Development and validation of the MEMOS-U code (link with WP TE – WEST/AUG) (VR)

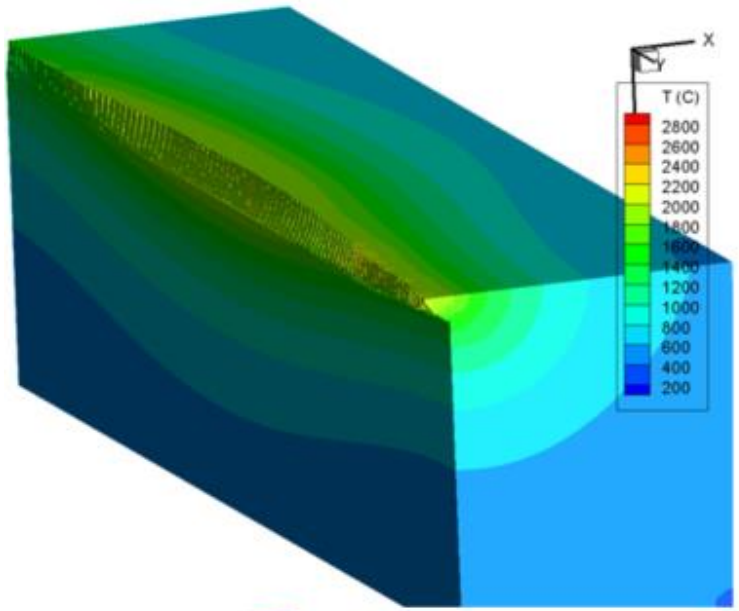
2021 activity

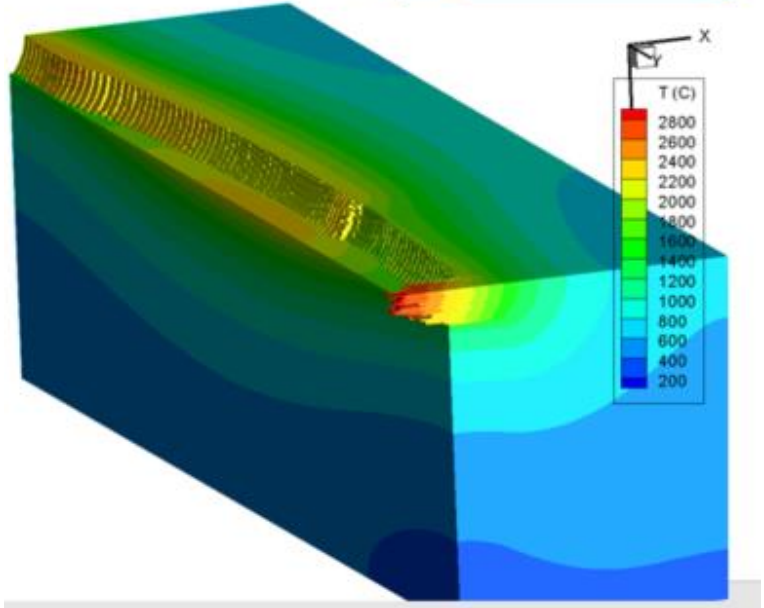
New regimes are addressed with MEMOS-U

- Electrically insulated PFC; Modelling of the floating W leading edge experiment in AUG
- ITER-like actively cooled PFC; Modelling of the W leading edge melting experiment in WEST
- Predictions for new materials (Nb and Ir) have been verified in the recent AUG experiment

- Development of new code version with adaptive meshing

Main cooling channels: thermionic emission



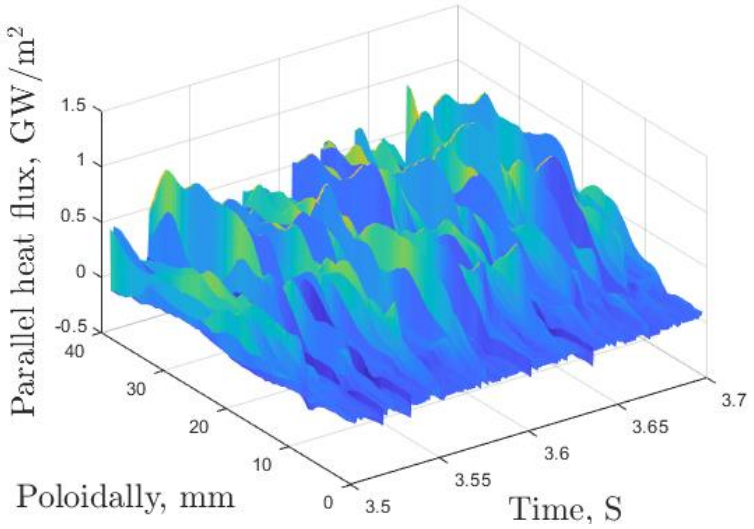


MEMOS-U simulations of the AUG W leading edge melting during pulse #33509

Upper figure: simulations **including thermionic cooling reproduce the surface erosion profile** and total excavated material volume with good accuracy.

