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Impact of X-point geometry and neutrals recycling on edge plasma turbulence

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P. Tamain¹, H. Bufferand², G. Ciraolo², D.-M. Fan³, N. Fedorczak¹, D. Galassi², Ph. Ghendrih¹, E. Laribi¹, B. Luce^{1,2}, Y. Marandet³, F. Nespoli^{1,3}, F. Schwander², E. Serre²



¹ CEA, IRFM, 13108 Saint-Paul-lez-Durance, France

² Aix-Marseille Univ, CNRS, Centrale Marseille, M2P2, Marseille, France

³ Aix-Marseille Univ, CNRS, Centrale Marseille, PIIM, Marseille, France



Bridging mean field and turbulence modelling

2 complementary but parallel paths in edge fluid modelling: **mean-field** ("transport") and **turbulence** codes

Code family	Mean-field	3D turbulence
Example codes	SOLEEDGE2D, SOLPS, EDGE2D, EMC3	TOKAM3X, GBS, BOUT++, GRILLIX
Mean field	✓	✓ (if flux-driven)
Turbulence		✓
3D	(EMC3)	✓
Realistic plasma geom.	✓	
Realistic wall geom.	✓	
Kinetic neutrals	✓	
Multi-species (impur.)	✓	
Drifts	(✓)	✓

