First multi-fluid Modelling Results of super-X Divertor in DEMO with Ar Seeding

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MOTIVATIONS

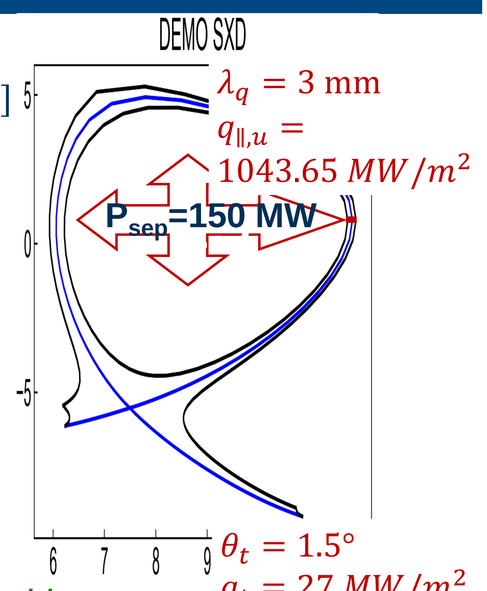
On DEMO:

- $P_{sep} = (2000 * 20\% + 50) - (150 + 150)[MW]$ 5
  Brem. Rad. Line Rad.
- Other design parameters: $\lambda_q = 3$ mm, $\theta_t = 1.5°$
- Thus target heat load estimated (R=9.6,a=):
  SN: $q_t \approx 36\ MW/m^2$
  SXD: $q_t \approx 27\ MW/m^2$

may be optimistic

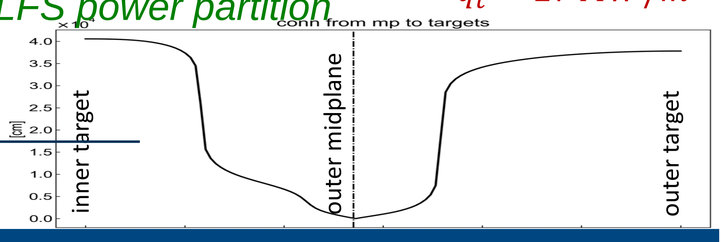
Beyond material limit!

- Large A_{wet}
- Large V_{div} for radiation
- *More even HFS/LFS power partition*



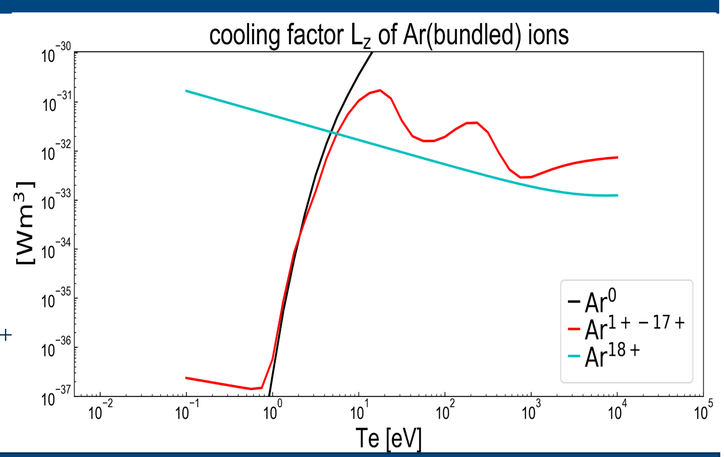
Simple 2-point model gives:

