Numerical modelling of underexplored edge plasma cases in tokamaks using the SOLPS-ITER code

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Introduction

- Boundary plasma and Scrape-Off Layer (SOL) play a key role in controlling particle and heat fluxes at the divertors and impurity accumulation, crucial for future fusion reactors.
- Numerical tools to support interpretation and complement experimental results, but also to investigate experimentally inaccessible configurations and design future scenarios.
- In this work, numerical investigation of fusion-relevant boundary plasma scenarios experimentally implemented at TCV and ASDEX Upgrade facilities, different both for magnetic geometry and plasma species.

Methods: SOLPS-ITER code

B2.5 — 2D plasma fluid code. Solves fluid equations for particle, momentum and energy transport

Provides the plasma background →

← Provides the sources for plasma fluid equations

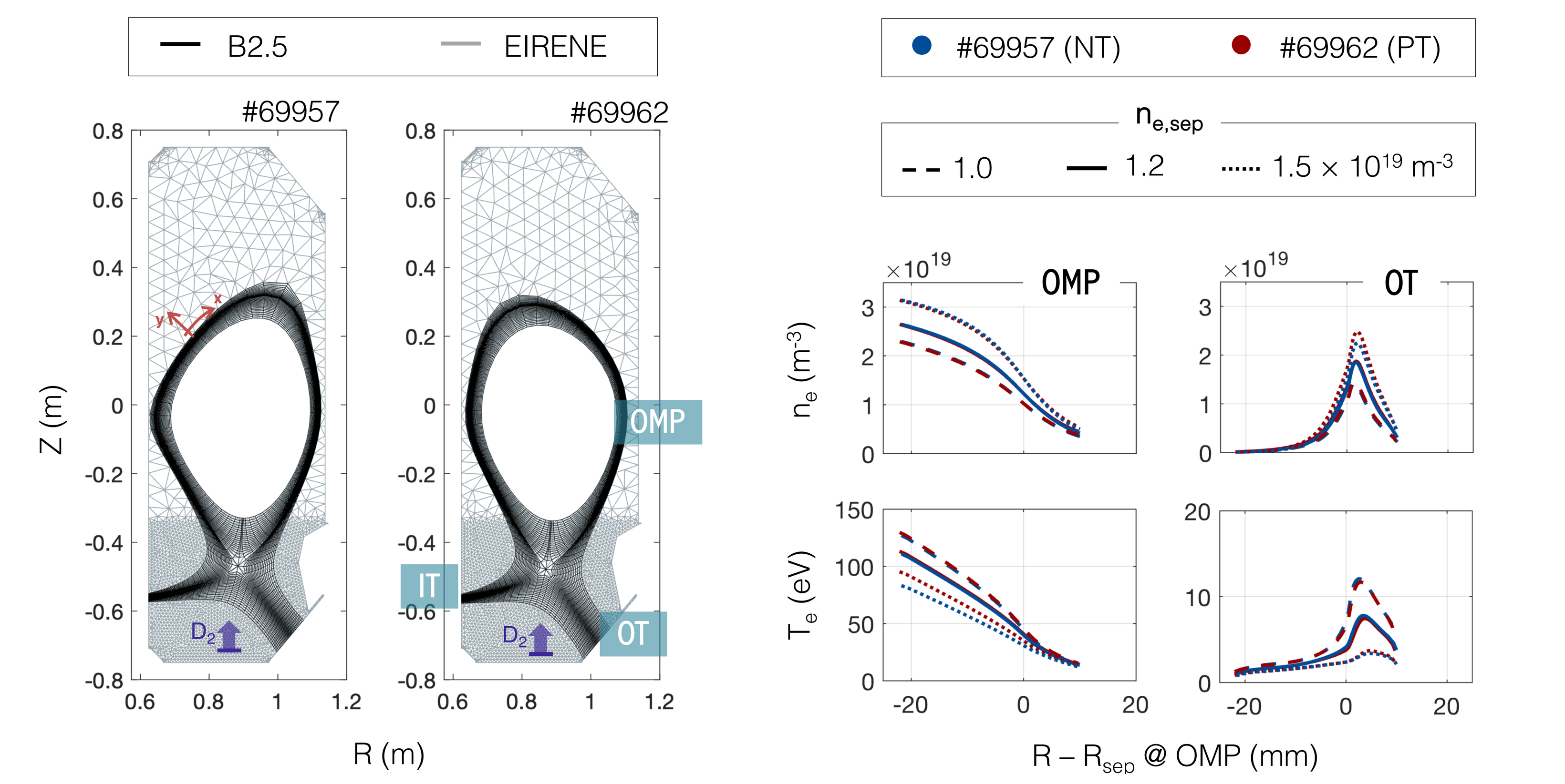
EIRENE — 3D neutral kinetic code. Computes Monte Carlo trajectories of neutral particles onto plasma bkg.

