EUROfusion

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Understanding radial density flattening in the far-SOL of H-mode plasmas on JET

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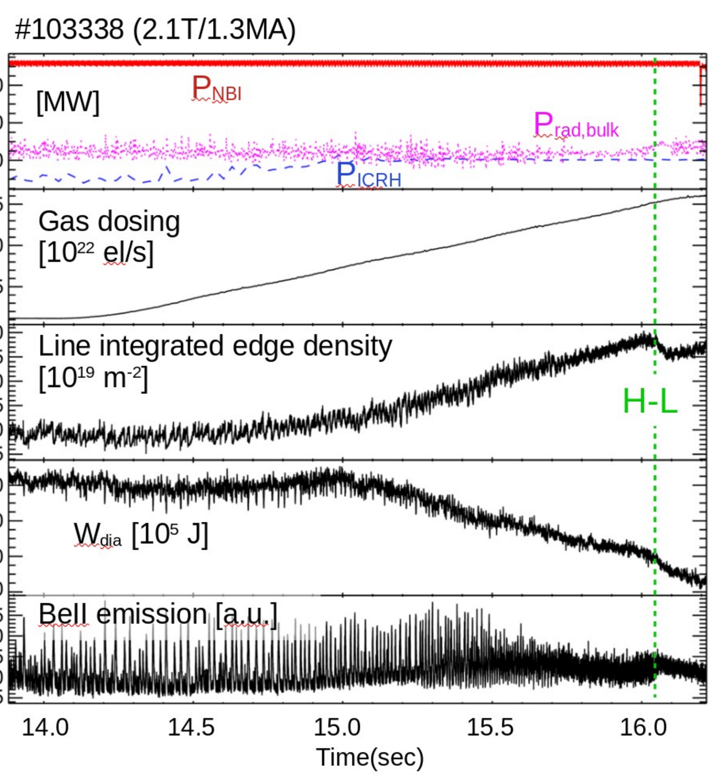
1. BACKGROUND

- Main Chamber (MC) W sputtering could far outweigh other W sources in new full-W ITER [Romazanov NF2022, Eksaeva PhysScripta 2022]
- Insufficient understanding of density flattening in far-SOL
  - → at present, no reliable prediction for n_e reaching MC tiles in ITER
  - → at present, no reliable prediction for MC W source in ITER

2. New H-mode density ramp experiments on JET

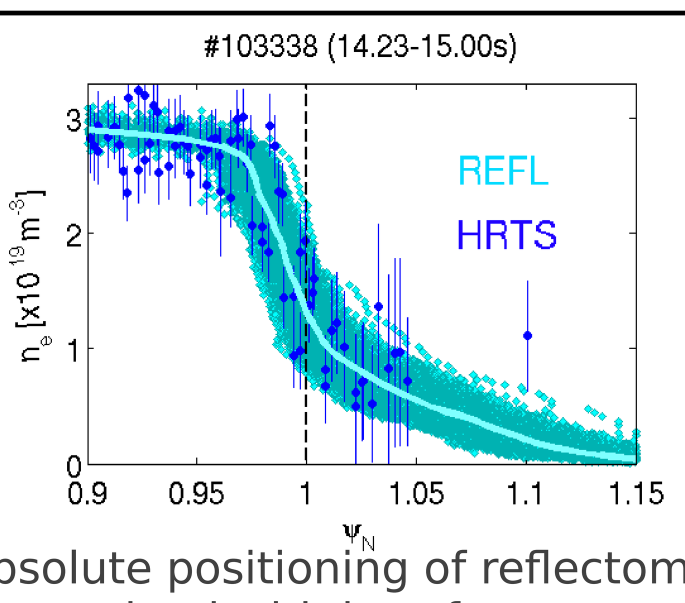


- Fuelling ramps up to H-L limit
- Gas or pellet fuelling ramps
- Discharge pairs with different triangularity, OSP geometry, Ip ($L_{||}$)
- Scenarios designed to take advantage of latest diagnostic improvements (reflectometry…)
- Different edge profile classifications explored ($T_{e,OSP}$, $\nu_{e,sep}$*, α_t,…)

