

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

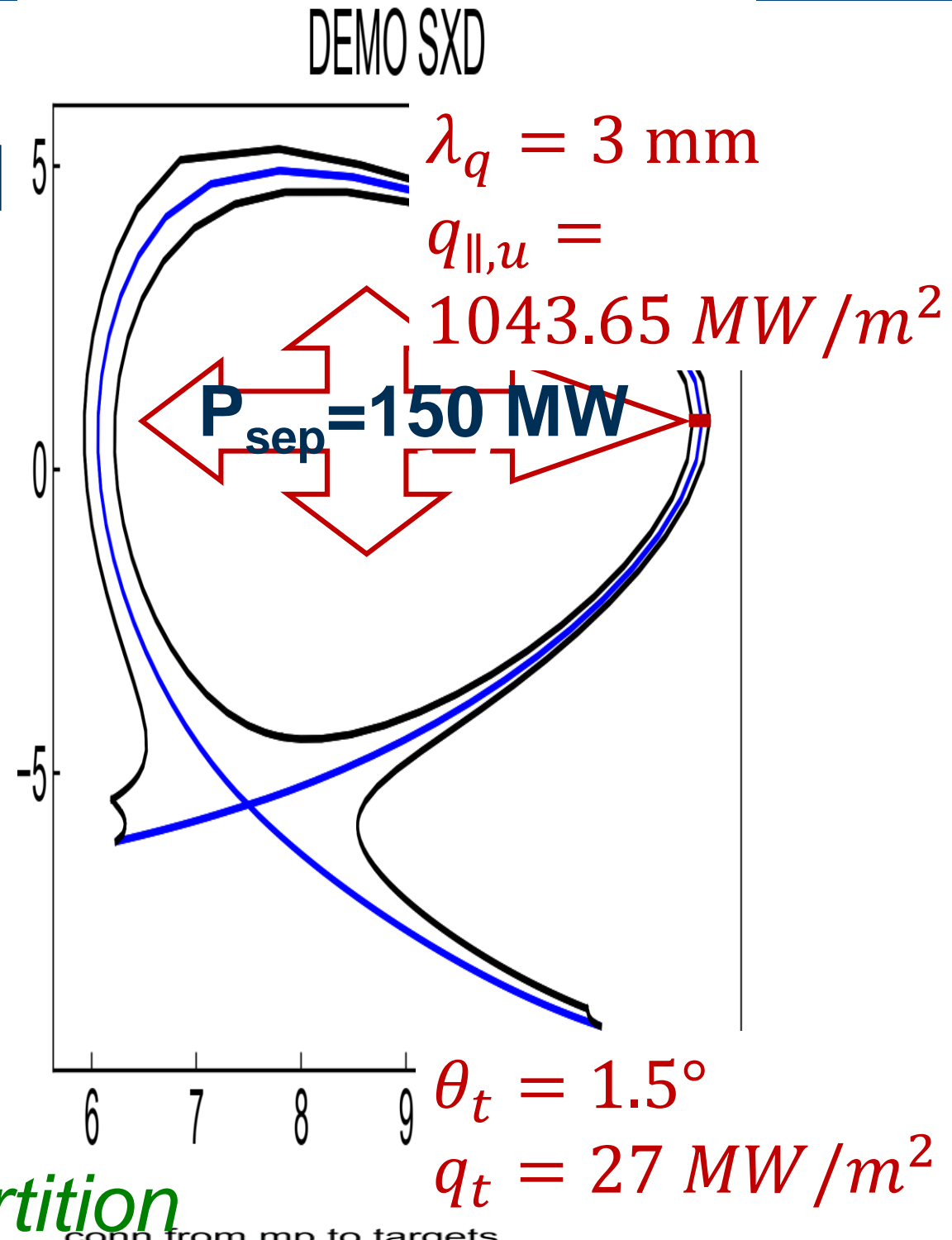
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## MOTIVATIONS

On DEMO:

