Advanced Power Exhaust Studies for New Lower Tungsten Divertor of EAST under High Power and Steady State Operations

ASIPP

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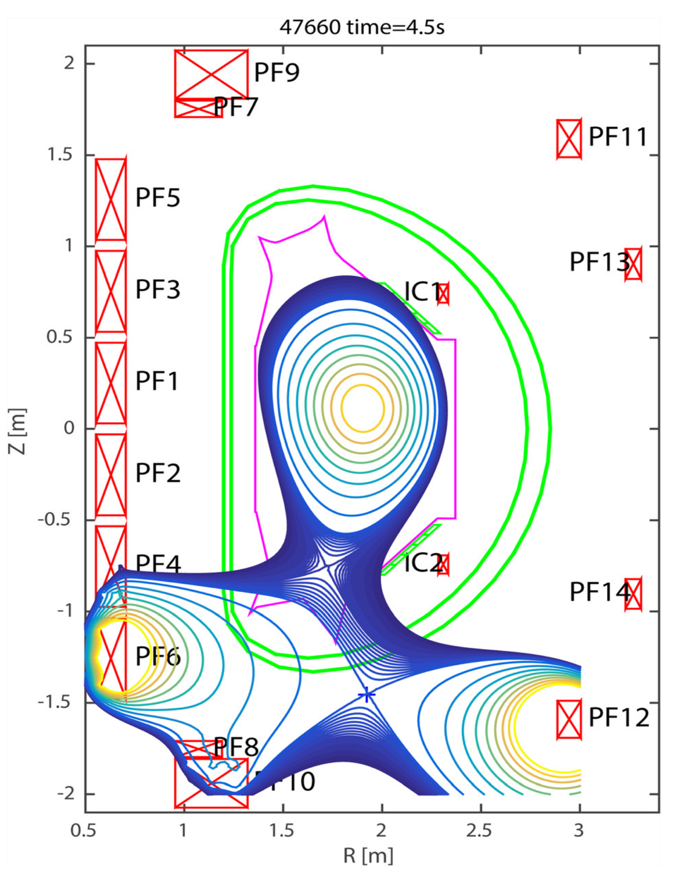
Divertor is one of the key components in Tokamak. The control of heat flux and erosion of the divertor target is one of the grand challenges facing the design and operation of next-step high power steady-state fusion. It is essential to efficiently dissipate power in the divertor to ensure the maximum steady-state power load at the divertor target below 10 ~ 15 MW/m^2 . In addition, adequate reactor lifetime dictates near zero-erosion at solid PFCs, so the electron temperature at the divertor target plates must be maintained at a low temperature with Te ≤ 5 ~ 10 eV to suppress erosion. In response to this challenge, recently Experimental Advanced Superconducting Tokamak(EAST) has launched a new initiative to develop and validate advanced divertor concepts for the design of new lower tungsten divertor. In general, developing an advanced divertor configuration requires:

