 250 – 550 °C, (~ 1000 specimens)

Copper irradiation (divertor heat sink)

- 5–30 dpa/fpy
- 6–8 appm He/dpa is (~DEMO), 48–50 appmH/dpa (~1.4x DEMO)
- >100°C, helium immersed specimens

Tungsten irradiation (armor)

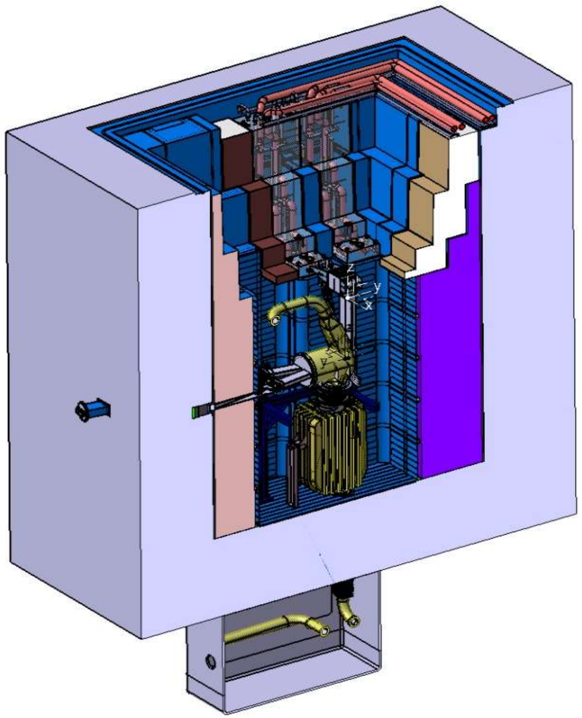
- Up to 800°C, assisted by self-heating
- 8x20 cm³ (cylindrical HT capsules)
- 1–3 dpa/fpy in W
- 9–10 appm He / dpa, (2x of DEMO), 20–29 appm H / fpy, (3x of DEMO)

