Max-Planck-Institut fur Plasmaphysik, EURATOM Assoziation

Whole Device ELM Simulations.

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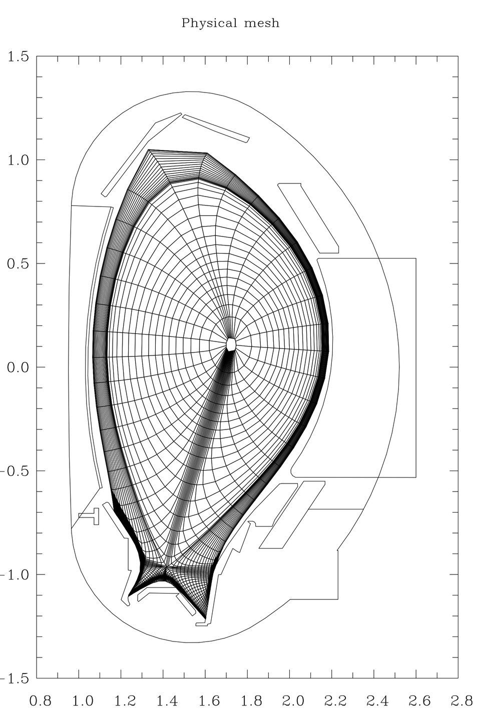
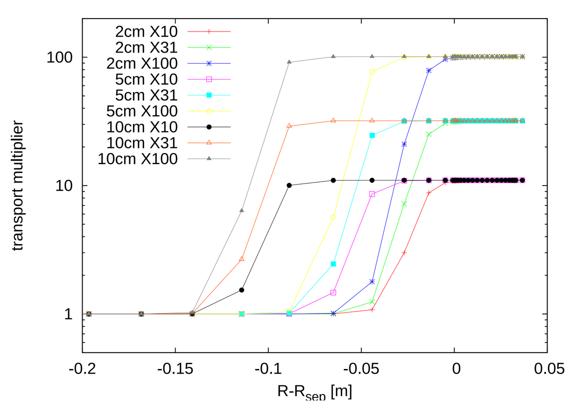
Deep Simulations



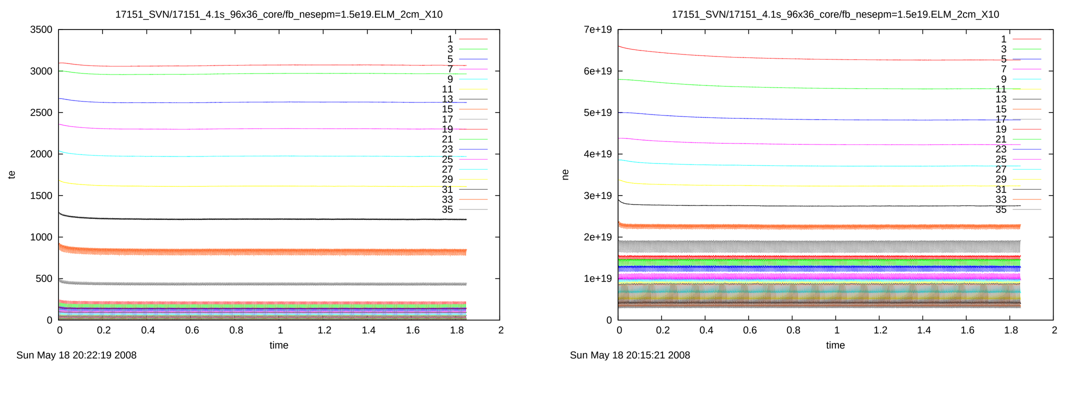
- based on AUG 17151
  - 4 MW ELMing H-mode
- Deep grid
- Sources from ASTRA simulation
- Transport coefficients fitted to give reasonable match
- D+C+He
- B2-EIRENE

