Modeling of H-mode EAST edge plasma with impurity seeding by SOLPS-ITER 3.2.0 on wide grid

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Introduction

- Recently the 2D transport codes were improved to operate on grids extended to the real walls [1, 2, 3]. However, runs with drifts remained a challenging task.
- First results from SOLPS-ITER 3.2.0 with drifts were achieved on structured meshes only [4], then on unstructured grids as well [5], but with fluid neutrals and without impurities.
- In the paper the new code SOLPS-ITER 3.2.0 is for the first time successfully applied to model the plasma edge of EAST H-mode discharges with full drifts, impurities and kinetic neutrals, see also [6].

Modeling setup

- P_{CEI} = 3.0 MW (assuming core radiation), $\Gamma_{SMBI} = 2.5 \cdot 10^{21}$ D at/s, ion $B \times \nabla B$-drift downwards;
- Γ_{seed} and absorption on pumping surfaces are fitted to match OT T_e and $j_{sat\parallel}$.

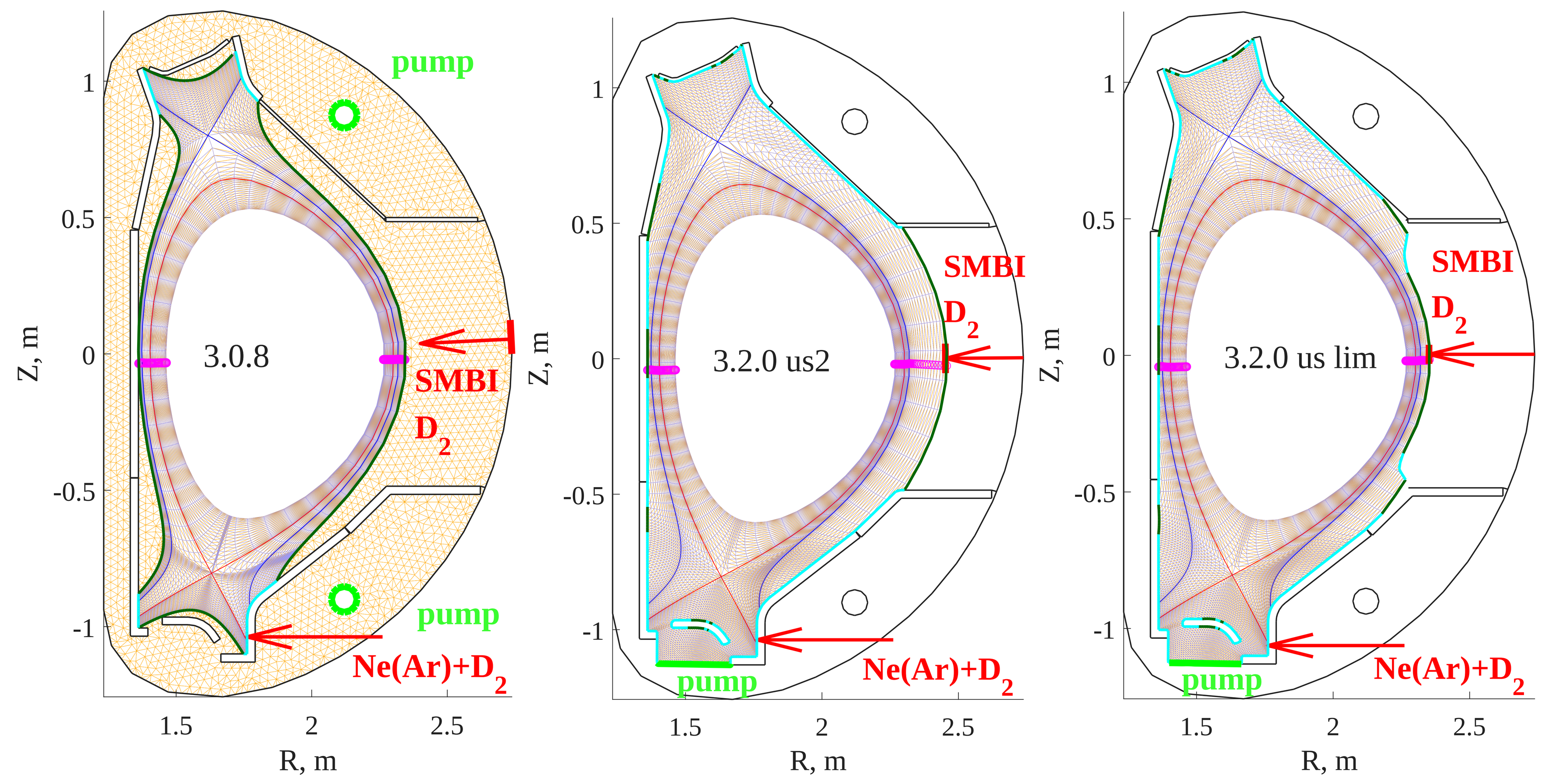

Figure: Standard mesh for SOLPS-ITER 3.0.8 modeling and two unstructured (us) meshes for SOLPS-ITER 3.2.0 (without limiter and with toroidally symmetric limiter.)

Modeling results

- 3.0.8 to exp – transport coefficients and BCs on wall are fitted to match experiments;
- 3.2.0 us2 – fitted transport coefficients on unstructured mesh without limiter;
- 3.2.0 us lim – same transport coefficients on unstructured mesh with limiter;
- 3.0.8 to us2 – BCs on wall are fitted to match the "3.2.0 us2" profiles;
- 3.2.0 enh tr – same as "3.2.0 us lim" with enhanced transport to match experiments.

