Deuterium MGI in ASDEX Upgrade Geometry

(First Preliminary Results)

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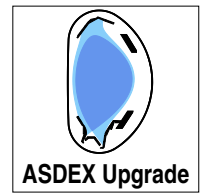


1. Experiments at ASDEX Upgrade
2. Deuterium MGI Simulations
3. Scans Performed
4. Observed Dynamics
5. Summary & Outlook

Experiments

- MGI experiments have been carried out in the past with Deuterium, Argon, etc with very different amounts of gas
- New experiments could possible within the MST1 campaign or the internal program
- It seems possible to run simulations at fully realistic ASDEX Upgrade parameters
  - Low dominant mode numbers
  - High densities
  - Temperatures strongly decreasing, i.e., resistivity increasing

Overview

- **ASDEX Upgrade equilibrium**
  $q_0 = 1.1$, $n_0 = 6 \cdot 10^{19} m^{-3}$, $B_0 = 2.5T$, $I_p = 1MA$
- **No current source**
- No “regular” particle source
- (uniform heat source should have been switched off...)
- **Neutrals source at outboard midplane (toroidally weakly localized)**
- Taylor-Galerkin stabilization
- Hyperresistivity/viscosity very low
- gmres_tol=1.e-5. . . 1.e-7
- Moderate poloidal grid resolution
- **Most cases with n=0,1,2**; Some with n=0,1 and n=0,1,2,3
- **Low resistivity**

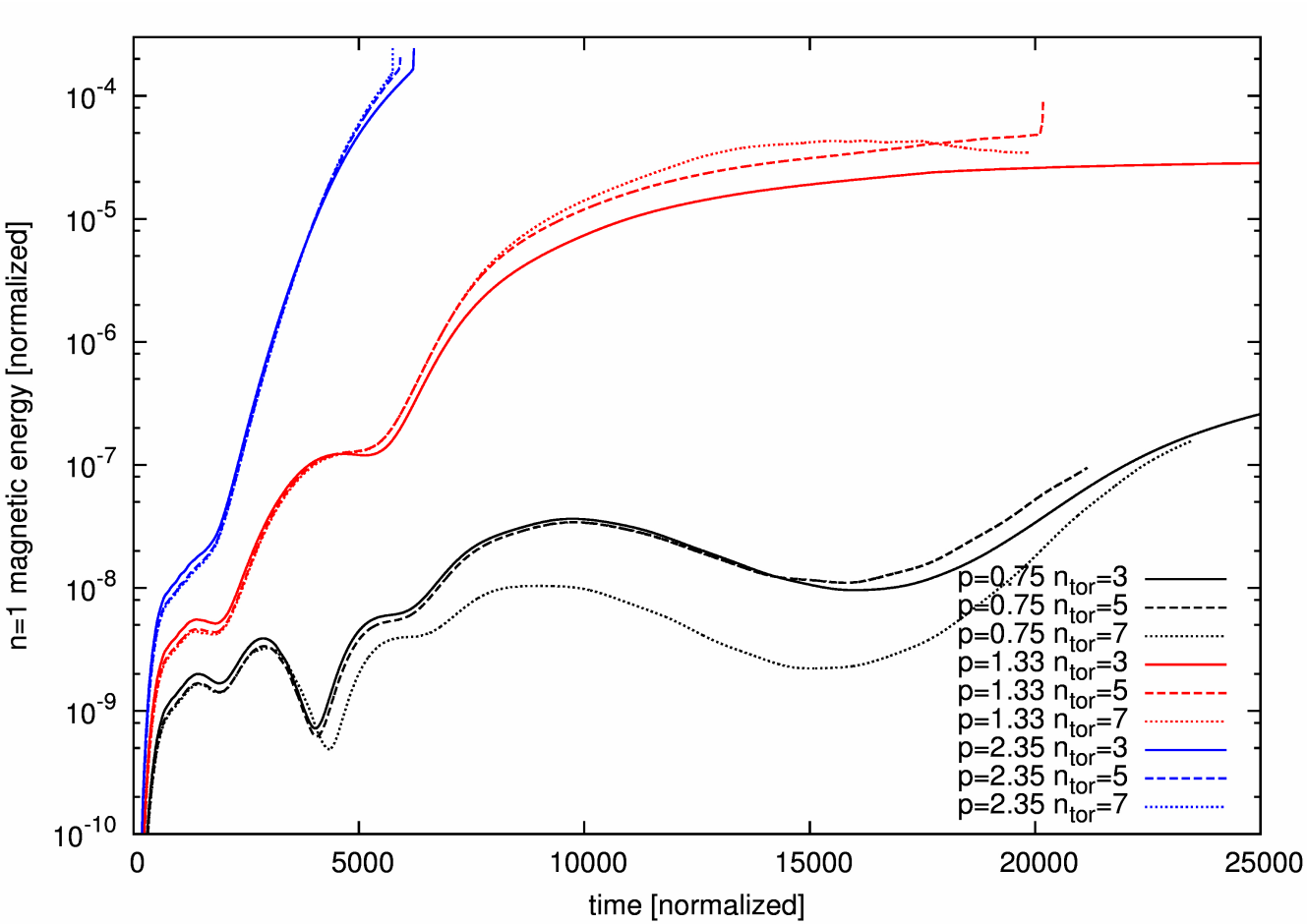
Scans

```
eta   = 3e-8
visco = 3e-7
tauIC = 5e-3
Zkpar = 1e3
n_tor = 5
```

- Scans performed:
  - Amount of Gas `p`
  - Resistivity `eta`
  - Viscosity `visco`
  - Diamagnetic Drift `tauIC`
  - Parallel Heat Conductivity `ZKpar`