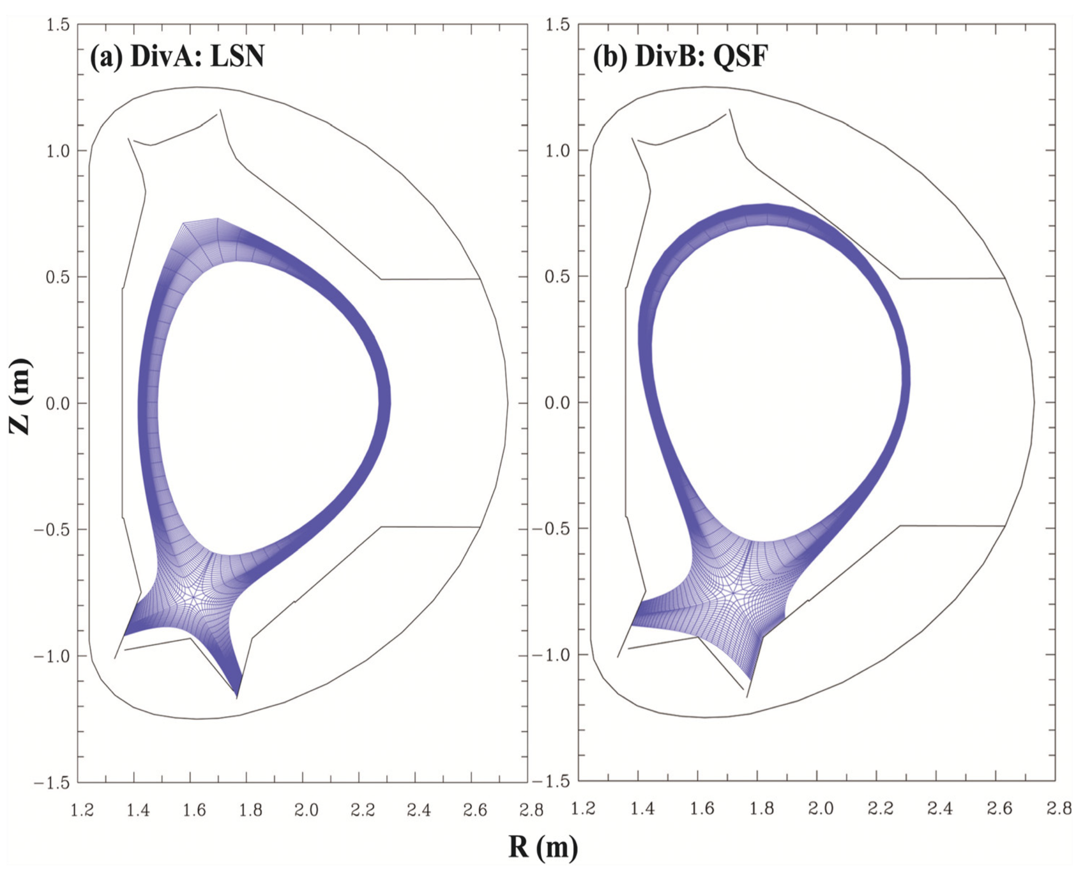
- Optimizing magnetic configuration to extend the plasma-wetted area through flux expansion, and increasing the divertor volume by increasing the field-line length;
- Increasing divertor closure by divertor baffling to improve divertor screening for recycling neutrals and impurities, hence increasing divertor neutral pressure, thus enhancing divertor particle and power exhaust.

Some alternative advanced magnetic configurations: quasi snowflake (QSF) and fishtail divertor (FTD)

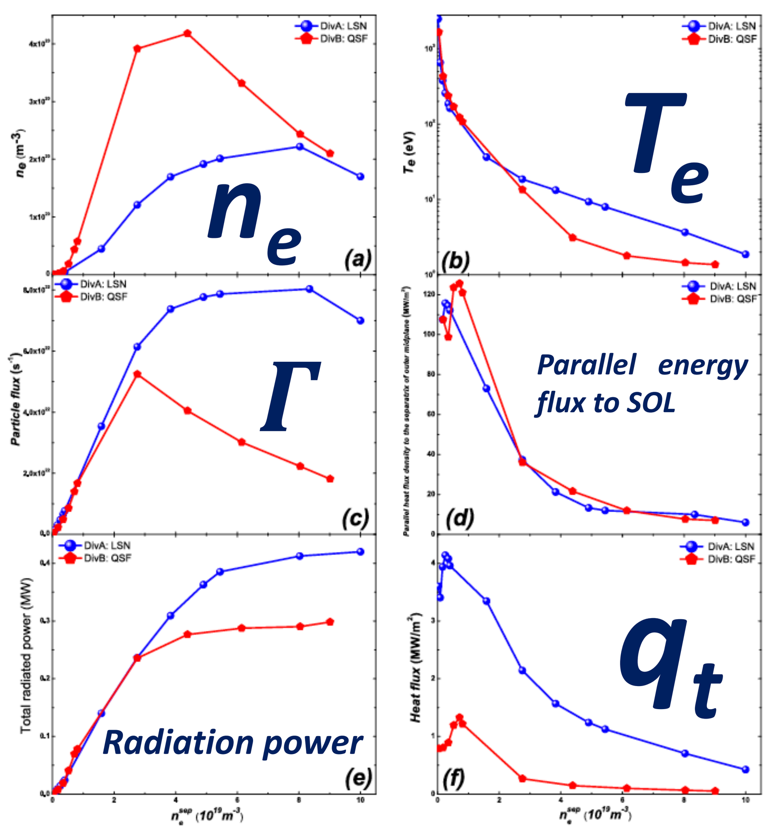
Quasi Snowflake (QSF)



