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EX/P3-14

SOL profile and fluctuations in different divertor recycling conditions in H-Mode plasmas

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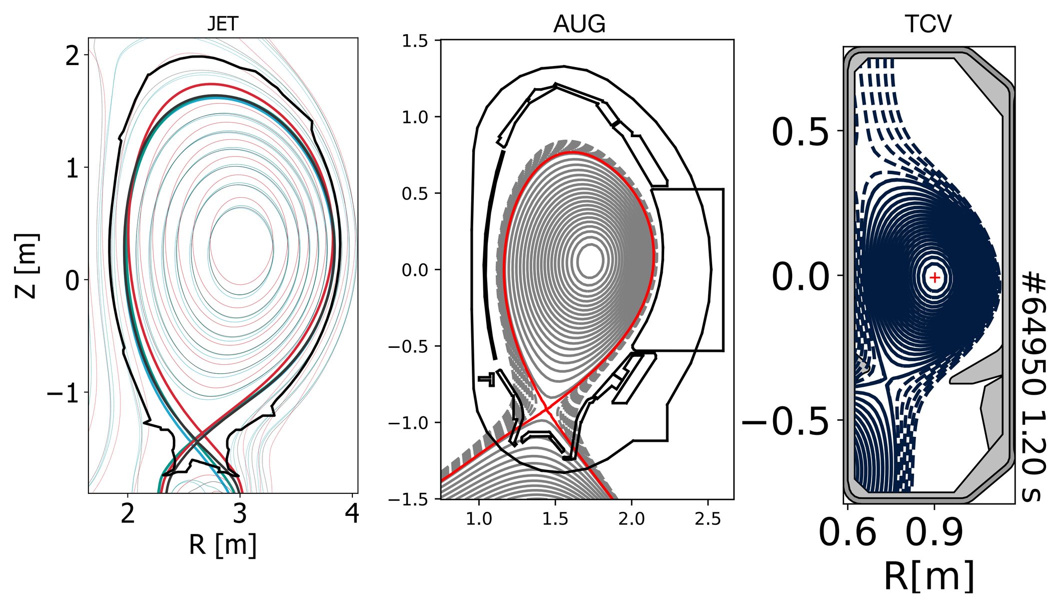
(i) Introduction and motivation

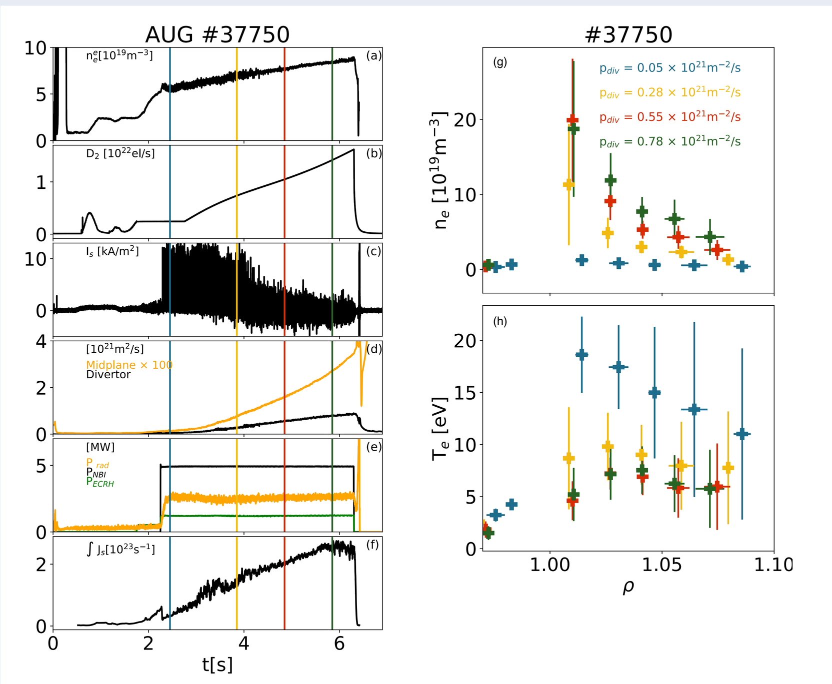
1. From the ITER divertor perspective high neutral pressure and partial detachment are needed to ensure maximum tolerable loads and avoid W recrystallization [1].
2. Experimental activity is needed to determine the level of SOL transport expected in these operational regimes, to provide reliable code validation mandatory for predictive simulations
3. In L-mode operations with high fueling and neutral pressure cause SOL density profile broadening a.k.a. shoulder formation [2–6]. In L-Mode the process is generally associated to an increase of convective filamentary transport
4. H-Mode operations suggest similar behavior with stronger link to achieved neutral pressure [7]

