Annex 1
EUROfusion Engineering Grants 2015
List of positions

1 PLASMA-FACING MATERIALS & COMPONENTS AND DIAGNOSTICS FOR PLASMA-WALL INTERACTION STUDIES

1.1 Materials, ex-situ material studies, PFC and wall probes engineering and testing

Position ref. EEG-2015/01
Contact Person: Marek Rubel rubel@kth.se

Job Description:

The successful candidate will work in an interdisciplinary field encompassing fusion-related material science & technology, engineering of PFC and wall diagnostics (spectroscopy and wall probes) for global characterisation for the quantitative assessment of life-time and fuel accumulation. The work can be divided into two main areas.
PFC engineering:

- component design, fabrication processes, testing methods and assessment of results, QA of PFC, modelling of components with respect e.g. to active cooling, neutron activation. Handling of contaminated materials will be strongly addressed.

Global characterisation:

- practical material research techniques (microscopy/metallography, ion, electron and X-ray techniques): capabilities and limitations. Fuel accumulation determination with background on hydrogen in materials: surface and global contents of deuterium and tritium.

EUROfusion Work Packages involved: WPJET2, WPPFC, WPMST1
Facilities to be used:

- *JET, AUG, WEST, and other machines where a direct insight into practical aspects of experimental procedures can be gained. Connection to W7-X to be established in order to prepare PSI studies in near future.*
- *Linear machines for Plasma Wall Interaction (PWI) studies: PSI-2, Pilot-PSI, Magnum-PSI*
- *High Heat Flux facilities: JUDITH-1 and JUDITH-2*
- *Laboratories for handling contaminated materials: Be Handling Facility at JET, hot cells (FZJ) and accelerators (VR, IST)*
- *Optical and laser laboratories*
- *Material research laboratories: e.g. microscopy, ion beam analysis methods, mechanical testing*

1.2 Spectroscopy, imaging techniques and electrical probes

Position ref. EEG-2015/02
Contact Person: Marek Rubel rubel@kth.se

Job Description:

The successful candidate will work in an interdisciplinary field encompassing fusion-related material science & technology, engineering of PFC and wall diagnostics (spectroscopy and wall probes) for global characterisation for the quantitative assessment of life-time and fuel accumulation.
In the first part we aim in optical engineering of spectroscopic systems in linear devices to allow measurement in the UV and VIS in order to characterise plasma conditions and PSI processes. This requires 3D reconstruction (tomography) via optical techniques to describe the (symmetric) emission at the target plate and emission in the plasma. This provides vital input in modelling of plasmas and verification of codes (e.g. SOLPS/EMC3-EIRENE) to be used at linear plasmas, tokamaks and stellarators. In the second part of the work the capabilities should be extended to the complex W7-X divertor where similar plasma conditions, but in a complex 3D structure, are expected.
The system shall include filtering systems to discriminate the different species. Overlap in the development of laser-based optical systems for plasma characterisation is foreseen.

EUROfusion Work Packages involved: WPJET2, WPPFC, WPMST1, WPS1?
Facilities to be used:

- *JET, AUG, W7-X, and other machines where a direct insight into practical aspects of experimental procedures can be gained. Connection to W7-X to be established in order to prepare PSI studies in near future.*
- *Linear machines for PWI studies: PSI-2, Pilot-PSI, Magnum-PSI*
- *High Heat Flux facilities: JUDITH-1 and JUDITH-2*
- *Laboratories for handling contaminated materials: Be Handling Facility at JET, hot cells (FZJ) and accelerators (VR, IST)*
- *Optical and laser laboratories*
- *Material research laboratories: e.g. microscopy, ion beam analysis methods, mechanical testing*

2 REAL-TIME CONTROL OF FUSION PLASMAS

Position ref. EEG-2015/03
Contact person: Stefano Coda Stefano.coda@epfl.ch

Job Description:

The successful candidate will work at the crucial intersection between fusion-oriented plasma physics and control engineering, with close connection to tokamak operation, to develop control strategies and concrete controllers applicable to a fusion reactor.
It is expected that the candidate will become familiar with existing control schemes and with the underlying control architectures in use at the main host facility and at EUROfusion facilities involved in the project. Initially, the primary focus should be on developing methods to avoid or mitigate disruptions, which pose the highest risk for ITER operation. An effective and robust system for disruption prediction still eludes the fusion community. Database building and analysis, using data from multiple devices, will be necessary to develop tools for disruption prediction based on physics and empirical scaling laws. Implementation and testing on one or more fusion devices will ensue. A key objective will be to generate a confident extrapolation to ITER. Additional control problems can be tackled in turn, depending on the candidate's inclination, and with a view to move towards simultaneous and integrated control of several key quantities. In particular, control strategies aimed at extending tokamaks' operational limits (high current, high density, high beta, high elongation) and/or to attain particular regimes (detachment, mitigated-ELM H-modes, novel high-confinement regimes, etc.) should be preferred. These can include vertical stability, NTM, sawtooth, ELM, radiation, and plasma configuration control.

