Thermal interaction of plasma with Gas Puffing

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Fuelling on ITER : a fundamental and open issue

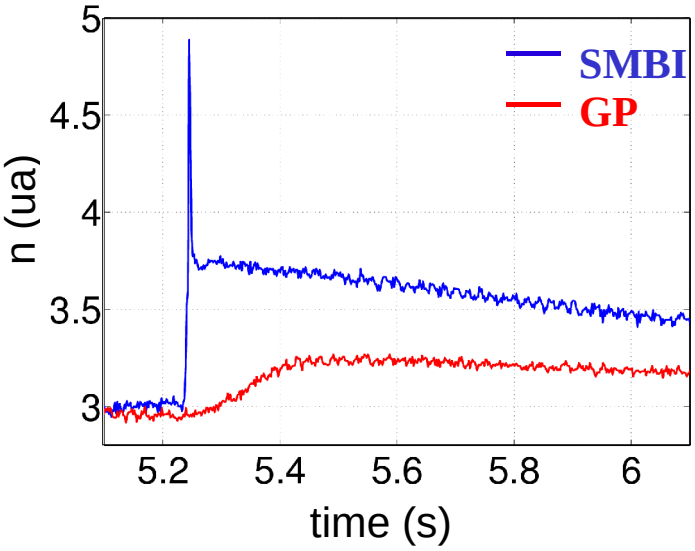
- ITER H-mode :
  - ➔ steep and high pedestal (T_e = 3-5 keV)
  - ➔ very large particle injection required

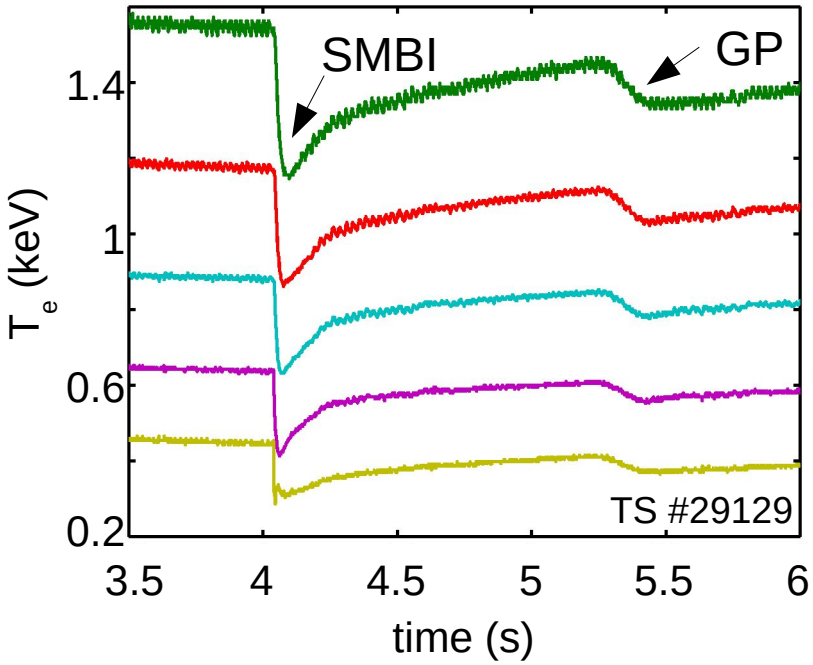
- practical issue : what kind of fuelling in ITER ?
  - ➔ feasible with Gas Puffing (GP) only ?
  - ➔ consequence on confinement

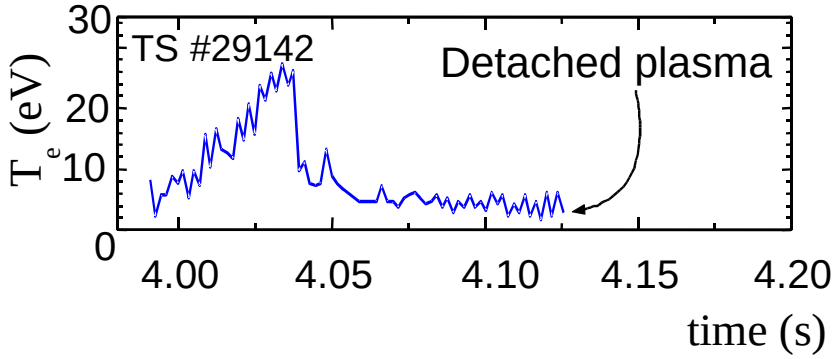
- theoretical issue :
  - ➔ influence of GP on plasma pedestal
  - ➔ influence of plasma profile on matter deposition

Close interaction between plasma profiles and GP

- Strong influence of the injection on the plasma
- Mater deposition dependent on plasma conditions, particularly thermal

