



Impact of penalized SOL boundary conditions on plasma turbulence

E. Caschera, Guilhem Dif-Pradalier, P Ghendrih, V. Grandgirard, P. Donnel,
X. Garbet, C. Gillot, G. Latu, C. Passeron, Y. Sarazin

► To cite this version:

E. Caschera, Guilhem Dif-Pradalier, P Ghendrih, V. Grandgirard, P. Donnel, et al.. Impact of penalized SOL boundary conditions on plasma turbulence. 46th European Physical Society Conference on Plasma Physics (EPS 2019), Jul 2019, Milan, Italy. cea-02555086

HAL Id: cea-02555086

<https://cea.hal.science/cea-02555086>

Submitted on 27 Apr 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

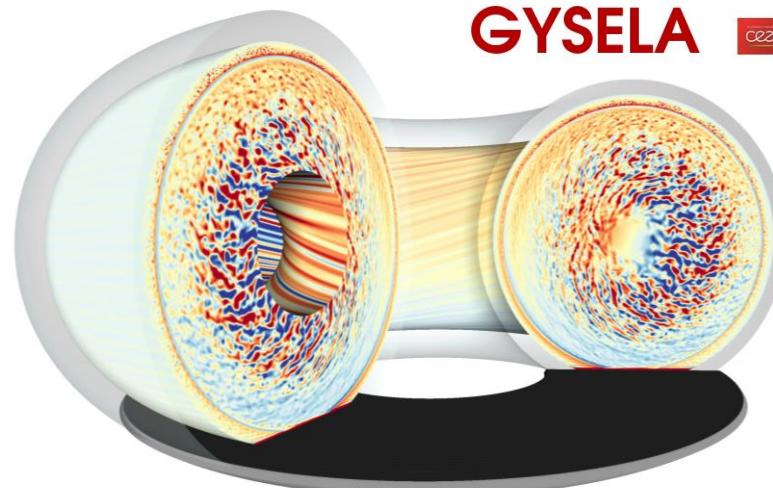
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Impact of penalized SOL boundary conditions on plasma turbulence

E. Caschera, G. Dif-Pradalier, P. Ghendrih,
V. Grandgirard, P. Donnel, X. Garbet, C. Gillot,
G. Latu, C. Passeron, Y. Sarazin

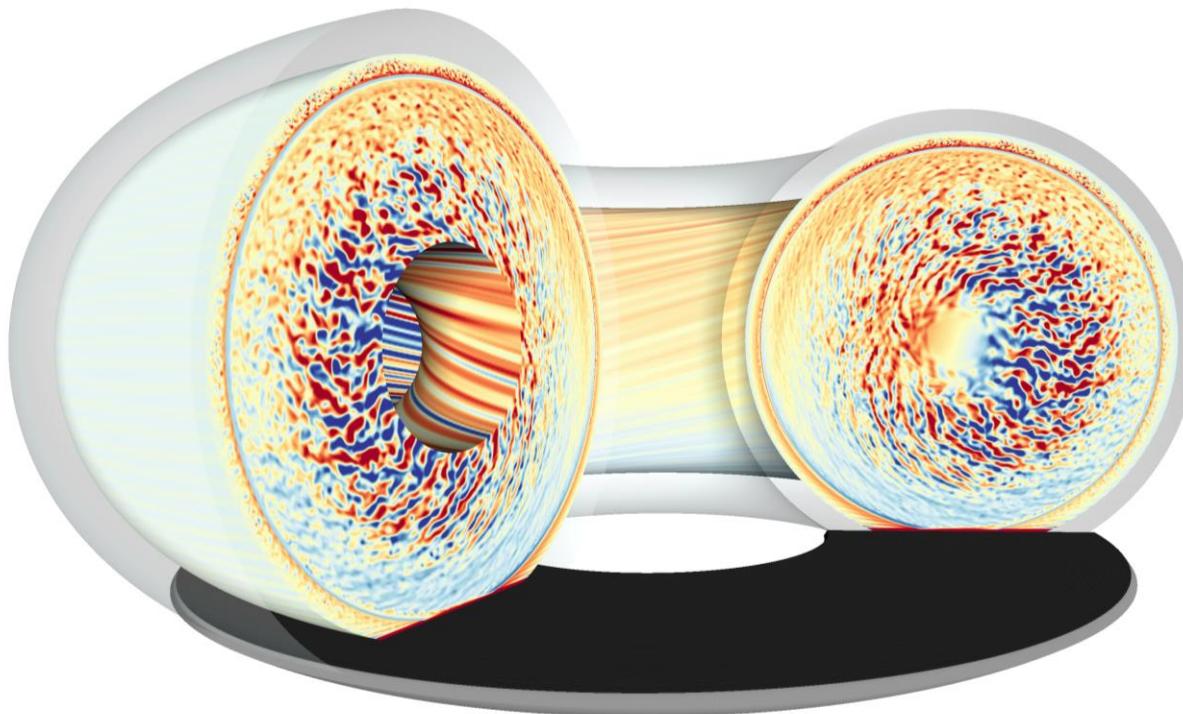
CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France