EUROfusion Work Packages involved: WPMST1, WPJET1, WPSA, WPDC
Facilities to be used:

- *TCV as the primary host facility*
- *AUG, MAST-U, and/or JET for further applications and cross-device comparisons*
- *JT-60SA for eventual application to a next-generation device*

3 SOFTWARE DEVELOPMENT ENGINEER TO BUILD A COMMON INTERFACE BETWEEN FUSION PHYSICS MODELLING CODES AND CAD MODELS

Position ref. EEG-2015/04
Contact person: Hendrik Meyer Hendrik.meyer@ccfe.ac.uk

Job Description:

The successful applicant would develop and implement software to enable the easy transfer of machine CAD data into physics modelling codes used within the fusion community. Many such codes require detailed machine descriptions, often in 3D. Such descriptions are usually contained in CAD files (e.g. CATIA, STEP files). Adding accurate 3D structures to modelling tools is currently a laborious task and, hence, machine descriptions are often not updated. On the other hand, CAD models are often too detailed for the physics codes and may contain inconsistencies (e.g. gaps etc.) that may lead to incompatibilities with the code. To resolve this, an interface would have to contain algorithms that reduce the detail of CAD drawings (e.g. creation of envelope structures, removal of bolts etc.) Possible areas that would benefit from such an interface are:

- Heat load on the first wall, by radiation, charge exchange, parallel heat flux and fast ions
- Neutron and neutrals modelling
- Modelling of MHD in the presence of conducting structures
- Equilibrium modelling including currents in conducting structures

The project would begin with a review of existing codes, workflows and formats within EUROfusion, including: CAD programs, existing workflows for interfacing to CAD information, the General Grid Description, and 3D mesh visualisation tools. A GUI based system providing the interface would then be developed. The output of the tool would be in the General Grid Description format developed by WPCD, since this is a common format for describing grids of arbitrary complexity for physics codes. The system would then be installed and demonstrated on JET, MST and/or W7-X devices.

EUROfusion Work Packages involved: WPMST1, WPCD, WPISA, WPS1
Facilities to be used: AUG, JET, MAST-U, TCV and W7-X

4 NUCLEAR MEASUREMENTS AND ANALYSES ON FUSION DEVICES (JET AND EUROPEAN NEUTRON FACILITIES)

Position ref. EEG-2015/05
Contact person: Paola Batistoni paola.batistoni@enea.it

Job Description:

The successful candidate will work in an interdisciplinary field encompassing fusion related neutron/γ-ray measurements, standard and innovative nuclear techniques, and numerical analyses for global characterisation of the radiation field in a fusion environment. The work can include one or more of the following main areas:

- Participation in experiments at JET on calibration of neutron detectors at 14 MeV neutron energy, including pre-analyses, design of measurements, measurements and analyses of data
- Participation in experiments of the neutron and gamma ray field at JET, of the neutron induced activation of fusion relevant materials, and of the shutdown dose rate in conjunction with DD and DT operations, including design of measurements, installation of detectors, measurements and data analyses
- Development and testing at JET of innovative neutron and tritium detectors to be used in ITER
- Preparation of measurements at home laboratory, including calibrations and characterization of detectors at European fusion neutron facilities.
- Analyses of experiments, including neutronics calculations and data elaboration and analyses.

The work will be carried out at JET and at European laboratories hosting 2.5-MeV and 14-MeV neutron facilities (FNG, ASP, DPF-1000).

EUROfusion Work Packages involved: WPJET3, WPJET1
Facilities to be used: European 2.5-MeV and 14-MeV neutron facilities (FNG, ASP, DPF-1000)

5 HIGH-POWER AND MICROWAVE ENGINEERING FOR ECRH SYSTEMS: PROTECTION AND RAMI STUDIES

Position ref. EEG-2015/06
Contact person: Andreas Dinklage dinklage@ipp.mpg.de

Job Description:

The successful candidate will work in an interdisciplinary, unique field encompassing fusion-related high-power microwave engineering & technology and integration engineering for the improvement of reliability, availability, maintainability, inspectability (RAMI) and efficiency for the different system components: gyrotrons, high-voltage power supplies, transmission lines, launcher, operating system and protection systems.
The protection of both the fusion device and components mainly concerns the detection of non-absorbed microwave power (stray-radiation, including that in the ECH launcher structures) and protection and mitigations measures for in-vessel components including diagnostics. The qualification of plasma break-down schemes has to take stray-radiation issues into account.
The candidate will conduct the protection and RAMI studies on the ECRH-system of W7-X. This system is the first of its kind to allow 10 MW operation for 30 minutes, comparable with the planned ITER ECRH system. W7-X will use ECRH as the main plasma start-up method. ITER also foresees ECRH assisted plasma start-up. An ITER relevant 4.5MW ECRH system consisting of 9 gyrotrons (presently being upgraded for higher power in the X2 and X3 modes), ITER relevant HE_{11} (63.5mm diameter) evacuated transmission lines, and real-time controlled launching antennae, is presently operated at CRPP on the TCV Tokamak.
The activities in the field of high power and microwave engineering will also include DEMO studies. The successful candidate will receive comprehensive training on the ECRH system on W7-X and TCV (CRPP), including investigation of plasma break-down and stray radiation detection and mitigation, including novel techniques for improvement of EC wave coupling. The candidate will be introduced to preparatory activity for the RAMI analysis on W7-X and TCV and will receive general training on microwave technology. The candidate is expected to lead the development of an ECRH plant model, ECRH control and protection systems and stray-radiation models in fusion devices (W7-X, TCV).

EUROfusion Work Packages involved: WPS1, WPHCD, WPS2, WPMST1

Facilities to be used:

- *W7-X (Greifswald, Germany), TCV (Lausanne, Switzerland) and other machines where a direct insight into practical aspects of experimental procedures can be gained.*
- *Laboratories for gyrotron development at KIT (Karlsruhe, Germany).*
- *Laboratories for microwave engineering at Technical University Eindhoven (Eindhoven, The Netherlands) and University of Stuttgart (Germany) and cooperation with ITER-IO (Cadarache, France)*

6 SOFTWARE ENGINEERING: IMAGING SOFTWARE FOR FUSION DEVICES

Position ref. EEG-2015/07
Contact person: Andreas Dinklage dinklage@ipp.mpg.de

Job Description:

The successful candidate will work in the strongly developing field of video data processing. Challenges lie in the processing of large amount of data for routine analyses but particularly novelty detection. Control and safety applications for real-time detection systems for integration in steady-state control and safety systems will be developed. Moreover, purely off-line analyses are to be assessed for periods of interest which, e.g. enter approaches for data compression techniques.

