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Simulation of tungsten erosion and edge-to-core transport in neon-seeded JET plasmas

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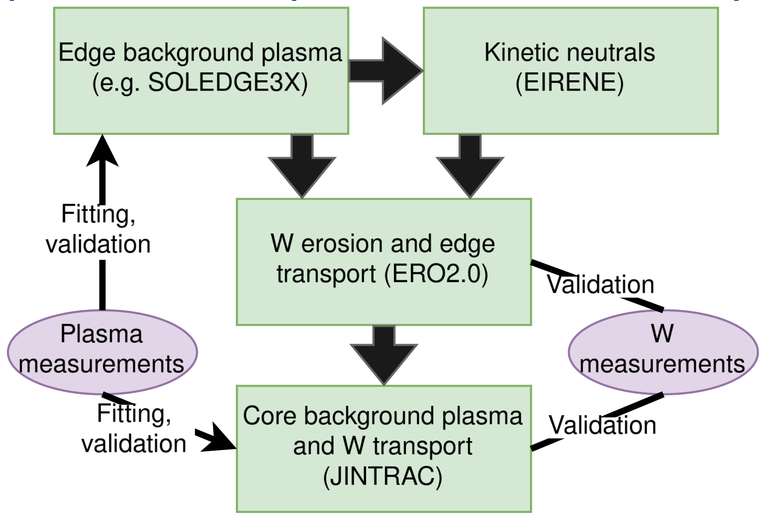
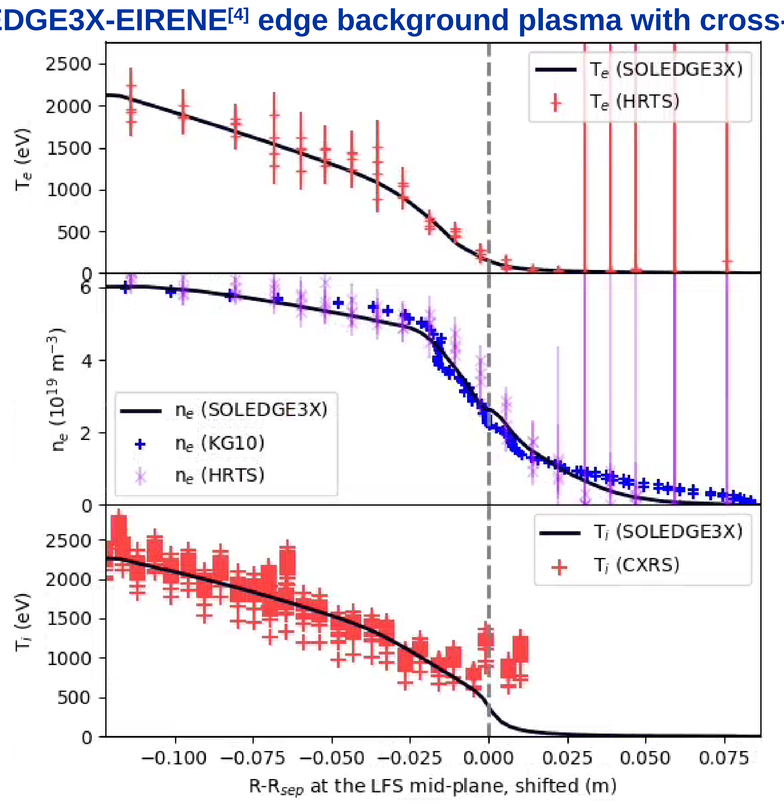
*** See the author list of E. Joffrin Nucl. Fusion 2024 10.1088/1741-4326/ad2be4*

Multi-stage simulation workflow: fitted plasma conditions, predictive W erosion and transport[1]



Goals:
- Assess predictive abilities of W erosion and transport models in Ne-seeded plasmas
- Improve understanding of W sources & transport in the JET-ITER baseline scenario[2,3]