GYSELA



HPC plasma modeling

GYSELA GYrokinetic SEmi LAgrangian



- Electrostatic ITG
- Global
- 5D full-f

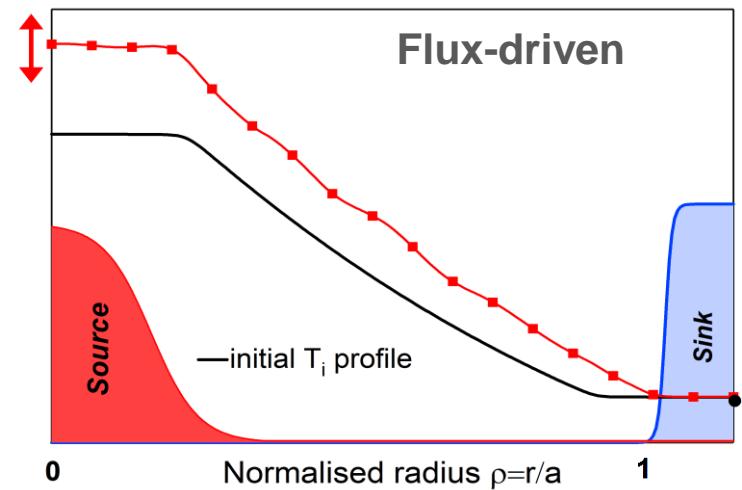
Huge computational effort

10^4 processors

10 millions h/monoproc

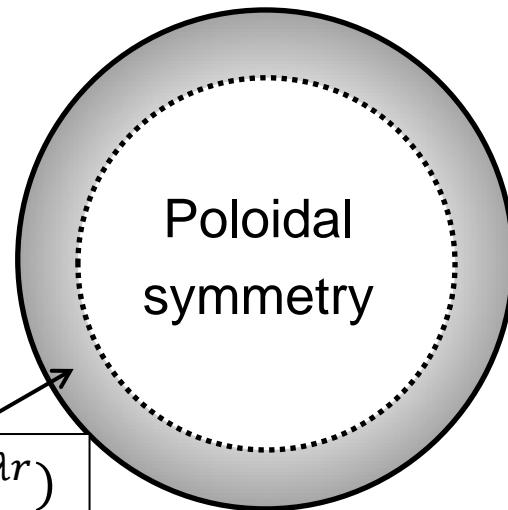
Penalization for plasma-wall interaction

- Plasma open system → boundary = Heat sink
- Affect edge-core turbulence [Dif-Pradalier PFR 2017]
- Realistic boundary = 2 directions
- Penalized immersed boundary as edge fluid codes [Bufferand, JNM, 2013],
[Isoardi, JPC, 2010]



Previous boundary

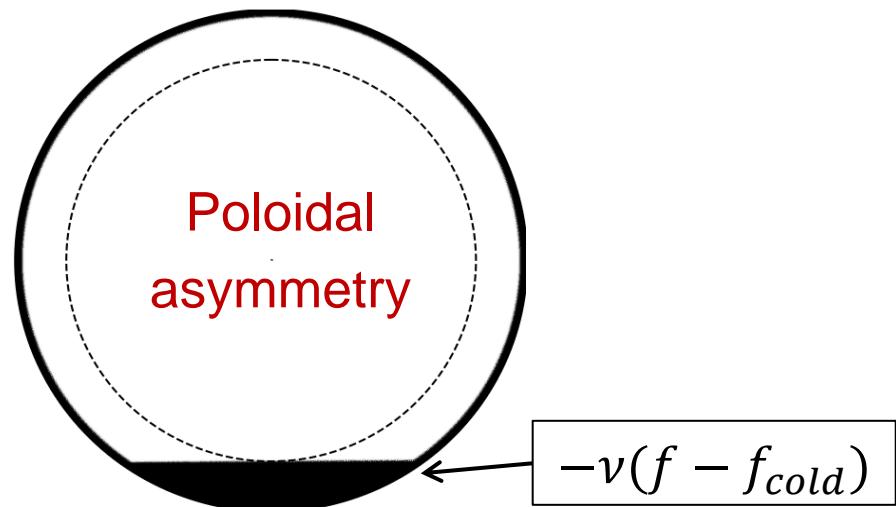
" symmetric SOL"



Limiter immersed boundary

" 2D SOL-like"

[Caschera, 2018]



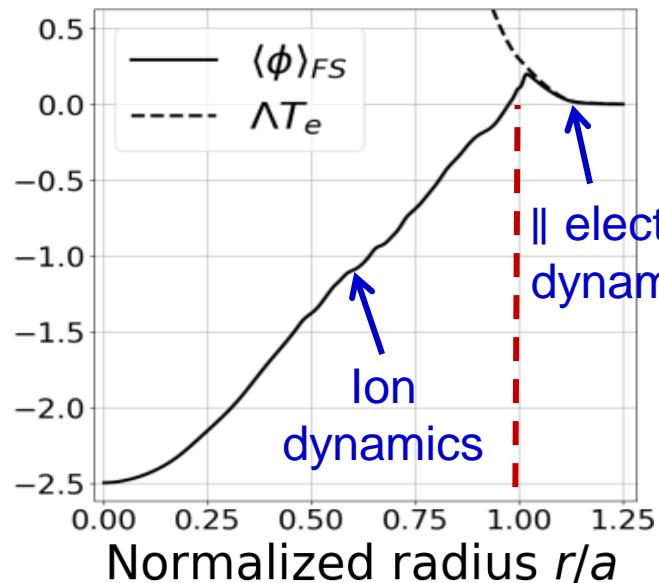
- Restoring towards exponential profiles

- Heat sink = Cold
- Resolution demanding ($v_{||}, \mu$) & (r, θ)
- \parallel transport in SOL, interrupts current loop
- Adiabatic electrons = NO $\perp e^-$ transport

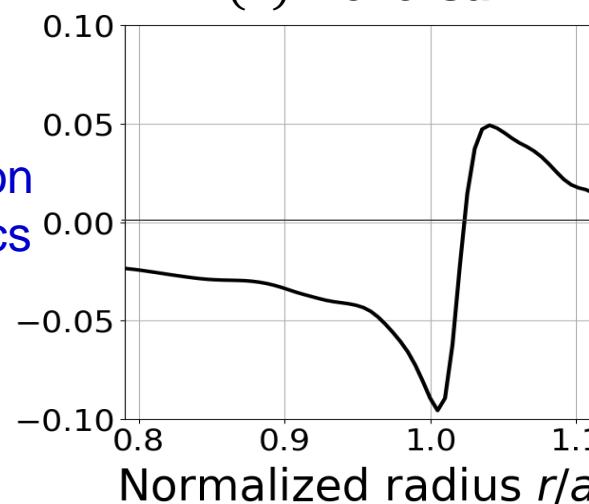
The reversed Er builds a transport barrier

- \parallel electron dynamic in the SOL $\rightarrow \langle \phi \rangle_{FS} = \Lambda T_e$
 - *core* dominated by ion physics
 - Reversed Er self-consistently generated (as experimental measurements)
- Edge transport barrier (not steady state simulation)