The candidate will apply leading edge software developments to specific applications such as: safety applications for ECRH break-down; IR surveillance of components exposed to high heat-loads in the first experimental phase of Wendelstein 7-X and other devices, with assessment and implementation of FPGA imaging developments; and video diagnostics of plasma discharges up to very high pulse lengths. In-vessel video surveillance and the fast detection of destructive plasma events and plasma termination events (e.g. carbon blooms) are further aspects for the application of the software developments. All application aspects are of high relevance to the safe operation of ITER and future fusion devices.

The successful candidate will be provided with training on imaging software tools, training on the inclusion of imaging hardware in safety loops and training on the imaging data processing of streaming data, multi-core CPU, GPU and FPGA based processing. The candidate will be involved in the development of safety compliant software tools relevant to the plasma break-down with ECRH and the development of automated analyses of streaming data and data compression techniques.

The grant will be supervised in international, interdisciplinary teams.

EUROfusion Work Packages involved: WPS1, WPMST1, WPPFC, WPJET1

Facilities to be used:

- *W7-X (Greifswald, Germany), WEST (Cadarache, France), JET (Culham, UK) and other machines where a direct insight into practical aspects of experimental procedures can be gained.*
- *Laboratories for gyrotron development at KIT (Karlsruhe, Germany).*
- *Laboratories for microwave engineering at Technical University Eindhoven (Eindhoven, The Netherlands) and University of Stuttgart (Germany) and cooperation with ITER (Cadarache, France)*

7 DATA INFRASTRUCTURE FOR THE SCIENTIFIC EXPLOITATION OF EXPERIMENTS WITH MACHINE GENERIC TOOLS

Position ref. EEG-2015/08
Contact person: Gloria Falchetto Gloria.falchetto@cea.fr

Job Description:

The project is focused on the technical development of modern concepts for handling data, documentation and analysis tools, aiming to support the operation and scientific exploitation of the new generation of fusion devices, such as JT-60SA and ITER.
The proponent, having a software engineer profile, will work in strict contact with infrastructure support IT experts, experimental data and integrated modelling experts.
The work will involve both the prototyping of machine generic tools and their test for systematic analysis of EUROfusion experiments.
The successful candidate will start with an assessment of the present technologies and will then address the following areas:
- Data handling and data model, mapping mechanisms between different data models.
- data access tools for experimental data of present and future machines (Medium Size Tokamaks (MST), JET, WEST, JT-60SA, ITER)
- Visualization tools
- GUI for parameterization of post-processing and simulation workflows

EUROfusion Work Packages involved: WPCD, WPSA, WPISA, WPMST1, WPJET1

Facilities to be used:

- JET , MST devices, WEST

8 MECHANICAL/NUCLEAR ENGINEERING: 3D NUMERICAL MODELLING FOR FUSION DEVICES, 3D BLANKET DEVELOPMENT AND REMOTE MAINTENANCE

Position ref. EEG-2015/09
Contact person: Andreas Dinklage dinklage@ipp.mpg.de

Job Description:

The successful candidate will work in leading edge applications of finite element modelling (FEMs). These FEMs are essential for the design and safe operation of fusion devices. The candidate will link expertise in different aspects of modern mechanical engineering considering electro-mechanical constraints from fusion devices. The evaluation of the extensive W7-X mechanical sensor system results and corresponding updates/corrections of the sophisticated FE-models as well as the assessment and optimization of new magnetic configurations provide highly useful experience for ITER and other large fusion machines.
In view of fusion reactor developments, it remains necessary to assess the specific 3D requirements of a blanket design in a HELIAS (W7-X like) -type power plant. Very closely related to the 3D design of breeder blankets, feasible HELIAS-maintenance concepts have to be developed to arrive at a sound integration of the 3D blanket. In addition, specific 3D developments are expected to be beneficial for related work on the tokamak DEMO breeder blanket design. The programme will improve the understanding of the influence of 3D structures on the overall design which is of high importance for the DEMO tokamak. For the topic of remote maintenance, a close coordination with the blanket design development right from the beginning is necessary to achieve a balanced and feasible maintenance concept.
The candidate will receive training on global FE models for W7-X and will be involved in mechanical assessments including FEM-validation based on measurement results in the start-up phase of W7-X. Training on neutronics and blanket development and training on remote maintenance concepts will be provided. After the training phase, the candidate will be responsible for updates of the existing FE models, participation in the operation preparation of W7-X, development of up-scaled FE models for the HELIAS line, transfer and exchange with ITER and DEMO studies. The candidate will be involved in the development of 3D blankets for HELIAS devices and the development of remote maintenance concepts for HELIAS FPPs.

