# Scrape-off layer simulations in a Double Null magnetic configuration

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Motivation for Double Null (DN) configuration

Simulation of Double Null SOL

Main features of the Double Null SOL

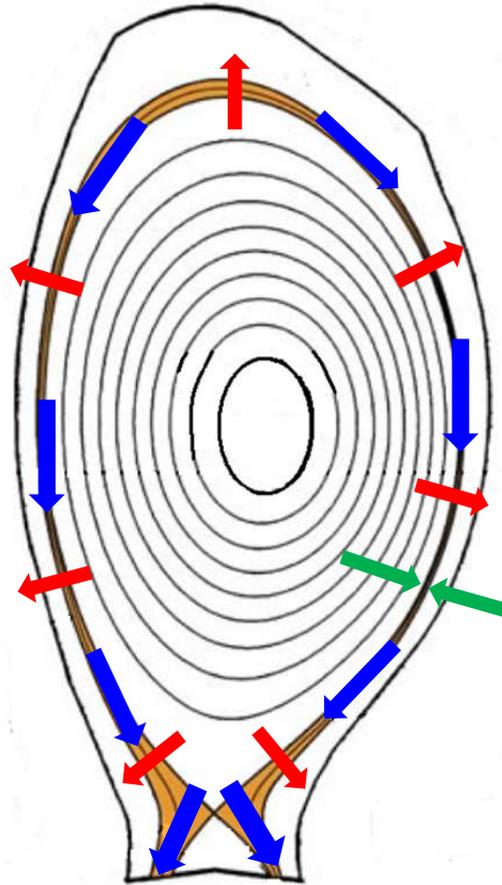ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

SWISS PLASMA CENTER

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# The Tokamak SOL

Cross-field
transport driven
by turbulence

Rapid parallel outflow
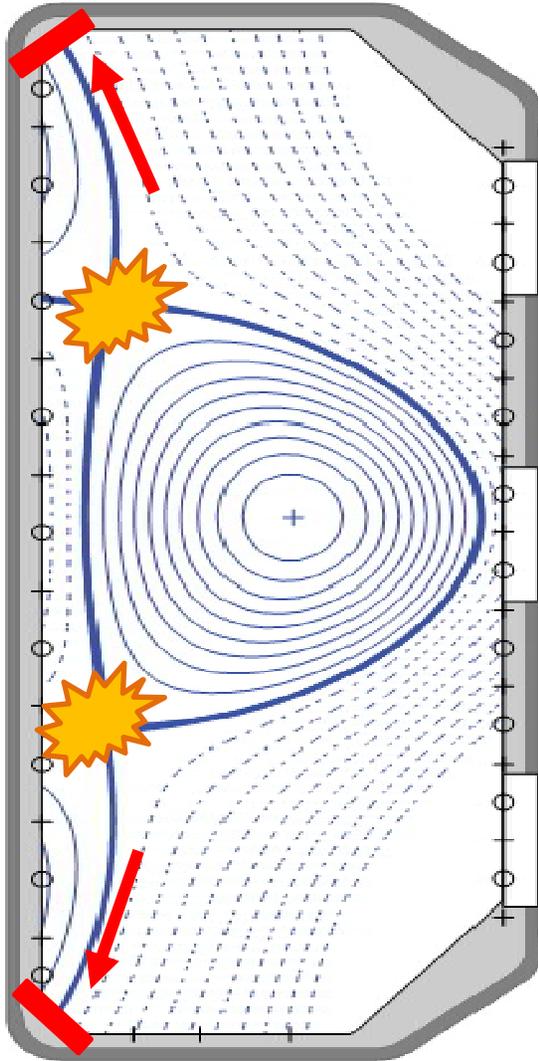
$L_{SOL}$ ~ 1cm-1mm

Heat exhaust

Impurity control

Plasma confinement

Plasma fuelling

Regulating neutral density

Ashes removal (He < 10%)

# DN: better power handling?



Share power evenly
between the two outer legs

Possibility of two radiation
fronts in detached operation
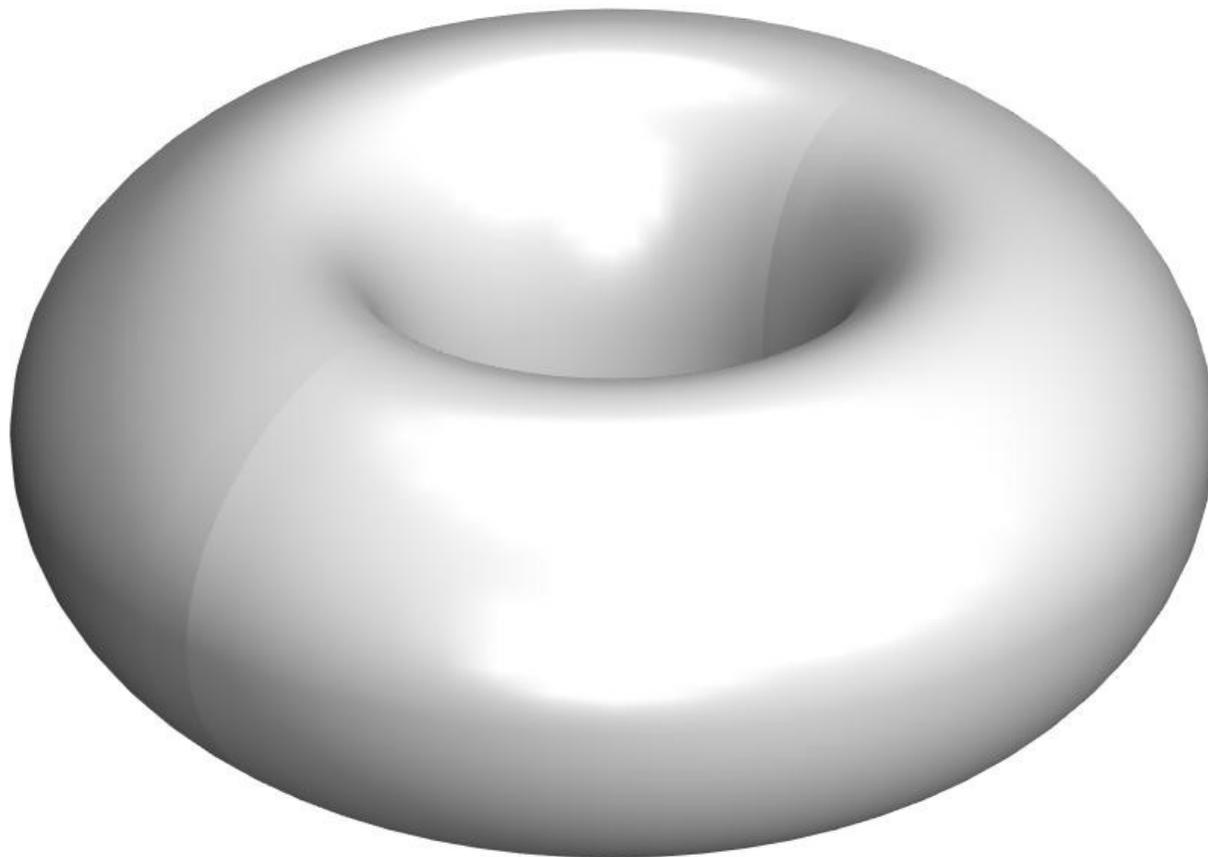
# DN: HFS ICRF launchers?