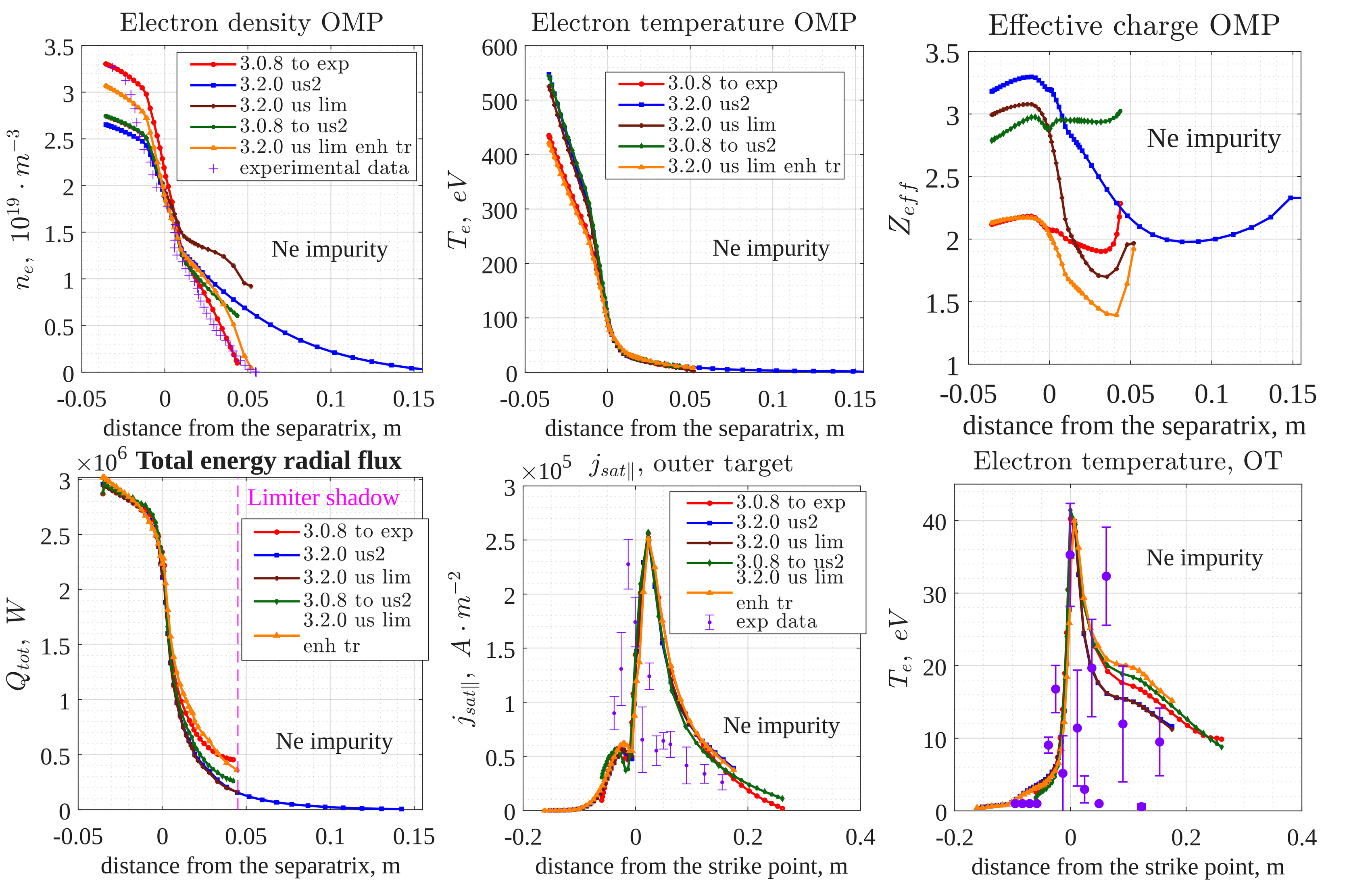

Figure: OMP profiles of n_e, T_e, Z_{eff} and energy radial flux; OT profiles of $j_{sat\parallel}$ and T_e; Ne modeling cases.