EUROfusion Work Packages involved: WPS1, WPS2, WPMST1, WPJET1, WPPMI, WPBB

Facilities to be used:

- *W7-X (Greifswald, Germany)*
- *Laboratories at KIT (Karlsruhe, Germany).*
- *Cooperation with ITER (Cadarache, France)*

9 CONSISTENT MODELLING OF DIVERTOR NEUTRAL AND RECYCLE FLOWS FOR INTEGRATED DIVERTOR DESIGN

Position ref. EEG-2015/10
Contact person: Christian Day Christian.day@kit.edu

Job Description:

The successful candidate will work in the interdisciplinary field encompassing divertor vacuum pumping, neutral flow modelling by modern numerical analysis methods and exhaust physics. In the past, divertor design has mainly been performed considering materials and power load aspects, whereas the aspect of efficient particle exhaust has not always been given the importance it deserves. This project shall integrate vacuum engineering and divertor physics and, thus, enable a sound design of the DEMO divertor, thereby utilizing the fact that divertor conditions (detachment, density field and recycle patterns) can be strongly influenced by varying the effective pumping speed. This holds in particular for the high density operation scenarios which are foreseen for DEMO and JT-60SA.
In the course of the project, the successful candidate will link divertor design with the vacuum system design in an integrated and self-consistent manner. In this way, a consolidated solution for optimum power handling and optimum vacuum pumping of the divertor shall be found.
Strong connections with JET and AUG through experimental campaigns for validation of the found design recommendations and supporting modelling work is foreseen. Support to the ongoing design developments in JT-60SA is expected.

EUROfusion Work Packages involved: WPSA, WPJET1, WPMST1
Facilities to be used: JET, AUG

10 WP BREEDING BLANKET

10.1 Tritium Breeding Blanket Design and Analysis

Position ref. EEG-2015/11
Contact person: Lorenzo Boccaccini Lorenzo.boccaccini@kit.edu

Job Description:

The Tritium Breeding Blanket is recognised to be one of the most important & novel parts of DEMO, where large knowledge gaps exist even with a successful ITER TBM programme. Considerable resources are allocated in the Roadmap Horizon 2020, within the so-called Project Breeding Blanket (WPBB), to investigate a number of attractive DEMO blanket system options aiming at the selection of the most promising and technically feasible.

The breeding blanket in a reactor is exposed to complex thermo-mechanical loadings and environmental conditions and its design must rely on neutronic, electro-magnetic, CFD, thermo-hydraulic and thermo-mechanical analysis and comply with rigorous nuclear regulations. Today, each task is mostly performed in isolation with independent software.

This call aims at the development of the candidates engineering skills in the area of breeding blanket design and represents a unique opportunity to work within a team developing breeder blanket concepts for a future nuclear fusion power plant. The candidate will be developing an integrated design tool that can provide rapid feedback on design iterations to facilitate finding optimal solutions for each of the blanket concepts. In order to develop the tool, the candidate must become conversant with and in some cases expert in various analysis techniques such as neutronic thermo-mechanical, CFD, and thermo-hydraulic. The candidate will also gain familiarity with relevant nuclear codes and standards (C&S) such that analysis procedures can be developed in sympathy with these, especially considering irradiation damage of materials and the design consequences this entails. In a second phase, the candidate is expected to merge the knowledge acquired in all these fields and effectively contribute to designing a versatile integrated platform tool for WPBB design. This tool should allow iterating easily between the different analyses and optimizing the design according to the results. Considering the Employment of Eurofer as a structural material for blanket components, previous work has shown a lack of criteria and assessment procedures for ratcheting and creep-fatigue interaction, especially when coupled with irradiation effects, this should also be taken into consideration. In a third phase, the candidate is expected to develop methodologies and analysis procedures that address specific failure modes. By comparing the approaches in different set of C&S, the candidate could develop and propose improved methodologies for the design of nuclear fusion components.

Main Work Package: WPBB
Interlinks with other Work Packages: WPBB, WPMAT, WPDIV, WPPMI
Facilities to be used: n/a

10.2 Thermo-hydraulic of PbLi loops and system/components design

Position ref. EEG-2015/12
Contact person: Lorenzo Boccaccini Lorenzo.boccaccini@kit.edu

Job Description

Several blanket concepts, now being investigated in the Breeding Blanket Project (WPBB) of the EUROfusion Consortium, employ LiPb as a breeder (Helium Cooled Liquid lead, Water cooled Liquid lead (HCLL, WCLL)) and as a breeder and coolant (Dual Cooled Liquid lead (DCLL)). The design of PbLi system loops is expected to have a major role in the concept evaluation and down selection of the blanket system and Balance of Plant (BoP). This requires several competences including thermal-hydraulics of liquid metals and mixture liquid-metal-gas/MHD effects/corrosion in PbLi/design of pumping system and neutronic and permeation of tritium through structural materials.

This call aims at the development of good engineering skills and practical experience needed for the design, the analyses and the development of relevant technologies for the PbLi loops. This includes sufficient knowledge to develop a preliminary thermal-hydraulic design of PbLi loops of the three liquid metal Breeding Blankets (BB), to contribute to the Integration with the BB designs and the selected BoP design solutions, competences about relevant components code and standards, like ASME code section III, RCC MRx, etc., required for the design of the BB PbLi systems

In particular, skills will be developed in the following areas:

- Design of the breeding blankets concepts of a DEMO fusion power reactor that rely on the use of LiPb as a breeder or coolant, i.e., DCLL/HCLL and WCLL,
- Capabilities and limitations of a system thermal-hydraulic code, like RELAP5-3D, applied to liquid metal fluid, a methodology applied to perform the design of a system accounting for multiples factors, including the compliance with nuclear regulations.
- Corrosion of structural materials with LiPb
- Development of protection coatings
- MHD effects
- Control/Purification of LiPb from radioactive transmutation products
- Investigation on Water-PbLi interaction

Strong interactions with a number of RUs involved in WPBB project are foreseen to collect, integrate and update the lead lithium loops design on the basis of WB outcomes.