Quiescent HFS

**Antenna and launchers here?**

## Calls for theoretical investigation!

plasma without damage
➢Efficient coupling

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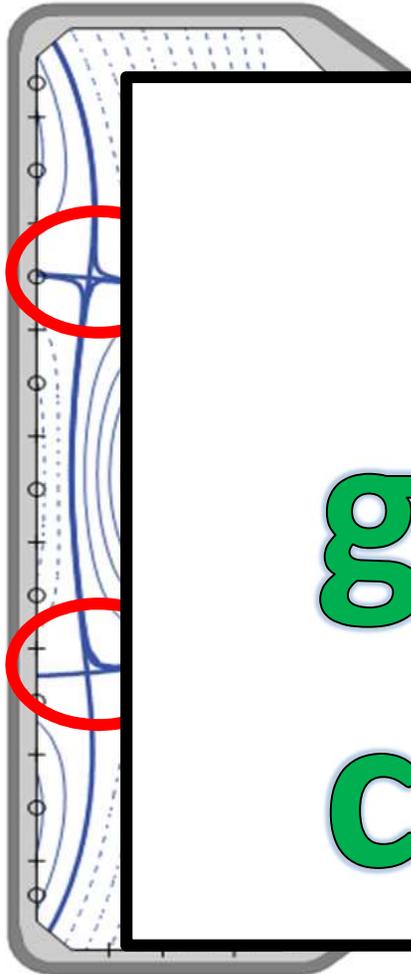# GBS: our simulation code

# GBS: our simulation code

2 fluid Drift Reduced Braginskii Equations
evolving $n, \phi, T_e, v_{\parallel e}, v_{\parallel i}$

Flux driven: no separation between equilibrium
and fluctuations
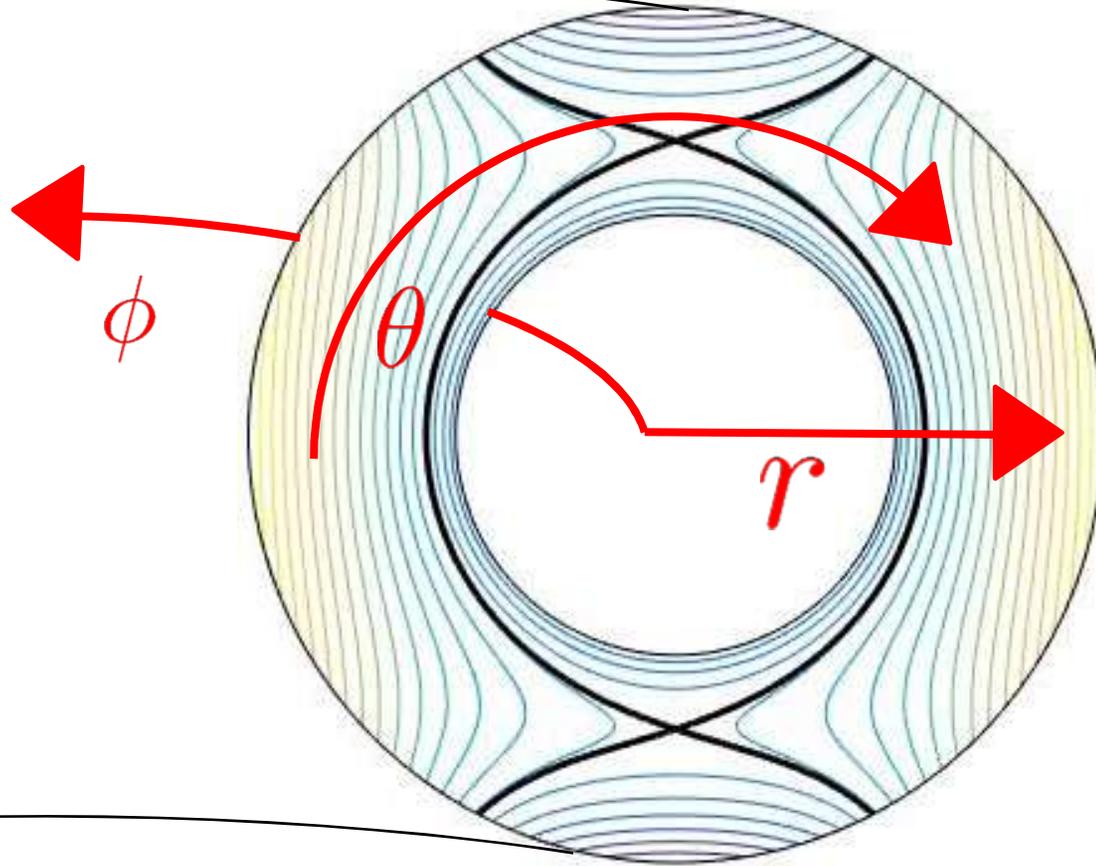
First principles boundary conditions
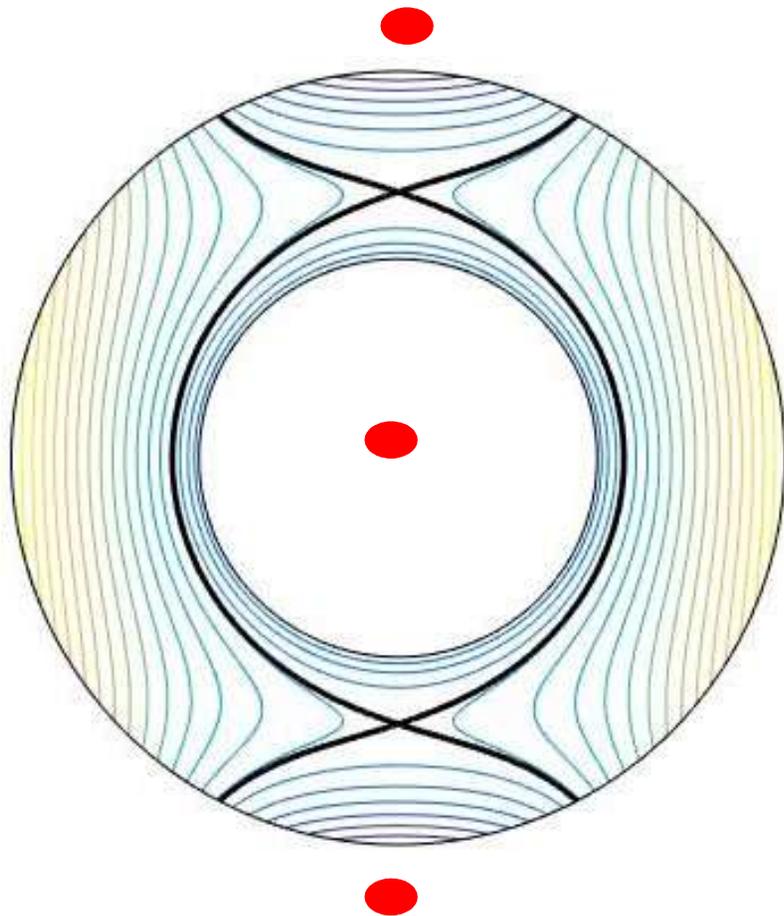
Finite differences, 4th order RK timestepping