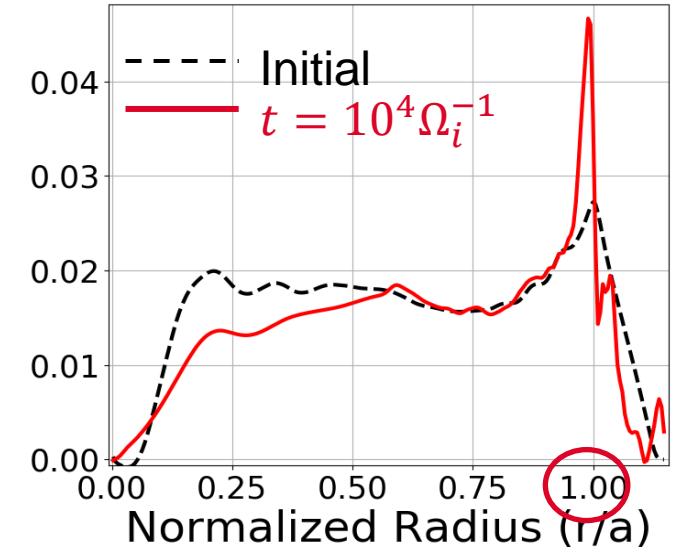
Electric potential



$E(r)$ Reversal

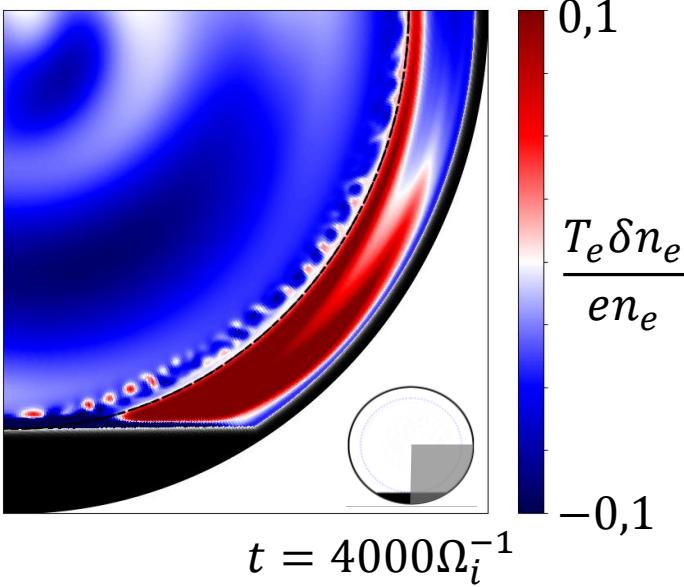


Temperature gradient

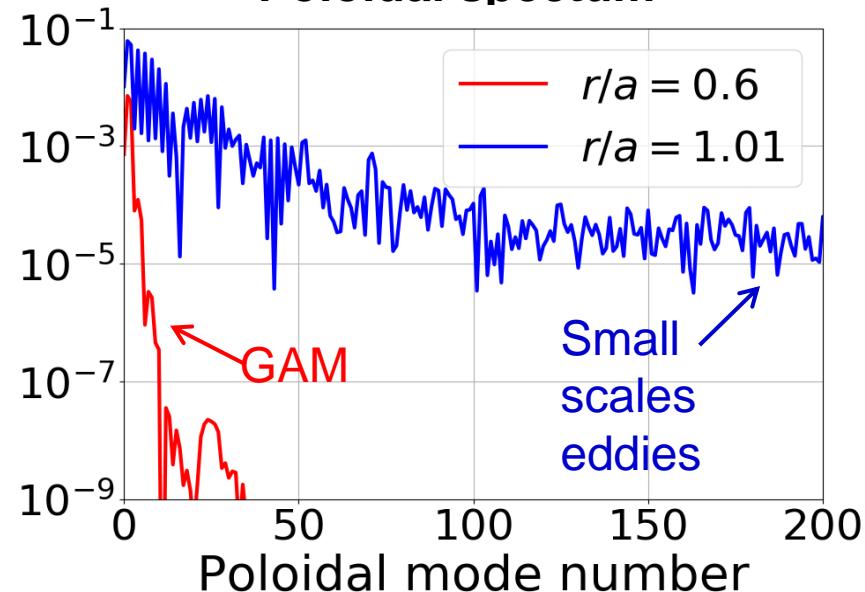


drives axisymmetric instability

Potential fluctuations



Poloidal spectrum



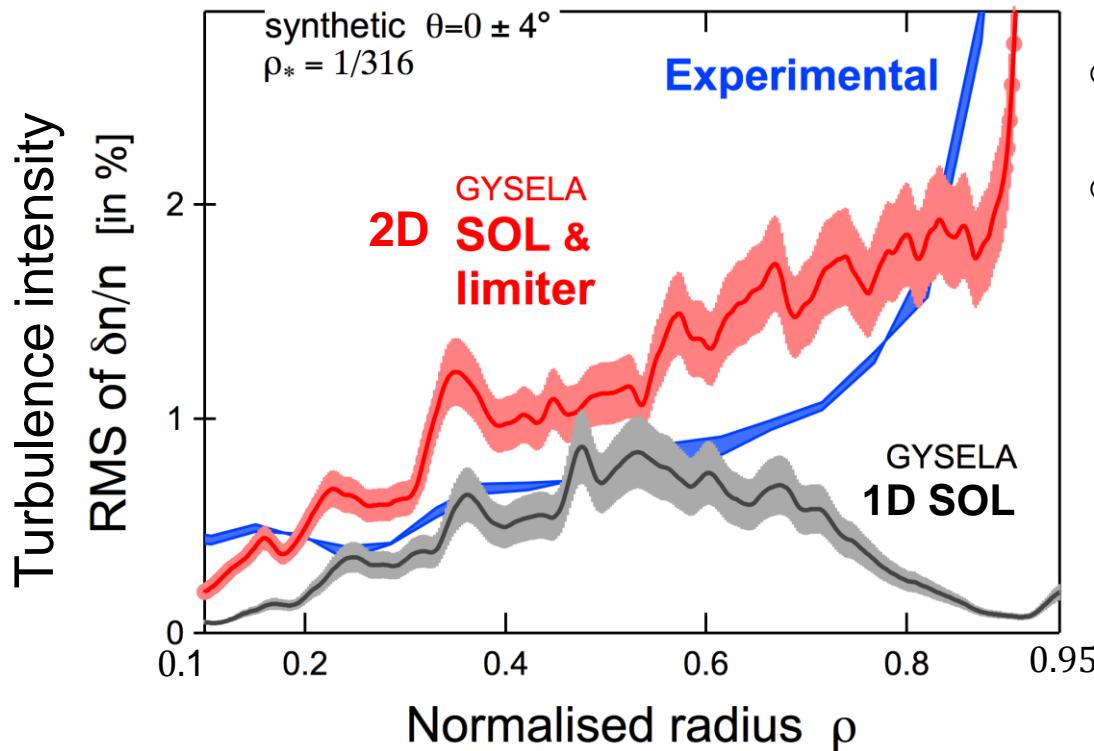
➤ Axisymmetric simulation, evolving only $n=0$ → « Neoclassical »