(ii) Machines and Scenarios

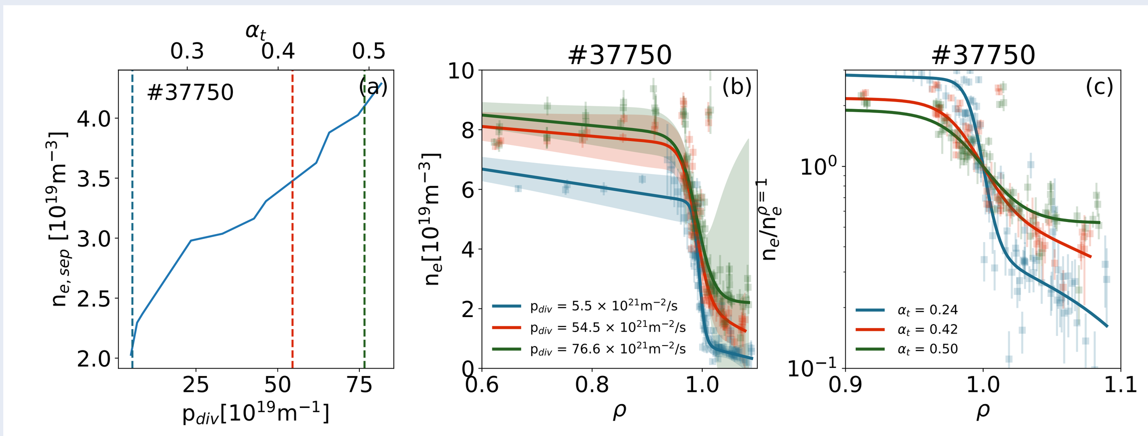
- JET ($R/a = 2.96/1.25$m, ITER-Like wall) explored in different divertor geometries.
  1. Low-δ, I_p=2MA, B_t=2.3T NBI=16MW, ICRH=2-3 MW operations, exploring different divertor geometries (VT5C, VT5D, VV and CC) and different levels of fueling
  2. Diagnostics: HRTS and Li-Be for profiles. Spectroscopy for target investigation [8]
- ASDEX Upgrade (AUG) ($R/a = 1.65/0.5$m, full-W divertor)
  1. $\delta_{top} \approx 0.1$, I_p=0.6-0.8MA, B_t=2.5T, P_{aux} =5-17 MW, FF gas
  2. Profiles obtained combining Thomson Scattering and Li-Be, Fluctuations investigated through Thermal Helium Beam (THB) diagnostic. Target profiles from embedded langmuir probes
- TCV ($R/a = 0.88/0.25$ m, baffled operation with graphite wall)
  1. High $\delta_t \approx 0.4$, I_p=170 kA, 1MW NBI heating
  2. Diagnostics: Divertor and first wall langmuir probes, Thomson scattering and Reciprocating Langmuir probe



