DONES Business Opportunities

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Jornada sobre oportunidades para jóvenes investigadores en Fusión

CIEMAT, June 22th 2023

Outline

- IFMIF-DONES Facility Description
- DONES Programme Governance and Management
- IFMIF-DONES Experimental Capabilities and Exploitation
- Opportunities for industry

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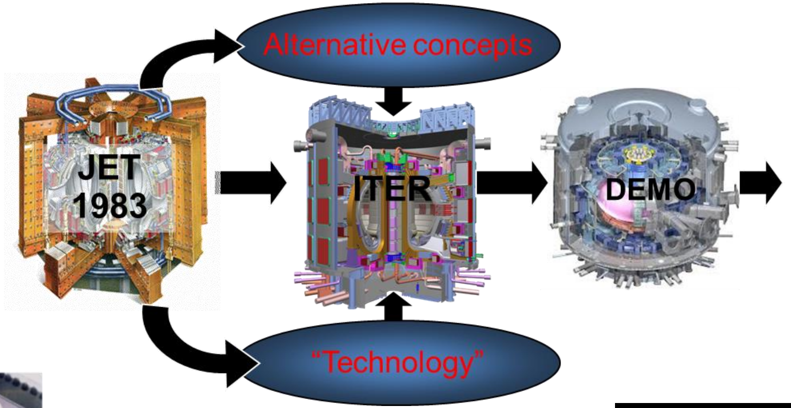
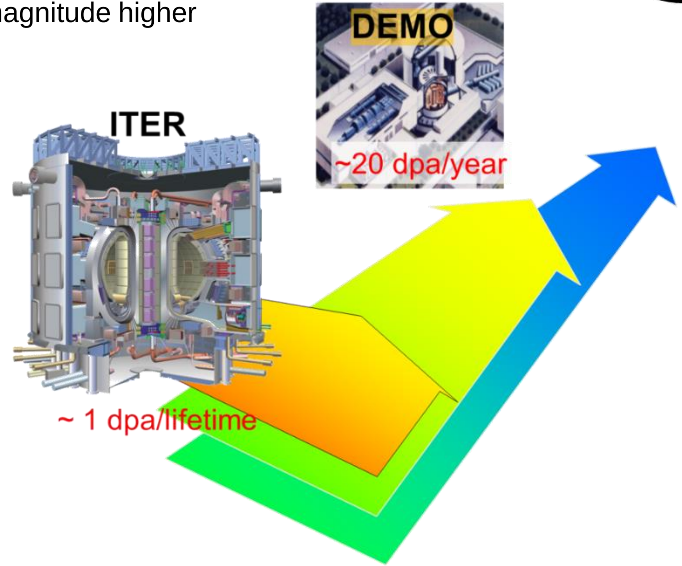
Why DONES?



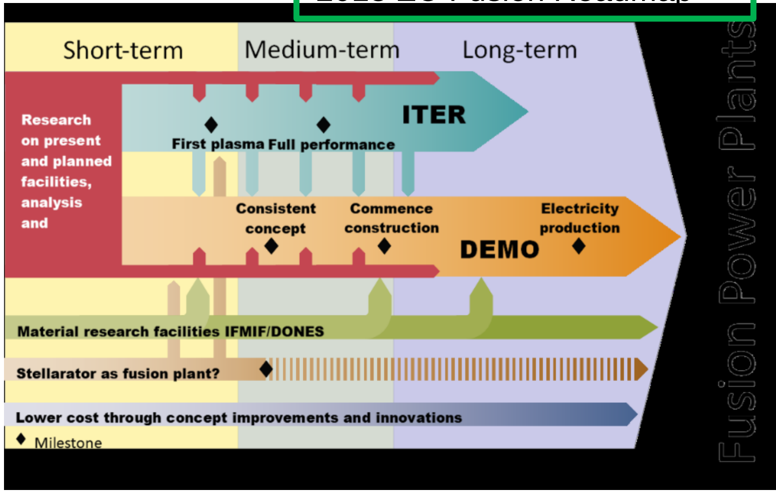
The power plant

EU strategy towards fusion energy

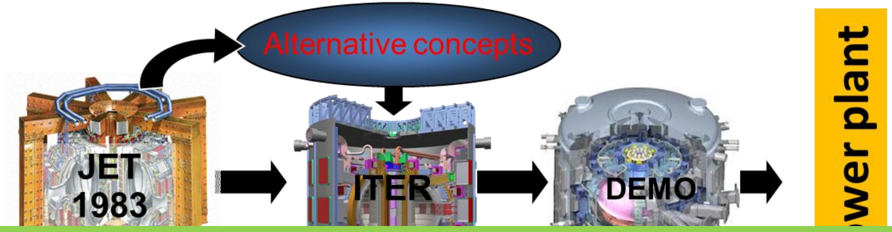
One of the main differences between ITER and DEMO is the radiation dose: at DEMO more that two orders of magnitude higher



2018 EU Fusion Roadmap



Why DONES?



