Fluid 1D ELM Modelling Status Report

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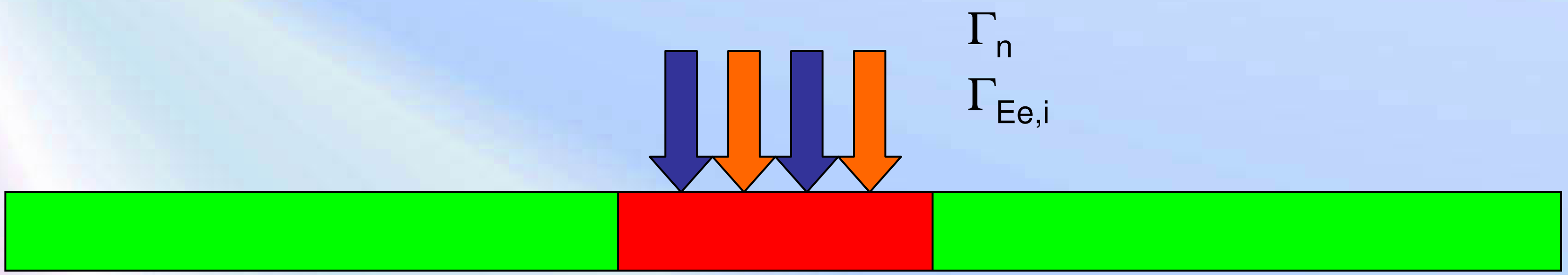
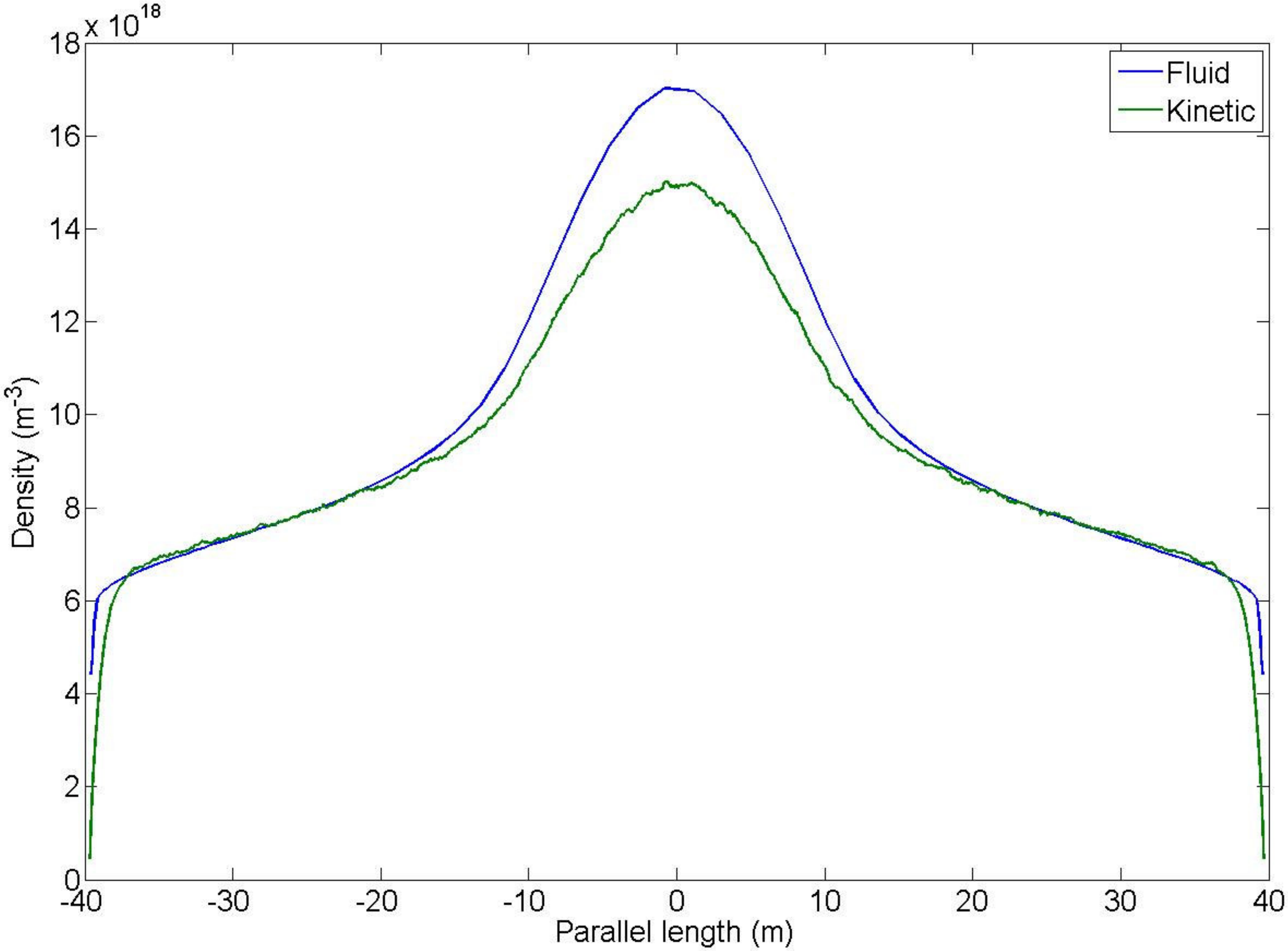
Model Problem Setup



