Annex 4

EUROfusion Engineering Grants AWP2023

List of positions

Contents

Relevant acronyms

Work packages acronyms used in this document:
WPSAE: Safety and Environment
WPMAG: Magnets
WPDES: Design
WPMAT: Materials
WPDIV: Divertor
WPRM: Remote Maintenance
WPPWIE: Plasma Wall Interaction and Exhaust
WPW7X: Wendelstein 7-X
WPTFV: Tritium, Fuel Cycle, Vacuum
WPBB: Breeding Blanket
WPBOP: Balance of Plant
WPDC: Diagnostics and Control
WPPRD: Prospective Research and Design
WPHD: Heating and Current Drive
WPSA: JT-60SA
WPPrIO: Preparation ITER Operation
WPTE: Tokamak Exploitation

Role/PMU acronyms:
DCT: DEMO Central Team
FSD: Fusion Science Department
FTD: Fusion Technology Department
KDII: Key Design Integration Issue (*you will be hearing more of this, or maybe not anymore…*)
PMU: Programme Management Unit
RO: Responsible Officer

Facility/Activity acronyms:
ACHs: Advanced Computing Hubs
ETASC: EUROfusion Theory and Advanced Simulation Coordination
JT-60SA: Tokamak in Japan – collaboration with EUROfusion
MAGNUM-PSI: Linear Plasma Generator for Plasma Surface Interaction (DIFFER, NL)
QSPA: Quasi-Stationary Plasma Accelerator – Ukraine
TCV: (from: Tokamak à Configuration Variable) – Tokamak at Swiss Plasma Centre
WEST: (from: W Environment in Steady State) – Tokamak at CEA Cadarache
W7-X, ITER, DEMO: (*if you don't know what these are, then you should not apply!*)

Project ID: **EEG23_P01**

Project Title: **Impact of Activated Corrosion Products on ITER Occupational Radiation Exposure**

EUROfusion RO: Work-Package Preparation to ITER Operation (WPPrIO contact: X. Litaudon) together with DEMO Safety office (contact J. Elbez-Uzan)

Background

With ITER under construction in the south of France, fusion research is entering the nuclear area. In fusion reactors (ITER and DEMO), Activated Corrosion Products (ACP) circulating in the cooling systems will represent a significant source of radiological hazard. Accurate estimation of the ACP activation is important for the licensing process and for maintenance operations. Indeed, corrosion and erosion phenomena mobilize activated materials transported in ex-vessel regions of the cooling system accessible to workers. Preliminary ITER evaluation of ACP radiation doses shows significant consequences for ITER Occupational Radiation Exposure. The calculations are performed by simulating the ACP inventory (*OSCAR-Fusion code*) and photon transport in 3D geometry with Monte-Carlo radiation transport code (*MCNP*). To improve the level of accuracy for ITER, EUROfusion has launched a dedicated task within WPPrIO on "*ACPs tools development and experiment for extrapolation to ITER*" with a dedicated experiment at the Frascati Neutron Generator (FNG) in Italy.

Objectives

The objective is to design, carry-out and analyse dedicated experiments at FNG in ITER relevant conditions, and, to develop a methodology for predictions. The other objective is to develop multi-disciplinary, unique and advanced skills in ACP assessment for fusion applications, and, to enhance the reliability/accuracy for ITER. The work will focus on expanding the ACP tools validation basis, improving the computational capabilities and mitigating uncertainties of ACP assessment as well as on supporting ITER. The trainee will perform calculations, design activities and participate in experimental activities to improve reliability, reduce uncertainties, and, to validate the ACP ITER tools and methodologies.

High-level work description

The high-level milestones to be achieved are as follows:
M1) Study of solubility models in OSCAR-Fusion code, corrosion and release laws for copper and steels
M2) Participate in the design, preparation, verification and experimental validation of ACP methodology and identify the main sources of uncertainty for ITER Occupational Radiation Exposure
M3) Implement in OSCAR-Fusion dissolution/corrosion models and validate with/without magnetic field
M4) Assess the impact of water chemistry, materials properties and radiolysis on ACP generation, transport and deposition.

Gantt chart of high-level activities

Duration in months:	1-6	7-12	13-18	19-24	25-30	31-36
Study of OSCAR-Fusion solubility models, corrosion and release laws for Cu and steels		Interim-report	Final report			
Optimization, verification and experimental validation of ACP methodology and identification the main sources of uncertainty for ITER Occupational Radiation Exposure						Report
Implementation and validation of dissolution and corrosion models with/without magnetic field				Report		
Impact of water chemistry, materials properties and radiolysis on ACP generation, transport and deposition					Report	

The grantee will carry out activities within an EU team in which he/she will be supported by neutronics, activation, ACP, material, corrosion, water chemistry and ORE experts. The trainee will acquire knowledge on fusion technology, activated corrosion products, neutronics, activation, materials, water chemistry and corrosion as well as on nuclear and safety issues of ITER. He/she will develop competences on ACP, radiation transport and activation codes (OSCAR-Fusion, MCNP and FISPACT) and on the experimental techniques for nuclear measurements and corrosion tests. He/she will have the opportunity to collaborate with ITER experts and to work in recognised research laboratories to acquire the knowledge and experience in the relevant areas. To complement the 'hands-on' training, he/she will attend conferences and dedicated courses.

Competences required before start of EEG

- Basic knowledge of fusion technology
- Master's degree in engineering (specialisation on nuclear or chemical engineering preferred) or Physics

Competence development during project

- multi-physics and technological skills in water chemistry, materials, corrosion, nuclear analysis and radiation protection
- Advanced user of nuclear codes
- Experimental techniques for nuclear measurements and corrosion test

Facilities used: Frascati Neutron Generator, materials laboratory

Mobility needs: FNG (1 year), ITER Organization (IO) (Max 6 months)

Future career possibilities

The broad and interdisciplinary skills developed in this program will allow the trainee to acquire distinctive knowledge and competences in the frame of fusion technology, tokamak, water-cooling circuits engineering, nuclear analyses, neutronics, safety, material, corrosion and water chemistry. The program will give him/her the opportunity to continue his/her carrier in the frame of research activities for ITER and DEMO within EU laboratories, Universities or at IO as well as specialised engineering in private companies.

Project ID EEG23_P02

Project Title **Ageing of ITER grade tungsten divertor components under tokamak plasma loading related to engineering of plasma-facing materials and components manufacturing**

EUROfusion RO S. Brezinsek, PL WPPWIE
WPTE, WPDIV

Background

Power exhaust is a crucial research area for next step fusion devices, and the design and manufacturing of the divertor, the most heavily loaded component in the device, is an engineering challenge. In particular, the first tungsten divertor in ITER will have to face unprecedented heat and particle loads and is planned to operate over ~10 years or 2000 hours of plasma time in the low duty cycle of ITER. It is therefore important to assess how the thermo-mechanical properties and the power handling capabilities of this actively cooled tungsten components will evolve after long time exposure to tokamak conditions and how this compares to high fluence plasma exposures in linear plasma devices.

Prototypes of the actively cooled tungsten ITER divertor (W monoblocks assembled on a copper heat sink) have been provided by potential ITER suppliers - including F4E candidates -for exposure in the WEST tokamak, using different material grades and manufacturing routes. The primary aim of this project is to assess ageing of these prototypes after exposure in tokamak conditions and to provide feedback for the ITER divertor series production and the expected ITER divertor lifetime. Secondly, the aging will be compared to high fluence exposures in MAGNUM-PSI and studies in electron beam facilities like JUDITH.

Objectives

This project will be based on (a) post-mortem analysis and assessment of thermo-mechanical properties of the various prototypes exposed in WEST, to be compared with (b) pre-characterization of non-exposed W monoblocks available from the production of the prototypes as well as to (c) monoblocks exposed in MAGNUM-PSI or/and e.g., JUDITH. The later exposure has partially been done before this grant.

