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SOL modelling of the JT-60SA tokamak initial operational scenario using SOLEDGE-EIRENE code

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Introduction&Background

The main aim of this work is to assess the realistic heat loads on the first wall of the JT-60SA tokamak. To achieve this scope, for the first time the entire chamber and the subdivertor region is modeled by the fluid transport code SOLEDGE3X-EIRENE [1]. Whereas the full power scenario #2 modeling was reported elsewhere [2] here we focus on scenario #2 initial phase with carbon divertor and limited heating power P_{aux} , which is the main scanned parameter. Standard computational mesh with pumps situated next to the strike points (STD) is compared with full chamber + subdivertor mesh (SUBD).

Scenario #2 main parameters [3]:

$$\langle n_e \rangle = 5.6 \times 10^{19} \text{ m}^{-3}$$

$$P_{aux}^{max} = 19/26.5/33 \text{ MW}$$

$$n_{e,sep} < 2.5 \times 10^{19} \text{ m}^{-3}$$

References:

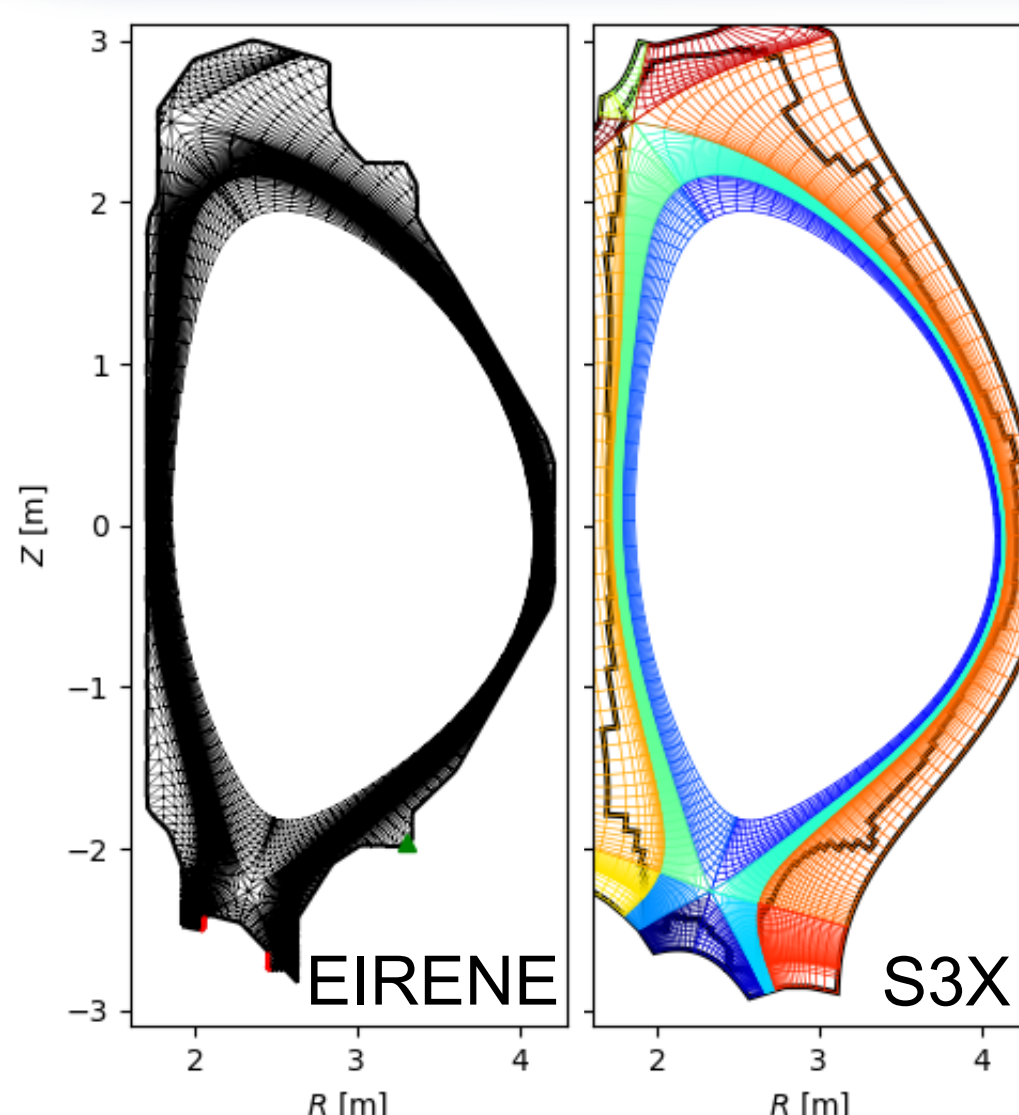
[1] H. Bufferand et al 2021 Nucl. Fusion 61 116052 (2021)

[2] N. Hayashi, et al., Proc. 26th IAEA Fusion Energy Conf., (2016)

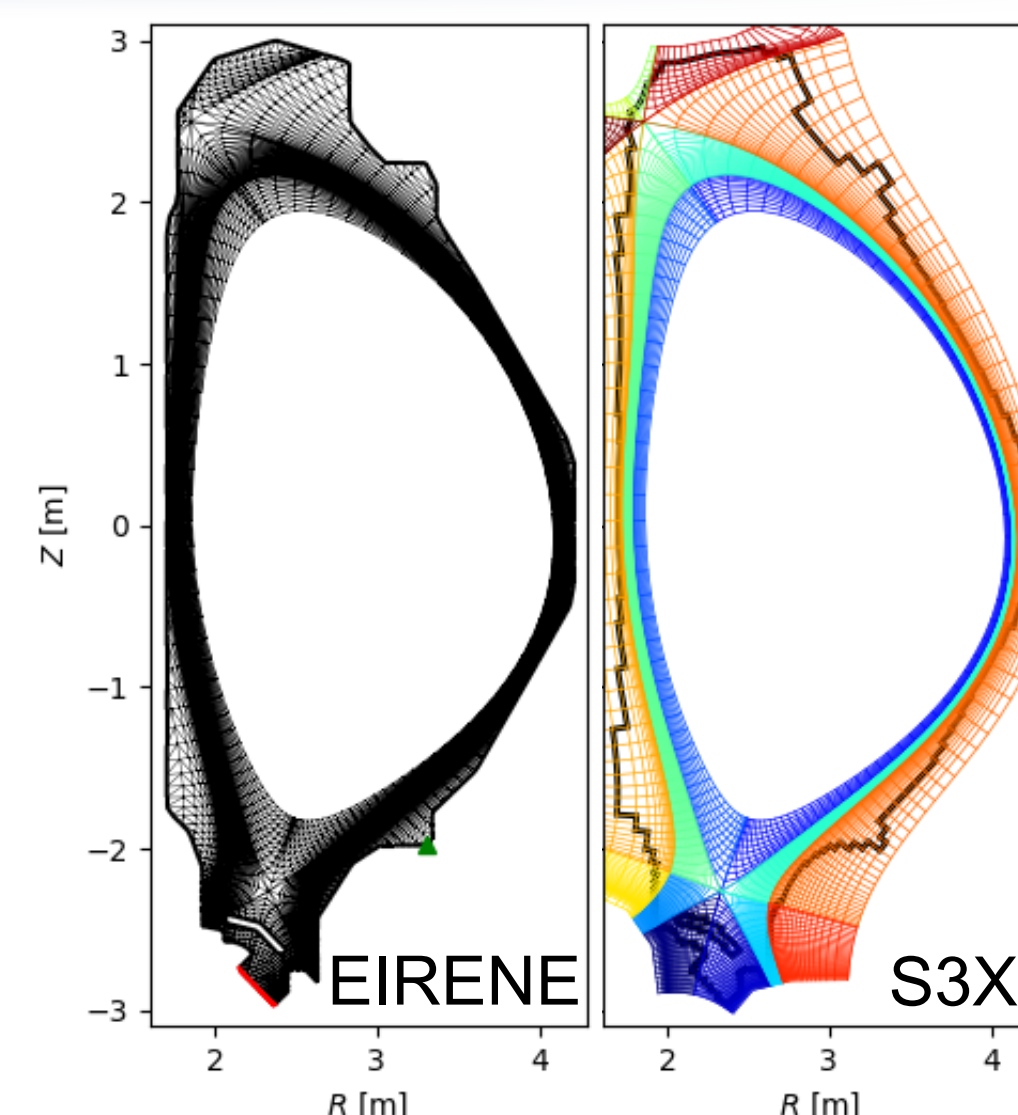
[3] JT-60SA Research Plan, Ver. 4, 2018/09