**Solution: geometrical coordinates**

# Double null implemented in geometrical coordinates

# Flux function based on 3 current carrying wires

Up-down and poloidally left-right symmetric

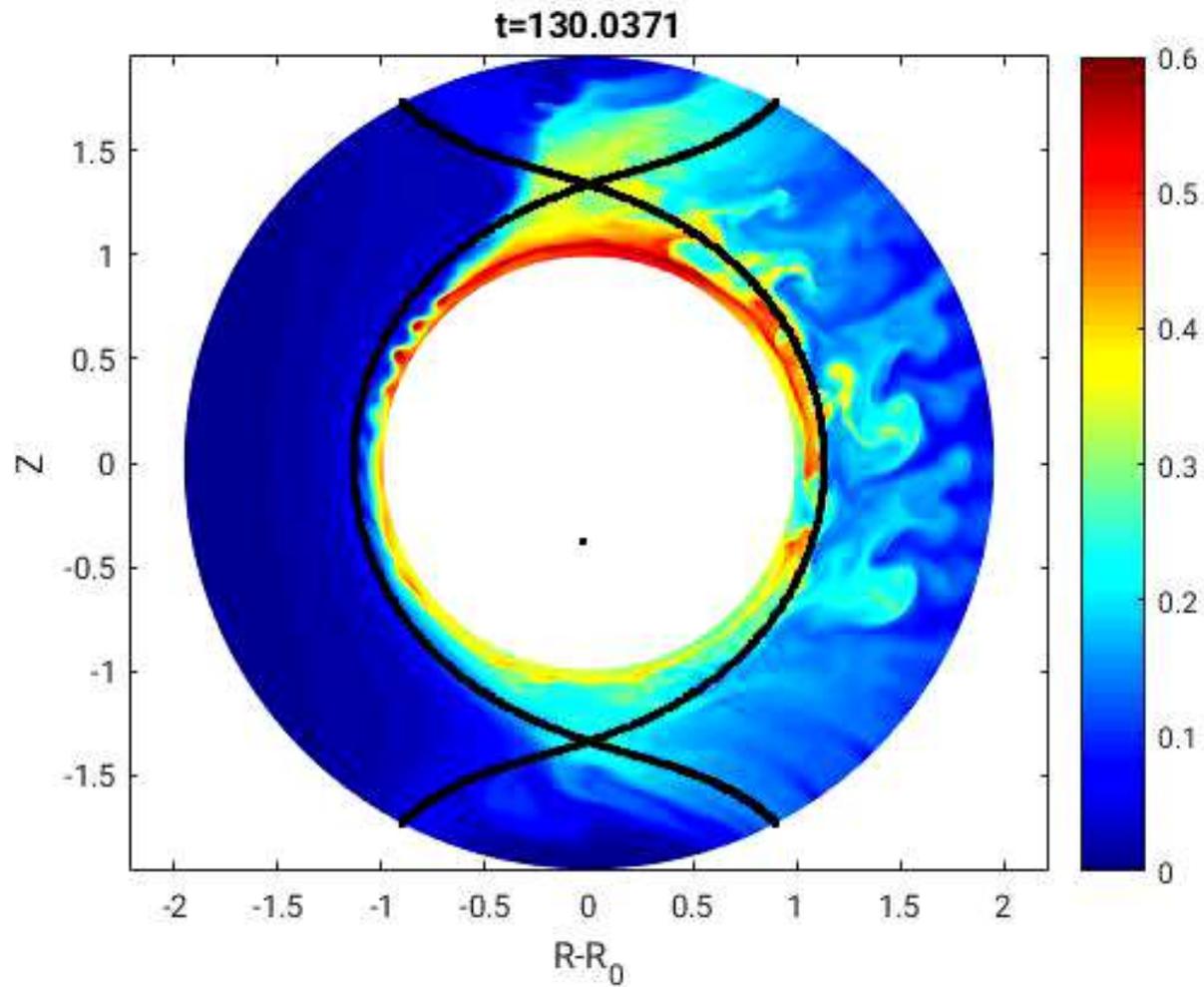Toroidicity effects are included

$q \simeq 3.5$ at inner boundary