- Physical parameters
  - Domain length: $L_{//} \sim 80$m
  - Pitch angle $B_\theta/B = 6^o$
  - Source temperature:
    - T_e = 240 eV, T_i = 260 eV, (steady)
    - $T_e = T_i$ = 1.5 KeV (ELM)
  - Electron free-flight time: $\tau_e \sim 3\ \mu s$
- Numerical parameters (fluid)
  - Spatial resolution: $\Delta x \sim L/100$, non uniform
    - Checked on pre-ELM steady state
    - Compared with PIC (BIT-1) results
  - Time step: $\Delta t \leq 10^{-9}$ s: $\Delta t << \tau_e$

Steady State (Pre-ELM) Density



$\alpha_e = 0.12$

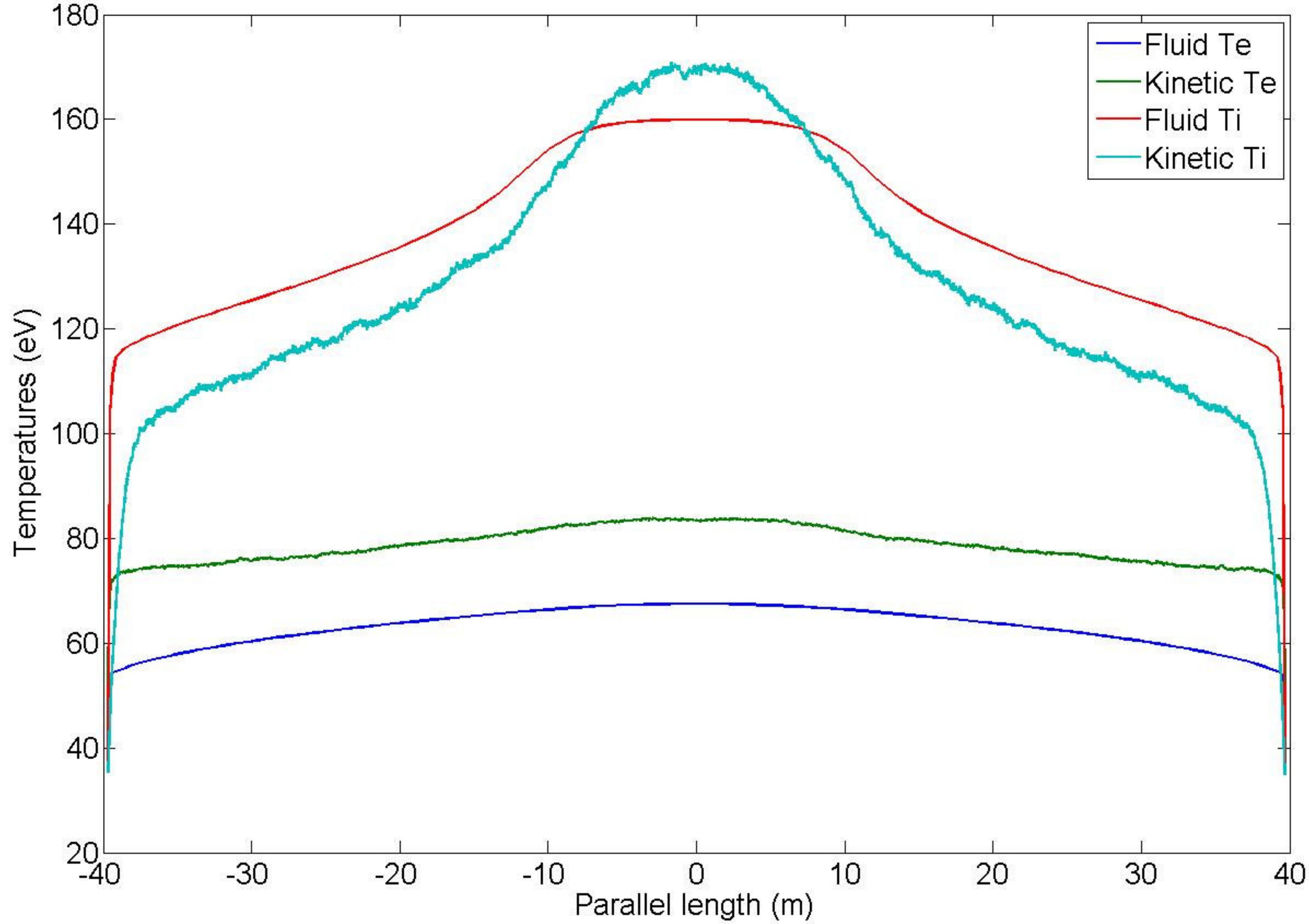
$\alpha_i = 0.2$

$\beta = 0.46$

$\gamma_e = 3.8$

$\gamma_e = 5.5$

Steady State Temperatures



$\alpha_e = 0.12$

$\alpha_i = 0.2$

$\beta = 0.46$

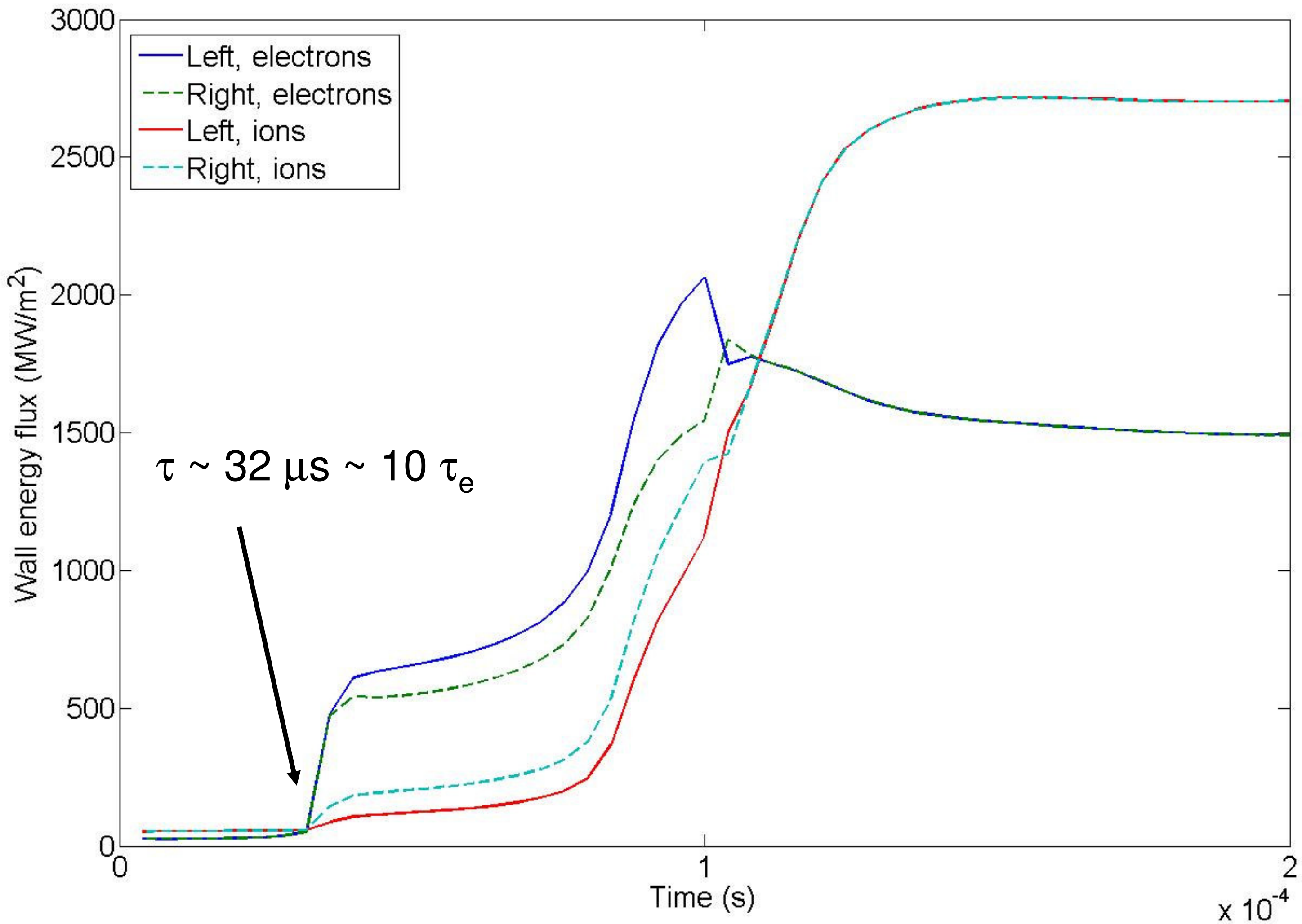
$\gamma_e = 3.8$

$\gamma_e = 5.5$

Transient (ELM) Evolution

- Three cases running in parallel:
  - Same boundary conditions/flux limiters as for the pre-ELM phase
  - Parameters time averaged over the evolution
  - Time dependent parameters
- ELM intended duration: 200 μs