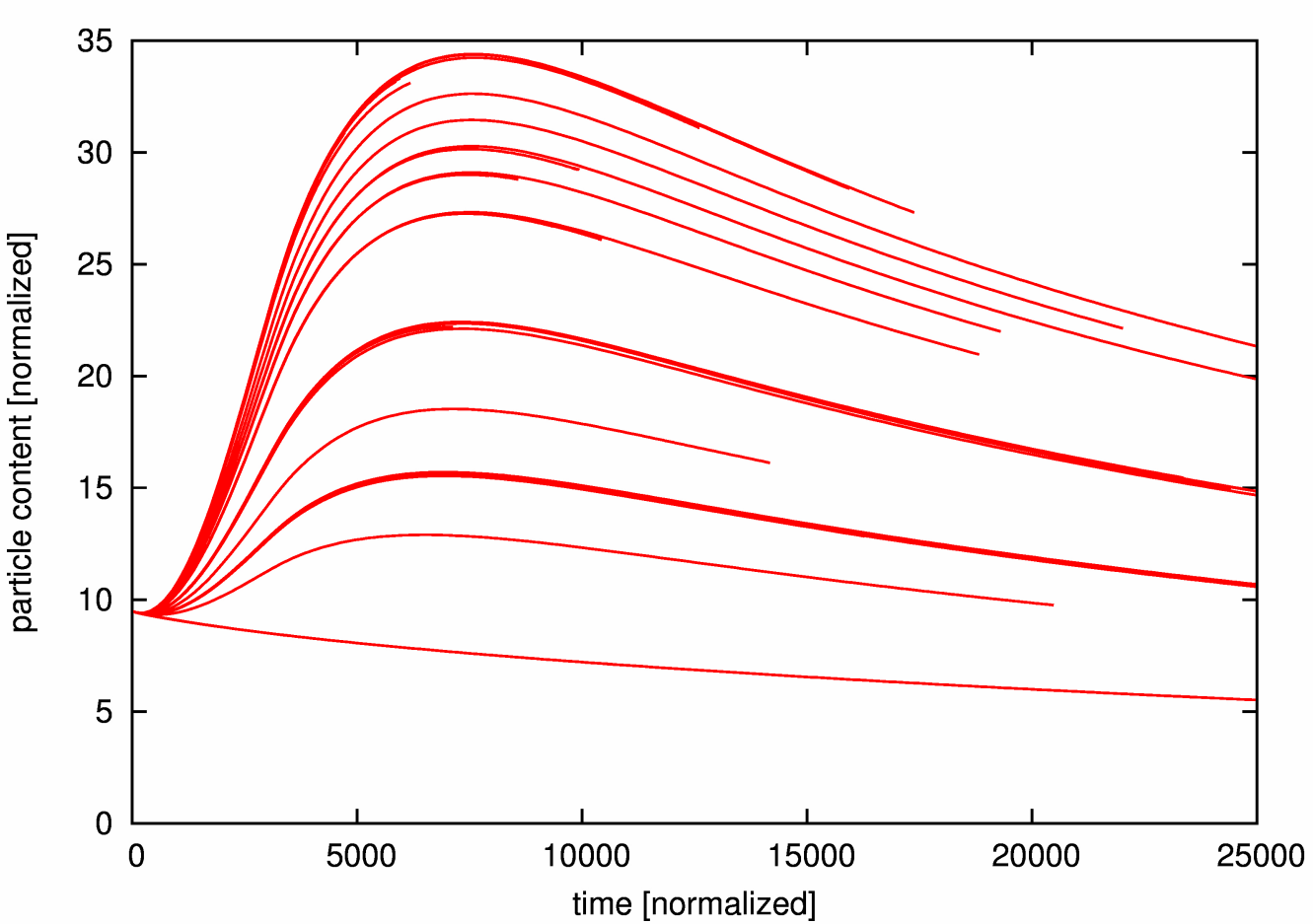
  - (Poloidal/toroidal resolution, source localization)

Convergence



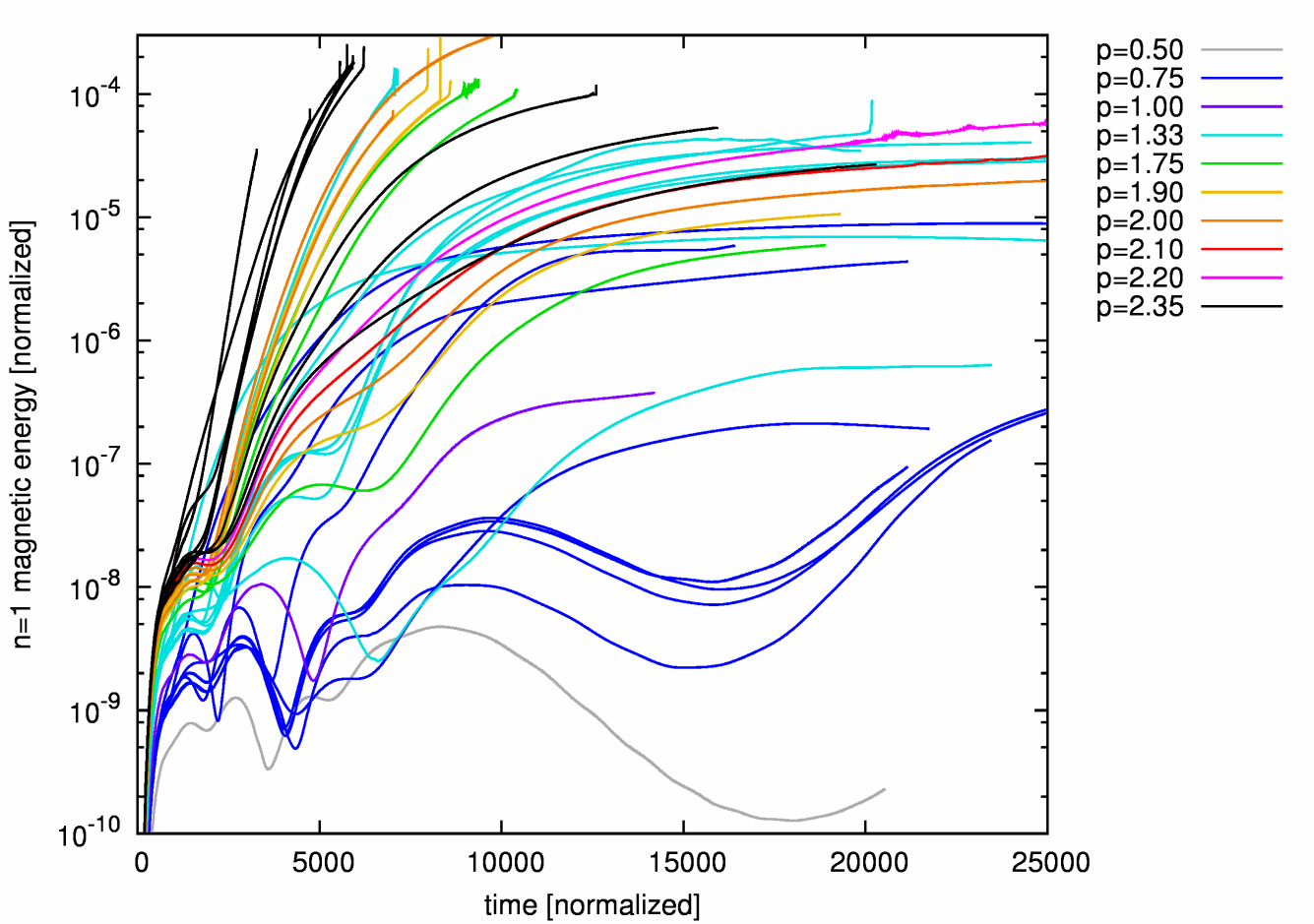
- Number of toroidal harmonics does not influence early phase significantly
- Toroidally more localized neutrals source $\rightarrow$ n=1 field perturbation remains dominant, perturbation increases (detailed comparison required)

