CONSORZIO RFX
Ricerca Formazione Innovazione

M3D simulations of disruptions and comparison with experiments

R. Paccagnella

In collaboration with: H. Strauss, J. Breslau, L. Sugiyama, S. Jardin

PPPL

MIT

This work was carried out in the framework of an **ITER/F4E contract** about :

M3D validation with experimental VDE data and scaling to ITER

OUTLINE:

- M3D simulations at high resolution: *(around 700,000 CPU hours on hopper)*

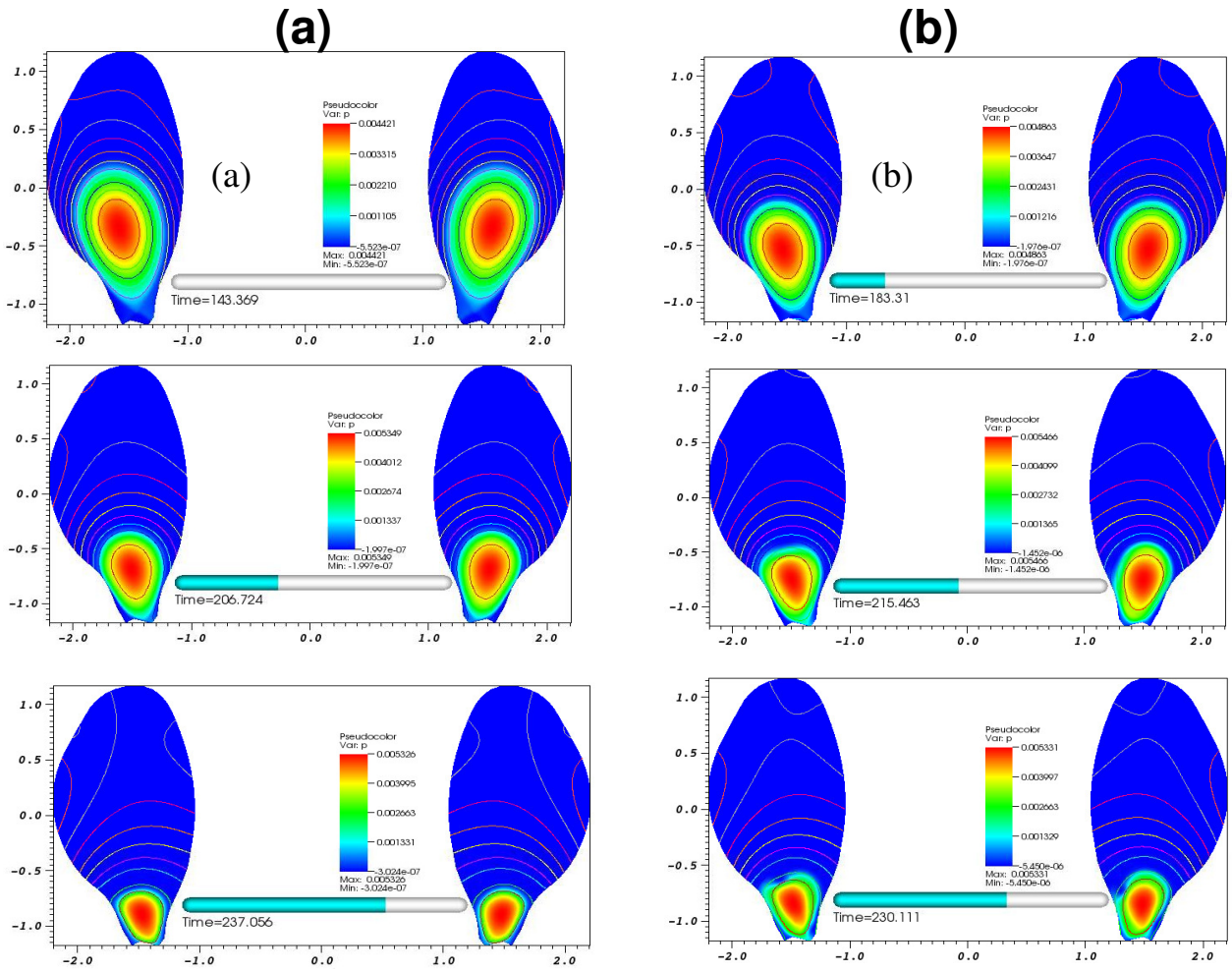
  effect of the transport coefficients changes