[4] L. Balbinot et al., in preparation

Simulations setup



Standard configuration (STD)



Subdivertor configuration (SUBD)

Input power @ core boundary scan:
 $P_{aux} = [15, 17.5, 20, 22.5, 25, 27.5, 30] \text{ MW}$
 Particle source @ core: $S_i = 1 \times 10^{21} \text{ part./s}$
 Deuterium fuelling: $\Gamma_D = 1 \times 10^{21} \text{ part./s}$
 C sputtering - Bohdansky formula
 EIRENE with simplified Kotov model
 (no elastic collisions on neutrals)
 No drifts

Wall properties:

$$R_D = 1.0$$

$$R_C = 0.1$$

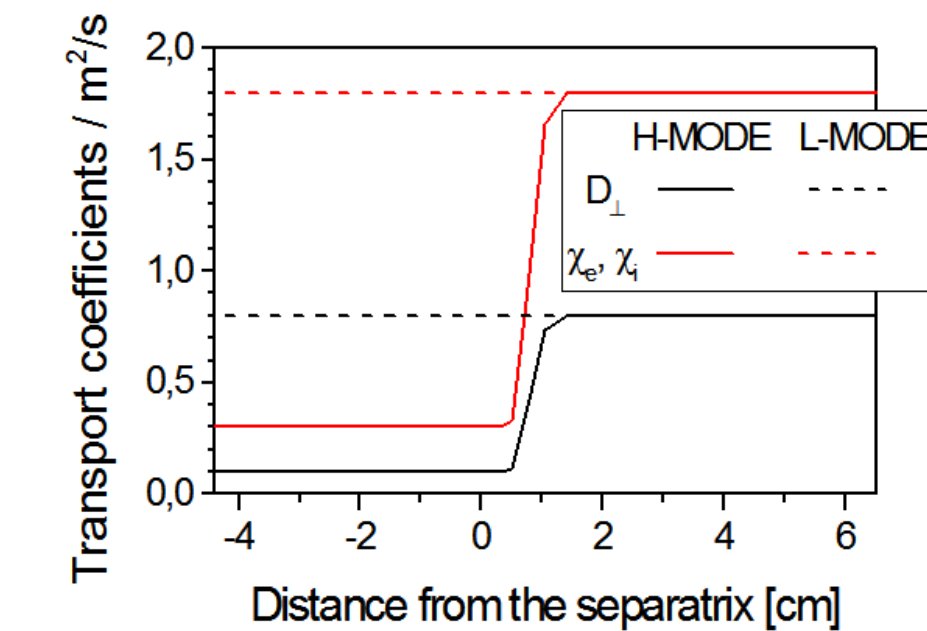
Pump albedo:

$$R_D = 0.95$$

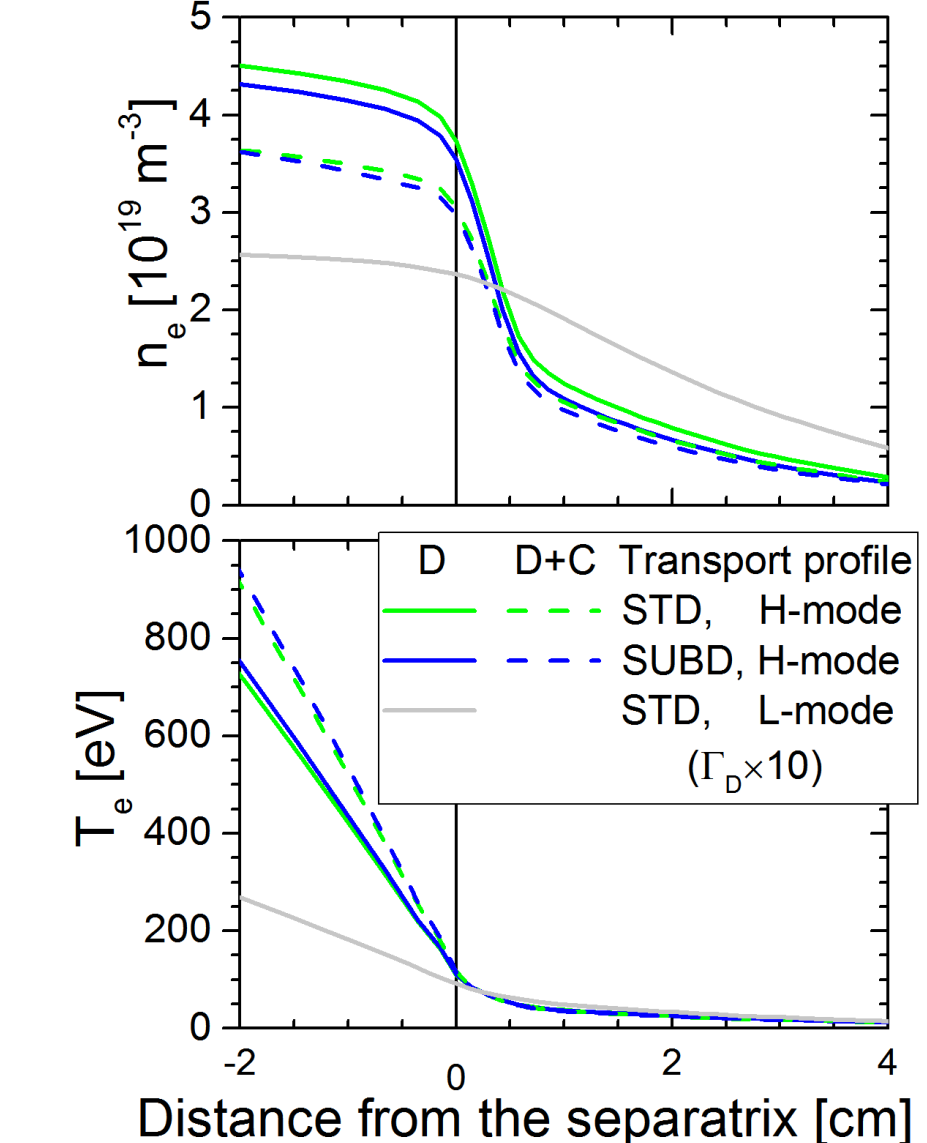
$$R_C = 0.1$$

OMP profiles

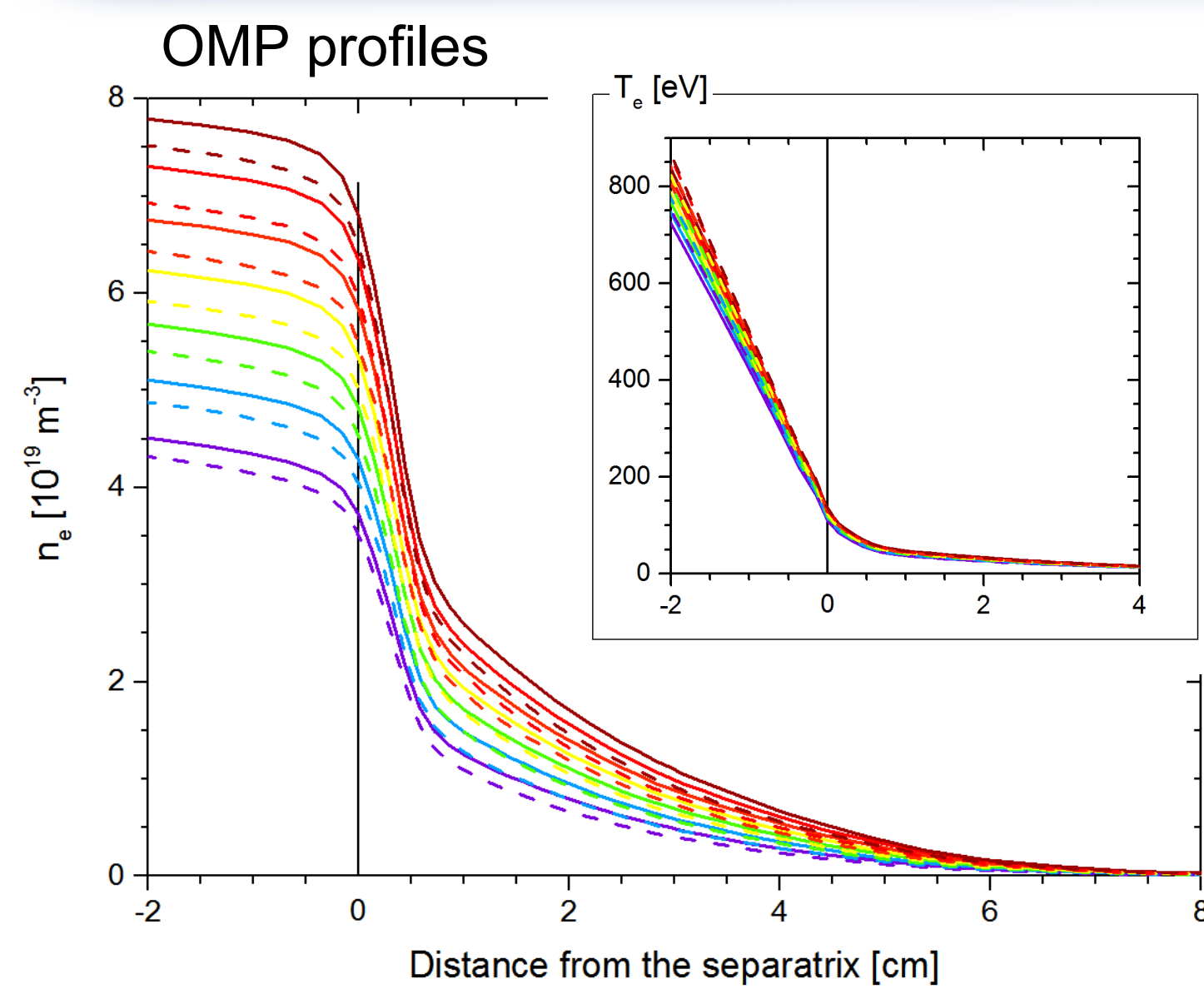
Transport coefficients @ OMP [4]