Particle Content



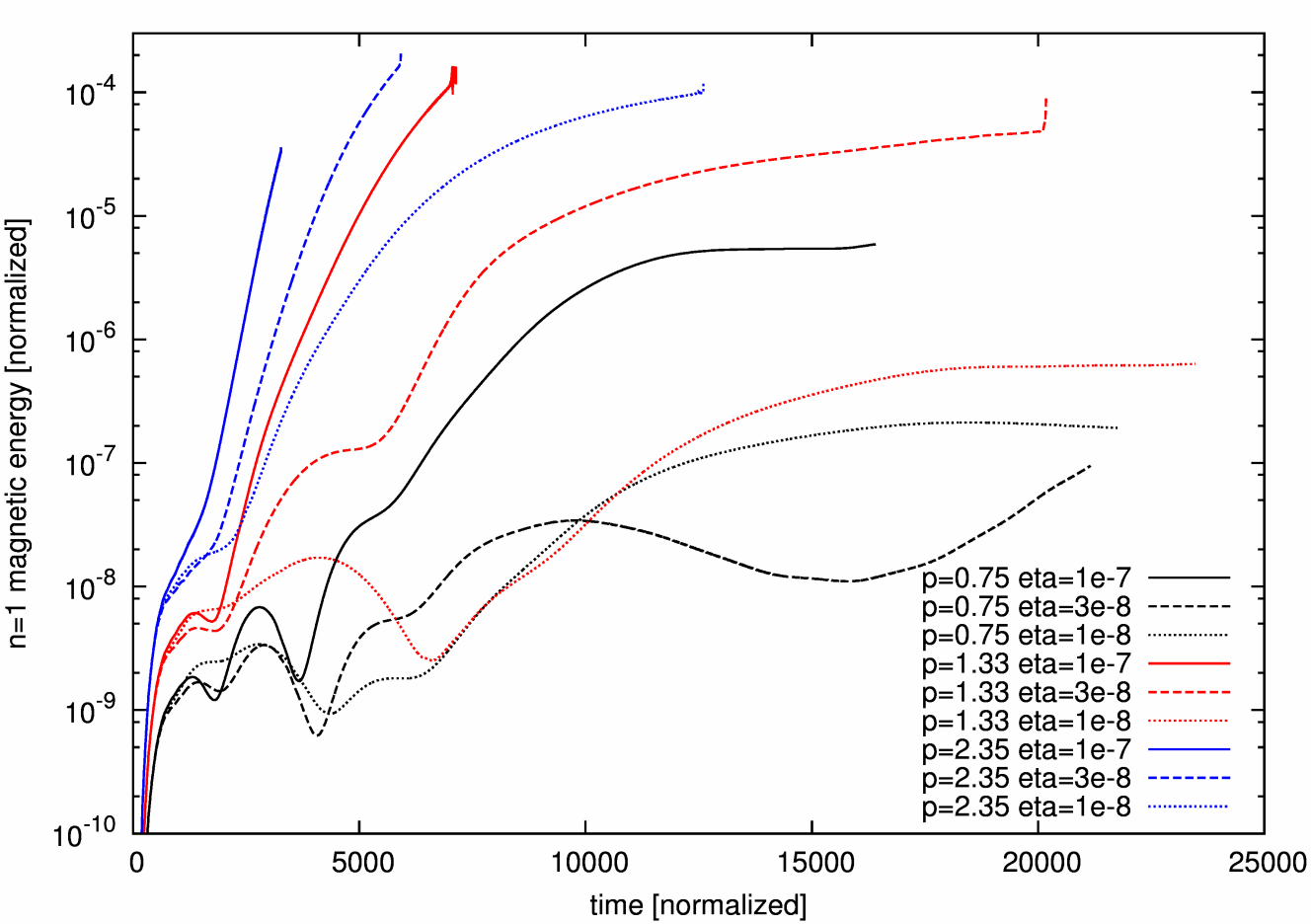
- Injection pressure 0.00. . . 2.35 bar
  (not directly comparable to experimental valve pressure)

The Simulation Zoo



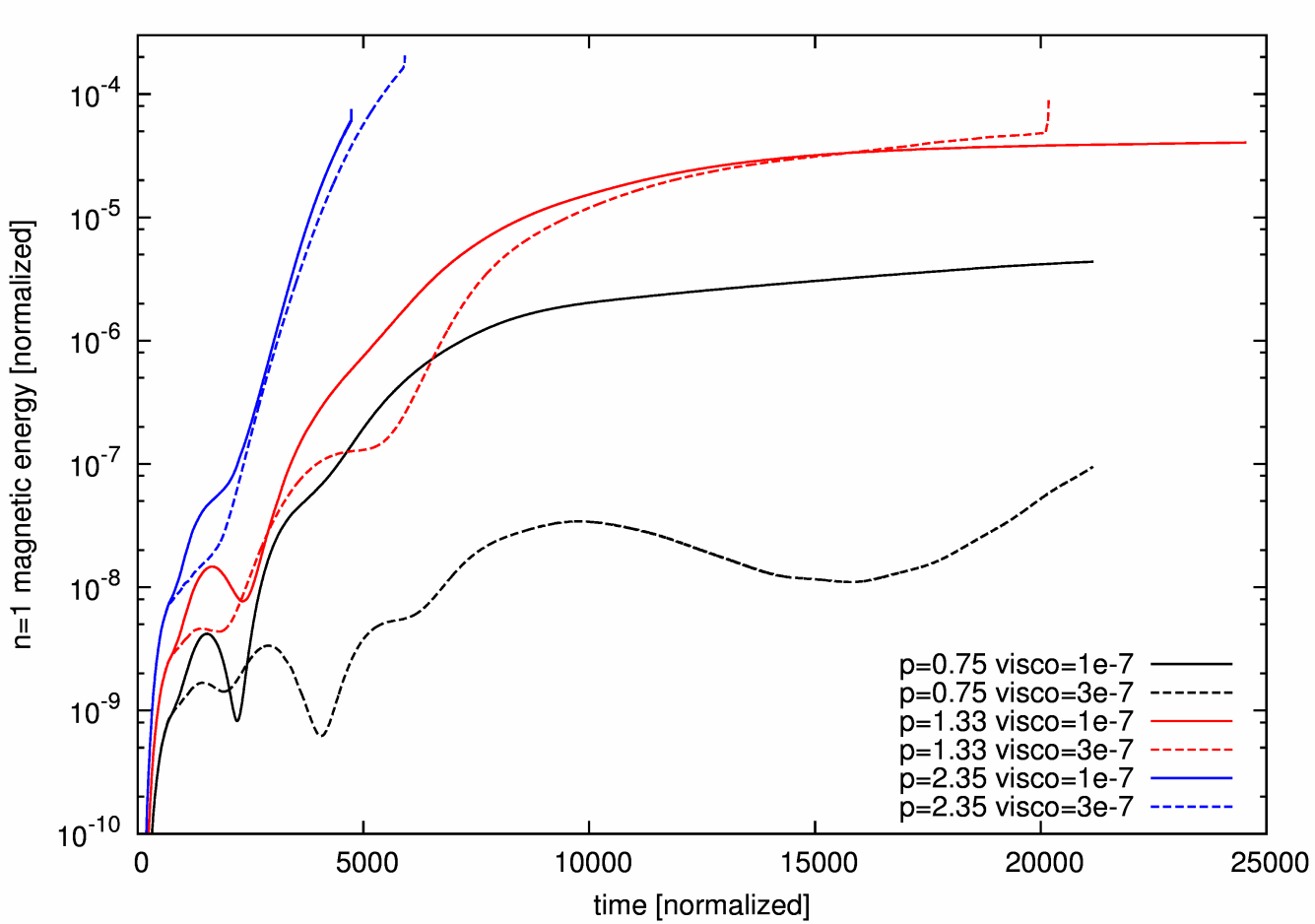
- Injection pressure has strong influence on disruption onset
- But other parameters also important
- Roughly 50 cases (”spikes” disappear with smaller time steps)