This project will therefore provide data on the ageing behaviour of the ITER tungsten monoblocks as a function of the production route of the W material used, the component manufacturing and assembly processes and plasma exposure conditions considering in particular processes like cycling loading around DBTT (Ductile to Brittle Transition Temperature), W recrystallization or loading with deuterium and/or helium plasmas.

It will train the proponent in understanding the complex manufacturing route of plasma facing components for fusion, the different techniques for qualification, and in assessing the plasma-facing components performance when exposed to tokamak conditions or linear plasma and electron beam conditions.

Work programme

The project will be organised as follow:

Activity 1: characterize each prototype in terms of : W supplier, W production routes (powder size, deformation routes, impurities, etc), targets manufacturer, W/Cu and CuCrZr/Cu bonding technology, heat treatments, machining tools and processes

Activity 2: perform characterization of unexposed W monoblocks and post-mortem analysis of divertor prototypes after their exposure in WEST. This work will allow to evaluate into more details the behaviour of each prototype under plasma exposure and to highlight the differences in ageing. Damage such as cracking, surface characterization (roughness, emissivity) as well as microstructure-related thermo-mechanical properties will be assessed.

Activity 3: participate in monoblock exposures in linear plasma MAGNUM-PSI and high heat fluxes (e.g. JUDITH) and assess damages of W monoblock proto types. Comparison with existing damage matrix for W mono blocks at high particle and power loading. Cross-comparison with damages and aging observed in WEST tokamak exposures

Activity 4: investigate the impact of materials and manufacturing parameters on the ageing response of targets under plasma exposure. In particular, the effect of impurities level and their location in the microstructure, the use of machining tools and induced stress or/and macro-damage as well as the surface roughness on the erosion, corrosion resistance and cracking will be addressed. Comparison with results from exposure in linear device or/and high heat flux facilities is foreseen.

The project will be carried out in close collaboration with the ITER Organization and the responsible team for the divertor (contact Tom Wauters), as well as in a European framework, gathering several laboratories with expertise in analysis of fusion exposed components (WP PWIE).

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Activity 1: manufacturing history of prototypes	■					
Activity 2: post-mortem analysis of prototypes		■	■	■		
Activity 3 comparison with linear plasmas and e-beams			■	■		
Activity 4: impact of manufacturing on ageing response				■	■	■

Gantt chart of high-level activities

Competences required before start (bullet points)

- Master's degree in engineering, specialised on materials

Competence development during project (bullet points)

- Expertise in fusion plasma facing components design and manufacturing processes

• Excellent teamwork and communication skills, including a good level of spoken and written English		• Advanced skills in plasma-materials interactions and surface analysis • Ability to work an international collaboration environment
Facilities used	WEST, high heat flux facility JUDITH or equivalent, linear plasma devices MAGNUM-PSI exposing actively cooled ITER grade components. Post-mortem analysis set up in various EUROfusion laboratories involved.	
Mobility needs	The proponent is expected to visit the various laboratories involved in relevant surface analysis in the WPPWIE framework (max. 2 months), as well as to interact regularly with the IO divertor team (max. 2 months).	
Future career prospects Potential next career steps in fusion after this EEG traineeship	This project will allow the proponent to candidate as a lead engineer for plasma facing component design and manufacture, in response to the needs in this area of several existing or future fusion devices, such as JT60-SA, W7-X, DTT, ITER and DEMO.	

Project ID	**EEG23_P03**
Project Title	**Qualification of low-pressure plasma spraying for fusion application and design of an in-situ application usable within a fusion-relevant device**
EUROfusion RO	Dr. Sebastijan Brezinsek, WP PWIE

Background

The exchange of damaged plasma-facing components (PFCs) in fusion devices is time- and resource-taking. The *in-situ* coating of PFCs can save resources and minimize the idle time. The low-pressure plasma spraying (LPPS) is an option for making tungsten coating for campaign-long operation without the exchange of components. The operation of LHD with the divertor plate coated with tungsten using LPPS demonstrated positive results [M. Tokitani et al. NME 2019].

This project scope comprises making the robust tungsten coating on carbon, steel and tungsten using the LPPS, coating qualification under fusion-relevant conditions and a pilot LPPS design for operation inside the fusion device usable for larger area coating as well as repair. The *in-situ* tungsten coating is of potential interest for several devices such as W7X, JT60-SA, WEST, etc. possibly ITER at the later stages of its exploitation and certainly, for the DEMO divertor.

Objectives

The proposed project aims the training of the candidate with an engineering background in the leading EU laboratories and research centres to explore and to qualify the option of LPPS tungsten coating for the *in-situ* application inside fusion devices in the EU and abroad.

Besides the general training purpose, the project will have three main objectives:

1. Obtaining the robust tungsten coating on carbon, steel and tungsten substrates with the necessary thickness of 100 microns and more.
2. Qualification of the best coatings under fusion-relevant plasma and heat load condition
3. Making a pilot design of the LPPS system for in situ tungsten coating inside fusion devices (e.g., on a remote handling arm)

High-level work description

a) The project will start with the literature research and introduction to the LPPS and material testing facilities at FZJ.

b) Then the candidate will learn and perform under the guidance of FZJ professionals the coating on carbon, steel and tungsten substrates using the LPPS systems and analyse the quality of the coatings: porosity, adhesion, thickness and homogeneity.

c) Subsequently the trainee will receive the introduction to plasma and heat load qualification and participate in the coating qualification using the linear plasma device PSI-2 at FZJ. The training is planned to be extended by the specialists from DIFFER in the Netherlands and IPP Garching in Germany, followed by the qualification of the best LPPS coatings under high plasma and particle loads in MAGNUM PSI and e.g., GLADIS facilities respectively. Sputtering resistance and robustness of the coating will be evaluated. The optimization of the coating technology will be made based on qualification.

d) Optimized coating technology will provide an input to the third phase of the project – the conceptual pilot design of the *in situ* LPPS system for fusion. It is expected that this phase will be enforced by an intensive exchange between the trainee and the specialists from interested EU facilities such as e.g. the WEST tokamak in France and the W7X stellarator in Germany. CAD and other trainings will be organized as well as part of the grant. It is also planned to present the conceptual pilot design to the interested fusion facilities and to discuss its further realization.

e) The project will end with final analyses and writing the final report

Months:	1-3	3-12	13-18	19-24	25-30	31-36
Introduction, literature research, gaining the initial experience with LPPS	■					
Making tungsten coating using LPPS, initial evaluation of coating quality and optimization of coating technology		■	■			
Qualification of the best coatings in fusion – relevant plasma and high heat load conditions			■	■		
Evaluation of required performance of the LPPS system for in situ coating and repair.				■		
Pilot design of the LPPS system for in situ fusion application.				■	■	
Completion of the project, final analyses data logging and final report on project						■

Gantt chart of high-level activities

Competences required before start of EEG (bullet points)

- Master's degree in engineering, specialisation on energy systems or equivalent. Interest in material testing
- Good communicability, ability to work both individually and within the group are highly desired, fluent English both in writing and speaking is required

Competence development during project (bullet points)

- General knowledge on fusion energy system, practical knowledge in fusion-related experiments, deep understanding of fusion-specific, magnetic, temperature, particle and heat load environment in fusion devices
- Vast practical experience in material testing, in design of fusion components, CAD knowledge at professional level

	• Better communicability, vast connections and collaborations within fusion community in the EU.
Facilities used	Required facilities • The low-pressure plasma spray facility in the Jülich Thermal Spray Center at the FZJ with several plasma guns for tungsten coating and its optimization • The linear plasma device PSI-2 at FZJ for plasma qualification of the coating Optional, but highly desired: • The MAGNUM PSI facility at DIFFER, The Netherlands of qualification of the best coatings under divertor-relevant high plasma fluxes (tbc) • GLADIS facility at IPP Garching for the high heat load tests (tbc)
Mobility needs	Mobility trips between FZJ, DIFFER and IPP Garching, and possibly to IRFM CEA Cadarache and IPP Greifswald for exchange with engineers from WEST tokamak and W7X advanced stellarator.
Future career possibilities	In case of the project success, the highly skilled engineer might continue his career on the EU fusion facilities, well implemented in the fusion community, with excellent knowledge and practical skills on: • Design of *in vacuo* devices for fusion facilities • Component engineering • Material properties • Understanding of magnetic, plasma, neutron and heat load environment in fusion devices Upon fulfilment of the project the trainee will in principle be capable to work for e.g. ITER diagnostic systems (still in progress), filling the potentially, critical gap in the project, strengthening the EU participation in the JT-60SA project and contributing to design of the EU DEMO components.