- Threshold on ExB shear
- ExB shear = poloidal velocity → Kelvin-Helmholtz

→ *Plasma polarization is sufficient to drive turbulence*

SOL is determinant for edge turbulence

➤ SOL impact on turbulent fluctuations

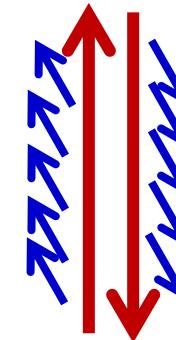


- Tore Supra profiles, Edge linearly stable
- Edge turbulence only with SOL+Limiter

Observed dynamics:

Shear @ separatrix

Turbulence
Inward
(Edge)



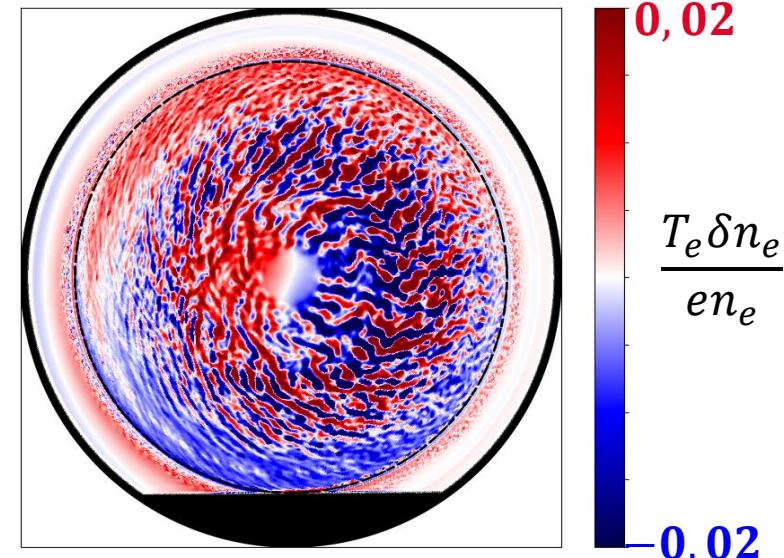
Turbulence
Outward
(SOL)

- ITG modes
- Same core turbulence

Global = core + edge + SOL

- 1) Transient barrier by Er reversal
- 2) Instability even in axisymmetric framework
- 3) Qualitative $\delta n/n$ experimental trend

Potential fluctuations



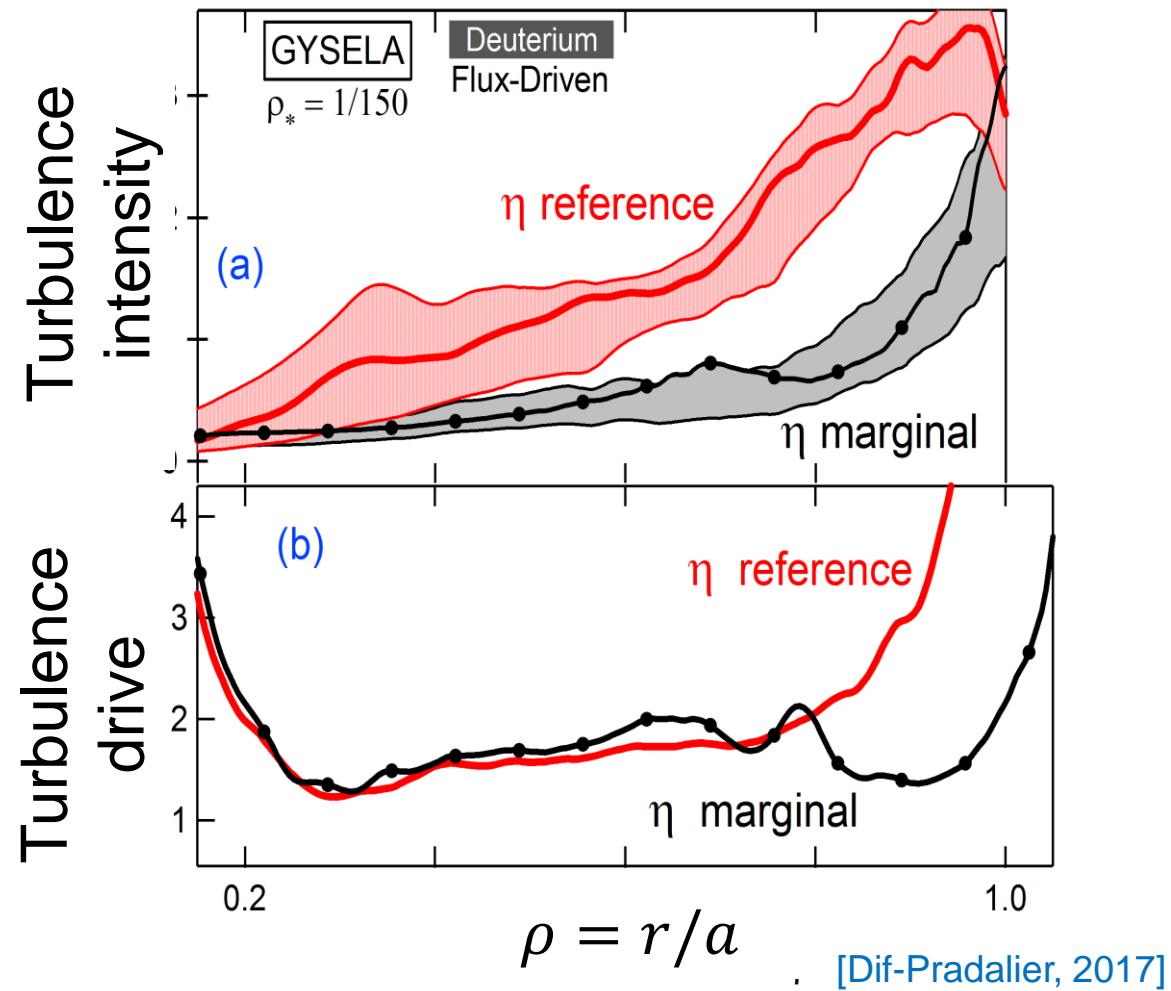
- Many different non-linear phenomena at a time:
Kelvin-Helmholtz, ITG, spreading, flows
- Push towards steady-state boundary layer