The EFIT equilibrium of QSF discharge 47660 shot at 4.5s



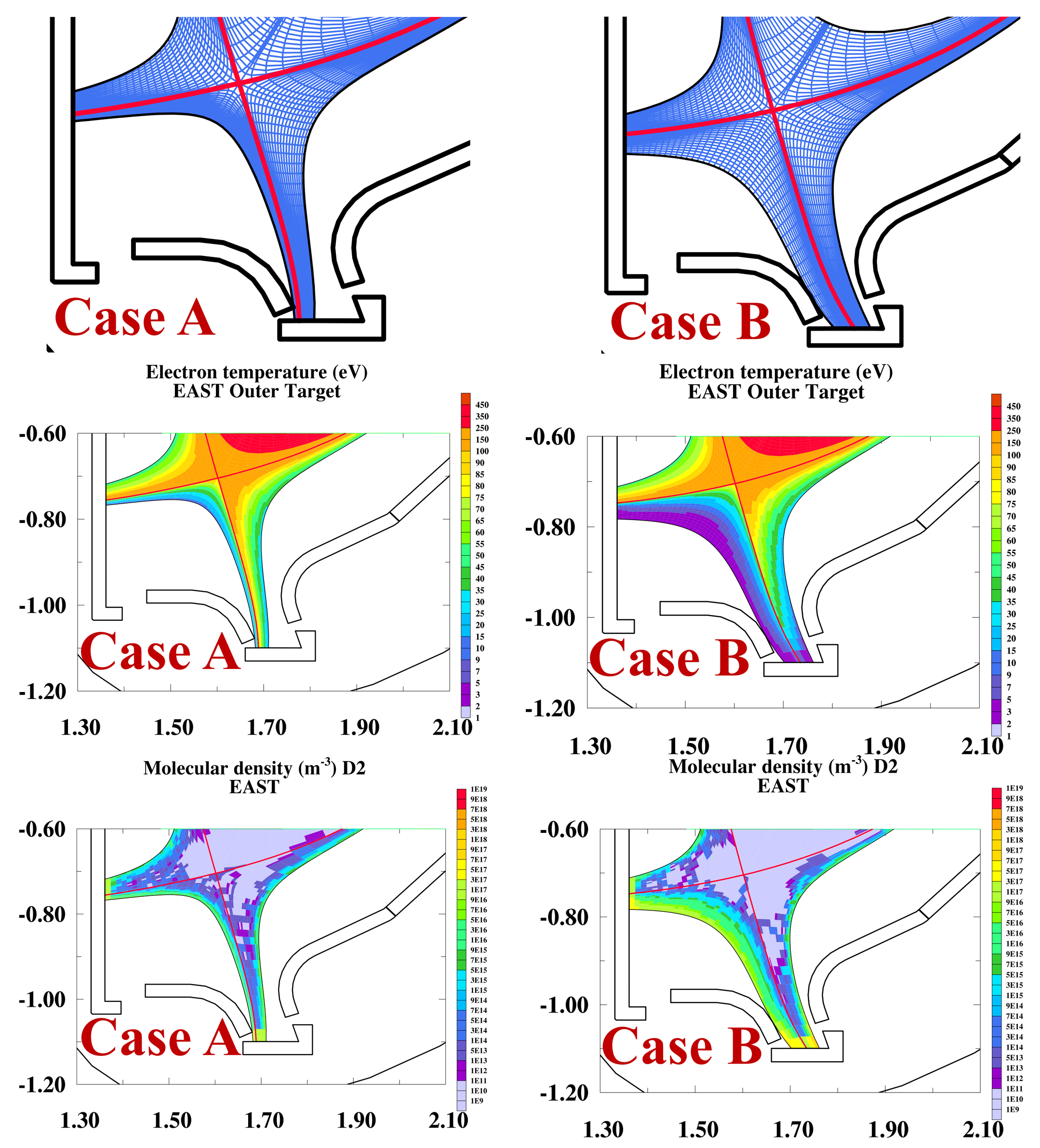
The computational meshes of both different EAST divertor configurations for SOLPS simulations: (a) LSN (DivA) and (b) QSF (DivB)