- comparison with some ASDEX and JET data

- M3D link with a 3D electromagnetic code

- Discussion/Conclusions

AUG initial eqdsk-equilibrium



Symmetric VDE **Non Symmetric VDE**

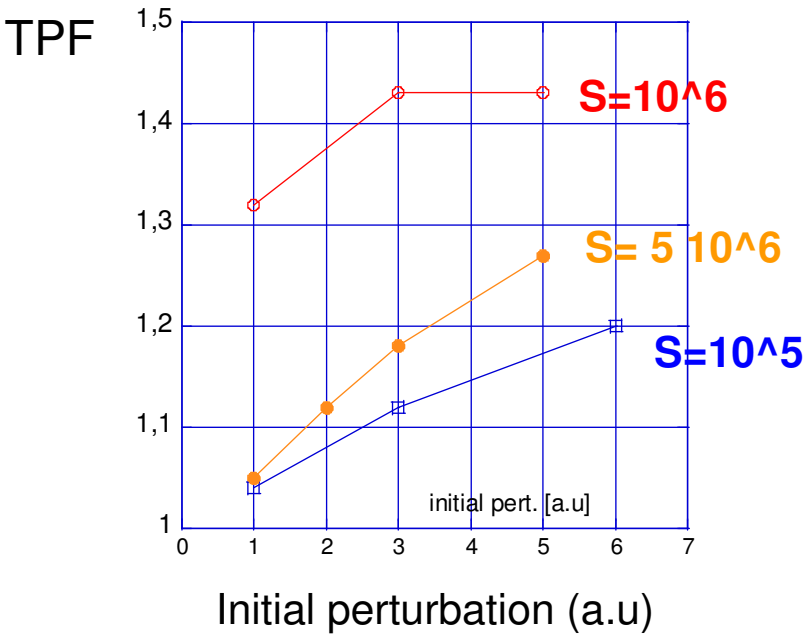
S= 5 10^6

16 toroidal planes

30000 vertices per plane

Observation:For small initial perturbations at high S the VDE remain symmetric

Effect of the initial perturbation

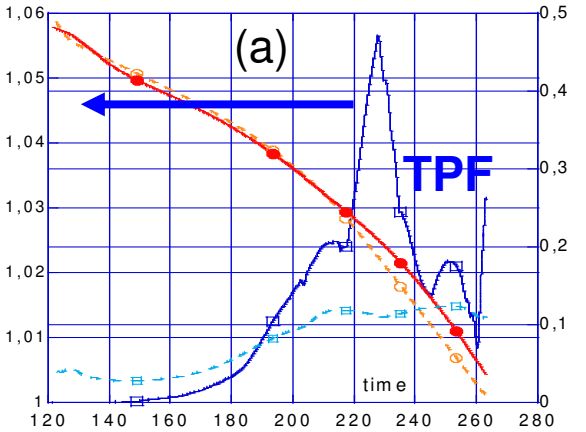


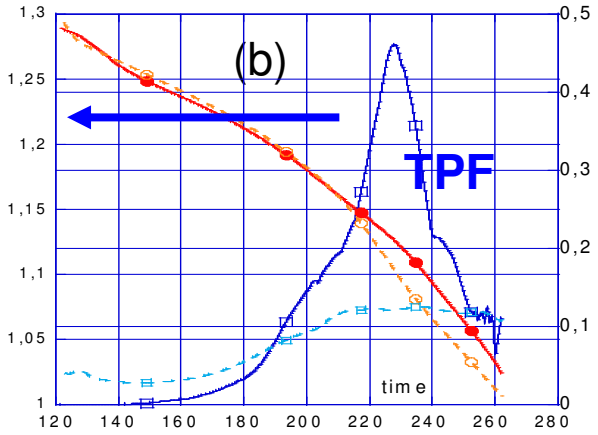
TPF = max (I_halo(ϕ)) / < I_halo >

I_halo → J_normal @ wall

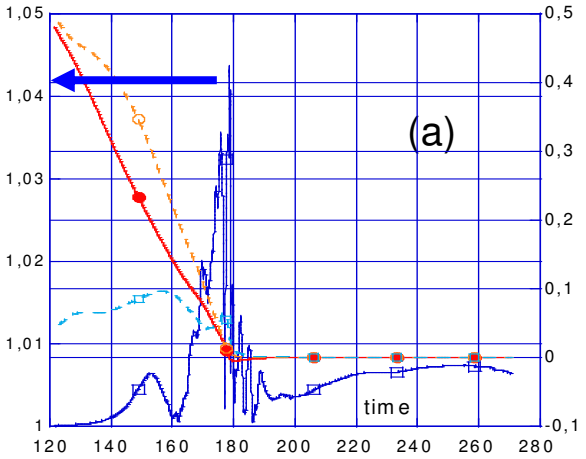
Note: at lower resolution
Initial perturbation often not needed to produce non symmetric cases

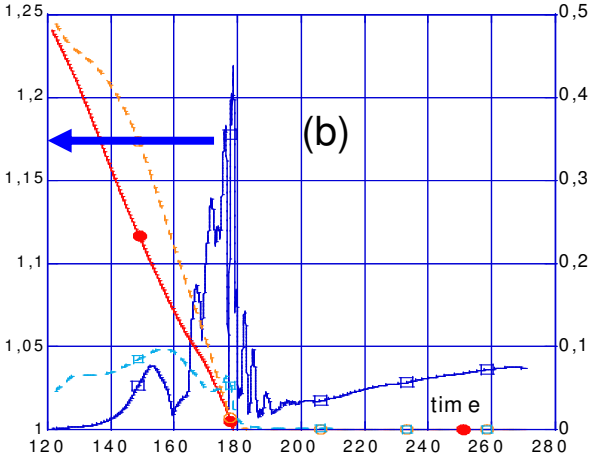
TPF, Current, pressure vs. Time (cases (a) and (b)): different S