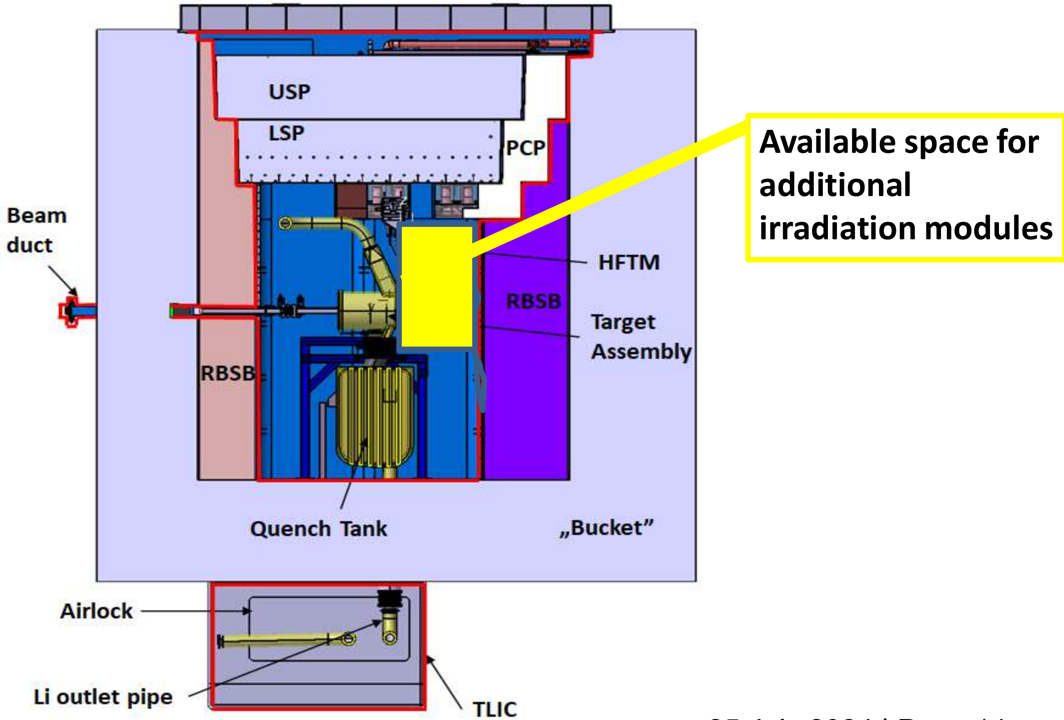


Adaptation for ODS-steels and vanadium materials can be easily implemented

Other modules ...

Other irradiation modules are also feasible (sequentially or simultaneously to the HFTM)





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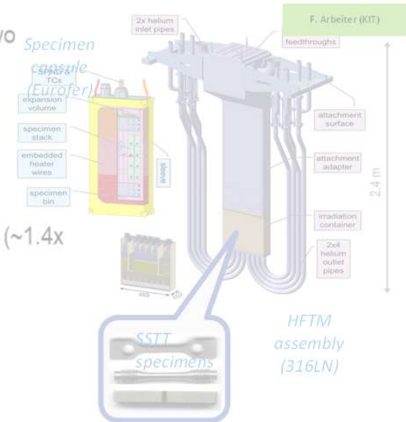
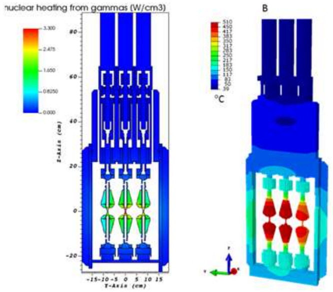


Adaptation for ODS-steels and vanadium materials can be easily implemented

Prospective irradiation modules for other materials properties characterization are feasible and proposed

- **In-Situ Creep Fatigue Test Module (ICFTM)**



In-situ creep/fatigue/crack-growth loading & measurement

Temperature range 250 – 550 °C in the high flux zone

Base materials, welds, dissimilar welds; optionally multiaxial loads

Summary of IFMIF-DONES experimental capabilities

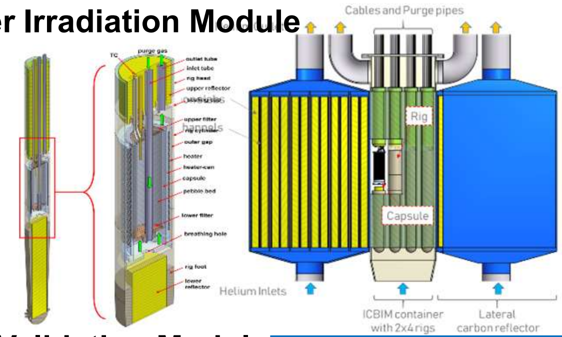
- ## Breeding Blankets relevant technologies

The different types of irradiation modules allow to address BB technologies issues which are key pending ones for accelerating fusion as an energy source. The facility design allows the installation of other materials or other irradiation modules (sequentially or simultaneously with the HFTM)

Prospective irradiation modules for tritium technologies validation

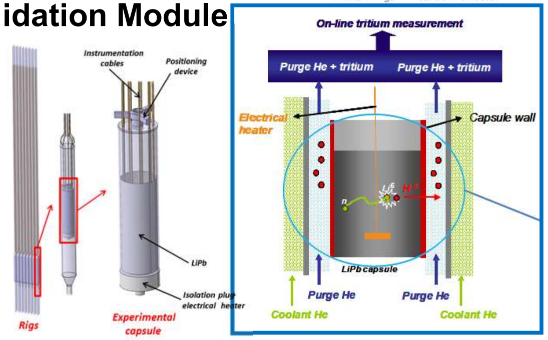
- **In-Situ Ceramic Breeder Irradiation Module**

In-situ irradiation and testing of ceramic breeder materials or Be in the temperature range 300 – 1000 °C in the medium flux zone, measuring tritium release