The peak values at lower outer target for both different EAST divertor configurations (DivA and DivB)

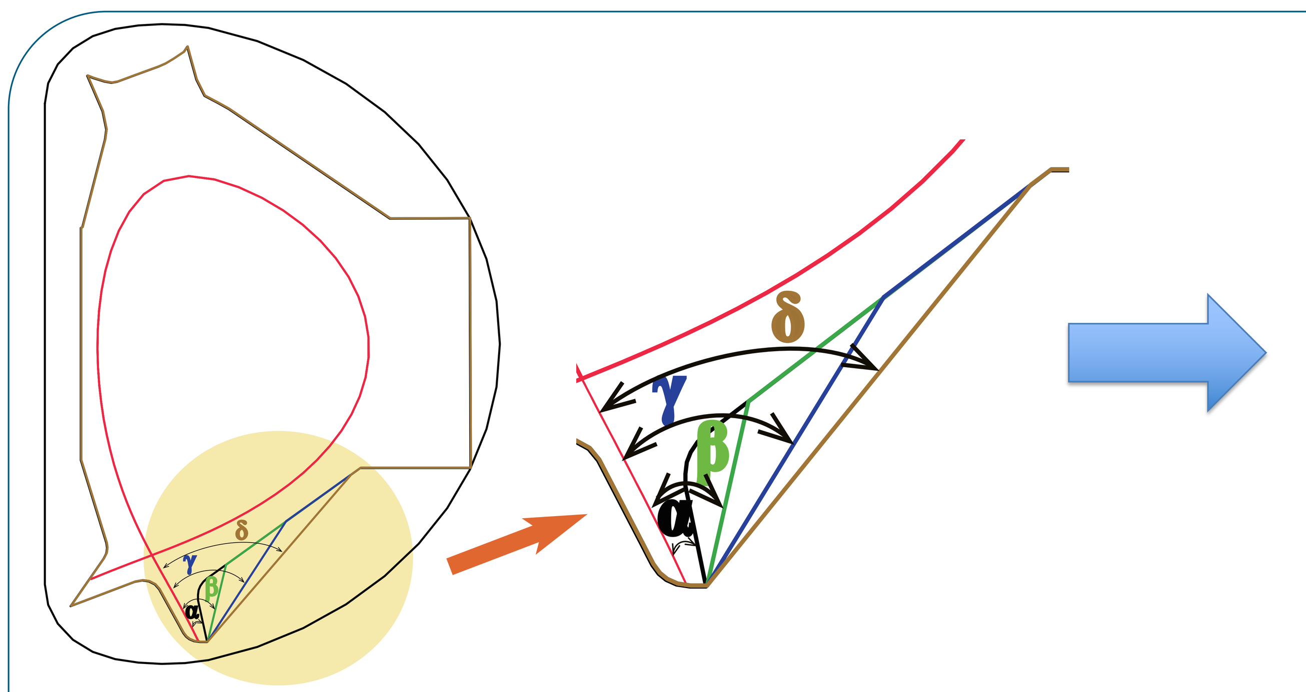
- With respect to EAST lower single null divertor configuration, the connection length of EAST QSF divertor configuration is increased by 30%. The flux expansion in the lower outer target is increased by a factor 4.
- SOLPS predicts quasi snowflake configuration significantly reduces the peak heat flux density at the lower divertor outer target, by a factor of 2–3, owing to the magnetic flux expansion. The density threshold for detachment is much lower for QSF, compared to LSN under the same upstream conditions.