Project ID	**EEG23_P04**
Project Title	**EU enhancement projects for JT-60SA: Divertor VUV Spectrometer**
EUROfusion RO	Carlo Sozzi, WPSA PL Marco Valisa, WPSA SA-EP.A04-T003 Task Coordinator
Background Description of context	EUROfusion in collaboration with F4E is procuring a Vacuum Ultra Violet (VUV) imaging spectrometer for the observation of the divertor of the JT-60SA tokamak sited in Naka, Japan. The spectrometer views the target from a top port through a series of relay mirrors and can discriminate the spatial origin of the emitted radiation, so that events can be distinguished when occurring at the X point, inner or outer leg respectively. This state-of-art instrument consists of a double spectrometer, covering two different wavelength ranges, which altogether span from 10 to 125 nm, a region that includes resonant lines of the most common elements expected in the device. Assembly, alignment and calibration of the spectrometer will take place in Europe at the ENEA laboratories in Frascati in 2022-2023. Given the technical commonality to both ITER (Korean DA) and DEMO (EUROfusion WPDC) VUV systems, this work programme opens a broad range of future career developments.
Objectives to achieve during EEG	Successful assembly and installation of the VUV diagnostics in JT-60SA, including all the preliminary tests. Alignment and calibration before plasma operation, interface with the data acquisition system and with the machine control system. Successful operation of the VUV diagnostics and production of validated physics data.
High-level work description High level description of activities and/or assignments, scope and structure. Expected milestones and deliverables.	The grantee will assist the VUV Enhancement PL in interfacing with F4E and EUROfusion for the coordination of the project, working with QST (Naka) for management of interfaces and for collaborative efforts, joining the VUV team in the assembly, alignment and calibration of the spectrometer in Frascati. He/her will participate to the installation, commissioning and calibration of the system diagnostic at QST, initiating the system exploitation and plasma data production in collaboration with the VUV team and the Experiment Team of JT-60SA.

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Alignment-test in Europe	■					
Installation in JT-60SA		■	■			
Alignment, calibration in JT-60SA				■		
First system operation and data production					■	■

Gantt chart of high-level activities

Competences required before start of EEG (bullet points)

- Engineers with a Master or PhD, Physicists with Master or PhD and relevant experience in Engineering
- Previous experience in one or more of the following areas: spectroscopy, optics, light detection technology, vacuum, physics data analysis
- Communication skills, keen to team work, capability of autonomous work

Competence development during project (bullet points)

- Development of state-of-art knowledge in spectroscopy systems for high temperature plasma devices, experience in management of high technology, complex projects
- Hands-on experience in spectroscopy, optics, light detection technology, vacuum, physics data analysis in the environment of a tokamak as a nuclear device
- Development of the communication skills, attitude to team work in a multicultural environment for trailing-edge scientific objectives.

Facilities used Recommended, optional	Spectroscopy laboratory in ENEA Frascati. JT-60SA tokamak
Mobility needs Optional, suggested missions (up to candidate to propose)	ENEA Frascati (Italy) – about 2 months RFX Padova (Italy) – about 1 month QST Naka (Japan) – about 3 months
Future career possibilities Potential next career steps in fusion after this EEG traineeship: what could be roles/positions for a successful graduate	Responsible officer for spectroscopy laboratory or spectroscopy systems in a plasma device. Project responsible for development of spectroscopy instruments

Project ID	**EEG23_P05**
Project Title	**Control engineering grant for supporting the implementation of tokamak controllers on multiple devices.**
EUROfusion RO	WPTE is the leading work package for the EEG, but the coordination of this EEG may include inputs from other work package (from TSVVs for reduced models or PWIE) when algorithms are tested (on detachment for example). This project also requires a strong support from the local teams of each concerned devices.
Background	Real-time control is a high-priority research topic for preparing ITER operations and DEMO design, in particular in the area of advanced control integration (such as detachment control) and disruption avoidance. This requires implementation of advanced control solutions and testing them on various devices with different hardware (sensors and actuators). Currently, there are scarce resources to re-implement similar solutions across different devices having different control system implementations, which significantly slows down development and testing of control solutions. To reduce this effort, it is desired to have a common framework (across EUROfusion devices) that allows easy sharing of control algorithms. For example, Matlab/Simulink is a common tool for control algorithm development and simulation across different devices. Several WPTE devices (TCV, WEST, ASDEX Upgrade), support the use of Matlab/Simulink for code deployment, and this is currently also being explored for JET and ITER. The candidate will therefore work on various EUROfusion devices to promote control algorithm reusability. One or more specific algorithms will be ported from one device to another as part of this work. This work does not require new hardware on the target devices.
Objectives to be achieved during EEG	• Define implementation/coding standards to enable efficient sharing of real-time algorithms across various machines. • Develop methods to deploy control algorithm on various WPTE machines. • Port at least 1 algorithm from one machine to another using these methods. (algorithm to be determined, see below).

High-level work description

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Define standards for sharing real time algorithms						
Upgrade the capabilities and develop software methods on JET and ASDEX Upgrade						
Demonstrate the new method by porting one algorithm on several devices another device.						

Gantt chart of high-level activities

Competences required before start of EEG (bullet points)

- Master’s degree in engineering, specialisation on Software Engineering or equivalent (C, C++, Matlab/Simulink would be a plus)
- Knowledge in control engineering
- Good relation skills and motivation to work in an international environment in different places.

Competence development during project (bullet points)

- Development of controller framework on multiple platforms
- Control in a complex tokamak environment and interaction with ITER constraints.
- Development of young control engineer for the operation of next step devices.

Facilities used	TCV, AUG, JET, and possibly WEST, MAST-U
Mobility needs	Missions for establishing the platform and organizing the implementation procedure is needed, in particular in TCV, JET, and AUG. WEST is another target following recent discussions. The candidate will be involved in the implementation of the platform prior to the experimental campaign as well as the commissioning and tests on plasma when the campaign starts. Mobility will typically last one to three months, depending on the work. Mobility can be used outside of the experimental campaign and campaign funds during the actual campaign
Future career possibilities	The development and start of ITER operation in the years to come will demand more control engineer profiles for advanced control solutions of complex plant. In addition, these profiles are also demanded in the industries.