Resistivity



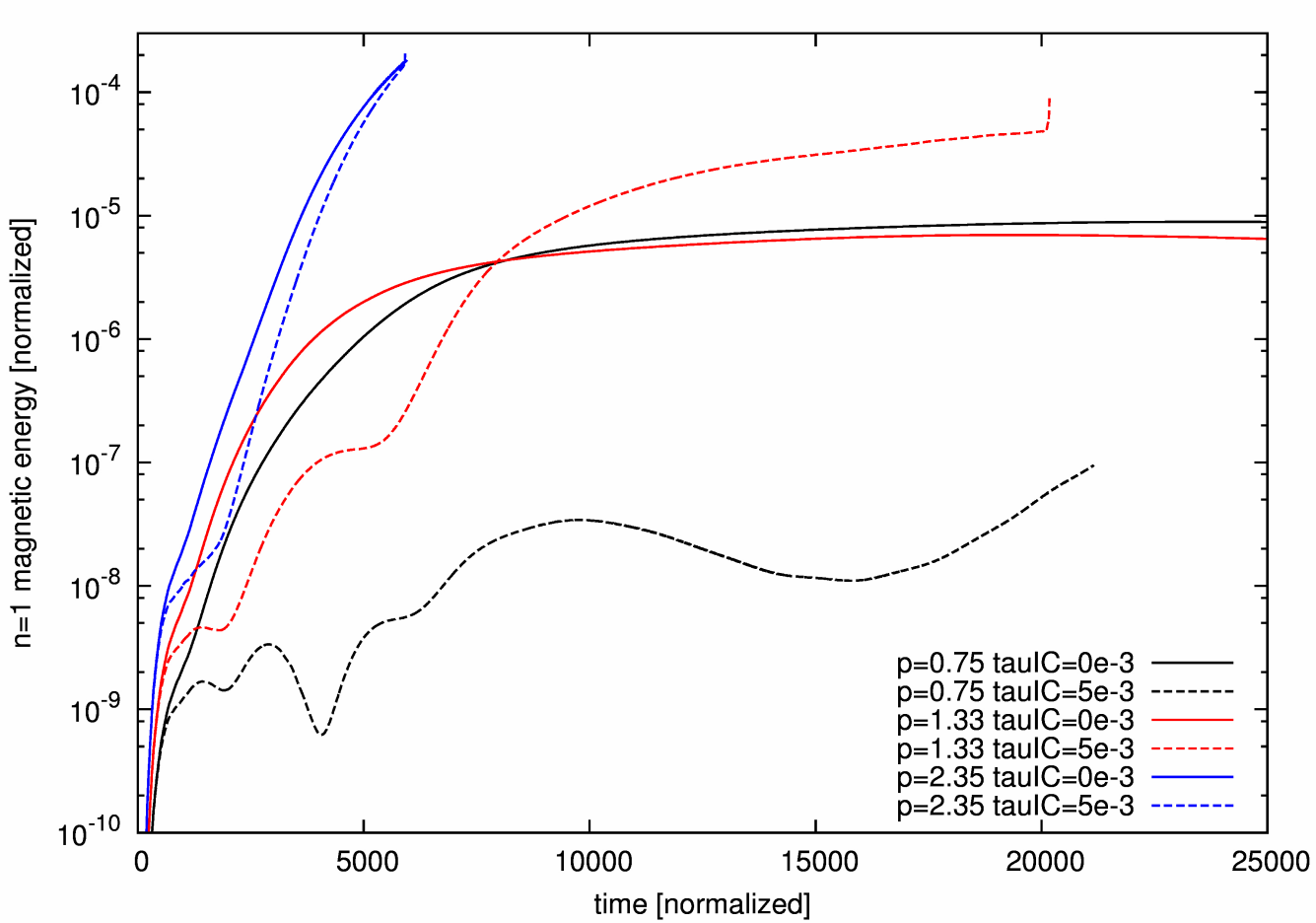
- Resistivity can easily make the difference between immediate disruption, delayed disruption, and no disruption at all

Viscosity Dependency



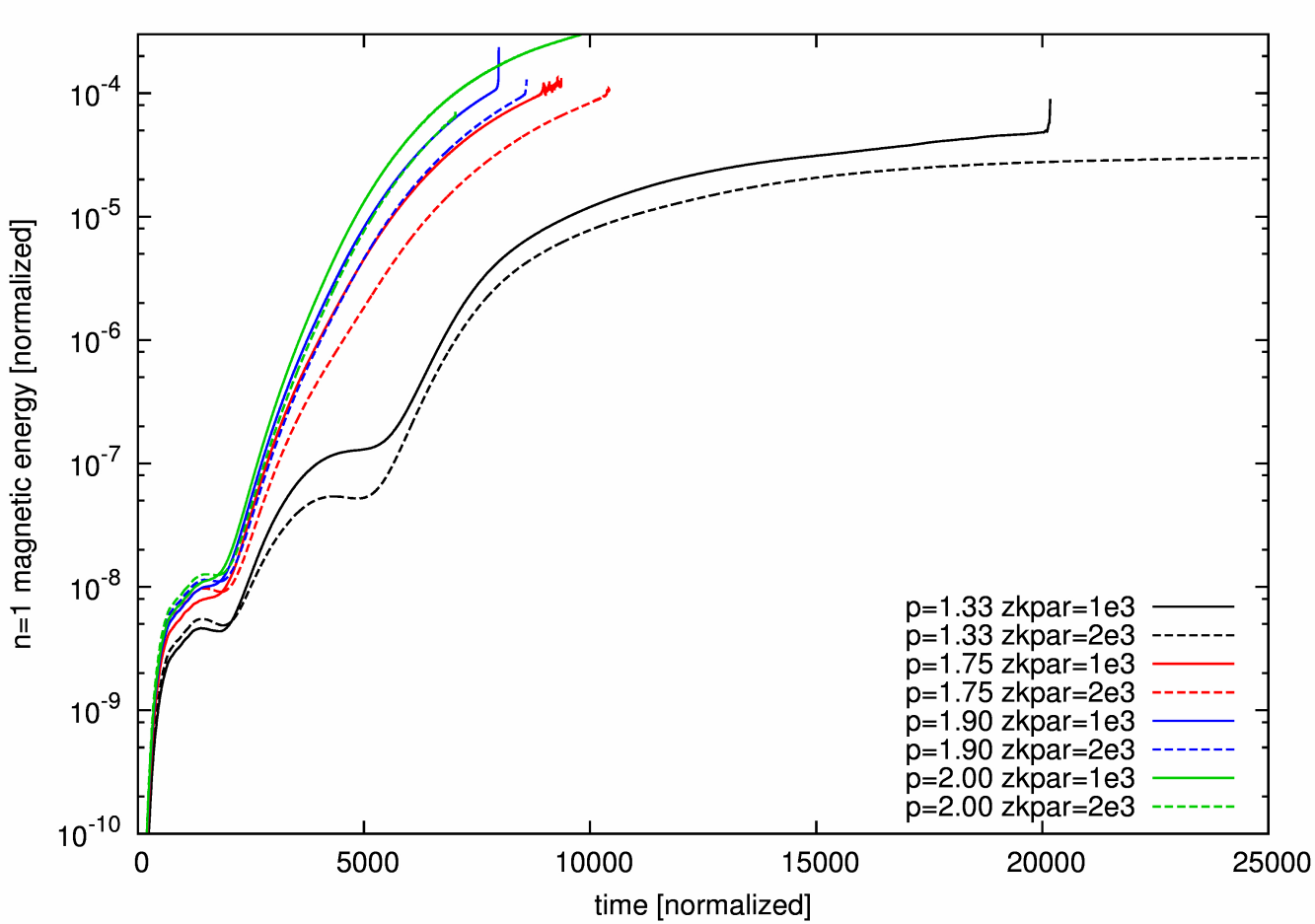
- Viscosity delays rise of perturbation
- Suppression for small gas amounts
- Small influence for large amounts of gas