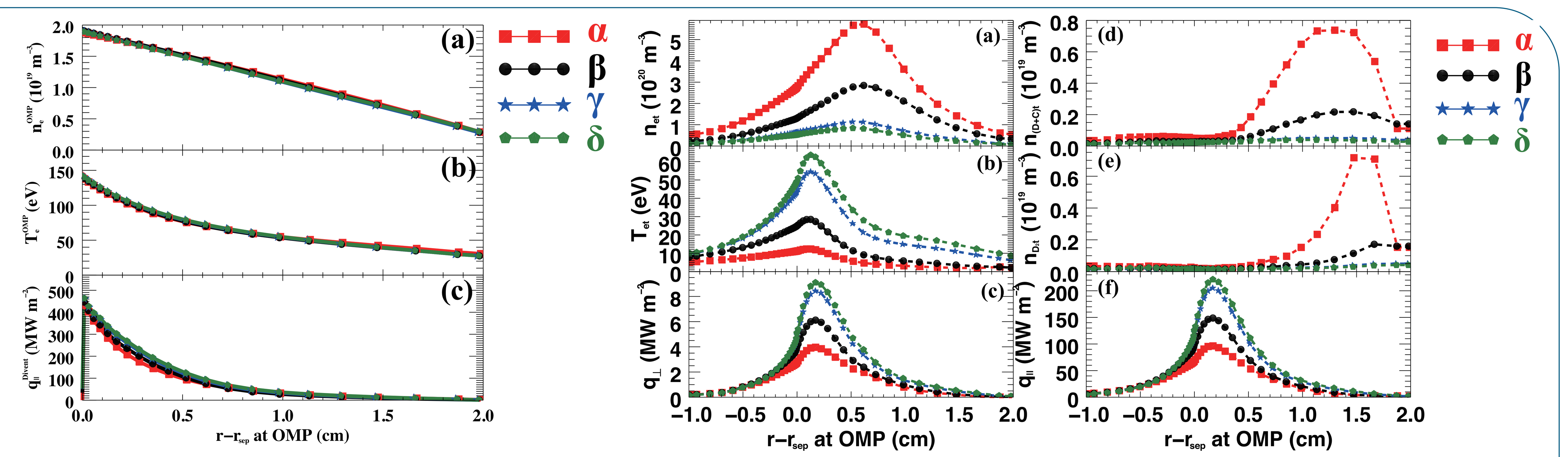
Fishtail Divertor (FTD)

