

“THEORY, SIMULATION, VERIFICATION AND VALIDATION”

TSVV TASK 7: PLASMA-WALL INTERACTION IN DEMO

THRUST 2 Meeting

D. MATVEEV | 10.06.2022



UNIVERSITY OF HELSINKI



Université
Sorbonne
Paris Nord



JÜLICH
Forschungszentrum

TSVV-07 PROGRESS REPORT



Tasks for 2022 (1/4)

1. Perform dedicated PIC studies with BIT-1 for DEMO-relevant high-density divertor sheath, provide relevant input for erosion, dust transport and transient melting simulations

BIT1 code updated to include particle species dependent memory allocation (proportional to the concentration of species). Updated BIT1 requires up to 30% less memory and is 10-30% faster. In the future – dynamic memory allocation envisaged.

Input files for extremely high density sheath ($\sim 10^{22} \text{ m}^{-3}$) generated, simulations pending until after PSI conference.

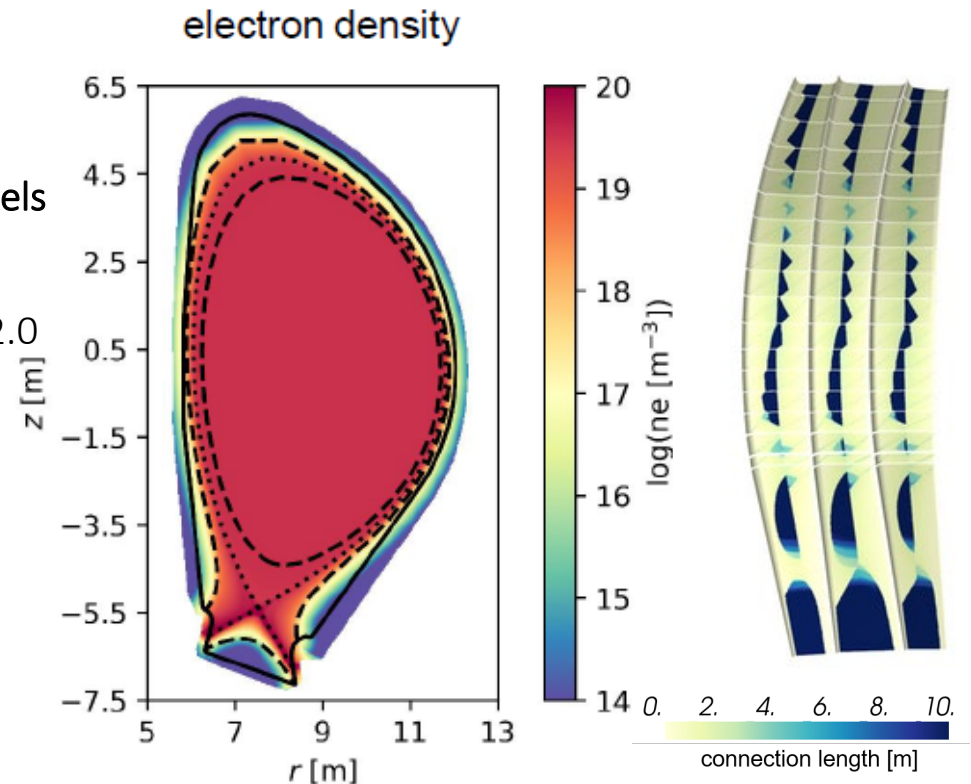
2. Perform full 3D ERO2.0 simulations using existing PWI databases, sheath models and the plasma solution, provide erosion-deposition maps and wall lifetime

Plasma equilibrium (2017) and SOLPS plasma solution implemented in ERO2.0

Meeting with DEMO team took place to clarify several aspects

First simulations of erosion-deposition in preparation

4. Post-process and implement in ERO2.0 the improved DEMO plasma solution



TSVV-07 PROGRESS REPORT



Tasks for 2022 (2/4)

3. Perform dedicated dust transport simulations with MIGRAINE for net deposition locations provided by ERO2.0 simulations

Based on 2021 MIGRAINE simulations using ITER geometries and low-power plasma profiles, estimates of long-term W dust inventory evolution in 12 remobilization scenarios were refined

Simple Markov chain fit models improved to sub-percent errors (dashed lines) →

Manuscript on the EUROfusion pinboard (#32593)