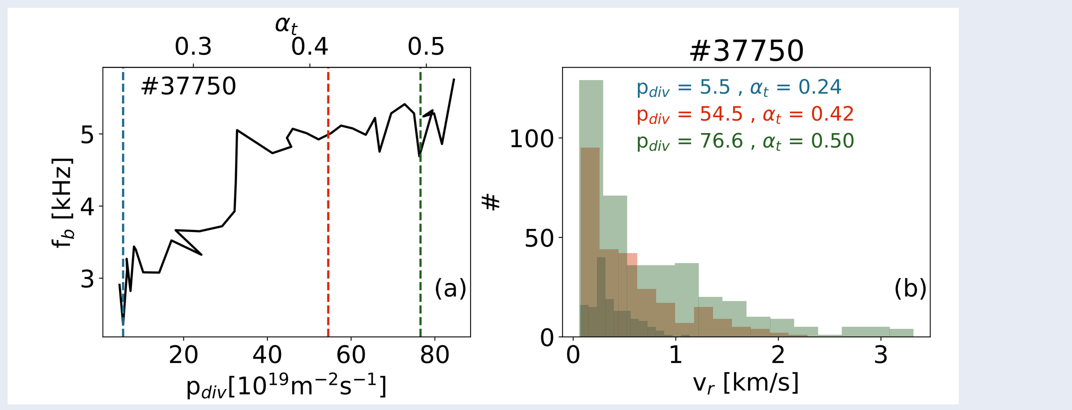
(iii) ASDEX-Upgrade



- Gas injection from divertor region controlled in Feed Forward
- ELM monitor exhibits clear transition to *small ELM regimes* [9], a.k.a. Quasi Continuous Exhaust (QCE) [10] from ≈ 4 s.
- No signature of target flux roll-over and divertor still in high recycling regime with T_e OSP ≈ 5-7 eV.

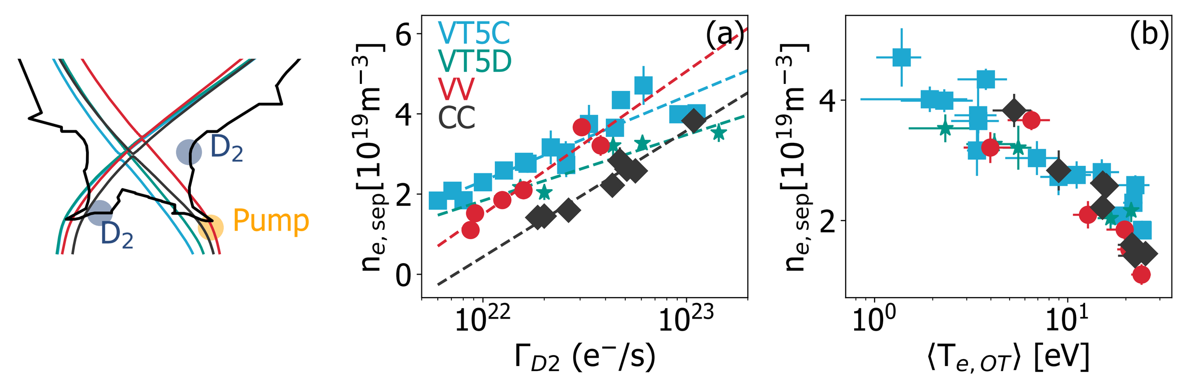


- Separatrix position determined from 2P model $T_{e,sep} \approx \left(\frac{7}{16}\frac{p_{sep} q_{cyl}^2 A}{\kappa_0^e \hat{\kappa} \langle\lambda_q\rangle}\right)^{\frac{2}{7}}$
- Strong correlation, already reported [11, 12], between divertor neutral pressure and separatrix density
- This implies a strong correlation as well with turbulence parameter $\alpha_t \approx 3 \times 10^{-18} R q_{cyl}^2 \frac{n_e}{T_e^2} Z_{eff}$ which describes the relative effect of the interchange drive on the drift-wave and it is closely related to the diamagnetic parameter α_d introduced in [13]
- Strong SOL profile flattening observed at higher $p_{div} \implies \alpha_t$