Main Work Package: WPBB
Interlinks with other Work Packages: WPMAT, WPDIV, WPPMI
Facilities to be used: All relevant LiPb loops and testing facilities in Europe.

11 WP DIAGNOSTIC AND CONTROL

11.1 DEMO control simulations

Position ref. EEG-2015/13
Contact person: Wolfgang Biel w.biel@fz-juelich.de

Job Description

The development of the DEMO plasma control system shall be prepared and supported by performing numerical control simulations. The goal of these simulations is to achieve a quantitative understanding of the expected control accuracy under DEMO conditions, taking into account the actual properties of the measurements and actuators available.

This call aims at the development of good engineering skills and practical competences in the following areas:

- plasma diagnostic and control systems on existing fusion devices as well as the systems under development for ITER
- plasma control requirements for DEMO
- diagnostic and actuator properties to be expected for DEMO conditions
- existing control models and simulation tools as relevant to DEMO control simulations
- requirements for new development of control models for DEMO conditions where needed
- simulation of the dynamic behaviour of the DEMO plasma control system for a number of key control parameters, e.g., Density and radiation in the core plasma
- Definition of typical control accuracies (amplitude of control deviations), time constants (settling time) and control reliability (disruption rate) for DEMO conditions
- control margins needed against relevant operational limits which should be taken into account in the definition of the plasma scenario, in order to reliably avoid disruptions.

Main Work Package: WPDC
Interlinks with other Work Packages: WPPMI, WPMAG, WPHCD, WPTFV, task force CD
Facilities to be used: n/a

12 WP DIVERTOR

12.1 Development of Divertor fabrication technology

Position ref. EEG-2015/14
Contact person: Jeong-Ha You you@ipp.mpg.de

Job Description

The divertor project WPDIV ('Work Package Divertor') has identified critical R&D needs in the fabrication technology applied to the divertor plasma-facing components which are supposed to withstand the pulsed high heat flux loads, intense bombardment of energetic plasma particles and severe irradiation of fast neutrons.

An actively cooled divertor target component consists of at least three different parts, namely, armor, heat sink and an interlayer, each of which is normally made of a different material. Thus, significant thermal stresses are expected during nuclear fusion operation due to the mismatch of thermal expansion under temperature fluctuation. The operational reliability of the divertor target in such a harsh loading environment relies essentially on the structural integrity of the component, in particular, at material interfaces, where thermal stresses tend to be concentrated and thus crack initiation most likely. In this context, the quality of material joining is of crucial importance and simultaneously a great technological challenge. There are several metallurgical options of joining developed so far for the plasma-facing components, however, there are still many technological issues that need to be solved. Therefore, the primary focus of the target engineering has been placed on the fabrication technology, especially, joining technology.

This call aims at the development of good engineering skills on the fabrication process of a divertor target component. In addition, the selected applicant will learn the design process and take part in experimental test campaigns. Interdisciplinary approaches and dynamic interaction with world class leading engineers in respective expertise areas are foreseen. The successful applicant will perform metallurgical design of joining process, verification of joining process performance through preliminary trials, manufacture of joint component and characterization of bond interface. He/she will get access to necessary facilities of the involved laboratories. Close supports with the WPDIV Project teams are foreseen.

Main Work Package: WPDIV
Interlinks with other Work Packages: WPMAT, WPBB, WPPMI
Facilities to be used: All relevant testing facilities in Europe.

13 WP HEATING AND CURRENT DRIVE SYSTEMS

13.1 Integrating a distributed ICRF antenna in DEMO.

Position ref. EEG-2015/15
Contact person: Minh Quang Tran mihnquang.tran@epfl.ch

Job Description

The design of Heating and Current Drive Systems with improved efficiency and reliability is an important area of research priority for DEMO and future fusion power reactors.

This call aims at the development of good engineering skills in the development and integration of a distributed antenna in the DEMO plant, including considerations about blanket design, T breeding, cooling, remote handling and the associated RF generators.
A distributed Ion Cyclotron Heating antenna is a concept that relies on the advantages of ICRF (high plug to power efficiency, ion heating, limited extrapolation for the generators and transmission lines from current performance) while avoiding some negative aspects (need to put the antenna in a port of limited size, limited coupling, impurity production) to provide a reliable and sturdy overall system for DEMO.
The RF generators are an important part of the RF system, while very few engineers or physicists are still familiar with analogue high power RF devices.

The candidate will need to familiarize him/herself with neutronic codes (MCNP), mechanical/thermal analysis codes (ANSYS) as well as CAD codes (CATIA) and RF codes (COMSOL/Microwave studio/HFSS). He/she will also need to learn about boundary conditions and constraints imposed by remote handling and quality requirements set by DEMO, as well as high power RF generators.

Interactions with several EU Research Institutions engaging in ICRF antenna design and development is foreseen, together with work in existing medium-size tokamaks and/or JET (e.g., work with and maintain the present AUG generators, support the maintenance and possible update of the JET generators, etc.). Working with the high power steady state IC system in Garching will provide the trainee with the full gamut of experience in this area.

Main Work Package: WPHCD
Interlinks with other Work Packages: WPMST2 WPCD, WPPMI, WPBB, WPRM
Facilities to be used: RF facilities in existing RUs, tokamaks

14 WP MAGNET SYSTEMS

14.1 Multiphysics analyses for magnet design

Position ref. EEG-2015/16
Contact person: Louis Zani Louis.zani@cea.fr

Job description:
Magnet systems represent a crucial technology for magnetic confinement fusion devices. Powerful magnetic fields are required for confinement of the plasma, and, depending on the magnetic configuration, for plasma initiation, ohmic heating, inductive current drive, plasma shaping, equilibrium, and stability control. Almost all design concepts for power producing commercial fusion reactors rely on superconducting magnets for efficient and reliable production of these magnetic fields. Future superconducting (SC) magnets for fusion applications require improvements in materials and components to significantly enhance the feasibility and practicality of fusion reactors as an energy source.