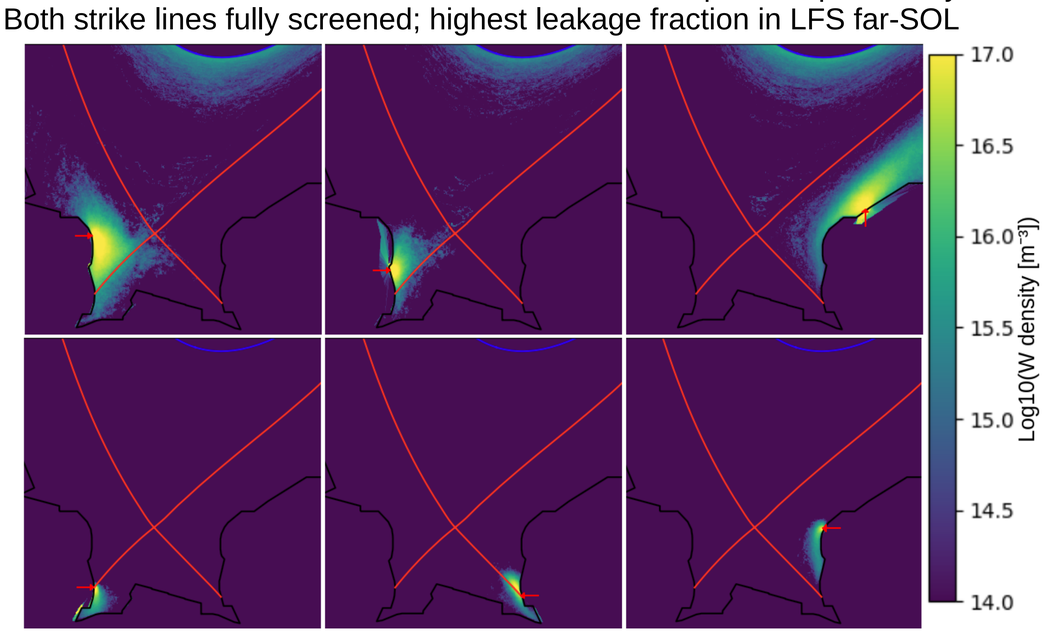
SOLEDGE3X-EIRENE[4] edge background plasma with cross-field drifts



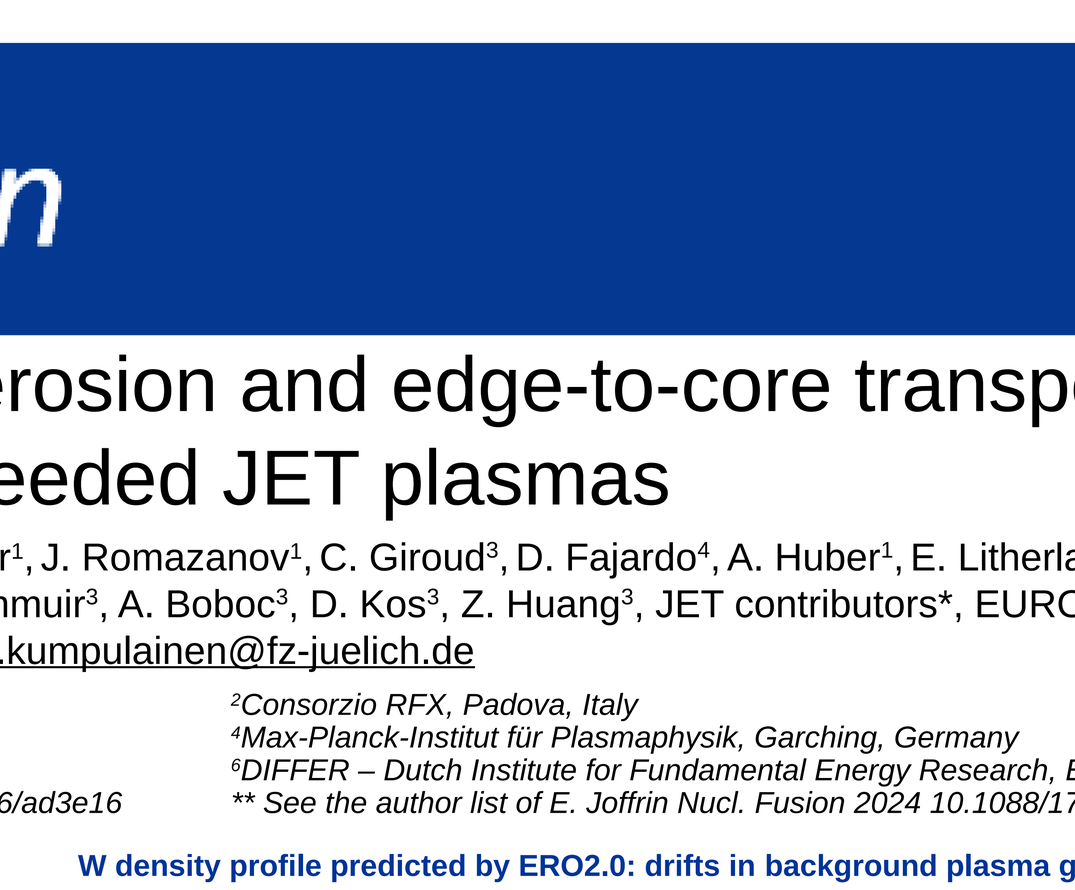
SOLEDGE3X (drifts) and SOLEDGE2D (no drifts) solutions with Ne seeding
D^0 wall fluxes, energy & angle distributions[5] from EIRENE[6] post-processing run

