



UNIVERSITY
of York



UK Atomic
Energy
Authority

Modelling 2D edge transport in MAST-U with Hermes-3

Lin Shih¹, David Moulton², Mike Kryjak², Christopher Ridgers¹

¹ York Plasma Institute, University of York, UK

² Culham Centre for Fusion Energy, United Kingdom Atomic Energy Authority

lin.shih@york.ac.uk

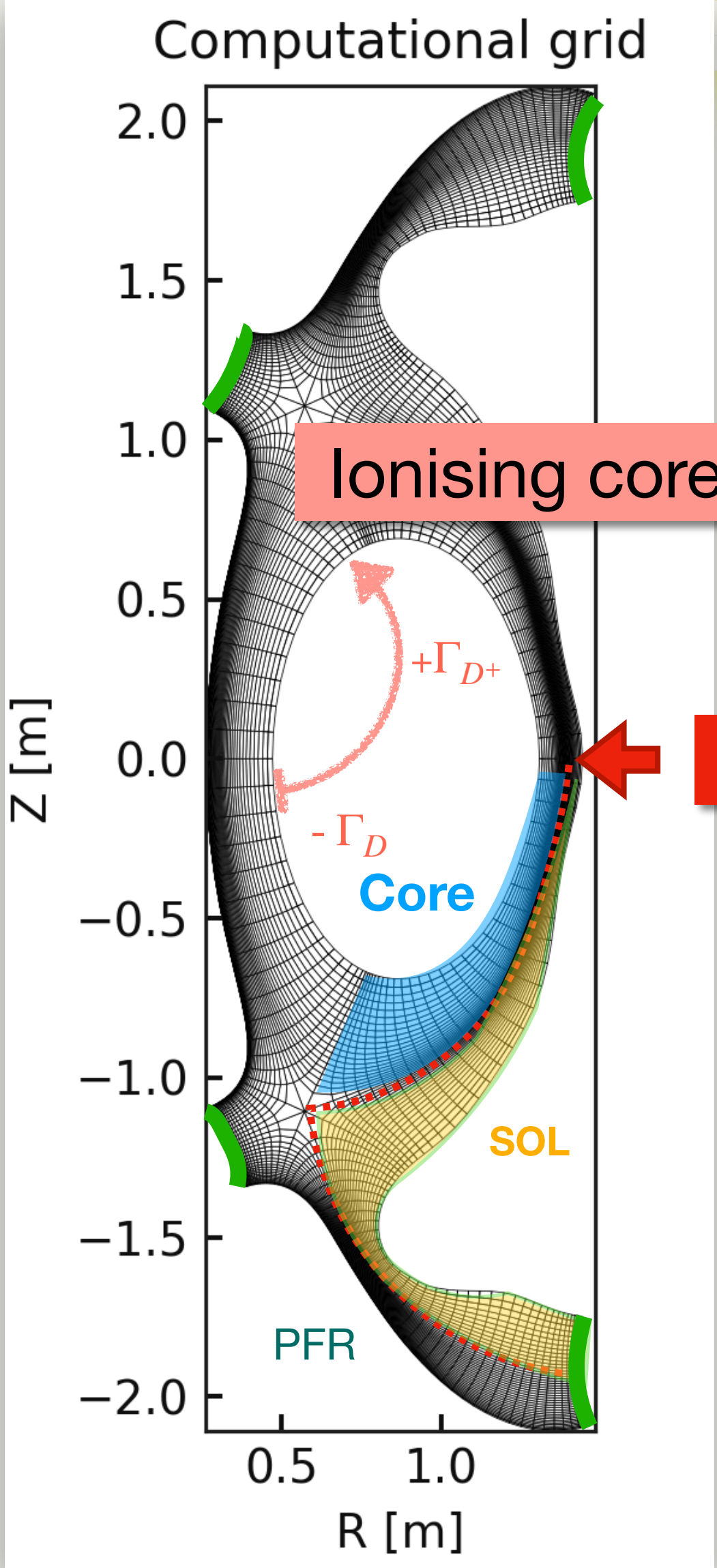
2026 Exhaust code workshop at UKAEA

Hermes-3 vs SOLPS-ITER

- By comparing EIRENE/SOLPS-ITER and Hermes-3, we hope to advance the exhaust modelling with Advanced Fluid Neutral equations [1][2]

Code	SOLPS-ITER	Hermes-3
Plasma model	Braginskii fluid equations	Braginskii fluid equations
Neutral model	Kinetic Model (EIRENE)	AFN equations with flux limiter applied
Pros	Realistic, accurate	Smooth and fast
Cons	Computational expensive, noisy	Inaccurate at low ion-neutral collisional region