Target Energy Fluxes



$\alpha_e = 0.12$

$\alpha_i = 0.2$

$\beta = 0.46$

$\gamma_e = 3.8$

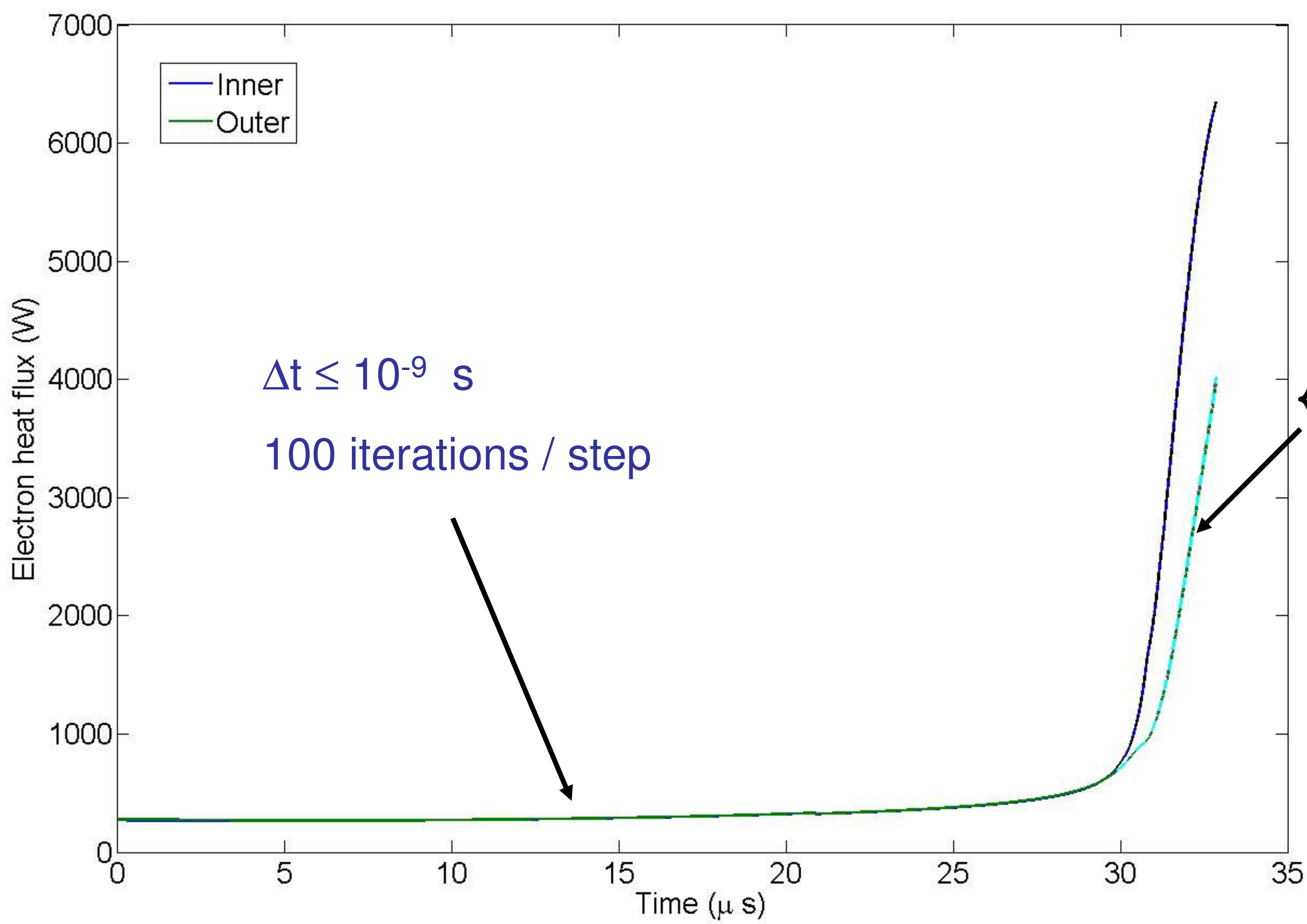
$\gamma_e = 5.5$

Fluid Model Behaviour

- The fluid (B2) model develop unrealistic asymmetries
- No physical reason ➔ they must be numerical
- Candidate solution strategy:
  - **Reduce the time step**
  - Increase the number of spatial nodes

Electron Heat Flux Traces

$\alpha_e = 0.12$ $\alpha_i = 0.2$ $\beta = 0.46$ $\gamma_e = 3.8$ $\gamma_e = 5.5$