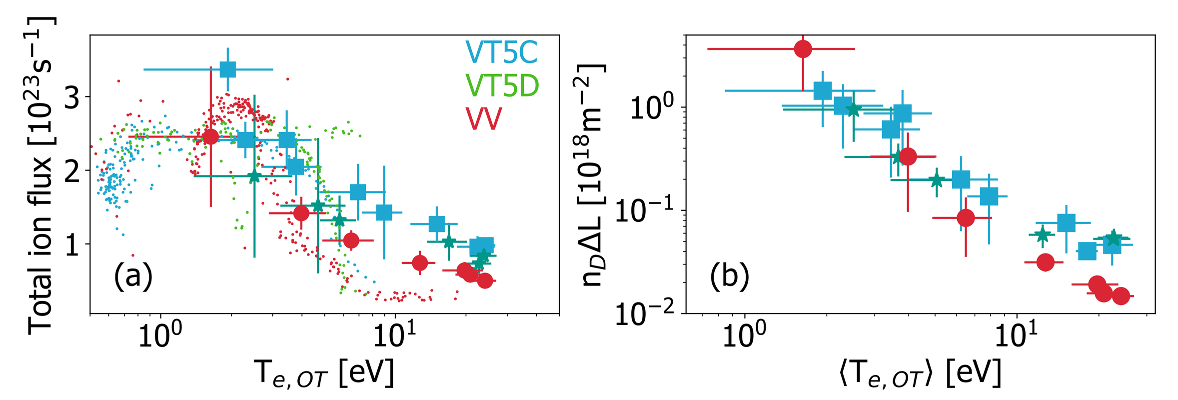


- Filament properties as a function of p_{div} or α_t monitored in the far SOL using Thermal Helium beam
- Blob frequency at $\rho \approx 1.07$ increases with α_t
- Population of fast filaments with $v_r \approx 1$ km/s grows whenever higher α_t values are reached

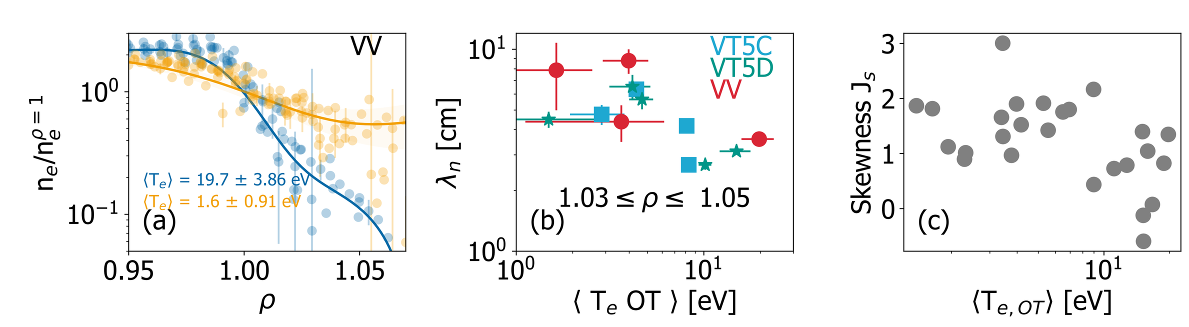
(iv) JET



- $n_{e,sep}$ response to fuelling different among the different geometry explored
- $n_{e,sep}$ reconciled in term of $\langle T_{e,OT}\rangle$, i.e. spectroscopically detemined OSP temperature [14]

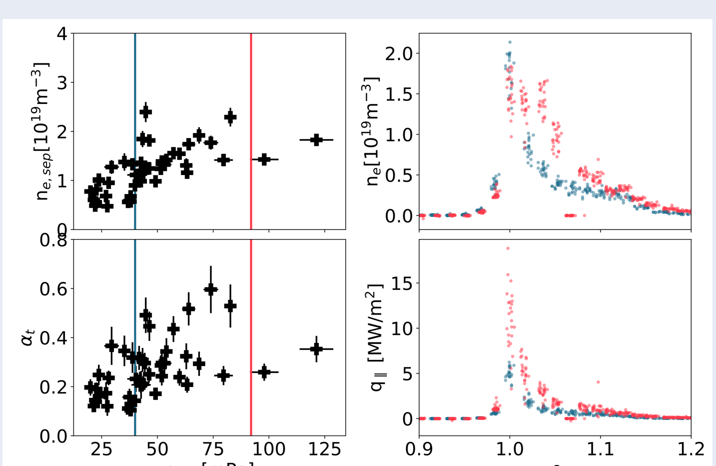


- $\langle T_{e,OT}\rangle$ properly describes the recycling divertor condition, independently from the explored configuration as seen from the Outer Target total flux scaling with $\langle T_{e,OT}\rangle$
- Line integrated neutral density estimate scales similarly with $\langle T_{e,OT}\rangle$ for all the configuration explored $\implies$ similar to AUG and TCV suggests a link between p_{div} and $n_{e,sep}$