- long runs
  - basic time-step is $10^{-5}s$
  - each "run" is 1000 time-steps and lasts about 1 day
  - chain a series of runs (> 150)
- ELMs implemented in *ad hoc* model
  - parameterized by multiplier of the transport coefficients
  - width of directly affected region
  - $200\mu s$ duration
  - repeated every $5ms$



Time traces for the "base" case ($2cm$, $X10$, $1.5 \times 10^{19} m^{-3}$)

- T_e at the outer midplane for a number of flux surfaces
- n_e at the outer midplane for a number of flux surfaces

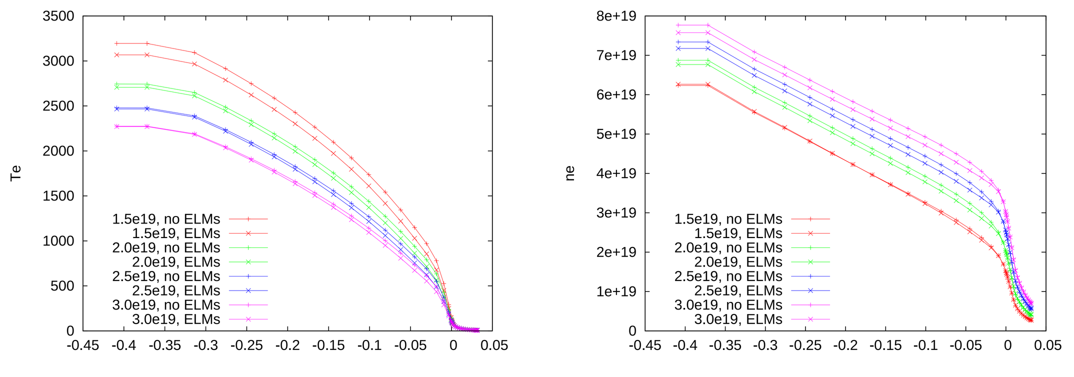


ELM Density Scan

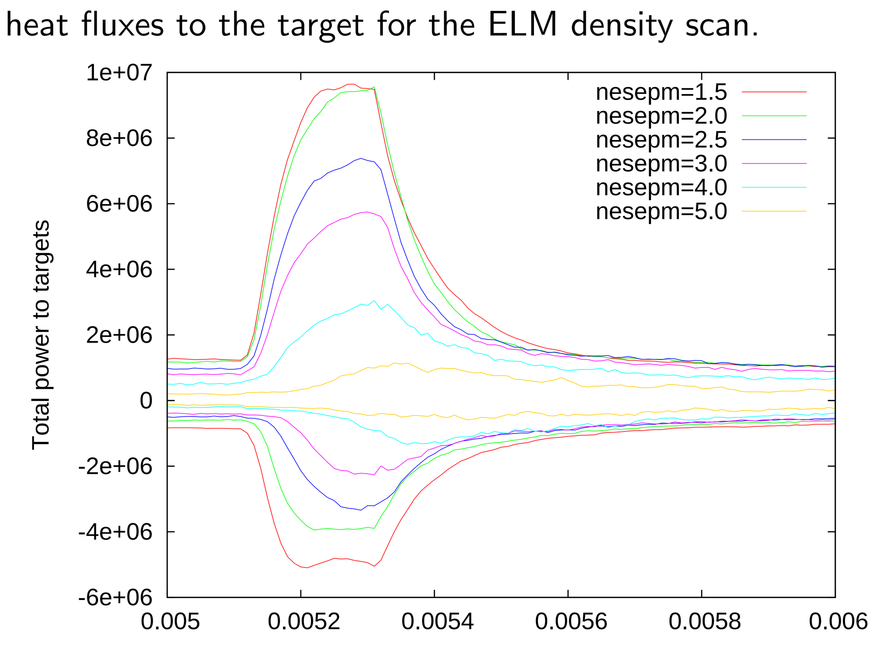
ELM sizes for the $2cm$, $X10$ density scan

density $(10^{19}) m^{-3}$	ELM energy drop (kJ)
1.5	3.462
2.0	3.548
2.5	3.554
3.0	3.549
4.0	3.475
5.0	3.260