Project ID	**EEG23_P06**
Project Title	**Integral component design for W divertor in Wendelstein 7-X using novel technologies**
EUROfusion RO	Andreas Dinklage, WPW7X
Background Description of context	Wendelstein 7-X will start long pulse operation with the water-cooled CFC divertor in 2022. As a next development step, the high plasma performance with a first wall consisting of reactor relevant plasma facing materials needs to be demonstrated in order to prove that a stellarator is a viable concept for a fusion power plant. For this purpose, a EUROfusion funded project WPDIV-W7X started in 2021 to develop a W based target element for W7X, and in 2022 this project was integrated in the broader IPP project for the concept development of the entire water-cooled W divertor including target modules, baffles, and their adjacent plasma facing components also in cooperation with WPPWIE. The goal of the IPP project is to come up with a detailed plan and budget in 2026 for the series production and installation of a W divertor. The project includes qualification of target elements, target modules and baffles and a design of the adjacent components.
Objectives to achieve during EEG	The aim of the EEG is to make an integral component design of the W divertor for W7X in CATIA exploiting the benefits from latest developments in 3D design, plasma modelling and manufacturing technology. The component design is constrained by design technologies and the complex and narrow 3D installation space in the plasma vessel. It is anticipated that component manufacturing and installation can be significantly be simplified using 3D additive manufacturing technologies for stainless steel and Cu alloys (either SLM or DED). As an approach to shorten the design cycles, the integral design will be streamlined by tools that are currently being developed at IPP to parametrise the geometry and to automate the exchange of CAD design data with physics based models like EMC3/Eirene and DIVGAS which are used to predict heat loads and exhaust performance. This integrated approach directly addresses critical areas with high load conditions. The genuine 3D environment of W7-X provides an ideal background to foster capabilities that are transferable to the entire EU fusion program.
Work programme High level description of activities and/or assignments, scope and structure.	In the first phase, principle options for manufacturing and installation technologies for target modules and baffles have to be collected. For each technology, the resulting design constraints and pros and cons have to be evaluated. For this task, the EEG candidate collaborates closely with project engineers concerned with the manufacturing and installation technologies for divertor and baffles. In this first phase, also the need for further tool development to facilitate the exchange of data between CAD and physics based models is to be identified. In the second phase, a conceptual integral design is made for divertor modules and baffles based on the most viable technologies. The goal is to minimise the amount of manufacturing steps and use a plug and play kind of support system for installation. For this task, the EEG candidate collaborates closely with physicists in the project team of the W divertor dedicated to EMC3/Eirene and DIVGAS simulations. In this phase, the interaction between CAD and physics based models will be accelerated in collaboration with software engineers enhancing the necessary tools to exchange data between those programs. In the final phase, using those tools, the design will be optimised towards the ease of manufacturing and installation (preferably plug and play) at one side and overload prevention and exhaust performance at the other side.

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Phase 1:						
Investigation of viable manufacturing technologies						
Design constraints evaluation						
Requirements for data exchange CAD and EMC3 / DIVGAS						
Phase 2:						
Conceptual design of target modules and baffles						
Acceleration of design cycle						
Phase 3						
Integral design optimisation of target modules and baffles						
Installation concept of optimised design						

Gantt chart of high-level activities

Competences required before start (bullet points)

- Master in engineering, specialisation on mechanical engineering or equivalent
- Track record in CAD modelling,
- Interest in additive manufacturing technologies, python programming

Competence development during project (bullet points)

- Specialisation in parametric CAD design in CATIA
- Expertise in SLM and DED for UHV and water-cooled applications
- Skills in EMC3/Eirene, design of HHF components, plug and play support systems

Facilities used	None
Mobility needs	Frequent missions to the project team in IPP Greifswald
Future career prospects	DEMO or other fusion devices design team

Project ID	**EEG23_P07**
Project Title	**Developing analysis tools for the design of large-scale fusion magnets**
EUROfusion RO	Cesar Luongo, DCT

Background

Design of a fusion tokamak is a highly constrained problem, in which multiple conflicting requirements need to be taken into account in the context of minimizing cost and complexity. The design of the DEMO superconducting magnets, in particular, also presents the designer with multiple trade-offs (V. Corato et al., "Strategy for Developing the EU-DEMO Magnet System in the Concept Design Phase," *IEEE Trans. On Applied Superconductivity*, vol. **32**(6), 4201407, DOI: 10.1109/TASC.2022.3153249, 2022). This project will address this basic need to optimize trade-offs in the design of fusion magnets.

Objectives

The project will aim to develop the analytical tools needed to accurately and efficiently define the proper parameters to explore magnet design space in the definition of DEMO concept. It will do this while, in parallel, provide the training and exposure to what are the main considerations when designing large-scale superconducting magnets. In particular, the need to meet all mechanical (structural), thermal, and electrical (protection/insulation) requirements, while doing so with simple, manufacturable designs using readily available materials; in other words, while minimizing risk. The end result of this project will be the toolset to conduct such design analyses.

Work programme

The project will embed the candidate within the concept design effort for DEMO, in particular on a number of initiatives to explore alternatives to the baseline at either end of it: higher field, more compact tokamak; and lower aspect ratio, lower field, less complex magnets. Within these efforts, the intent is to develop and apply the analytical (FEM) tools to guide design decision-making. Three areas of emphasis for application of multi-physics FEM tools will be pursued under this project:

- Mechanical models that allow us to explore the viability of alternative structural concepts, in particular in the compact/high-field regime. The FEM models need to be capable to assess not only the structures (casing and connections for TF coils), but also the stress levels in the winding pack. It involves both electromagnetic and mechanical analysis
- In parallel, develop winding pack FEM models to study the possibility to have "dry" coils, in which the superconductor is not directly in contact with the coolant (helium), but cooling is done through a conduction path. This activity is relevant to study design space for magnets using LTS conductors in the low-field regime, or, HTS coils
- Develop the analytical tools to study the trade-off between coils manufacture/positioning tolerances and error fields, and explore design options for error field correction post-assembly (e.g., what capabilities the 3D coils need to have, or the optimal placement of small correction coils integrated to the TF coils to achieve such post-facto correction).

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Structural modelling of magnets for tokamaks	■	■	■	■		
Thermal modelling of dry winding packs		■	■	■	■	
Tolerance analysis, error fields, and correction methods				■	■	■

Gantt chart of project tasks

Competences required before start (bullet points)

- Master's degree in engineering
- Experience in the use of FEM codes or similar analytical tools, in particular for multi-physics design problems
- Excellent communication skills in English (verbal/written)

Competence development during project (bullet points)

- Specialisation in the analysis and design of superconducting magnets of size relevant to fusion
- Ability to understand trade-offs in the design of large magnets, and apply analysis techniques to drive design decisions
- Advanced skills in the solution of multi-physics problems in magnets or other electromechanical devices

Facilities used	N/A (standard office equipment)
Mobility needs	Frequent missions, for a total of up to 9 months over the EEG, to the DEMO Central Team located in Garching, Germany, and ability to travel at institutions involved in the development and testing of high-performance magnets
Future career prospects	The selected candidate will develop a set of magnet design skills that will allow them to continue on a career path as a magnet designer or magnet system integrator within a central fusion project; or easily transition to an industry in the area of superconducting magnet design and manufacturing. The selected candidate could also transition to become a system integrator on other complex electromechanical or cryogenic devices.

Project ID: **EEG23_P08**

Project Title: **Minimisation and Control of tritium in DEMO**

EUROfusion RO: Joelle Elbez-Uzan, DCT/WPSAE

Background
Description of context

Definition of tritium inventory is a key foundation to the whole safety demonstration of a fusion machine. Several phenomena contribute to establish tritium release in normal and accidental conditions. Despite huge efforts to develop and refine the source term, some major open questions remain to be addressed to propose tritium mobilisation. In particular, the outgassing rates must be investigated in several environmental conditions. Considering the DEMO breeding system, the determination of tritium inventory, permeation rates and mobilisation represent a domain with benefit to the whole fusion community.

Objectives
to achieve during EEG

Based on the existing results related to the build-up inventory in the different systems, the outgassing rates of tritium from material in DEMO, and generated dust during operation, the EEG will establish a reference document reflecting the results performed in that domain. He/she will get familiar with the tritium retention/ transport mechanisms and underlying modelling approaches used in the various systems including the associated uncertainties of the models and the material properties database used in the models. In a second phase, the EEG will propose the R&D actions required to fulfil the gaps for the establishment of the adsorption/permeation/outgassing values. In a third phase, the EEG will manage the R&D actions identified at phase two from an operational standpoint.

Work programme
High level description of activities and/or assignments, scope and structure.