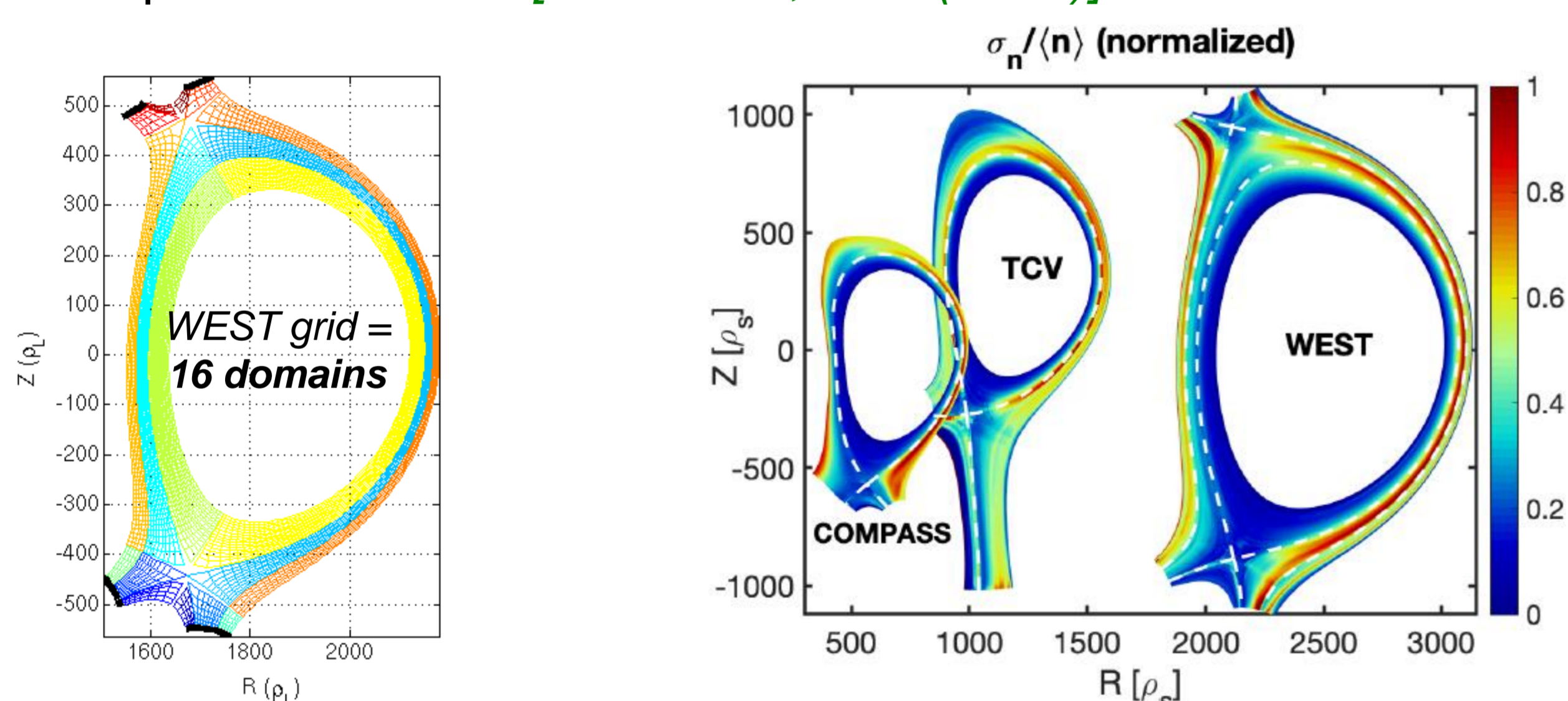
This poster

Experiments: strong interaction between turbulent transport and divertor geometry / density regimes [T. Eich, EPS2019; A. Wynn, NF2018]
 Predictive capabilities possible only with **self-consistent treatment of both facets of physics**

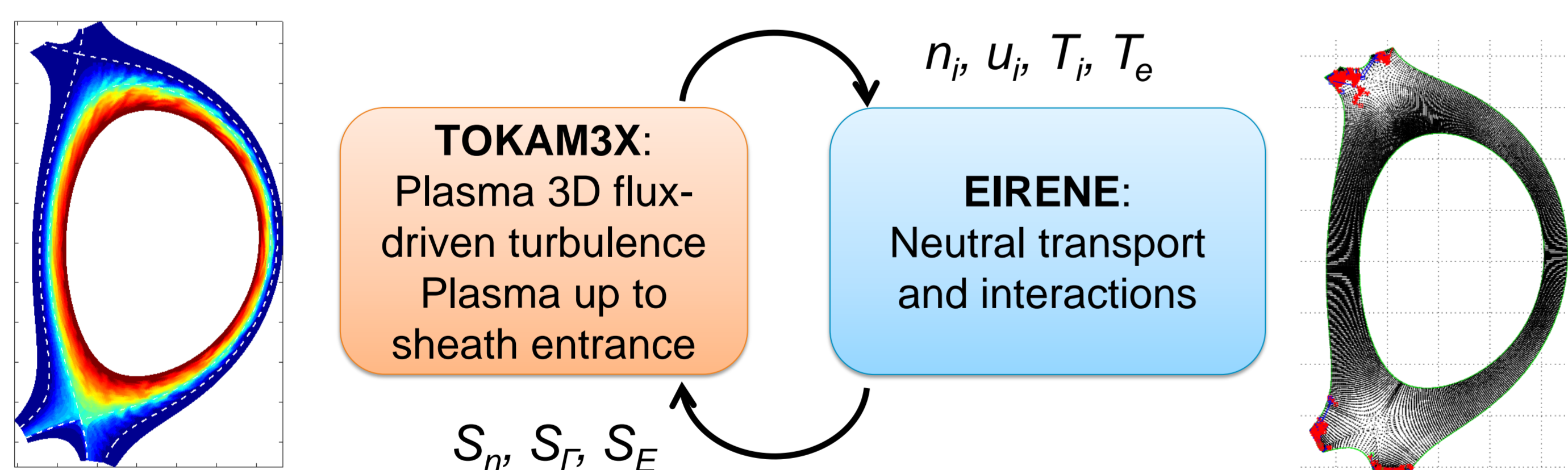
This presentation: overview of recent results with TOKAM3X code to bridge the gap = **turbulence in X-point geometry** and **with neutrals recycling**
 Parallel effort: new code checking all the above boxes => see **poster 33**

The TOKAM3X-EIRENE code package

3D fluid-drift equations (see attached slides)
 arbitrary magnetic geometry (axisymmetric) made possible by domain decomposition method [P. Tamain, JCP (2016)]



