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]:

$\langle n_e \rangle = 5.6\times10^{19}\ m^{-3}$

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

$n_e^{sep} < 2.5\times10^{19}\ m^{-3}$

References:

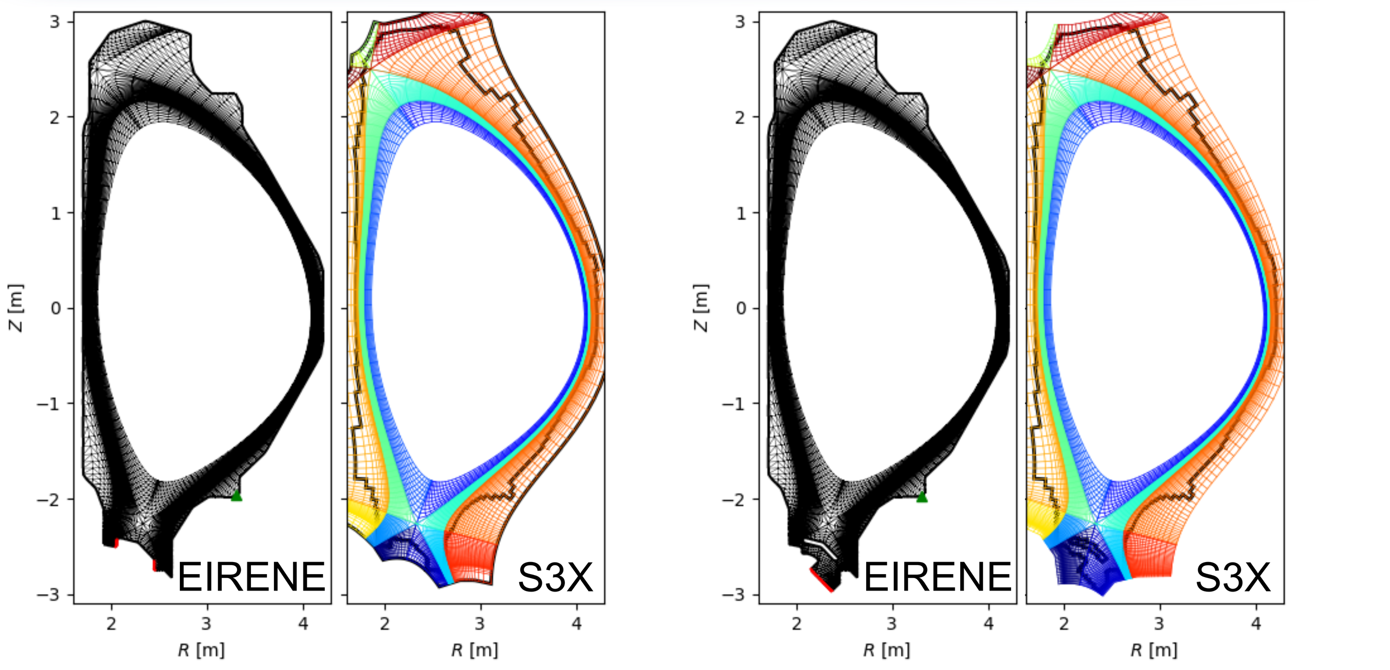
[1] H. Bufferand et al 2021 Nucl. Fusion 61 116052 (2021)

[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] MW

Particle source @ core: $S_i = 1\times10^{21}$ part./s

Deuterium fuelling: $\Gamma_D = 1\times10^{21}$ part./s

C sputtering - Bohdansky formula

EIRENE with simplified Kotov model (no elastic collisions on neutrals)

No drifts

Wall properties:

$R_D = 1.0$

$R_C = 0.1$

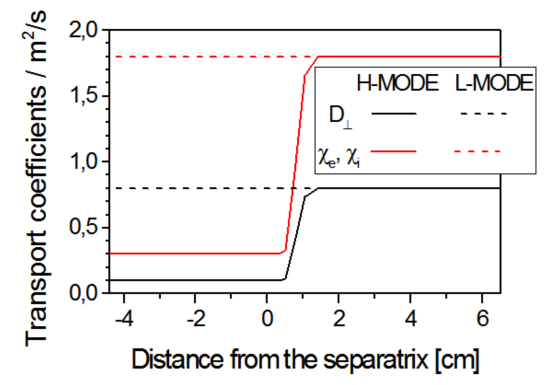
Pump albedo:

$R_D = 0.95$

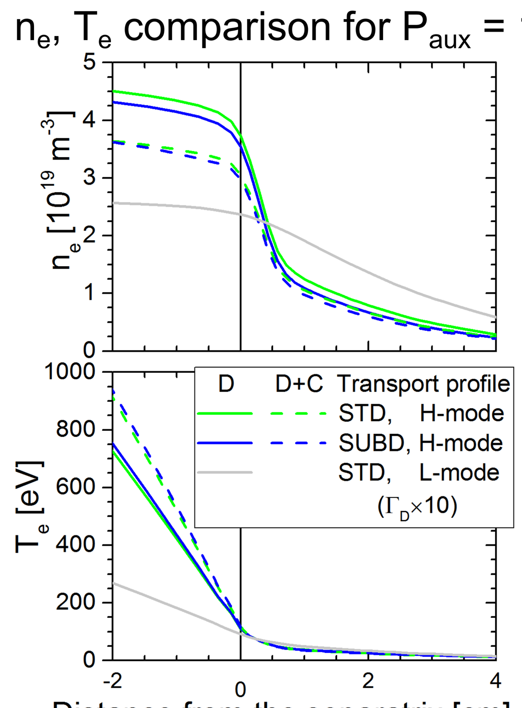
$R_C = 0.1$

OMP profiles

Transport coefficients@OMP [4]