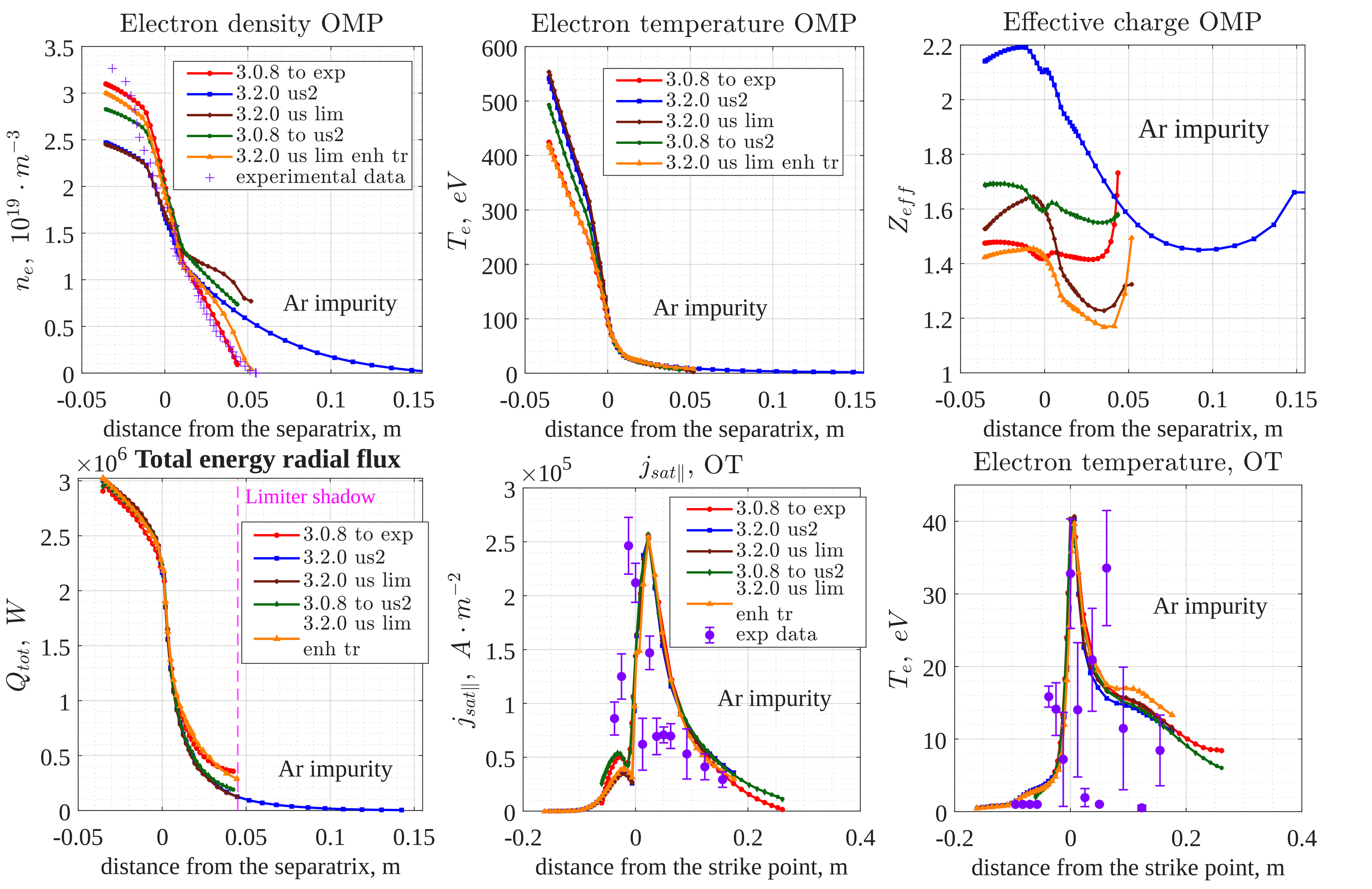

Figure: OMP profiles of n_e, T_e, Z_{eff} and energy radial flux; OT profiles of $j_{sat\parallel}$ and T_e; Ar modeling cases.

With fixed input power P_{CEI} and outer target power P_{OT} the adjustable parameter is P_{wall} (power to the wall or into limiter shadow). A decrease of P_{wall} leads to the increase of P_{rad}, c_{imp} and Z_{eff}, and vice versa.

For cases with smaller P_{wall} (and bigger P_{rad}, c_{imp} and Z_{eff}) the radiating spot below the inactive upper X-point is more pronounced.

Modeling results (continued)

