The role of parallel connection length in power exhaust performance in DEMO

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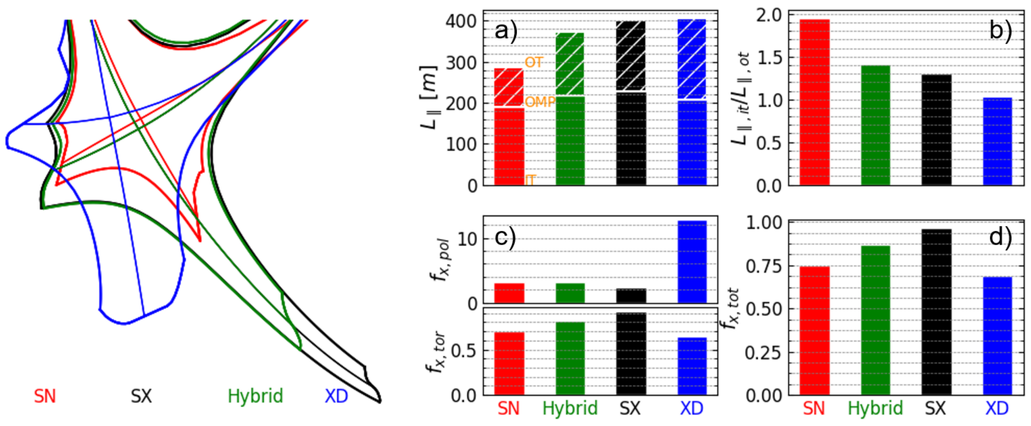
1. INTRODUCTION

- Larger margin to the boundaries of the operational space concerning core and power exhaust requirements is appreciated especially for reactor plasma.
- SOLPS-ITER simulations with are used: fluid neutral, bundled argon charge states, currents, diffusive coefficients $D_\perp$=0.1m^2/s, $\chi_{\perp e,i}$=0.1-0.3m^2/s , no drifts.
- We **aim to demonstrate the role of the connection length** in the outer divertor **in core and power exhaust performance by investigating 4 configurations**, shown bellow.



The 4 configurations differ most in 2 measures:

i. The **connection length from outboard midplane (OMP) to the outer target**, thus also **the ratio between the connection length to the outer and to the inner** target,

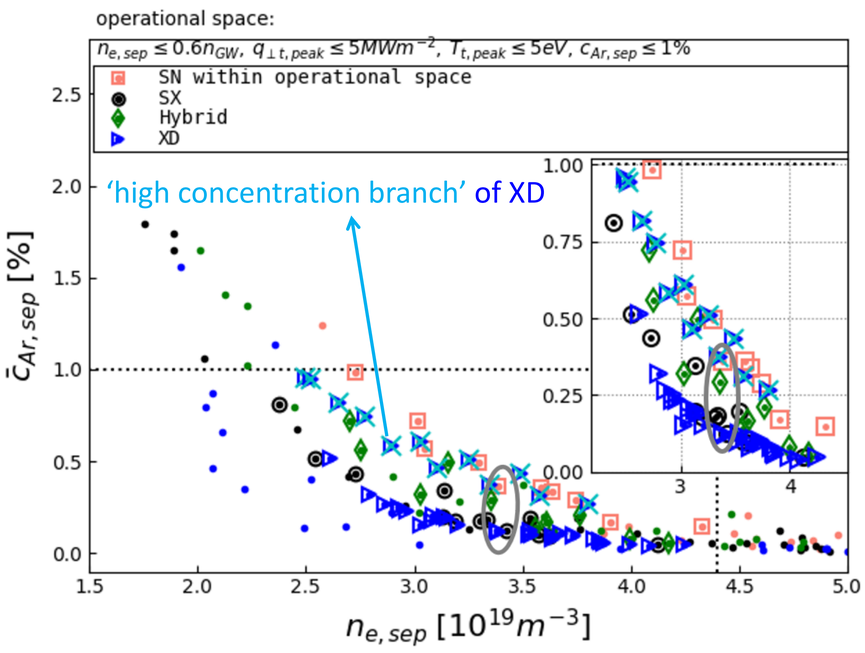
ii. The **poloidal flux expansion** at the outer target.

2.1. OPERATIONAL SPACE

1. Each configuration collapses on distinctive curve. XD has bifurcation, overlaps with SX, or SN (called 'high concentration branch').