- 2D steady-state, attached MAST-U #46895 super-X connected double-null, 1 MW input power.
- EIRENE was simplified to adapt the Hermes-3 feature (grid, no molecules, neutral boundary conditions)

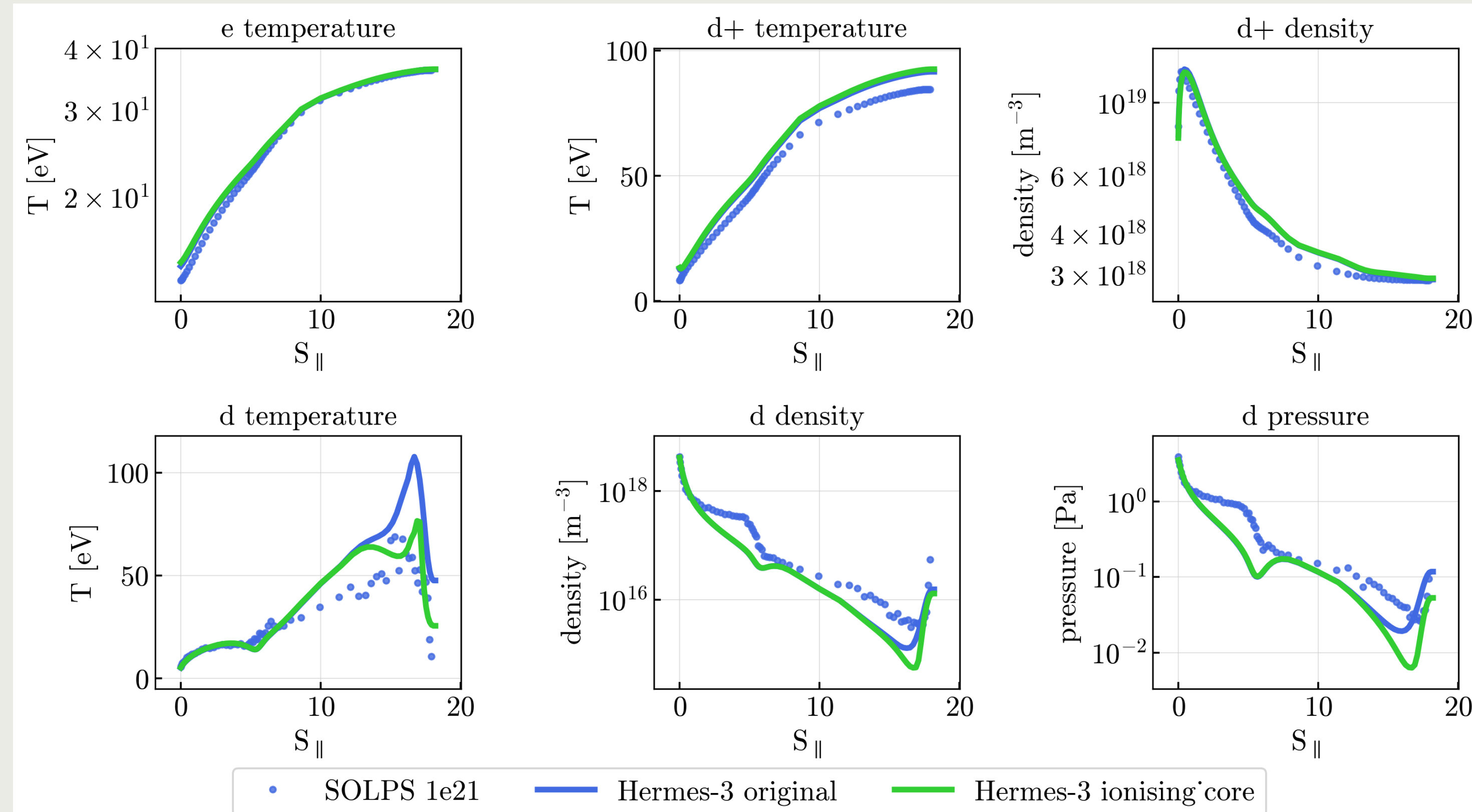


- Different D_2 puff rates to match upstream density
 - Hermes-3:
 $6 \times 10^{20}/s$
 - SOLPS: $10^{21}/s$

[1] N. Horsten, Nucl. Fusion, Aug. 2017, [2] W. Van Uytven et al., Nucl. Fusion, 2022

