



POLITECNICO MILANO 1863
gabriele.alberti@polimi.it

¹Politecnico di Milano, Dipartimento di Energia, 20133 Milano, Italy – ²Istituto per la Scienza e Tecnologia dei Plasm, CNR, Milan, 20125, Italy
³Forschungszentrum Jülich GmbH, Institute of Fusion Energy and Nuclear Waste Management – Plasma Physics, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany
⁴ISTP-CNR/Consorzio RFX, corso Stati Uniti 4, 35127 Padova, Italy

Motivations and goals

- The Divertor Tokamak Test (DTT) facility is a large experiment currently under design and construction at the ENEA Research Centre in Frascati (Rome, Italy). The main aim of DTT is assessing possible alternative solutions for the heat and power exhaust problem of future fusion plants [1].
- One of the major challenges in this framework is plasma-wall interaction (PWI). Materials can undergo **erosion**, which poses a limit to components lifetime, and eroded impurities can migrate into the core plasma, causing dilution and cooling [2]. These effects must be monitored and controlled in all DTT foreseen scenarios.
- The aim of this work is evaluating erosion/deposition due to deuterium (D) plasma and core contamination contribution of the DTT tungsten (W) divertor, using the ERO2.0 code [3] in two magnetic configurations: a **positive triangularity (PT)** scenario and a **negative triangularity (NT)** one. Both are investigated at full power (27 MW entering scrape-off layer) with **neon (Ne) seeding** to achieve detachment.

Simulation setup

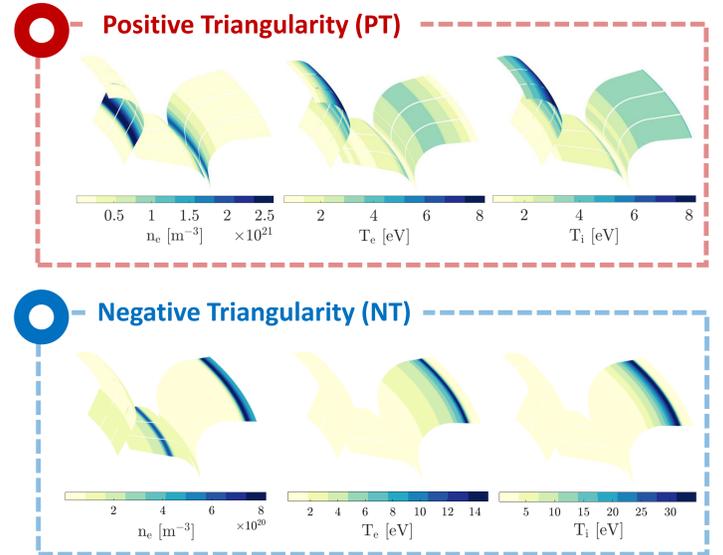
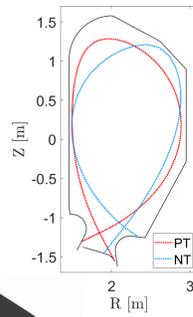
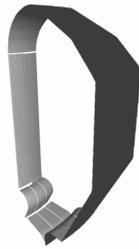
ERO2.0: 3D Monte-Carlo code for erosion and impurity migration modelling

- 20° toroidally symmetric 3D sector of DTT full-tungsten (W) components
- Background plasma from multi-fluid 2D edge plasma solver (SOLEEDGE for PT, SOLPS-ITER for NT) with toroidal symmetry
- Erosion estimate based on local plasma conditions, test particles (TPs) for eroded W accounting for collisions with plasma, atomic processes...
- m_{eff} and Z_{eff} for TP interaction with D-Ne plasma, Ne^{n+} ion fluxes for erosion evaluation

