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Neon seeding effects on two JET high performance baseline plasmas

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1. Motivation for the modelling of two JET high performance baseline plasmas (Ne-seeded / unseeded)

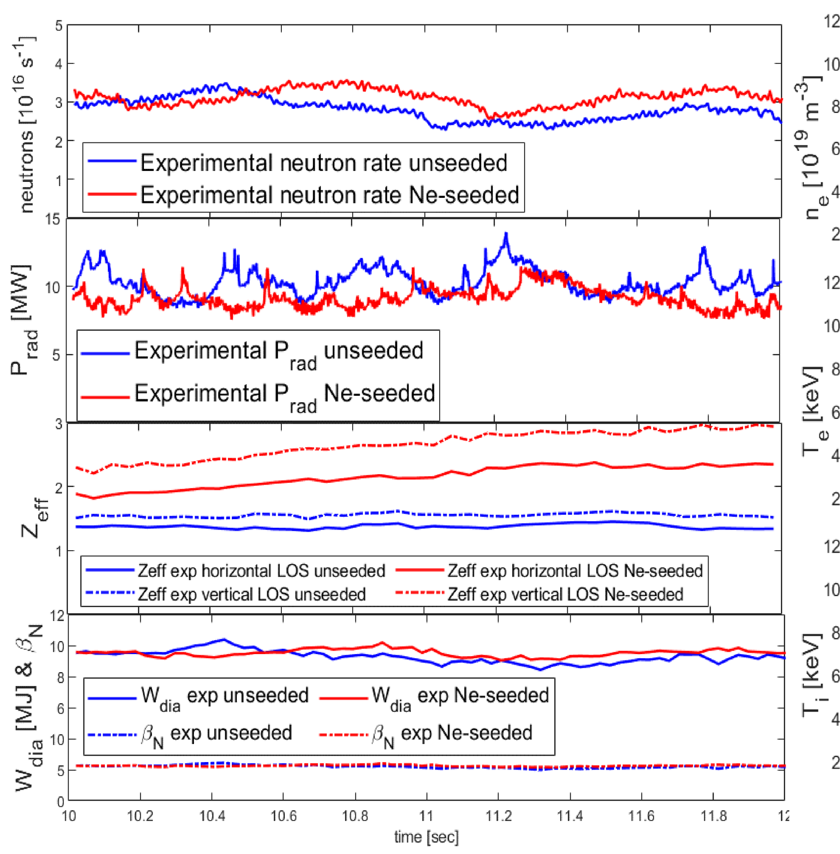

Figure 1: Neutron rate, Z_{eff}, P_{rad}, W_{dia} and β_N experimental time traces in the modelled time interval [50-52s].