$$\alpha_t \sim q_{cyl}^2\, R\, (n_{e,sep} / T_{e,sep}^2)\, Z_{eff}$$

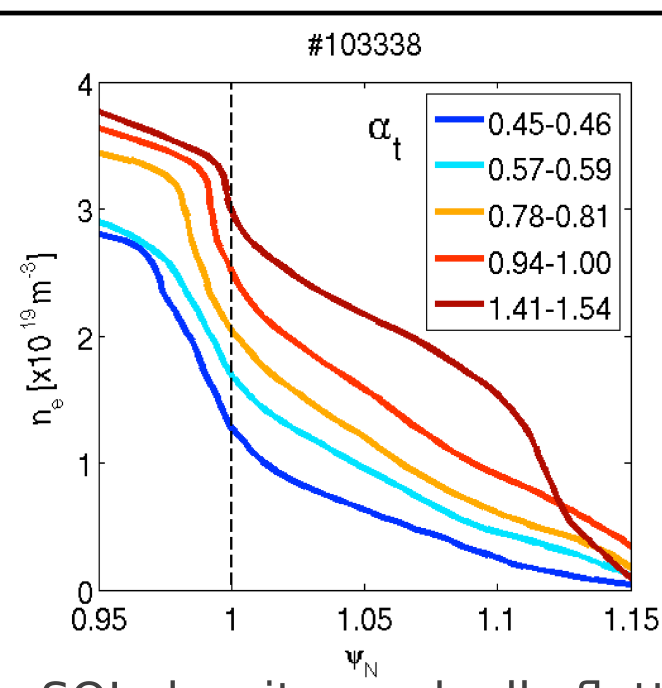
for exact formula see eqn. 10 in Eich NF 2020

3. Profiles analysis



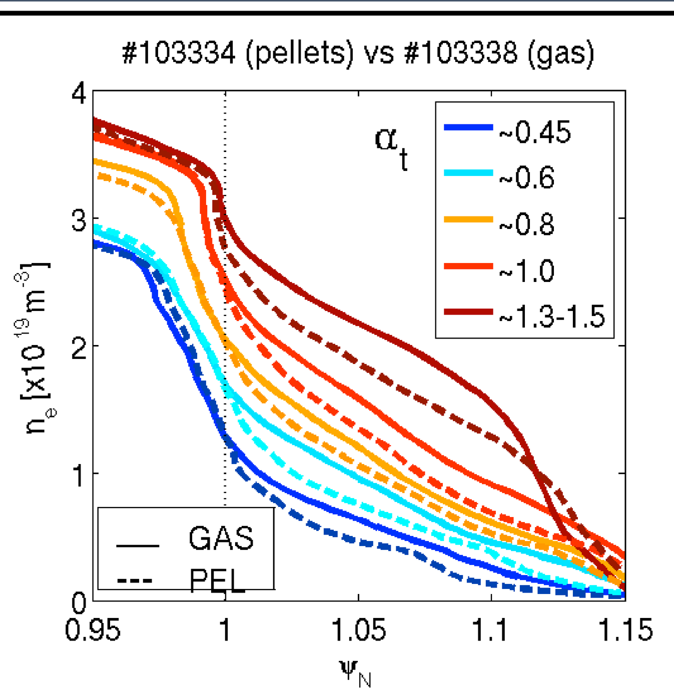
- Absolute positioning of reflectometry constrained with interferometry
- HRTS positioned iteratively through power balance [Eich NF 2020]
- Level of consistency yields error bars

4. Impact of gas puffing



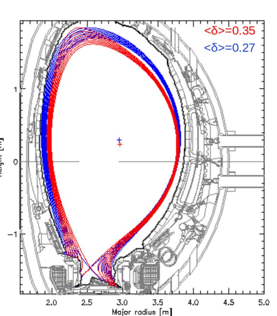
- Far-SOL density gradually flattens with increasing α_t
- α_t well above 1: density shoulder