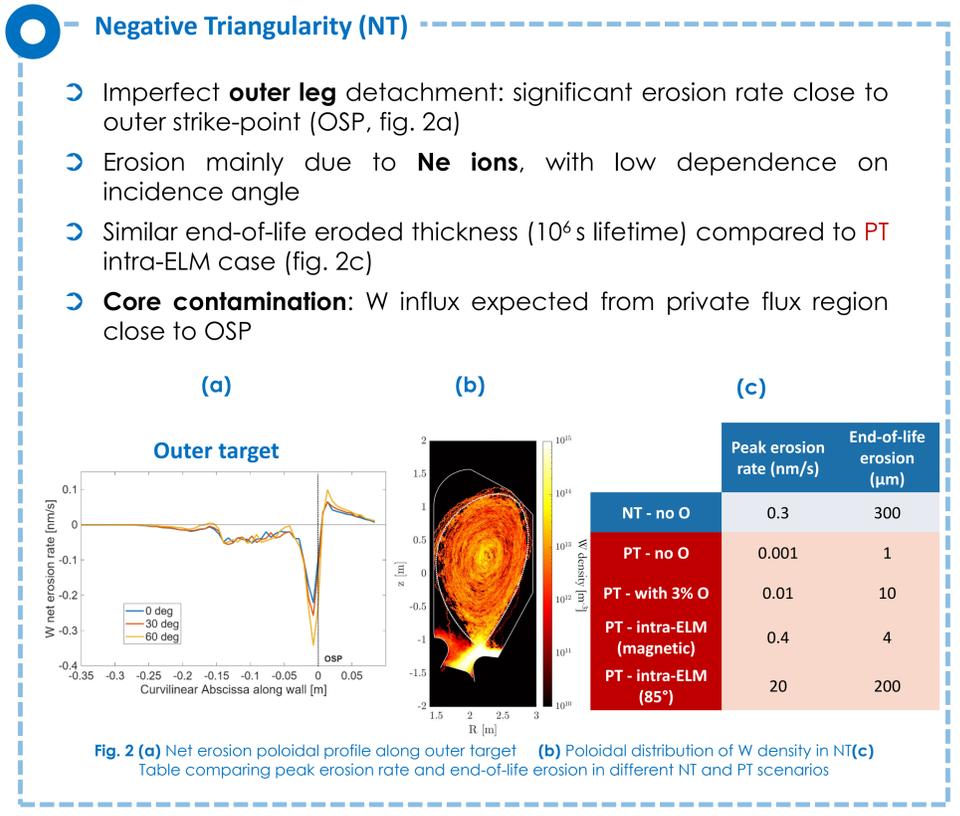
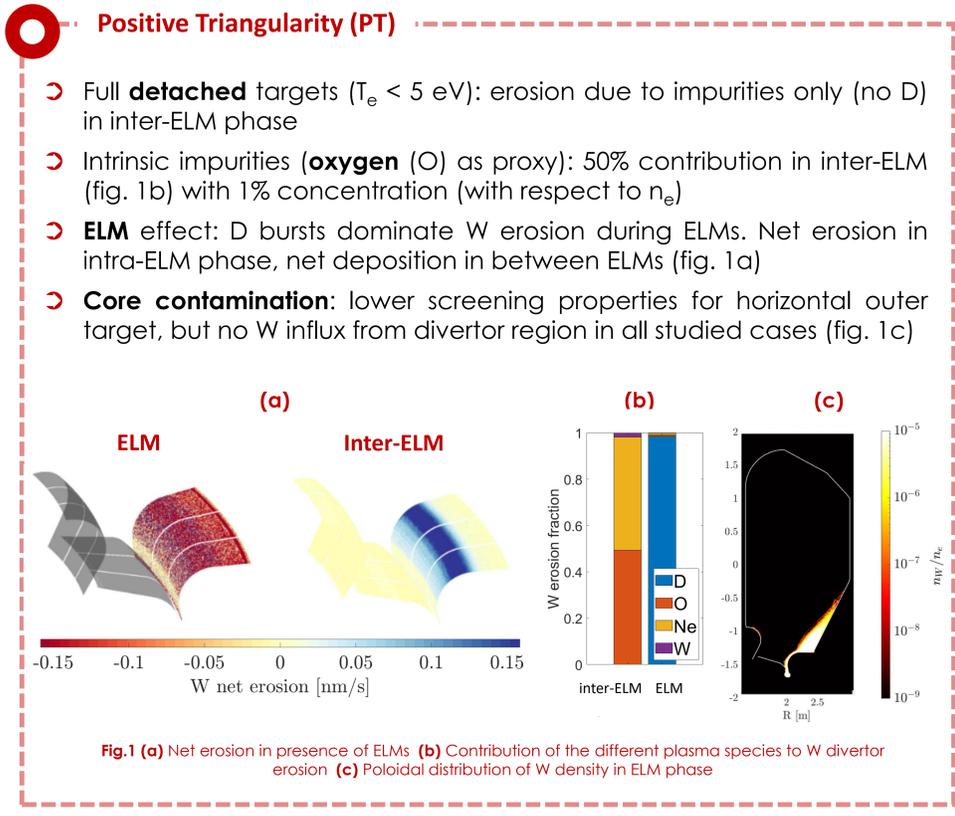
$$m_{\text{eff}} = \frac{\sum n_i m_i}{\sum n_i} \quad Z_{\text{eff}} = \frac{\sum n_i Z_i^2}{n_e}$$

Edge Localised Modes (ELMs) modelling in PT scenario

- Periodic bursts of energetic particles from core due to instabilities
- Intra-ELM: same T_e and T_i for migration, $2*n_e$, 1 keV D^+ ions, magnetic field incidence angle, ELM duration = 1 ms [4]
- Particle tracing in variable intra/inter-ELM plasma background [5]



Results and discussion



Conclusions and future perspectives

- Net erosion mainly due to ELMs in PT thanks to good detachment conditions
- Significant Ne erosion close to OSP in NT due to imperfect detachment, with end-of-life erosion close to PT case with ELMs
- No W influx in PT, lower W screening in NT from private flux region close to OSP
- Complete the assessment of NT erosion and core contamination including the presence of intrinsic impurities (as oxygen)
- Perform local simulations in dome-targets gaps to assess the optimal position of W erosion/deposition diagnostics (e.g. quartz microbalance)

References

- [1] F. Romanelli et al, Nucl. Fusion 64.11 (2024) 112015
[2] R.D. Smirnov et al, Phys. Plasmas 22 (2015) 012506
[3] J. Romazanov et al, Nucl. Fusion 62 (2022) 036011
[4] A. Kirschner et al, Nucl. Mater. Energy 18 (2019) 239244
[5] H.A. Kumpulainen et al, Nucl. Mater. Energy 33 (2022) 101264