Experience & Learning:

A key aspect of this EEG is an initial knowledge related to tritium physical and chemical properties, together with a knowledge of their entities regarding tritium. This knowledge should cover the way the tritium inventory will be produced in the breeding blankets, consumed in the plasma reaction, transported and transferred into the fuel cycle, and adsorbed/permeated/desorbed in various systems and components inside the facility. Therefore, the initial phase of the EEG will be dedicated in the learning of the basis of the T transport modelling. The goal is to get a better understanding of:

(i) the existing bibliography of tritium inventory definition,
(ii) the modelling tools existing for tritium inventory definition,
(iii) the experimental facilities working on tritium and deuterium, focusing on adsorption, permeation, and desorption of tritium,
(iv) the proposal of the adequate R&D needed to allow a full tritium inventory control.

Outputs:

- To support experience and learning, work will be allocated on the 'experience and learning placements' allowing the granted person to refine, train and acquire the adequate knowledge,
- A bibliography review of the existing literature regarding tritium physical and chemical phenomena for fusion purposes will allow to assess the relevant parameters need to propose a tritium inventory control inside the facility; this bibliography will cover both the studies, experiments and modelling tools used to assess tritium inventory in various components and systems.
- A proposal of further R&D will be proposed with ranking properties and a list of experimental facilities from where the R&D can be performed.

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Tritium learning	■					
Tritium studies Bibliography		■	■			
Tritium tools and facilities bibliography			■			
R&D tritium proposals				■		
DEMO report Delivery					■	■

Gantt chart of high-level activities

Competences required before start

- Master's degree in engineering
- Track record in:
  - Safety engineering and assessments
  - Chemical engineering
  - Tritium knowledge (e.g., transport physics and modelling)
- Skilled in working with and connecting people of different technical disciplines
- Excellent communication skills in English (verbal/written)

Competence development during project

- Specialisation in chemical process engineering for tritium
- Expertise in the physical phenomena associated with tritium
- Knowledge on the regulatory requirements related to plant with Tritium

Facilities used: Relevant facilities in various Research Units (e.g. TRIEX-II and HYPER-QUARCH II facilities at ENEA Brasimone R.C., CLIPPER facility at CIEMAT, training at Tritium Laboratory Karlsruhe (Germany))

Mobility needs: Frequent short visits at the DCT in the PMU of Garching, research units hosting T/D facilities.

Future career prospects
Potential next career steps in fusion after this EEG traineeship

This is an area of high priority in fusion where there is a shortage of skills.
Expert for joining design and/or operation teams aiming at the realisation of D-T fusion systems.
Attractive opportunities at European and International Research and Development Institutions working on fusion.

Project ID	**EEG23_P09**
Project Title	**DEMO RAMI Analyses**
EUROfusion RO	David Maisonnier, DCT

Background
Description of context

DEMO will be a prototype of fusion reactor designed to prove capability to produce electrical power in a commercially acceptable way. Key elements of any engineering development of the reactor include the definition of reliability and availability requirements (or targets), reliability and availability analysis, reliability testing, and "reliability growth". The latter refers to the structured process of finding root causes for reliability problems and predicting and monitoring the increase of system's reliability through successive phases.
Since reliability and availability are strictly related to maintenance and inspection activities performed on the plant during the operating phases, the integrated approach in reliability and availability optimization is based on the four issues: Reliability, Availability, Maintainability and Inspectability (RAMI).
A multitude of factors are important to achieve a satisfying RAMI level: design of systems; manufacturing quality; operational environment; design and development of the support systems; level of training and skills of the people operating and maintaining the system; maintenance procedures; availability of spare parts for system repairs; and the diagnostic aids and tools (instrumentation) available to check system processes and capability to detect normal and abnormal operating parameters. All these factors must be understood to achieve a plant with a desired level of RAMI.

Objectives
to achieve during EEG

This EEG will perform RAMI analyses of DEMO systems, particularly critical from a RAMI and safety point of view because of their complexity, the challenging operation conditions and/or of their safety functions. The RAMI analyses will provide indications on the possible design improvements in order to reach an acceptable RAMI target for the overall DEMO, meeting the safety requirements. The grantee, in developing the analysis process required for DEMO, will work with RAMI and nuclear safety specialists in the DEMO Central Team (DCT) and with other specialists in the labs that will host the grantee. In the labs, the grantee will be supported by RAMI and safety expert specialists able to do the necessary tutoring and / or collaborate in the required analyses.

Work programme
High level description of activities and/or assignments, scope and structure.

During the Concept Design Phase, the most important activity on RAMI is to understand the rationale of the plant, the related functions, requirements and constraints for the different systems. During plant development, the most important RAMI activity is to identify potential failure mechanisms and to make design changes to remove them or to mitigate consequences of the failures. During realization and installation, the most important RAMI activity is to ensure quality in manufacturing so that the inherent RAMI qualities of the design are not degraded. Finally, in operations and support, the most important RAMI activity is to monitor performance in order to facilitate retention of RAMI capability, to enable improvements in design (if new plant upgrading will be foreseen), or of the support system (including the support concept, spare parts storage, etc.).
Interim and final reports on the work carried out will be written by the grantee. The work may also be presented at international fusion conferences and papers published in their proceedings. Attendance a two/three such conferences in the course of the grant will also give the grantee valuable exposure to the broader world of scientific and engineering research for fusion power.

Months:	1-6	7-12	13-18	19-24	25-30	31-36
In-depth study of DEMO system design, selection of systems to analyse and identification of functional breakdown	■					
Functional analyses by IDEFØ diagrams and Failure Mode and Effect Analysis (FMEA) of the systems selected		■	■			
Identification and/or collection of statistical data to use in RAMI analyses, recording data into the Fusion Component Failure Rate Data Base (FCFRDB)		■	■	■	■	■
Reliability Block Diagram (RBD) analyses on systems selected			■	■		
Review of the analyses carried out in the first two years and/or analyses of other systems not yet analysed					■	■

Gantt chart of high-level activities

Competences required before start (bullet points)

- Engineers holding a master's degree
- Skilled in working with and connecting people of different technical disciplines
- Excellent communication skills in English (verbal/written)

Competence development during project (bullet points)

- Knowledge of fusion systems and aspects of the DEMO design
- Knowledge of nuclear reliability and safety issues
- Skill in functional analysis
- Skill in scientific/engineering computing
- Specialisation in RAMI analyses

Facilities used	Not applicable
Mobility needs	Frequent short visit to the DEMO Central Team and at Research Units involved in the design and development of DEMO systems for a total less than 12 months.
Future career prospects Potential next career steps in fusion after this EEG traineeship	RAMI analyses shall be applied in all the complex systems in nuclear fusion. The know-how acquired during the grant can certainly be utilised in the future within nuclear fusion activities but also in many other high-tech industrial sectors.

Project ID	**EEG23_P10**
Project Title	**DEMO Systems code modeller**
EUROfusion RO	Matti Coleman, DCT

Background
Description of context

As part of systems code development activities, EUROfusion is leading the development of BLUEMIRA, a new, open-source fusion reactor design tool. BLUEMIRA combines the 0/1-D systems code PROCESS, with the 1.5-D transport and fixed boundary equilibrium PLASMOD, 2-D fixed and free boundary equilibrium solvers and optimisation procedures, 3-D CAD generation, and more. The idea is to be able to rapidly design DEMO reactors from scratch to a reasonable level of fidelity.

Quite a few additional pieces of functionality (solvers, optimisation problems, etc.) are required to deliver the planned set of capabilities, with many more beneficial capabilities also envisaged.