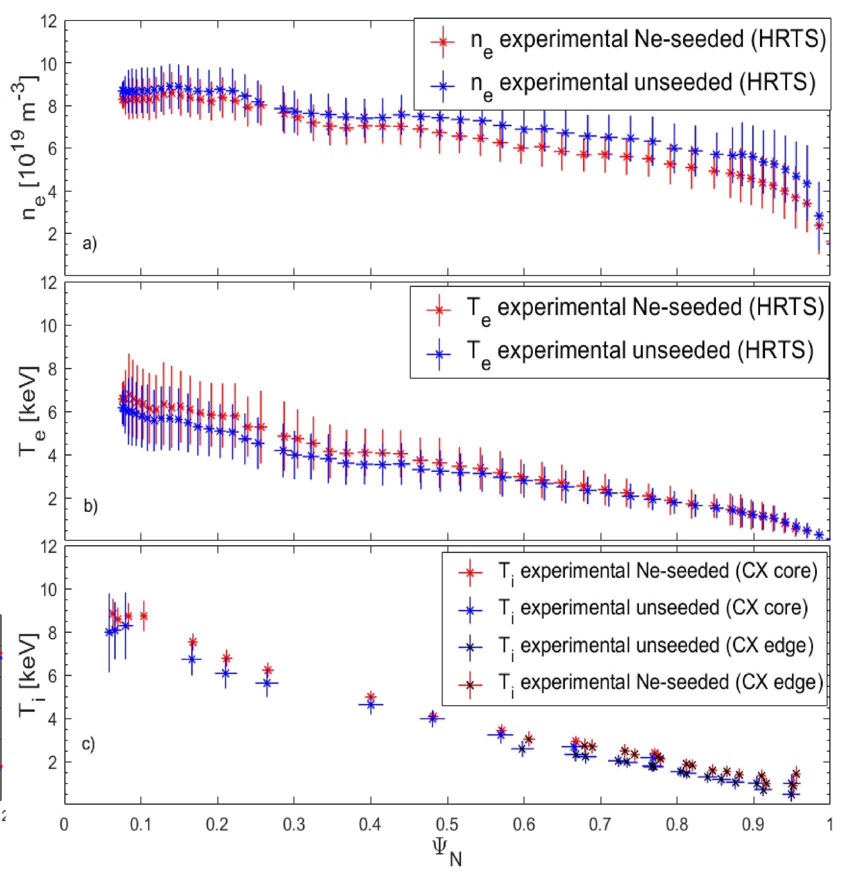

Figure 2: Electron density (a), electron temperature (b), ion temperature (c) experimental profiles for JPN 96994 (red) and JPN 96730 (blue).

- Neon seeding on JET has been proved to be compatible with high performance plasmas and can lead to higher confinement with respect to the equivalent unseeded pulses [1].
- Two JET high performance baseline [2] plasmas, JPN 96994 (Ne-seeded) and JPN 96730 (unseeded) are modelled in this work (3 MA / 2.8 T, β_N = 2.2, $P_{add} \approx$ 32 MW).
- Ne-seeded pulse exhibits slightly higher neutron rate (+11.4%) and confinement time (+11.5%) than the unseeded one.

2.1 Fully predictive modelling of JPN 96994 (Ne-seeded) with 9 channels with QuaLiKiz first-principle transport model

JETTO-QuaLiKiz-SANCO fully predictive simulations with 9 channels (n_e, T_e, T_i, n_D, Ω, n_{Be}, n_{Ne}, n_{Ni}, n_W).

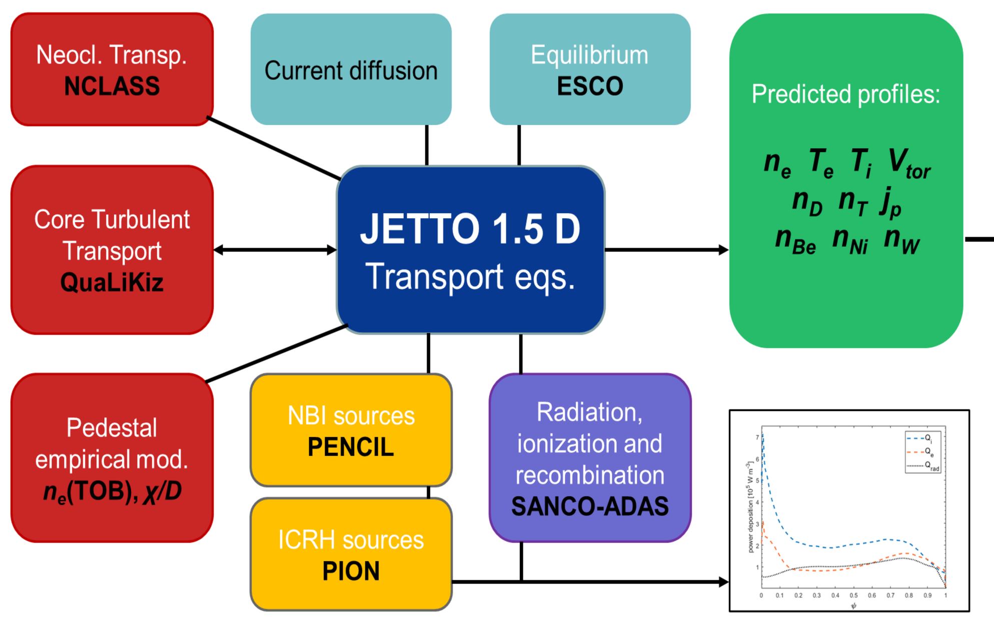

Figure 3: JINTRAC Integrated modelling framework [3] using QuaLiKiz [3, 4] transport model.