n_e, T_e comparison for $P_{aux} = 15 \text{ MW}$



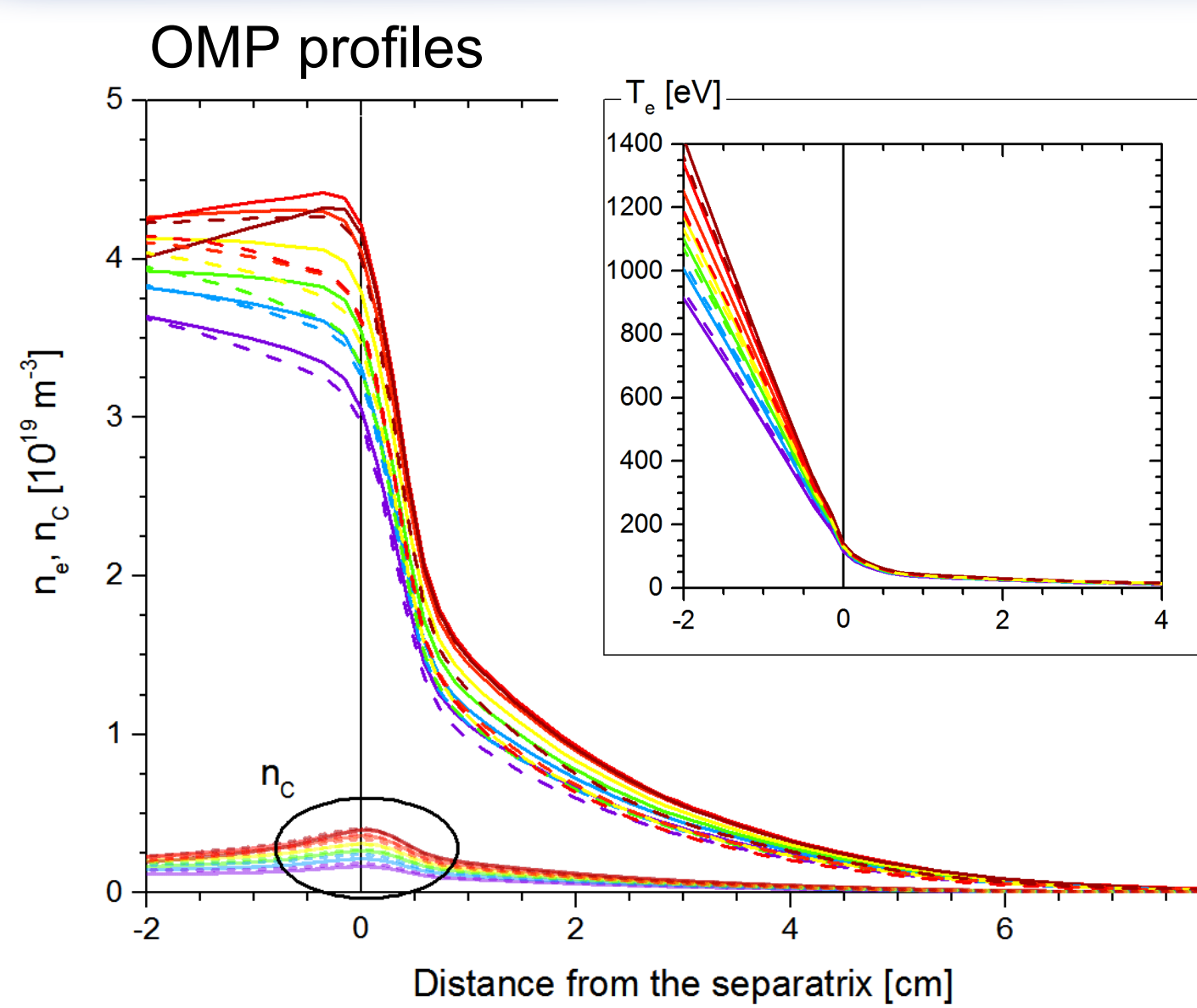
Power scan - pure D plasma



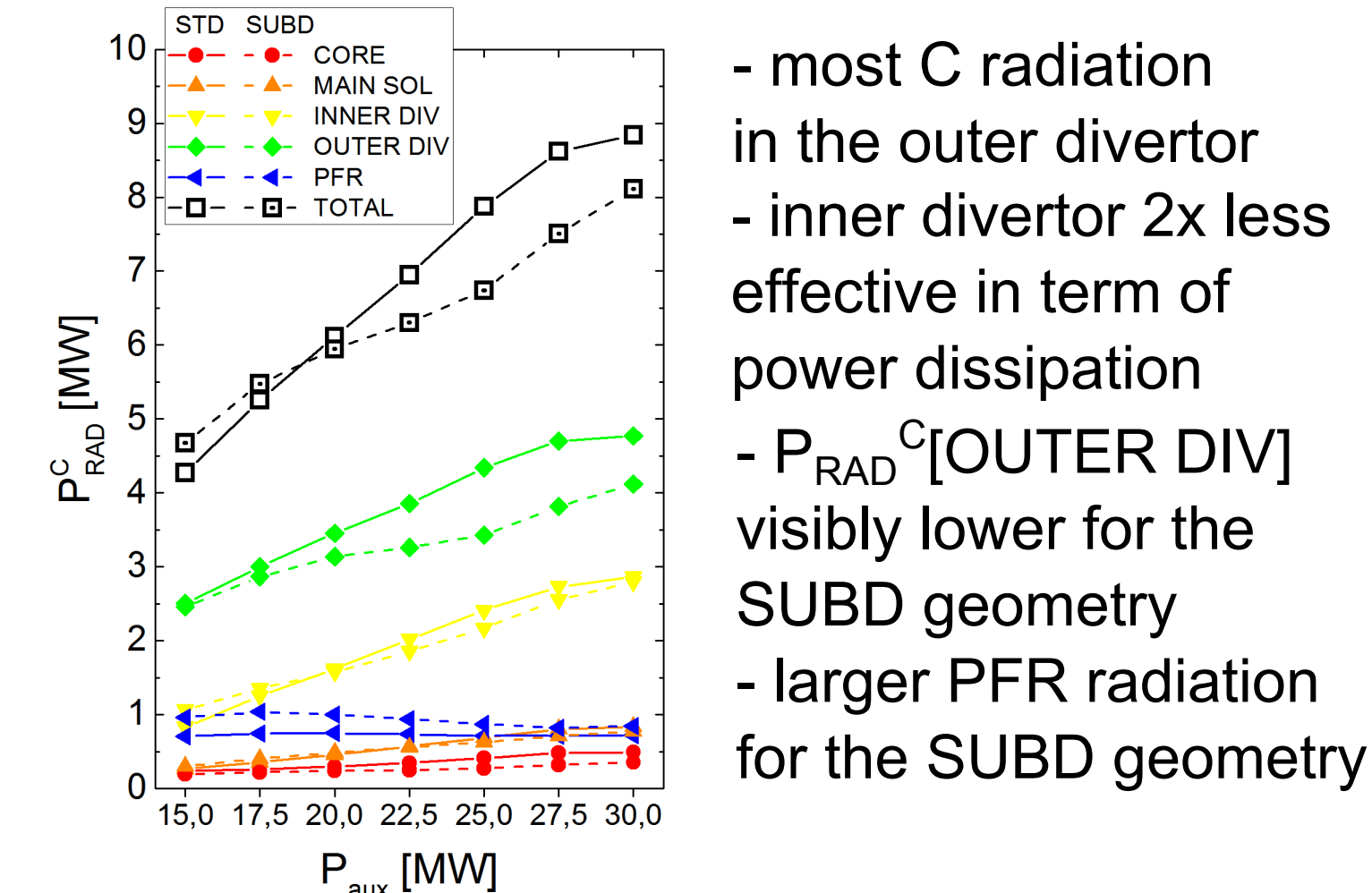
H-mode	P_{aux} [MW]
STD	15
SUBD	17.5
	20
	22.5
	25
	27.5
	30

- Rise of n_e with increasing P_{aux} (stronger for pure-D cases)
- Limited effect on T_e profile
- rise of n_C with increasing P_{aux}
- negligible effect of different geometry