Diamagnetic Drift



- Diamagnetic drift delays rise of perturbation
- Saturation levels also affected
- Small influence for large amounts of gas

Parallel Conductivity



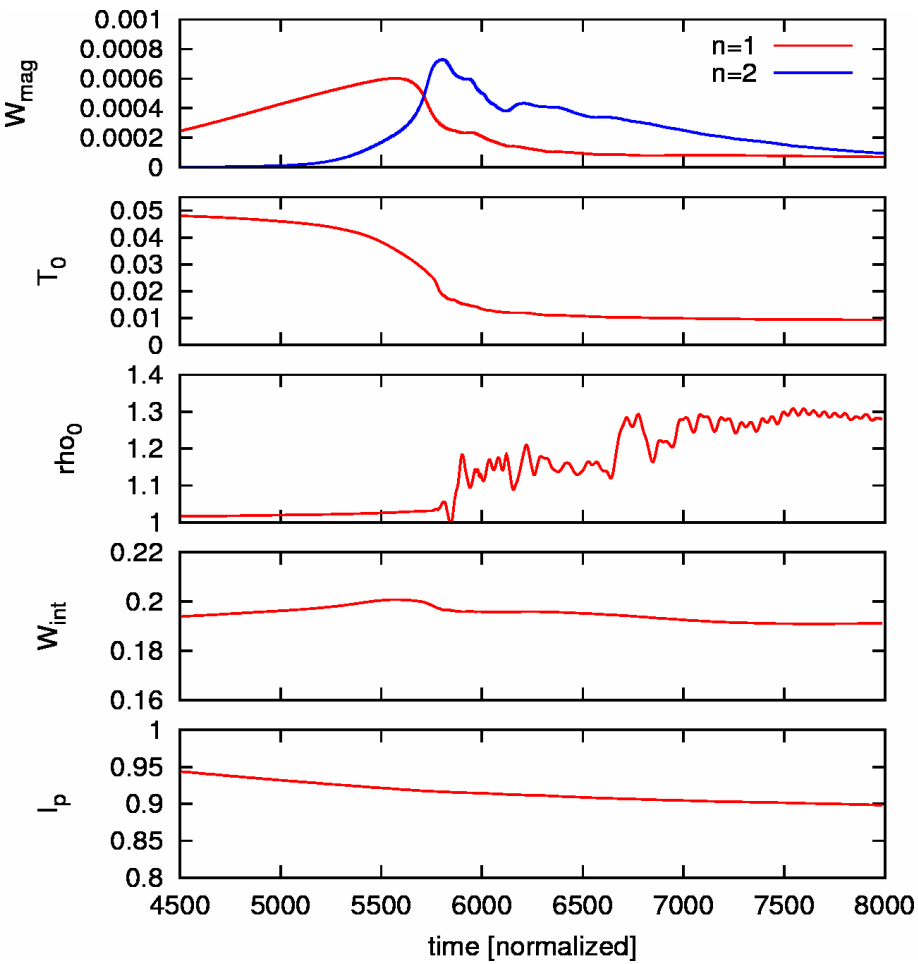
- Parallel conductivity has a slightly stabilizing effect

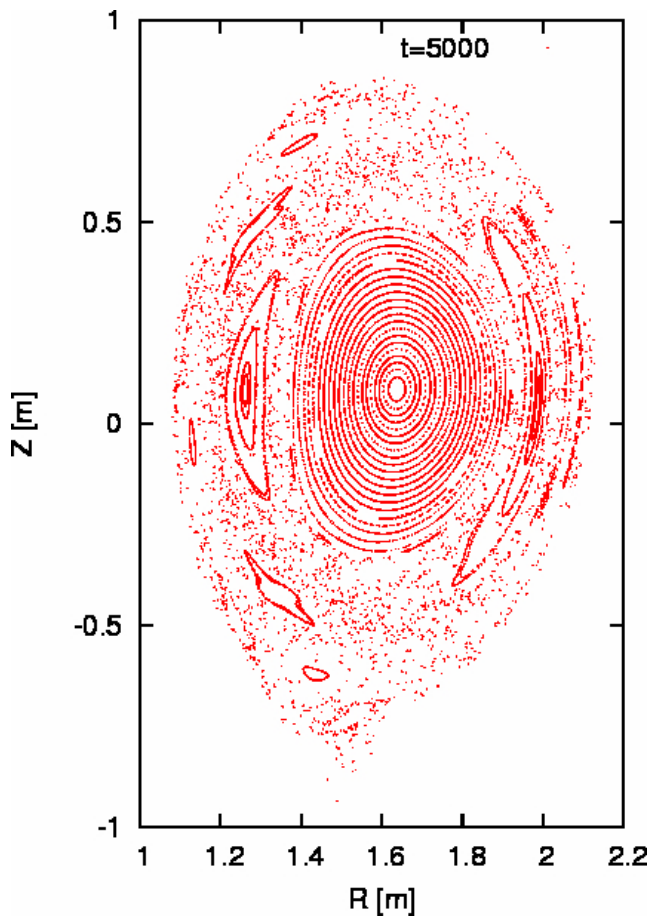
Dynamics with $q_0 > 1$

- Dilution: density increases, temperature drops, pressure not affected much
- Islands and stochastisation of outer plasma, further temperature drop
- Drop of q_0, crash of the center
- Instabilities loose drive and drop in amplitude
- Ohmic heating leads to some re-heating