This call aims at the development of good engineering skills and practical experience in the areas of design, thermal-hydraulic & electromagnetic analyses of superconducting magnet systems and the supporting cryogenic plant. Investigations on thermal-hydraulic behaviour of magnet conductors is of major importance as it assesses the level of safety during operation, which is central for design robustness.

The candidate will first need to familiarize with design notions and computational tools used for designing SC magnet systems. In a second phase, it is foreseen that he/she will analyse the various design concepts being considered and possibly confront them with outcomes of experimental tests. Interactions with the WPMAG project team is expected and with several EU Research Institutions engaging in SC magnet design and development, exchanging considerations at different scales including system level. As a third and final stage it is expected that he/she will contribute to build interfacing tools for integrating thermal and electromagnetic code into a wider platform tool that would include other items (mechanics, etc...). This would include work on data processing modules and on tool integration in the multiphysics platform.

Main Work Package: WPMAG,
Synergies with other Work Packages: WPBB, WPDIV, WPPMI
Facilities to be used: Available SC magnets testing facilities in various RUs

15 WP MATERIALS

15.1 Heat Sink and Composite Materials

Position ref. EEG-2015/17
Contact person: Michael Rieth Michael.rieth@kit.edu

Job Description:

The development/ qualification of radiation resistant structural and high heat flux materials, including Design Codes & Standards for conditions of interest is one of the most important priorities of the Fusion Roadmap Horizon 2020 and such activities are being implemented by the EUROfusion Consortium within the WPMAT Project.

This call aims at the development of good engineering skills and practical experience in the field of advanced high-heat-flux materials. The candidate is expected to familiarize him/herself with the very demanding design requirements for the main components in DEMO and will be able to perform tailor-made developments and optimization of advanced materials for fusion applications. The programme will provide the theoretical and practical/experimental background for the complex interdisciplinary areas, which are connected to this area.

Skills will be developed in the following areas:

- Manufacturing of composite materials (fibre and particle reinforced, laminate structures, …) for heat sink, structural and/or functional applications
- Modelling of composite structures
- Characterization of microstructure (incl. thermal stability)
- Determination of thermo-mechanical and thermo-physical properties (database input, related to WPMAT-EDDI)
- Application related characterization (steady state thermal loads) of actively cooled components (interaction with training programme 1)
- Joining and component manufacturing (related to WPDIV)
- Operation and data acquisition from tests in high heat flux test facilities JUDITH 1 & 2, GLADIS
- Mechanical and thermo-physical testing
- Use of FEM-tool: ANSYS or equivalent

Main Work Package: WPMAT
Interlinks with other Work Packages: WPMAT-EDDI (Engineering Data & Design Integration) and WPDIV.
Facilities to be used: Available High-Heat-Flux test beds available in Europe, e.g, JUDITH, GLADIS, FE-200 (and other available HHF testing facilities)

15.2 Steel Expert in Nuclear Fusion

Position ref. EEG-2015/18
Contact person: Michael Rieth Michael.rieth@kit.edu

Job Description

The development / qualification of radiation resistant structural and high heat flux materials, including Design Codes & Standards for conditions of interest is one of the most important priorities of the Fusion Roadmap Horizon 2020 and such activities are being implemented by the EUROfusion Consortium within the WPMAT Project.

This call aims at the development of good engineering skills and the experience in the field of steels. The candidate is expected to familiarize with the very demanding design requirements for the main components in DEMO and will be able to develop tailor-made enhancements and optimization of advanced materials for fusion applications. The programme will provide the theoretical and practical/experimental background for the complex interdisciplinary areas, which are connected to this area.

Skills will be developed in the following areas

- Metallurgy, influence of chemical composition, and steel production
- Steel properties (under fusion relevant operation) and underlying mechanisms
- Thermodynamic phase calculation and related properties of complex alloyed steel
- Neutron damage and activation in steels: underlying phenomena, analysis, assessment, calculation (IREMEV), and effective countermeasures
- Codes and standards, material database, licensing, etc. (EDDI)
- Advanced processing and joining w.r.t. component fabrication and design (e.g. WPBB)
- State-of-the-art steel analysis, characterisation and damage assessment

Main Work Package: WPMAT
Interlinks with other Work Packages: WPBB, WPDIV.
Facilities to be used: Production, processing and fabrication facilities in industry, plus other relevant facilities available in European RUs.

16 WP PLANT LEVEL SYSTEM ENGINEERING, DESIGN INTEGRATION AND PHYSICS INTEGRATION

16.1 Fusion Plant Design Optimisation Studies

Position ref. EEG-2015/19
Contact person: Mark Shannon mark.shannon@euro-fusion.org

Job Description

The task of choosing an appropriate set of machine parameters and engineering technologies in a Fusion Power Plant involves trade-offs between the attractiveness and technical risk associated with the various design options. One of the crucial points is the size of the device and the amount of power that can be reliably produced and controlled in it. This is the subject of R&D and depends upon the assumptions on the readiness of required advances in physics (e.g., heat exhaust, choice of regime of operation, efficiency of non-inductive Heating and Current Drive (H&CD) systems, etc.), technology and materials developments.