Power scan - D+C plasma



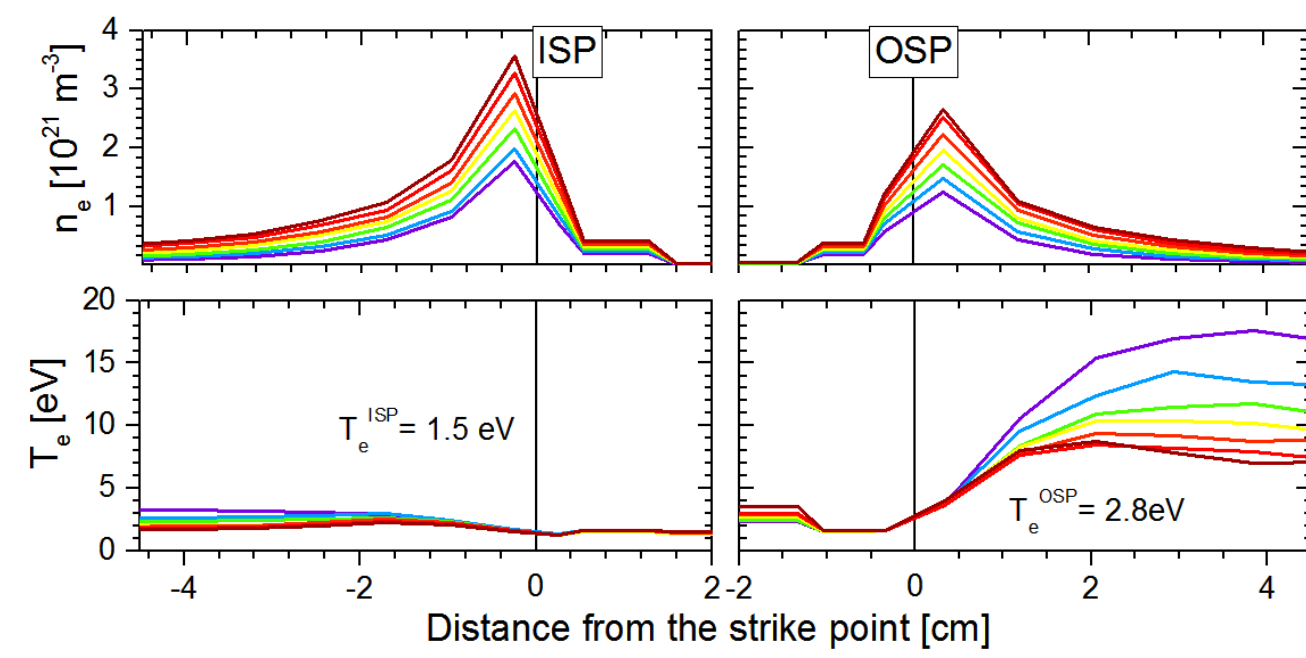
C radiation power



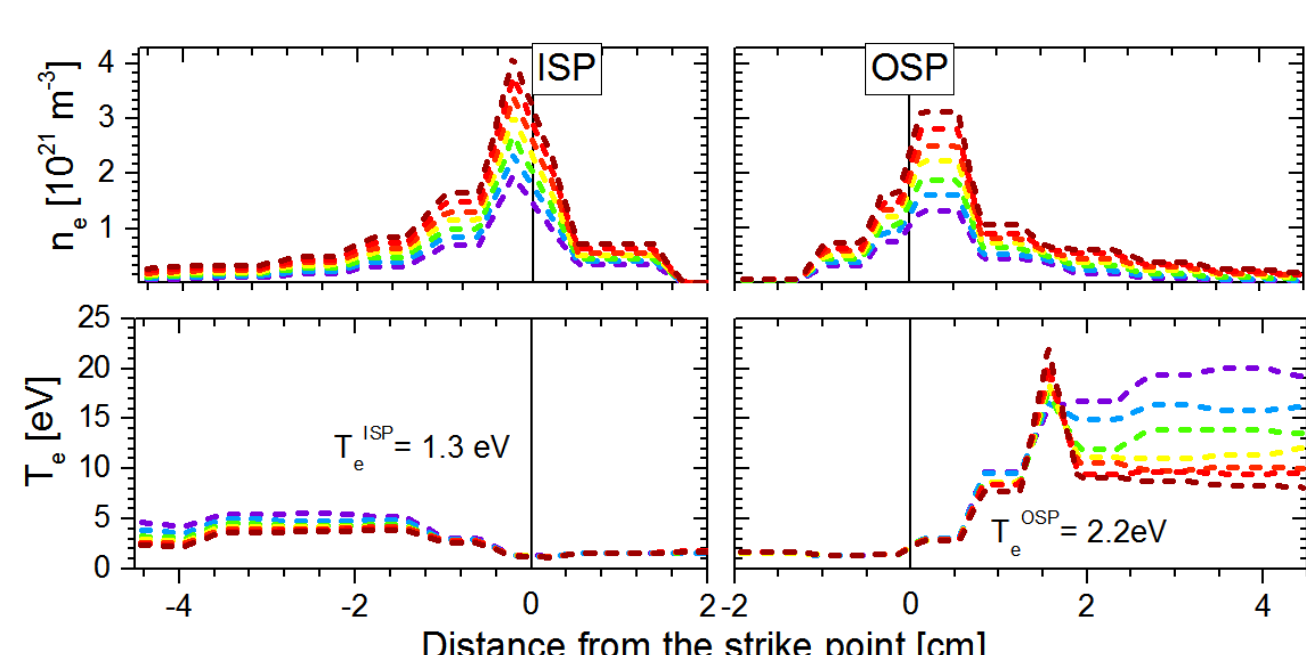
- most C radiation in the outer divertor
- inner divertor 2x less effective in term of power dissipation
- P_{RAD}^C [OUTER DIV] visibly lower for the SUBD geometry
- larger PFR radiation for the SUBD geometry