Dynamics

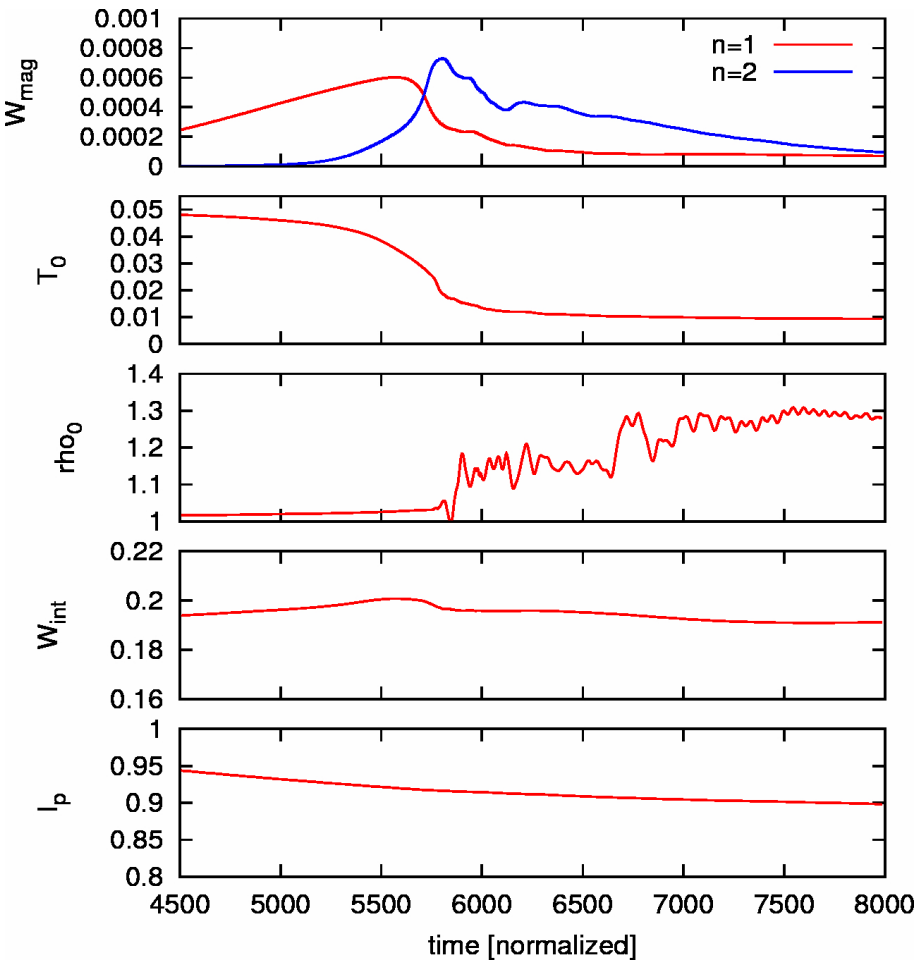
Central Crash

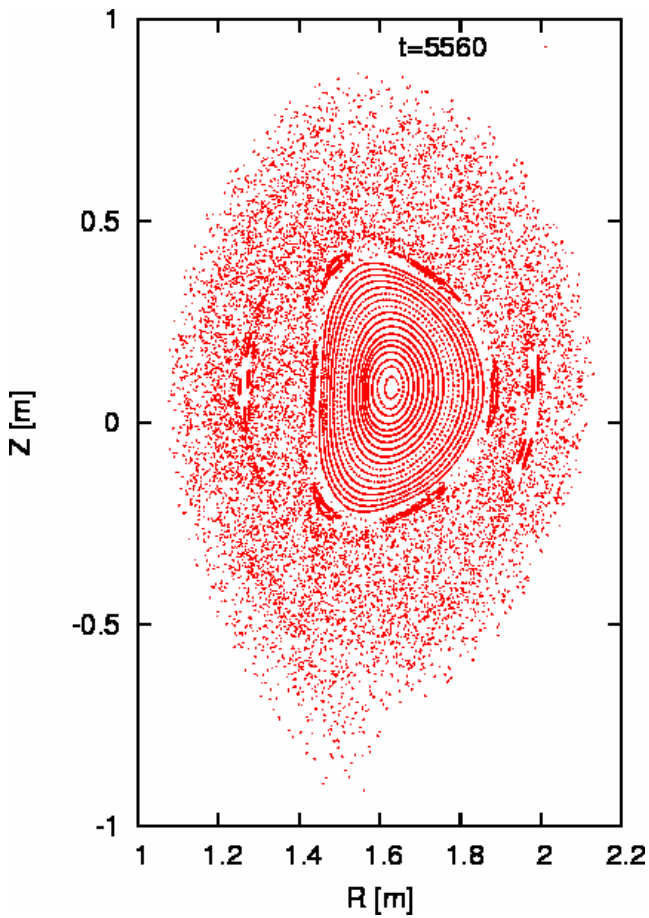




- Drop of core temperature five within a few hundred microseconds
- Central q close to 1 at crash
- No current spike

Central Crash





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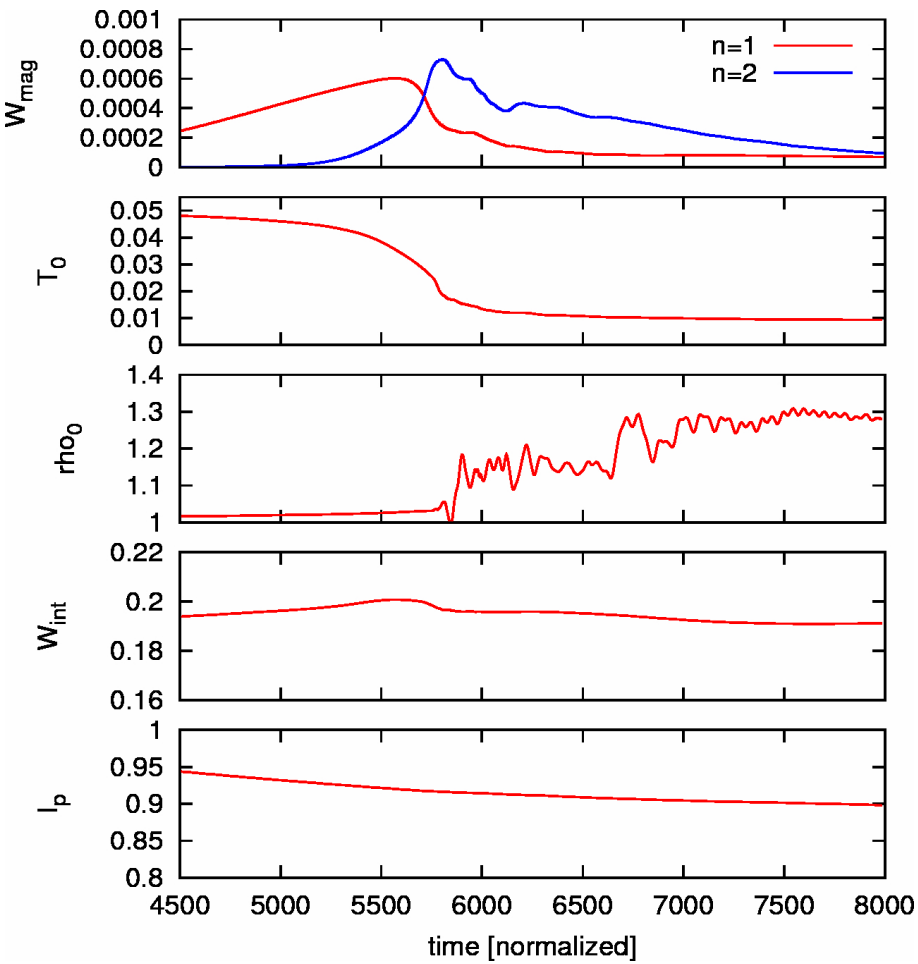