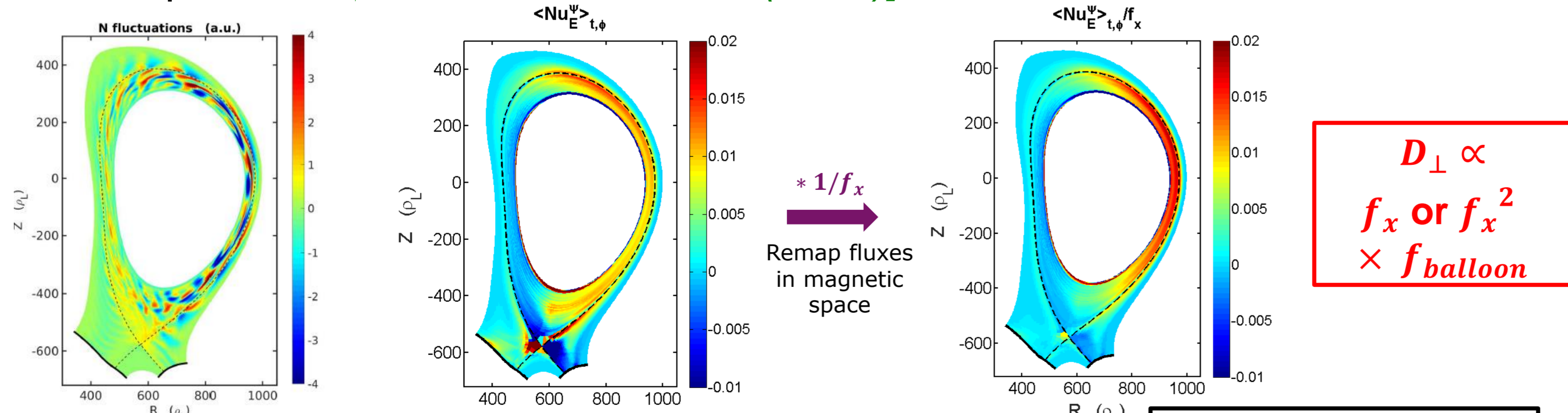
TOKAM3X coupled to EIRENE via same architecture as SOLEEDGE2D-EIRENE 2D transport package [H. Bufferand, NF2015; D.M. Fan, CCP2018]



Turbulent transport in X-point geometry

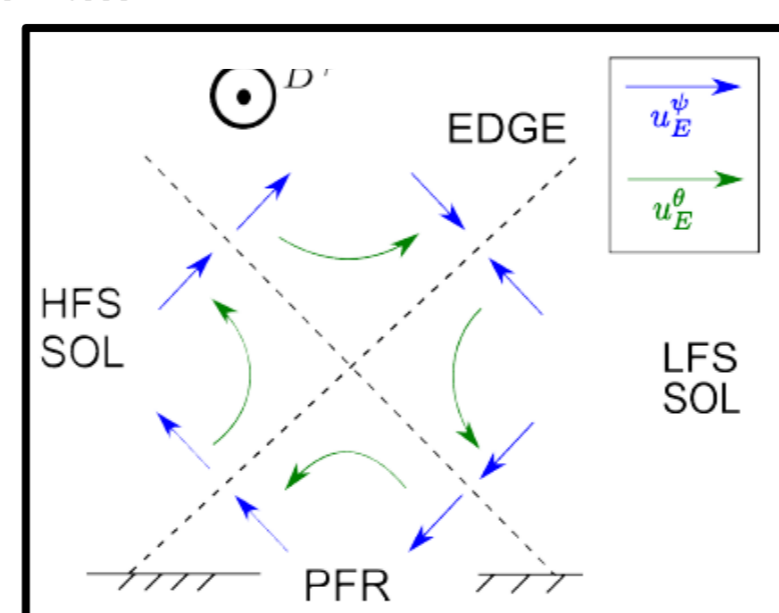
Key properties of edge turbulence and flows remain similar to limited plasmas [D. Galassi, NF2017]
 Large intermittency and fluctuation level increasing with r, $k_{||} \rightarrow 0$, ballooning

Shaping (flux expansion) plays important role in poloidal distribution of transport level [D. Galassi, NME 12 (2017)]