Background reading:

- Franza et al., “MIRA: a multi-physics approach to designing a fusion power plant”, accepted in Nucl. Fus., 2022, https://iopscience.iop.org/article/10.1088/1741-4326/ac6433/pdf
- Coleman and Mcintosh, “BLUEPRINT: A novel approach to fusion reactor design”, Fus. Eng. Des., 2019, https://scientific-publications.ukaea.uk/wp-content/uploads/1-S2-0-S0920379618308019-MAIN.PDF
- Coleman and McIntosh, “The design and optimisation of tokamak poloidal field systems in the BLUEPRINT framework”, Fus. Eng. Des, 2020, https://www.sciencedirect.com/science/article/abs/pii/S0920379620300922?via%3Dihub
- Albanese et al., “Optimization of the PF coil system in axisymmetric fusion devices”, Fus. Eng. Des., 2018, https://www.sciencedirect.com/science/article/pii/S0920379618305246?via%3Dihub
- Lazarus et al., “Control of the vertical instability in tokamaks “, Nucl. Fus. 1990, https://iopscience.iop.org/article/10.1088/0029-5515/30/1/010/pdf
- Portone, “The stability margin of elongated plasmas”, Nucl. Fus., 2005, https://iopscience.iop.org/article/10.1088/0029-5515/45/8/021/pdf

Objectives
to achieve during EEG

The overarching objective of this EEG is to support the implementation of the BLUEMIRA reactor design tool, with a particular focus on plasma equilibrium and magnetostatics aspects.

During this EEG, the successful candidate will:

- Engage actively with the core development team of BLUEMIRA
- Make wide-ranging contributions to the open-source BLUEMIRA code
- Support the WPDES team by performing studies of the EU-DEMO reactor design space using BLUEMIRA

The nature of the studies will be dictated by the specific aspect of priorities of the DEMO design and will vary, but a strong emphasis will be placed on toroidal field and poloidal field system design.

Work programme
High level description of activities and/or assignments, scope and structure.

The work programme should include some key activities:

- Implement a model to estimate the passive vertical stability of plasmas due to the presence of passive conducting structures
- Improve the BLUEMIRA magnetostatics module, e.g. by adding ferromagnetic materials
- Improve the BLUEMIRA equilibrium module, e.g. by adding optimisation constraints or changing the iteration scheme.
- Add and/or modify design optimisation problems for EU-DEMO in BLUEMIRA, e.g. by modifying the TF coil shape optimisation problem to include the optimisation of ferritic inserts to meet a specified TF ripple constraint
- Implement automatic generation of a 3-D finite element model of the magnet coil cage from the generated CAD models and boundary/load conditions using BLUEMIRA's interface to Fenics
- Parameterise alternative EU-DEMO reactor options in BLUEMIRA, e.g. negative triangularity, alternative in-vessel segmentations.

Months:	1-3	7-12	13-18	19-24	25-30	31-36
Training in BLUEMIRA, literature review	■					
Implementation of a vertical stability model in BLUEMIRA		■	■			
Improvements of magnetostatics and equilibria modules			■	■	■	
Development of aspects of the EU-DEMO design workflow			■	■	■	
Reactor design studies					■	■

Gantt chart of high-level activities

<table>
<tr><td colspan="2">Competences required before start (bullet points)

• Master in Engineering
• Track record in:
  o Innovation
  o Complex problem-solving
  o Design optimisation
  o Plasma equilibria
  o Finite element method
• Skilled in:
  o Python
  o Linux
  o Git
  o Scientific programming
• Excellent communication skills in English (verbal/written)</td><td>Competence development during project (bullet points)

• Expertise in:
  o Plasma equilibria
  o Magnetostatics
  o Finite element method
  o Tokamak design
• Advanced skills in:
  o Design optimisation
  o Software engineering</td></tr>
<tr><td>Facilities used</td><td colspan="2">Linux computer</td></tr>
<tr><td>Mobility needs</td><td colspan="2">Frequent periodic visits at PMU Garching, a maximum of 9 months over the 3 year EEG period.</td></tr>
<tr><td>Future career prospects
Potential next career steps in fusion after this EEG traineeship</td><td colspan="2">After this traineeship, the successful candidate could:
• work in fusion reactor systems codes
• work in fusion reactor magnet system design
• work on tasks in WPDES
• work as a research software engineer</td></tr>
</table>

Project ID	**EEG23_P11**
Project Title	**Development of control and simulation tools for the design and optimization of DEMO and DTT scenarios**
EUROfusion RO	Mattia Siccinio, DCT
Background Description of context	The design of scenarios for future tokamaks requires simulation tools able to accurately take into account closed loop control. Also, the definition of new scenarios requires the availability of open loop optimization procedures and closed loop control algorithms, to deal with constraints and limitations starting from the early design phase. Different simulators have been developed in the past decades for this purpose. These are typically composed of a free boundary Grad Shafranov solver, a transport solver plus controllers [1÷3]. However, none of the tools developed is acknowledged as a robust solution by the scientific community. In this perspective, preliminary work has been carried out on ASTRA-SPIDER code coupled with CREATE controllers [4] to simulate DEMO scenarios. This flight simulator is the starting point for the present EEG. [1] Parail V. et al. (2013) Nuclear Fusion, 53 (11) [2] Besseghir K. et al. (2013) Plasma Physics and Controlled Fusion, 55 (12) [3] Kessel C.E. et al. (2007) Nuclear Fusion, 47 (9) [4] Frattolillo D. et al. "Development of Magnetic Control for the EU-DEMO flight simulator and application to Transient Phenomena" Submitted to SOFT 2022, on Eurofusion Pinboard FTD-DCT, 0.WPTRED, 31884 [5] Mattei M. et al. (2013) Automatica, 49 (1) [6] di Grazia L.E. et al. (2022) Fusion Engineering and Design, 176 (1) [7] Tartaglione D. et al., Plasma magnetic control for DEMO tokamak using MPC, submitted to SOFT 2022, on Eurofusion Pinboard FTD-WPDC, 31384 [8] Walker M.L. et al. (2014) Fusion Engineering and Design, 89 (5)
Objectives to achieve during EEG	The main objective of the EEG is to implement novel control solutions in an integrated simulation environment, including closed loop magnetic and kinetic control, with applications to DEMO and DTT scenarios. Three main lines of activities will be developed. 1. Constrained magnetic model based control. Tokamak control has to be ensured also during fast transients. To this purpose, Model Based Predictive Control (MBPC) solutions will be explored [5, 6, 7] and implemented, and compared with more “classical” solutions. 2. The possibility to integrate magnetic control with other control functions, like kinetic control, will be explored. Supervisory model-based controllers will be designed and tested. 3. Scenario simulations. Relevant DEMO and DTT scenarios will be optimized with the developed functions. This can require the definition of synthetic diagnostics.
Work programme High level description of activities and/or assignments, scope and structure.	The activities are organized in three main phases plus a dissemination one. • Phase 01. Implementation of constrained control techniques on the ASTRA-SPIDER Simulator. Plasma position, shape and current control will be implemented on the basis of a voltage driven control scheme in parallel with a suitable vertical stabilization controller. This will be done under the PCSSP [8] environment. The proposed control techniques will be implemented both for DEMO and DTT. A period of eight months will consist of work under the supervision of a CREATE tutor to elaborate the optimal control strategy, whereas a period of four months will be supervised by an IPP tutor to include the control strategy in the ASTRA/SPIDER dynamic simulator. Part of both periods shall be in person in Naples (IT) and Garching (DE), respectively (see below). • Phase 02. Definition of Scenarios on DEMO and DTT. Six months will be supervised by the IPP tutor, two months by the DTT tutor to define DEMO and DTT scenarios of interest, and four months with a CREATE tutor to evaluate specific control laws adjustments for the proposed scenarios. Part of this period shall be in person in Frascati (IT), see below. • Phase 03. Integrated control and specific support functions. The possibility to adopt supervisory MPC control to integrate different kind of controllers will be implemented both for DEMO and DTT. In particular kinetic control will be considered for DEMO and heat load control for DTT. Four+two months will be spent under IPP and DTT tutor supervision respectively, and six months under CREATE tutor supervision for integrated control design. Candidate tutors for CREATE, IPP and DTT are Prof. Massimiliano Mattei, Dr. Emiliano Fable and Prof. Roberto Ambrosino, respectively.