5. Impact of pellet fuelling

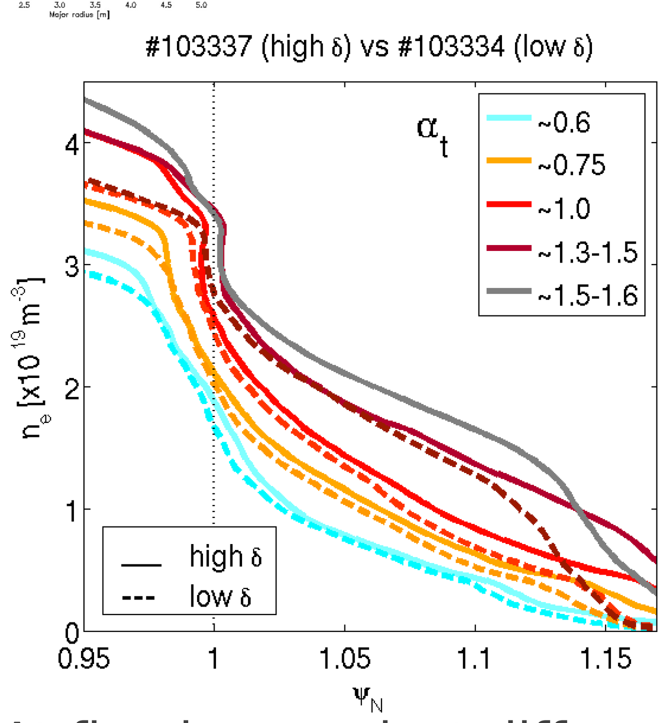


- At fixed α_t, pellet fuelling yields lower absolute n_e both in near- and far-SOL (but not $n_{e,sep}$ itself)
- However, difference originates mostly from near-SOL (where profiles diverge)
- Radial decay in far-SOL similar
- Density shoulder formation also with pellets