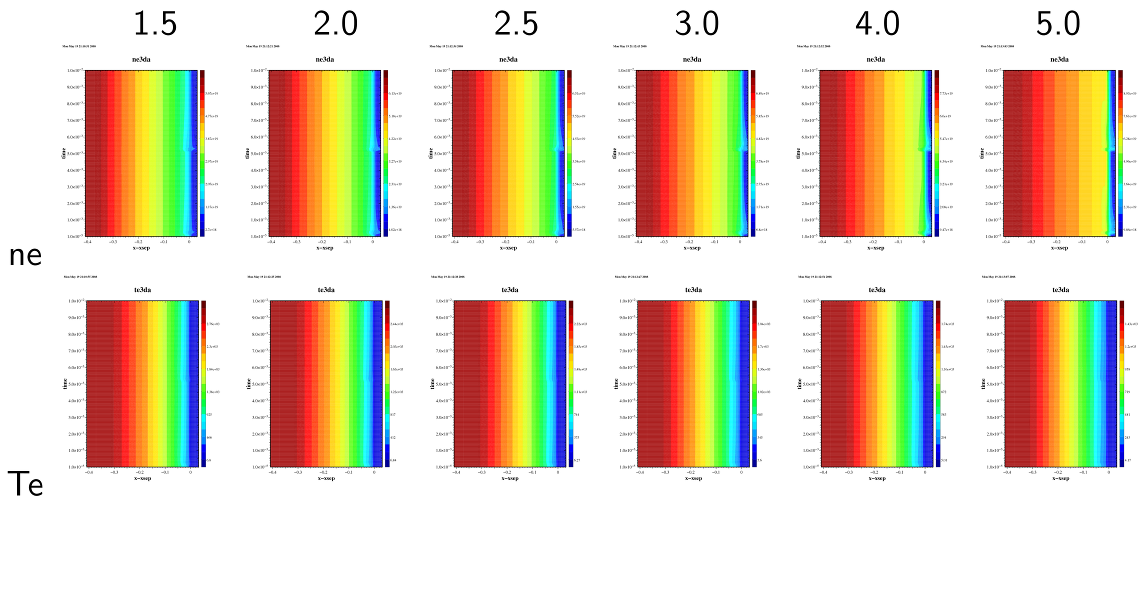
Comparison of the profiles with and without ELMs for the density scan cases.



And the heat fluxes to the target for the ELM density scan.



Impact of the ELMs on the density and temperature profiles: the last two ELMs of the sequence.