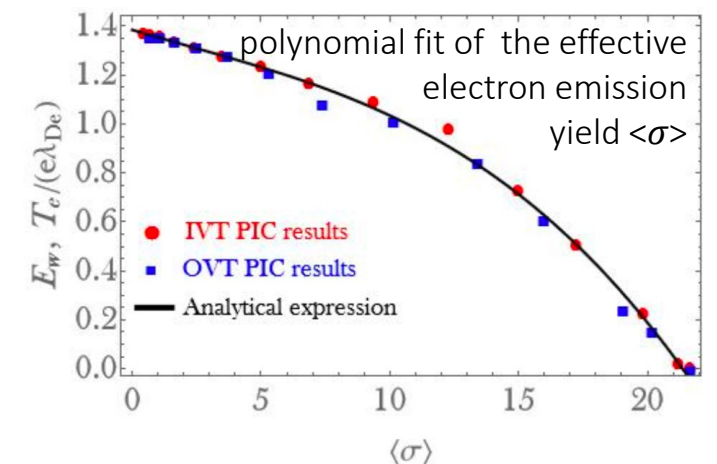
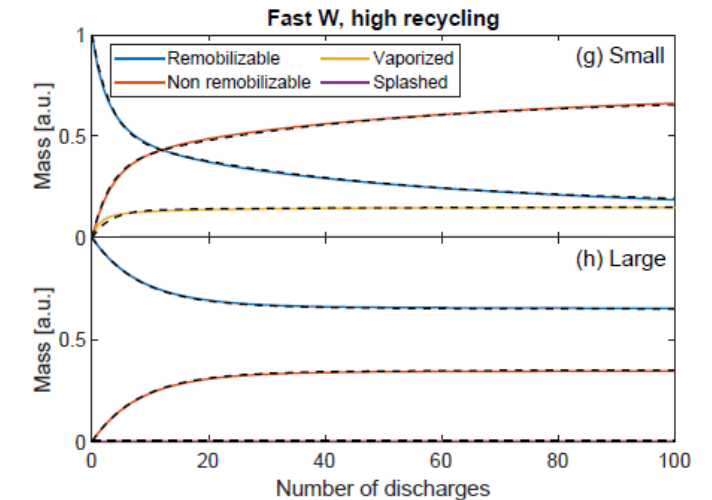
ACH collaboration regarding MIGRAINE parallelization is close to completion!

5. Perform PIC simulations with SPICE to identify whether the escaping current scales with electron thermal velocity or on ion sound speed

PIC simulations result in escaping current $\sim v_{Te}$ with second-order effect of Ti

Additional simulations of TE+SEE+EBS confirm the validity of the simple model

To be published in NF in 2022



TSVV-07 PROGRESS REPORT



Tasks for 2022 (3/4)

- Run cumulative MD simulations utilizing available W-H interatomic potentials to simulate supersaturated W surfaces under ion irradiation; **compare to static cases**

Studied pure and supersaturated W irradiated by D and D₂ ions → no difference due to molecules

Supersaturation decreases the sputtering, that seems to be not due to dilution, neither enhanced reflection

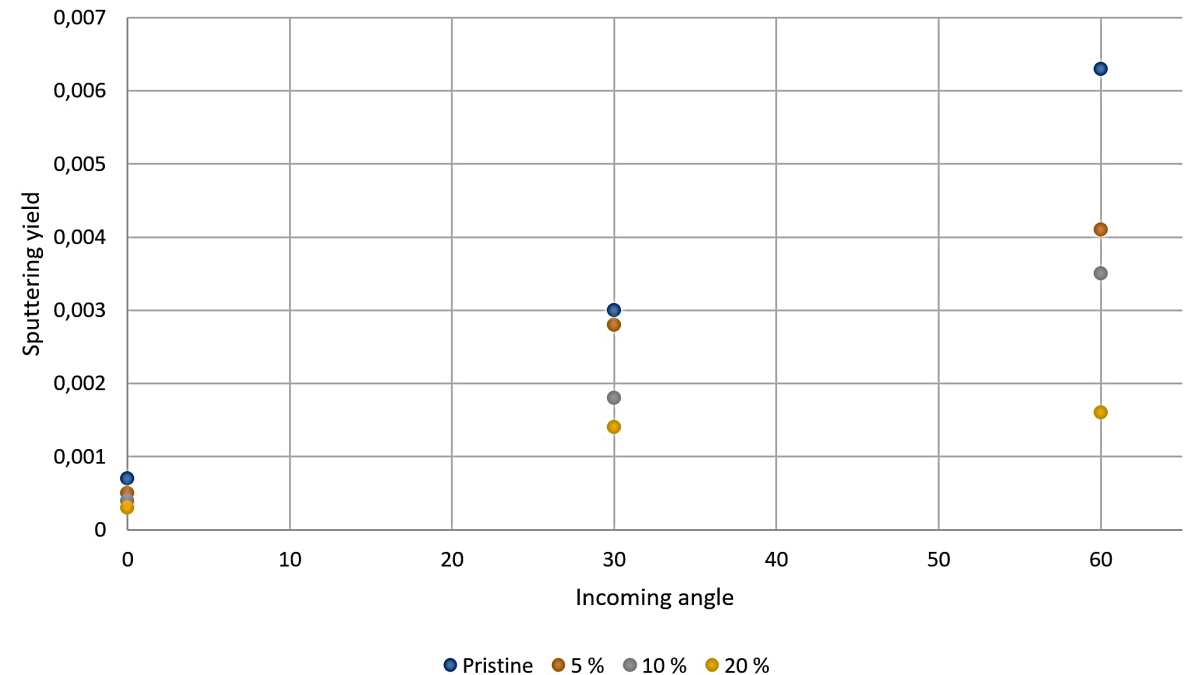
- Implement representative values of surface heat fluxes and halo current densities during DEMO VDEs for transient melting simulations with MEMOS-U