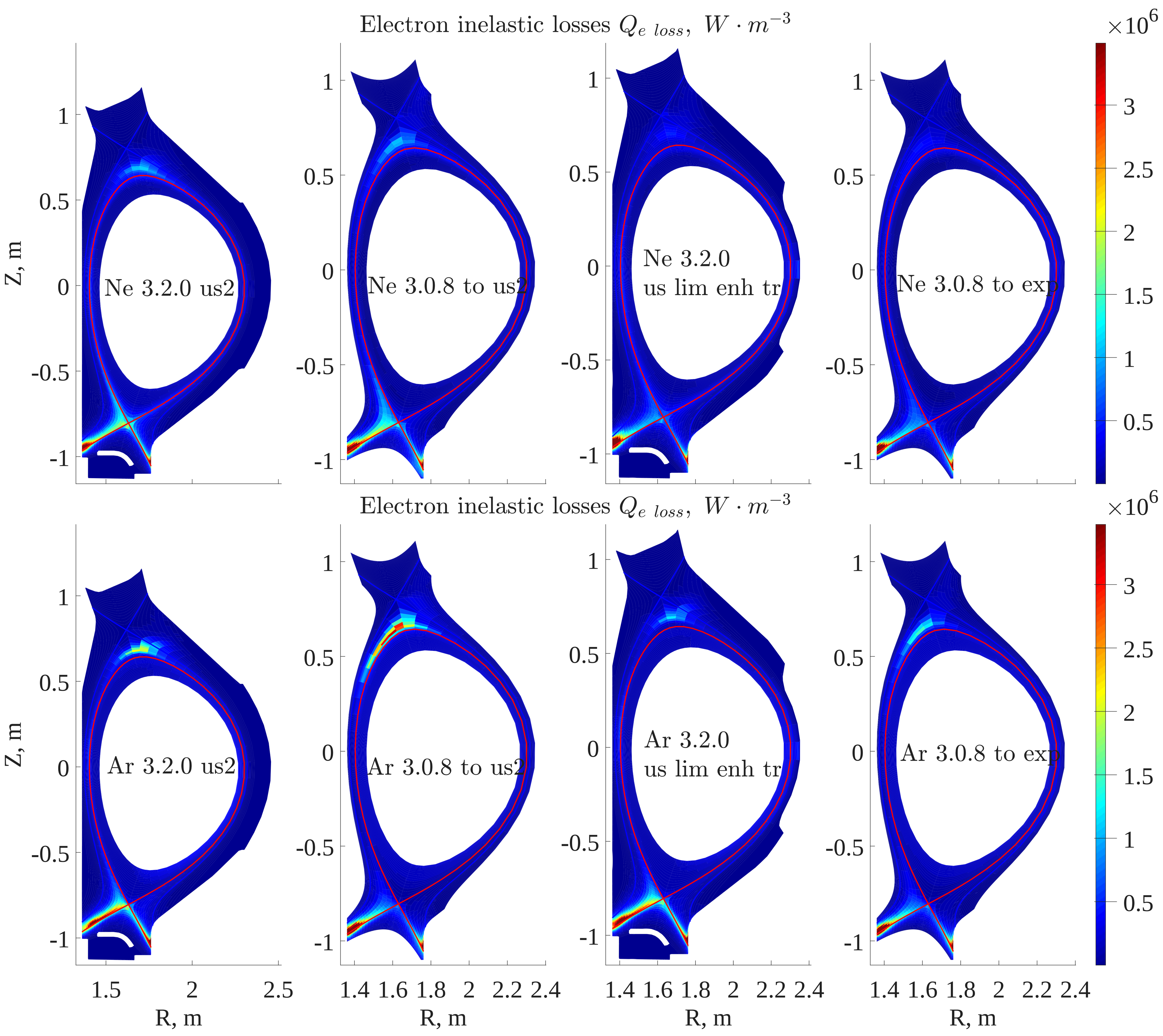

Figure: 2D profiles of electron radiation losses.

Radiating spot below the top inactive X-point

This spot is similar to the developed XPR near the active bottom X-point in dedicated experiments.

- In the middle of the spot all energy income by electron and ion parallel heat conductivity is spent to radiation, ions transfer energy to electrons via collisional exchange. Big flux expansion enhances temperatue drop at the top.
- Below (close to the primary separatrix) there is no poloidal minimum in T_e, ion energy source via parallel conductivity is compensated by $B \times \nabla B$ convention
- Above (closer to X-point) the energy source is small, T_e drops to $\sim$ 5 eV to reduce radiation losses.