At LCFS $q \to \infty$ and $L_c \to \infty$

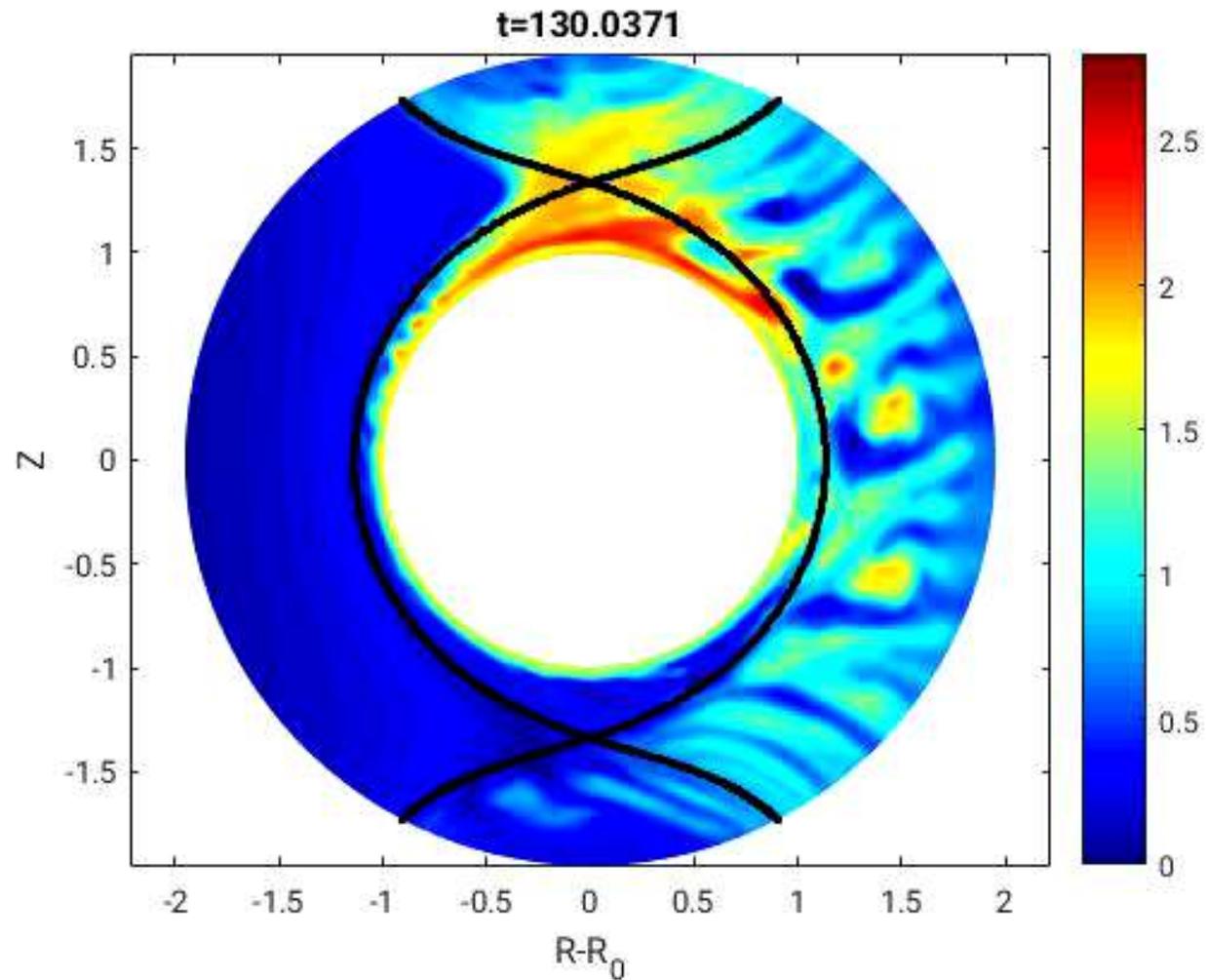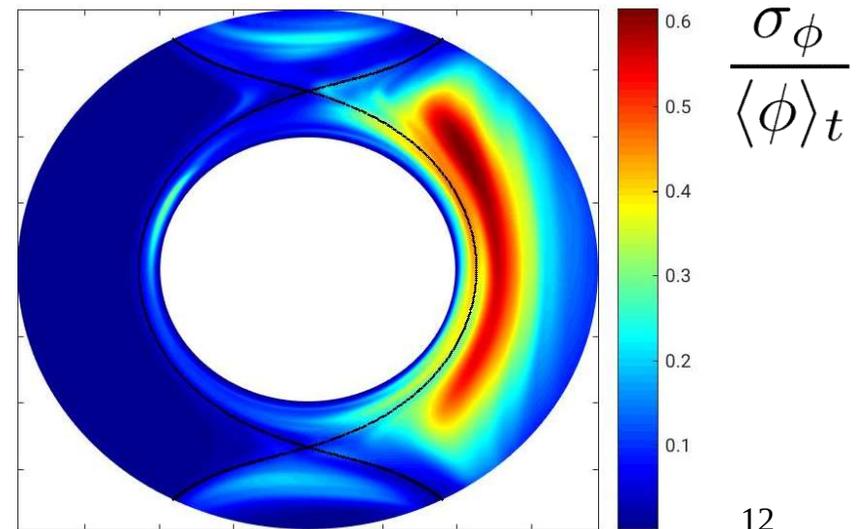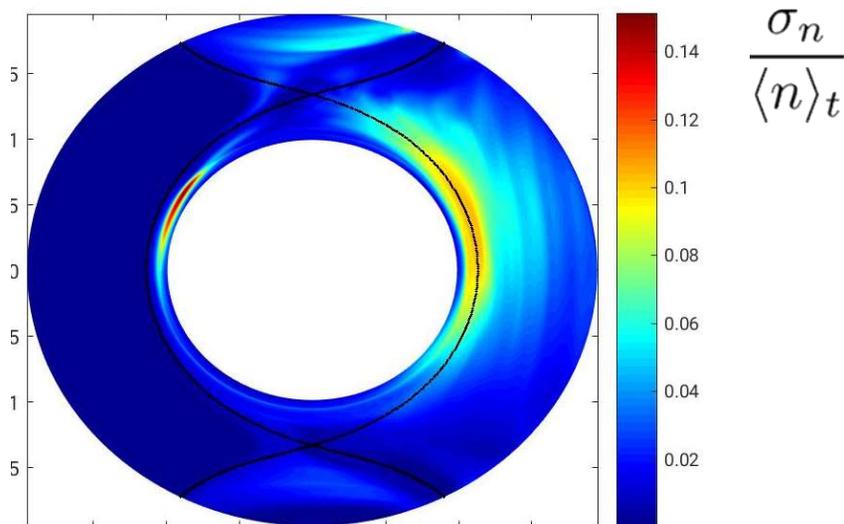Strong magnetic shear close to X points
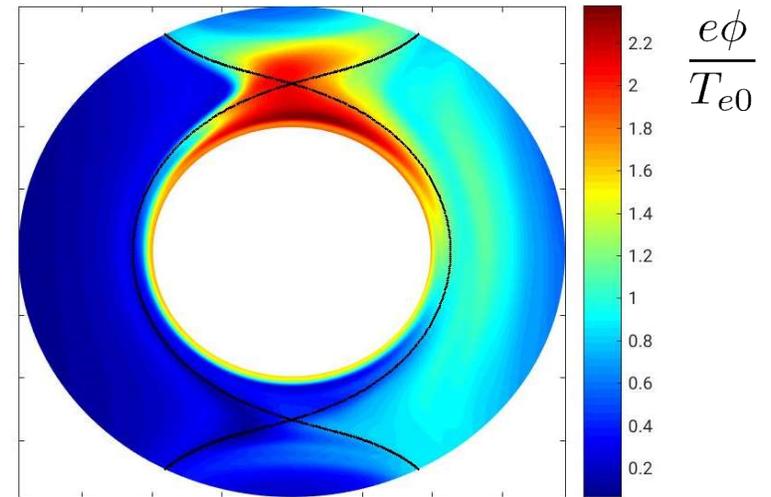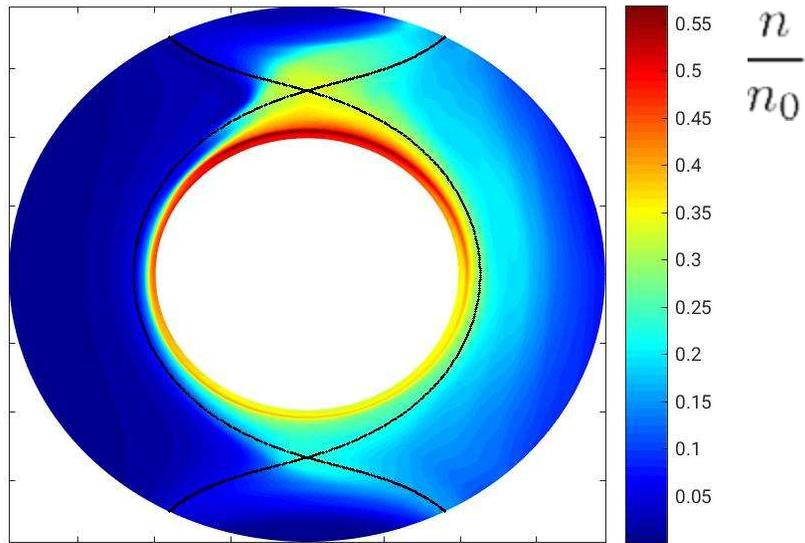
**B** field include 1/R dependence

