PS4-90

Overview of European Fusion Neutron Source activities within the IFMIF/EVEDA Project

ISFNT-15

D. Jimenez-Rey[1,2]*, H. Dzitko[2], Y. Carin[2,3], S. Becerril[4], P. Cara[2], D.N. Dongiovani[5], F. Martin-Fuertes[1], F. S. Nitti[5], T. Pinna[5], Y. Qiu[6], B. Renard[3,7], and EU-FNS team

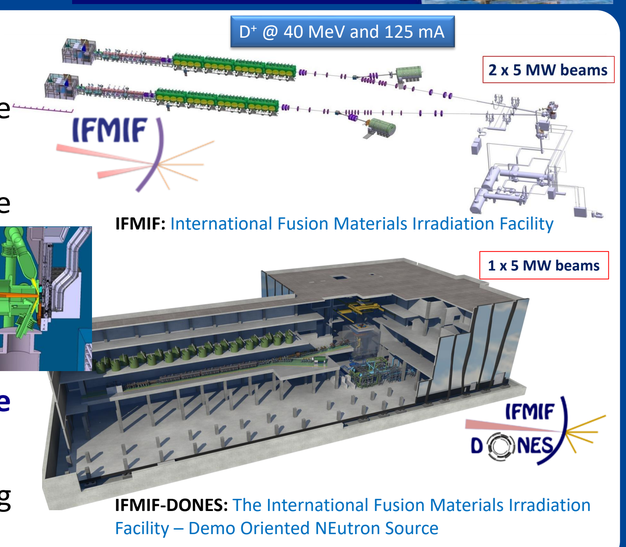
[1]CIEMAT, Madrid, Spain. [2]IFMIF/EVEDA Project Team, Rokkasho-mura, Aomori, Japan. [3]Fusion for Energy (F4E), BA/IFMIF, Garching, Germany. [4]IFMIF-DONES consortium. [5]ENEA, Brasimone, Italy. [6]KIT, Karlsruhe, Germany. [7]IRFU, CEA, Université Paris-Saclay, France

***d.Jimenez@ciemat.es** & David.Jimenez@ext.f4e.europa.eu

Introduction

See PL5 contribution, Hervé Dzitko "Overview of Broader Approach activities" (13-Sep)
See P5B2 contribution, Yann Carin "IFMIF/EVEDA achievements overview" (14-Sep)
See PL9 contribution, Angel Ibarra "Status of IFMIF-DONES Project" (15-Sep)

- The **EU fusion roadmap** defines as a key facility for the fusion **development the fusion-like neutron source** for testing the candidate materials for fusion reactors
- The **Fusion Neutron Source (FNS) is conceived to generate fusion-relevant neutrons through Li(d,xn)**, by means of a linear particle accelerator to obtain an intense deuteron beam (125 mA, 40 MeV) impinging onto a liquid lithium target
- High Neutrons flux, up to **10^{14} n/(cm^2·s)**, will irradiate, under controlled conditions, the candidate samples in the Test System
- Since **2021 EU and JA have been developing different FNS facilities**
- **Common Europa (EU)-Japan (JA) FNS design activities have been defined in the frame of a new international collaboration, the Broader Approach Phase Two (BA-II),** in addition to IFMIF Engineering Validation and Engineering Design Activities (IFMIF/EVEDA)
- **Several EU Engineering Design (ED) and Lithium Facilities (LF) design activities** required for advancement in an FNS design are being developed from **2022 to 2025** under two Procurement Arrangements (PAs)



IFMIF: International Fusion Materials Irradiation Facility

IFMIF-DONES: The International Fusion Materials Irradiation Facility – Demo Oriented NEutron Source

Engineering Design Activities (ED06-2)