EU strategy towards fusion energy

One of the main difference
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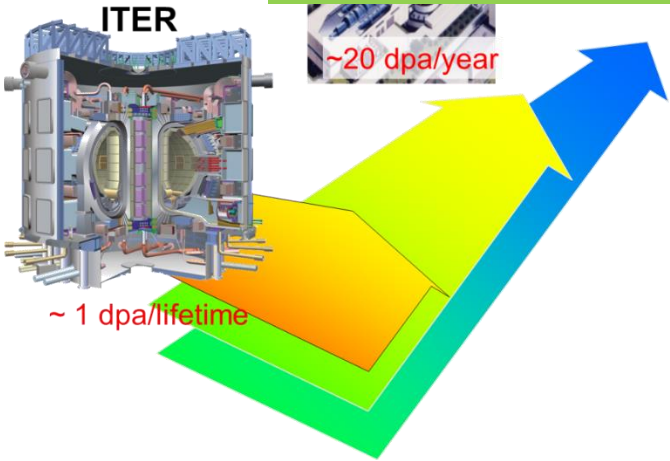
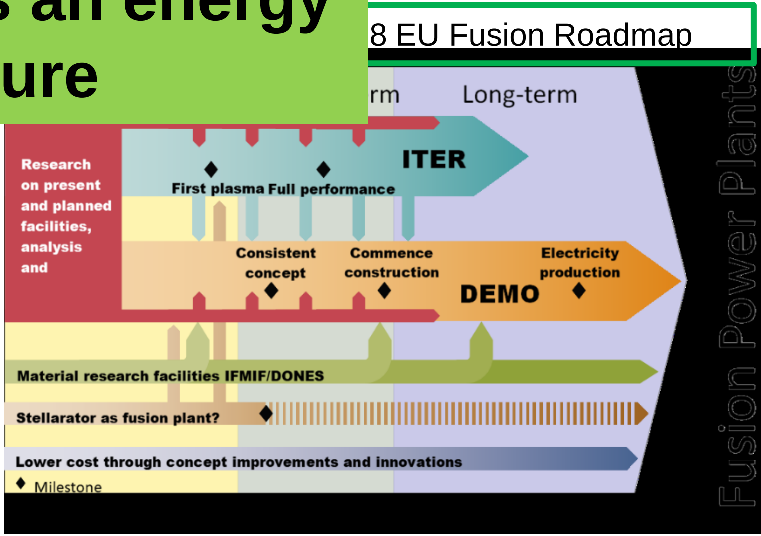
of magnitude higher

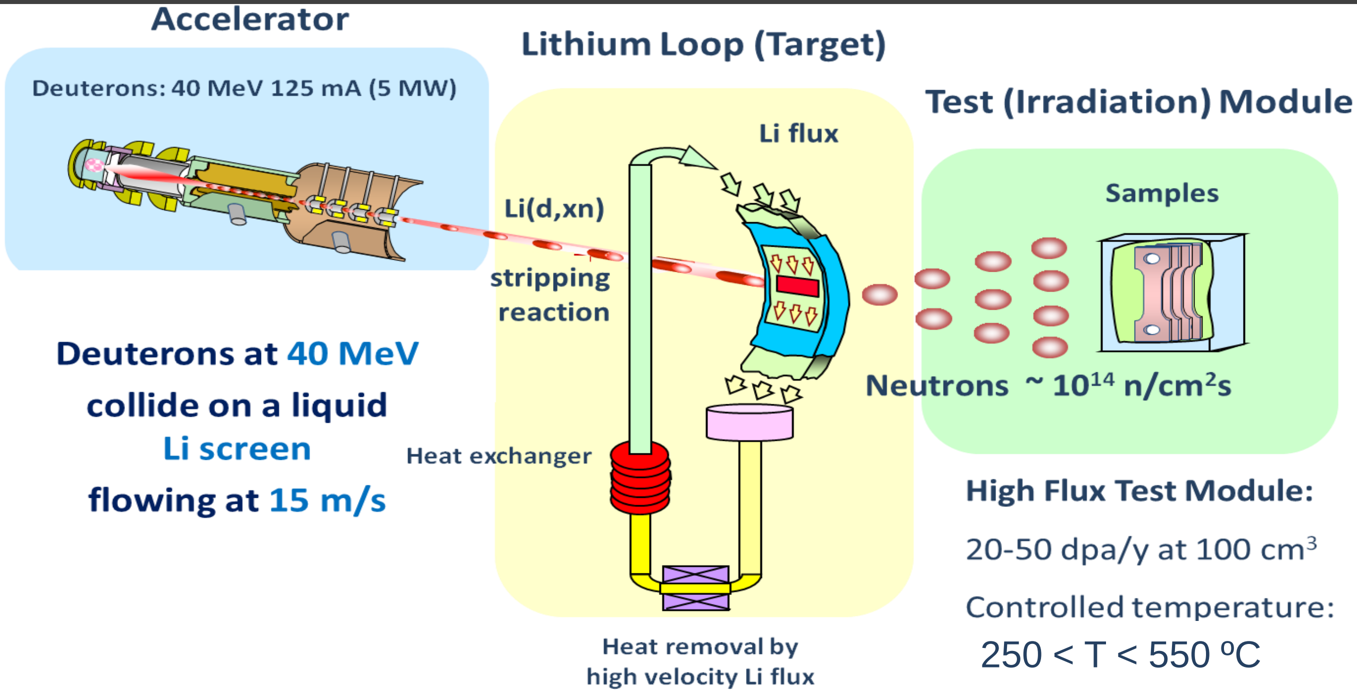
DONES will be a key element in the development of fusion as an energy source for the future





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

What is IFMIF-DONES?