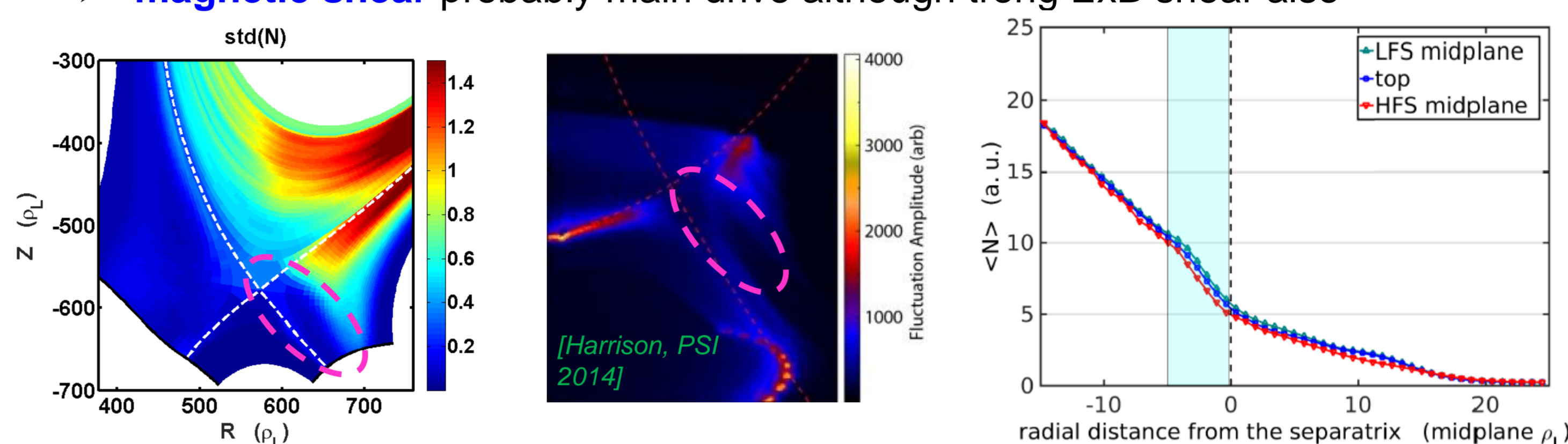
Complex steady ExB flux pattern around X-point [D. Galassi, NF2017]

Poloidal shear of radial ExB velocity at X-point as new mechanism for filament disconnection identified [F. Nespoli, submitted to NF]



Quiescent region systematically observed in X-point vicinity and along the separatrix [D. Galassi, Fluids 4 (2019)]

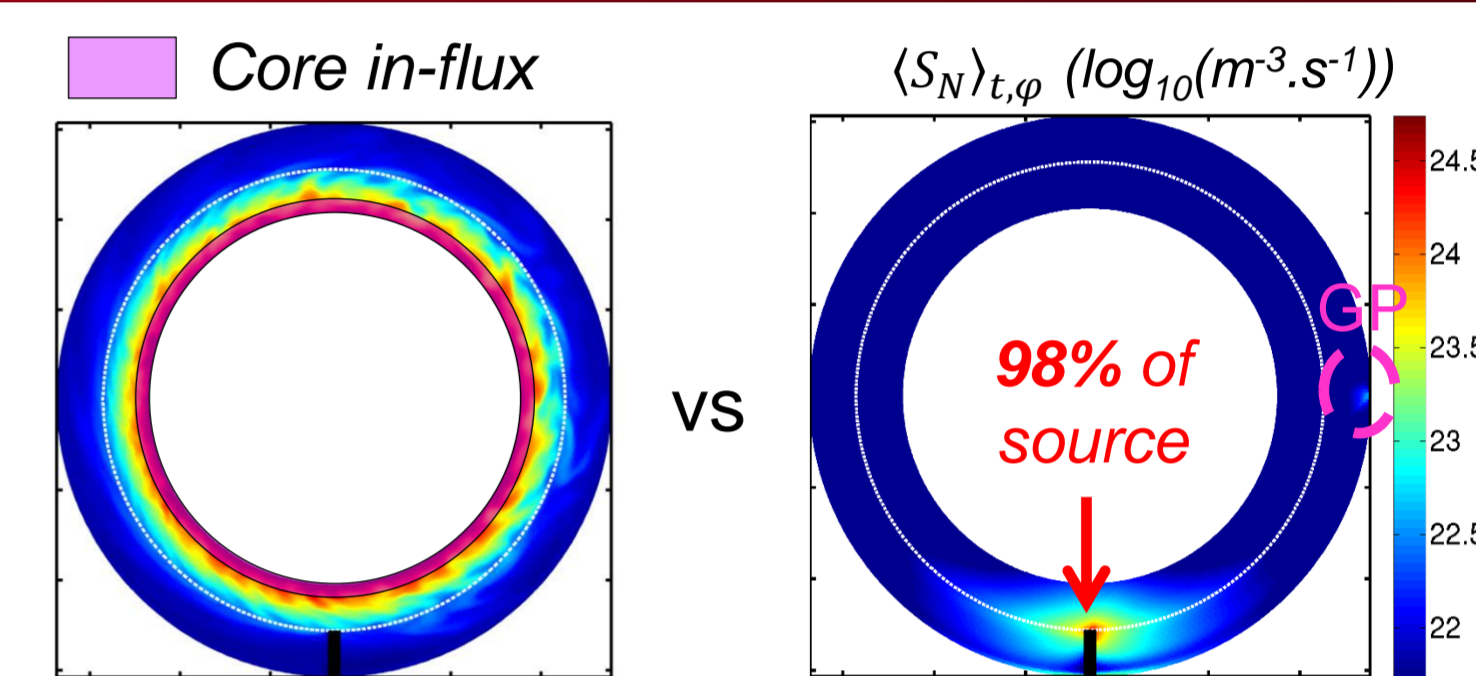
- λ_{SOL} reduced vs limited simulation
- mild edge transport barrier even upstream
- magnetic shear probably main drive although strong ExB shear also