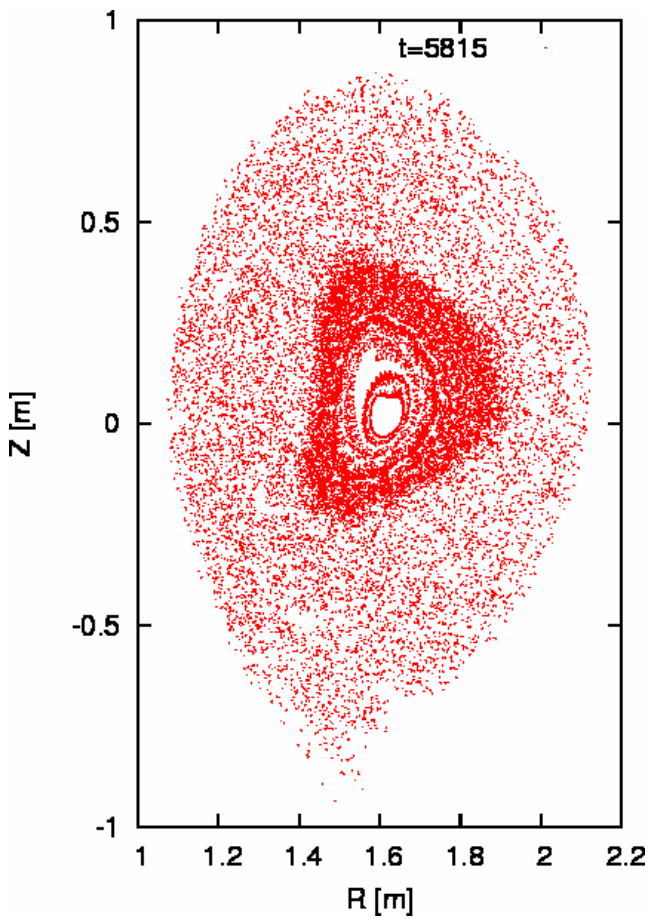

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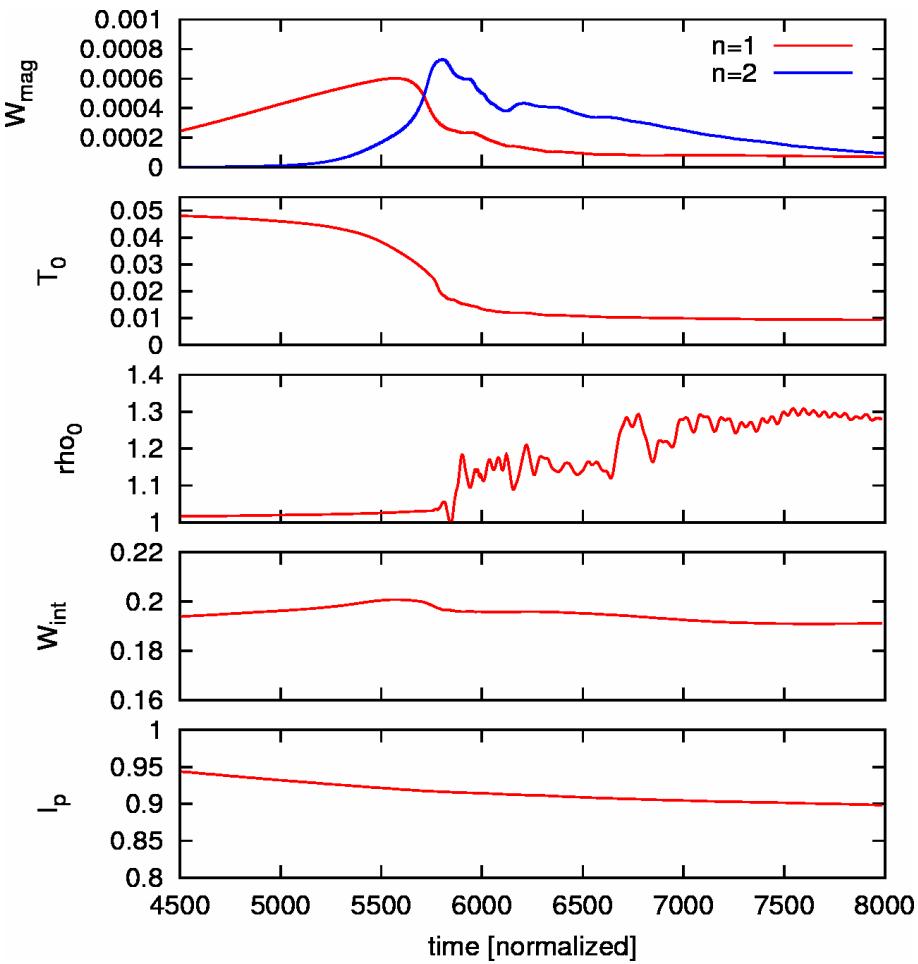

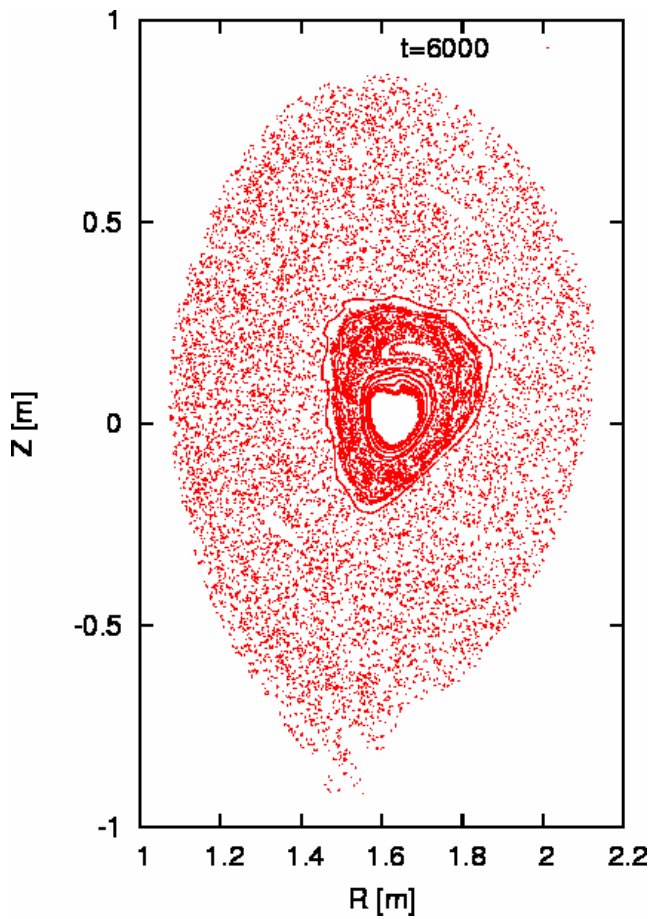

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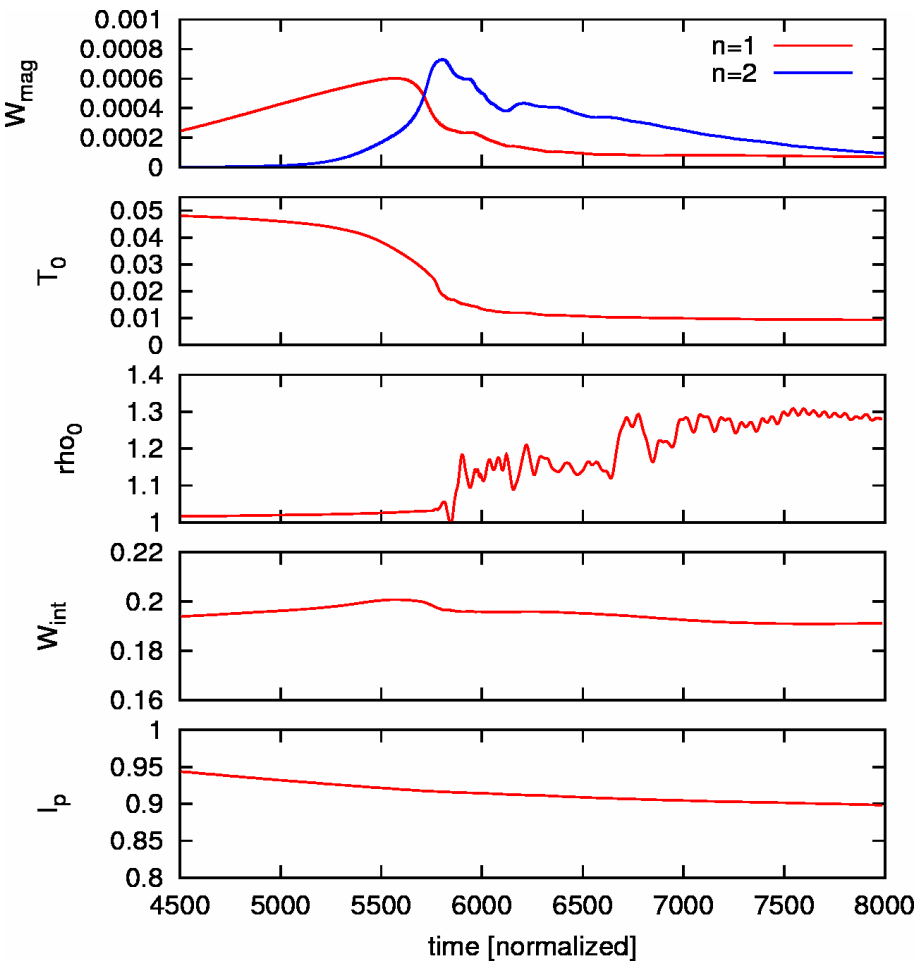