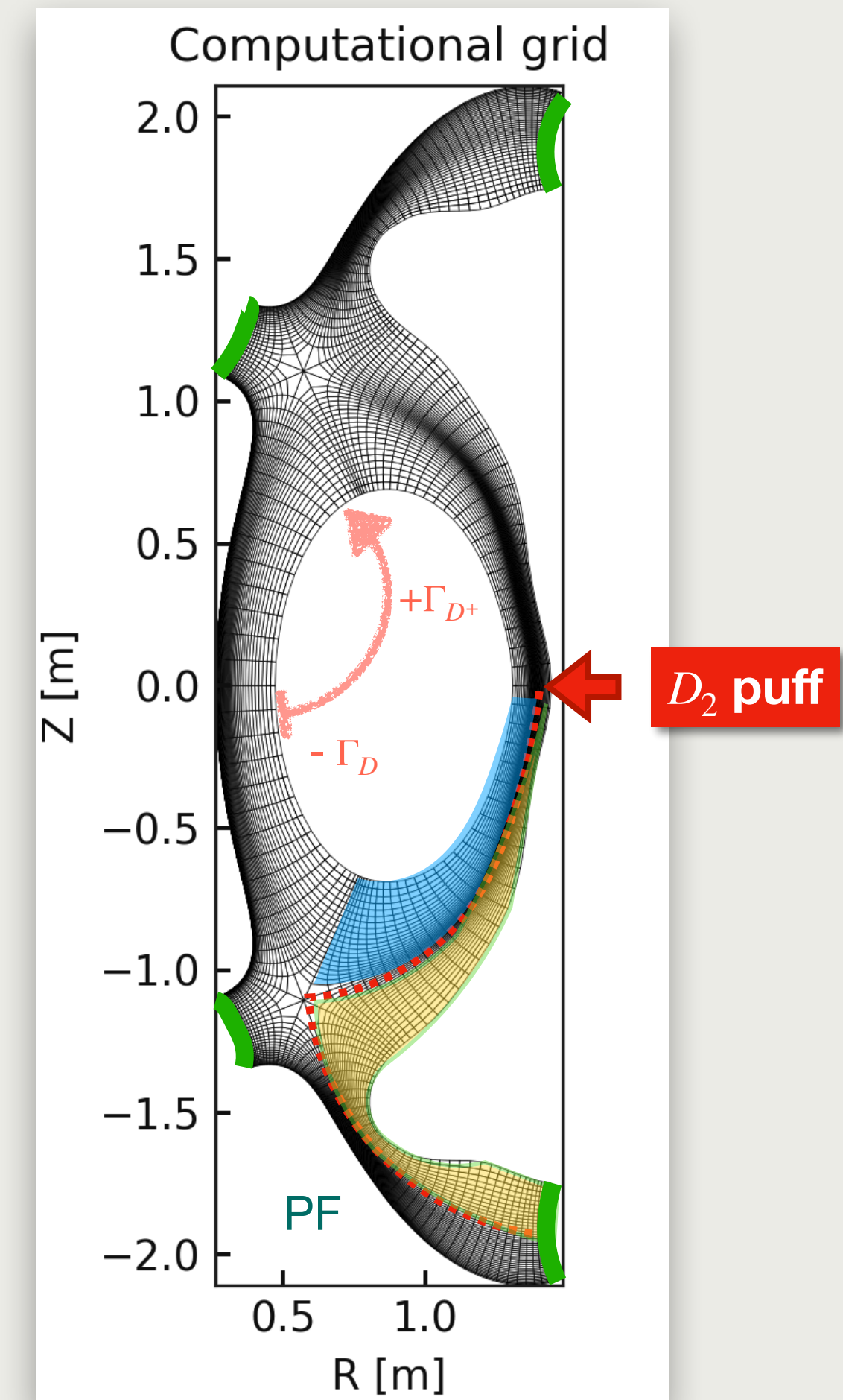
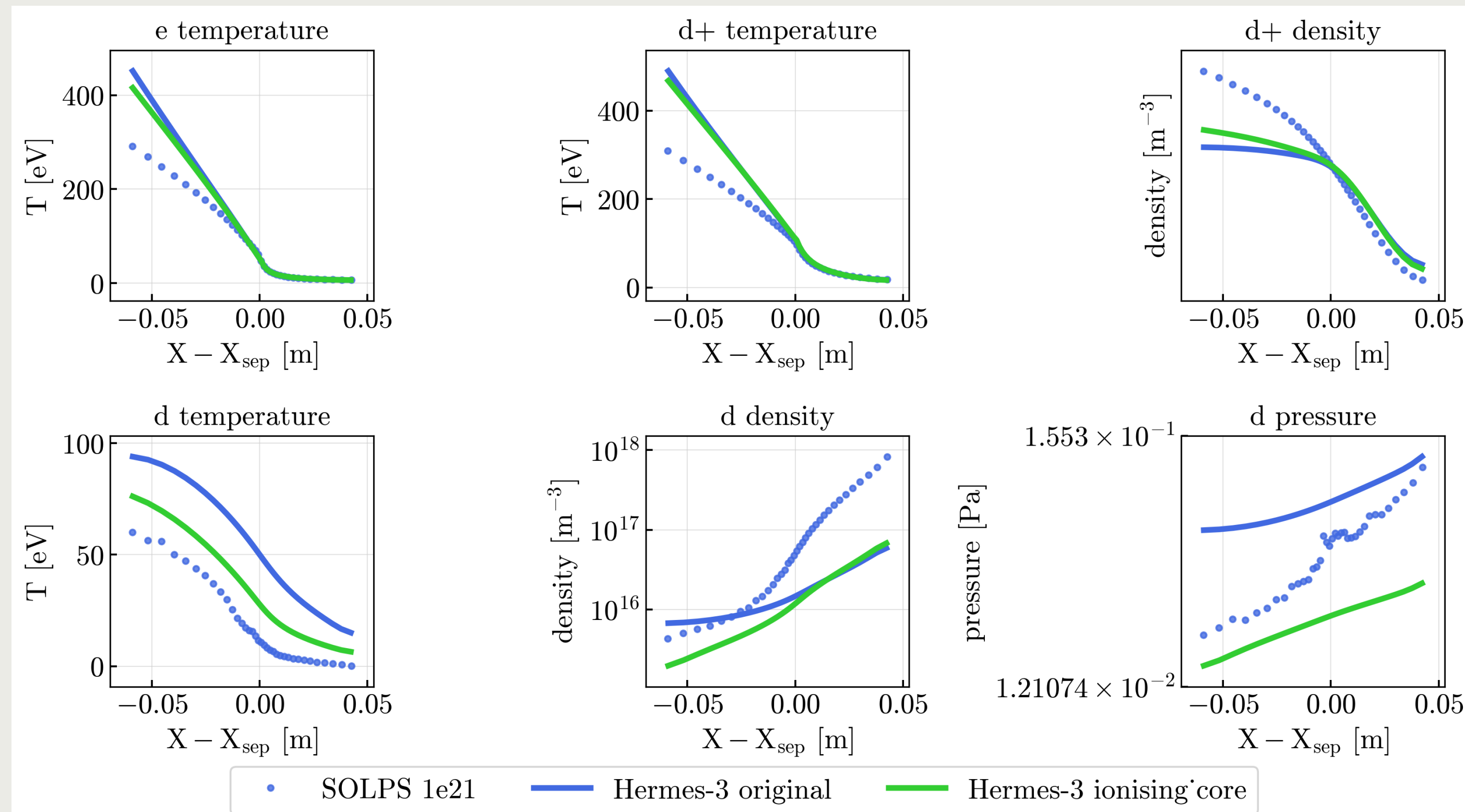
First SOL ring profile

- The ionising core boundary, matching a SOLPS-ITER feature, has recently been implemented in Hermes-3.
- It reduces the peak neutral temperature by 57%, but lowers the neutral density.



Neutral gas penetration issues

- The ionising core boundary improves neutral gradients significantly, but raises the plasma density by only 10%, so the plasma discrepancy remains.
- Hypothesis:** fast kinetic neutrals penetrating deeper into the core in SOLPS, while high ion–neutral collisionality limits penetration in the neutral fluid model.



Conclusion & Future work



- **Take away:**
 - With a tuned puff, the codes show qualitatively good agreement in the SOL, but Hermes-3 under-predicts core densities.
 - An ionising core boundary condition is newly implemented in Hermes-3 ([PR #576](#)) , reduces the discrepancy at OMP, whereas the remaining difference requires further investigation.
- **Ongoing and future work**
 - To address the neutral penetration issue, we are tuning the flux limiter and increasing the charge exchange rate in both codes to probe kinetic effects.
 - Once penetration is resolved, the next stage is include molecules in this study and move on to the detachment and time-dependent transient studies with Hermes-3.