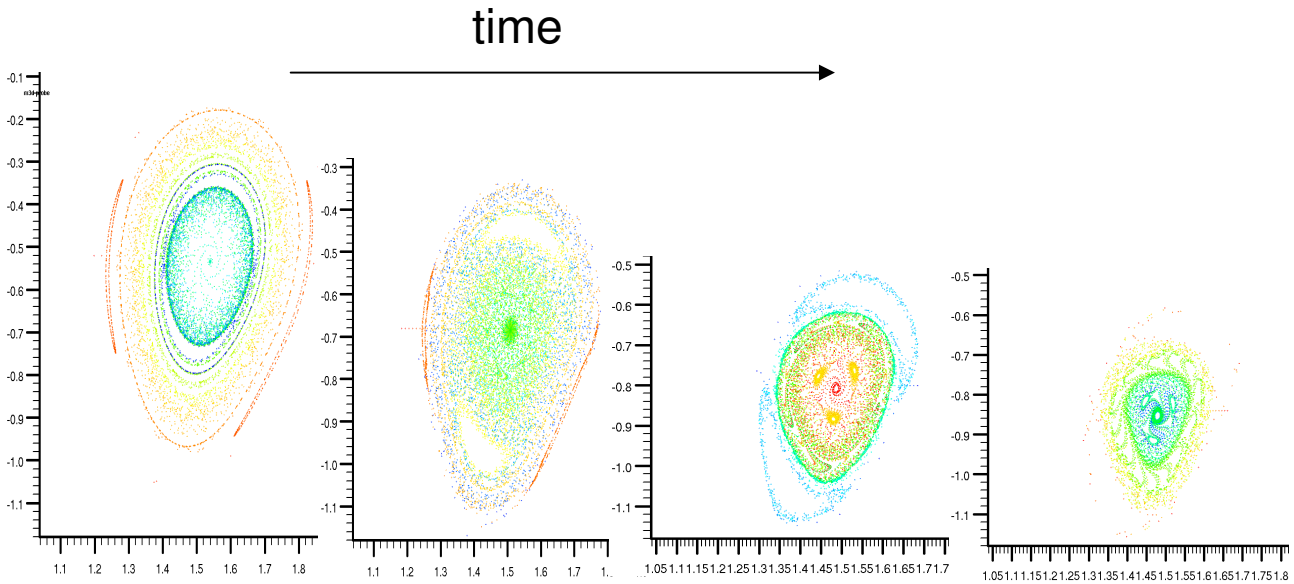
S=5 10^6





S=10^5

During VDE a 2/1 resistive mode develops, producing field line stochasticity



2 competing mechanisms:

- n=0 VDE determined by tau_wall (but also by S → current channel diffusion)
- n=1 resistive kink growth

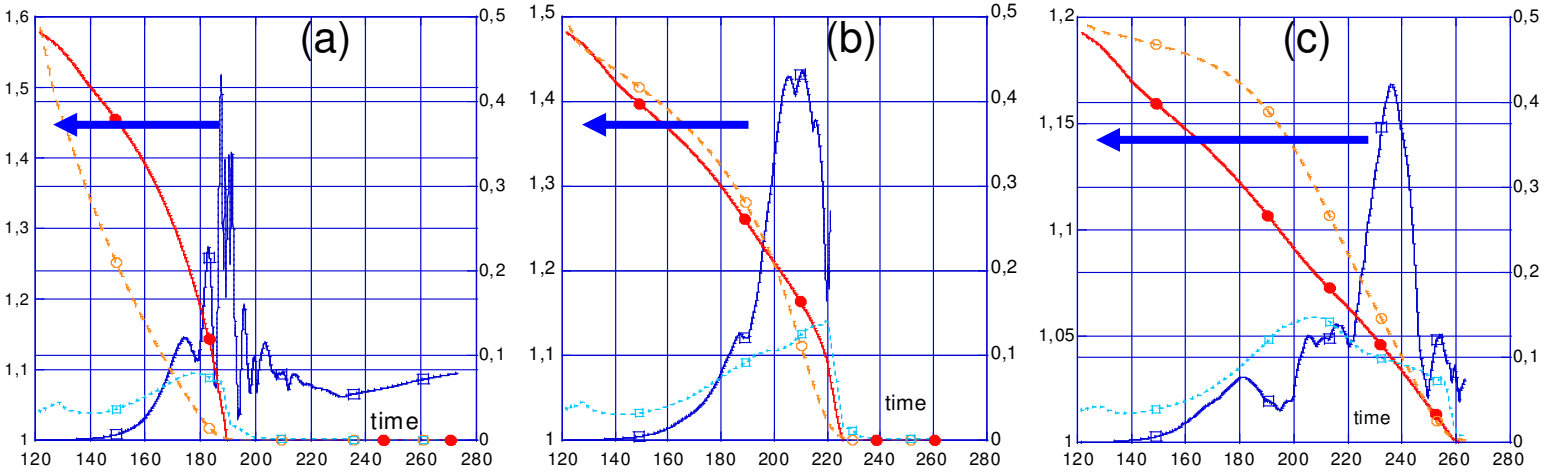
NUMERICALLY DIFFICULT to resolve well both this 2 time scales (tau_wall too short)