**Limiter boundary leads to new physics
in GYSELA simulations**



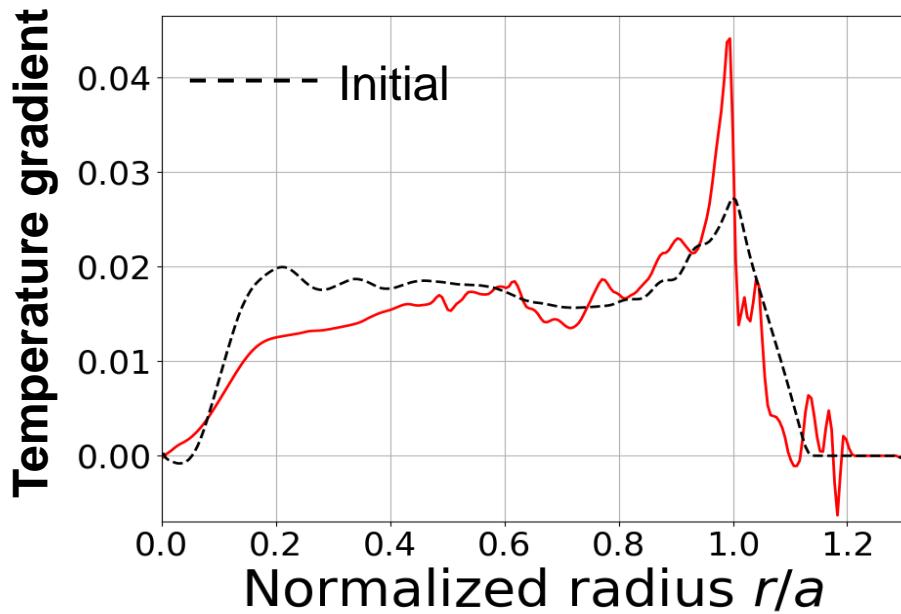
Back-up slides

Evidence of edge-core interplay

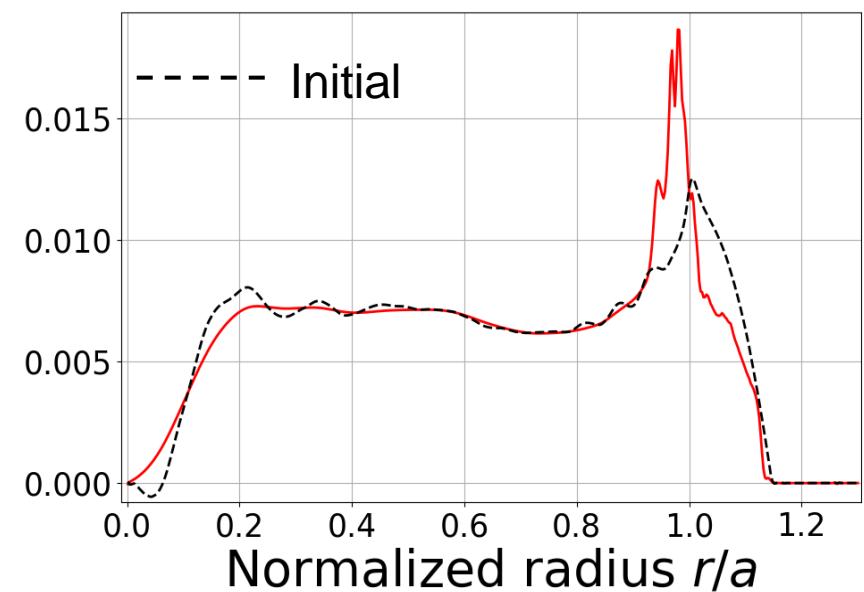


The weak transport barrier depends on core dynamics

$$E_r(r > a) = \Lambda T_e$$



$$E_r(r > a) = 0$$



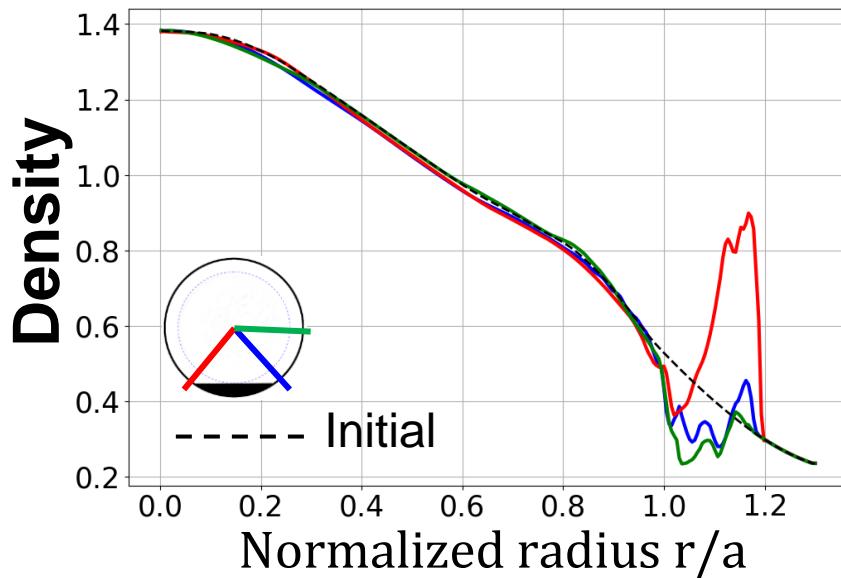
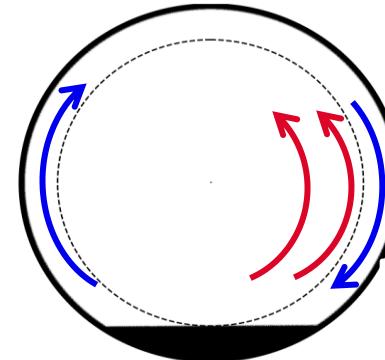
E_r Reversal at separatrix modifies SOL poloidal symmetries