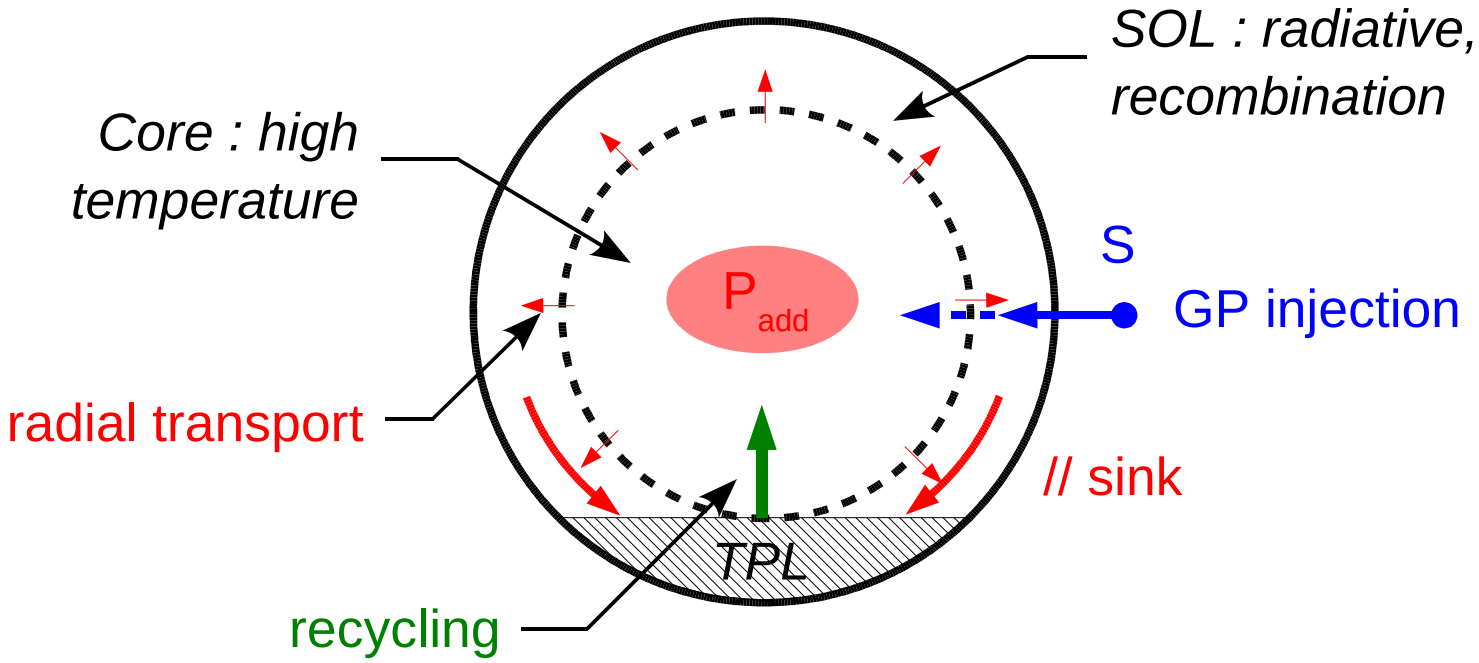






0D reservoir model

Matter and energy balance in 2 reservoirs : SOL & core



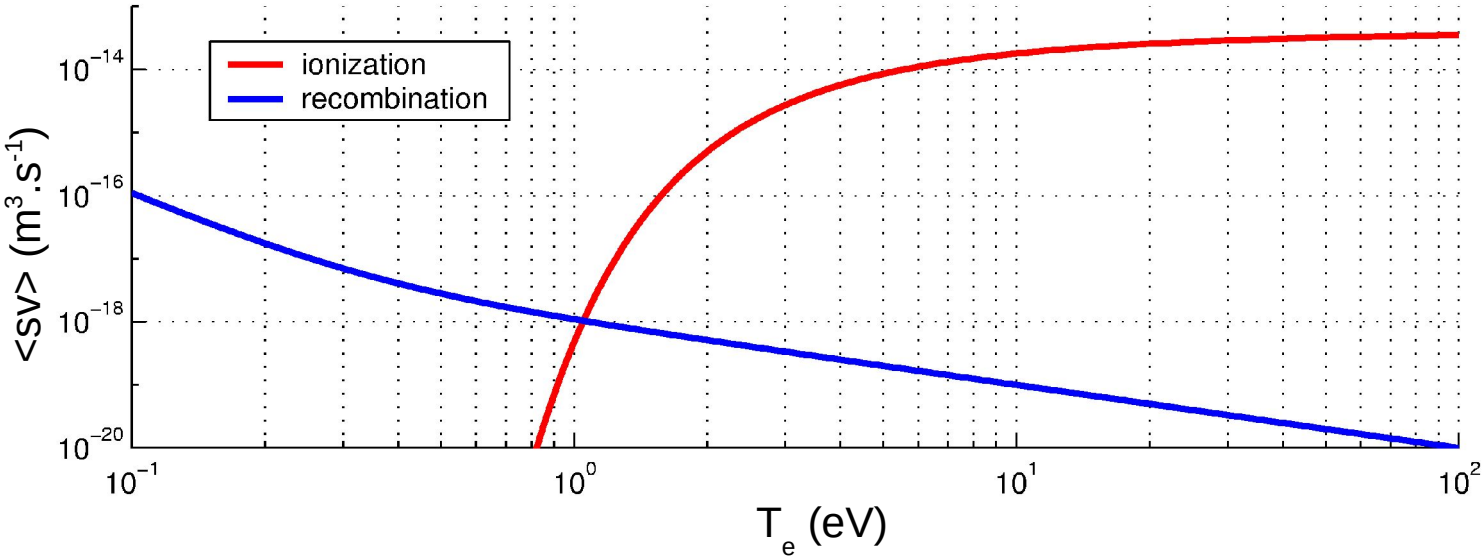
Main parameters : P_{add}, S, C_z

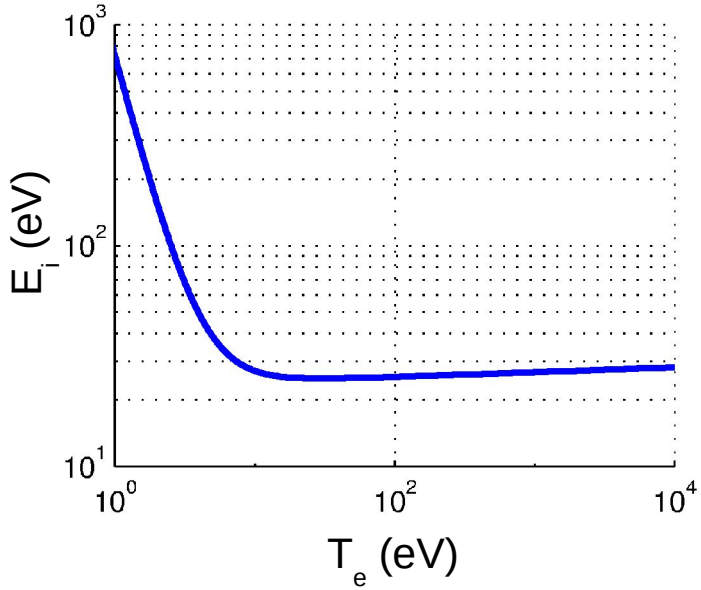
$$n\sqrt{T} \propto S$$

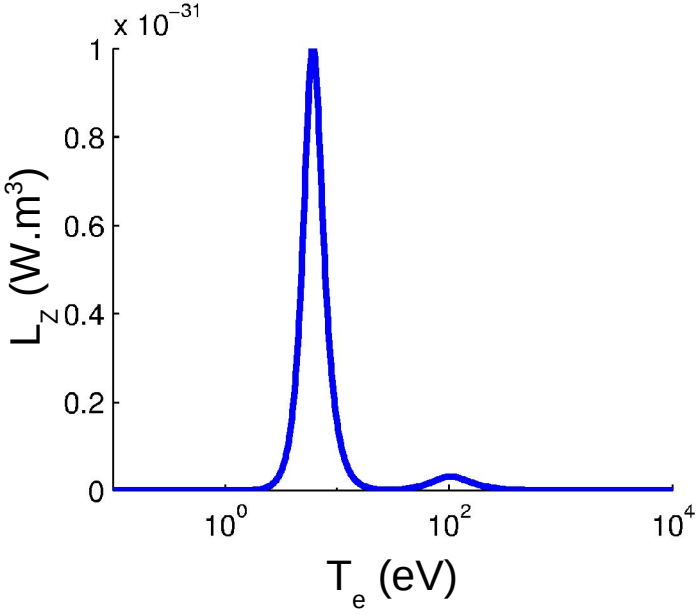
$$nT\sqrt{T} \propto P_{add}$$

$$\frac{P_{add}}{S}$$

T_e dependances