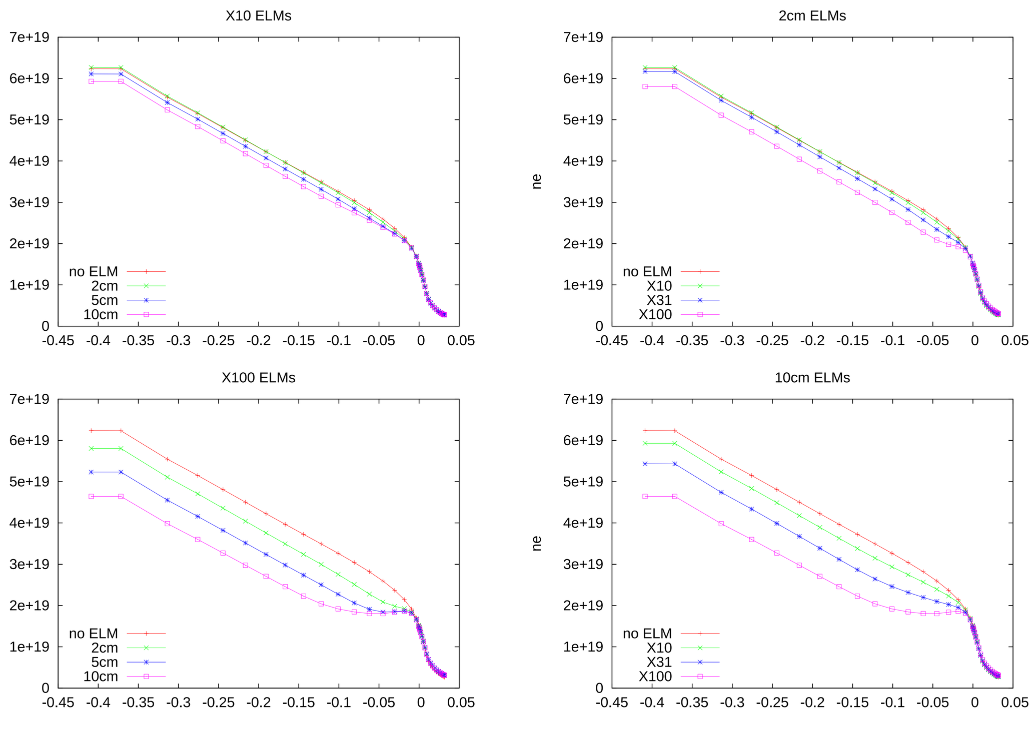
ELM Size/Strength Scan

ELM sizes for the $1.5 \times 10^{19} m^{-3}$ ELM strength scan.

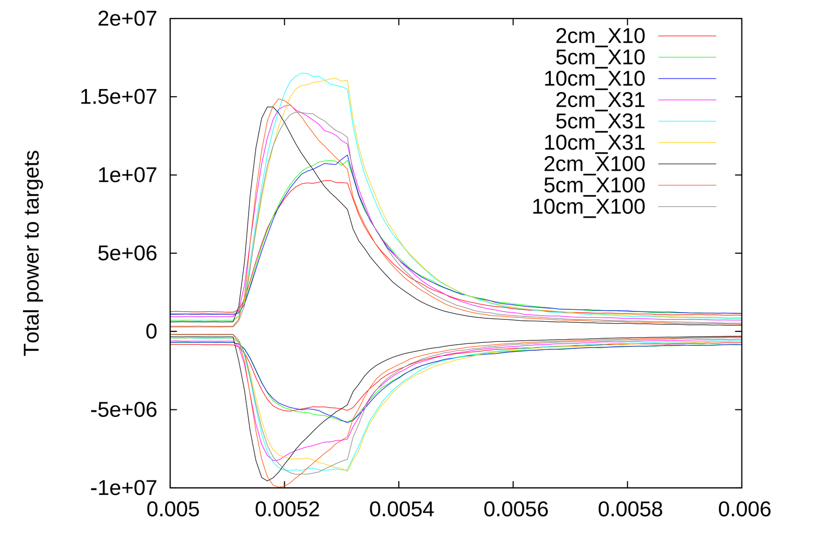
depth (cm)	ELM energy drop (kJ)		
	transport multiplier		
	X10	X31	X100
2	3.462	6.635	10.277
5	3.900	7.595	11.473
10	3.871	7.483	11.410

Fractional drop for the stored energy compared to the no ELM case for the ELM strength scan.