This call aims at the development of good engineering skills in the area of fusion reactor design and in particular in the process of evaluating design options on the DEMO project to ascertain the benefits of understanding the relationship/s between particular parameter pairings or within interfaces with respect to their relative influence over critical performance targets and then to conduct an investigation on a particular pairing or interface. This engineering research grant represents an exciting opportunity to work within a team of Physicists and Engineers to optimise the conceptual design of the next generation fusion power plant. The role involves the assessment of different design aspects of the machine to deduce which opposing aspects should be studied in conjunction to define the best compromise. One of these design aspect pairings would then be executed by the candidate. The candidate would develop System Engineering skills to resolve key plant requirements and resulting functions to elicit design aspects critical to overall performance targets, exercise analysis techniques to perform sensitivity studies in which chosen design aspect parameters are varied and be engaged with interface management, to understand and explore wider implications of design point compromises elsewhere in the machine design space.
The candidate is expected to

- work alongside experienced System Engineering & Integration engineers to elicit a list of key parameters and interfaces for the DEMO power plant;
- develop a list of key interfaces and parameter pairings that are perceived to be crucial to delivering key performance targets for DEMO. This is done by canvassing opinion and gleaning information from past studies. Context and justification statements for each candidate pairing / interface should then be prepared.
- Devise the format for a prioritisation meeting to determine which candidates should be addressed as the highest priority.
- Become involved in the execution of one of the candidate areas of investigation, contriving a pathway to answering key questions about how systems affected by the pairing are helped or hindered as one parameter is varied against another. This work would involve some numerical analysis.

Main Work Package: WPPMI
Interlinks with other Work Packages: All other WPs are involved in this task
Facilities to be used: n/a

16.2 Design and analysis of advanced divertor configurations in respect of their electro-mechanical feasibility for a DEMO class device.

Position ref. EEG-2015/20
Contact person: Mark Shannon mark.shannon@euro-fusion.org

Job Description

Heat-exhaust systems must be capable of withstanding the large heat and particle fluxes of a fusion power plant. The baseline strategy for the accomplishment of Mission 2 "Heat-exhaust systems" consists of reducing the heat load on the divertor targets by radiating a sufficient amount of power from the plasma and by producing "detached" divertor conditions. Such an approach will be tested by ITER, thus providing an assessment of its adequacy for DEMO. However, the risk exists that high-confinement regimes of operation are incompatible with the larger core radiation fraction required in DEMO when compared with ITER. Alternative solutions for the divertor are therefore necessary to provide a risk mitigation strategy for DEMO. These concepts will need not only to pass the proof-of-principle test but also an assessment of their technical feasibility and integration in DEMO.

This call aims at the development of good engineering skills and the experience in the field of power exhaust. The candidate is expected to familiarize with the very demanding design requirements for the design and analysis of advanced divertor configurations in respect of their electro-mechanical feasibility for a DEMO class device. The programme will provide the theoretical and practical/experimental background for the complex interdisciplinary areas, which are connected to this area.

Interactions with several EU Research Institutions engaged in alternative divertor designs and analyses and development are foreseen, together with work in existing medium-size tokamaks. Several tools for the analysis are available and their predictions can be tested on European and international machines with advanced configurations, e.g.., MSTs in Europe and EAST in China. The trainee will also interact with the teams of the Projects involved in this area (e.g., WPDIV, WPDTT1, WPDTT2, WPPFC and WPPMI) for the analysis of some specific aspects (electro-mechanical loads, thermal loads, fatigue, etc.) related to the design of the divertor components for advanced magnetic configurations.

Specific skills will be developed in the following areas

- Advanced magnetic configurations (e.g. snowflake)
- Edge parameters and their influence on divertor design
- Design and analysis of divertors taking account of several aspects (electrical, mechanical, thermal, neutron damage, fatigue)

Main Work Package: WPPMI
Interlinks with other Work Packages: WPDIV, WPDTT1, WPDTT2, WPPFC
Facilities to be used: MST1 tokamaks in Europe and EAST in China

17 WP REMOTE MAINTENANCE SYSTEMS

17.1 Design of control systems for remote handling of large components.

Position ref. EEG-2015/21

Contact person: Antony Loving antony.loving@ccfe.ac.uk

Job Description

The development of robust and demonstrated remote repair and maintenance schemes for the in-vessel components of DEMO and future fusion power reactors is an important priority of the Fusion Roadmap Horizon 2020 and work is being implemented in the EUROfusion Consortium in the WPRM Project.
The remote handling of large deformable objects such as DEMO blanket modules will require accurate, reliable, and timely motions of very heavy objects whilst respecting tolerances of tens of millimetres. This difficult task would not be possible without taking into account the structural deformation of the object under static and dynamic loads.
The availability of accurate simulation of structural deformations under large loads, as well as the integration of the deformation model into adaptive controllers is urgently required in order to reduce the need for full scale mock-ups of remote operations. Full scale mock-ups are highly expensive, and require the presence of all associated equipment and infrastructure.

This call aims at the development of good engineering skills and the experience in the area of designing control schemes for the remote handling of large and heavy components such as Blanket Modules. Such control schemes will require integration of control techniques with dynamic models of the shape of the component being handled as it deforms under load.