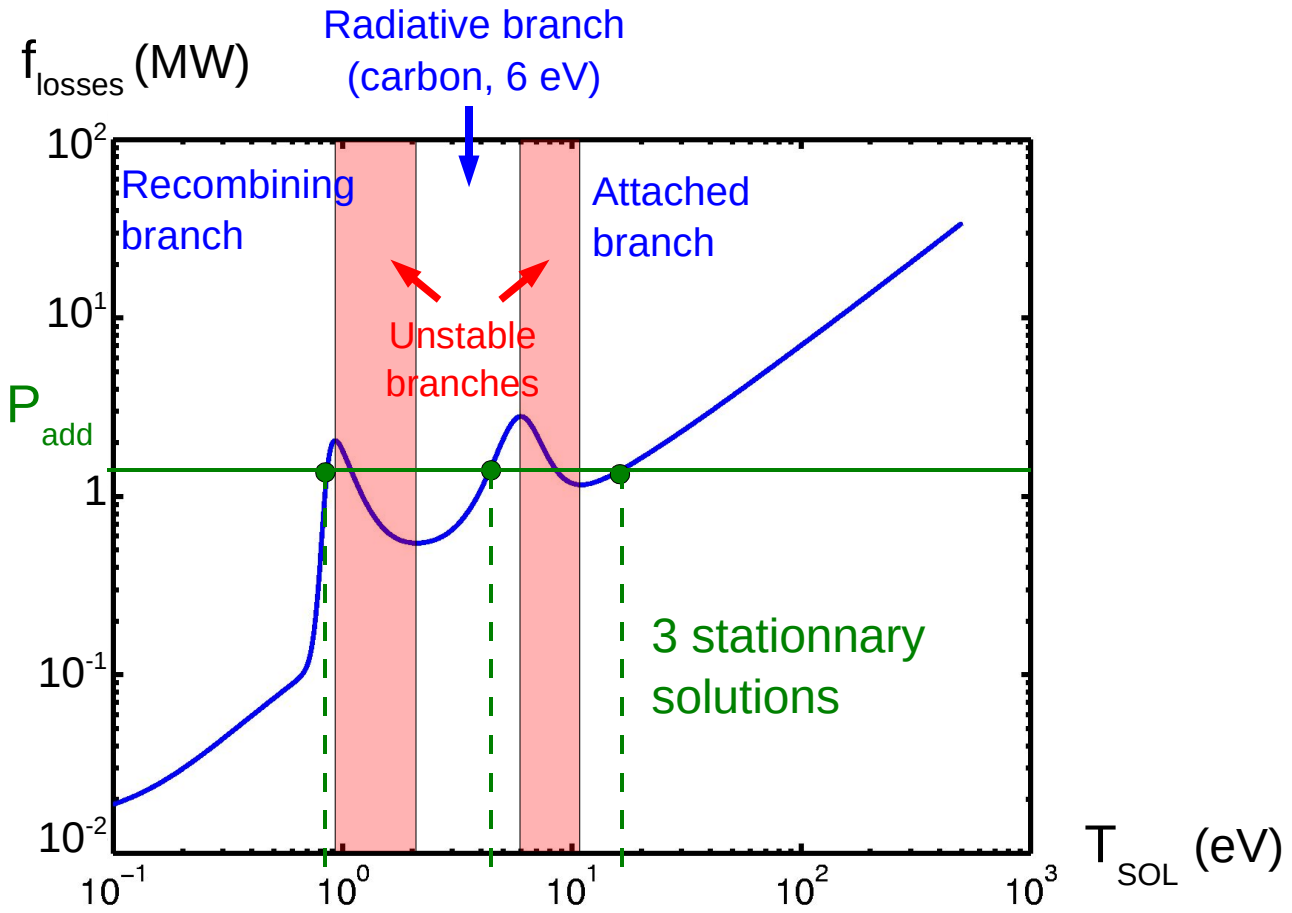






GP can trigger thermal bifurcations

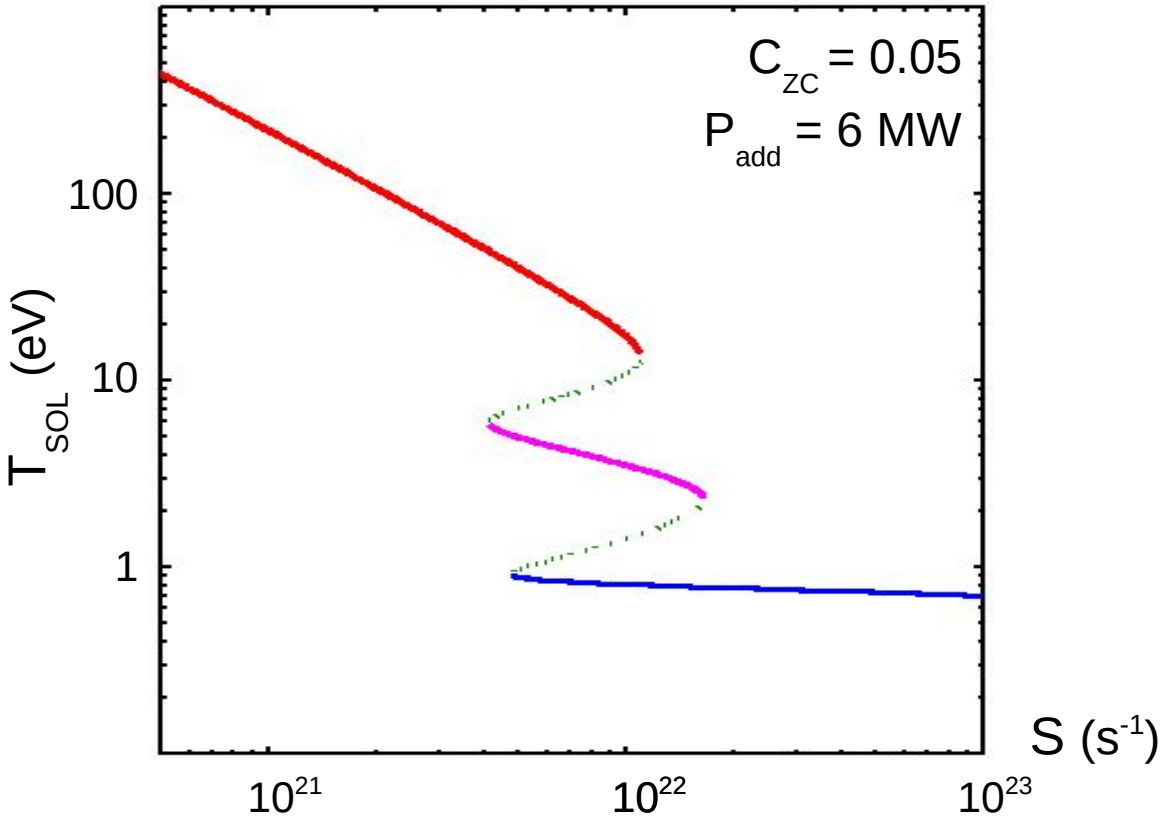
Steady state : $P_{add} = f_{losses}(T_{SOL}, S, ...)$ $\longrightarrow$ $T_{SOL} = f(S, P_{add}, ...)$



Thermal bifurcations (2)

GP can trigger thermal bifurcations

Steady state : $P_{add} = f_{losses}(T_{SOL}, S, ...)$ → $\boxed{T_{SOL} = f(S, P_{add}, ...)}$