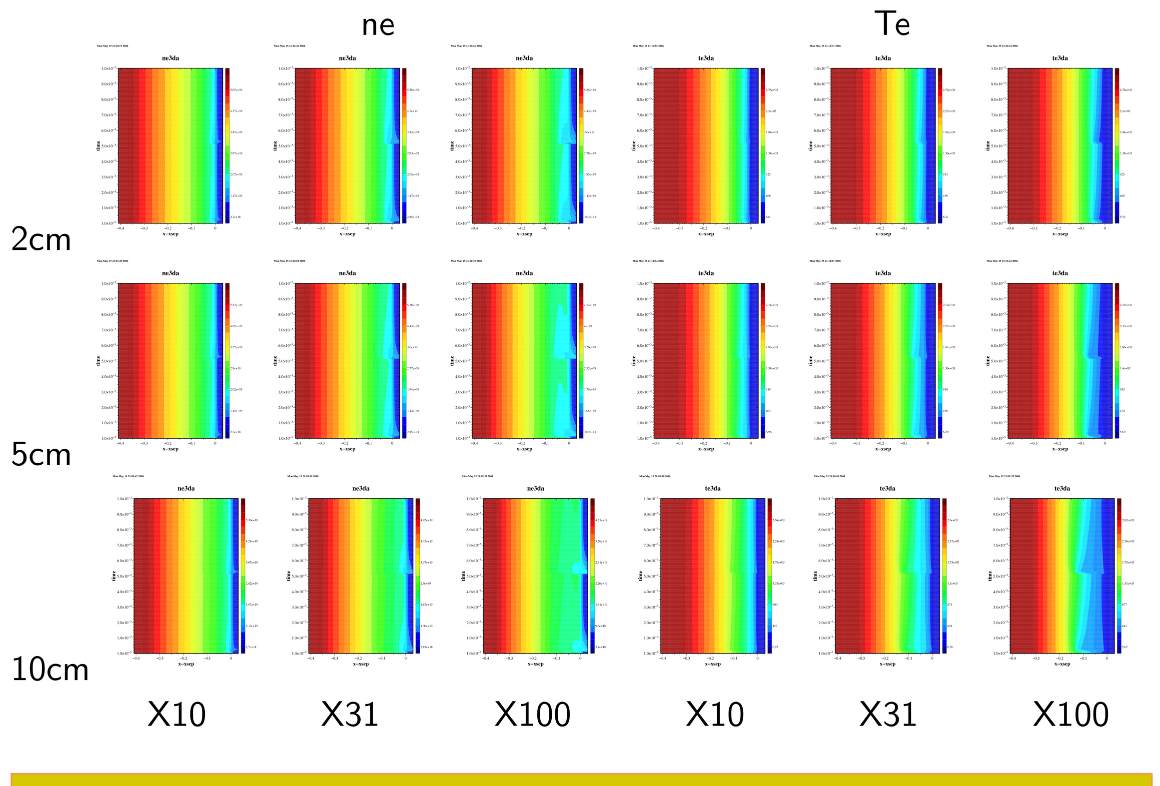
depth (cm)	fraction of stored energy		
	transport multiplier		
	X10	X31	X100
2	0.94	0.88	0.79
5	0.89	0.78	0.65
10	0.82	0.65	0.48



And the heat fluxes to the target for the ELM size/strength scan.

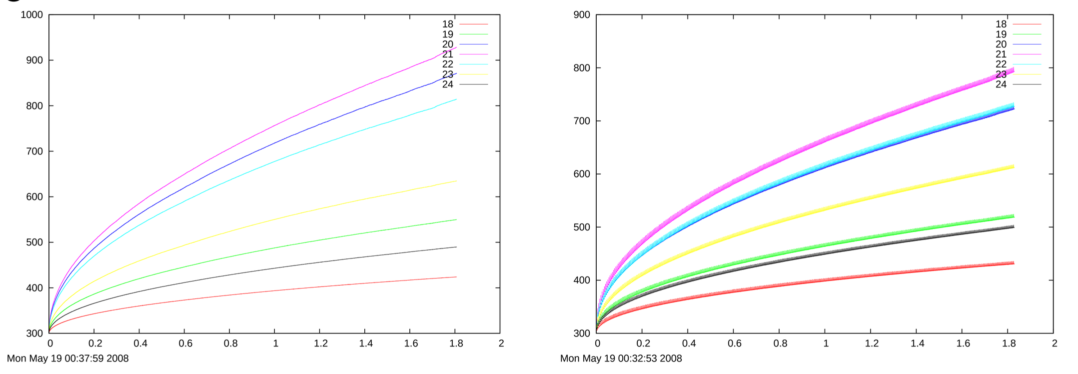


Impact of the ELMs on the density and temperature profiles: the last two ELMs of the sequence.