TPF, Current, pressure vs. Time (cases (a) and (b)): different χ_perp

χ_perp= 10^-3

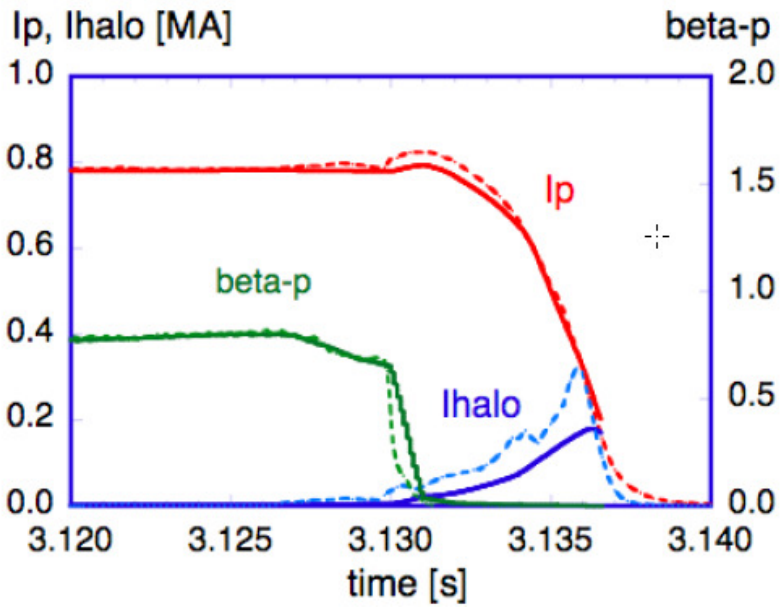
χ_perp= 10^-4

χ_perp= 10^-5



Thermal quench can be simulated by high χ_perp but also TPF & current relative timing is affected

ASDEX experimental data (similar in Jet) :