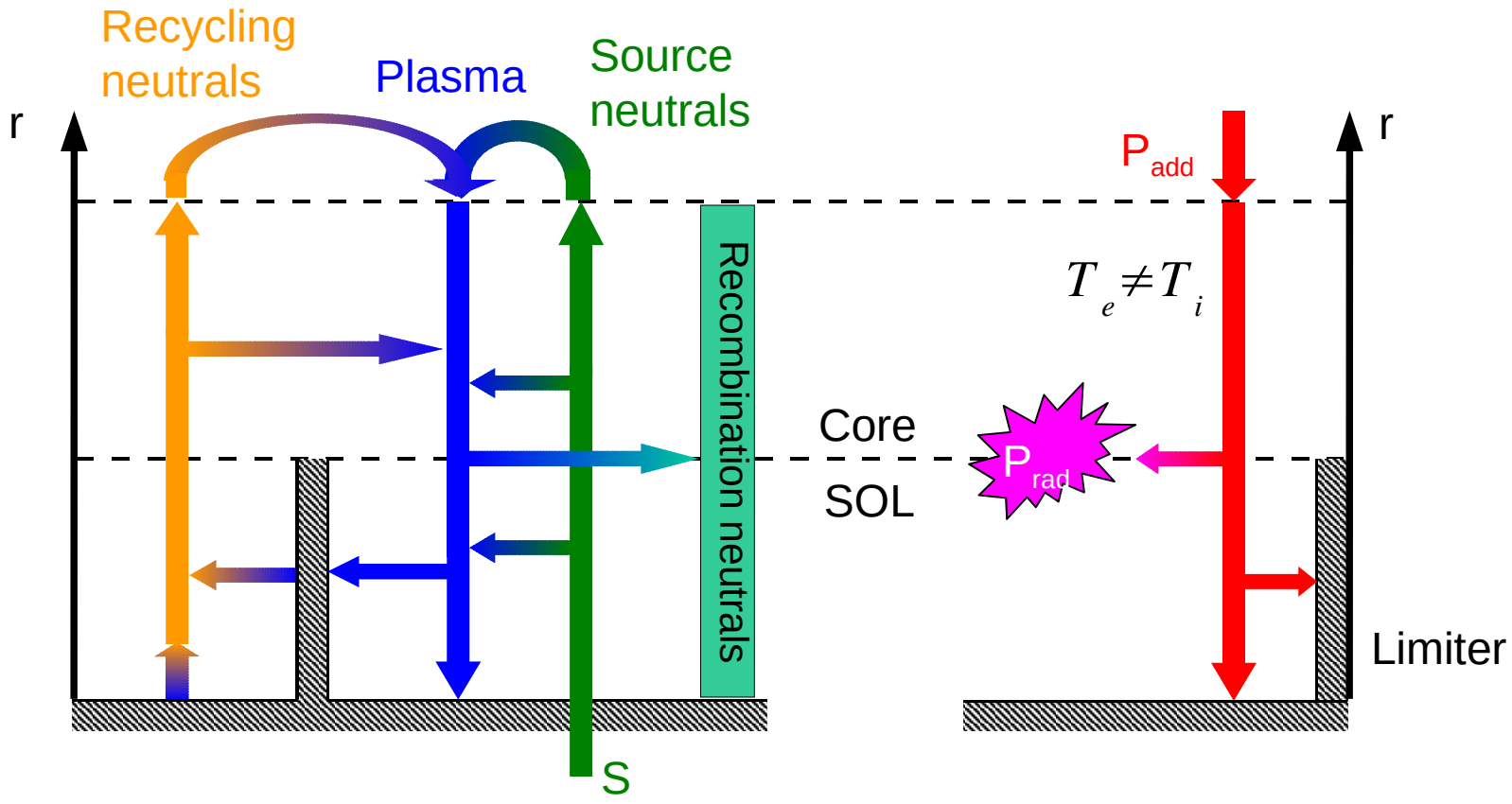


Radial dynamics : model

1D radial model

~ same as previous 0D model

➔ fluid description, 3 neutral species

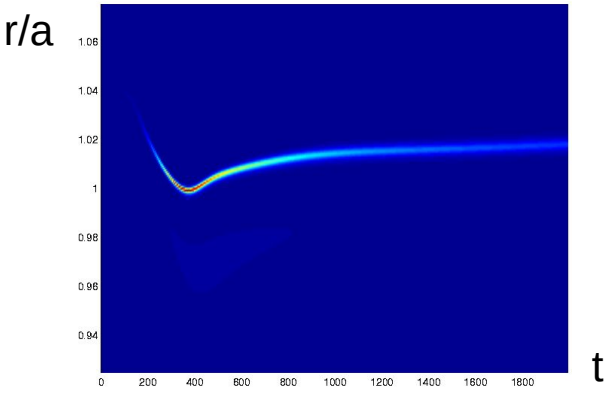