A review incl. state-of-the-art estimates for W melt stability and droplet release is under review (EUROfusion #32322)

The MEMOS-U model is being implemented in a new code using the open-source AMReX adaptive meshing framework

Contact with ACH has been initiated in order to plan the parallelization work in 2023

Sputtering yield at different incoming angles for different D levels in the material



TSVV-07 PROGRESS REPORT



Tasks for 2022 (4/4)

8. Implement the gyromotion module in SDTrimSP-3D

Current work: optimization of gyro-module (run time, load balancing), implementation of crystalline lattice capabilities

Future work: cross-check with ERO2.0, evaluation of sample exposures in AUG, cross-validation with MARLOWE and MD

9. Implement neutron damage and damage stabilization models in retention codes

Ongoing: added source terms for creating traps by neutron bombardment (from dpa profiles) and for trap annealing

Paper on mobile dislocations (first steps to the diffusion of neutron induced traps) published (EUROfusion #31807)

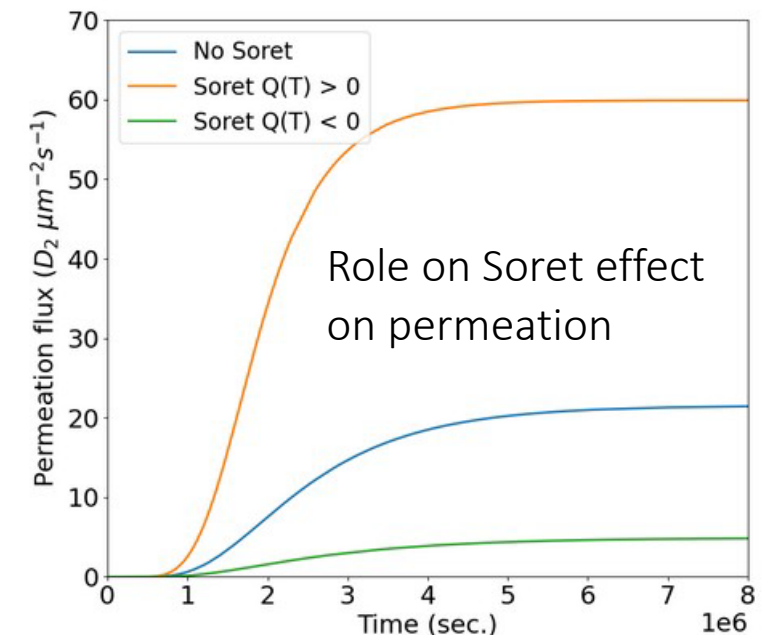
10. Perform TESSIM and FESTIM simulations of fuel accumulation in DEMO PFC and permeation to coolant (w/o neutrons)

TESSIM: paper by R. Arredondo, NME 2021 (EUROfusion #29201)

FESTIM: 3D simulations of a DEMO monoblock done;
PSI poster cancelled (paper in preparation instead)

Poster at SOFT: He bursting model and indirect coupling of H/He transport

Soret effect simulations: verified by test case from E. Martínez, JAP 2021



TSVV-07 PROGRESS REPORT



Summary

Tolerable delay with simulations of D supersaturated W (delay from 2021 + slow interatomic potential)

Tolerable delay with ERO2.0 simulations (delay from 2021)

Still no updated SOLPS solution (end of year realistic); still no angular resolved CX fluxes

Diffusion-trapping data for EUROFER can be limiting factor for simulations of retention/permeation

Man power: FZJ open position still under discussion, for the moment -> Juri Romazanov

ACH support for MEMOS-U and RAVETIME in 2023 still not fully agreed (which ACH?)

No detailed planning for IMASification yet

Possibility of a common offline full team meeting in 2023?