Target profiles - electron density & temperature

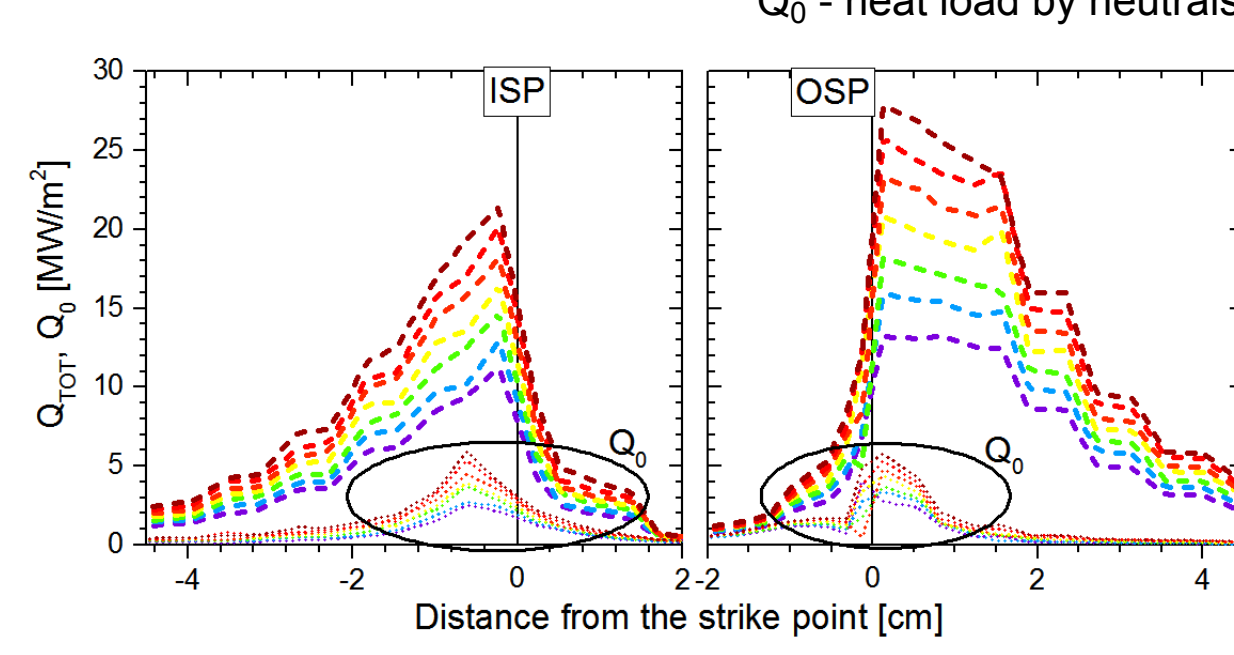
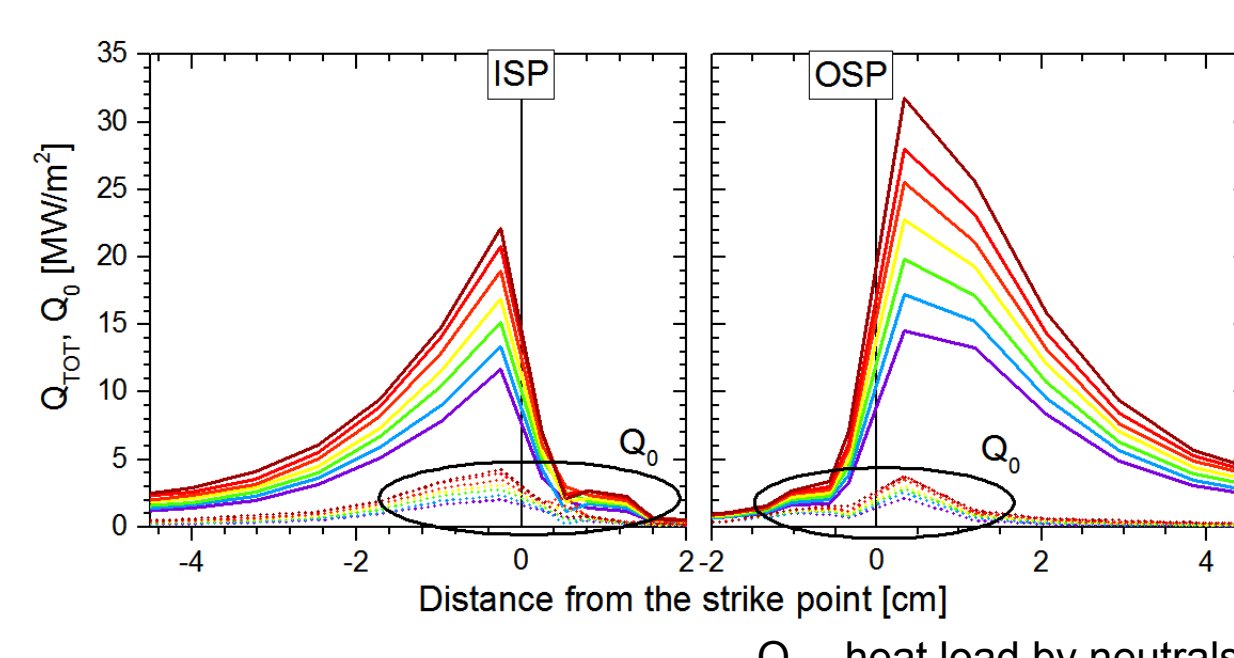
STD



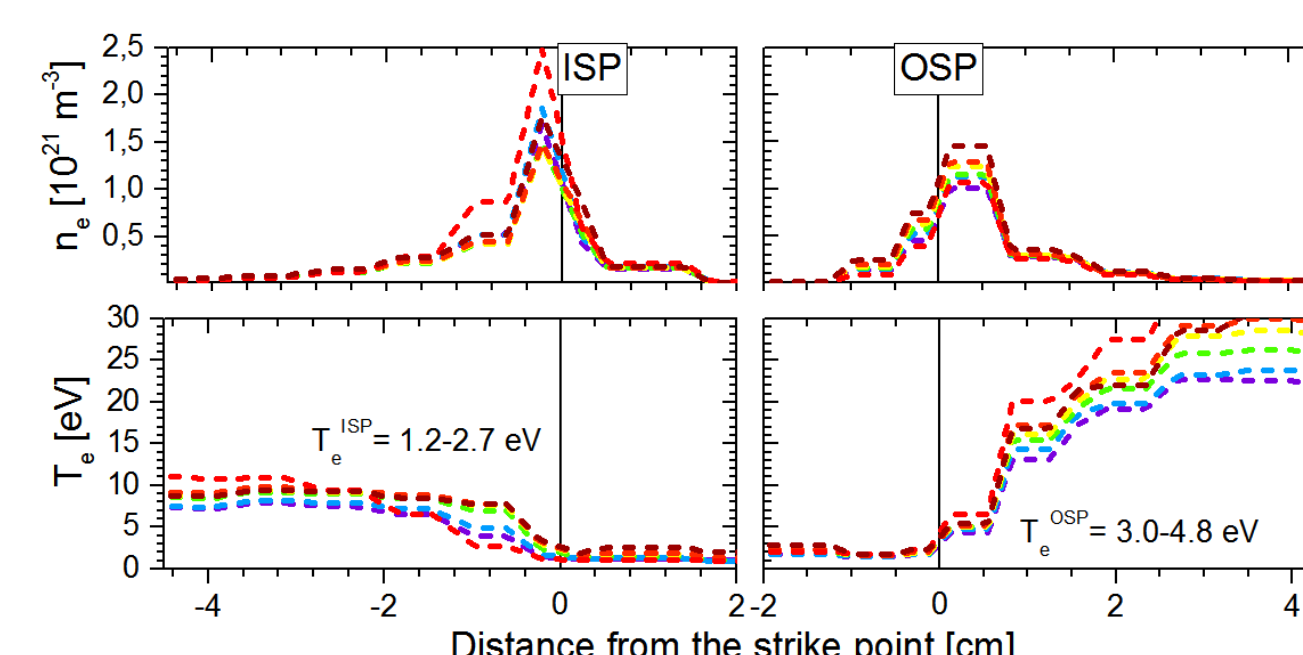
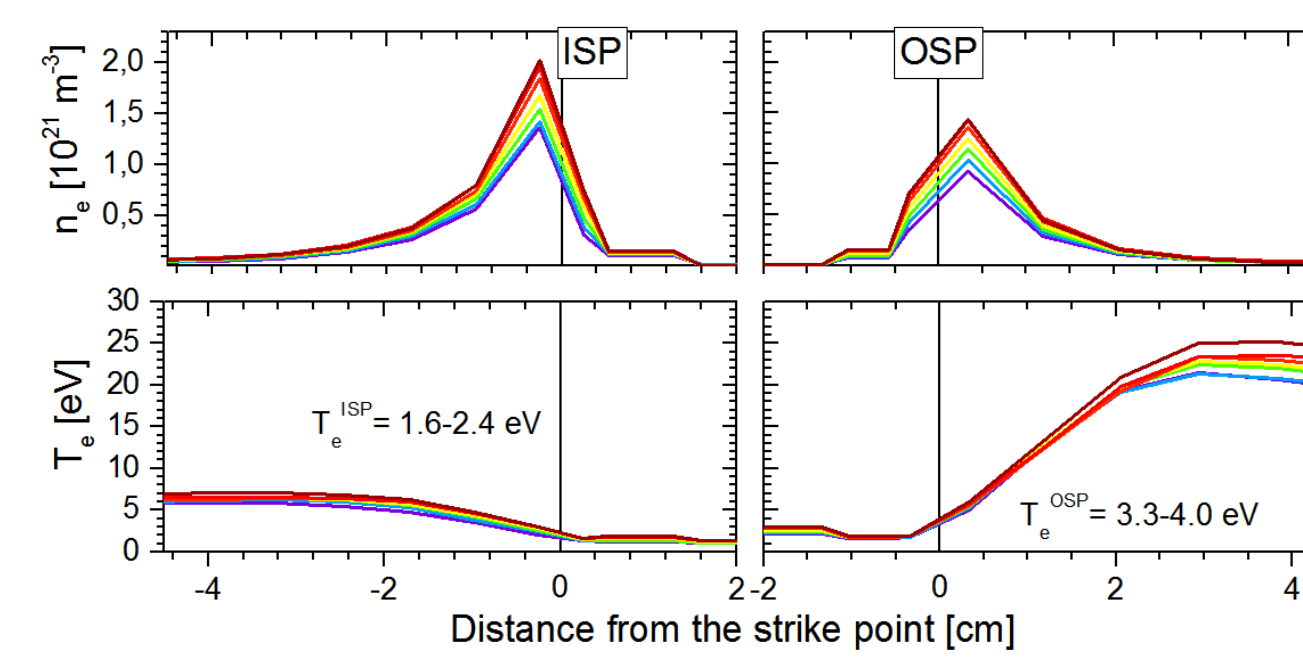
SUBD