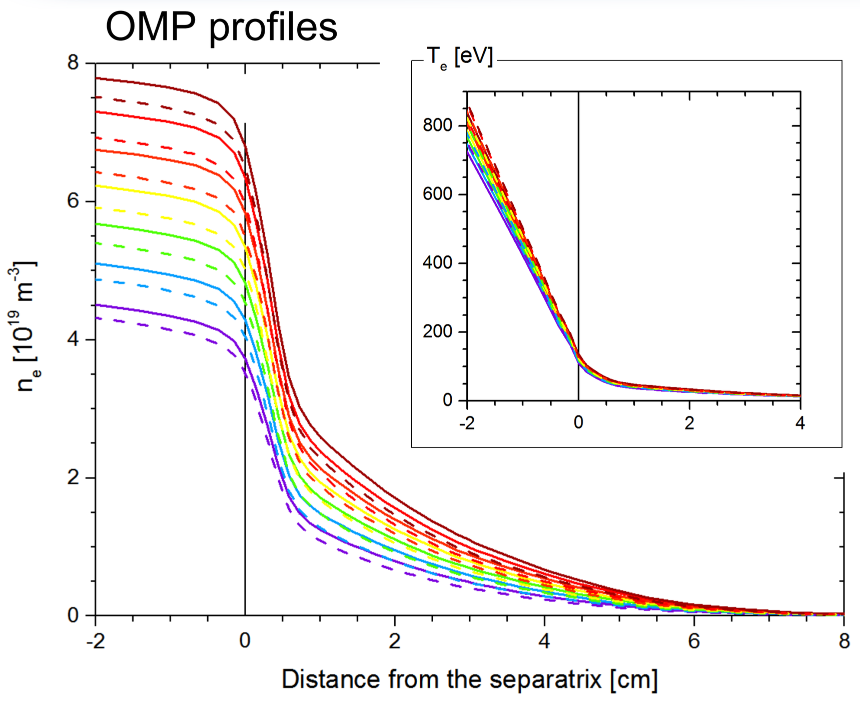


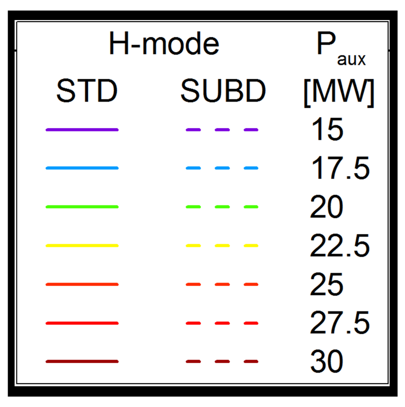
n_e, T_e comparison for P_{aux} = 15 MW



Power scan - pure D plasma

OMP profiles

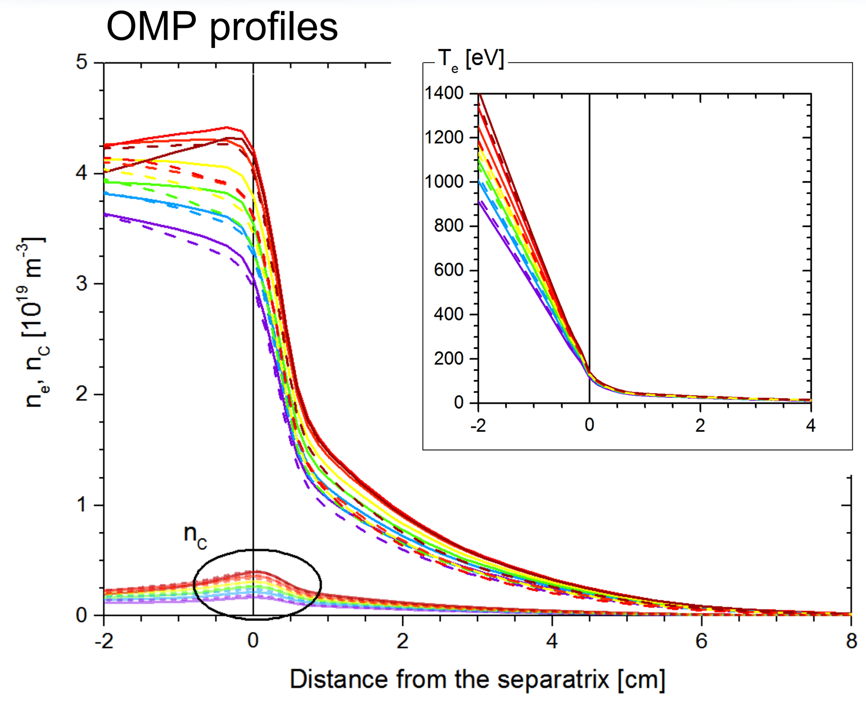




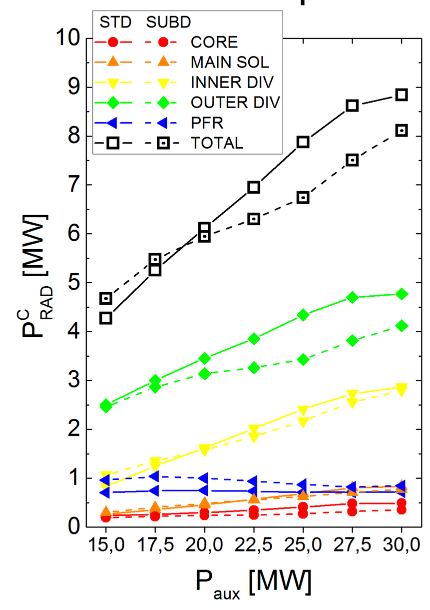
- Rise of n_e with increasing P_{aux} (stronger for pure-D cases)
- limited effect on T_e profile
- rise of n_C with increasing P_{aux}
- negligible effect of different geometry