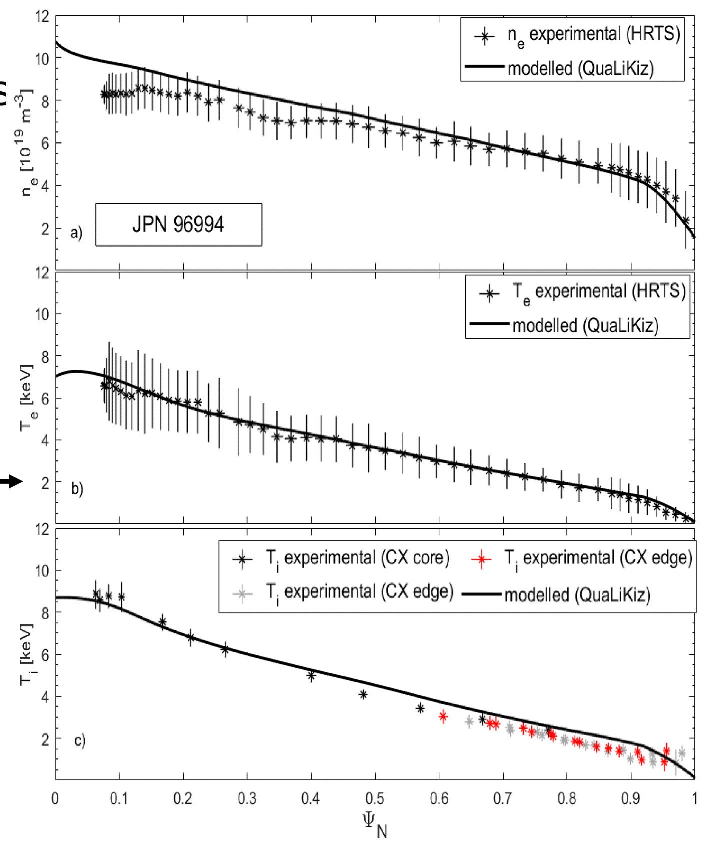

Figure 4: Electron density (a), electron temperature (b), ion temperature (c) profiles predicted in the simulations and experimental profiles with error bars.

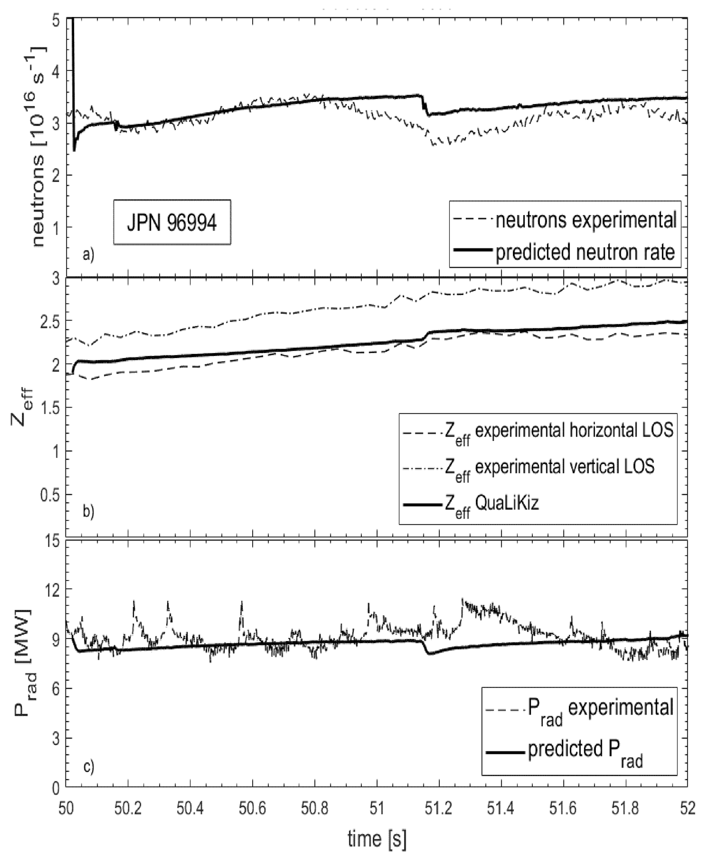

Figure 5: Neutron rate (a), Z_{eff} (b), P_{rad} (c) predicted and experimental time traces in the modelled time interval [50-52s].