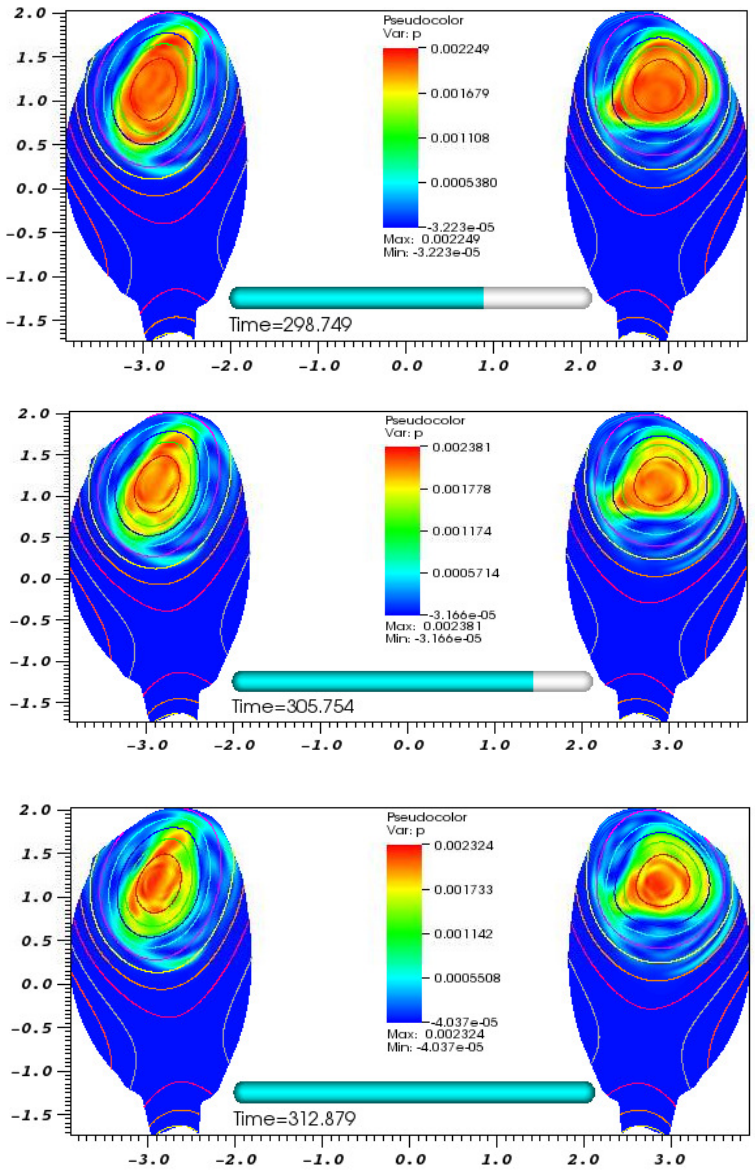


- thermal quench well before current quench
- halo max at ½ of current decay time

SIMULATIONS:

- **if χ_perp → high max-TPF too late**
- **if χ_perp low → no thermal quench bef. current quench**