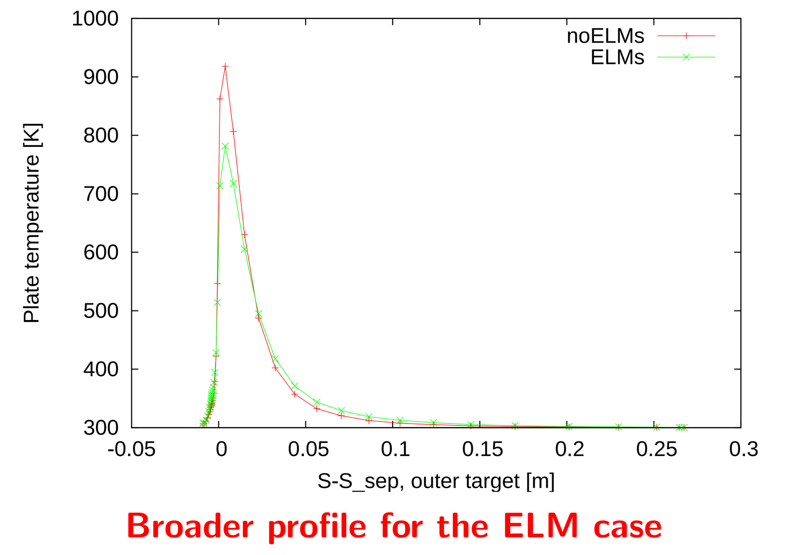


ELM Impact on the Plate Temperature

Plate temperatures without and with ELMs for various positions along the target.



Comparison of the target temperature at the same time for the no ELM and ELM simulations.

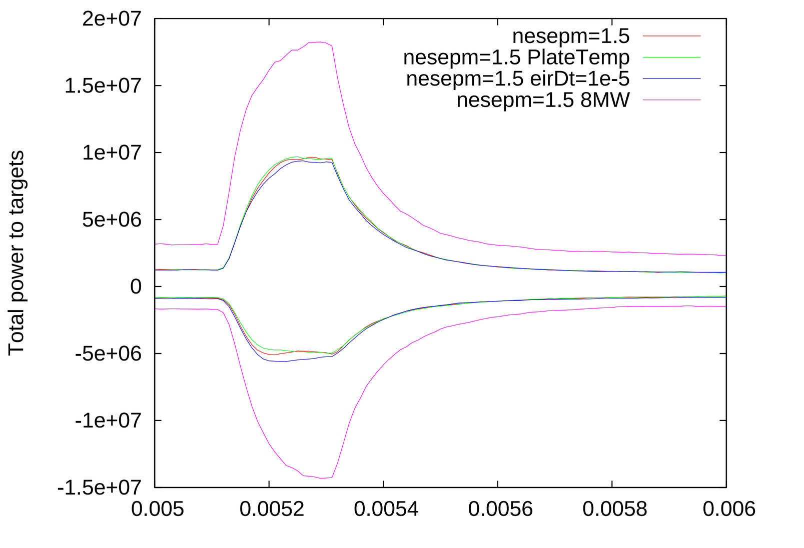


Broader profile for the ELM case

EIRENE Time Dependence, $8MW$, ...