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

One of the more powerful accelerators in the world

Challenges:high power, high space charge, cw wave

Biggest Li loop in the world

Challenges: Biggest Li loop in the world, power management, impurities management – corrosion risks-,

Challenges: RH, reability and long term control,…

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

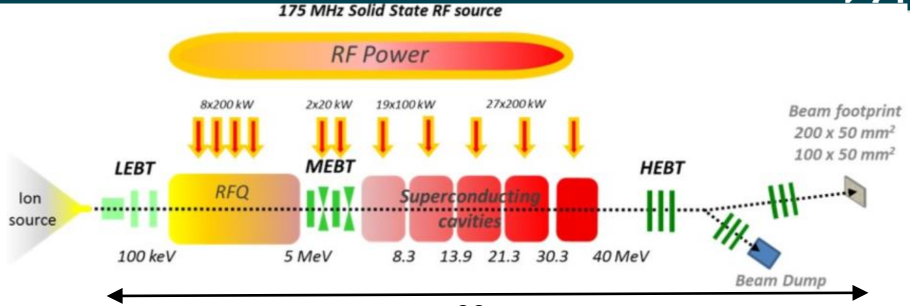
The Site

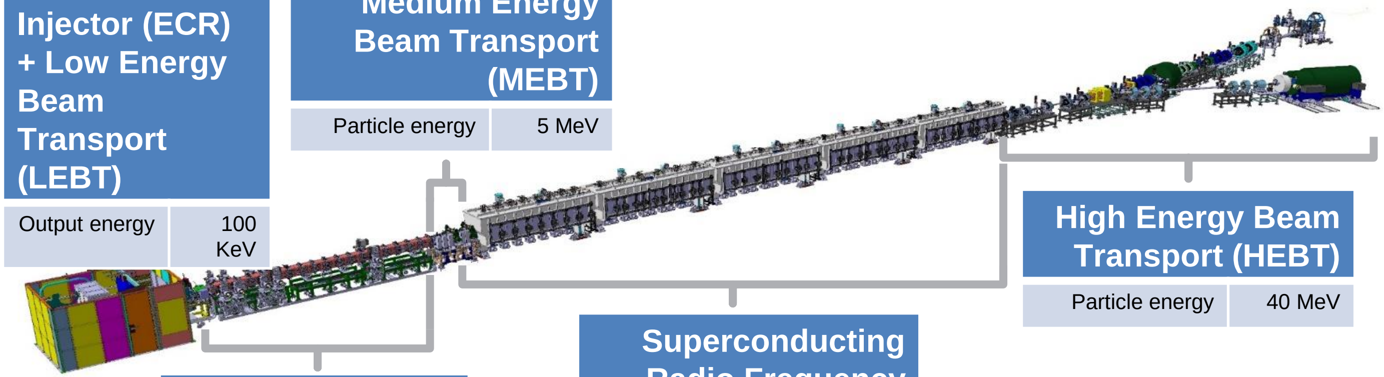
It will be located in t .8 km southwest from

Accelerator systems summary

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

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





Injector (ECR) + 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)