2. At same density $n_{e,sep}$, Hybrid, SX, XD have lower upstream argon concentration $\bar{c}_{Ar,sep}$, than SN. Vice versa is true.

3. The curves of Hybrid, SX, XD lie below that of SN. The Hybrid curve lies between that of the SN and SX.

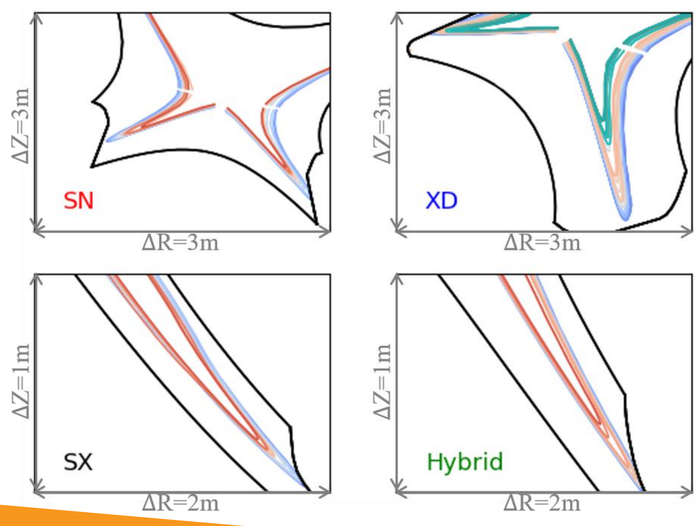


4. With similar connection length, different poloidal flux expansion, curves of SX and XD overlap.

5. Factors of difference in $\bar{c}_{Ar,sep}$ at same $n_{e,sep}$ coincides difference in connection length.

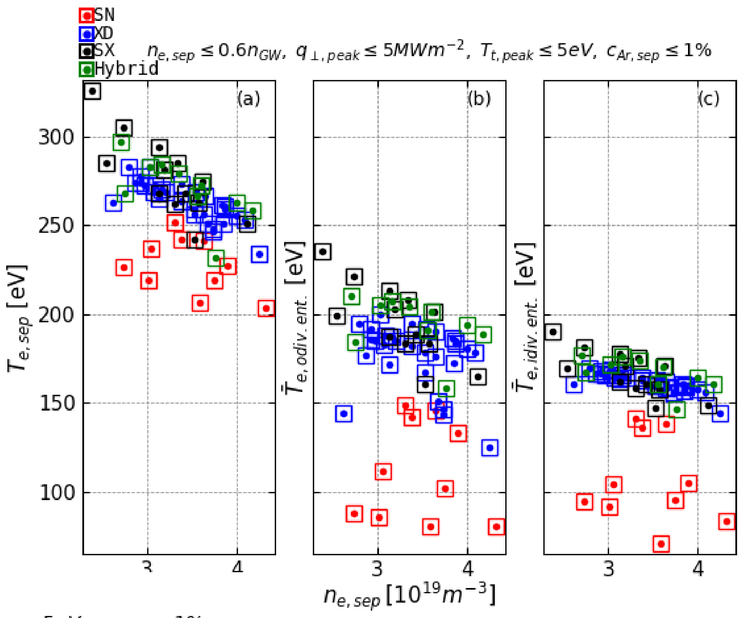
6. Relevant geometric parameter is connection length in the outer divertor.