6. Impact of triangularity

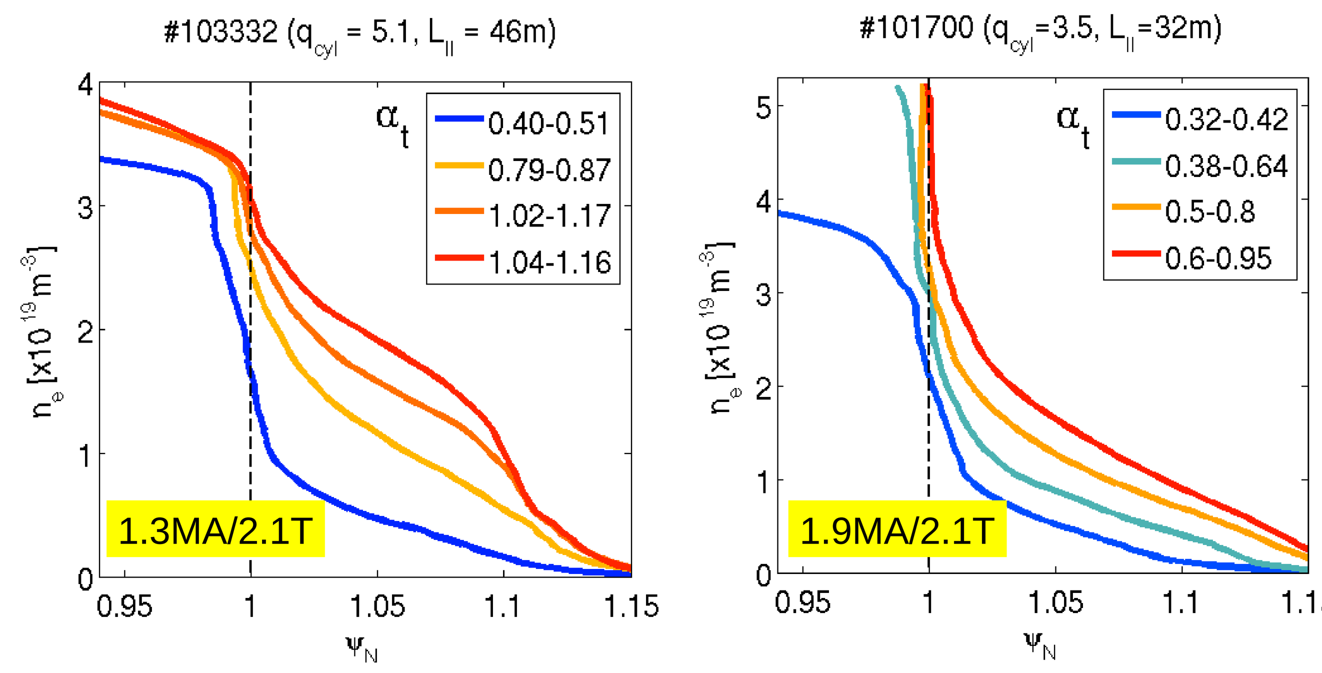


- Upper triangularity increased by 50%
- Div.geometry fixed



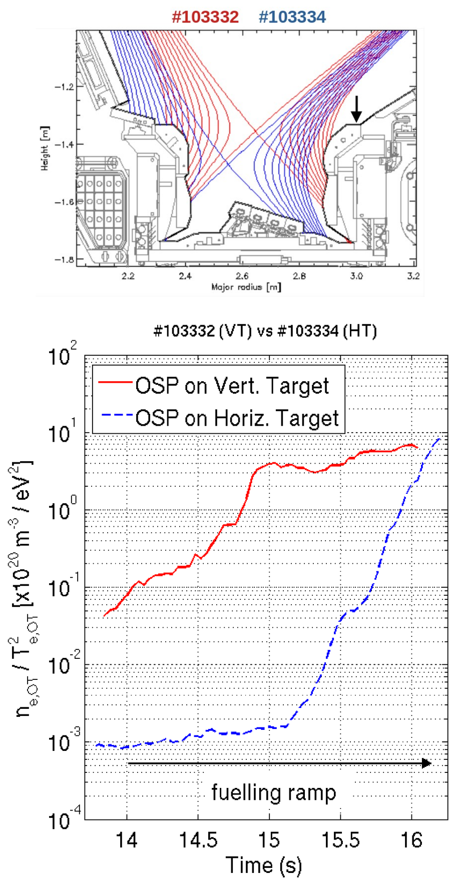
- At fixed α_t: modest difference
- Increased δ opens access to higher absolute ne (higher density shoulder) in SOL

7. Impact of plasma current (at fixed B_{tor})

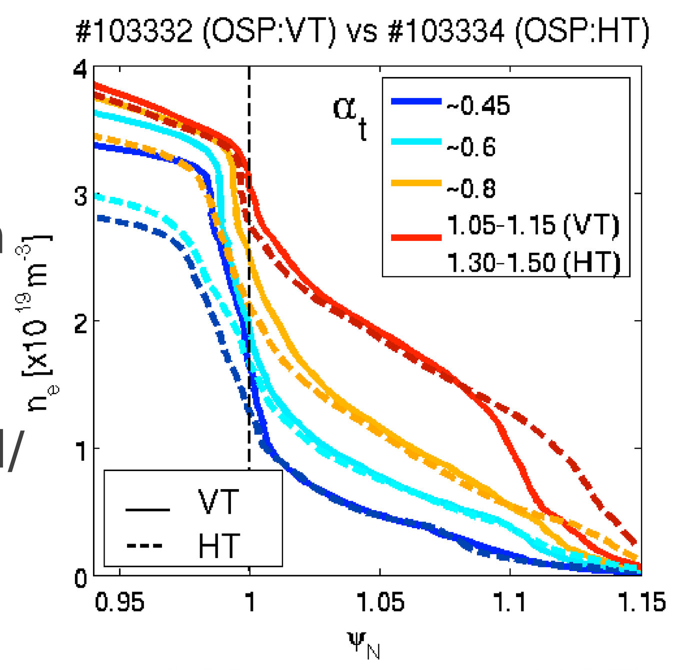


- Repeat same fuelling ramp at higher Ip (lower $L_{||}$) until H-L
  → density shoulder absent!