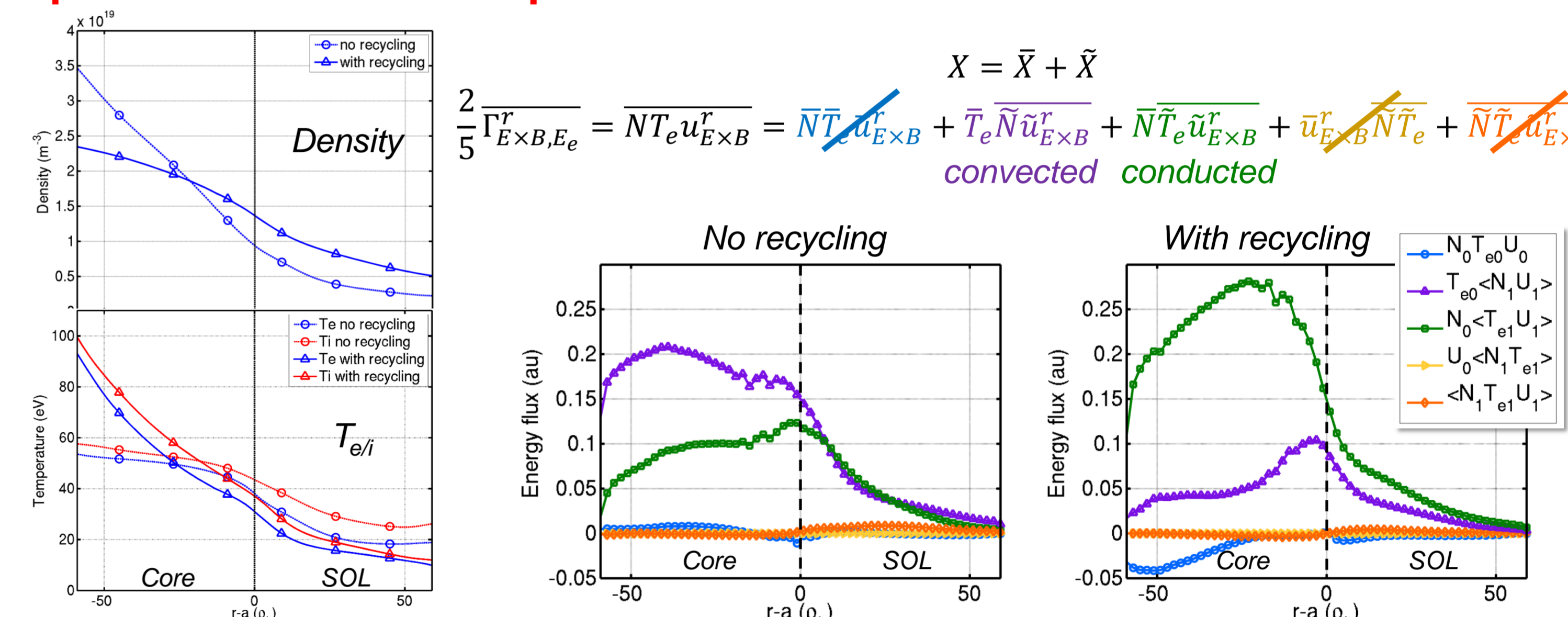
Turbulence with self-consistent neutrals recycling

Compare core particle influx with self-consistent fuelling (GP + recycling) [P. Tamain, PSI2018]

ρ_*	$v_* \left(\frac{v_{col}}{\omega_c} \right)$	GP (s^{-1})	P_{heat} (kW)	Wall mat.	R_{rec}
$3.9 \cdot 10^{-3}$	$5 \cdot 10^{-2}$	$1.3 \cdot 10^{20}$	105	Be	0.99