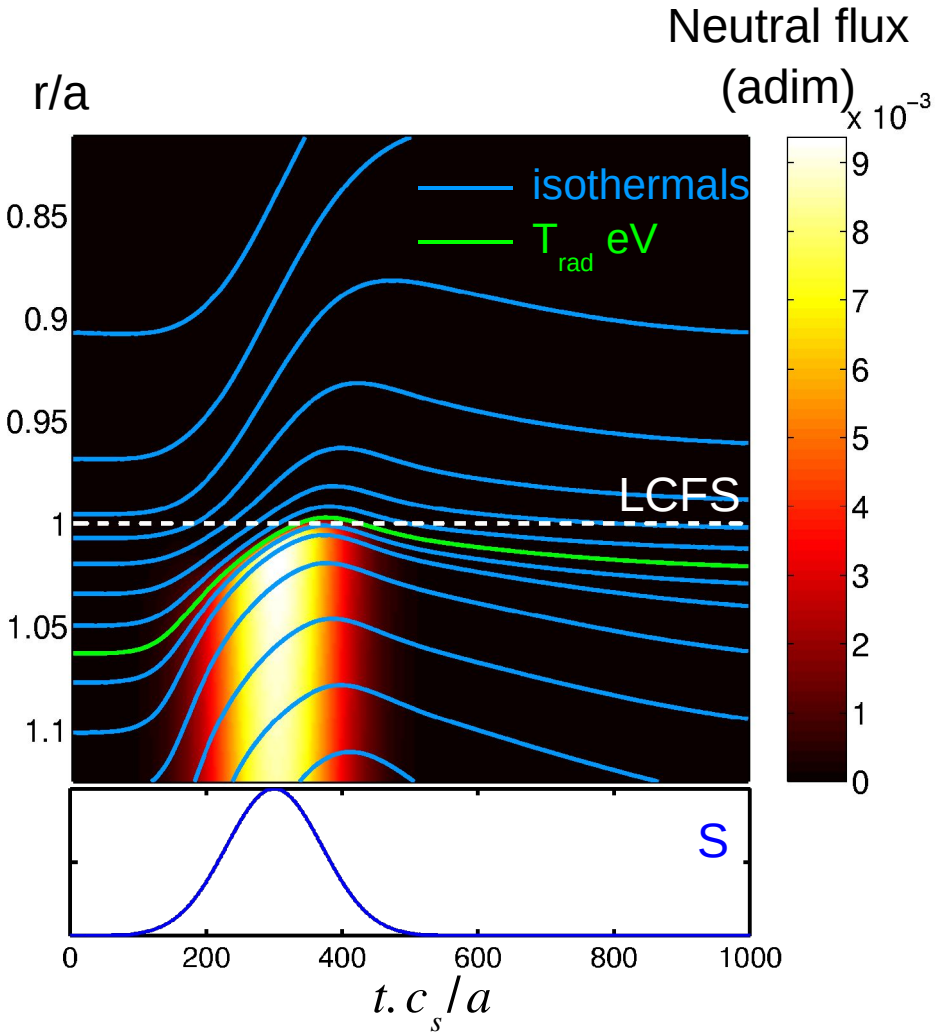
Plasma radial response to GP

Propagation of a cold front into the plasma

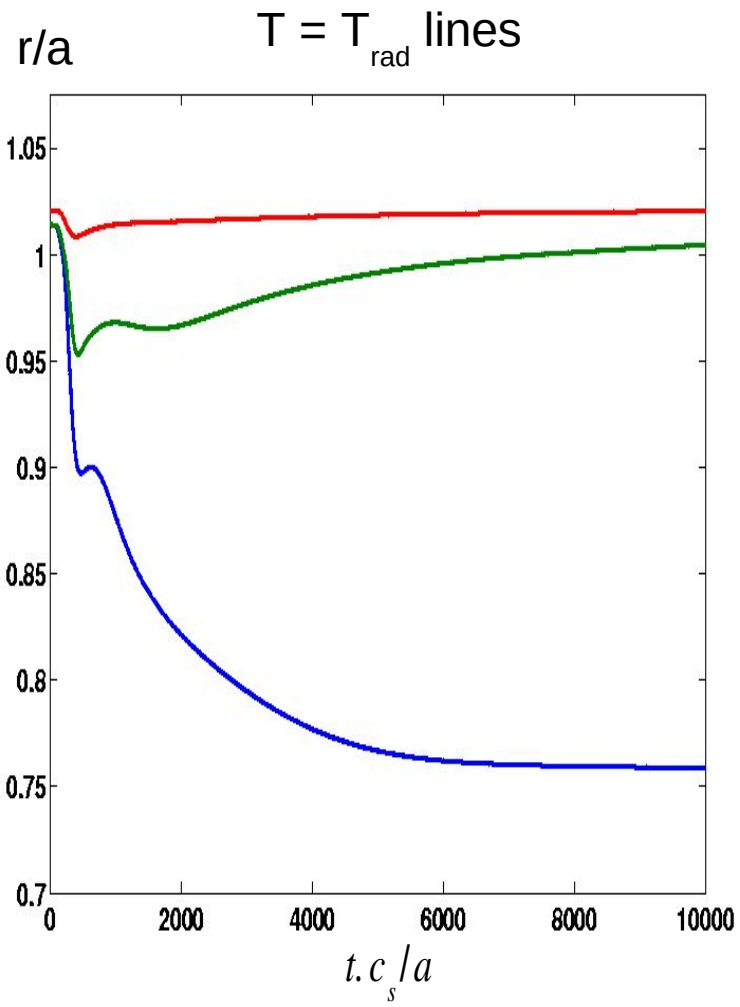
Cold front which propagates into the plasma