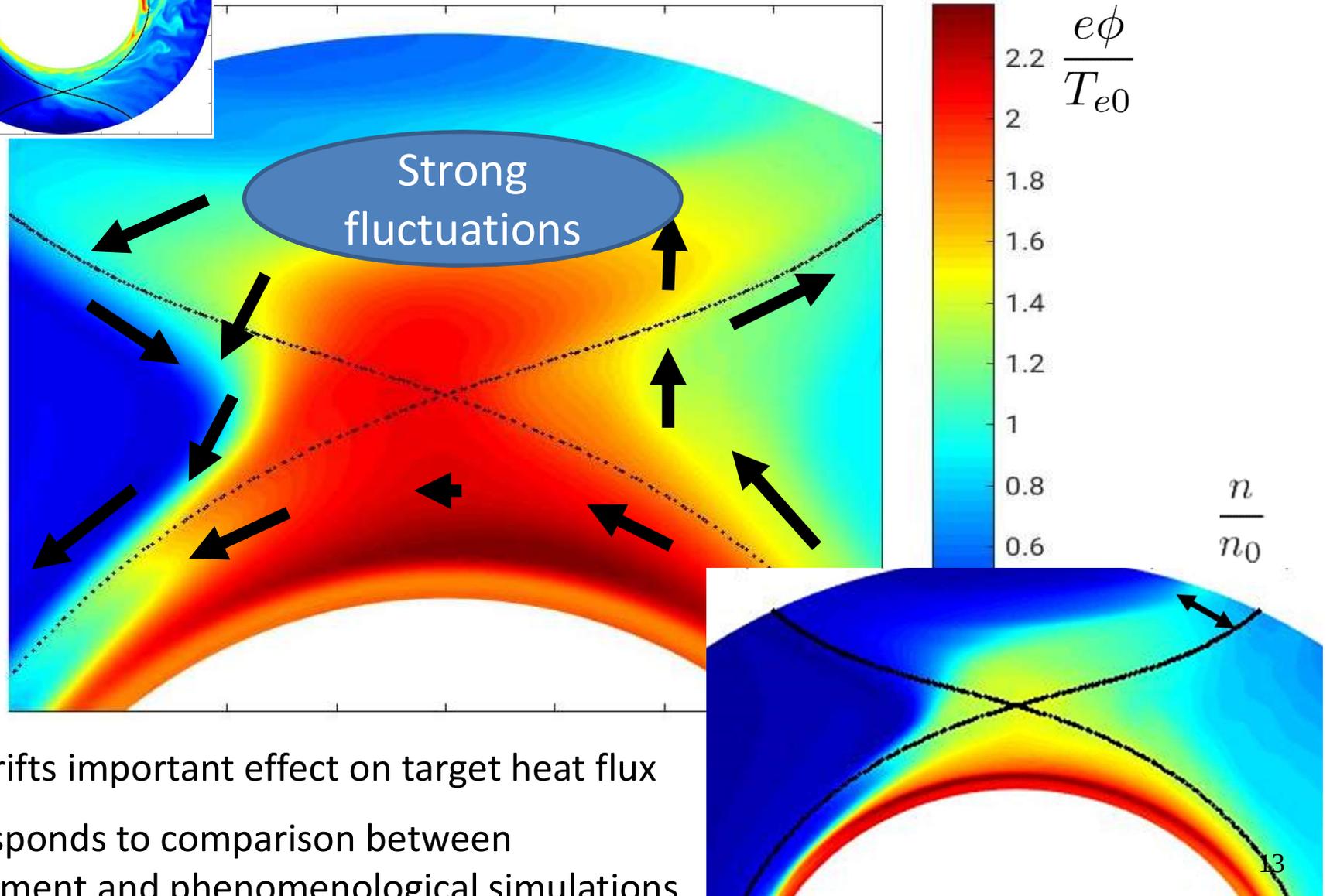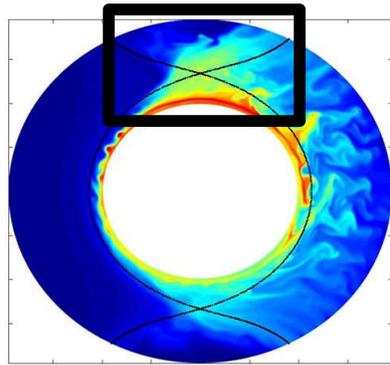# First results – density evolution in poloidal plane

# First results – electrical potential evolution in the poloidal plane



t=130.0371
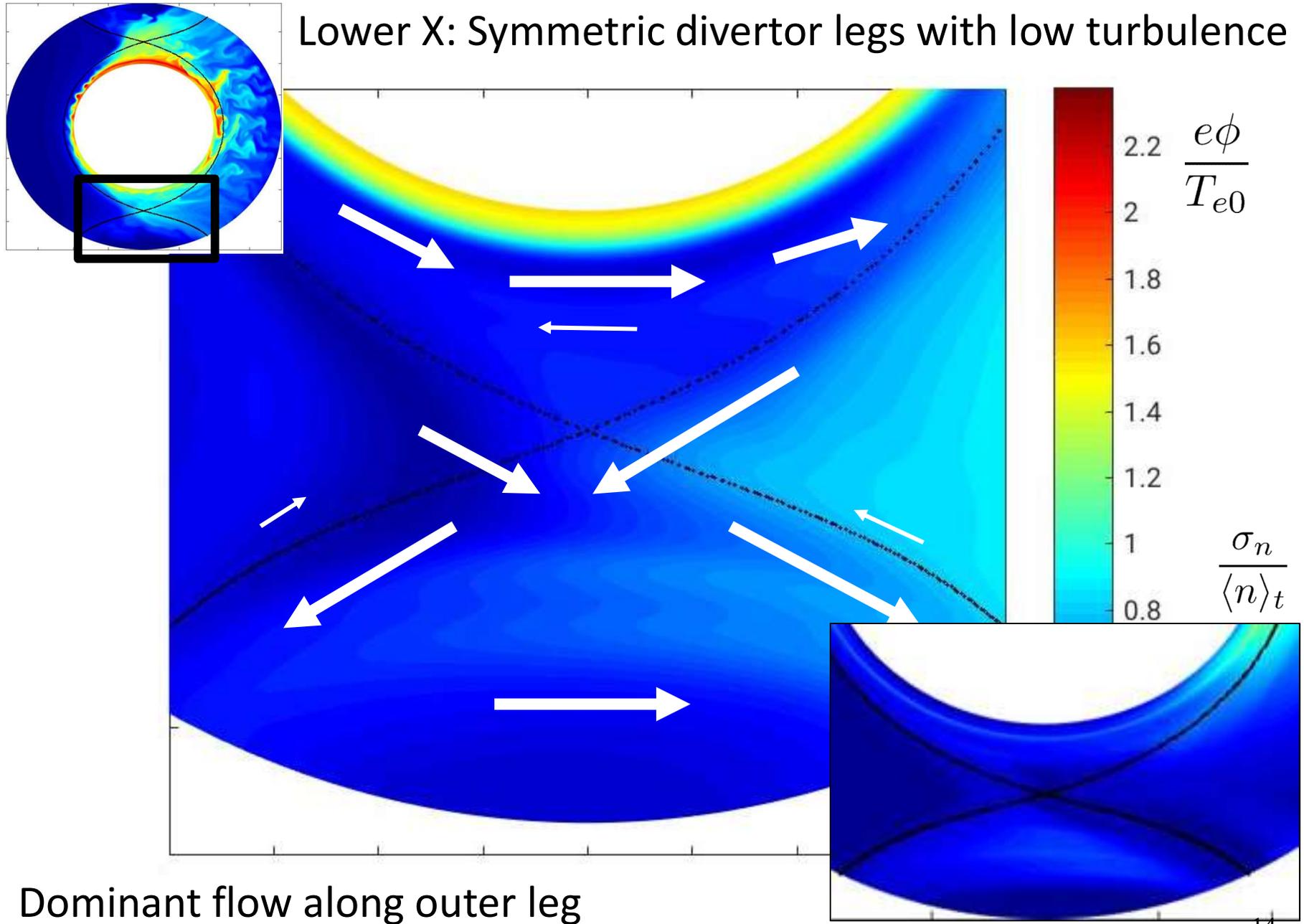
# Complex Equilibrium and Fluctuation Pattern