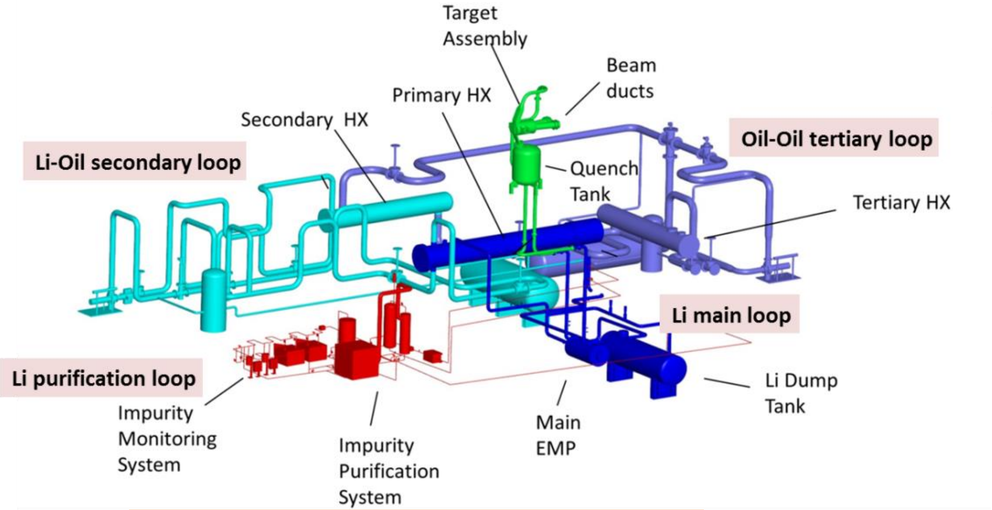
Particle energy	40 MeV

Main involved technologies

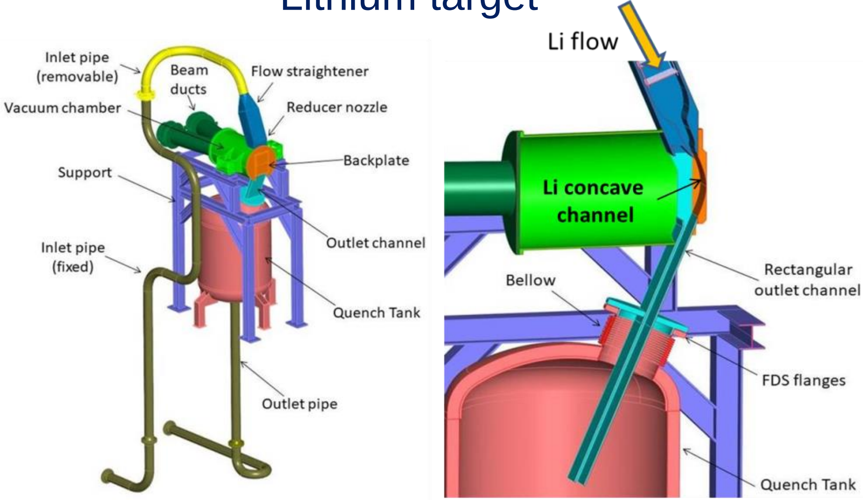
- **RF**
- **Cavities**
- **Magnets**
- **Mecatronics (Cu, Nb, Al,…)**
- **Criogenics**
- **Vacuum**
- **Power supplies**
- **Cooling technologies**
- **Sensors and diagnostics**
- **Control (hardware and software)**

Li systems summary

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



Lithium target



Li volume ~8 m^3 Li flow rate ~100 l/s
Temperature (cold side) ~300 °C

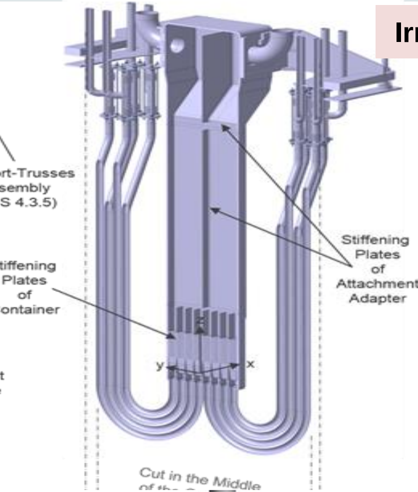
Jet thickness: 25±1 mm Li flow velocity: 15 m/s
Chamber pressure: 10^{-3} Pa Heat flux: 500 MW/m^2