Power scan - D+C plasma

OMP profiles



C radiation power

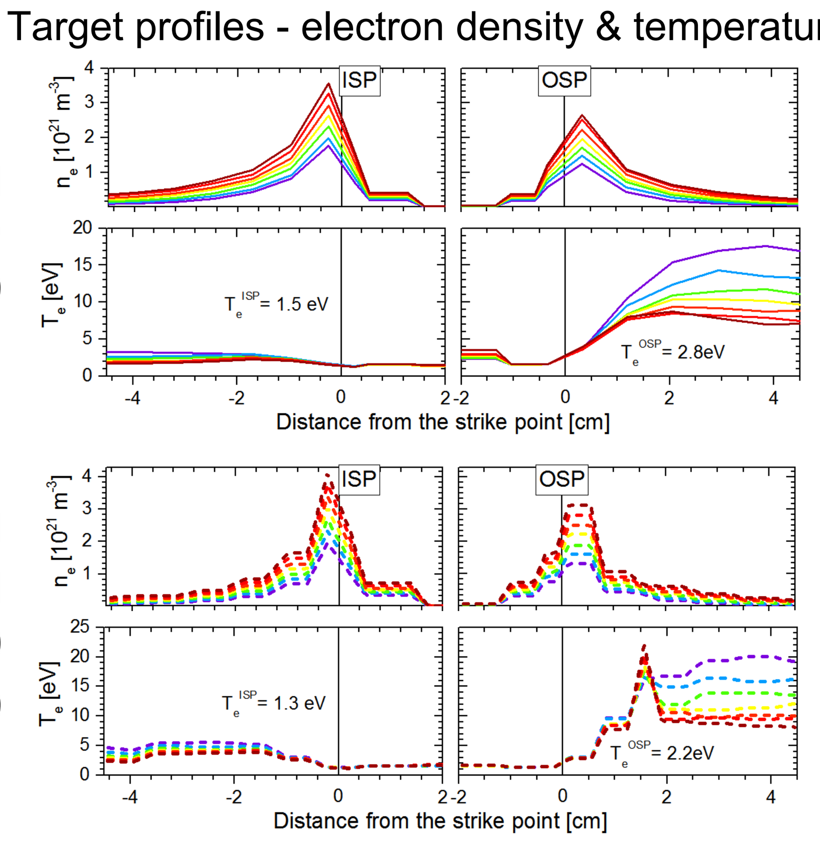


- most C radiation in the outer divertor
- inner divertor 2x less effective in term of power dissipation
- P_{RAD}^C[OUTER DIV] visibly lower for the SUBD geometry
- larger PFR radiation for the SUBD geometry

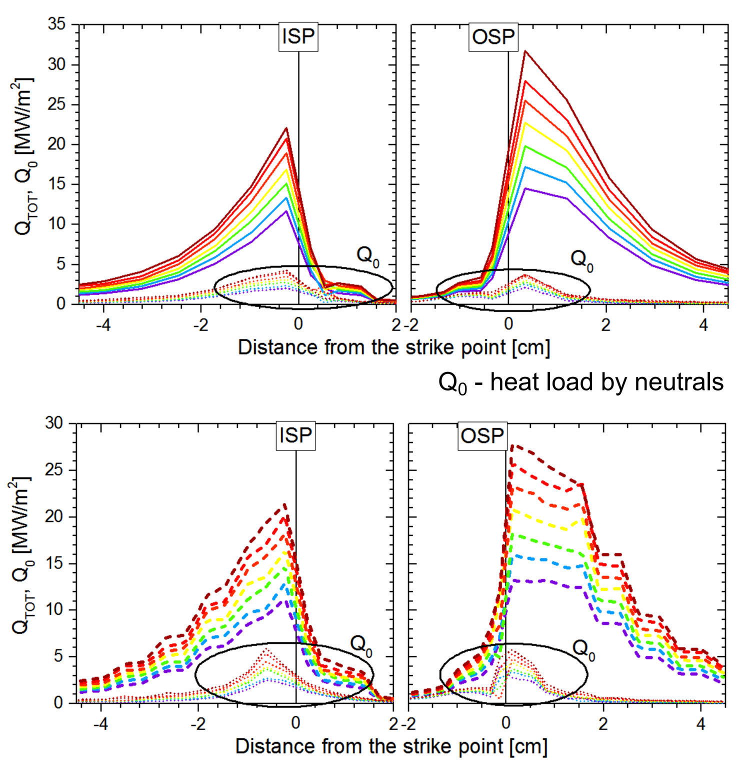
Target profiles - electron density & temperature