2.2 Fully predictive modelling of JPN 96730 (unseeded) with 9 channels with QuaLiKiz first-principle transport model

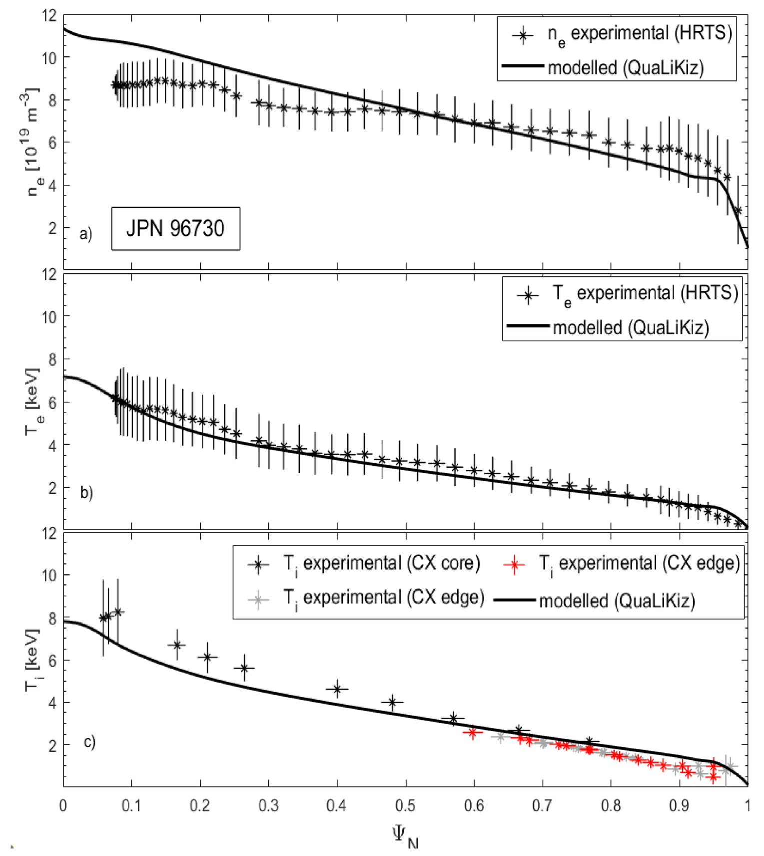

Figure 6: Electron density (a), electron temperature (b), ion temperature (c) profiles predicted in the simulations and experimental profiles with error bars.

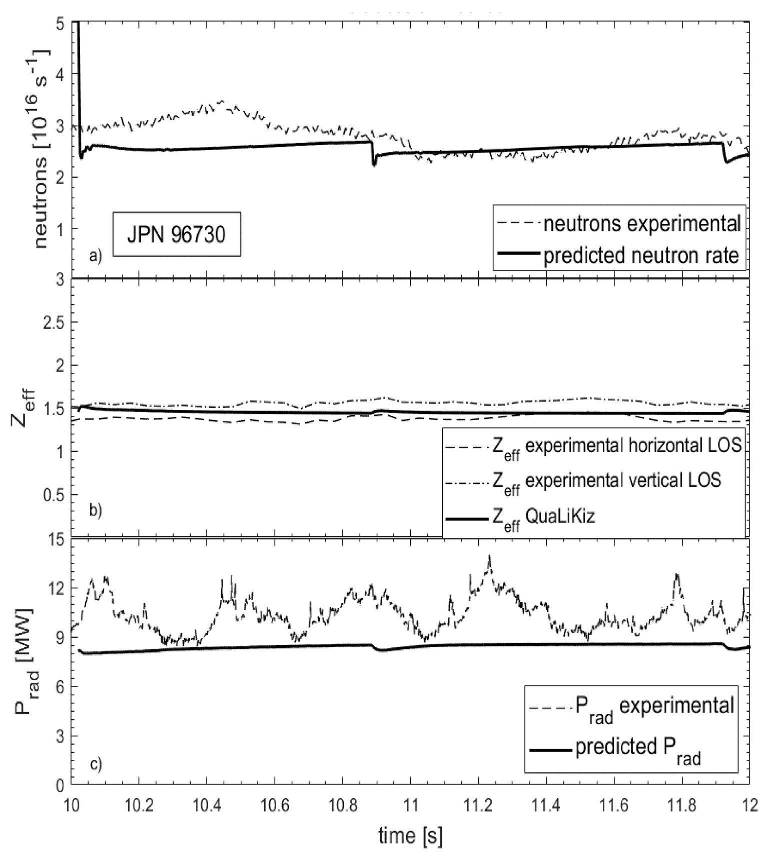

Figure 7: Neutron rate (a), Z_{eff} (b), P_{rad} (c) predicted and experimental time traces in the modelled time interval [50-52s].