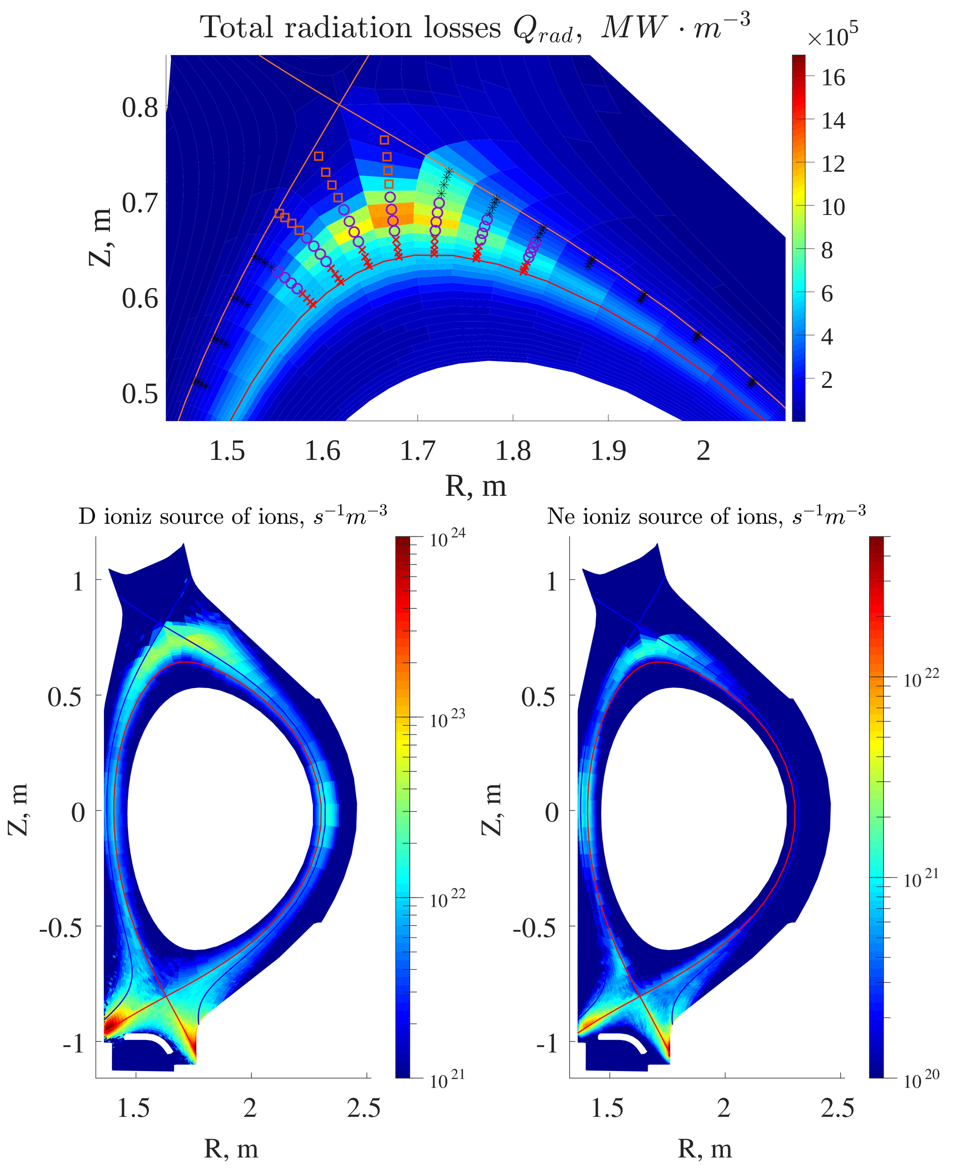

Figure: Top: Zones (group of cells on computational mesh) which are used for detailed energy balance analysis (plotted on the top of the 2D radiation losses). Bottom: ionization sources for D and Ne ions

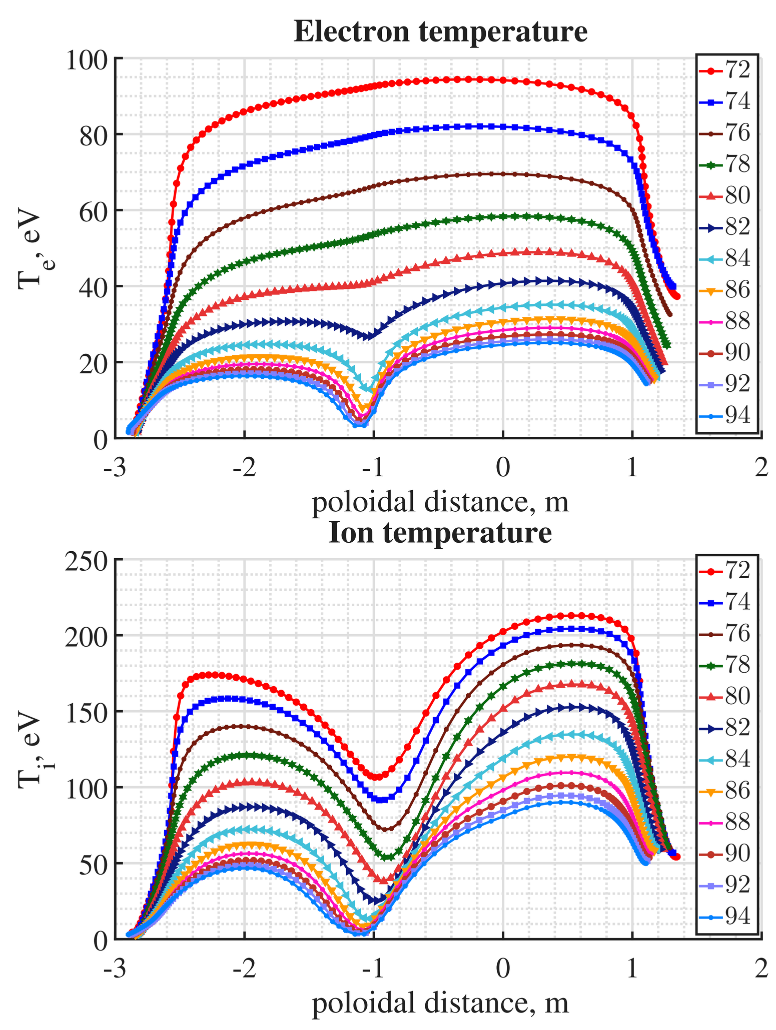

Figure: Poloidal plots of T_e and T_i along flux tubes between primary and secondary separatrix from inner to outer lower targets, x=0 corresponds to OMP. Flux tube index increases from primary (72) to secondary (94) separatrix.

Conclusion & Discussion

- A satisfactory agreement of SOLPS-ITER 3.2.0 modeling results to the experiments and to older SOLPS-ITER version 3.0.8 (on structured mesh with the artificial wall boundary) is demonstrated.
- To achieve the agrement to experiments, P_{wall} should be increased, however, impurity density still remains big.
- A radiating spot below the inactive upper X-point is observed in the modeling, which is a typical phenomenon of DDN topology discharges. Indication of such a spot presence are found in DDN experiments and modeling.
- Investigation of the initial mechanism of the plasma cooling and impurity accumulation near the upper X-point is left for the future analysis.

References

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