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

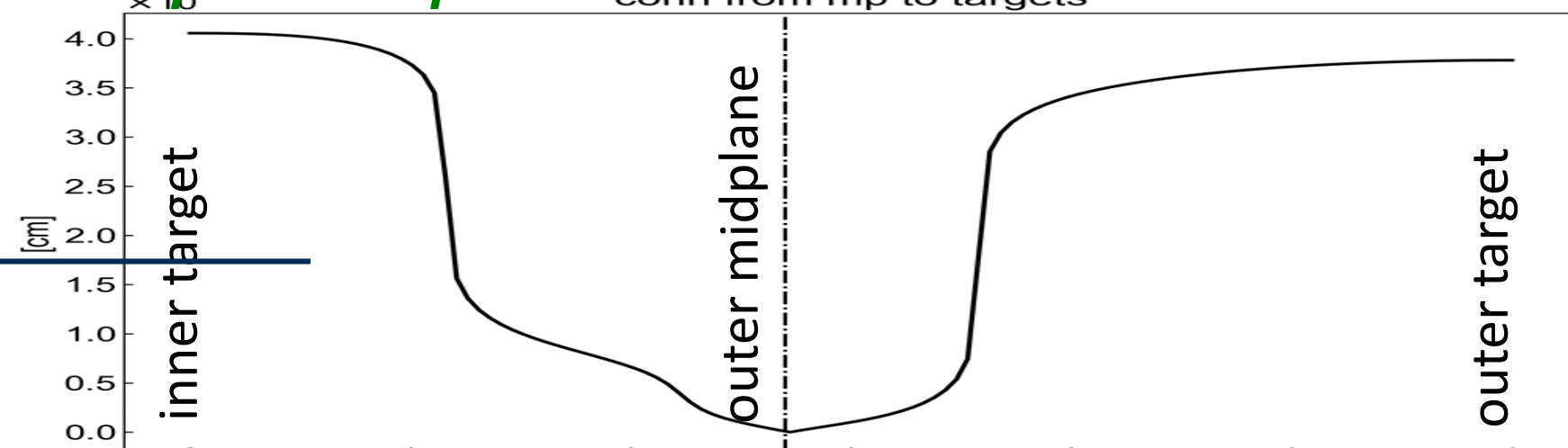


Beyond material limit!

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

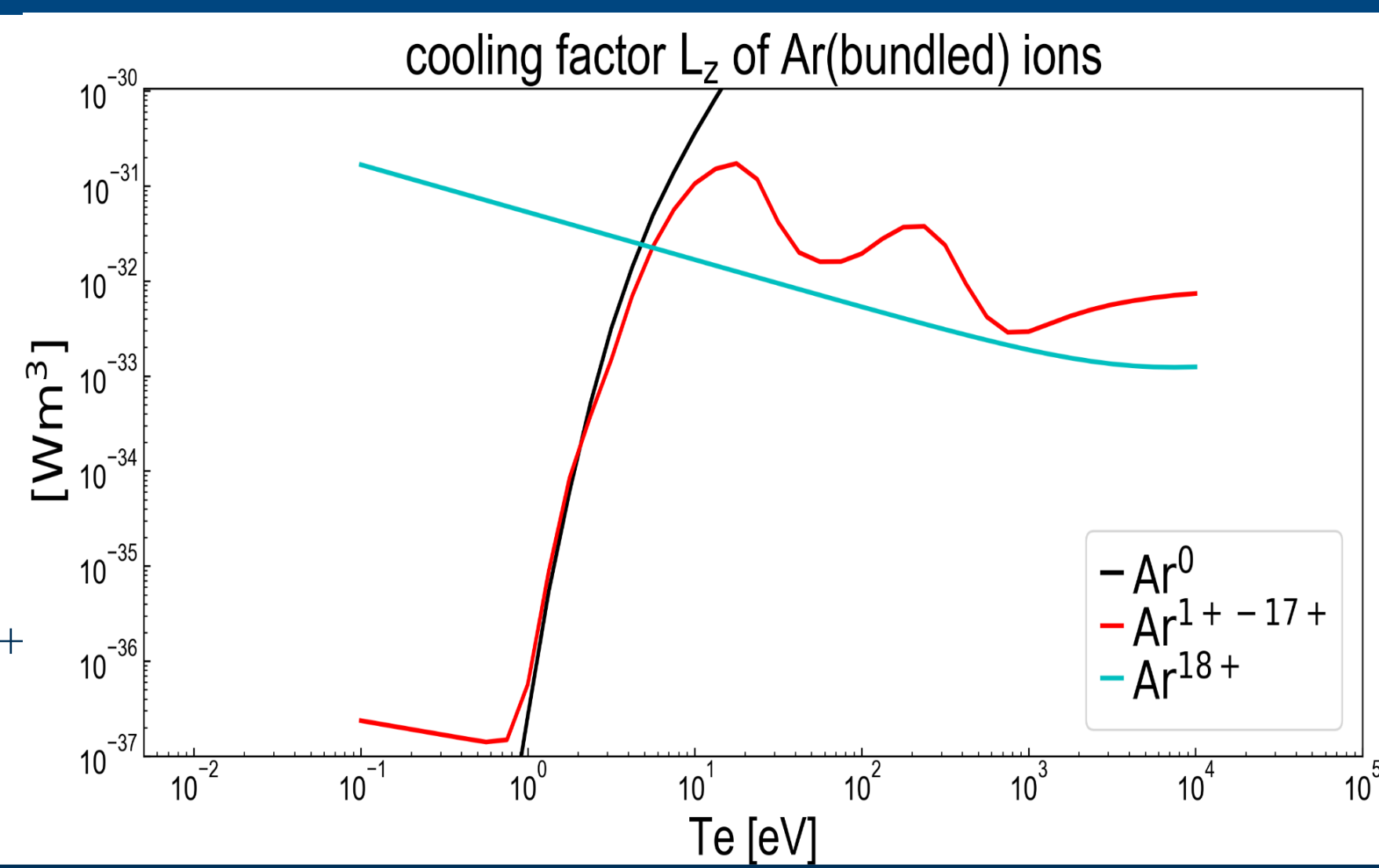
Simple 2-point model gives:

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



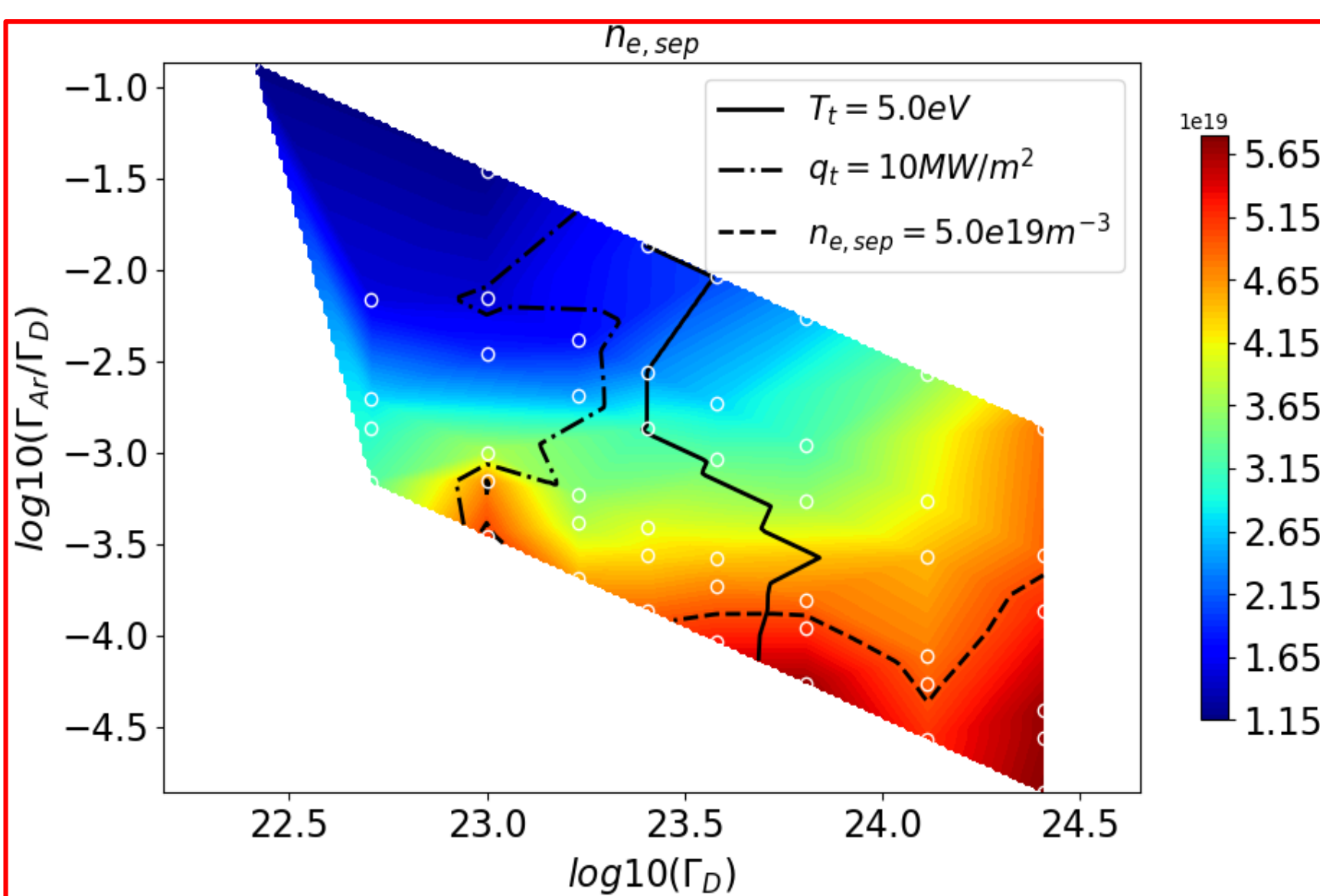
## SETUP

- ✓ SOLPS-ITER
- ✓ D+He+Ar
- ✓ Fluid neutrals
- ✓ Parallel currents
- ✓ Throughput  $\Gamma_D$  &  $\Gamma_{Ar}$  scan
- ✓ Ar bundled:  $Ar^0, Ar^{1-17+}, Ar^{18+}$
- ✗ drifts