# Upper X: Circulation around X point



Strong fluctuations

$$\frac{e\phi}{T_{e0}}$$

$$\frac{n}{n_0}$$

ExB drifts important effect on target heat flux

Corresponds to comparison between experiment and phenomenological simulations

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Lower X: Symmetric divertor legs with low turbulence

$\frac{e\phi}{T_{e0}}$

2.2
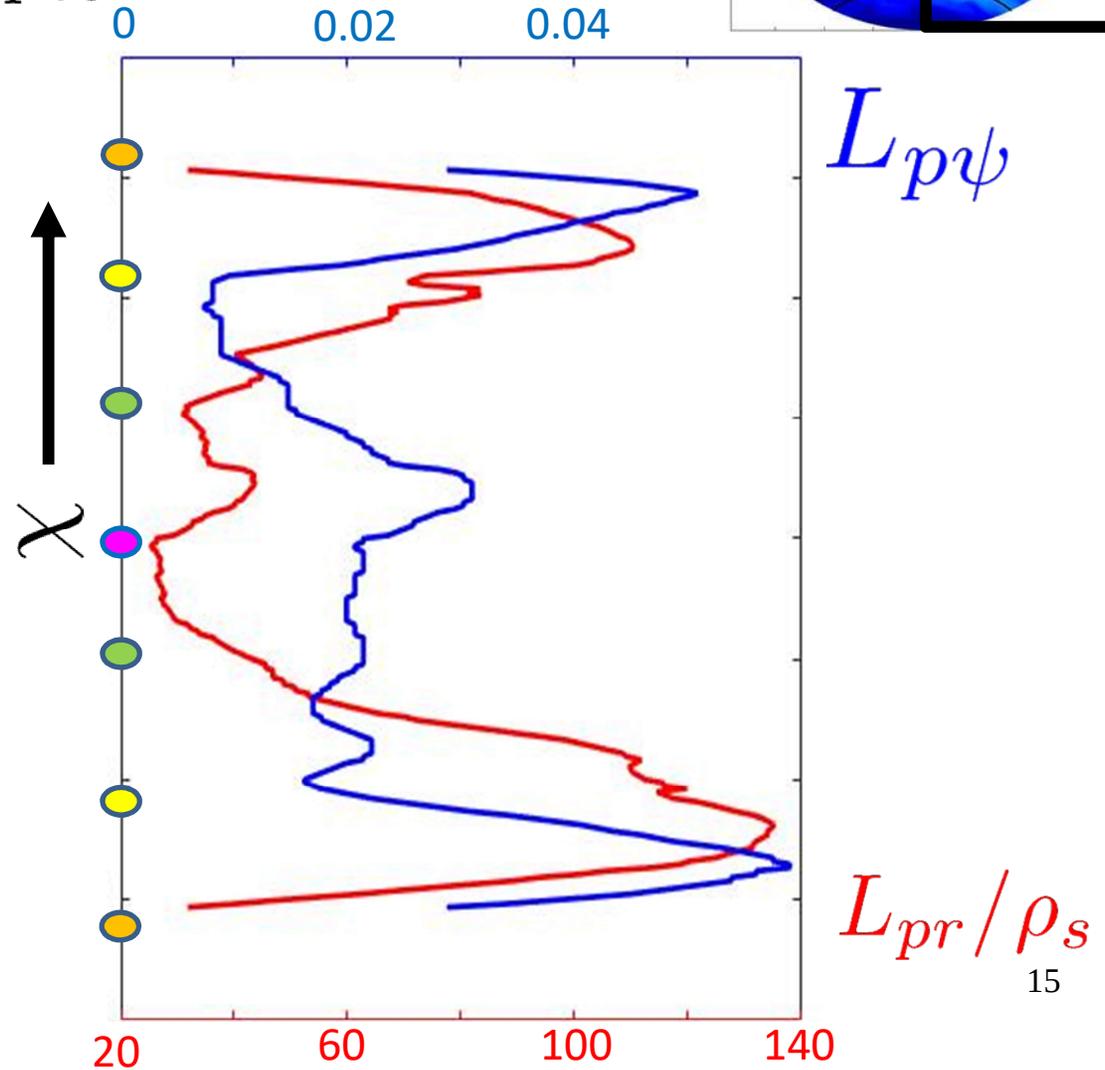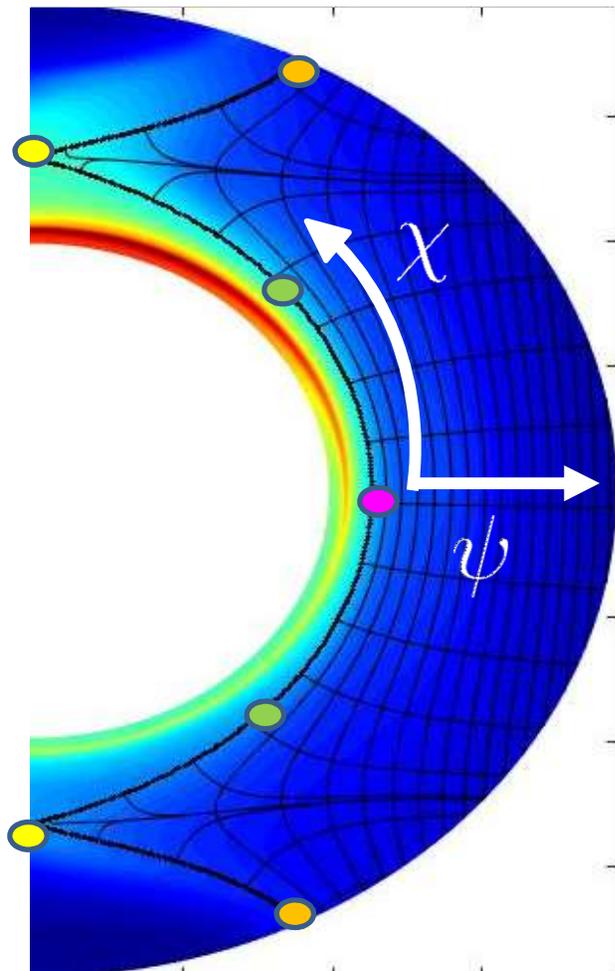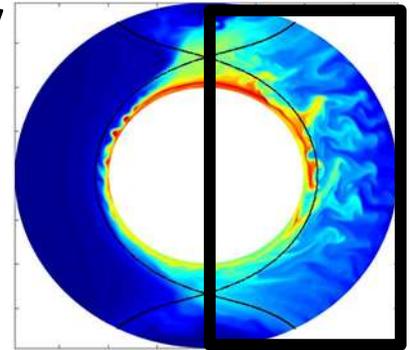2
1.8
1.6
1.4
1.2
1
0.8