- Mesh based on magnetic equilibrium
- Cross-field transport modelled as diffusive
- Applicable to tokamak and linear geometries
- Specification of BC, gas puff and pumping
- Possibility to turn on drifts and currents
- Possible coupling with erosion codes

TCV Tokamak

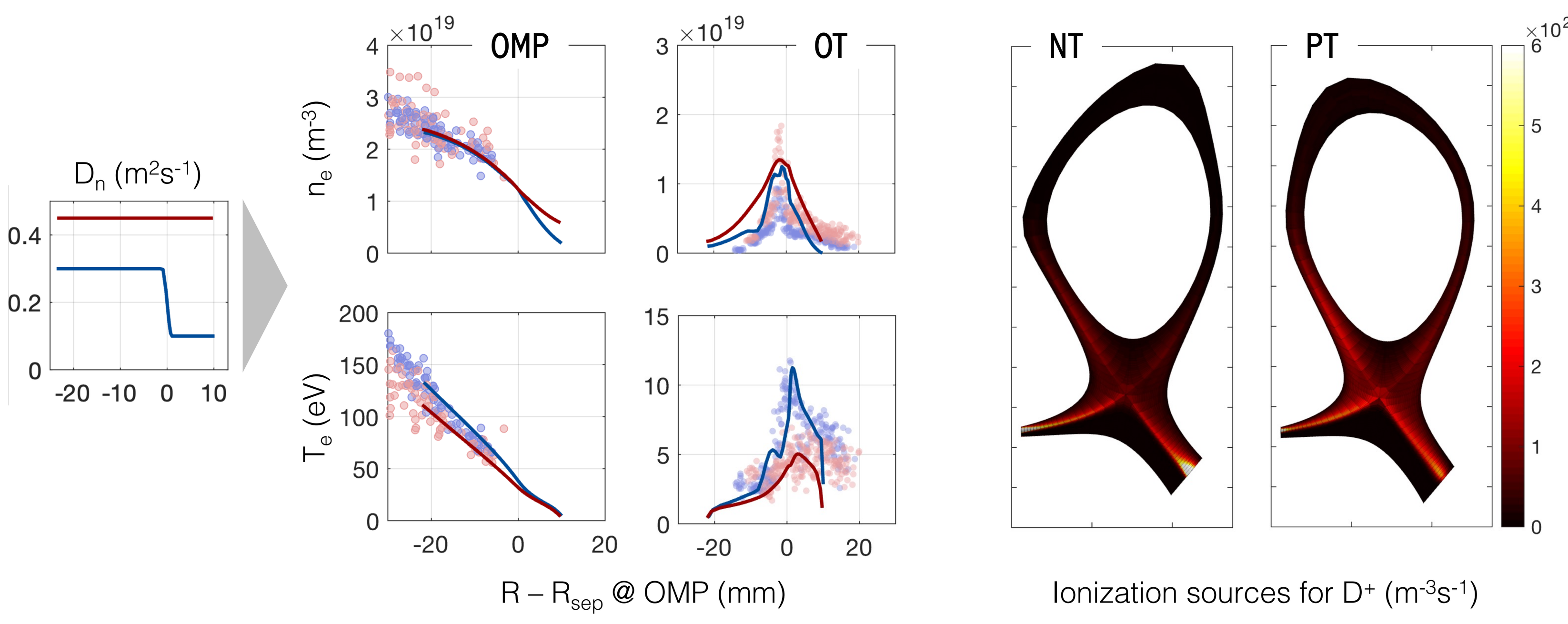
Objective: L-mode deuterium discharges with fixed divertor geometry and opposite upper triangularity: lower divertor cooling and *harder* detachment in Negative Triangularity (NT) compared to Positive Triangularity (PT), but identical upstream conditions.