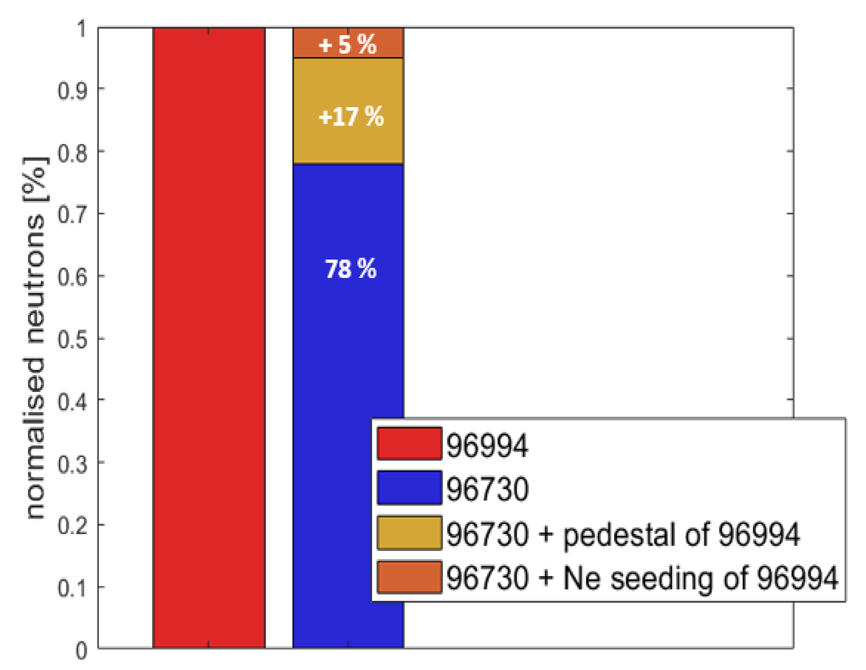

Figure 8: averaged neutron rates normalised to the performance of the reference modelling of JPN 96994. Imposing the pedestal characteristics of JPN 96994 on JPN 96730 allows to gain ~ 17% on performance, while imposing the Ne seeding rate allows to gain ~5%.

3. Neon effects on transport

Ne seeding causes a reduction in the growth rates of both ITG (low $k_\theta\rho_S$) and ETG (high $k_\theta\rho_S$) modes. Similar results were obtained for the same Ne-seeded shot [7] and on different Ne-seeded shots [1, 8].