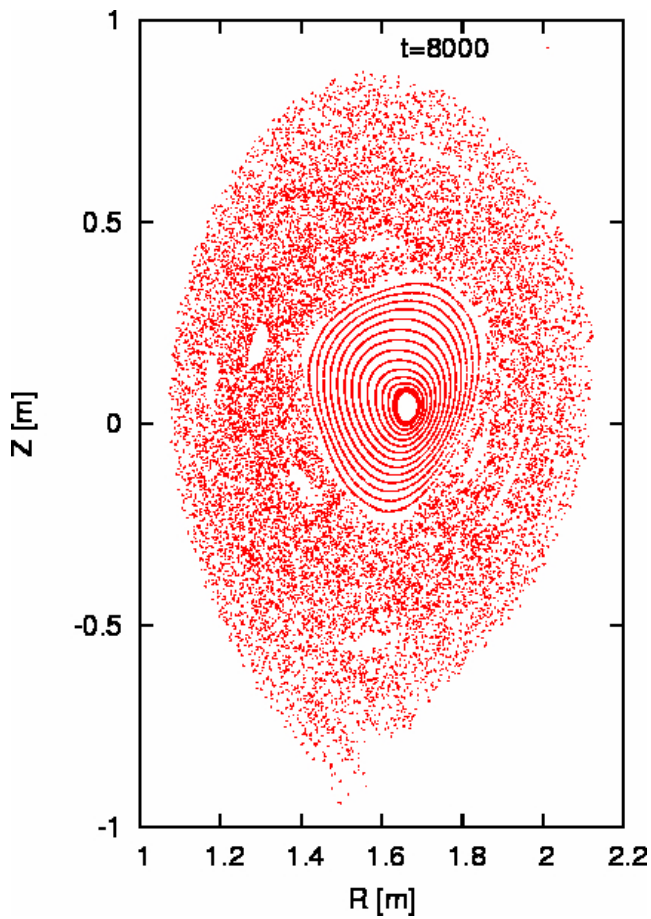

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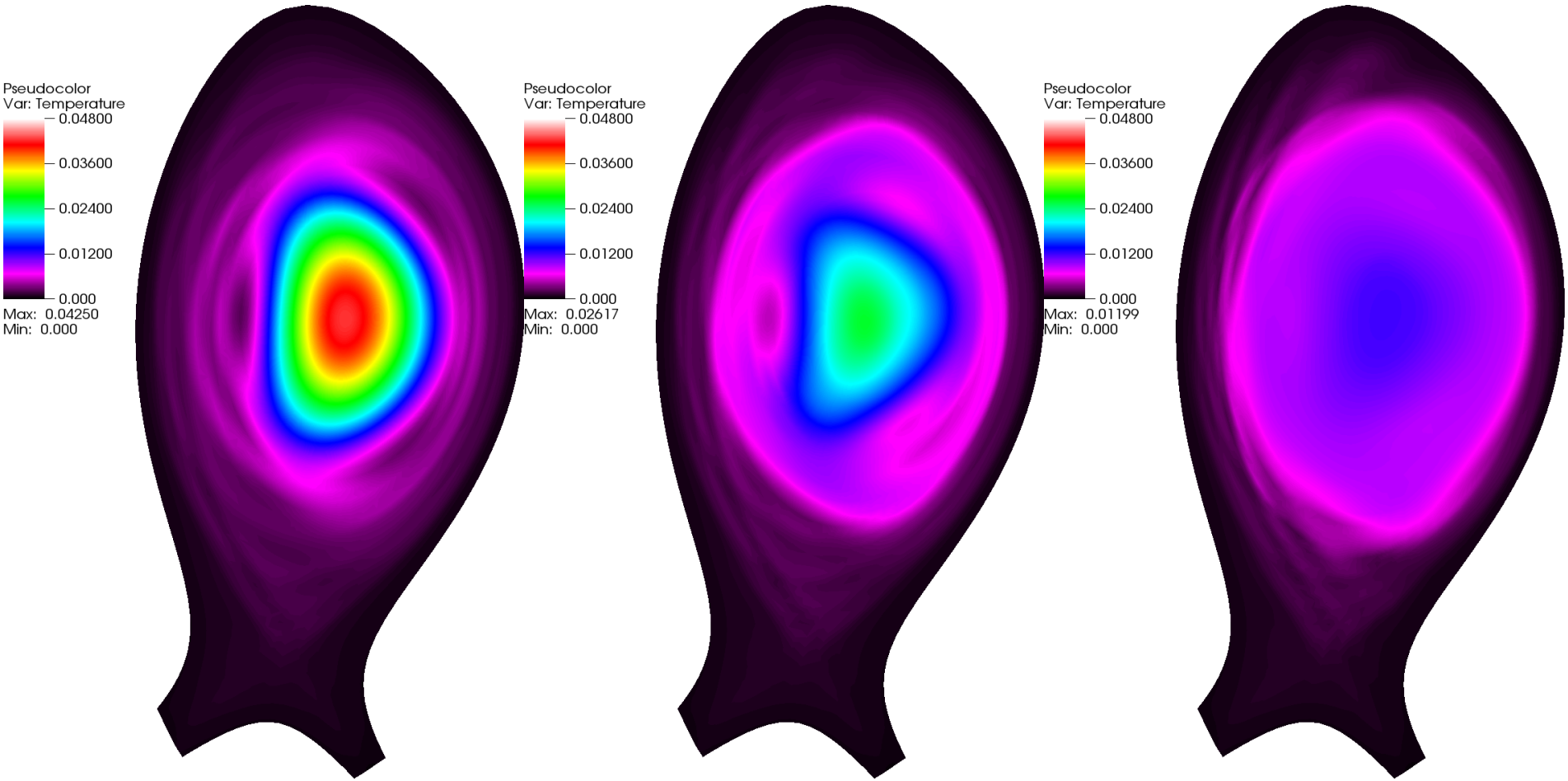
Thermal Quench



- t=5340, 5740, 6140
- Sudden loss of core confinement: $T_e = 2keV \rightarrow 500eV$
- Impurity radiation should be important

Summary & Outlook

- Deuterium MGI simulations for ASDEX Upgrade
- Realistic parameters seem feasible
- Important role of resistivity and diamagnetic rotation

- Could be interesting for validation of non-deuterium MGI: Existing experiments with different amounts of gas; future dedicated experiments; parameters easier to achieve than JET

- PhD on natural and mitigated disruptions planned (M. Hoelzl and G. Pautasso); strong collaboration with G. Huijsmans and E. Nardon including several visits to Cadarache foreseen, master student at ASDEX Upgrade could be a candidate