Gantt chart of high-level activities

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Phase 01 – Development and implementation of constrained control techniques in ASTRA/SPIDER under PCSSP Preliminary tests on DEMO and DTT.	■	■	■	■		
Phase 02 – Definition of DEMO and DTT relevant Scenarios		■	■	■		
Phase 03 – Integrated Control				■	■	■
Phase 04 – Dissemination						■

Competences required before start (bullet points)

- Scientists with an MSc or PhD in Engineering
- Advanced skills in Magnetic Control Design and in particular on constrained model based control design
- Capability to simulate closed loop plasma scenario evolutions including magnetic control
- Excellent communication skills in English (verbal/written)

Competence development during project (bullet points)

- Scenario design and simulation for large tokamaks
- Integrated control
- Use of DEMO/DTT/ITER simulation tools and infrastructures

Facilities used

EUROfusion high performance computational facilities. Involvement in dedicated experiments desirable, but not essential.

Mobility needs

An amount of 8 months is then requested for mobilities:

- 3 months in Naples (IT) at Consorzio CREATE
- 3 months at PMU Garching and IPP Garching (D)
- 2 months in Frascati ENEA (IT)

In case the candidate belongs to one of those associations, the corresponding allocated mobility could be employed for a longer stay in the other laboratories involved. The remaining part of the mentoring is anyway assumed to happen remotely, under the coordination of EUROfusion RO.

Future career prospects

Potential next career steps in fusion after this EEG traineeship

- Control design engineer in ITER or DTT or in other European or International Tokamaks
- Expert in design of plasma scenarios
- Expert in control integration and assessment

Project ID

EEG23_P12

Project Title

Tritium permeation and retention in DEMO in-Vessel Components

EUROfusion RO

Rudolf Neu, DCT

Background
Description of context

Tritium self-sufficiency presents a critical engineering challenge for DEMO, requiring efficient breeding and extraction systems, as well as minimizing tritium losses to the surrounding systems, such as plasma-facing components, vacuum vessel, cooling system, etc. Structural and plasma-facing components will act as a tritium sink, as tritium will be accumulated at defects in the bulk of these components and may permeate into the cooling system. Therefore, modeling of tritium retention and permeation in these components is required for the engineering designs of the tritium breeding and safety systems. However, the required material parameters for performing these calculations still have large uncertainties. Therefore, a combination of laboratory studies and extrapolation by modeling is needed to make reliable predictions for DEMO.

Objectives
to achieve during EEG

The objective of this EEG program is to improve the material database on trap formation and tritium trapping in DEMO divertor, limiter and first wall materials and to use this database as input for computer simulations to make predictions for DEMO. To extend the material database laboratory experiments are foreseen investigating the formation of traps in DEMO divertor, limiter and first wall materials due to displacement damage and He accumulation. The results of these experiments are then modeled by state-of-the-art diffusion trapping codes to validate the input parameter assumptions and to benchmark the code. The validated modeling tools can then be used to make predictions for DEMO conditions.

High-level work description
High level description of activities and/or assignments, scope and structure.

Activity 01 : Experiments on Influence of He on retention in displacement damaged EUROFER (10 months)
Activity 02 : Modelling of results from activity 01 (4 months)
Activity 03 : Experiments on the evolution of trap sites with temperature w/wo the presence of He (10 months)
Activity 04 : Modelling of results from activity 02 (4 months)
Activity 05 : Modelling predictions for DEMO (8 months)

Months:	1-10	10-14	14-24	24-28	28-36
Activity 01	■				
Activity 02		■			
Activity 03			■		
Activity 04				■	
Activity 05					■

Gantt chart of high-level activities

Competences required before start (bullet points)

Candidate with a pronounced taste for experimentation and numerical modelling/simulation for technological application.
Master's degree in engineering with skills in the following fields:

- Ion solid interaction
- Vacuum science and technology
- Modelling and numerical simulation
- Programming ability in Python and/or Mathematica
- Excellent communication skills in English (verbal/written)

Competence development during project (bullet points)

- Bridge-Building between fusion physics / engineering
- Expert knowledge on experiments / modelling on reactor relevant H transport and storage in wall materials
- Strengthening of scientific/engineering profile (autonomy, versatility)

Facilities used

High current ion beam facility/high intensity plasm source, Accelerator, H Permeation Facility, Thermal Desorption Set-Up

Mobility needs

Visits to Research Units where facilities are used

Future career prospects
Potential next career steps in fusion after this EEG traineeship

Expert for tritium transport in wall materials at ITER or in the DEMO design team or in other International Institutions dealing with the realisation of D-T fusion systems.
This is an area of high priority in fusion where there is a shortage of skills.

Project ID: **EEG23_P13**

Project Title: **RAMI for IFMIF-DONES**

EUROfusion RO: Angel Ibarra (WPENS)

Background
Description of context

The goal of DEMO Oriented NEutron Source (DONES) is to irradiate fusion materials in a simulated fusion irradiation environment. To be able to carry out the experiments in a reasonable period of time, a 70% of operational availability was established as a basic target for DONES facility design, making RAMI analysis one of the key elements on the engineering development and operation of the facility.
Many different factors are important and must be properly understood and evaluated to achieve a satisfying RAMI level going from the systems design, components qualification, identification failure mechanism or mitigation measurements. RAMI is also very relevant for safety evaluation.

Objectives
to achieve during EEG

Key objective to be developed during the training can be summarized in the development of a good knowledge on RAMI techniques used in fusion and other big-science facilities in such a way that later on the grantee can take some responsibility on some aspects related to RAMI of a fusion facility. This requires to became familiar with the RAMI databases, their characteristics and how they can be improved with time as well as to understand the different topics to which RAMI techniques can be applied (for example, safety evaluation, operation and maintenance of a facility or design improvement)

High-level work description
High level description of activities and/or assignments, scope and structure.

A close interaction with the DONES team is foreseen. Work to be developed along the time can be summarized in the following subtasks:

1) To develop a good knowledge on RAMI techniques used in fusion and other big-science facilities (including theory and software tools)
2) To be familiar with the RAMI failure databases with special emphasis in the one used for DONES RAMI evaluation, to develop a systemic work in order to identify missing data and to identify if data coming from the LIPAc facility can be used for the improvement of the database
3) To develop a specific analysis of the Accelerator section of the DONES facility both from the availability point of view as well as from the safety point of view in order to identify if both aspects can be improved by some design changes

Months:	1-6	7-12	13-18	19-24	25-30	31-36
RAMI theory and practise on RAMI software tools, knowledge on DONES project	xxxxx	xxxxx				
Review of available DONES RAMI studies	xx	xxxxx				
Review and Update of DONES RAMI database		xx	xx	xx	xx	xx
RAMI evaluation of DONES Accelerator Systems		xxxxx	xxxxx	xxxx		
Fault Tree analysis for Safety for Accelerator-relevant events				xxxxx	xxxxx	xxxxx

Gantt chart of high-level activities

Competences required before start of EEG (bullet points)

- University degree in Engineering
- Competent in scientific/engineering computing, with capability of setting up complex computer models.
- Excellent communication skills in English (verbal/written)

Competence development during project (bullet points)

- RAMI expertise for big-science facilities
- Nuclear reliability and safety expertise
- DONES facility knowledge and all related technologies
- Ability to integrate into an international and multicultural environment
- Good organisational skills and ability to work under pressure.

Facilities used
Recommended, optional

LIPAc (IFMIF/EVEDA prototype accelerator located in Rokkasho), if possible
Computer facilities at the hosting RU

Mobility needs
Optional, suggested missions (up to candidate to propose)

Short stays in Rokkasho (Japan), ENEA (Italy), Granada (Spain)

Future career possibilities
Potential next career steps in fusion after this EEG traineeship

The know-how acquired during the grant can certainly be utilised in the future within nuclear fusion activities but also in many other high-tech industrial sectors.
Possible future involvement in the realisation of the DONES facility.