$\frac{\sigma_n}{\langle n \rangle_t}$

Dominant flow along outer leg
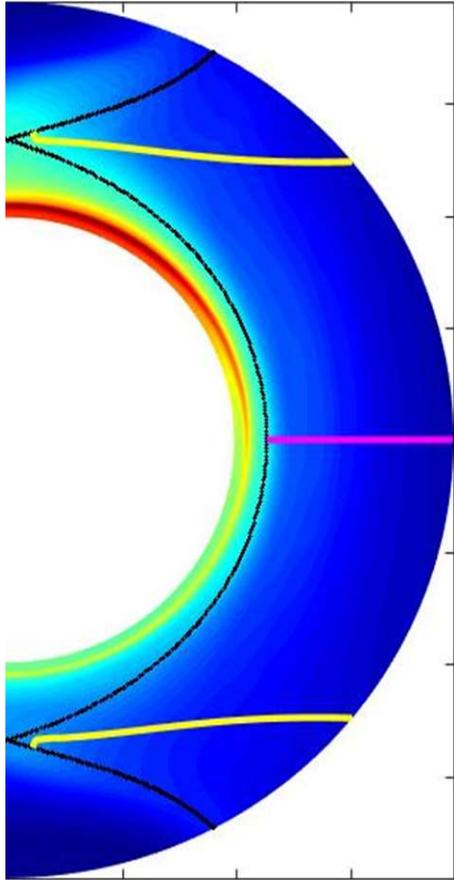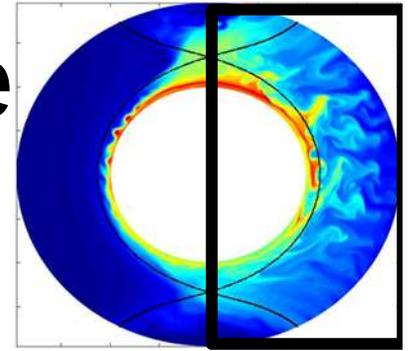
Strong shear across leg

Low turbulence on leg

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# LFS: minimum pressure spatial decay length at midplane

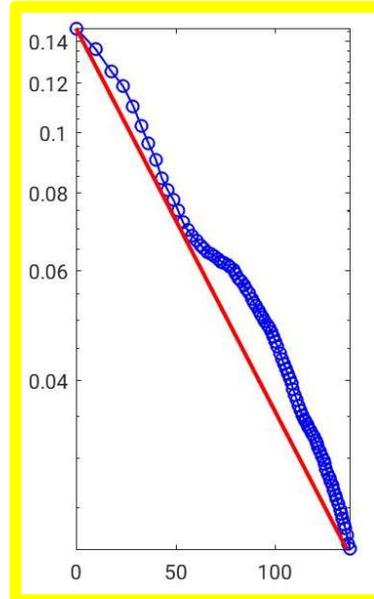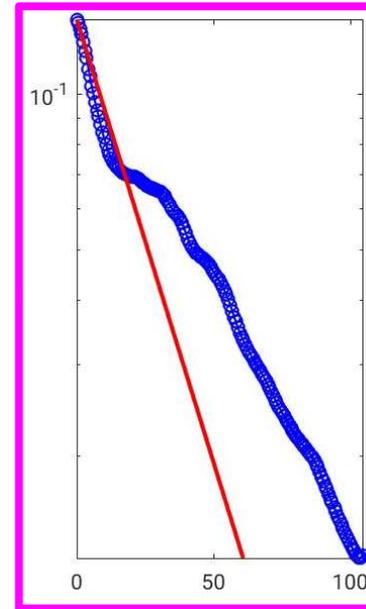$$p_e = p_{e0}e^{(-r/L_{pr})} = p_{e0}e^{(-(\psi - \psi_0)/L_{p\psi})}$$
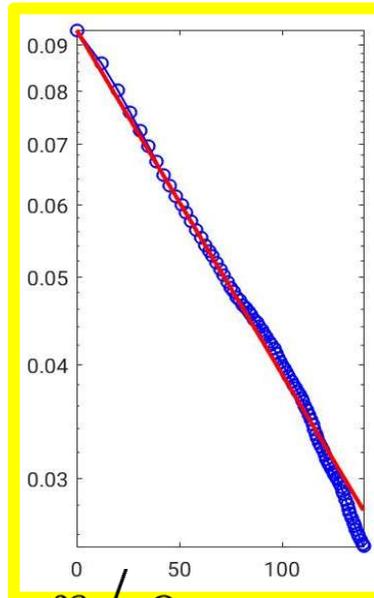


$L_{p\psi}$

$L_{pr}/\rho_s$

# LFS: narrow feature at midplane



Single scale length

More than one scale length

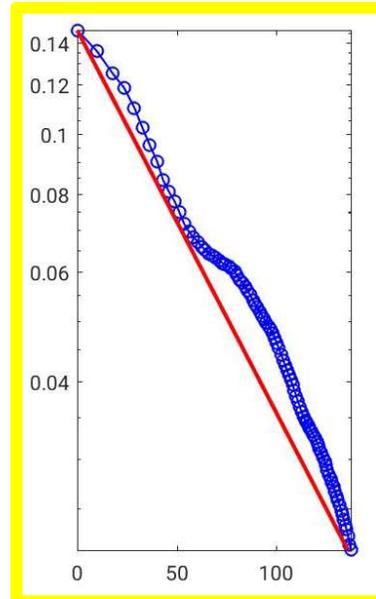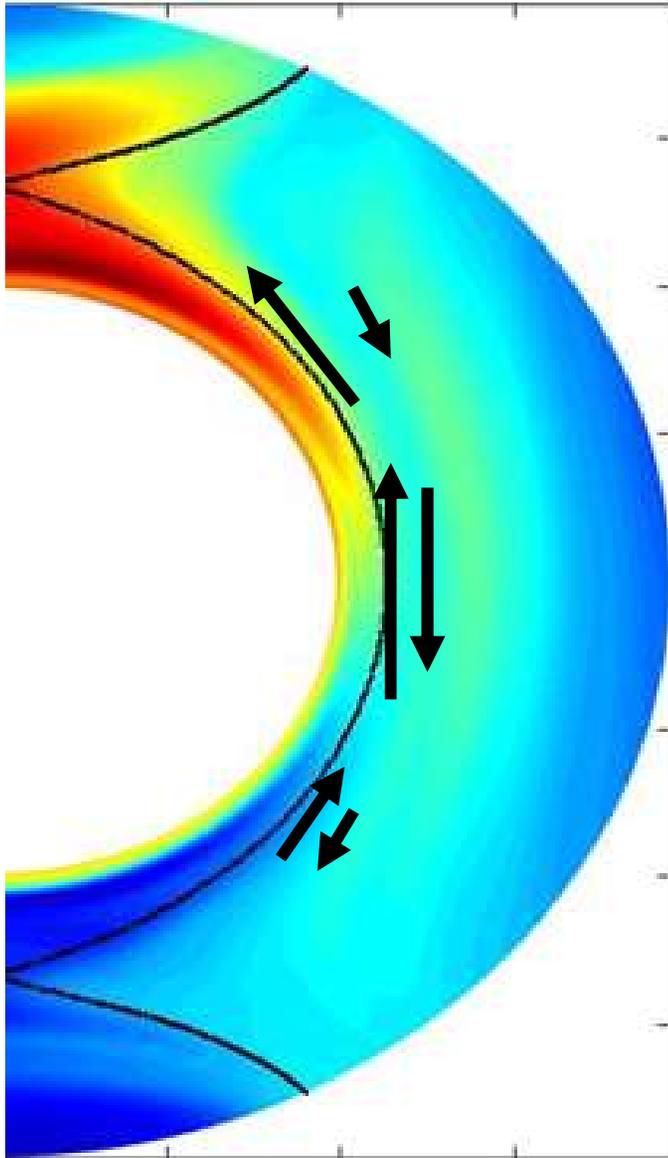Decay with $\psi$ takes similar form