ERO2.0[7] simulation study of W screening in the JET divertor

Artificial W point sources placed in the inner and outer divertor (red arrows)
All 6 divertor sources better screened than LFS mid-plane separatrix by factor > 2000
Both strike lines fully screened; highest leakage fraction in LFS far-SOL



W density profile predicted by ERO2.0: drifts in background plasma greatly improve W screening



No drifts:

Both targets semi-detached, closer to Langmuir probe data than the drift case

W sputtered mainly by $Ne^{6...10+}$ at HFS shoulder, D^0 CXN and Ne on LFS

W build-up in upstream SOL due to near-SOL flow reversal

Drifts:

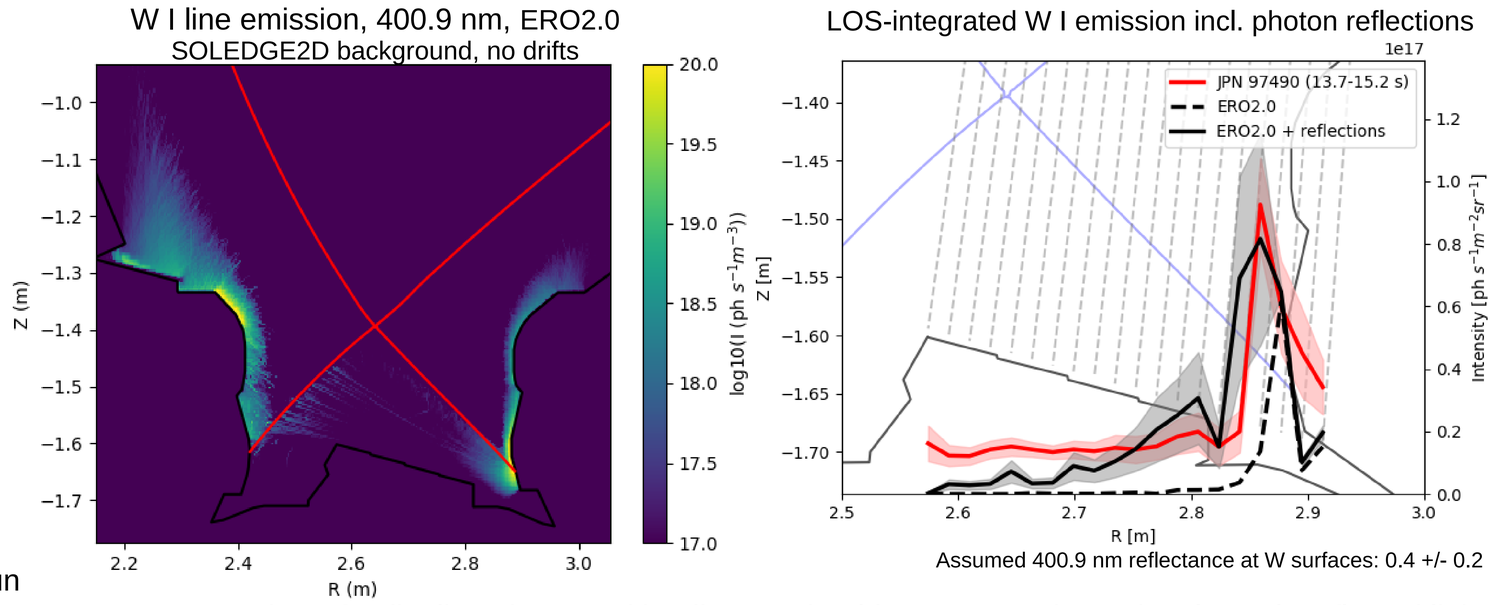
Attached outer divertor
→ increased W erosion and prompt redeposition on LFS