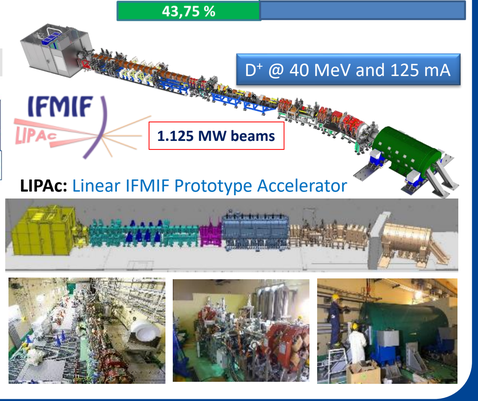
- EU-FNS is developing **5 main activities inside ED-PA** based on the engineering, modelling, calculation, and experimental activities of FNS:
  - ✓ **Tritium migration estimation** in FNS during normal operation & maintenance and incident/accident, together with T stability in solid/liquid Li
  - ✓ **Erosion/deposition modelling** in the lithium loop considering activation products
  - ✓ **Accident analysis in Safety** including: general failure mode analysis, Safety Control System monitors and signals, Li Loop analysis and transport analysis of material at risk
  - ✓ **Optimization of the Li-oil heat exchanger** under gamma radiation conditions
  - ✓ **The use of LIPAc** (9 MeV & 125 mA) as a key testing facility for future FNS construction, testing new diagnostics, making neutronic and activation studies, and use for the analysis of the operational experience reliability data collection (RAMI)

Deliverables Timeline of Engineering Design (PA_ED-06-2 EU)

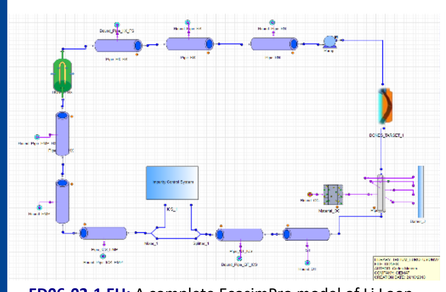
PA-ED02-EU	2021	2022	2023	2024	2025
ED06-2-1 EU: Tritium migration in the Li loop		31 Mar 220	31 Mar 220	31 Mar 110	
ED06-2-2 EU: Erosion/deposition modelling in the Lithium loop				31 Mar 220	
ED06-2-3 EU: Accident analysis in Safety			30 Jun 220		28 Feb 680
ED06-2-4 EU: Study and design on the optimization of the Li-Oil HEx			31 Jan 220	~~31 Jan~~ 220	
ED06-2-5 EU: Use of LIPAc as a testing facility					
ED06-2-5.1 EU: Use of LIPAc for validation of sensor and diagnostics			31 Sep	31 Oct	28 Feb 470
ED06-2-5.2 EU: Use of LIPAc for real materials activation studies			31 Sep	31 Oct	28 Feb 250
ED06-2-5.3 EU: Use of LIPAc for RAMI data from LIPAc exploitation			31 Sep	31 Oct	28 Feb 240
ED06-2-5.4 EU: Use of LIPAc for Neutronics validation calculations			31 Sep	31 Oct	28 Feb 440
ED06-2-5.5 EU: Use of LIPAc for other activities					28 Feb 290
Total credit (BAUA)		**220**	**660**	**550**	**2370**

▽ Notification Point ▼ Deliverable

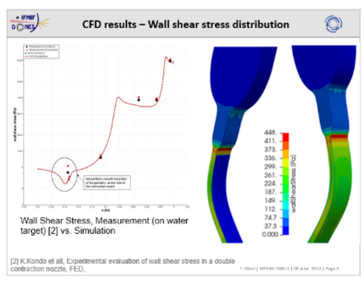
Budget (23 %): 43,75 %



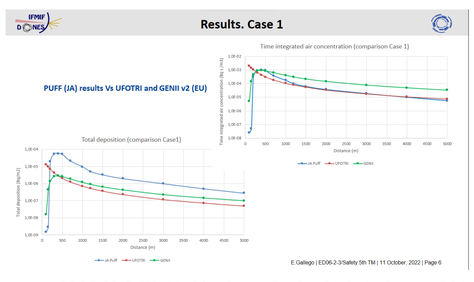
LIPAc: Linear IFMIF Prototype Accelerator



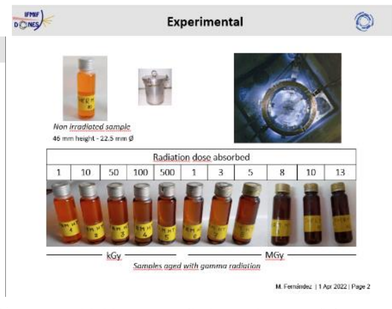
ED06-02-1 EU: A complete EcosimPro model of Li Loop to predict the T transfers in the Li loop & Li rooms