$$q_{\parallel u} \propto T_{e,u}{}^{7/2}\ \kappa_{0e}/L_{\parallel}$$



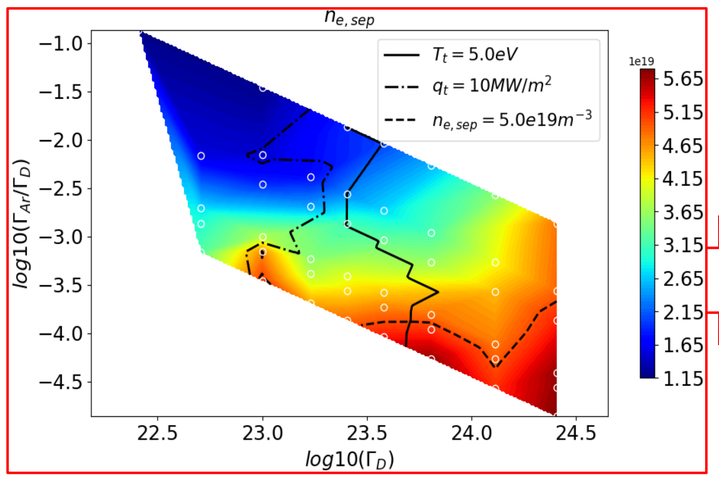
SETUP

√ SOLPS-ITER
√ D+He+Ar
√ Fluid neutrals
√ Parallel currents
√ Throughput Γ_D & Γ_{Ar} scan
√ Ar bundled: Ar^0, Ar^{1-17+}, Ar^{18+}
X drifts



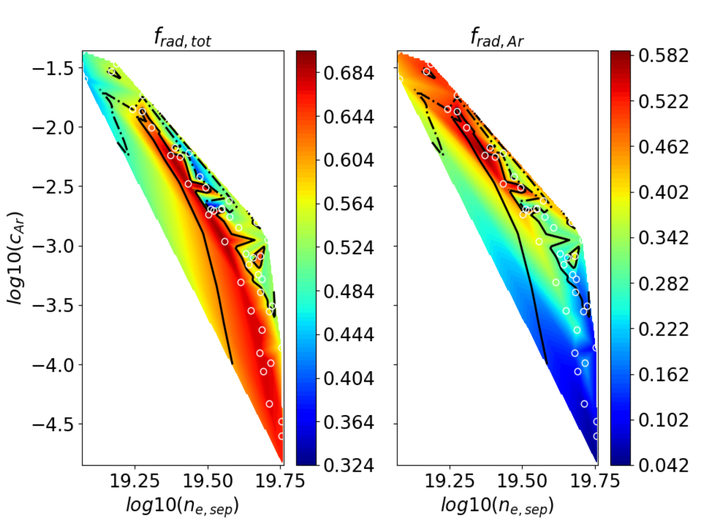
RESUTLS – Parameters Scan

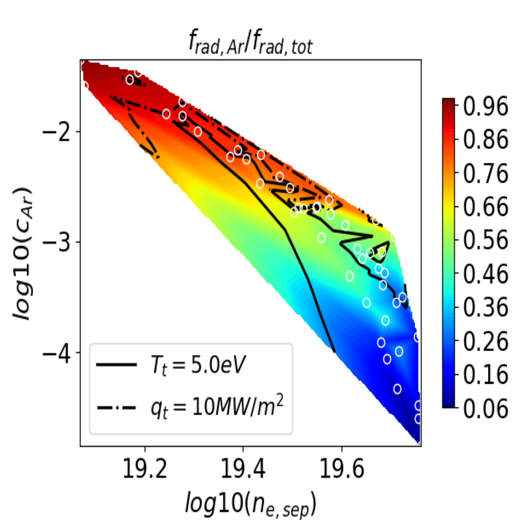
Parameters scan to explore operation window in SXD for DEMO:



Flexible operation window concerning:
1) targets(both)conditions
&
2) Greenwald limit

Ar seeding largely affects $n_{e,sep}$ - decreases with Ar seeding





at present design parameters:

- **DEMO NEEDs radiation to achieve $T_t \leq 5eV$; but do NOT regarding**
- **$q_t \leq 10mw/m^2$.**
- **Mainly hydrogenic radiation instead of impurity radiation within operation window.**