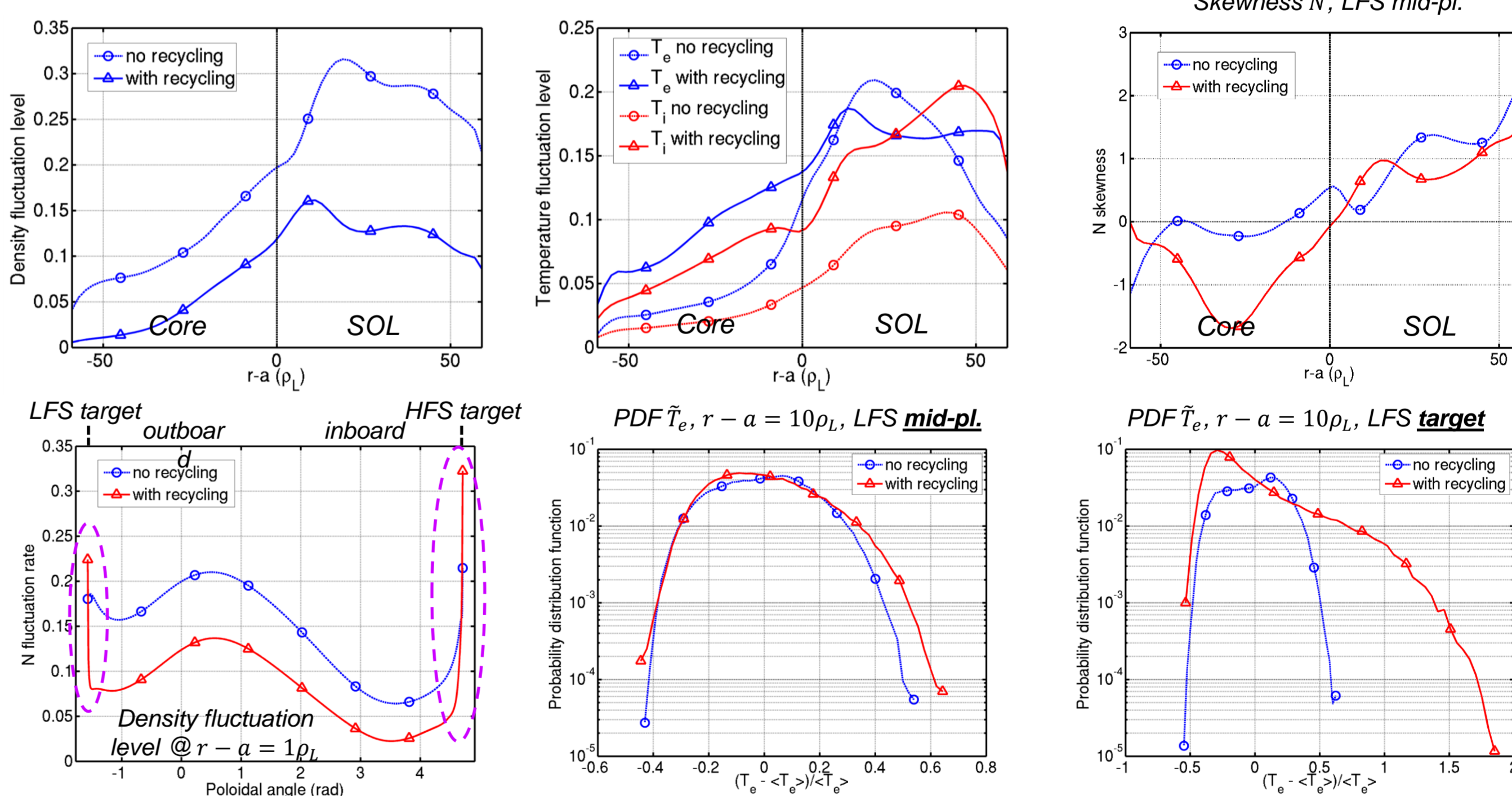


Change in particle source location leads to major reorganization of profiles and heat transport mechanism from convected to conducted



Response of turbulence very dependent on poloidal position

- Far from targets: drop of \bar{N} , increase of \bar{T} , intermittency and structure unchanged
- Close to targets: strong increase of intermittency and fluctuation rate, incl. $q_{||}$



X-point turbulent simulation with neutrals?

- X-point geometry enhances source relocation effect
- Turbulence regime strongly impacted
 - Intermittency replaced by quasi-coherent mode
 - Relevance of new regime?