1. Can the experimental differences be justified only by the different magnetic geometry?



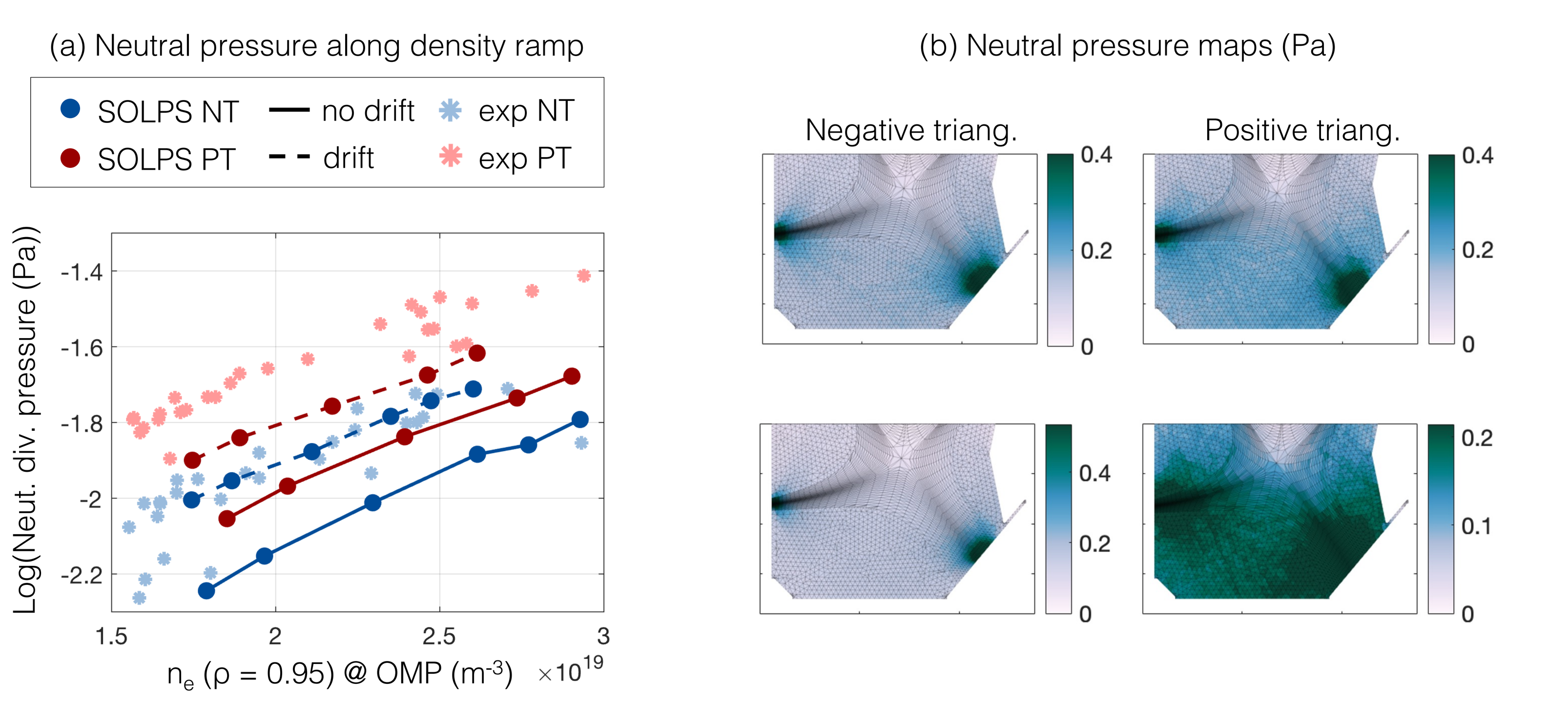
No difference in the plasma profiles at fixed transport coefficients for the two configurations.