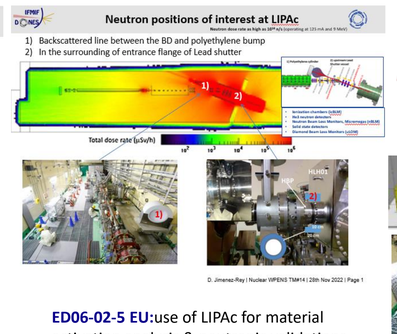
ED06-02-2 EU: Modeling of the erosion/corrosion process & the distribution of the ACP & Be3N2



ED06-02-3 EU: Verification of Design Basis Accidents (DBA) for facilities and systems related to the neutron source



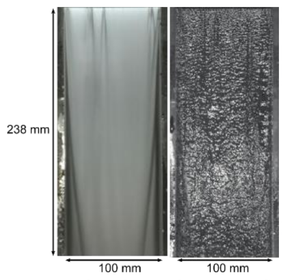
ED06-02-4 EU: Radiation resistance of the coolant fluid for the Li loop heat exchanger



ED06-02-5 EU:use of LIPAc for material activation analysis & neutronic validations

Lithium Design Activities (LF06-2)

- LF-PA activities of EU-FNS includes **3 main activities inside ED-PA:**
  - ✓ **Li purification system validation activities** by means of pilot plants 1:1
  - ✓ **Li target diagnostics** design and validation by laser for thickness measure
  - ✓ **Erosion/corrosion analysis and modelling** on the materials of a dismantled test loop, the **EVEDA Lithium Test Loop (ELTL)**



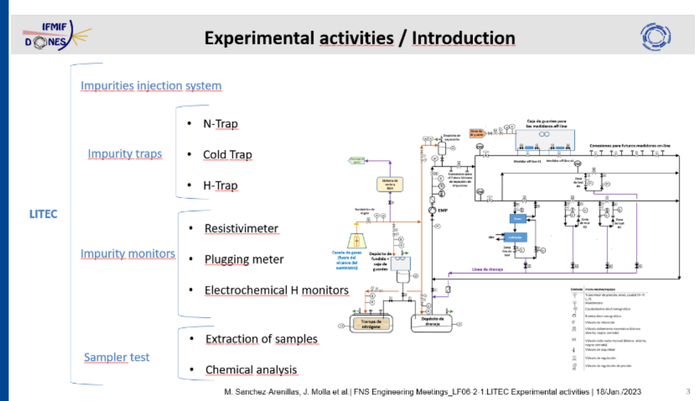
Images of the free surface lithium flow in ELTL taken with 2 s and 10 μs exposure time [Kondo et al. (2015), Wakai et al. (2016)]

Deliverables Timeline of Lithium Design (PA_LF-06-2 EU)

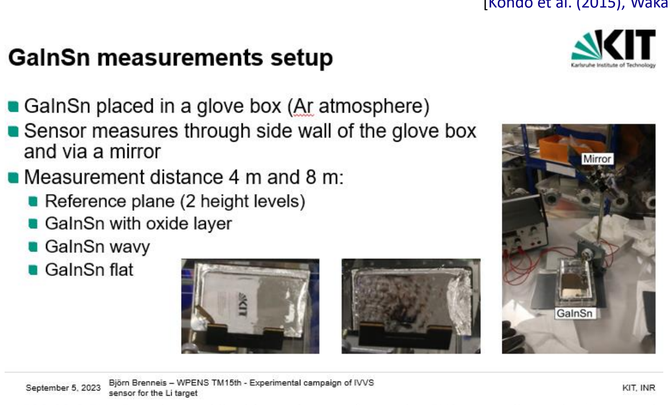
PA-LF02-EU	2021	2022	2023 (Today)	2024	2025
LF06-2-1 EU: Li purification system validation activity		31 Dec 440	30 Sep		28 Feb 2480
LF06-2-1 EU: Li target diagnostics design and validation				31 Mar	28 Feb 770
LF06-2-1 EU: Erosion/corrosion analysis on ELTL materials		31 May 110			
Total credit (BAUA)		**110**	**440**		**3250**