LIMITER brakes the current loop → SOL poloidal asymmetries

SOL Polarization

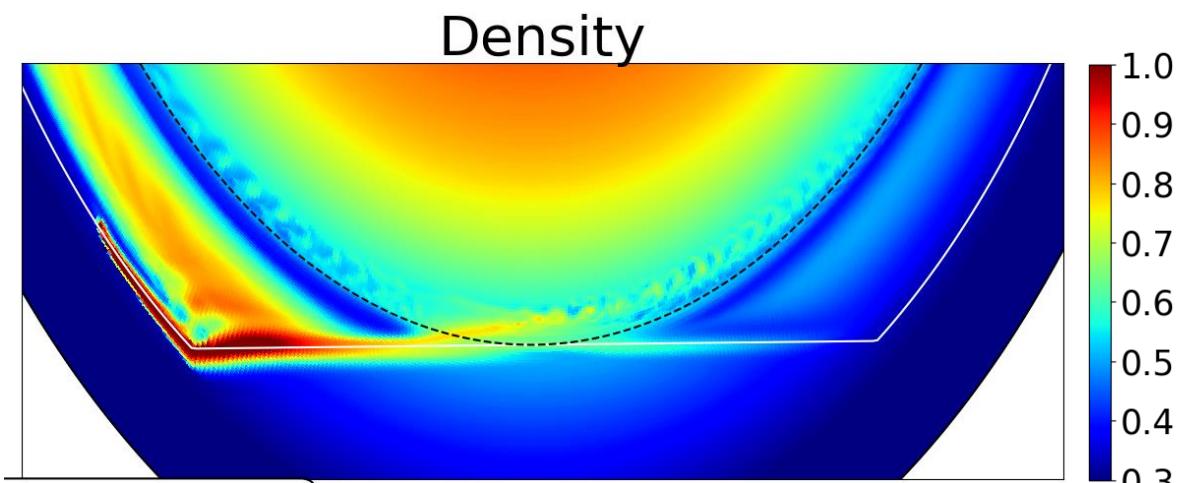
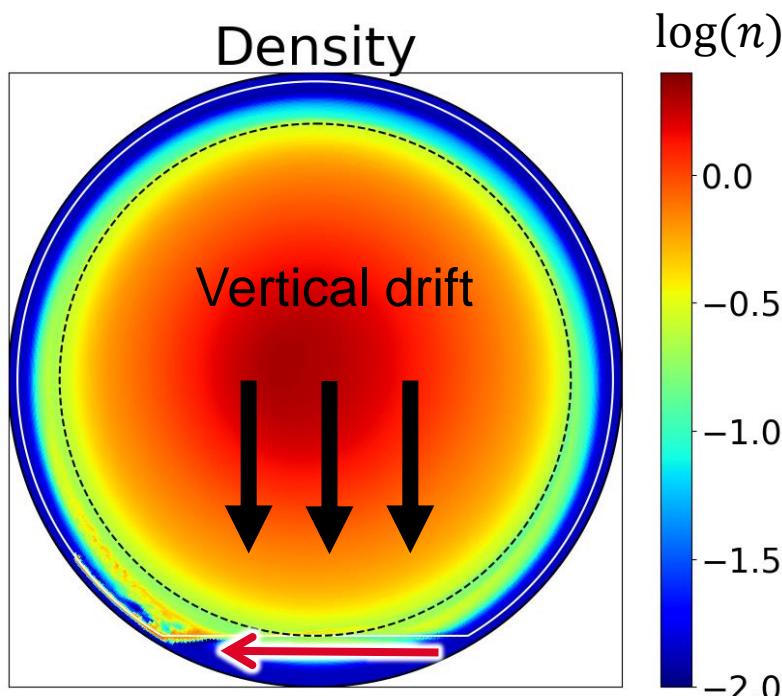
Reversed $E_r \leftrightarrow v_\theta$