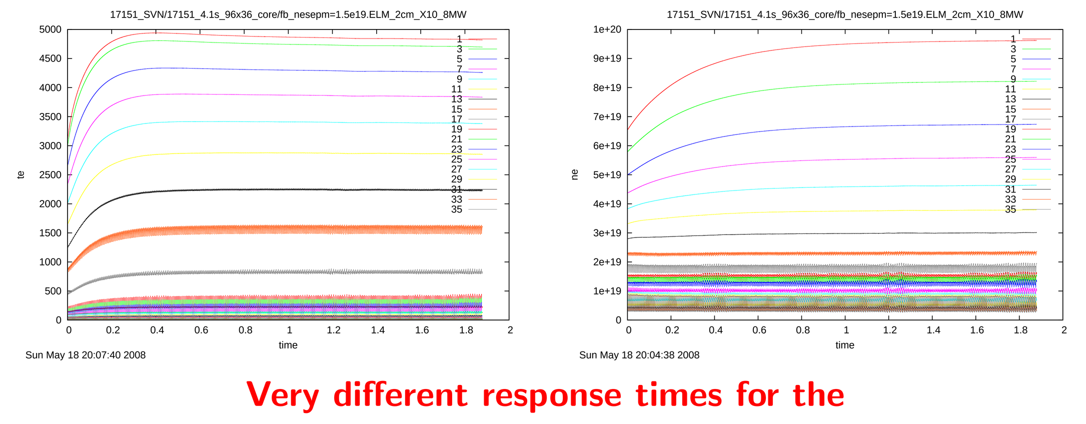
In addition to the density and ELM size/strength scans, runs were done with

- time dependent EIRENE
- with the thermal plate model
- power increased to $8MW$



The three $4MW$ cases are very similar

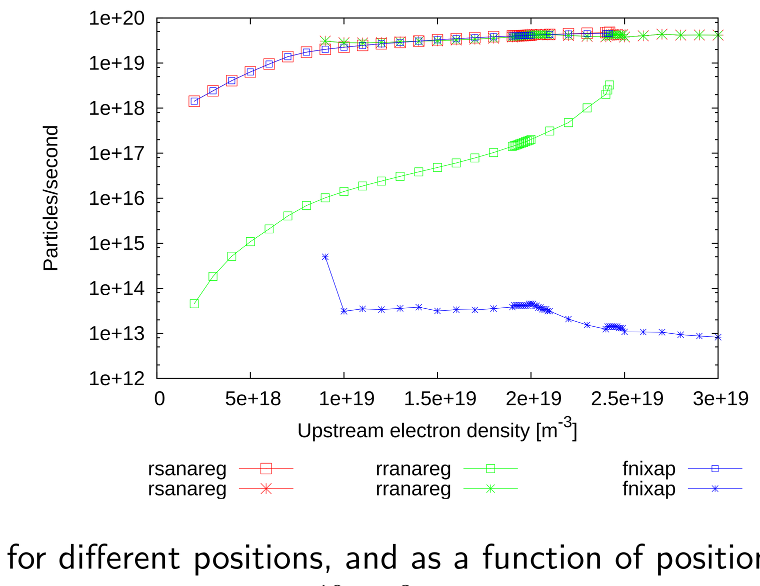
Time evolution for the $8MW$ case.



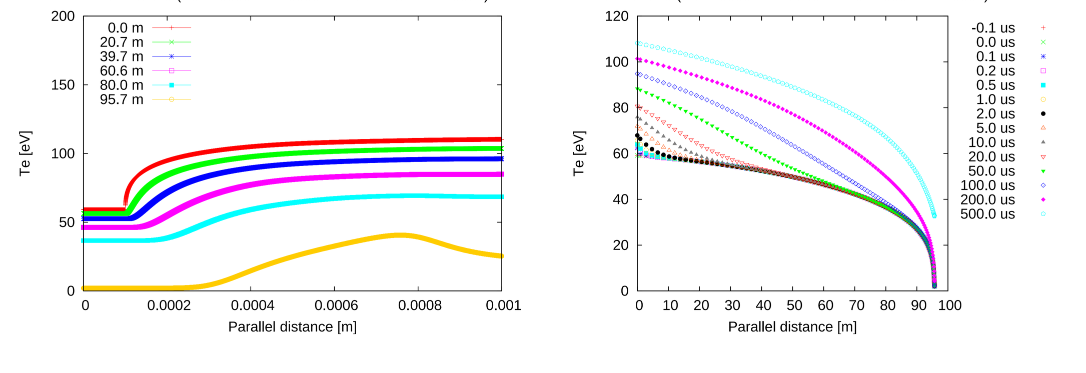
Very different response times for the temperature and density profiles