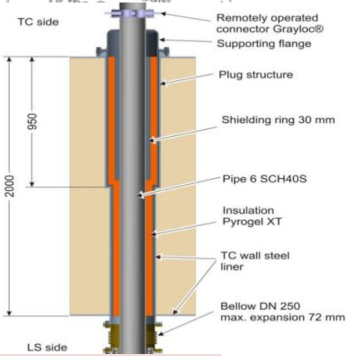
Main involved technologies

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

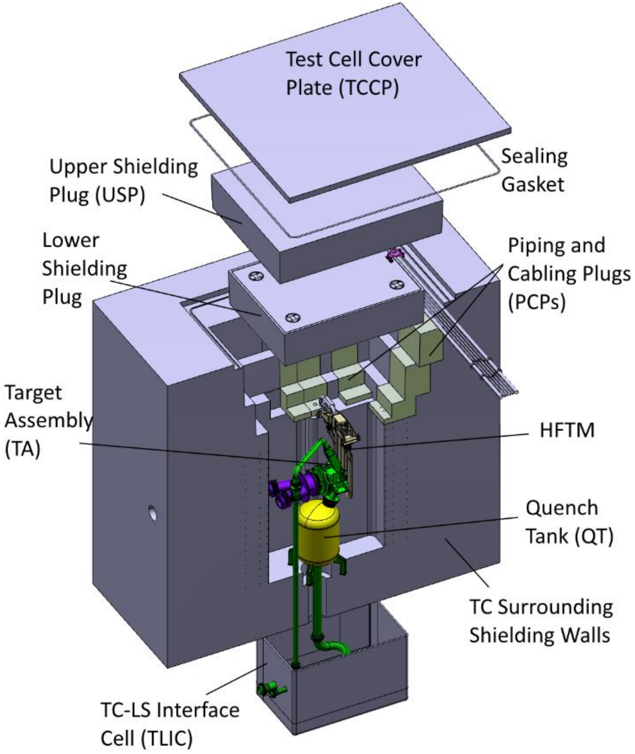
Test Systems summary

Irradiation module

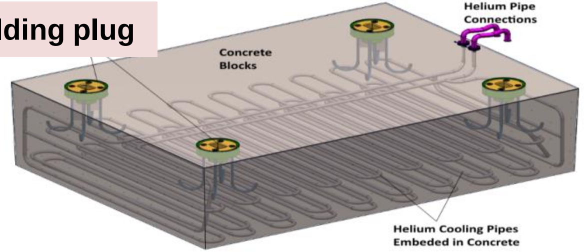




Duct penetration



Cooled shielding plug



Main characteristics driven by the presence of neutrons and Li

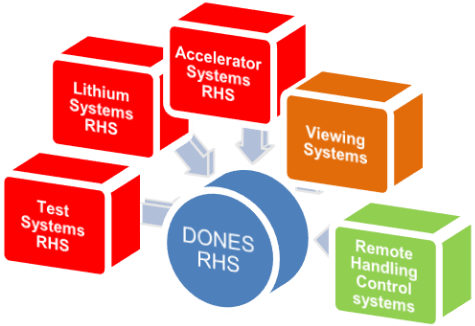
- **Internal components cooling by He**
- **Remote Maintenance required**

Main involved technologies

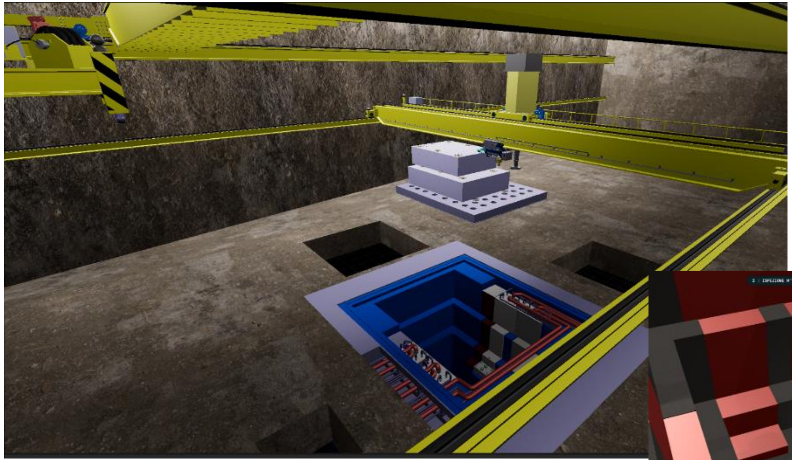
- **Mecatronics**
- **He and water cooling**
- **He, Ar and water systems**
- **Shielding materials and technologies**
- **Remote maintenance**
- **Vacuum**
- **Diagnostics**
- **Control (hardware and sofware)**

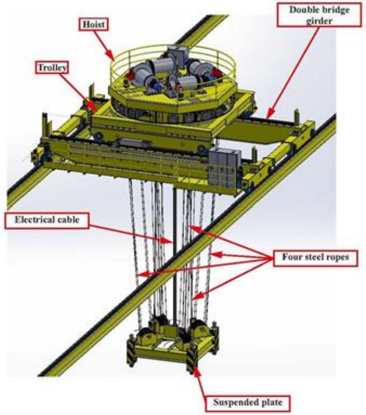
Remote Handling system

- ❑ Main Remote Handling Equipment : HROC and ACMC
- ❑ Access Cell big enough for storage of all components



Access Cell





Main involved technologies
- Special cranes
- Telemanipulators
- RH tools
- Radiation monitoring

Others systems and transversal topics

- Do not forget “conventional” systems: half budget will go to buildings and conventional systems

- Do not forget “transversal” activities: maintenance, safety, security, control,… they will be continuos activities all along the time of the facility

Main involved technologies

- **Buildings**
- **Cooling**
- **HVAC**
- **Control (hardware and software)**
- **Gas management**
- **Electrical systems**
- **Electronics**