- **In-Situ Liquid Breeder Validation Module**

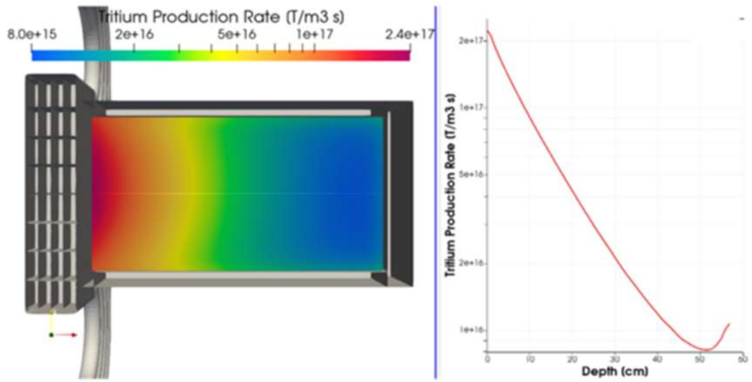
In-situ irradiation and testing of different containers of PbLi in the temperature range 300 – 600 °C in the mediumflux zone, measuring tritium release, permeation and extraction techniques



Prospective irradiation modules for functional testing of Model Blanket Module

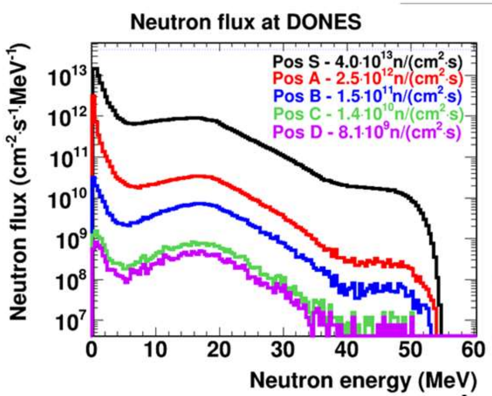
Interest raised based on:

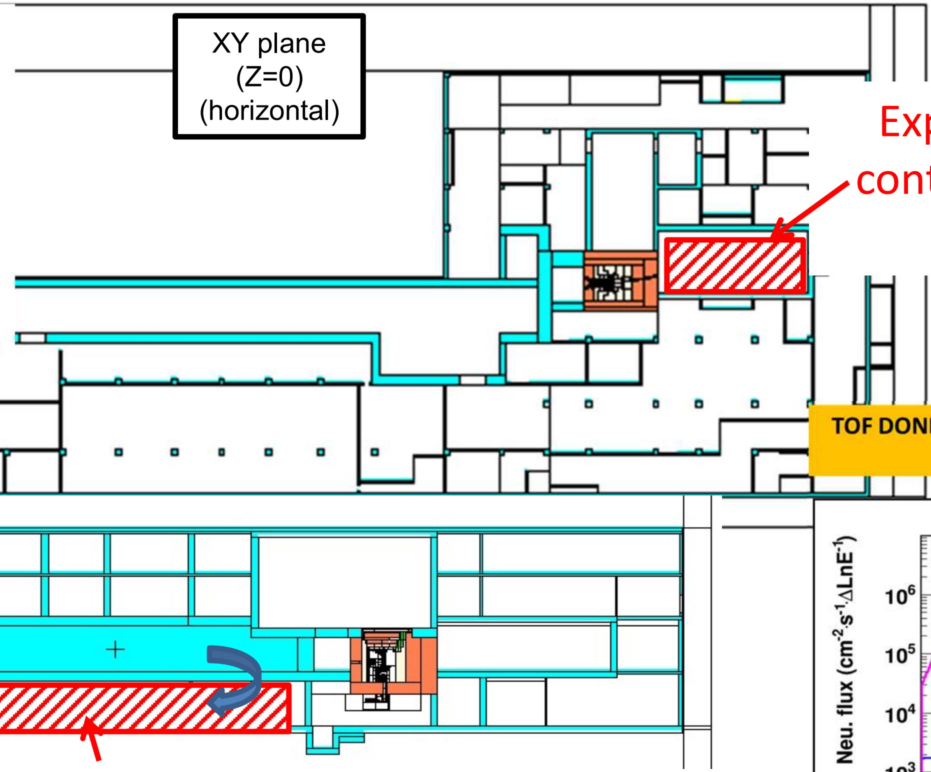
- An irradiation area similar in size to the typical "unit size" of different BB
- Neutron axial gradient similar to the one in DEMO
- Feasibility of heat loads similar to the one in DEMO first wall