▽ Notification Point ▼ Deliverable

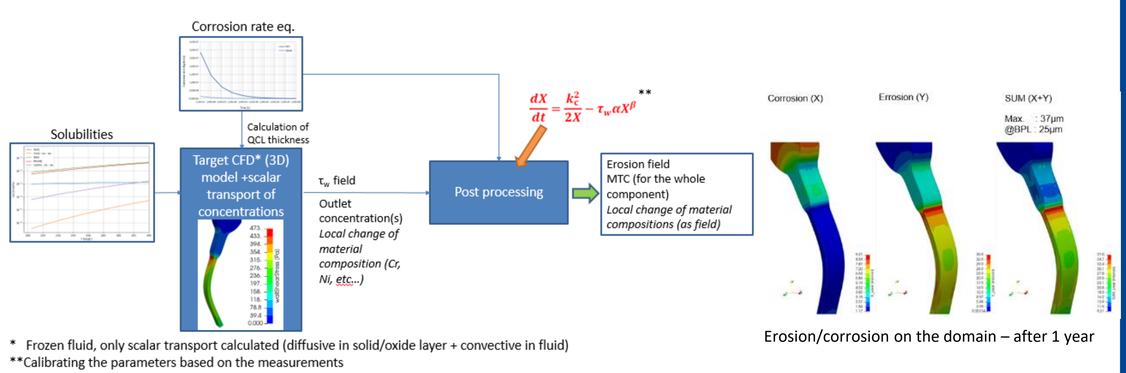
Budget (2.8%): 43.75%



LF06-02-1 EU: Definition of the experimental program to be executed in the 1:1 pilot plant of 1000l (to be operative in 2025-2025)



LF06-02-2 EU: Experimental liquid metal set-up for testing FNS target diagnotics (Laser and ITER in Vessel Viewing System (F4E)) for Li thickness measurement



* Frozen fluid, only scalar transport calculated (diffusive in solid/oxide layer + convective in fluid)
**Calibrating the parameters based on the measurements

Erosion/corrosion on the domain – after 1 year

LF06-02-3 EU: Development of 3D CFD quasi-experimental model of the ELTL_TA section for prediction of the wall shear stress distribution

Beyond 2025 (ED06-03 & LF06-3)

- The content (modelling, calculation, engineering and experimental activities) of both new PAs and budget are being defined, in order to be agreed early 2024:
  - ✓ **LF06-3: Lithium Target Enhancement - Part 2 (EU)**
  - ✓ **ED06-3: Design feedback for neutron source - Part 2 (EU)**
- The LF06-3 activities are linked to experimental Li loop facilities operation under nominal conditions
- The ED06-3 activities are strongly correlated with LIPAc commissioning/operation schedule and advances

FACILITIES of common interest by JA-EU to be used:

- **LIPAc** as the unique world d+@125 mA experimental facility for perform FNS studies on i**nstrumentation, activation studies, safety, control, tested operational procedures, RAMI, extraction of lessons learned, etc**
- **LITEC Li Loop** and experiments for impurities studies
- **QST purification loop**
- **OSAKA Li Loop** for free surface Li diagnostics (laser and radar) experiment PS4-108
- **LIFIRE** for LI extreme conditions studies

Summary

- **Activities on engineering design, modelling, calculation and experimental studies are being performed by EU-HT** for the fast track of the FNS (based on IFMIF) of common interest for EU and JA
- **Highly interesting and fruitful bidirectional R&D collaboration between JA-EU for the development of future FNSD**
- **The activities continuation beyond 2025 (ED/LF06-3) are being drafted and will discussed** in the ISFNT Satellite Meeting "FNS-Technical Meeting#2 (FNS-TM#2)"

JA-EU Collaboration

This work was undertaken under the Broader Approach Agreement between the European Atomic Energy Community and the Government of Japan. The views and opinions expressed herein do not necessarily state or reflect those of the Parties to this Agreement.