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| **Project Title** | **3MF** = **M**elt **M**otion for **M**agnetic **F**usion  **a new code to simulate reactor-relevant melting in all geometries** |
| **EUROfusion RO** | WPPWIE PL S. BrezinsekWPTE and WPDES |
| **Background** | The [MEMOS-U code](https://iopscience.iop.org/article/10.1088/1361-6587/abd838#:~:text=The%20MEMOS%2DU%20code%20has,shallow%20melting%20and%20surface%20deformation.) is the only European code that is capable of simulating the motion of induced metallic melts coupled with the thermoelectric response of large-area wetted PFCs, thus providing [realistic surface deformation profiles](https://iopscience.iop.org/article/10.1088/1741-4326/abadac). The MEMOS-U model predictive capability was successfully tested in [multiple dedicated EUROfusion experiments](https://iopscience.iop.org/article/10.1088/1402-4896/ac1cf4) featuring melting under ELM, disruption and steady state heat loads as well as different material compositions and exposure geometries, both passive and active cooling, both grounded and electrically insulated PFCs. MEMOS-U is part of WPPWIE, WPDES, WPTE and is the exclusive tool for [ITER melt budget predictions](https://iopscience.iop.org/article/10.1088/1741-4326/ac38c7/meta), MEMOS-U is foreseen in TSVV-7, but no further development to optimise the code for fast and advanced applications.is within the framework possible.  |
| **Objectives**  | Implement the validated MEMOS-U physics model in the new code **3MF**, utilizing modern programming repertoire and frameworks with clean and adequate overall architecture in order to allow for:* adaptive meshing to facilitate cost-efficient computations of the large-scale separation problem typical for fusion scenarios with large wetted areas and shallow melt layers
* efficient parallelization
* ‘physics-driven’ input file and user friendly interface
* coupling of heat and fluid solvers with a current propagation solver to allow refined Lorentz force estimates
* flexibility for various scenarios (PFC geometry, wetting geometry, active cooling, etc)
* interpretation of transient melting scenarios in present fusion-relevant plasma devices
* exploration of transient load melting scenarios of relevance to future reactors,

this makes it compatible with the novel infrastructure applied in the TSVVs.  |
| **High-level work description**  | The new code **3MF** will utilize the adaptive mesh refinement package [AMReX](https://amrex-codes.github.io/amrex) for the construction of optimized non-uniform grids that allow to perform highly resolved calculations on the melt-plasma interface and to relax the grid size further away. Both AMREX native solvers as well as external solvers are to be employed. Milestones:* Compete the testing and benchmarking of the 2D and 3D heat solver
* Complete the testing and benchmarking of the 1D and 2D fluid solver
* Implement the current propagation equation in 3D and test the solver
* Enable the full coupling between all three solvers
* Enable the possibility to define in the input files the scenario and relevant physics of the boundary conditions to be employed
* Comparison of **3MF** with MEMOS-U runs on existing benchmark cases from portfolio of experiments performed in WEST, ASDEX Upgrade and JET.

Deliverables* MEMOS-U physics model implementation in a new code **3MF** with fully coupled heat, fluid and current propagation solvers, which allows to simulate various scenarios by defining relevant physics parameters through the input file
* Predictive modelling of ITER, DEMO, and HELIAS relevant melting scenarios with **3MF**
* Interpretative modelling of an existing or new benchmark case from portfolio of eexperiments performed in WEST, ASDEX Upgrade and JET.

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| Months: | 1-6 | 7-12 | 13-18 | 19-24 | 25-30 | 31-36 |
| *Testing of heat and fluid solvers* |  |  |  |  |  |  |
| *Implementation of current propagation solver* |  |  |  |  |  |  |
| *Coupling of the three solvers, testing* |  |  |  |  |  |  |
| *Embodiment of flexible geometry and input* |  |  |  |  |  |  |
| *Interpretative modelling of existing melting scenarios from portfolio of experiments* |  |  |  |  |  |  |
| *Modelling of reactor relevant melting scenarios* |  |  |  |  |  |  |

*Gantt chart of high-level activities* |
| **Competences required** before start of EEG (bullet points)* Engineers holding a Master Degree. A recipient of a Master degree or PhD in a University of Technology or Physics will also be considered as an eligible candidate.
 | **Competence development** during project (bullet points)* Knowledge; heat transfer with phase change, fluid dynamics, surface processes in reactor relevant conditions
* Skills; Numerical modelling of *free-surface* MHD flows with phase transitions
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| **Facilities used**Recommended, optional (not strictly required) | Benchmark of the code in existing or new experiments performed. Group of fusion facilities under FSD (e.g. AUG, JET, WEST, MAGNUM-PSI). Decision to be made depending on timelines. |
| **Mobility needs** | Visit to WPDES in Garching (1month) and participation in experiments on a EUROfusion facility (tbd.)  |
| **Future career possibilities**  | There is need and demand for engineers and users in the area of PFC damage analysis in view of lifetime and safety. The candidate will experience both parts computational engineering to create the code as well as application of the code in interpretative or predictive manner. The capabilities of the engineer include also the “non”-melting case of power handling analysis. Therefore, the candidate has multiple chances for a position in the European or International Fusion Research System.  |