Information day for the up-coming call for proposals for a framework partnership agreement for the

Development of simulation tools for the exploitation of the HCLL and HCPB TBS operation in ITER

The testing of Tritium Breeder Blanket concepts as part of the ITER mission has been recognized as an essential milestone in the development of a future reactor ensuring tritium self-sufficiency, extraction of high grade heat and electricity production. Two European Test Blanket Modules (TBMs) will be installed in ITER equatorial port #16 based on two reference breeder blankets concepts for DEMO reactor specifications currently under development in Europe:

- the Helium Cooled Lithium Lead (HCLL) concept which uses the eutectic Pb-16Li as both tritium breeder and neutron multiplier;
- the Helium Cooled Pebble Bed (HCPB) concept which features lithiated ceramic pebbles (Li$_4$SiO$_4$ or Li$_2$TiO$_3$) as tritium breeder and beryllium pebbles as neutron multiplier.

Each TBM is equipped with a radiation shield, forming the TBM set, which is housed in one of ITER standardized Port Plugs. The TBM set is connected through piping with several sub-systems required for their operation; together the TBM set, piping and ancillary sub-systems form the Test Blanket System (TBS). The sub-systems of the HCLL and HCPB TBS are independent for each TBS, although they may be located in common areas of the ITER Complex: Port Cell 16 (hosting the PbLi loop and some components of the Helium Cooling sub-systems and Tritium Extraction sub-systems), the CVCS area (hosting the Helium Coolant and Purification sub-systems) in the Tokamak building (in blue in Figure 1) and the tritium building (hosting the Tritium Extraction sub-systems, in green in Figure 1).
The aim of modelling activities for the F4E TBM program is to develop computer simulation tools that reproduce the behaviour of the HCLL and HCPB Test Blanket Systems during ITER operation based on computational models of the physical phenomena involved. The tools shall be aimed first at optimizing the exploitation of TBS operation towards the fulfilment of the TBM project scientific mission as part of the technology validation test in ITER. As such, but on a longer term, they will also be used to support the analysis of the experimental data collected during TBM operation (correlative function) and may be considered as a basis for developing tools dedicated to fusion blanket design, such as DEMO (predictive function).

The scope of this 4 years long Framework Partnership Agreement (FPA) concerns the development and qualification of the basic physics modelling blocks required to simulate the processes taking place in the TBS. Their coupling in an integrated simulation tool is not part of the scope of this FPA. The following scientific areas of research are considered:

1. **Thermo-hydraulic analysis, magneto-hydrodynamic (MHD) analysis and chemistry** of lead-lithium alloy Pb-16Li.
2. **Tritium transport** in solids, liquids, gases and interfaces.
3. Structural analysis of selected TBS components, including the **thermo-mechanical response of the pebble beds** of the HCPB Breeder Units.
4. **Electro-magnetic analysis** of ferromagnetic structures.
5. Thermo-hydraulic analysis of high pressure Helium.

Depending on the level of maturity of each area and the availability of commercial software packages, the development of simulation tools may be addressed first through the identification and numerical solution of the mathematical representation (ie, fundamental equations) of the physical processes. Then the optimization of algorithms and numerical schemes shall be performed, including the development of code parallelization when justified by the complexity of the calculations.

In addition, Validation and Verification (V&V) activities are an important part of the scope of this FPA for some of the aspects considered. They include benchmarking by comparison with analytical solutions or results of other simulation tools, possibly certified or validated by relevant processes or authorities, as well as the design, procurement and operation of experiments executed with instrumented test section as relevant as possible to TBS components design. Validation of the models is also possible through the comparison with experimental data already collected during past experimental activities in support of TBS design.

Finally, the developed simulation tools shall be applied to TBS design specifications in order to predict the performance of selected TBS components and to provide quantitative analysis of the expected accuracy of the predictions during ITER operation. Another objective is to provide support to the development and design integration of TBS instrumentation, for example the optimization of the number and location of sensors to be deployed.

The description above has been provided to clarify the type of activities that may be considered during the execution of the Specific Grants within this FPA. They could be subject to change, and are not necessarily applicable to all scientific areas considered. Only the proper tender documentation will provide the exact scope of the FPA.