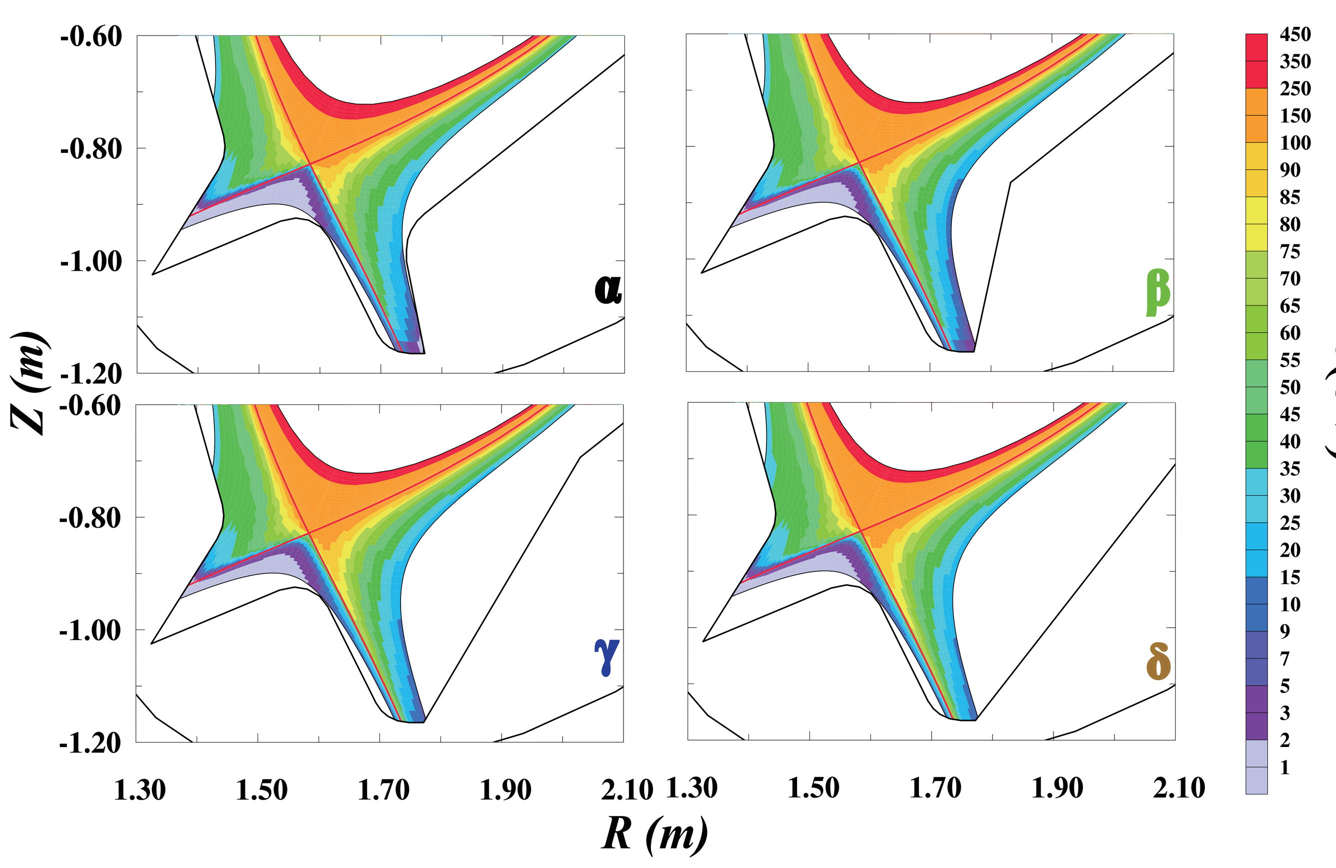


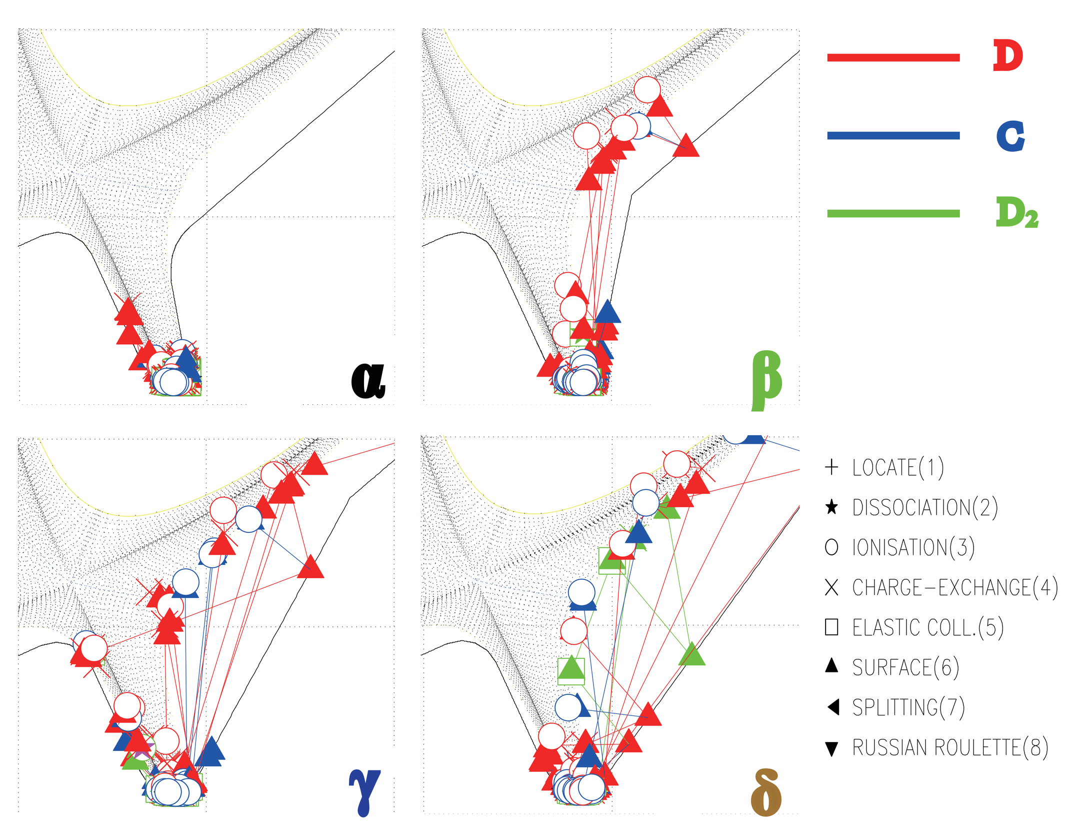
- When the outer strike point moves to the corner, Te at the outer target can be reduced significantly and more neutrals can be trapped.