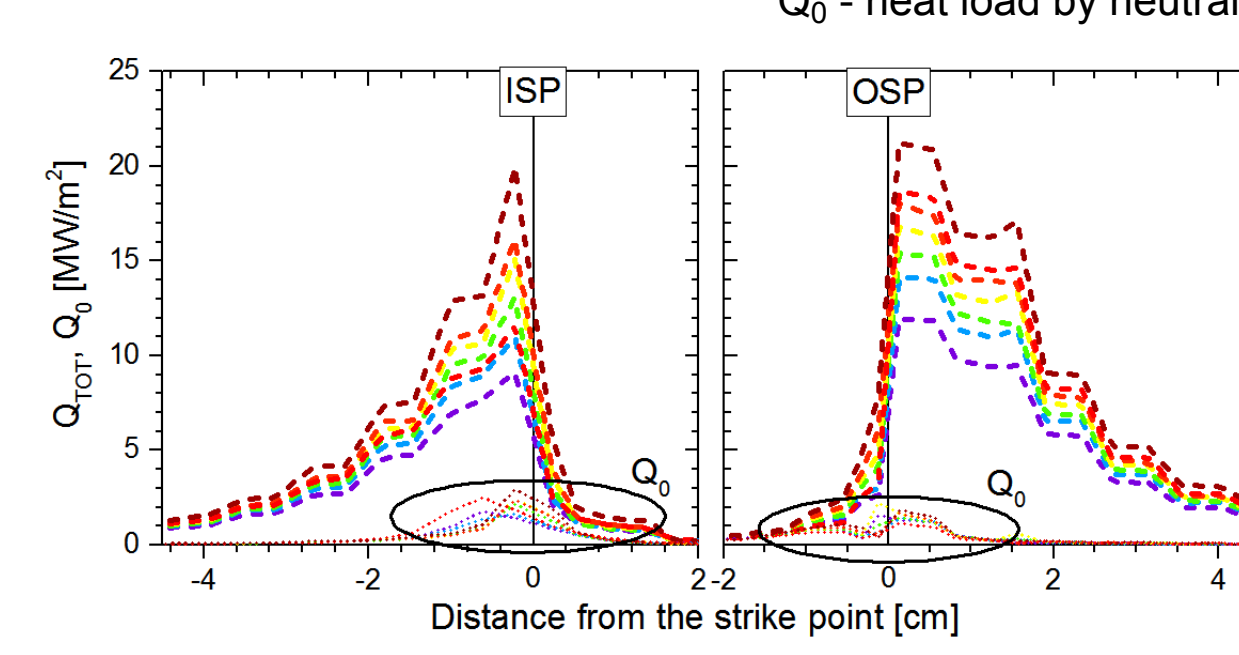
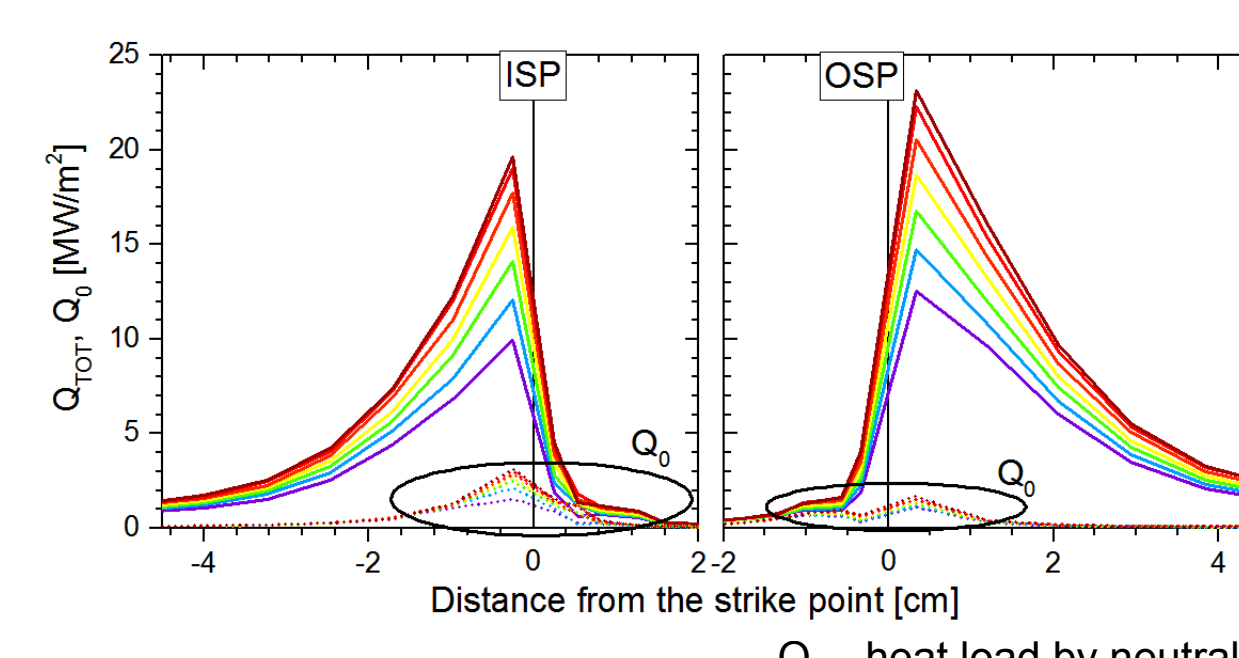
Target profiles - heat load