Cold, dense SOL reduces W erosion at HFS shoulder

Stronger parallel-B SOL flows, no flow reversal
→ better W screening

Higher T_e on LFS
→ shorter W^0 ionisation MFP
→ better W screening

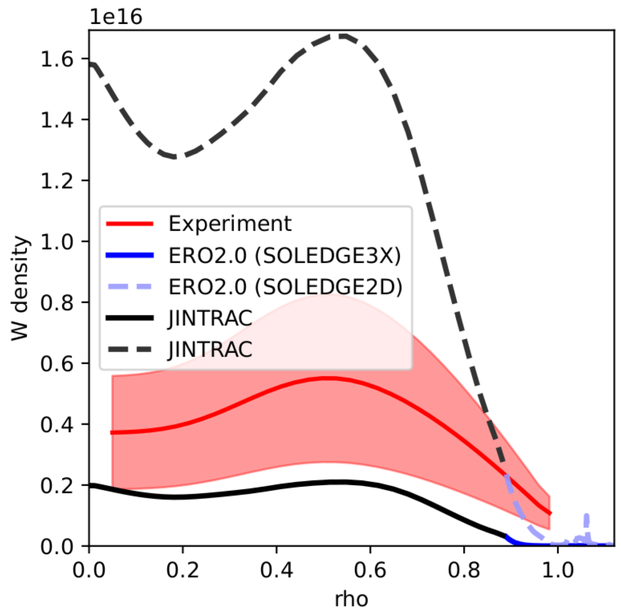
Validation of predicted W I line emission in the divertor



Assumed 400.9 nm reflectance at W surfaces: 0.4 +/- 0.2

Spectrometer view of strike line obstructed by divertor shoulder: measured W I signal mostly reflected light

Comparison of experimentally inferred[8] and predicted W density in the main plasma (JINTRAC)



ERO2.0 predicts the W density at ρ > 0.9

JINTRAC[9] W boundary condition set to match ERO2.0 W density at the pedestal top

Neoclassical transport: NEO[10] (W, Ne, Ni), NCLASS[11] (D)

Turbulent transport:
QuaLiKiz-NN[12] + ad-hoc Bohm-gyro-Bohm[13]

n_e, T_e, T_i, Z_{eff} profiles fitted to experiment
(adjusted BgB coefficients, Ne & Ni boundary conditions)

Heating, radiation, current, rotation, fuelling prescribed

Conclusions

W density profile more accurate with a SOLEDGE3X background (drifts) than with SOLEDGE2D (no drifts)

W transport very sensitive to edge & core plasma profiles
→ total modelling uncertainty > factor of 3

Effective W screening in the SOL, especially with drifts: high n_e, sufficient T_e, strong D^+ flow towards divertor

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