STD

SUBD

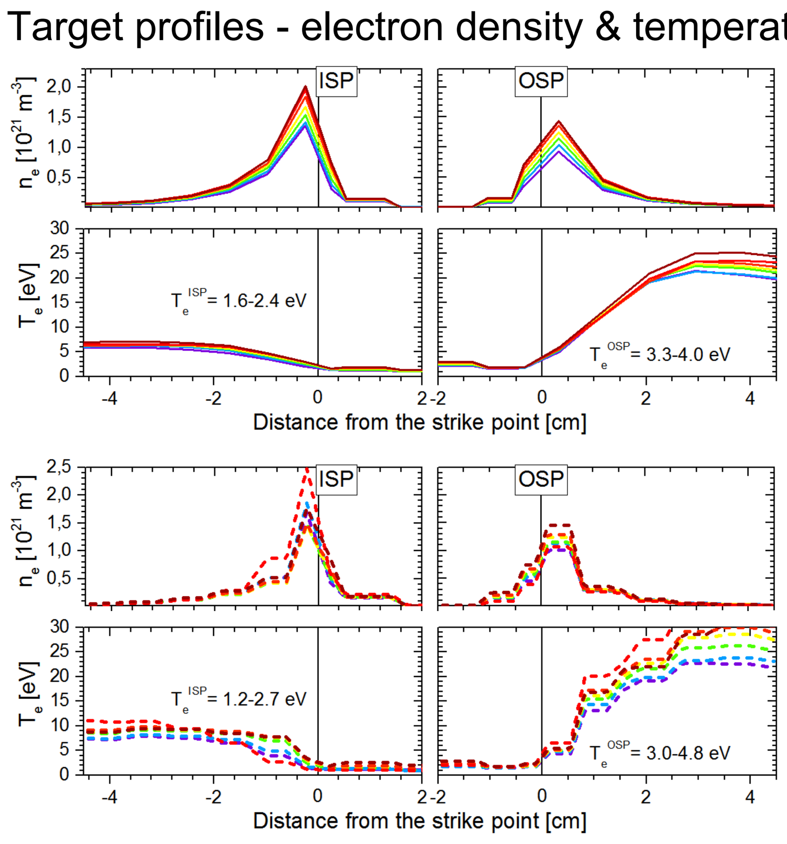


Target profiles - heat load

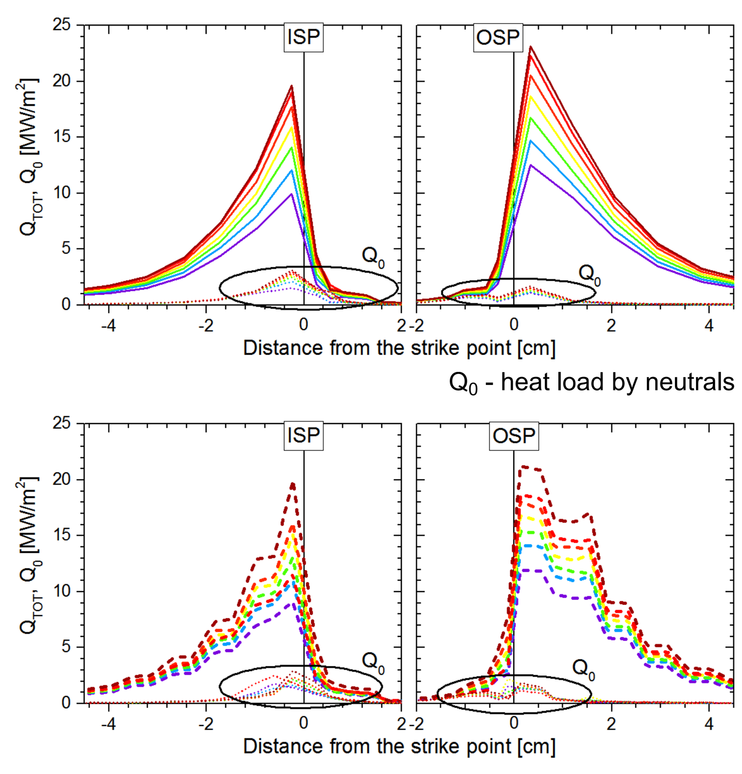


Q_0 - heat load by neutrals

Target profiles - electron density & temperature



Target profiles - heat load

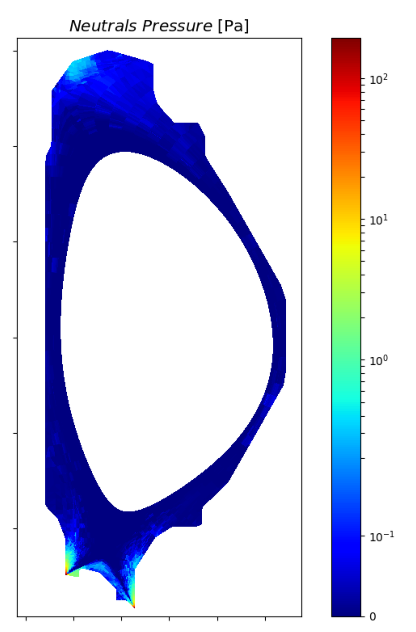


Q_0 - heat load by neutrals

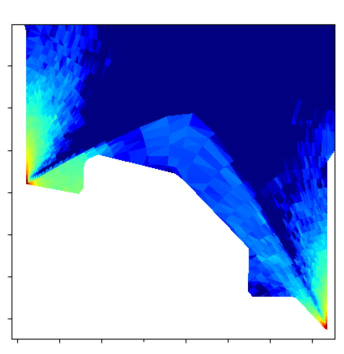
STD

SUBD

Neutrals pressure 2D map



STD geometry

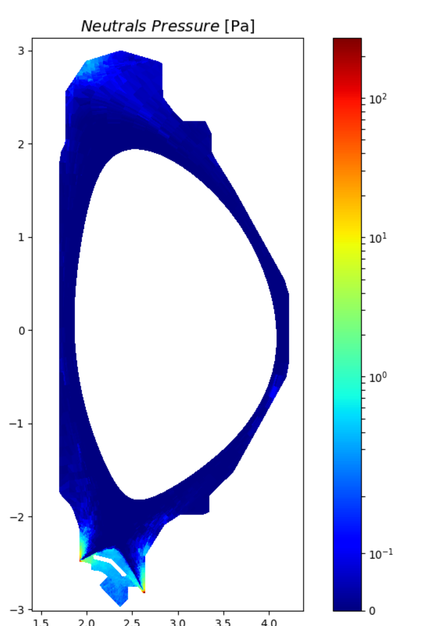


- large pressure difference between the inner and the outer divertor volume

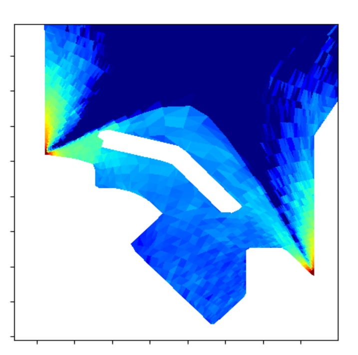
Conclusions

- a power scan was performed for the JT-60SA initial research phase fully inductive sceanrio #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, $5.6\times10^{19}\ m^{-3}$, already for P_{aux}=20 MW
- in D+C cases the nesep rise is less pronounced, a rise in n_C is observed from $1.6\times10^{18}\ m^{-3}$ for P_{aux}=15 MW to $n_C=4.0\times10^{18}\ m^{-3}$ for P_{aux}=30 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 MW cases the peak heat load exceeds the 10 MW/m² 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 MW

Neutrals pressure 2D map



SUBD geometry



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

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