A correct modelling of the thermal quench is needed



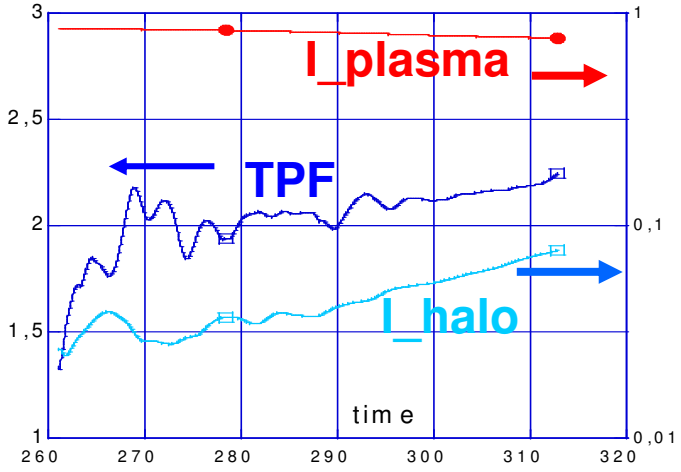
JET SIMULATION with an

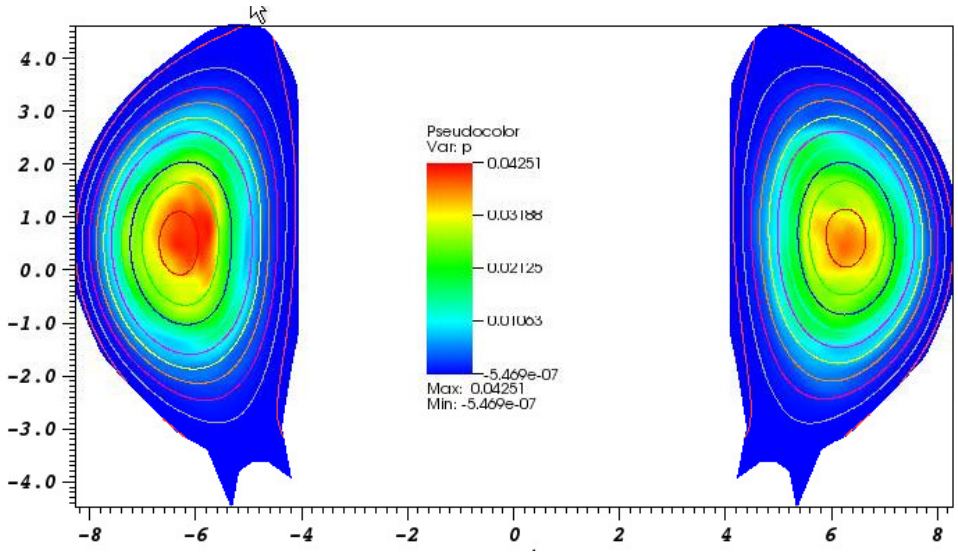
applied initial perturbation

(otherwise a 2D evolution is obtained)