- **Maintenance**
- **Safety and security**
- **….**

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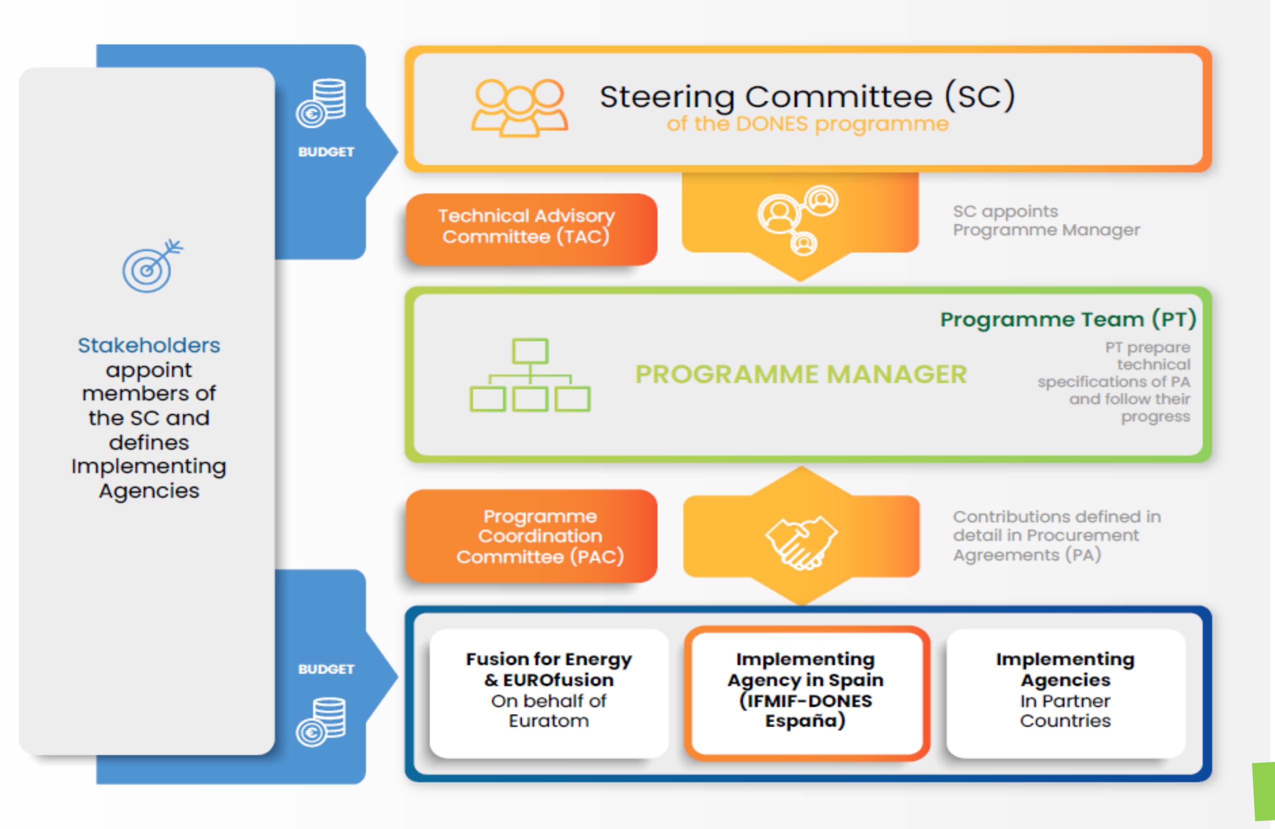
Project Organization



- Fast and flexible implementation
- Project run by flexible Project Team and relying on In-Kind Manpower contributions from different partners
- Design Authority with the Programme Team
- Owner/Operator responsibility on the Spanish Legal Entity

Similar to the Broader Approach model

1st DONES Steering Committee was held in Granada, March 16th 2023

(it means the start of the Construction Phase of the DONES Programme)

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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

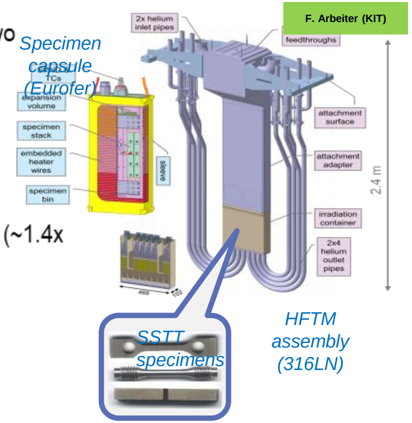
- 13-35 dpa/fpy up to 300 cm³ (22-50 dpa/fpy with two accelerators)
- 10-15 appmHe/dpa, 45-55 appmH/dpa.
- 250 – 550 °C, (~ 1000 specimens)

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)

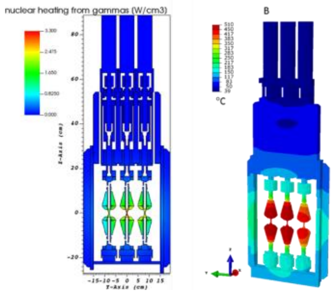
- Up to 800°C, assisted by self-heating
- 8x20 cm³ (cylindrical HT capsules)
- 1–3 dpa/fpy in W
- 9–10 appm He / dpa, (2x of DEMO), 20–29 appm H / fpy, (3x of DEMO)



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

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

- **In-Situ Irradiation Module for Diagnostics (IIMD)**
- **In-situ Irradiation Module for Superconductor materials** (probably outside of Test Cell)
- **In-situ Irradiation Module for corrosion testing in flowing media**

Summary of IFMIF-DONES experimental capabilities

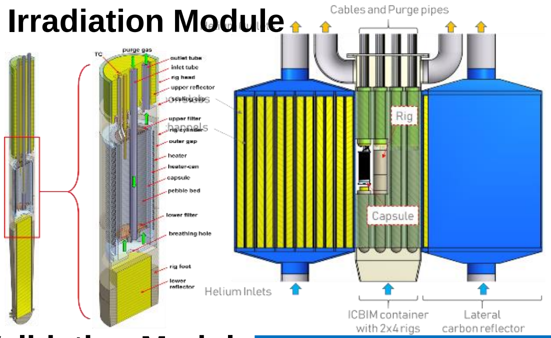
- # Breeding Blankets relevant technologies