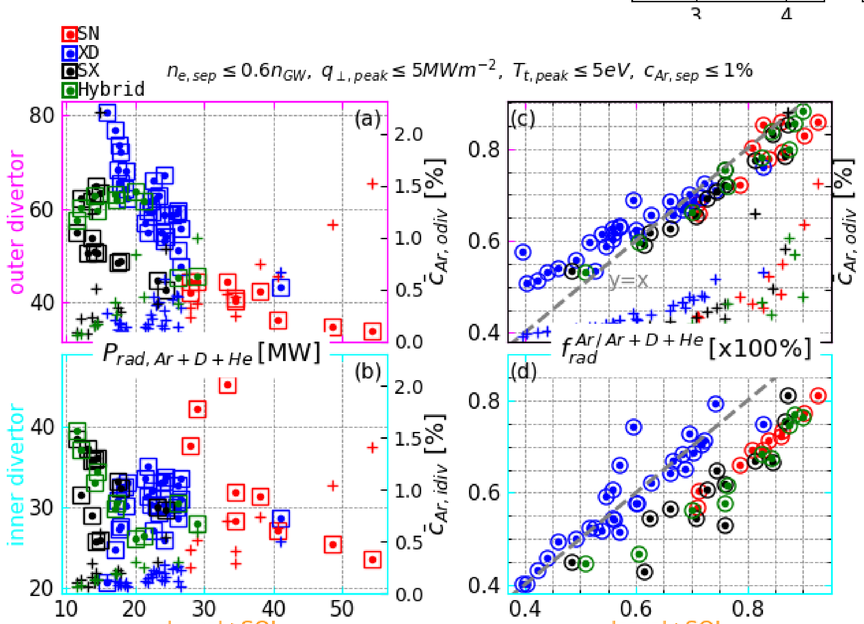
- ❑ **5 eV front most close to the X-point in SN, followed by Hybrid, least in SX**.
- ❑ XD: 5 eV front detaches from outer target, but attaches at inner target. Contrary to SN.
- ❑ 'high concentration branch': 5 eV front much closer to the X-point.



2.2. RADIATION DISTRIBUTION

- **Longer connection length, higher upstream temperature** (OMP, divertor entrance) like 2-point model predicts
- T_{eu} seemingly dependent on $n_{e,sep}$ because conductive heat flux varies at different density due to radiation upstream
- Same reason for large scatter in SN data.



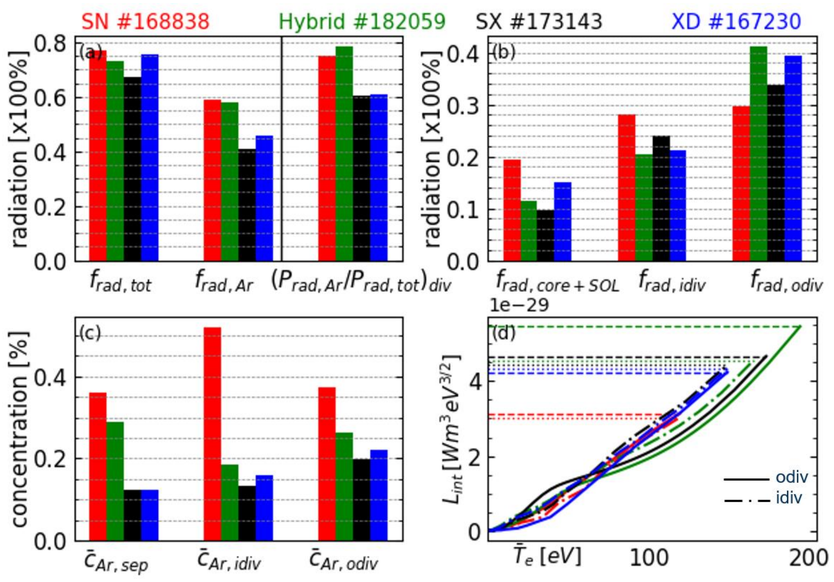


1) Radiation lower in the core, higher in the outer divertor in XD, Hybrid, SX **with longer connection length** than SN.

2) Higher/comparable radiation in divertor divertor in XD, Hybrid, SX despite lower concentration.

3) Argon radiation dominants. Argon radiation fraction higher in core at higher concentration.

- ❖ Simulations at same density: SN has highest concentration also in the divertor, factor ~1.45-1.85 higher in outer divertor, ~2.85-3.85 higher in inner divertor than Hybrid, SX, XD.
- ❖ $P_{dissipate} \propto c_{Ar} L_{int}$. Larger L_{int} compensates for lower of c_{Ar} ⇒ higher/comparable radiation in outer/inner divertor in Hybrid, SX, XD



- ❖ SN has higher enrichment in inner divertor, SX, XD has higher enrichment in outer divertor. ⇒ in/out asymmetry

3. CONCLUSION

- ➢ **The longer connection length in outer divertor, the larger margin to the boundary values of the operational space is obtained.**
- ➢ **Longer connection length to the outer target than to the inner target may cause bifurcation, risking losing the better performances.**
- ➢ **Longer connection drives higher temperature upstream**
- ➢ **Higher temperature upstream may enable the divertor to radiate more. Configuration with longer connection length radiates less above the X-point owing to lower impurity concentration.**

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