1d simulations

- 1d simulations
- $\approx 100m$
- D
- B2
- exhibit bifurcations

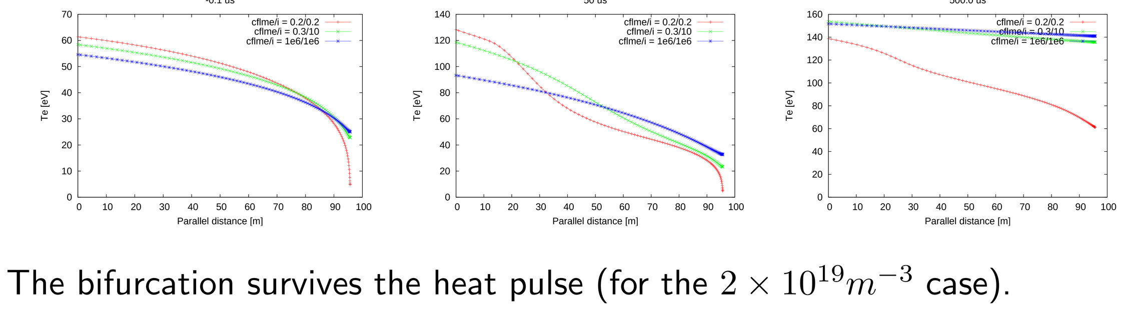


T_e as a function of time for different positions, and as a function of position for different times (upstream density $1.5 \times 10^{19} m^{-3}$).

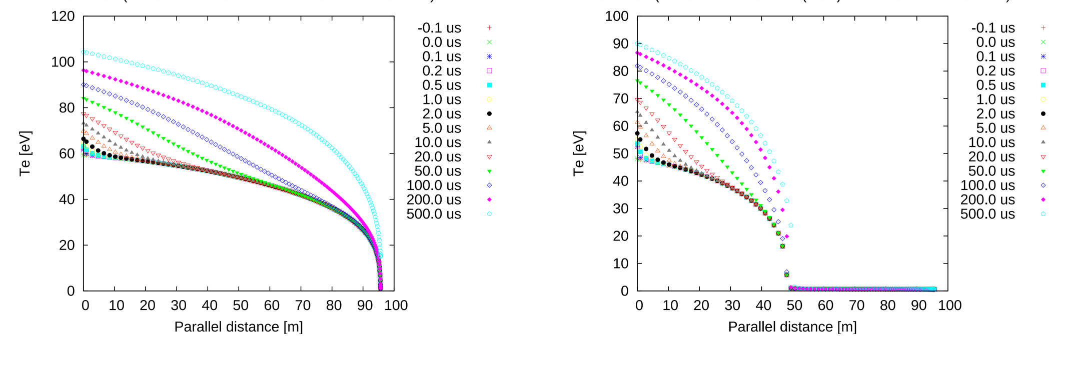


However, parallel heat flux limiters have a very strong influence on the plasma, here for an upstream density of $0.5 \times 10^{19} m^{-3}$.

From left to right, just before the start of the "ELM", at $50\mu s$ and $500\mu s$.



The bifurcation survives the heat pulse (for the $2 \times 10^{19} m^{-3}$ case).



Summary

- Can follow the impact of ELMS on main plasma, SOL, targets, ...
  - not really the route forward for standard calculations
    - each run took more than half a year of elapsed time
    - the combined set of runs took more than 10 years of cpu time
- Amongst the results
  - At higher densities, ELMs seem to affect the global density profile more than the global temperature profile
  - At lower densities, ELMs seem to affect the global temperature profile more than the global density profiles
  - ELM size increases strongly with the transport multiplier
  - ELM size increases weakly with the ELM depth
  - Total stored energy drops with both ELM size and strength
    - to less than half for the most extreme case
  - The final plate temperature profile was broader for the case with ELMs, and the peak temperature lower
  - 1d calculations showed a bifurcation in the steady state calculations
  - Also showed a strong dependence on the kinetic flux limiters