2. What assumptions about the transport regimes need to be introduced?



Suppressed particle diffusivity in NT. Attached ionization sources in NT, partial detachment in PT.

3. Simulation of a separatrix electron density scan, to investigate the neutral pressure evolution.

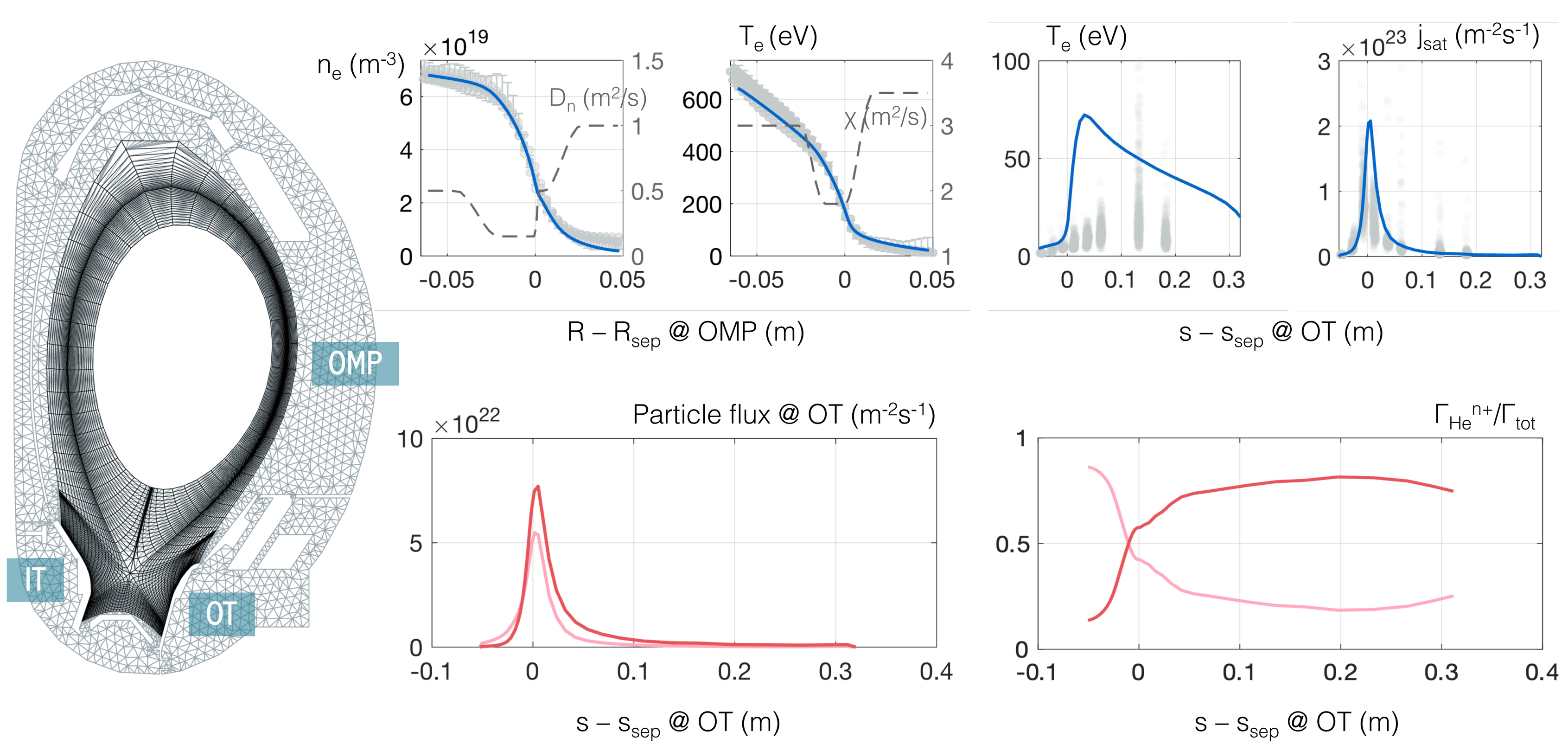


Lower neutral divertor pressure in NT coherent with experimental data. Neutral pressure distribution interpreted