Additional experimental areas

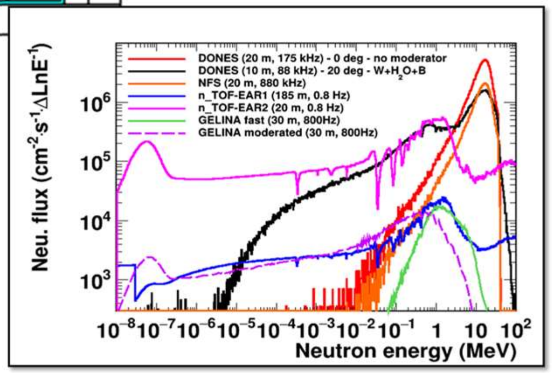
Very high neutron flux at very high energies!!!





Experiments with continuous neutron beams

TOF DONES would be world's highest intensity TOF neutron source



Experiments with pulsed deuteron/neutron beam

Magnets would deflect the beam downwards

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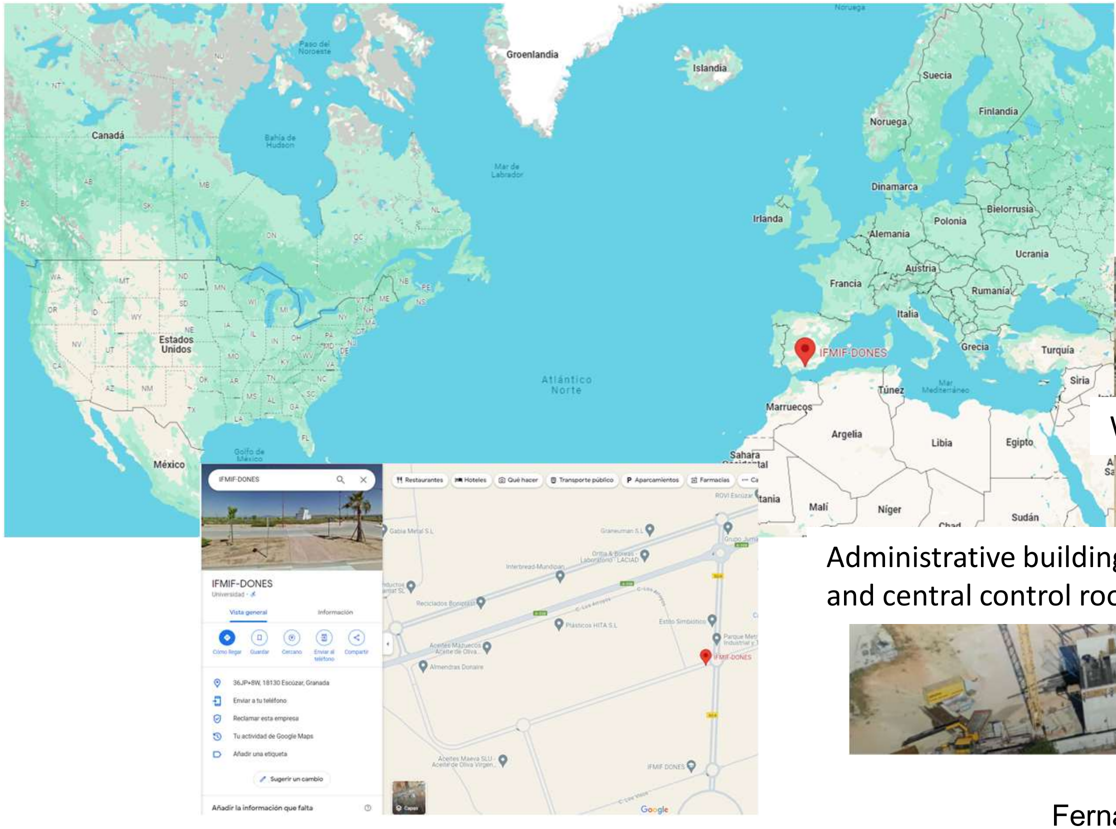
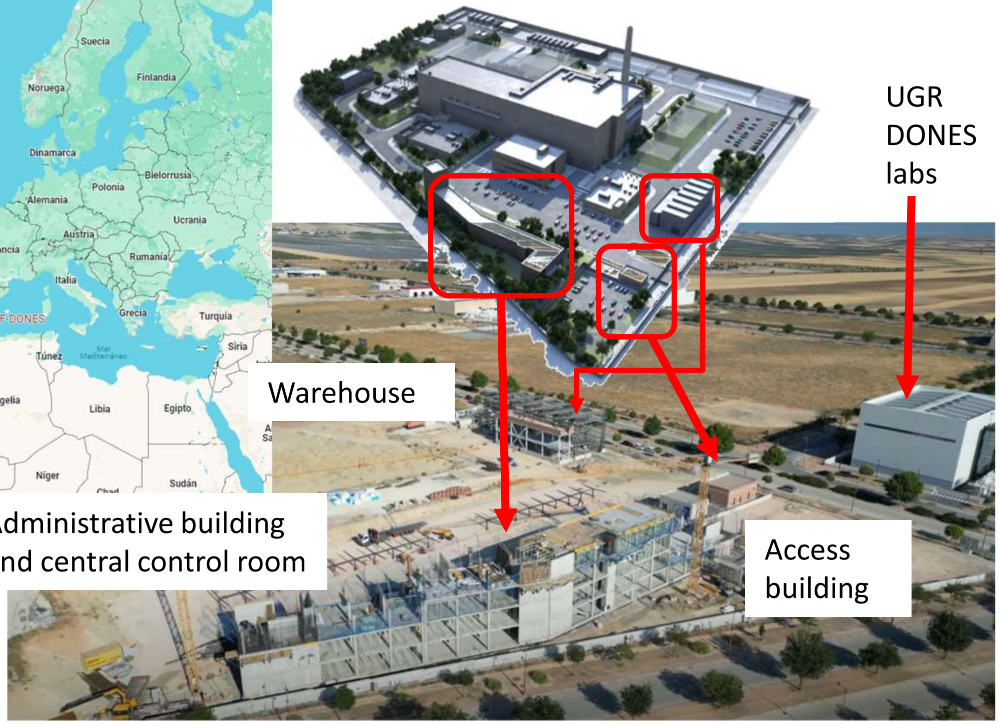
The Site

It is located in the Granada province (Andalusia region – southern Spain), 18 km southwest from Granada city in the Granada Metropolitan park (Escúzar)



[IFMIF DONES Work Progress: June 2024 (youtube.com)]



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Summary

- Materials, with emphasis in irradiation effects, is one of the key pending issues in the development of fusion as an energy source
- IFMIF-DONES is the EU proposed fusion-like neutron source being built in Granada (Spain)
- IFMIF-DONES is based on a high current D accelerator hitting on a liquid Li moving at high speed. It will allow irradiation of around 1000 engineering-relevant samples at a dose rate higher than 10 dpa/fpy. The engineering design of the facility has been developed during the last 7 years
- Facility design is flexible enough to accommodate different irradiation needs that will evolve along the time
- The Project is progressing properly gaining momentum, international consensus and technical readiness.


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