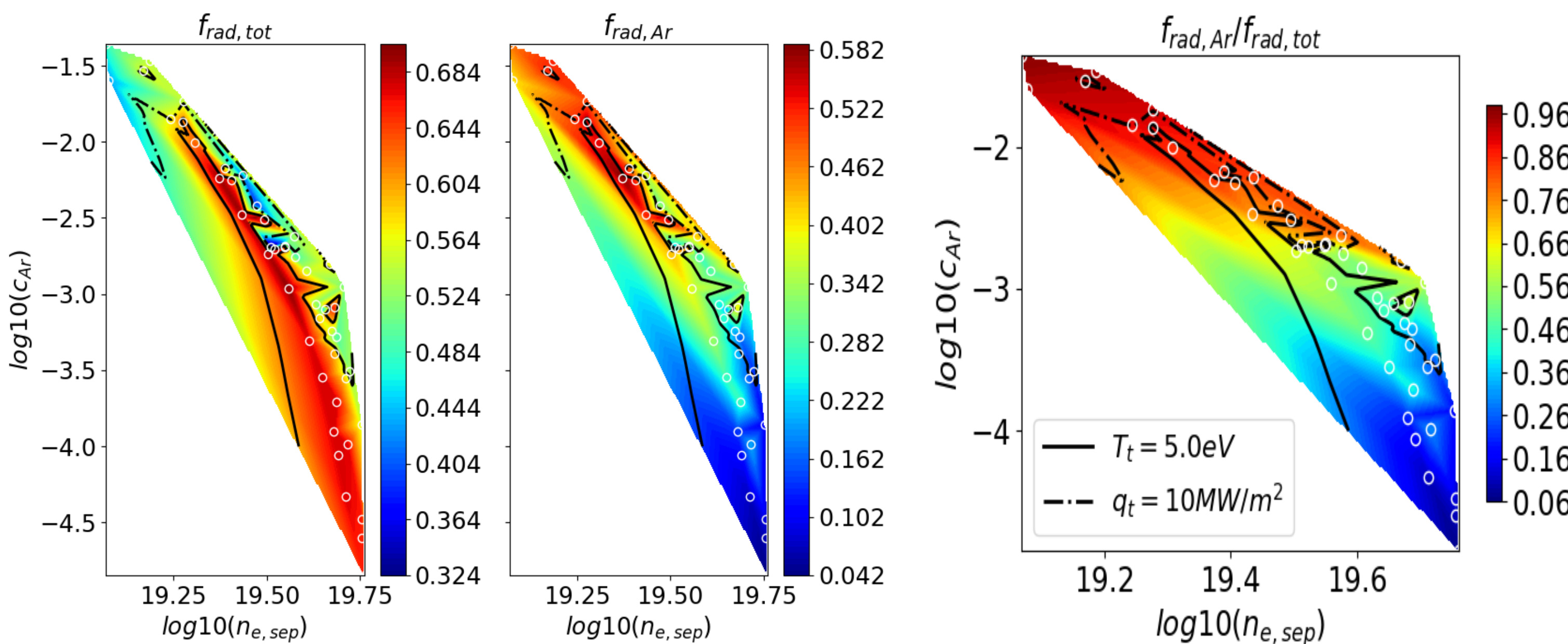
## RESULTS – Parameters Scan

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