Inverse rotation btw core/SOL

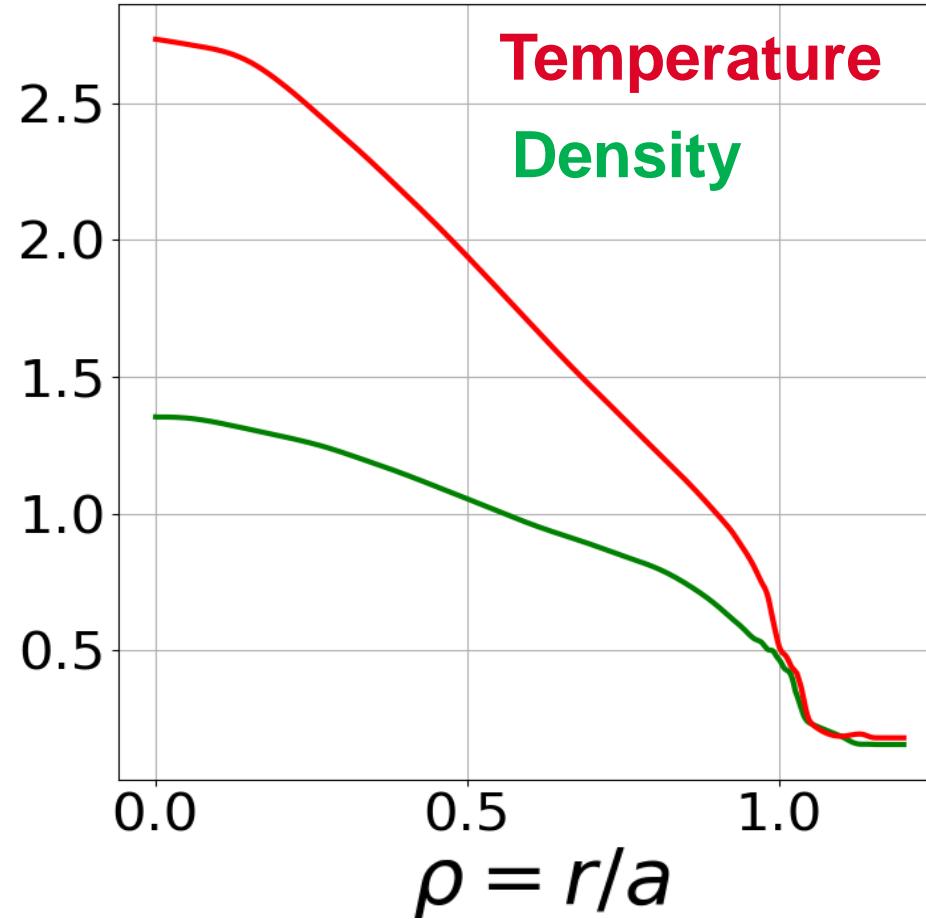


- Vertical drift + SOL flows
- HFS density accumulation
- Barrier at separatrix

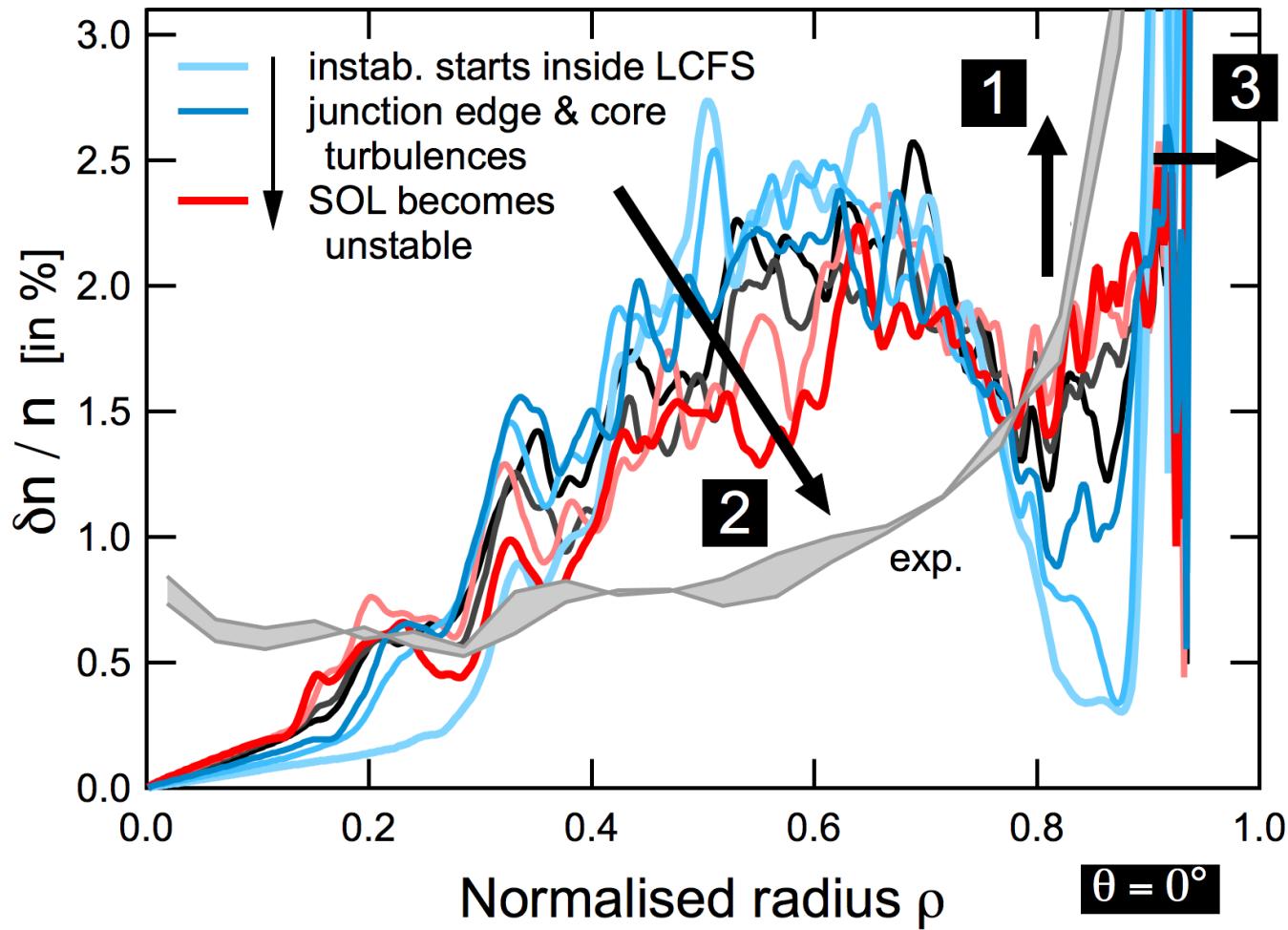
Initial transient in the SOL

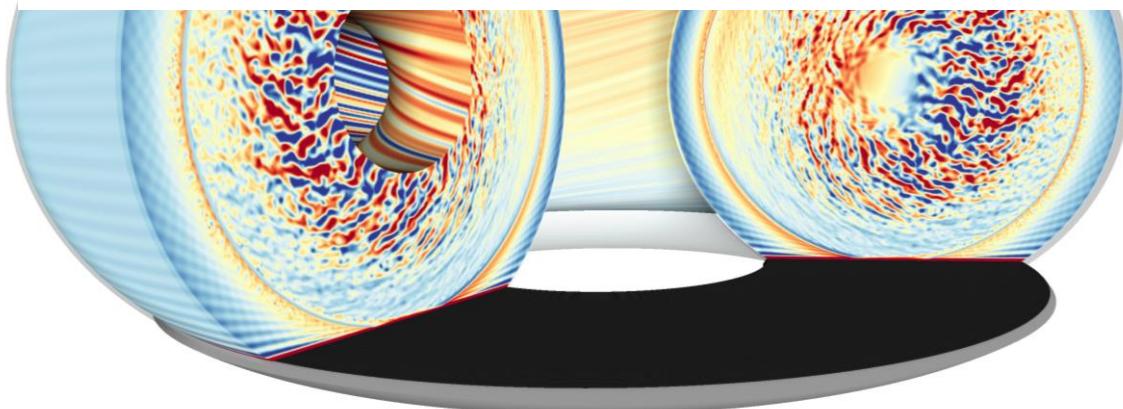
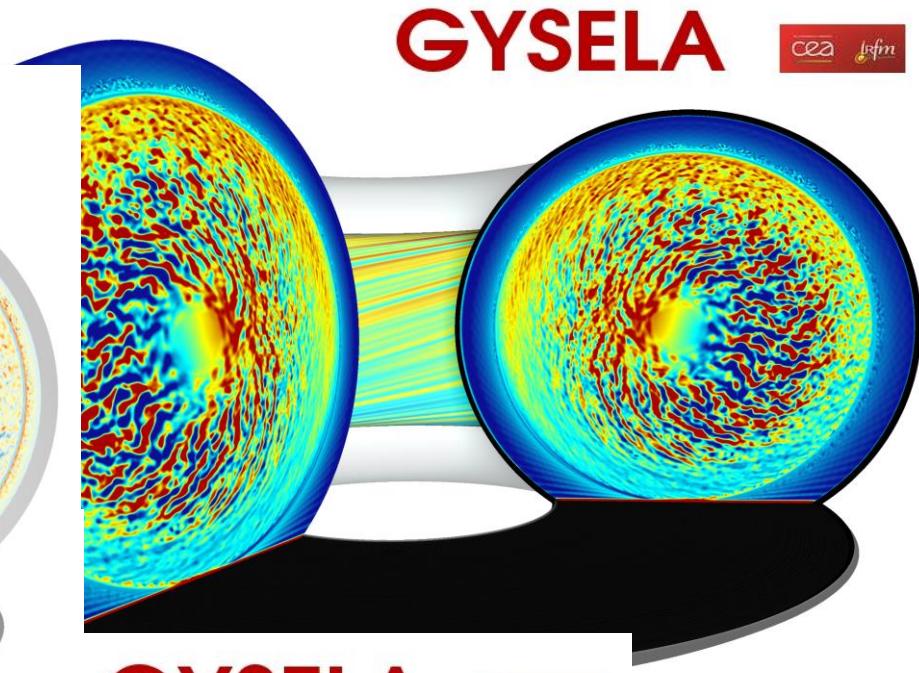
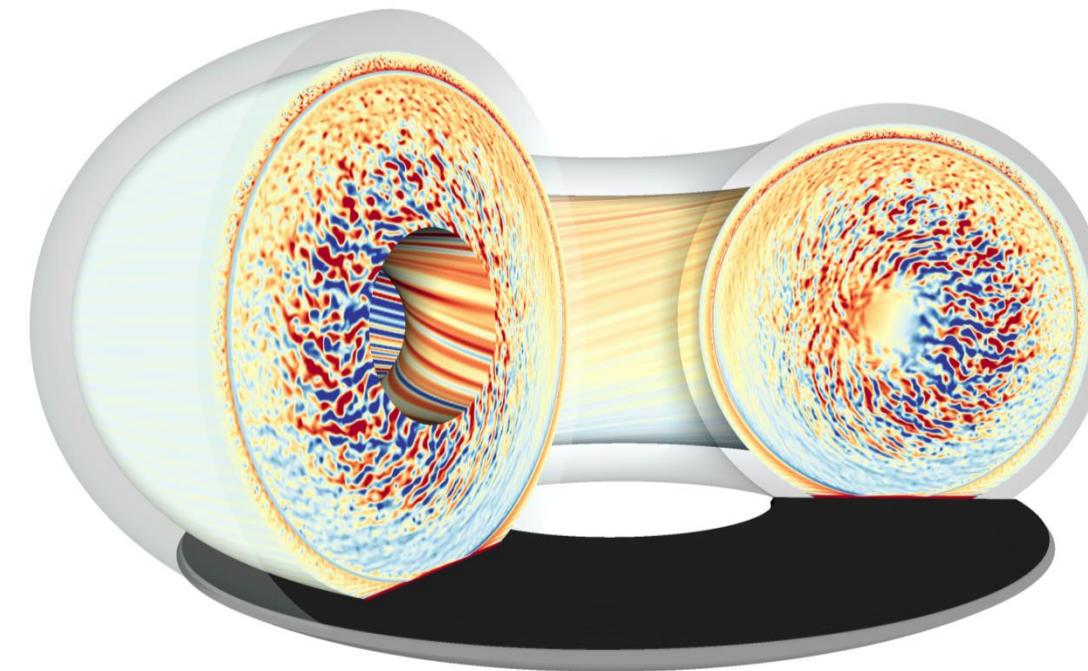


Axisymmetric simulations: barrier on the profiles



Recovering $\delta n/n$ behavior