CONCLUSION

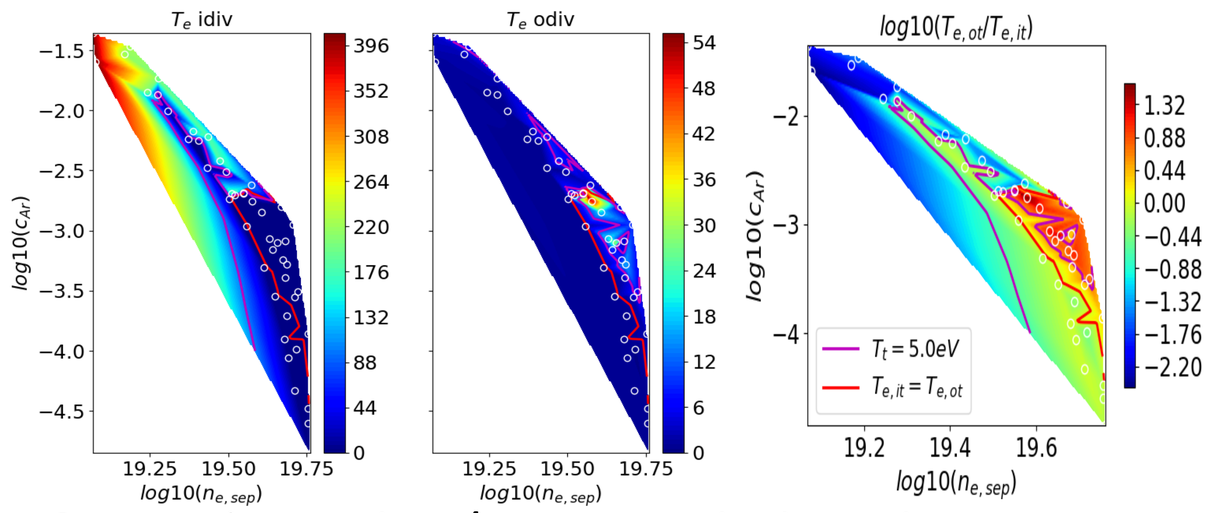
✓ **With current design parameters, SXD configuration allows a large operation window (T_t, q_t, $n_{e,u}$, Γ_D, Γ_{Ar} concerned) on DEMO.**

✓ **Within the operation window Inner/Outer symmetry can be achieved; while asymmetry maybe due to self-reinforced thermal current between the targets.**

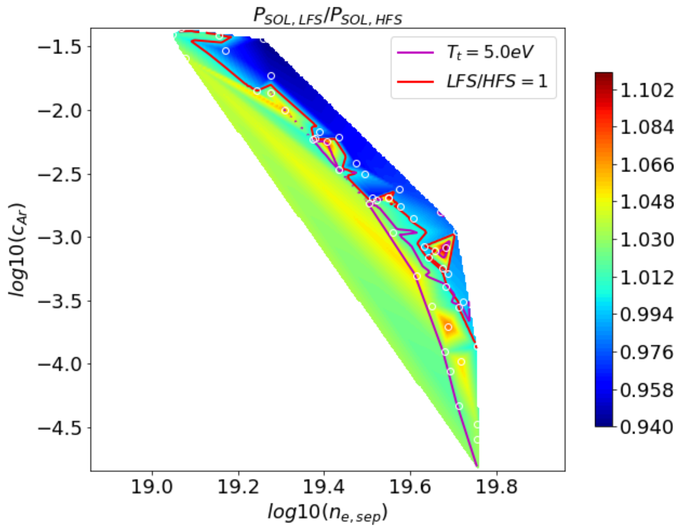
✓ **With current design parameters, target peak q_t is NOT much problem, but radiative dissipation of power is NEEDED to keep T_t below 5eV.**

✓ **Power split between HFS/LFS at LFS midplane varies by $\pm 10\%$, echoing simple 2-point model estimate.**

RESULTS – Inner/Outer Divertor Asymmetry



- **Symmetry between inner/outer target exists in certain parameter range.**
- **Region of inner/outer symmetry overlap with $T_t \leq 5eV$ region.**
- **Reason for asymmetry: self-reinforcement of thermal current.**



- **Power partition between HFS/LFS plasma deviates from 2-Point model by about ±10%**
- **Region of low T_e at both target appears only at higher power to the LFS.**

Outlook Work

- **Matrix scan at more conservative design parameters:**
  - Lower line radiation level in DEMO core to favor fusion efficiency ($150MW \rightarrow 50MW$)
  - Decrease expected λ_q ($3mm \rightarrow 1mm$)
  - Increase the inclination angel at target ($1.5° \rightarrow 3°$)
- **Matrix scan of parameters of physical meaning (n_e, c_{imp} etc.),** instead of merely engineering parameters (Γ_D, Γ_{imp}).

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