considering the balance between recycling and ionization processes.

ASDEX Upgrade Tokamak

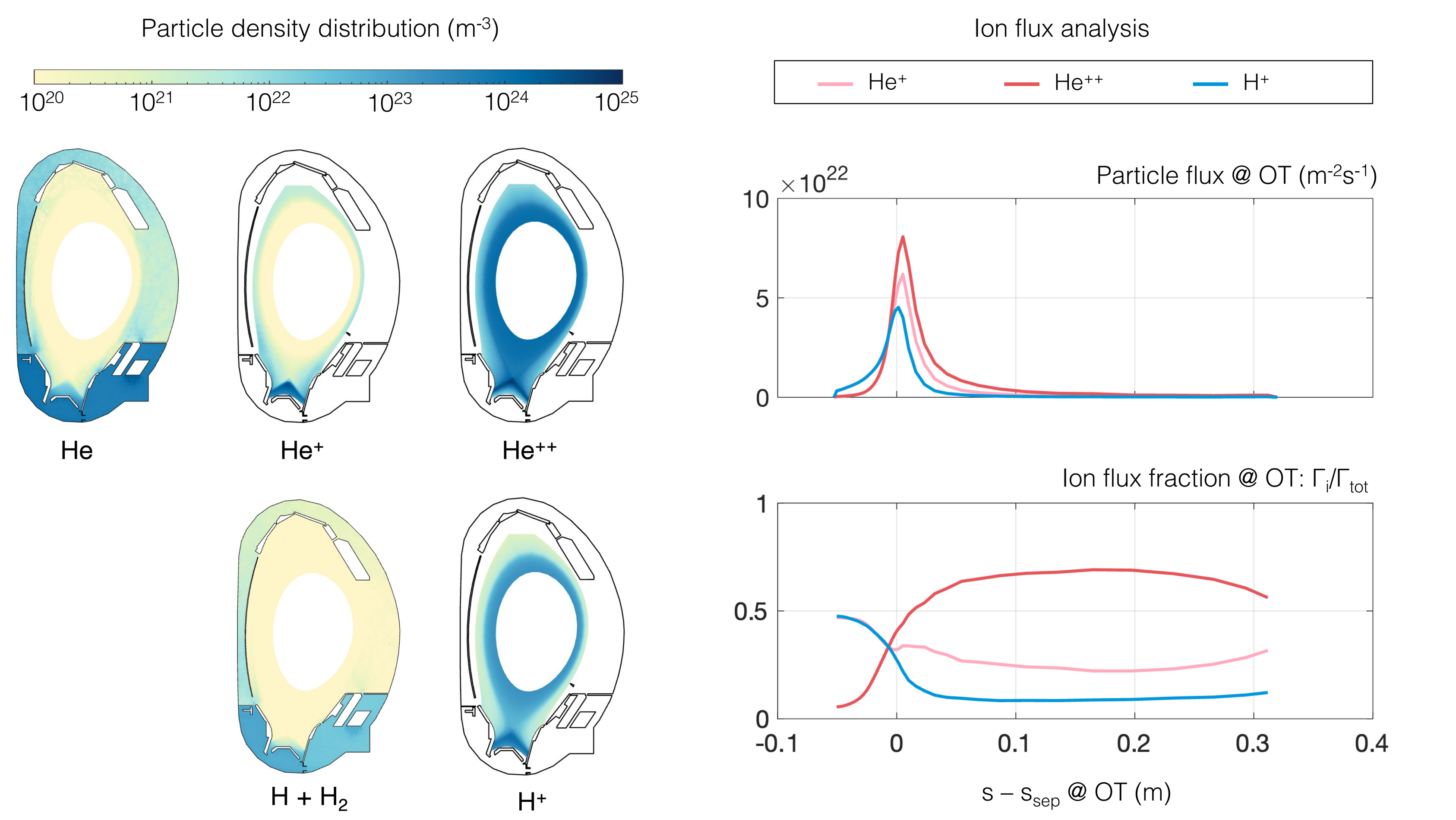
Objective: Helium H-mode (+ H-based NBI) plasma discharge performed to investigate He Plasma Material Interaction (PMI) on W-based samples. The objective is to model the inter-ELM plasma parameters and analyze the fluxes reaching the outer divertor target for eventual erosion modelling (ERO2.0).