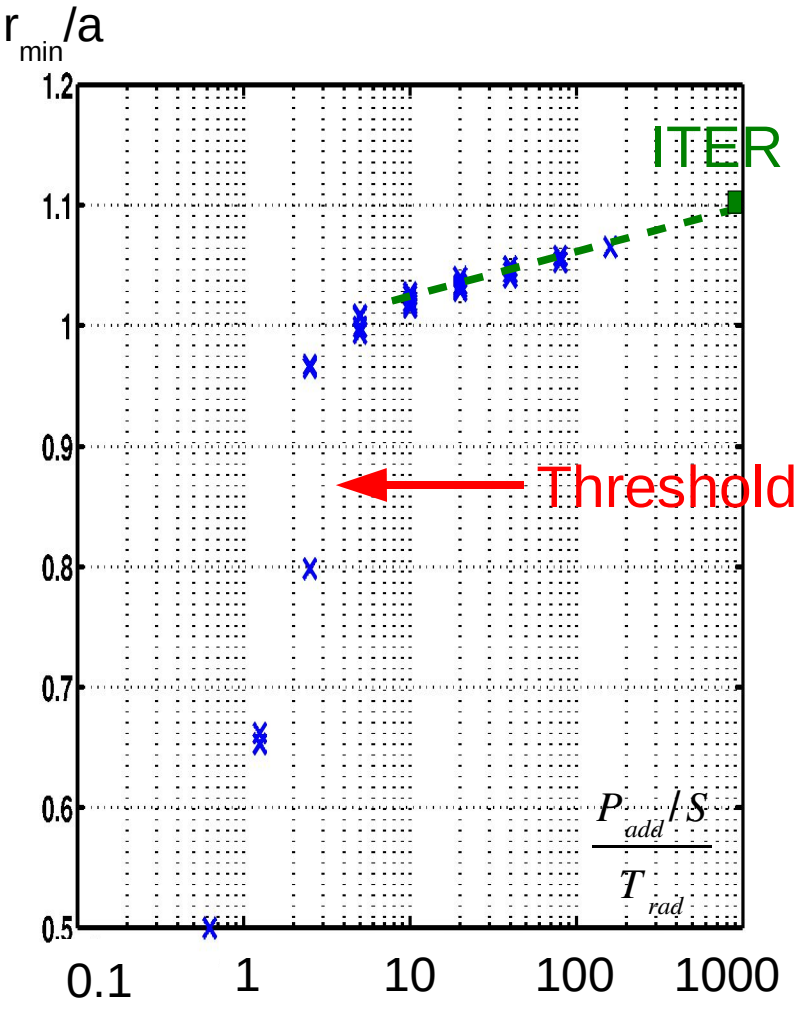
- ➔ steep temperature gradient
- ➔ radiative layer
- ➔ very localized matter deposition





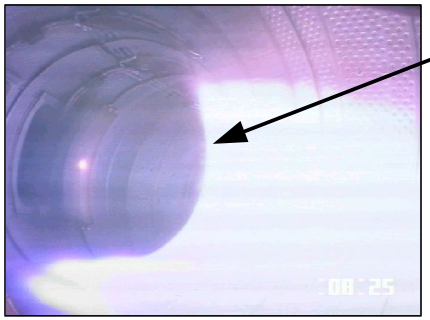
Perturbation depth dependence with P_{add}/S

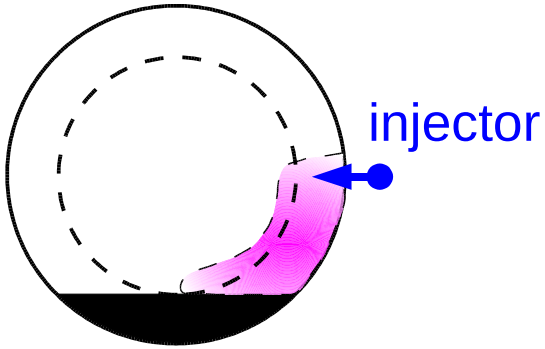




Parallel localization ?