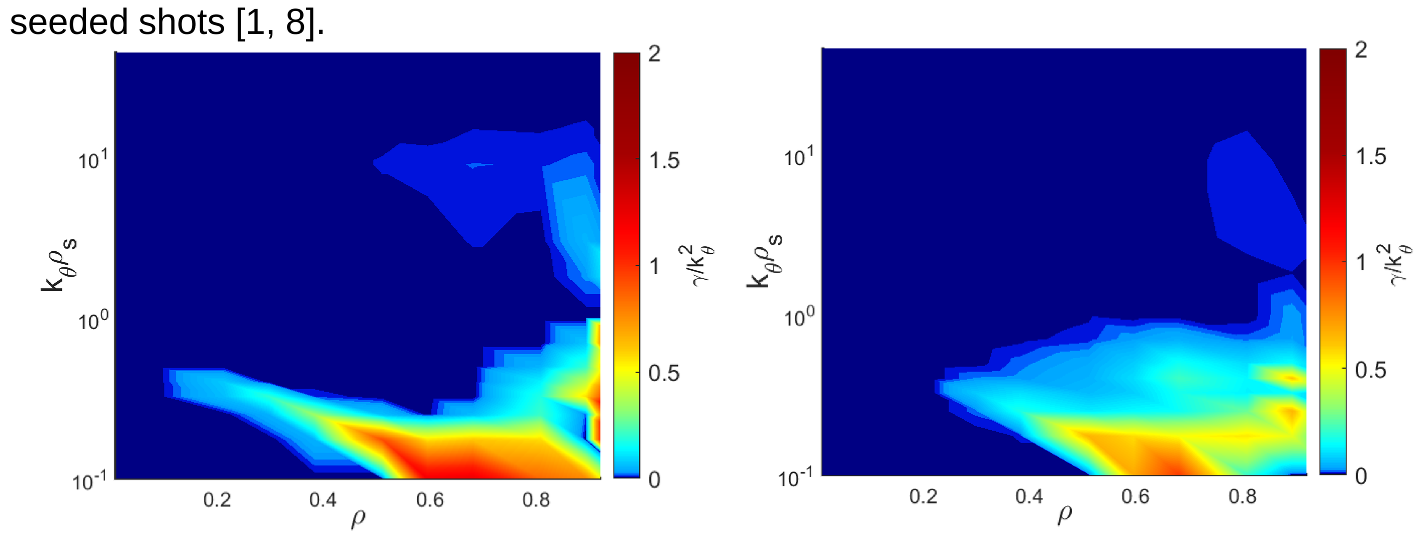

Figure 9: QuaLiKiz turbulence spectra for unseeded (left box) and Ne-seeded (right box) shots. A possible theory on turbulence stabilization by impurities and ExB shear can be found in [6].

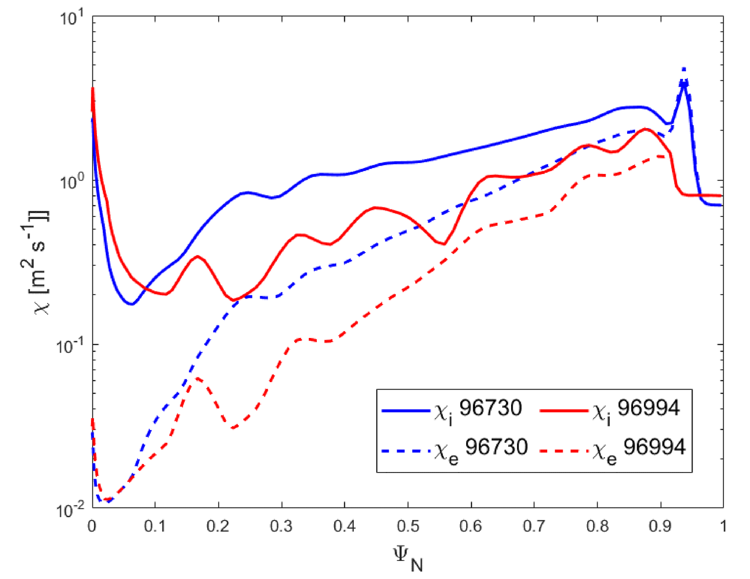

Figure 10: electron (dashed line) and ion (solid line) thermal diffusivities for Ne-seeded (red) and unseeded (blue) shots, averaged between [11.37 - 11.87s] and plotted in logarithmic scale. It is clear from the figure the reduction of the diffusivities in the Neon seeded shot (red lines).

4. Conclusions

- The simulations are in good agreement with the experimental measurements for both of the analysed shots, therefore allowing QuaLiKiz to capture the difference in transport between the pulses.
- Ne seeding seems to cause a reduction in the ion and electron thermal diffusivities. Microstability analysis suggests that Ne seeding stabilizes the ITG and ETG turbulent modes (similar results obtained in [1, 7, 8]).
- Further modelling suggests that the confinement improvement of JPN 96994 is caused by a combination of improved pedestal parameters and turbulence stabilization induced by Neon injection.

Essentials references: [1] Giroud C. et al, "*High performance Ne-seeded baseline scenario in JET-ILW in support of ITER*" (2022) at this Conference (I4.108), [2] L. Garzotti et al 2019 Nucl. Fusion **59** 076037, [3] Zotta V. K., et al "Moderate beta baseline scenario in preparation to D-T operations at JET" (2021) at 47th EPS Conference on Plasma Physics [4] Bourdelle C., et al 2016 *Plasma Phys. Control. Fusion* **58** 014036, [5] Citrin J. *et al* 2017 *Plasma Phys. Control. Fusion* **59** 124005, [6] G. M. Staebler et al, 1999, Phys. Rev. Lett. **82**, 1692, [7] J. Garcia et al Phys. Plasmas 29, 032505 (2022), [8] Marin M. et al "*Integrated modelling of Neon impact on JET H mode core plasmas*" submitted to Nucl. Fusion

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