Single scale length

$\ln(p_e/p_{e0})$

$r/\rho_s$

# LFS: Narrow feature due to strong ExB flow shear
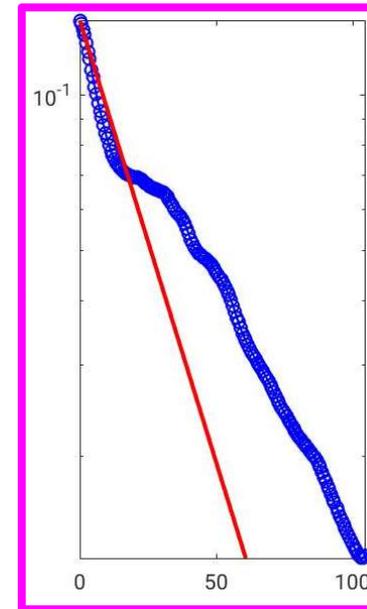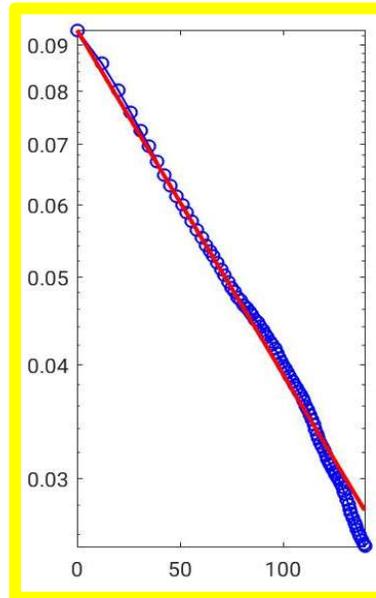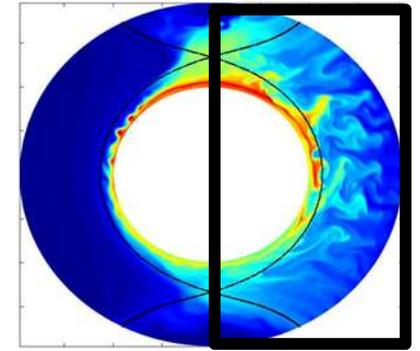


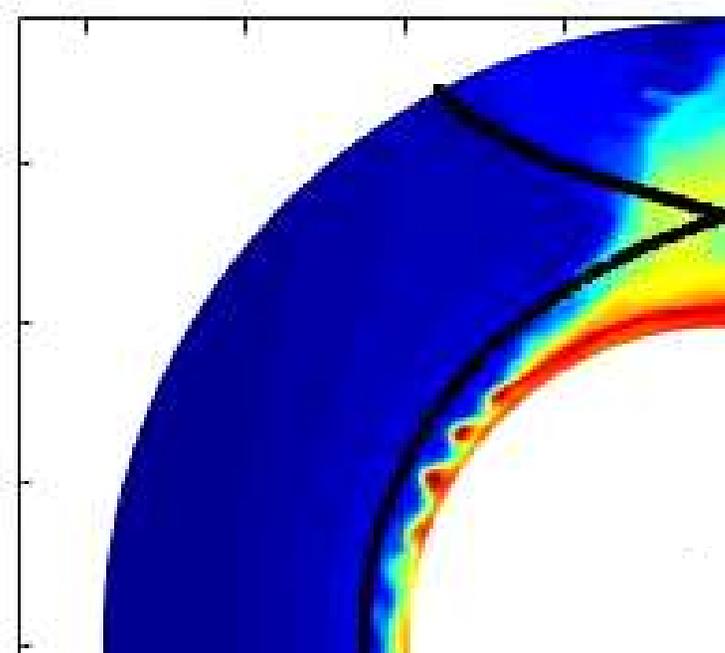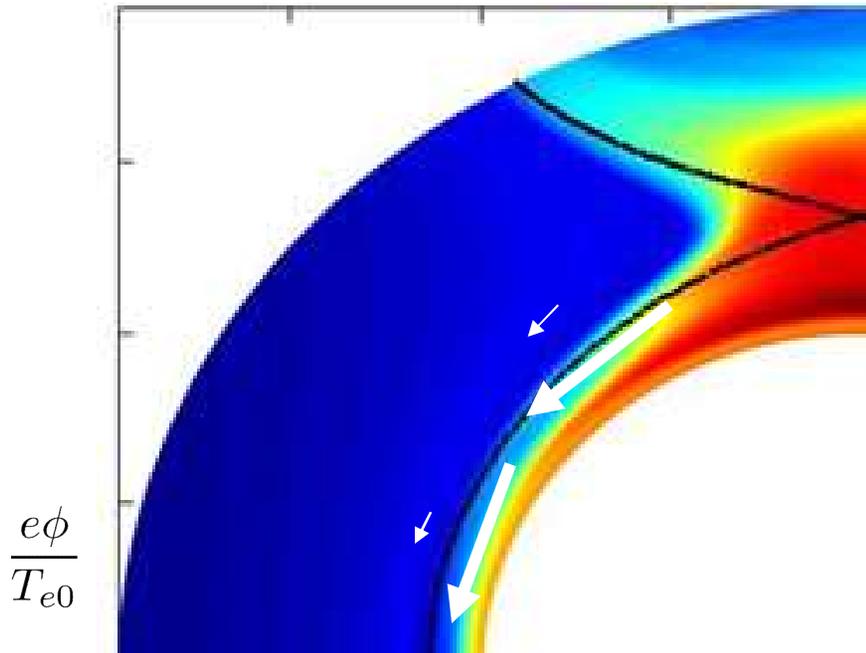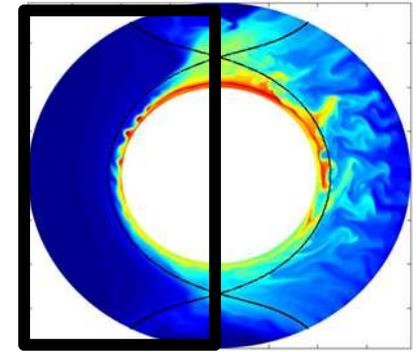$$\omega_{E \times B} \sim \gamma_{BM}$$

ExB shear flow driven by high potential fluctuations

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# HFS: very little plasma outside LCFS



No interchange drive

Pressure at LCFS 10x lower than LFS

Very strong flow shear -> KH instability?



$$\frac{e\phi}{T_{e0}}$$

$$\frac{n}{n_0}$$

# Concluding Remarks

- First simulations of plasma turbulence in the SOL of a double null configuration
- Leveraging upgrade to GBS simulation code
- Initial analysis shows a complex flow pattern
- Up-down and left-right asymmetry in divertor legs
- Highly turbulent LFS with narrow feature at midplane
- Quiescent, almost empty HFS

# Questions?