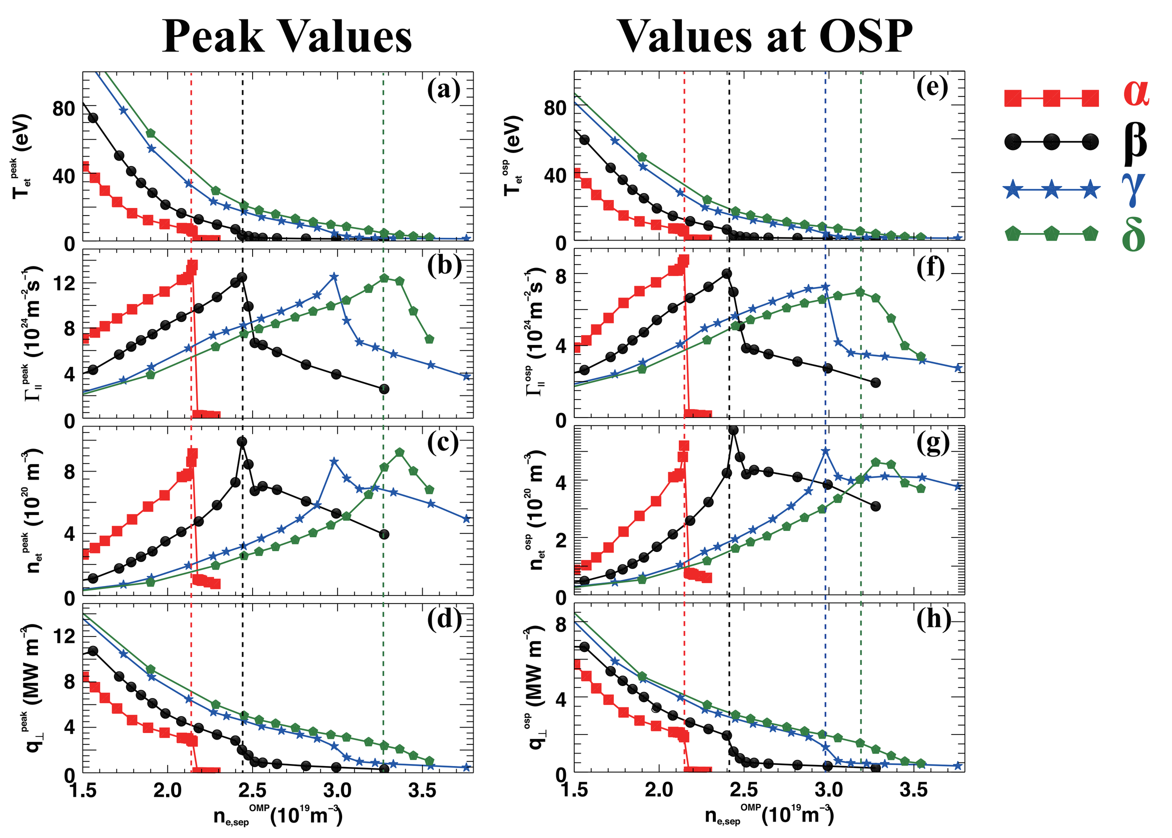
Increasing divertor closure by divertor baffling











Increasing divertor closure can significantly:

- trap more neutrals from 0.04 x10^{19} to 0.75x10^{19} m^{-3} with the same upstream separatrix density $n_{e,sep}$ = 1.9 x10^{19} m^{-3}
- facilitate the onset of detachment decreasing from 3.20 x10^{19} to 2.14 x10^{19} m^{-3}
- the divertor radiated power is also increased from 200 to 450 kW and the peak heat flux density at the divertor target is reduced from 9.3 to 3.8 MWm^{-2}.