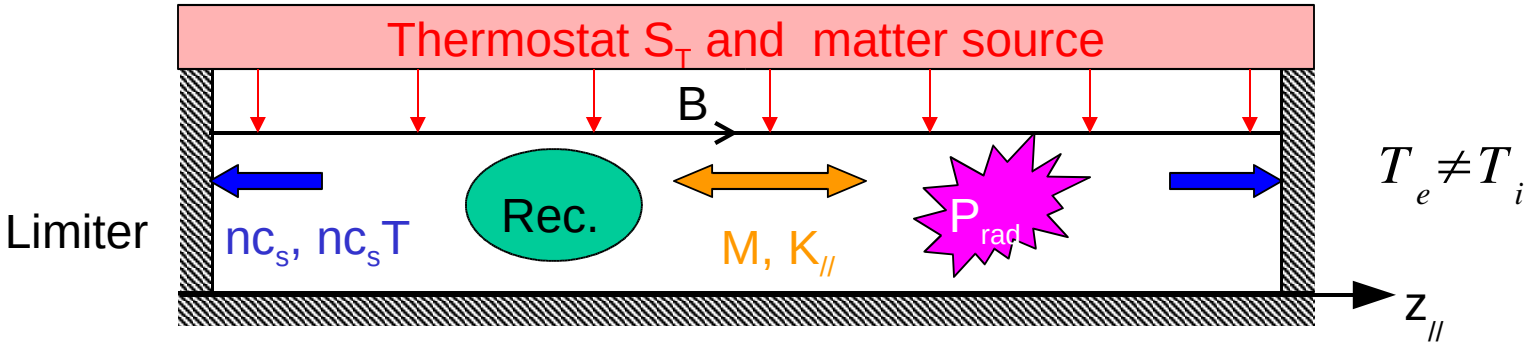
Experimental clue





- indication of non-homogeneity along parallel direction

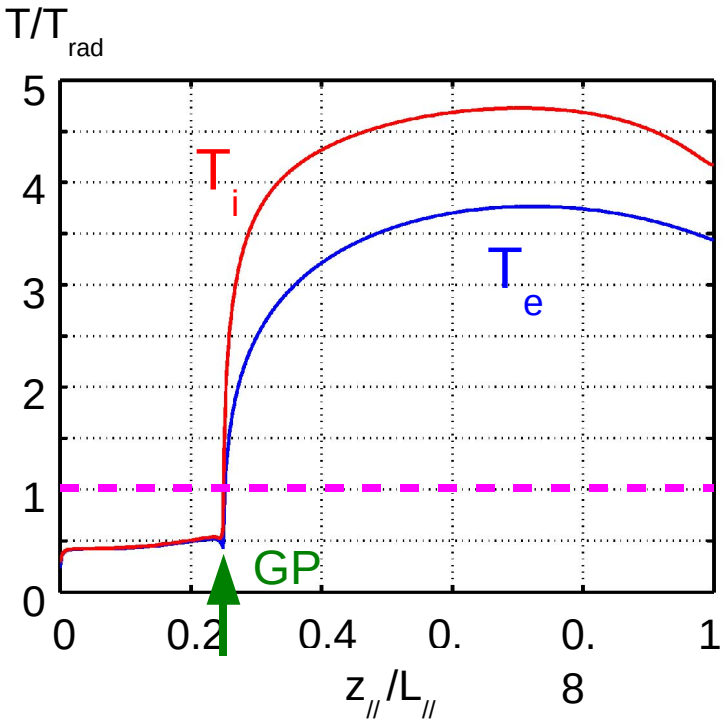
1D parallel model in the SOL

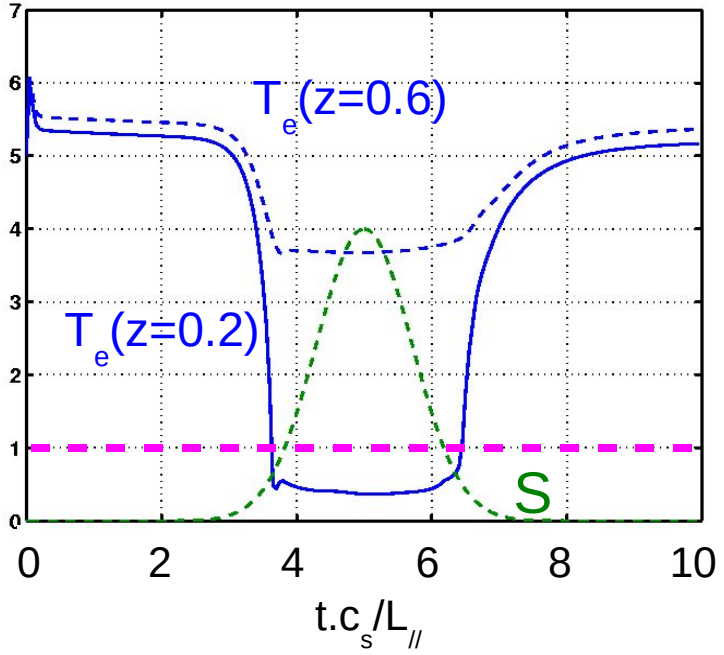


Plasma // response to GP

Localized bifurcation of the SOL along parallel direction

- in spite of strong parallel diffusion, the thermal bifurcation can stay localized
  - ➔ "detached" plasma on the limiter side of the injector





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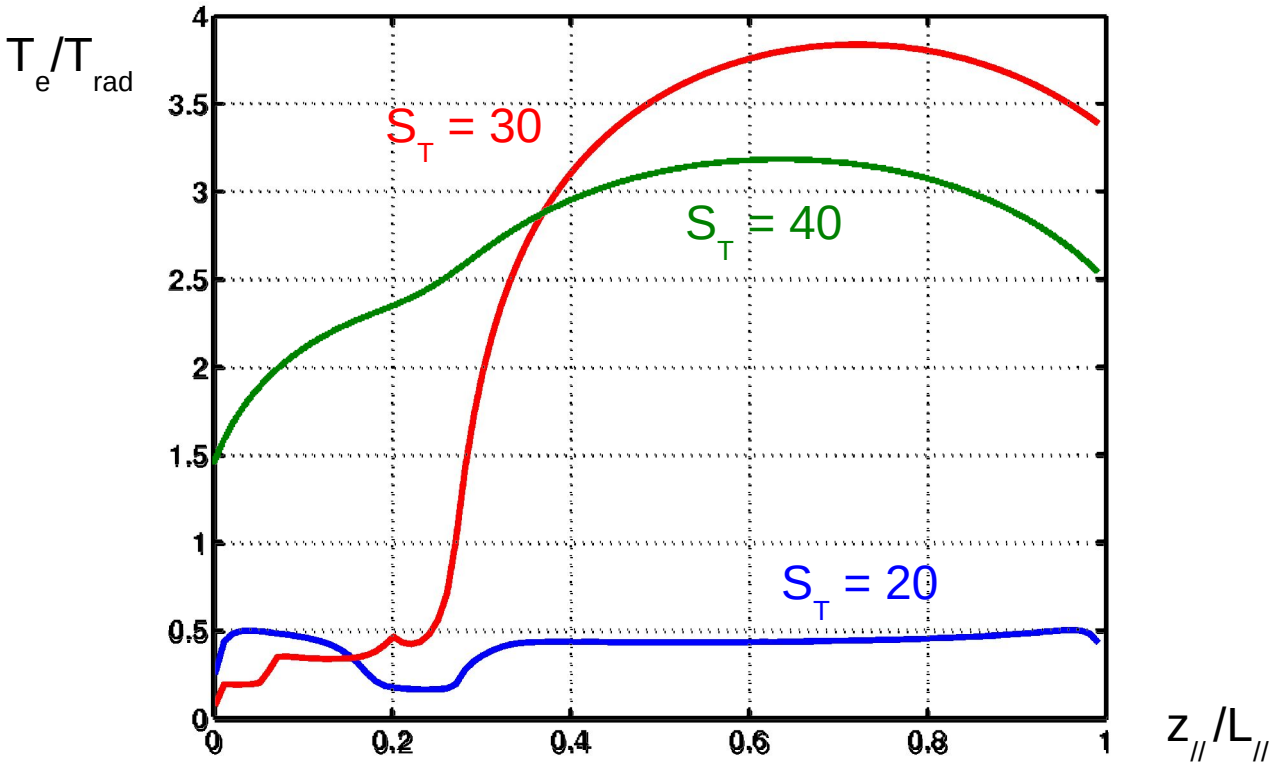
Parallel loc., parametric study