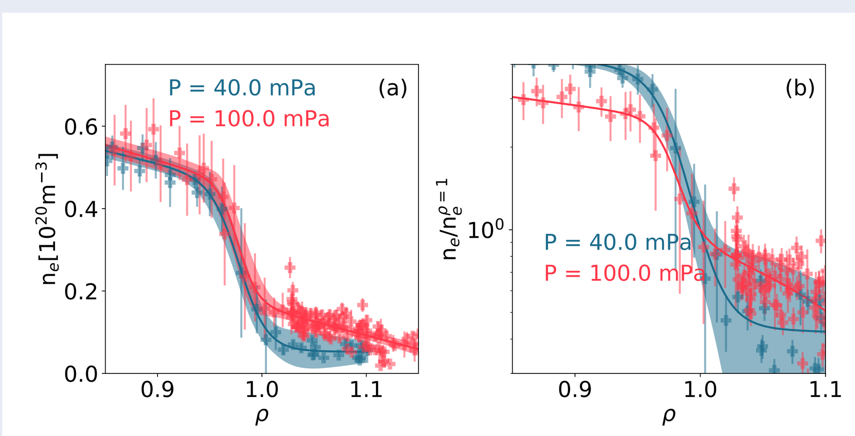


- At higher recycling → higher separatrix density we observe a flattening of the far SOL profiles (shown only VV profiles)
- e-folding density length λ_n scales with $\langle T_{e,OT}\rangle$ for all the explored divertor geometries
- Fluctuations at the wall measured by Langmuir probes: increase of inter-ELM skewness at lower $\langle T_{e,OT}\rangle$ suggesting increasing filamentary activity reaching the first wall

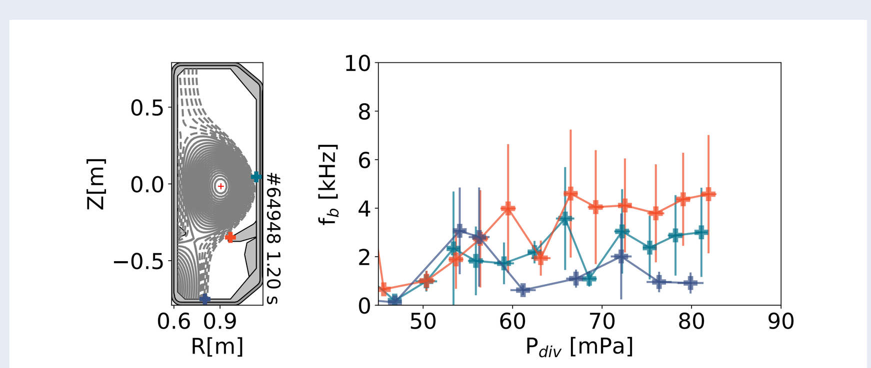
(v) TCV



- Similar scaling of $n_{e,sep}$ and α_t with higher neutral pressure
- Broader n_e^t and $q_{||}^t$ at higher p_{div} similar to what observed in AUG. Target still in high-recycling regime (not shown) [10]



- Similar density at top of the pedestal
- Pronounced shoulder formation in the far SOL profiles at higher p_{div}



- Inter-ELM Filamentary activity at the wall at different poloidal locations by looking into wall mounted probes
- Clear indication if increase blob filaments at higher $p_{div} \Rightarrow \alpha_t$ at the midplane and on the divertor nose

(vi) Conclusions

- Cross-machine investigation of SOL profile and fluctuations in high density H-Mode
- Separatrix collisionality increases at high fuelling mediated by $n_{e,sep}$ dependence from neutral pressure/recycling condition. More balloning turbulence dominated separatrix condition achieved
- At higher p_{div} and α_t flatter profiles observed in all devices
- Frequency filaments increases with p_{div} and whenever measurements faster filaments observed in the far SOL

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