1. Modelling of an H-mode pure He plasma



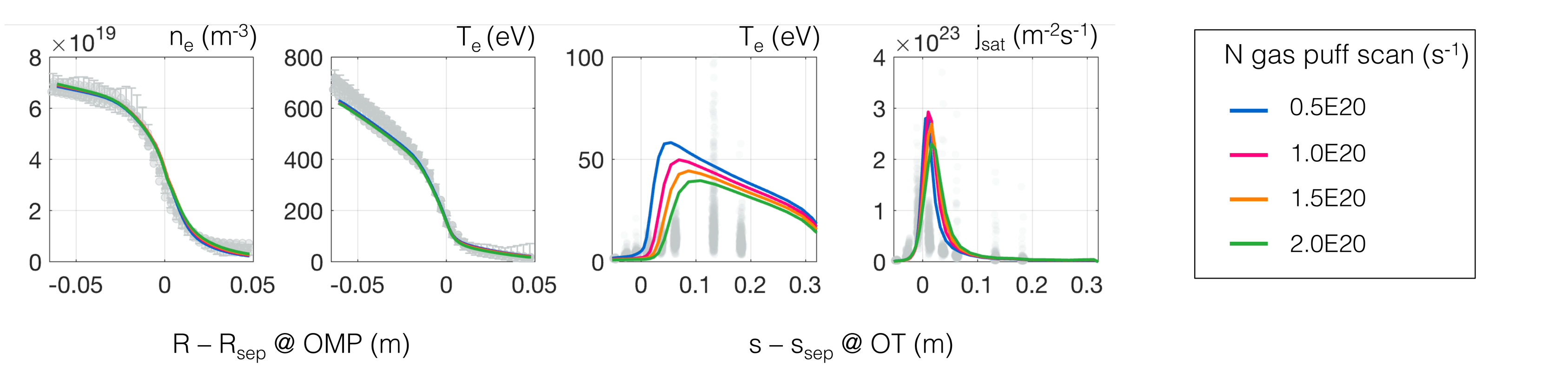
Good agreement with experimental data, yet overestimation of Te @ OT.
He⁺ and He⁺⁺ fluxes at the Outer Strike Point are comparable in magnitude

2. Inclusion of H from NBI in experimental proportions (n_{He}/n_e ≈ 45% @ core border)



He⁺ and H⁺ associated with NBI accumulating in the PFR and dominating the flux to OT there.

3. Inclusion of N as a proxy for radiating impurities leads to lower T_e @ OT



Inclusion of radiating impurities (N taken as a proxy) may contribute to the decrease of Te @ OT.

References and relevant literature

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EUROfusion

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