8. Role of divertor geometry

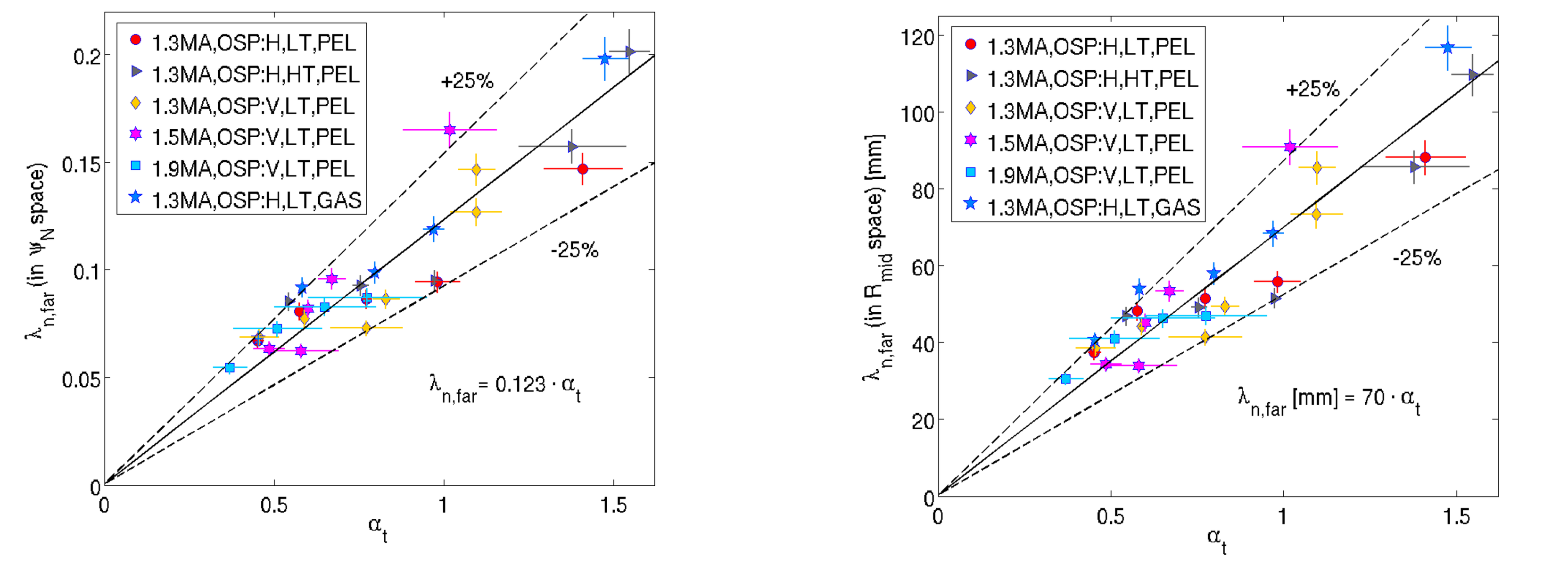


- Horiz. vs Vert.Target
- Very different OSP collisionalities (governs electrical disconnection of filaments)
- Profiles at fixed α_t:
  - Steeper ne in pedestal/ separatrix/nearSOL
  - In far-SOL differences largely disappear!
  - Density shoulder formation similar



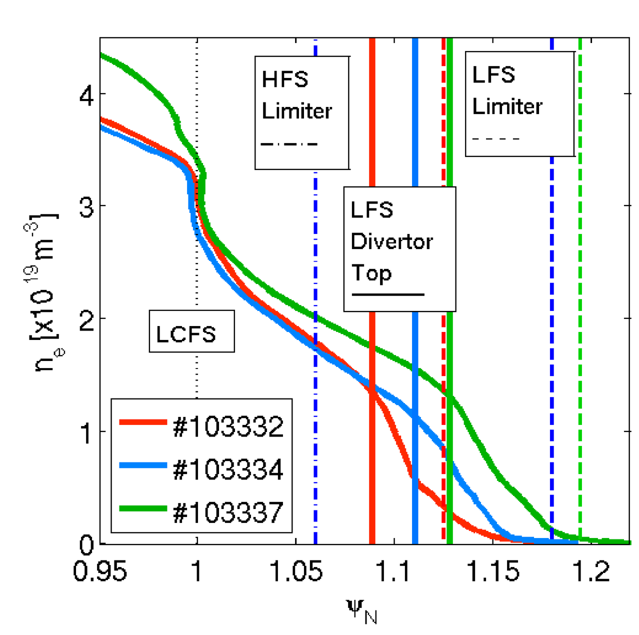
→ OSP geometry NOT found to impact radial ne transport in far-SOL

9. Density decay length in far-SOL



- α_t unifies dataset! Linear correlation both in flux- and real- space.
  → α_t good descriptor to quantify far-SOL density flattening on JET

10. Outer inflection radius



- Pulses run with higher than normal clearance to outer wall
- Shoulder inflection NOT set by intersection with limiters but LFS divertor top
  → route to reduce MC W source?

11. MAIN CONCLUSIONS

- SOL ne profiles carefully evaluated for very diverse set of discharges
- α_t unifies measured ne radial decay lengths in far-SOL:

$$\lambda_{n,far}\,[\psi_N] = 0.123(\pm 25\%) * \alpha_t$$
$$\lambda_{n,far}\,[mm] = 70(\pm 25\%) * \alpha_t$$

- *Inner* inflection radius (near-/far-SOL transition): $\psi_N \sim 1.01\text{-}1.02$
- *Outer* shoulder inflection radius can be moved away from LFS limiters!

JET

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