The first phase work shall be aimed at developing the necessary skills and knowledge in the practical usage of dynamical simulation methods including continuum mechanical modelling and simulation for calculating shapes and other properties of structures under large loads. The second phase shall be focused on the trainee developing a thorough understanding of the design and implementation of control systems as presently used on state-of-the-art remote handling transporter systems. The candidate is expected to interact with a number of experts in the field of remote handling control system design, and with ongoing design activities in order to gain a thorough appreciation for the practicalities of RH control system design. A third phase shall be targeted at incorporating deformation models into real-time motion control systems. This will involve contributing to the designing and simulation of a closed-loop control system that is able to robustly adapt in order to successfully move a deformed component through a complex trajectory with very tight tolerances.
It may also be possible for the trainee to integrate developed control systems to the existing JET transporter systems.

Main Work Package: WPRM
Interlinks with other Work Packages: WPDIV, WPBB, WPDC, WPMAG, WPPMI
Facilities to be used: Available Remote Maintenance facilities in various RUs, JET

18 WP SAFETY AND ENVIRONMENT

18.1 Tritium behaviour

Position ref. EEG-2015/22
Contact person: Neill Taylor neill.taylor@ccfe.ac.uk

Job Description
Technologies related to the storage, handling and processing of tritium are key to any D-T fusion plant such as DEMO. As the main radiological hazard present in the facility, the control and confinement of tritium is essential for safety. The main systems involved are tritium storage, fuelling systems that supply tritium to the plasma, vacuum systems that extract the plasma exhaust, systems that separate the un-reacted hydrogen isotopes in this exhaust, and systems that extract and process the tritium generated in breeding blankets. Also of importance is the retention of tritium in components inside the vacuum vessel, the potential mobilization of this in accidental conditions, and the paths by which this tritium could be released from the plant. The dispersion of released tritium in the environment, including in organically-bound form, and the potential paths to a dose uptake by members of the public, are behaviours that must be fully understood in order to properly characterize the hazards. Equally important is the removal of tritium absorbed into the materials of components being disposed of at end of life.

This call aims at developing an understanding of the behaviour of tritium and skills in the engineering of the tritium systems. These will include tritium handling, processing and analytics. The candidate will be involved in the development of several of the areas mentioned above for a future fusion power plant, DEMO, with contributions to an experimental or tritium modelling activity in at least one of: tritium extraction, tritium vacuum pumping, tritium recovery from coolants, tritium purification, isotope separation, tritium storage, fuel mixing and control. In addition the candidate will participate in the development of improved models for use in safety and environmental assessments.

Main Work Package: WPSAE
Interlinks with other Work Packages: WPTFV, WPBB
Facilities to be used: n/a

18.2 Safety analysis

Position ref. EEG-2015/23
Contact person: Neill Taylor neill.taylor@ccfe.ac.uk

Job Description
One of the motivations for the development of fusion power is its potentially excellent safety and environmental characteristics. However to fully realize the potential safety performance, care must be taken at the design stage to provide all required safety functions with a high degree of reliability. These are mostly related to the confinement of tritium and of neutron-activated material. In order to assess if the design is adequate in this respect, as well as to ultimately satisfy a nuclear regulator, safety analyses are performed. These use computer modelling to assess the possible consequences of a range of accident scenarios based on postulating failures in key components. A variety of analyses, including neutron activation and thermal-hydraulic analyses, are performed as part of these studies as well as a computation of the impact on members of the public of accidental releases of radioactive material.

This call is aimed at providing a broad knowledge of the systems of a tokamak plant that are important for the safety performance, together with familiarization of all parts of the safety analyses, from the systematic selection of accident sequences through to the calculation of their potential consequences. Radiological impacts on personnel within the plant will also be studied. Participation in the safety analyses of DEMO, including developing and running some of the computer models, will provide an expertise in nuclear safety analysis, as well as more general modelling skills.

Main Work Package: WPSAE
Interlinks with other Work Packages: Some interaction with all other Work Packages can be expected.
Facilities to be used: n/a

19 WP TRITIUM, FUELLING & VACUUM SYSTEMS

19.1 Vacuum Material Engineer

Position ref. EEG-2015/24
Contact person: Christian Day Christian.day@kit.edu

Job description:
The materials that are exposed to vacuum inside the plasma chamber and on the first wall will show significant outgassing in the dwell phase in between the plasma pulses, when the torus chamber has to be pumped to ultra-high vacuum so that the next plasma pulse can be initiated. In order to maximize DEMO availability, this dwell phase shall be minimised (target performance to be of the order of 20 min). Currently, there is not sufficient understanding of which are the most influential parameters to control and limit this outgassing in a fusion environment (with material damages due to neutron irradiation and at temperatures significantly above room temperature). It is essential to strengthen the efforts in this area, as it may turn out to be a show-stopper if the power plant is not on stream above a certain percentage of operational time.

This call aims at the development of good engineering skills and the experience in the areas of vacuum material engineering for fusion power plants. This shall include:

- Multi-disciplinary learning of materials under vacuum;
- Working in a first-of-its kind activity;
- Working with the leading experts in vacuum and materials;
- Having direct influence on the DEMO engineering design;
- Knowledge on thermal outgassing and its dependence of temperature and material choice and history as well as on the degree and type of neutron irradiation damage.

After an initial thorough literature review, some baseline introduction in vacuum technology, related material science, and state-of-the-art outgassing modelling, the candidate shall develop the fundamental equations and compile a database of material properties to be utilized in subsequent numerical solutions. It may well be that literature data differ by orders of magnitude, so that clarification experiments may be proposed and conducted (if possible) or other approaches are developed, so as to be able to perform reliable estimations. The main objective of this activity is to provide a justified estimate of the dwell pump-down time in a DEMO environment and to derive from parametric calculations, working correlations on how the dwell time depends on particular influential properties.

Main Work Package: WPTFV
Interlinks with other Work Packages: WPMAT
Facilities to be used: Available facilities in various RUs