**



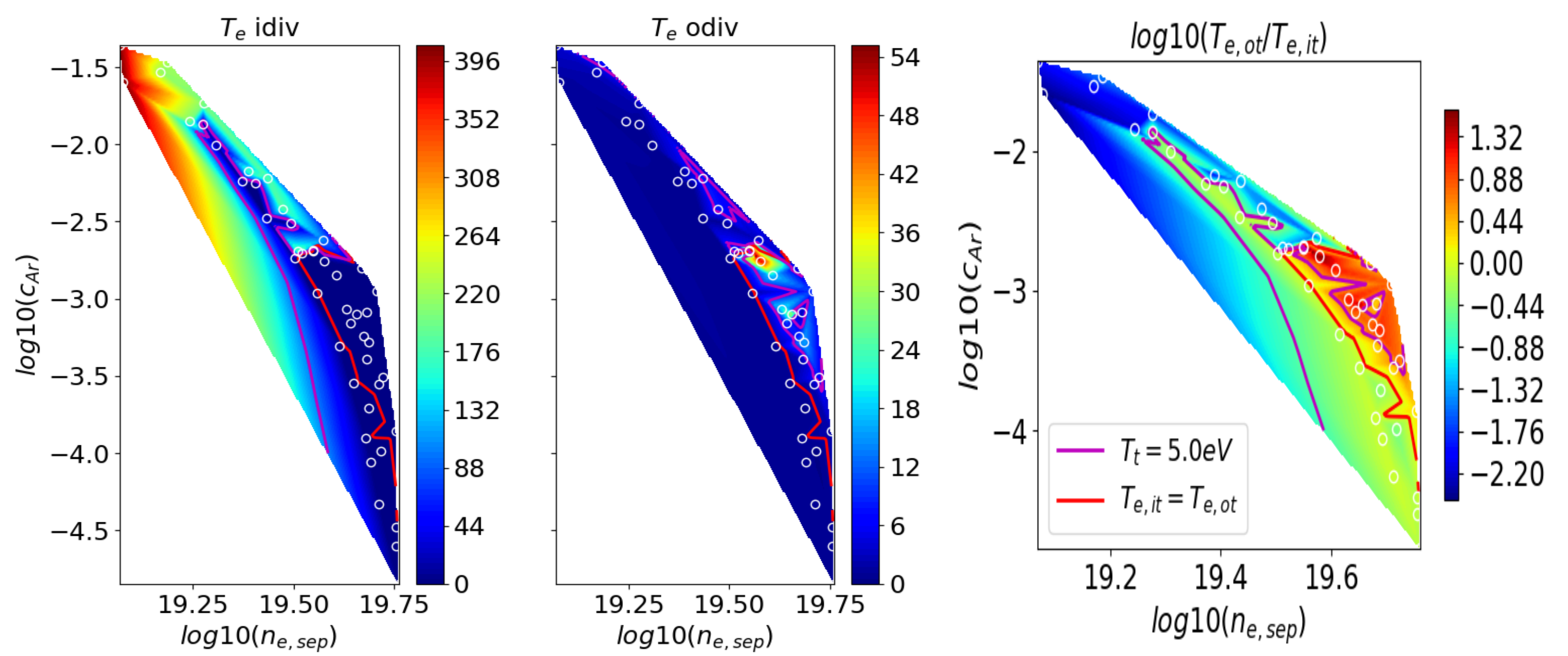
at present design parameters:

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

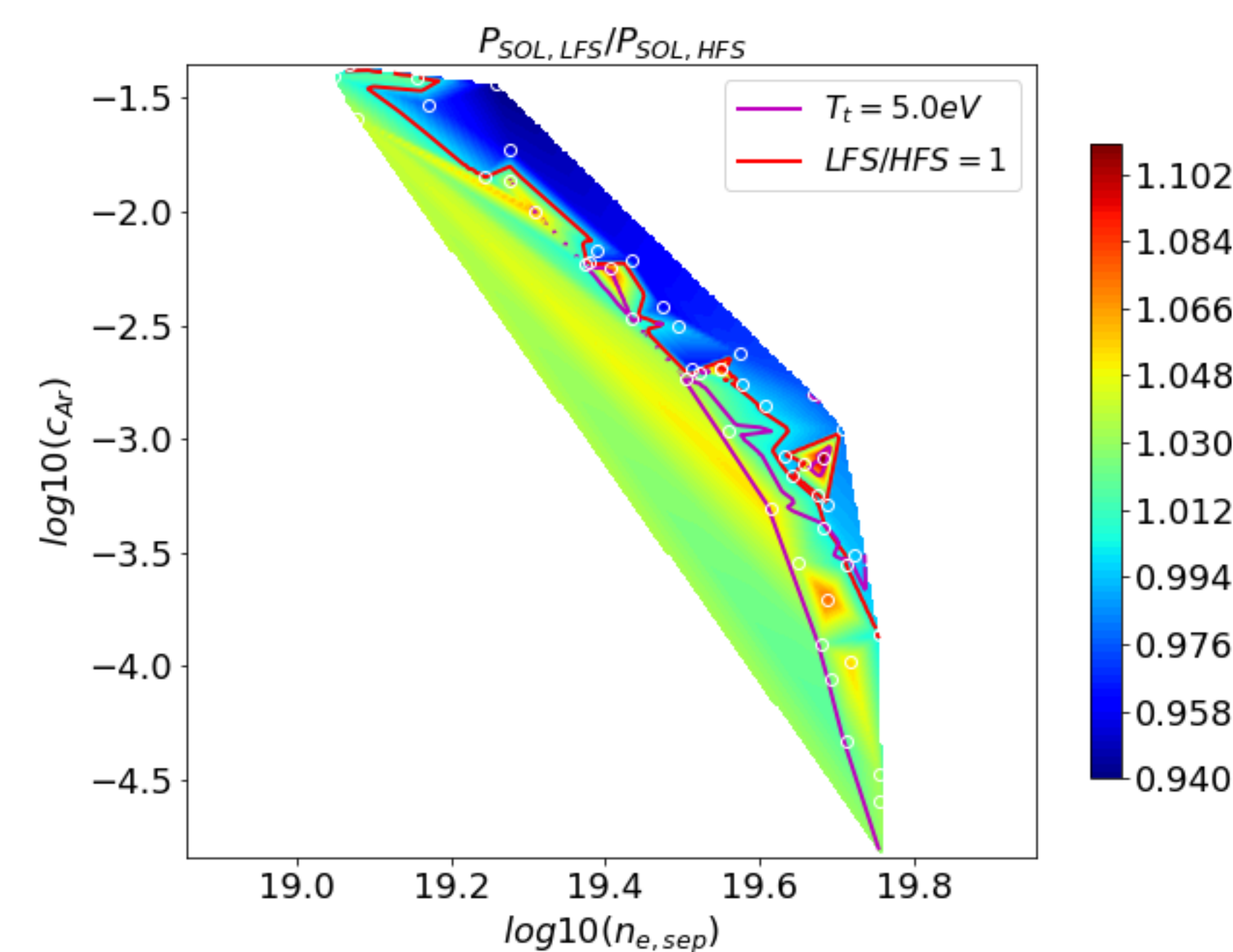
## CONCLUSION

- ✓ With current design parameters, SXD configuration allows a large operation window ( $T_t, q_t, n_{e,w}, \Gamma_D, \Gamma_{Ar}$  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  $\pm 10\%$
- 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 ( $150 \text{ MW} \rightarrow 50 \text{ MW}$ )
  - Decrease expected  $\lambda_q$  ( $3 \text{ mm} \rightarrow 1 \text{ mm}$ )
  - Increase the inclination angel at target ( $1.5^\circ \rightarrow 3^\circ$ )
- Matrix scan of parameters of physical meaning ( $n_e, c_{imp}$  etc.), instead of merely engineering parameters ( $\Gamma_D, \Gamma_{imp}$ ).