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

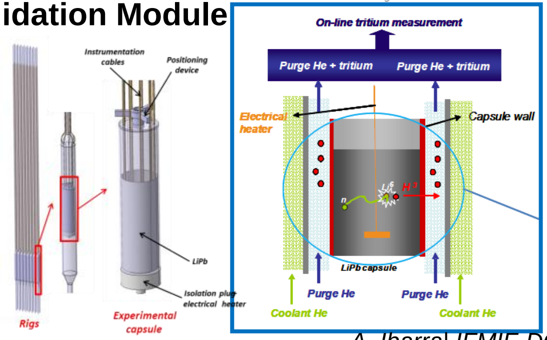
- **In-Situ Ceramic Breeder Irradiation Module**

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



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

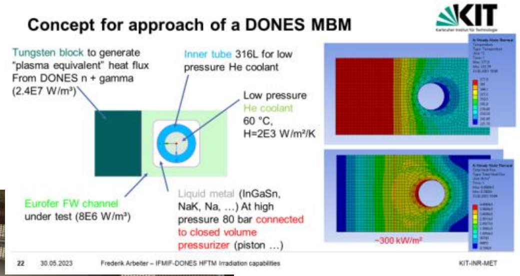
In-situ irradiation and testing of different containers of PbLi in the temperature range 300 – 600 °C in the high flux zone, measuring (time resolved) tritium release, permeation and extraction techniques



Prospective irradiation modules for functional testing of Model Blanket Module

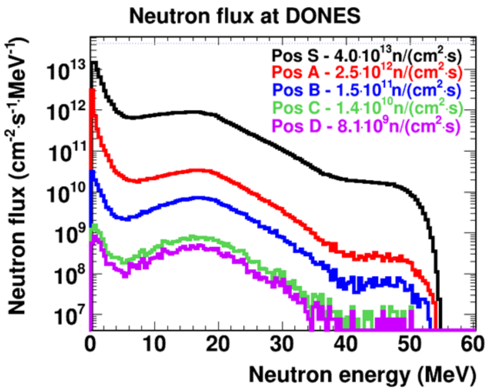
Interest raised based on:

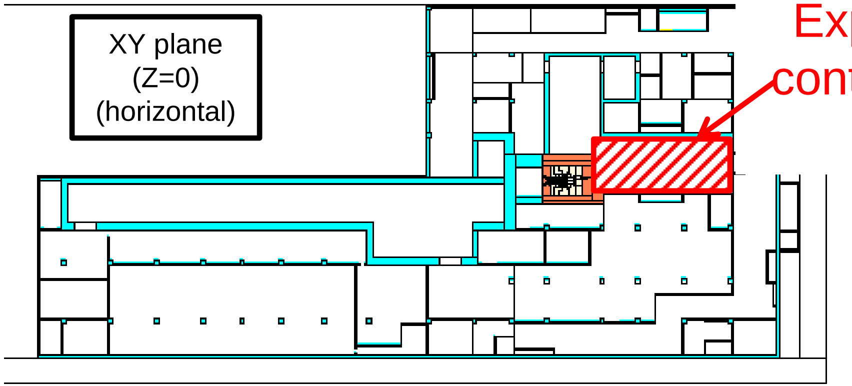
- an irradiation area similar in size to the typical "unit size" of different BB
- Neutron axial gradient similar to the one in DEMO
- Feasibility of heat loads similar to the one in DEMO first wall



Additional experimental areas

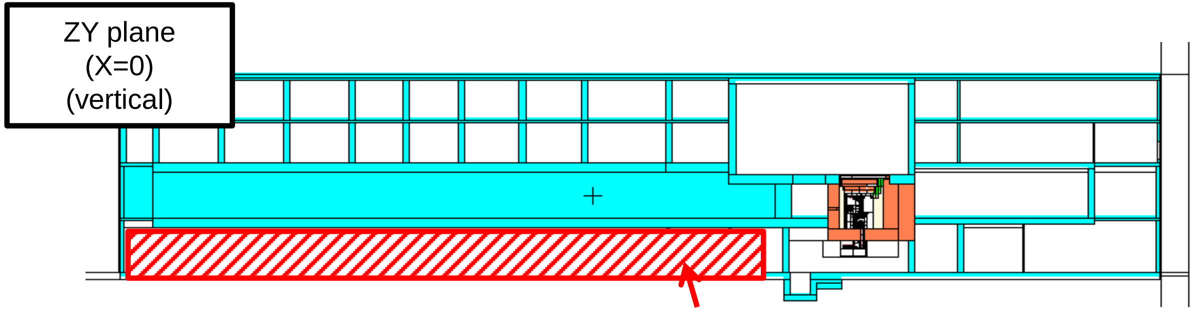
Very high neutron flux at very high energies!!!