Project ID	**EEG23_P14**
Project Title	**Breeding Blanket Engineer to aid component experimental testing and qualification**
EUROfusion RO	Lorenzo Virgilio Boccaccini, WPBB

Background
Description of context

The development of the Breeding Blanket design for DEMO requires the execution of experimental activities for testing and qualifying system and components at the intended operational conditions; this activity can be extended to the development of ITER Test Blanket System (TBS). The existing (HELOKA, KIT) and newly developed facilities (WL and LIFUS5/Mod4 loops in ENEA) will have twofold capabilities:
1) Investigating the design features and performances of scaled down or portion of DEMO breeding blanket components.
2) Simulating/reproducing the coolant systems for the ITER TBS, with the potential for the upgrade to full-scale plant simulator, to support the engineering design phases, safety analysis, licensing and the connected code validation activities.

Objectives
to achieve during EEG

The Grantee will develop skills in the design of experimental test sections and complex systems, as well as skills in the fields of thermal-hydraulics and thermo-mechanics, thanks to participation in construction/upgrading and operation phases of the experimental facilities. They will also acquire competences as professional experimentalist, which are extremely important because rare in research institutions and connected with "real" technology.
These skills will be achieved contributing to the following main tasks' objectives of primary importance for the BB of DEMO (and if possible, to extend them to TBM of ITER):

i) design of test sections, including the part related to the instrumentation and the acquisition systems;
ii) design of the experimental tests, i.e., procedures of test executions;
iii) execution of testing and data analyses.

High-level work description
High level description of activities and/or assignments, scope and structure. Expected milestones and deliverables.

During the EEG, it is expected that the candidate will:

- work in close cooperation with the BB design teams in order to gain experience and familiarity with the different systems, available data and already existing experimental infrastructures
- acquire familiarity with BB design issues in order to identify the main needs and phenomena to be investigated in the experimental campaigns
- optional: extend this activity including the TBM exchanging information with F4E in order to evaluate and to ensure the suitability of the requirements of the experimental infrastructure design
- identify the interfaces between the different facilities and test sections
- with particular regard to the test section reproducing a First Wall (FW) of Breeding Zone (BZ) mock-up, learn fundamentals of the specific heater systems, e.g. of vacuum systems working with an Electron Beam (EB)
- select and implement the most appropriate sensors and diagnostics for measuring the relevant parameters for the experimental campaign focused on the FW or BZ.
- support the design and commissioning phases of the mock-up and its related experimental campaign
- elaborate raw data collected from experimental tests, write reports describing the experiments and validate numerical models adopted in codes

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Collection of existing data on the BB design	■					
Definition of experimental needs and requirements of the test section(s), as well as the different interfaces	■					
Set-up of a first draft of the test section, including heater system and the appropriate instrumentation		■	■			
Definition of the experimental test matrix				■		
Support to the mock-up commissioning phase				■	■	
Support and execution of the experimental campaign				■	■	
Data elaboration and code validation					■	■

Gantt chart of high-level activities

Competences required before start of EEG (bullet points)

- Master's degree in Engineering
- Track record in thermo-fluid-dynamics or thermo-mechanical analysis (water, gas or liquid metal)
- Skilled with FEM and/or TH codes
- Excellent communication skills in English (verbal/written)
- Excellent communication skills and attitude to work in multi-disciplinary groups

Competence development during project (bullet points)

- Specialisation in design of systems and components (i.e., experimental facility and mock-up) and use of design software
- Expertise in design, execution, and analyses of experimental tests
- Acquisition of competences in instrumentation and process control technology
- Advanced skills in teamwork

Facilities used Recommended, optional	W-HYDRA platform at ENEA Brasimone Research Centre, with particular focus on Water Loop and LIFUS5/Mod4 experimental facilities (PbLi loop). HELOKA platform in KIT for testing of Helium cooling technology.
Mobility needs Optional, suggested missions (up to candidate to propose)	Short visits to European Institutions (e.g., ENEA Brasimone, KIT, etc).
Future career possibilities Potential next career steps in fusion after this EEG traineeship	The Grantee will become experienced engineer in design and experimental activities with a focus on BB technologies. The Candidate will have the chance to participate in the construction/upgrading and operation of an experimental facility. The Candidate will have excellent perspective to continue their career in both research institutions and industry.

Project ID	**EEG23_P15**
Project Title	**EC System Mechanical Design**
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Background
Description of context

The present baseline heating technology for all plasma phases of DEMO is Electron Cyclotron Wave (ECW), with a total need of 130 MW to fulfil the various functions: break-down, ramp-up assist, plasma core heating, neo-classical tearing modes (NTM) stabilization, mitigation of the thermal instability (TI), ramp-down assist. Initial RAMI analyses indicate that an installed power of the order of 216 MW (108 Gyrotrons with a unit power of 2 MW, occupying 6 equatorial ports) is needed to ensure a high reliability. During Horizon 2020, a pre-concept design was produced. The ECW system for DEMO is now entering into the Concept Design Phase during which the design will be refined, with particular care given to the integration issues, but also to the compliance with the loads imposed on the system, such as nuclear and electromagnetic radiation, electromagnetic forces, remote handling and safety considerations.

Objectives
to achieve during EEG

The main objective of the EEG is to train a young engineer in the various aspects related to the design of an ECW launcher, in view of giving them a broad background on the subject matter. This naturally encompasses mechanical design aspects, to be completed with the development of skills in other domains such as the microwave optical design and waveguide design, cooling design, assembly and welding procedures, irradiated materials, remote handling, nuclear safety, etc. Having developed competences in all these domains, the trainee will then become a key element to ensure the coherence of the launcher conceptual design and the compliance with the loads.

High-level work description
High level description of activities and/or assignments, scope and structure. Expected milestones and deliverables.

The trainee is expected to have a background in mechanical design. The project will be articulated around three series of activities:

1. The first activity is to get familiar with the pre-concept design of the ECW system, from the gyrotron building to the launcher, for which they will visit the involved institutes (CNR, KIT, SPC).
2. The second activity will consist in developing the EEG's skills in the domains that determine the loads, by means of interactions with work packages of interest (e.g., WPBB, the work package on the breeding blankets, for neutronics, PSD, the Plasma System Division for electromagnetic loads, WPRM, the work package on remote maintenance/handling, WPSAE, the work package on safety and environment).
3. They will then further specialise in aspects that are more specific to a launcher design able to withstand the loads, such as the selection of materials, the selection of technical solutions, e.g., for the assembly of the mirrors or for the mirrors steering mechanisms if any, and the cooling of the launcher components.

At the end of the EEG training, the candidate will have acquired a broad spectrum of knowledge and will be a key element in the evolution of the ECW system design.

Months:	1-6	7-12	13-18	19-24	25-30	31-36
Familiarisation with ECW pre-conceptual design and software tools						
Loads determinations. *Milestone M1: Report on the review of the loads on the ECW system*				*M1		
Milestone M2: *Report on materials, technologies and processes applicable to the ECW system design.*						*M2

Gantt chart of high-level activities

Competences required before start of EEG (bullet points)

- Master or PhD degree in engineering
- Some experience in CAD software (e.g., CATIA) and/or Multiphysics modelling software (e.g., ANSYS, COMSOL) would be a plus.
- Interpersonal and communications skills. Teamwork.
- Excellent communication skills in English (verbal/written)

Competence development during project (bullet points)

- The trainee will develop a broadband spectrum of knowledge and expertise in various domains, such as optical design, electrodynamics, physical and mechanical properties of irradiated materials, material science, cooling technology etc.
- The trainee will get used to the use of Multiphysics academic and/or commercial software. They will gain experience in the analysis of a complex system under many aspects.
- The trainee will develop their presentation skills and ability to discuss and work with experts in various domains.

Facilities used	None
Mobility needs	Missions to various institutes in Europe (e.g., SPC, CNR, KIT, etc.) are foreseen
Future career possibilities	The type of profile that will be developed during the EEG training period is highly needed, at least within WPHCD, and difficult to find. A successful trainee would then have good chances to get a position in which his/her talents will be exploited.