Target profiles - electron density & temperature



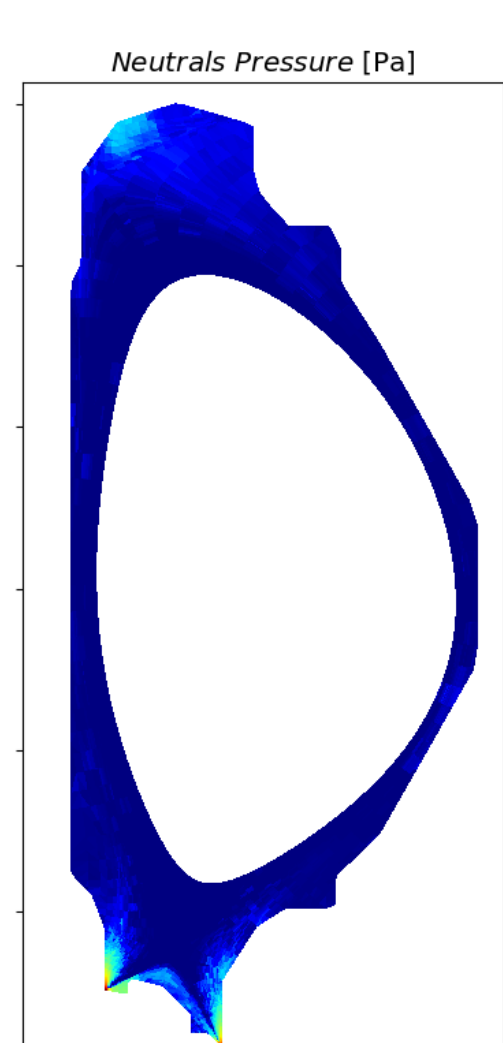
Target profiles - heat load



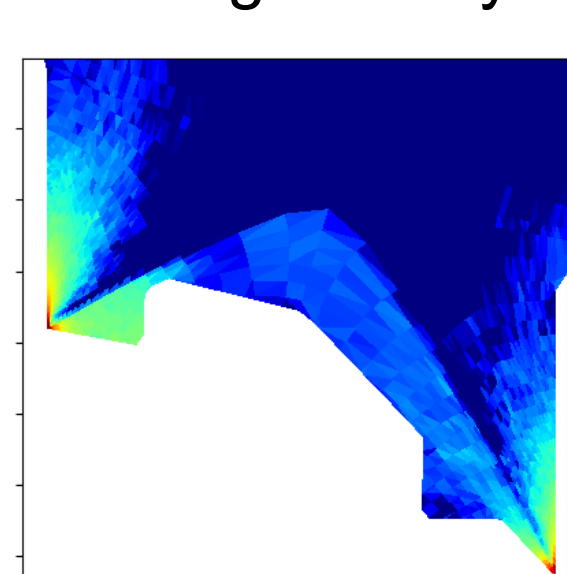
STD

SUBD

Neutrals pressure 2D map



STD geometry

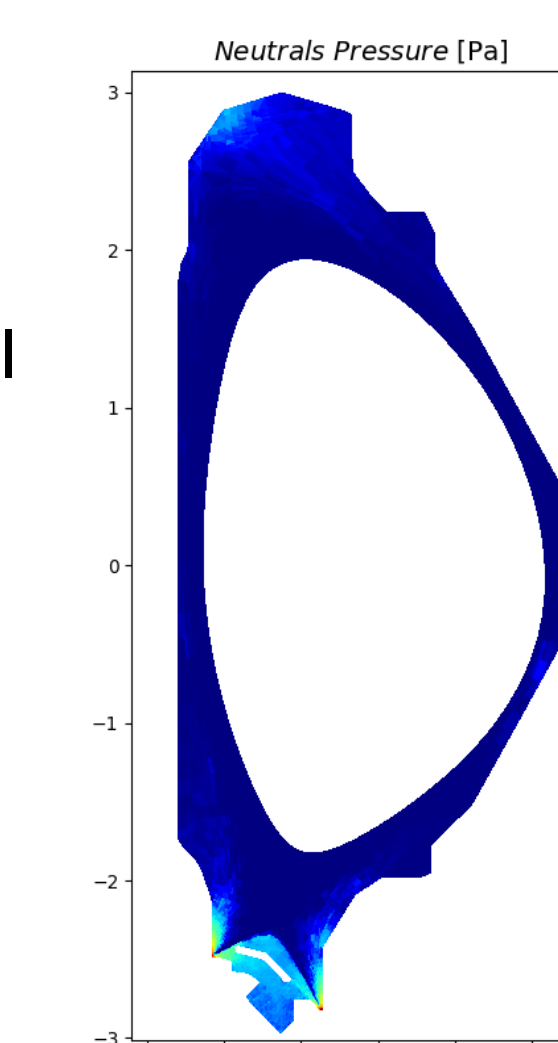


- large pressure difference between the inner and the outer divertor volume

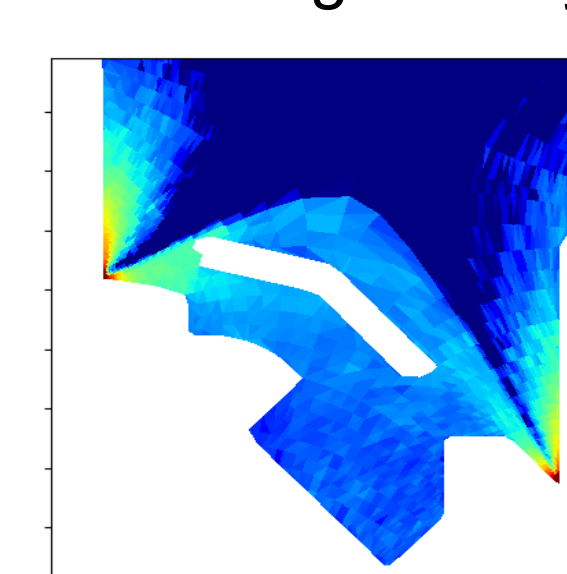
Conclusions

- a power scan was performed for the JT-60SA initial research phase fully inductive scenario #2 of JT-60SA in the range of [15, 30] MW
- increase in P_{aux} leads to increase of $n_{e,sep}$, which for pure-D cases exceeds the nominal n_e in the core, $5.6 \times 10^{19} \text{ m}^{-3}$, already for $P_{aux}=20 \text{ MW}$
- in D+C cases the $n_{e,sep}$ rise is less pronounced, a rise in n_C is observed from $1.6 \times 10^{18} \text{ m}^{-3}$ for $P_{aux}=15 \text{ MW}$ to $n_C=4.0 \times 10^{18} \text{ m}^{-3}$ for $P_{aux}=30 \text{ MW}$
- dominant C radiation losses take place in the divertor, the role of the main chamber SOL and CORE volume is limited, D-related losses are ~ 0.7 - 1.0 MW for all cases
- already for the lowest $P_{aux}=15 \text{ MW}$ cases the peak heat load exceeds the 10 MW/m^2 limit; as in previous research [4], additional power dissipation mechanism is required
- the presence of subdivertor causes local differences in neutral density, but has only minor effect on the final result: 1-1.5 MW lower of P_{RAD}^C [TOTAL] for $P_{aux}>22.5 \text{ MW}$

Neutrals pressure 2D map



SUBD geometry



- subdivertor presence results in more equal neutrals distribution in inner and outer divertor