...continuation needed

TPF > 2 before current decay



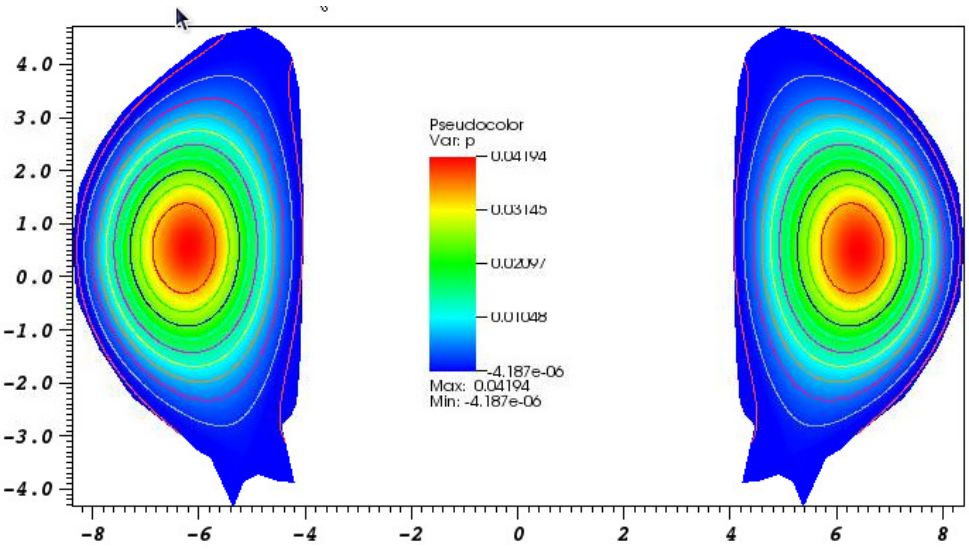


ITER case :

(16 toroidal planes
195,000 triangles x plane)

Initial perturbation with q(0) < 1

...Time continuation needed



Initial perturbation with q(0) > 1 (Eqdsk from F4E)

DISCUSSION:

- good separation of time scales is difficult
- good simulation of thermal quench is probably needed to provide reliable initial conditions for the VDE phase

3 stages of disruptions:

(i) vertical drift
(ii) thermal quench
(iii) current quench

Proposal:

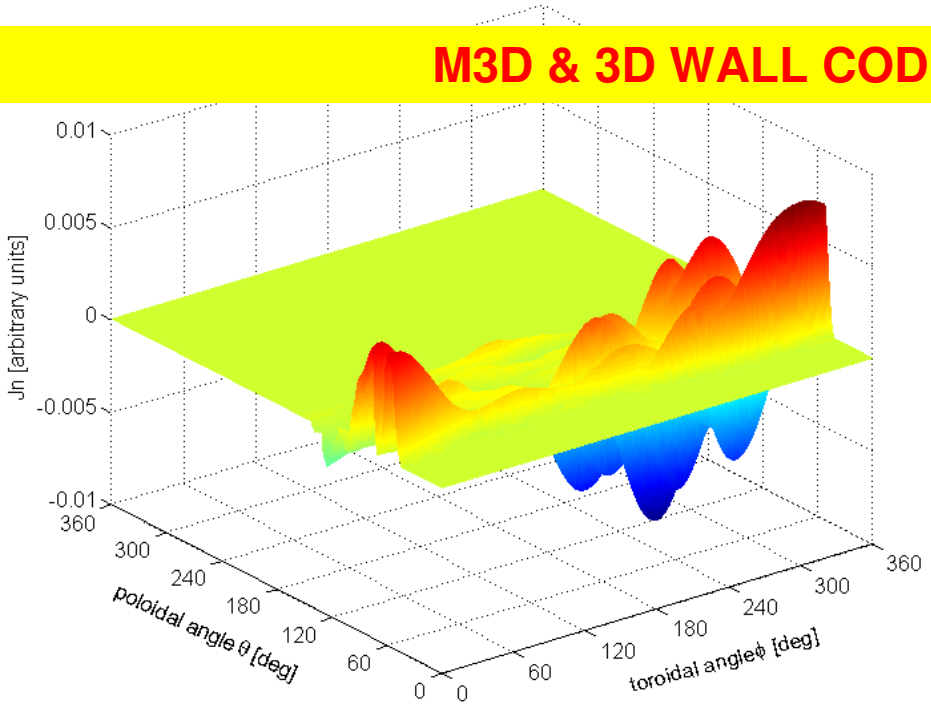
(i) Simulation mostly in 2D (like TSC or DINA)