Lower figure: simulations **neglecting thermionic cooling lead to ten times higher excavated volume** and much more material ejection from the edge

Heat load:



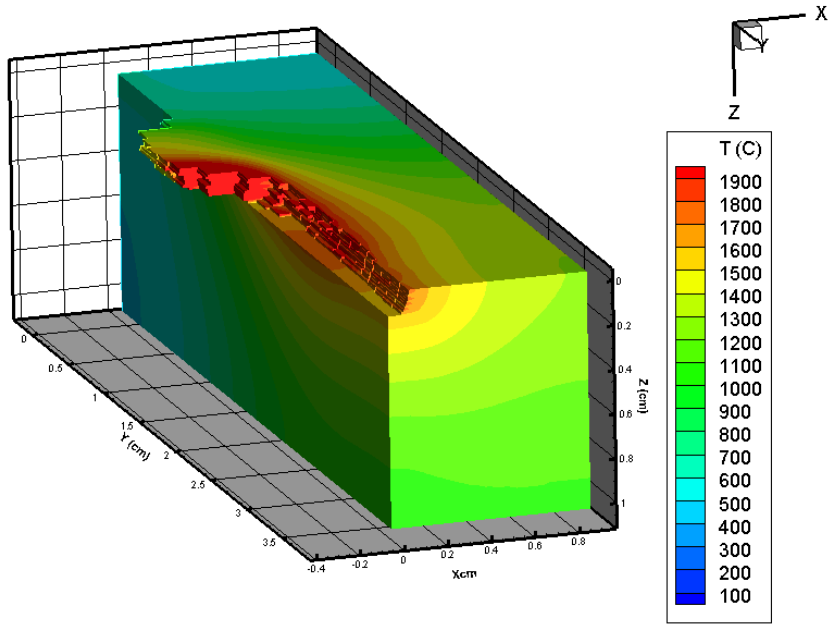
Floating lamella in AUG modeling: summary

More complex scenario with an unusual energy deposition due to the evolution of the sheath heat transmission coefficient

Simulations showed satisfactory agreement with the experimental evidence including additional experimental constraints (increase of the deposited energy compared to the grounded case and back-side temperature raise).

Quantitive results reveal a clear physical mechanism;

- acceleration by **gravity** is much lower than that by JxB force in the grounded case (~ $10^3\ m/s^2$)
- but heat flux to the floating lamella is such that very deep, ~ 1 mm, and **sustained** melt pools are created explaining fully the large displacement oberved



Temperature on the deformed 3D domain, at the end of exposure (4.98 sec)