Self-organized heat sink

1. Heat & momentum sink

- Cold immersed boundary
- Poloidally asymmetric
- \parallel transport in SOL

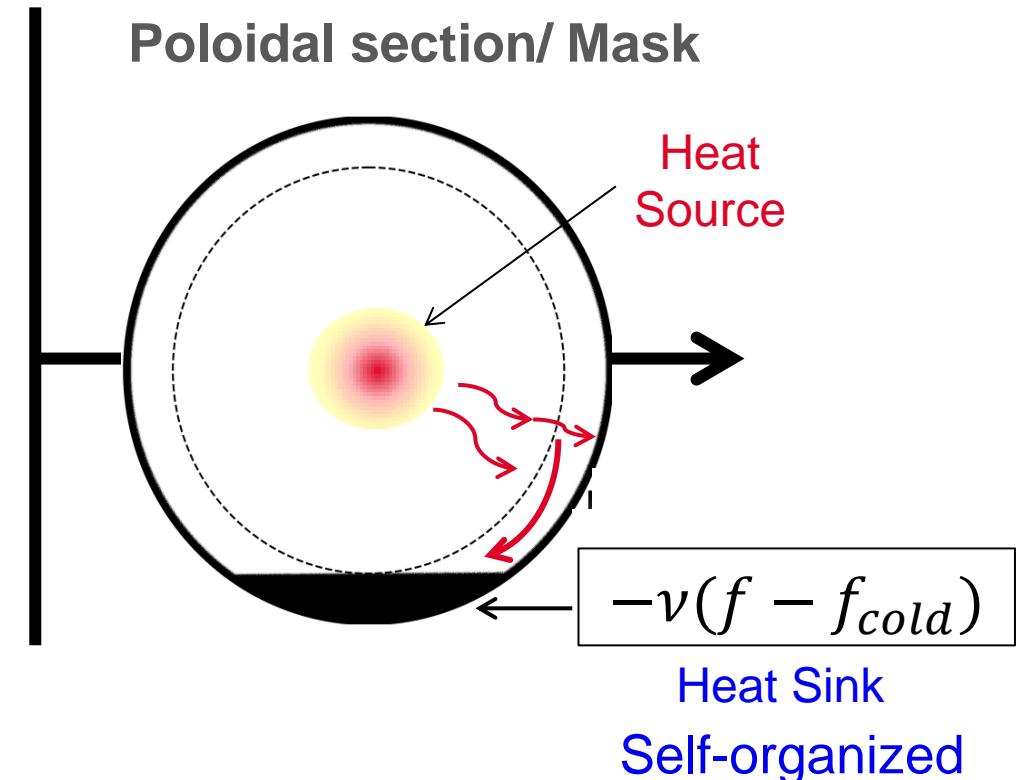
- All heat reaching the limiter is removed
- SOL = boundary for core
- Drift killed in the boundary

Adiabatic electrons

NO Particle sink,

Constrained \perp particle transport

NO recombination



Different SOL equilibrium

Adiabatic electrons

Flux surface averaged profiles