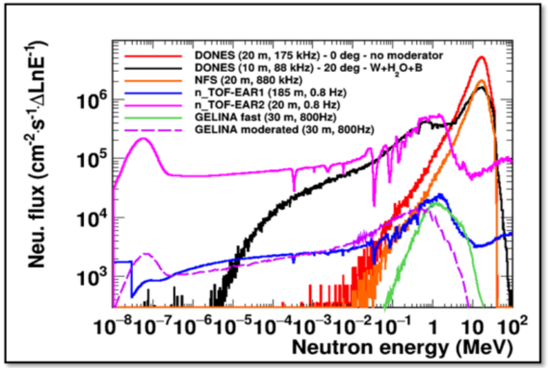




Experiments with continuous neutron beams

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





Experiments with pulsed neutron + deuteron beams

Posible DONES upgrades and/or acceleration strategies

Discussions are presently going on in order to define posible acceleration strategies for fusion development. They can have some impact on DONES future baseline

Add reloading capabilities:

- It will allow to go over to 50 dpa limit
- It will be required additional hot cell capabilities to manage reloading of irradiatied materials in a new irradiation module
- Cost estimate –TBC- 20 M€ *(3% of additional investments)*

Add partial on-site facilities:

- It will allow acceleration to obtain critical results after the irradiation (1-2 years faster)
- It will be required additional hot cell capabilities for PIE
- Cost estimate –TBC- 30 M€ *(4-5% of additional investments)*

Add a second Accelerator:

- It will allow a significant acceleration (results to be obtained a factor around 1,75 faster)
- it will be required an additional complete Accelerator, some addtional AS+TS auxiliaries systems, bigger building, upgrade of some Plant Systems
- Cost estimate –TBC- <330 M€ *(40% of additional investments)*

Others….

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Opportunities for the industry-I

In all the Big-Science projects, industry must be involved in the Project as soon as posible (both for the benefit of the Project and for the benefit of the industry)

- A specific effort has been made in the DONES Project to promote the participation of the industry since the beginning:
  - Industry was involved in the Validation Activities (IFMIF/EVEDA Project) during the last 15 years: most of the EU contributions were developed by EU industry
  - Industry is being involved very significantly in the engineering design and prototyping work developed up to now
  - Collaboration projects with industry are being strongly promoted (ACTECA, FUSION FUTURE, …. projects in the Spanish case)

But this is also a work for you!!!:
If you are interested you must start to be familiar with the Project as soon as possible

I+D publico-privada en DONES

El proyecto IFMIF-DONES lleva desde sus inicios fomentando la colaboración público-privada:

- Cerca de **35 M€ movilizados** en **I+D** alrededor de DONES, en los últimos 6 años
- Más de 30 empresas y 14 centros de investigación españoles (públicos y privados)
- A día de hoy, el mayor volumen proviene de proyectos del **Programa Misiones del CDTI (MICIN)**

ACTECA	FUSION FUTURE	DONES NEXT	DONES EVO	DONES FLUX	NEURON DONES
2017-2020 **8 M€**	**2020-2023** **6 M€**	**2021-2023** **2 M€**	**2021-2024** **6 M€**	**2022-2024** **3 M€**	**2022-2025** **9 M€**

Opportunities for the industry-II

Most of them already issued during the last few months and now running!!!

- **Short term contracts**:
  - Calls for auxiliary building construction (12 M€), DONES research building (6 M€), three different prototypes construction (0,5-1,5 M€ each), some labs under development
  - CPI (CDTI) for Accelerator and Test and Target Systems Integrated validation components (around 35 M€)

Very soon!!!

- **Medium term contracts** (linked to the initial steps of the program):
  - Engineering support (expected maybe in 2023)
  - Buildings and other plant systems (several contracts maybe from 2024-2025)
  - Contracts linked to Croatian contributions (expected from 2024)
  - Accelerator systems (injector, RFQ, RF, SRF,…) (expected maybe from 2024-…)
  - Li systems (Li loop others…) (expected maybe from 2025-…)

Still to be defined

Most of them will require Industry Consortia to be developed!!!

Presente y futuro: Las personas

La formación y atracción de talento joven es fundamental para el presente y sobre todo para el futuro del Programa.

Iniciativas en marcha:

1. **DONES Xcitech** (School on Science and Technology) (40 alumnos)
2. Contratos de **movilidad** (5 personas)
3. Contratos pre-doctorales (10 personas)

XCITECH School on Science and Technology

IFMIF DONES GRANADA

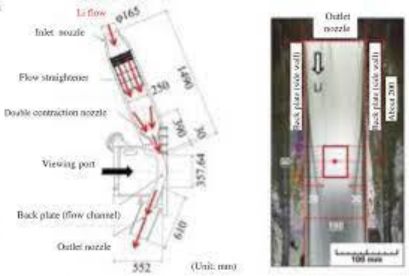
Presente y futuro: Oportunidades

Contratos previstos en 2023:

- **2 contratos pre-doctorales** (**convocatoria abierta!**)
- 10 contratos de ingeniería y administración

Áreas:

- Safety
- Gestión de proyectos
- Ciclo de vida e IT
- Ingeniería mecánica avanzada
- Aceleradores
- Integración de ingeniería
- Obras de Edificación
- Contratación pública



Previsión de contratación de personal durante las fases de construcción y puesta en marcha

EUROfusion

FUSION FOR ENERGY

DONES

IFMIF-DONES ESPAÑA

Gracias por vuestra atención!

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

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