(ii) High time and spatial resolution needed (maybe M3D-C1..)

(iii) Realistic wall time and wall structure needed

..next

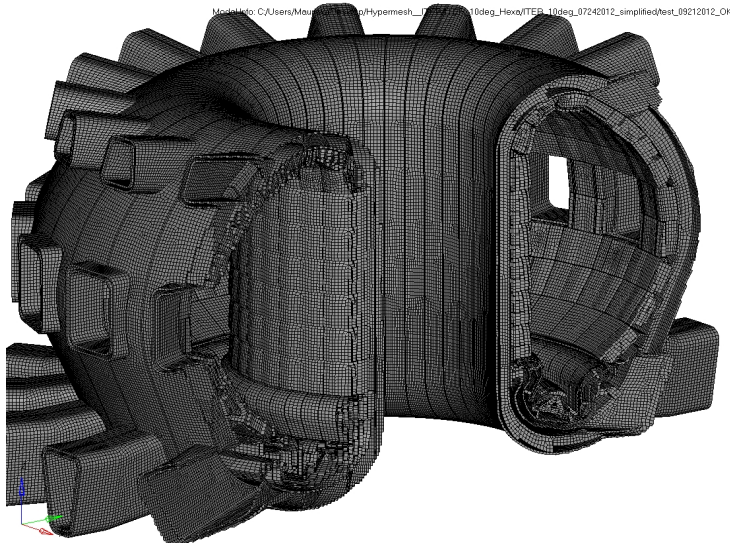
M3D & 3D WALL CODE (WEAK) COUPLING

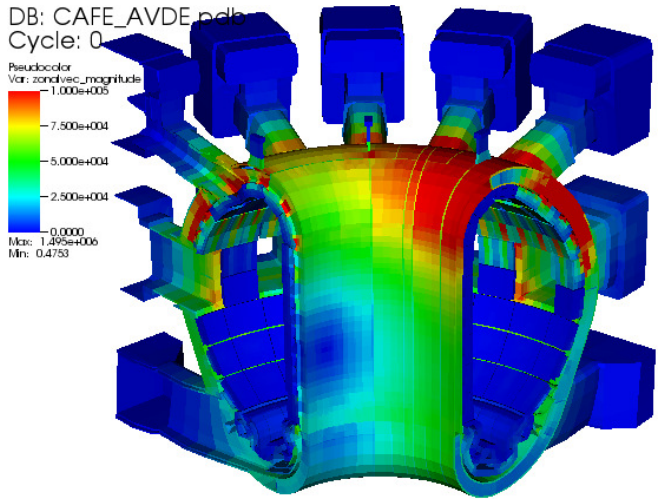


..Work in progress

M3D halo distribution @ wall

ITER 3D WALL MESH





Realistic Wall current distribution

CONCLUSIONS:

- high S, high resolution M3D simulations of AUG, JET and ITER has been done
- comparison with data not completely satisfactory
- **time separation of VDE (2D) and MHD (3D) should be addressed**
- **good thermal quench simulation needed**
- **several separate steps of the simulation probably needed**
- **realistic walll coupling needed for force evaluation on structures**