Very different birfucation regimes

- importance of the interaction with perpendicular transport



Conclusion

Thermal interaction plasma/GP : a key issue for GP mechanisms comprehension

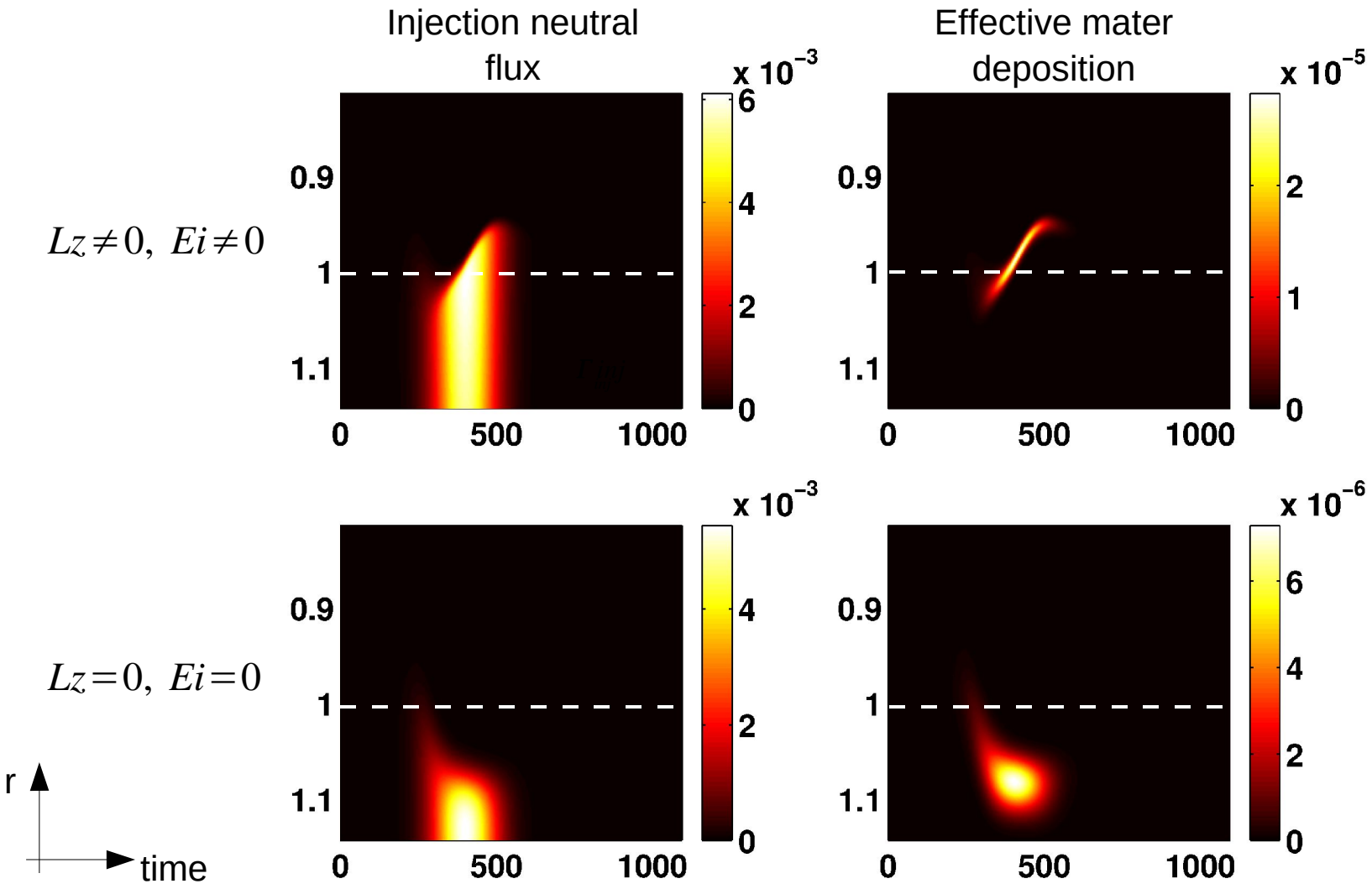
- Thermal bifurcations trigerred by GP

- Bifurcations are a key point in matter deposition and plasma reaction dynamics
  - ➔ ⚠ effect on pedestal stability

- Perturbation can remain localized along parallel direction
  - ➔ favouring penetration of the source
  - ➔ limiting negative impact of GP on confinement

- Interaction between perpendicular and parallel directions is fundamental => 2D (work in progress)

Comparison with/without bifurcations (1)



Comparison with/without bifurcations (2)