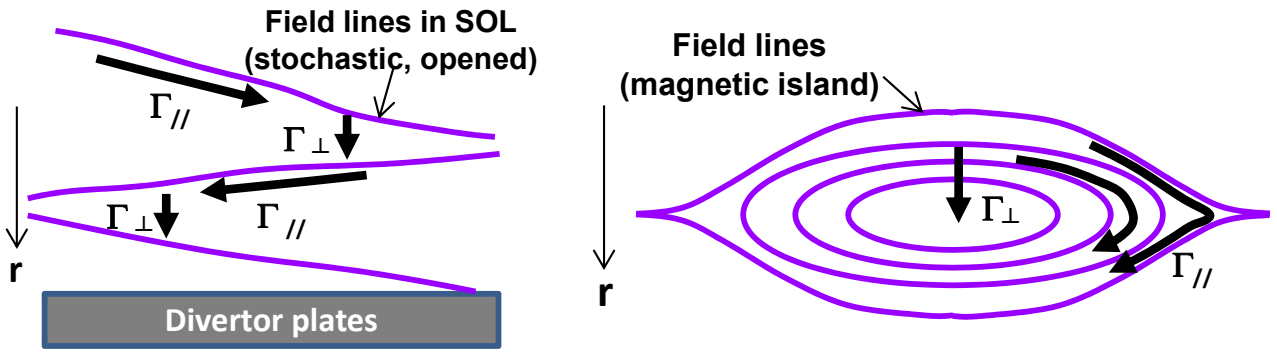
OV/4-4: Multi-machine comparison has identified key parameters to control transport, possible impact on divertor functions under 3D effects, and research area to be explored for future reactors.

The 3D effects : competition between transports parallel (//) and perpendicular (⊥) to magnetic field, in open field lines or magnetic islands.

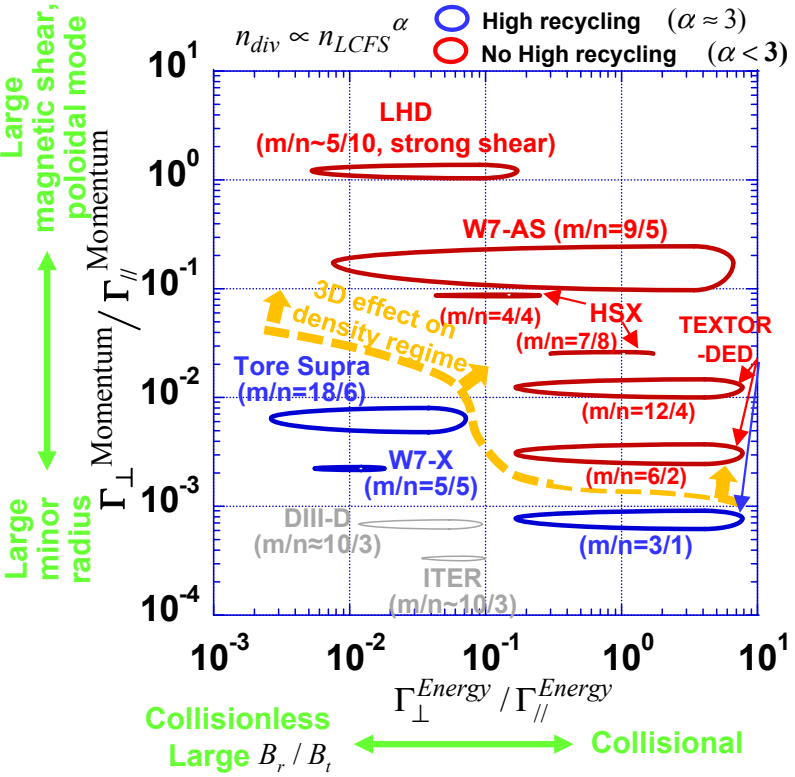


$\Gamma_{//,\perp}$: **Particle, momentum, energy flux //, ⊥ to magnetic field** $\quad \frac{\Gamma_{//}}{\Gamma_{\perp}} = 10^5 \sim 10^8$

2D axi-symmetric $\quad \Gamma_{//}\left(\frac{B_\theta}{B_t}\right)^2 >> \Gamma_{\perp} \quad \left(\frac{B_\theta}{B_t} \sim 0.1\right)$

3D effect emerges in stochastic field, magnetic islands $\quad \Gamma_{//}\left(\frac{B_r}{B_t}\right)^2 \sim \Gamma_{\perp} \quad \left(\frac{B_r}{B_t} = 10^{-4} \sim 10^{-3}\right)$

Divertor density regime with 3D effects



Possible impacts on divertor functions in 3D divertor configurations

Observations	Devices	Key parameters	Interpretation	Divertor functions
$n_{div} \propto n_{LCFS}^{\alpha+1}$ $T_{div} \propto n_{LCFS}^{-\alpha}$ $\alpha = 2 \rightarrow \leq 1$ (weak div-LCFS coupling)	W7-AS, LHD, TEXTOR-DED, HSX†	$\Gamma_{\perp}^{Momentum} / \Gamma_{//}^{Momentum} >> 1$	//-momentum loss → $p_{LCFS} > p_{div}$	Pumping efficiency ↓ Phys. Sputtering ↑ Detach. onset density ↑ (?)
		$\Gamma_{\perp}^{Energy} / \Gamma_{//}^{Energy} >> 1$ $\Gamma_{//,conv}^{Energy} / \Gamma_{//,cond}^{Energy}$ ↗	Reduction of //-energy conduction	
Core decontamination	TEXT, Tore Supra, W7-AS, W7-X†, LHD, TEXTOR-DED, TJ-II	$D_{stochastic} / D_{\perp} >> 1$	Enhanced friction force	Impurity screening ↑
		$\Gamma_{\perp,ion}^{Energy} / \Gamma_{//,ion}^{Energy} >> 1$	Ion thermal force suppression	
		$\lambda_{st-SOL} / \lambda_{imp}$ ↗	Shallow penetration of neutral impurity	
Detach. stabilization	W7-AS, LHD, Tore Supra	w_{island}	Radiation modulation by islands	Heat removal ↑
		$\Delta x_{LCFS-div}$ $\Delta x_{LCFS-island}$	Core-edge decoupling → particle fueling↓, core impurity penetration↓	
MARFE stabilized	TEXTOR-DED	f_{RMP}	Avoid localized cooling by RMP rotation	Control of edge radiation ↑