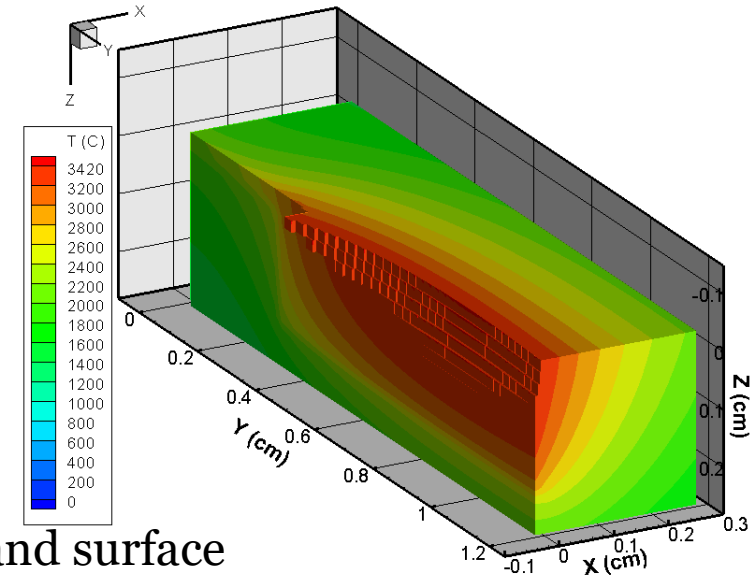
Sample topography as seen from above

WEST experiment modeling: summary

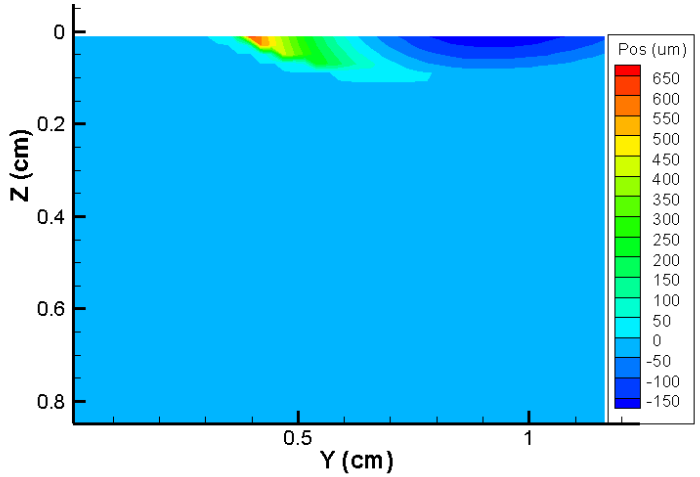
- Active cooling was implemented

- Modest energy input (surface temperature is just above melting point) and striping by JxB result in formation of very shallow (few to 20 micron) melt layer
- The JxB acceleration is alsmost as high as in AUG and JET transient ELM melting exeriments but high viscous damping is responsible for very low terminal speed of just a few cm/s

- Surface modification profile and excavated volume can be matched within uncertainties of the experimental heat flux



Temperature and surface deformation on the 3D domain after 5 s of exposure (zoomed in near the edge)



Surface deformation (normal direction) plotted versus z, y coordinates, after 5 s of exposure (~2.5 s melting)

NB: postmortem profile is a cummulative result of melting in 3 exposures!

Ni and Ir experiments in AUG

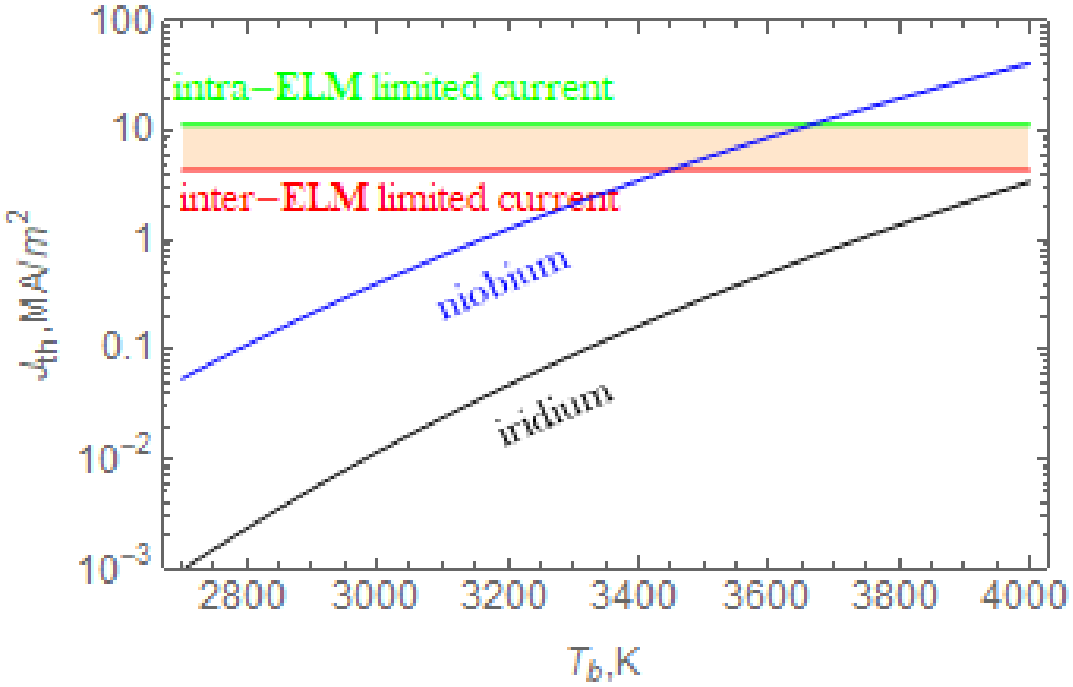
- The basic idea: ***Ir*** **($W_f = 5.3$ eV) vs** ***Nb*** **($W_f = 4.2$ eV)** as *poor vs good emmiter* and *similar* thermal properties

- Design simulations of the experiment with MEMOS-U (2020) revealed that in leading edge geometry scenario the escaped thermionic emission for Ir sample reaches limiting regime

- Sloped geometry was suggested with prediction of very limited melting and displacement for Ir and Nb entering into sustained melting with possible material ejection

- Spring 2021 experiment in AUG confirmed the predicted picture

Final modelling with the experimental heat fluxes to be carried in the near future



Presentations/publications

Development of the MEMOS-U macroscopic melt dynamics code - benchmarking and applications, Ratynskaia, Thoren, Tolias, *et al*, PFMC 2021, invited

Development of the MEMOS-U macroscopic melt dynamics code - benchmarking and applications, Ratynskaia, Thoren, Tolias, et al, 2021 *Phys. Scr.* **96** 124009

Modelling of recent tungsten melting experiments with MEMOS-U
Ratynskaia, Thoren, Tolias, *et al*, 30th ITPA DivSOL Topical Group Meeting 2021

Modelling of plasma facing components melt dynamics
Ratynskaia, 19th European Fusion Theory Conference, October 2021, invited