$\Delta t \leq 3\times10^{-10}$ s

100 iterations / step

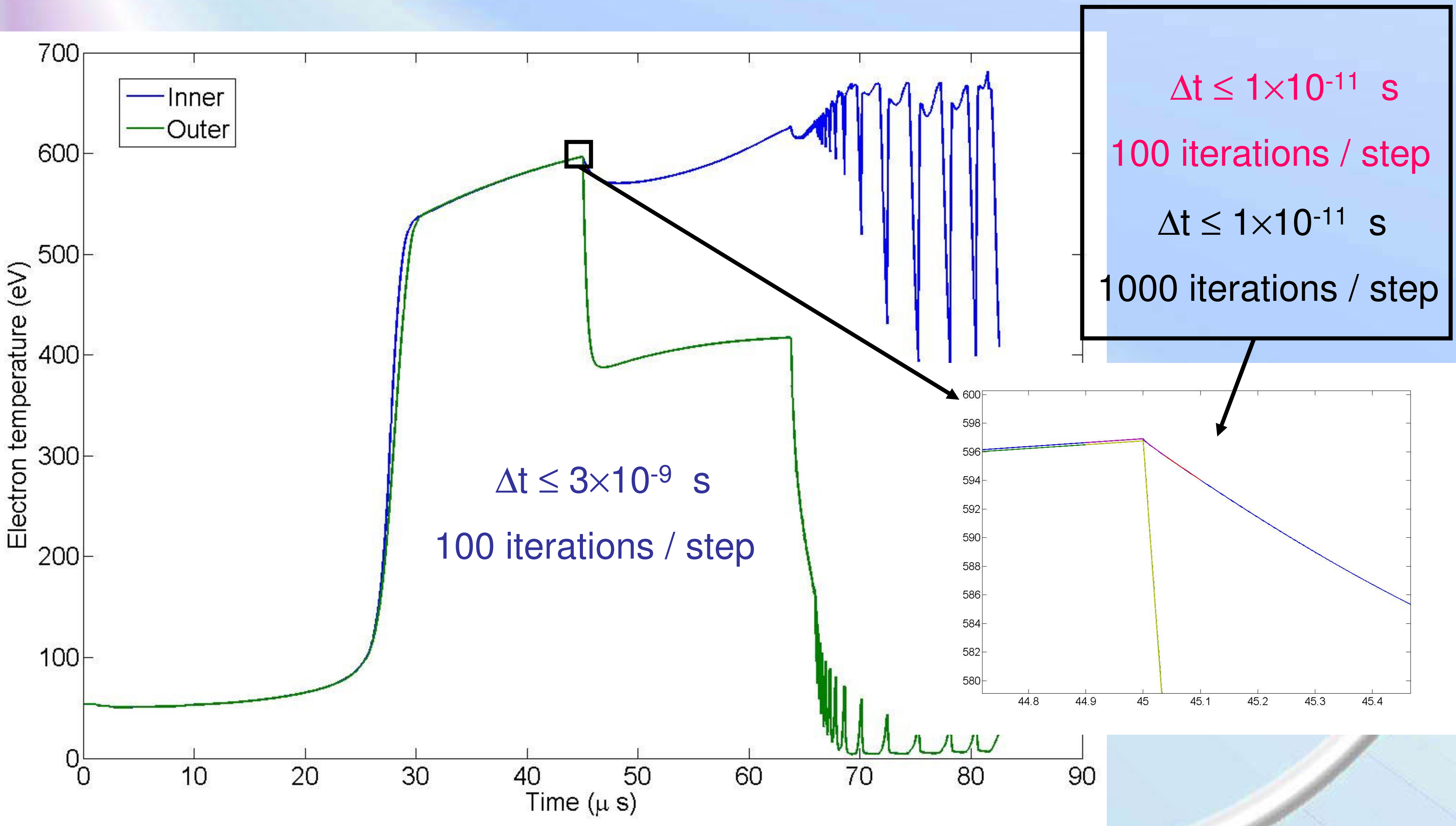
$\Delta t \leq 3\times10^{-11}$ s

100 iterations / step

$\Delta t \leq 3\times10^{-10}$ s

1000 iterations / step

Electron Target Temperatures

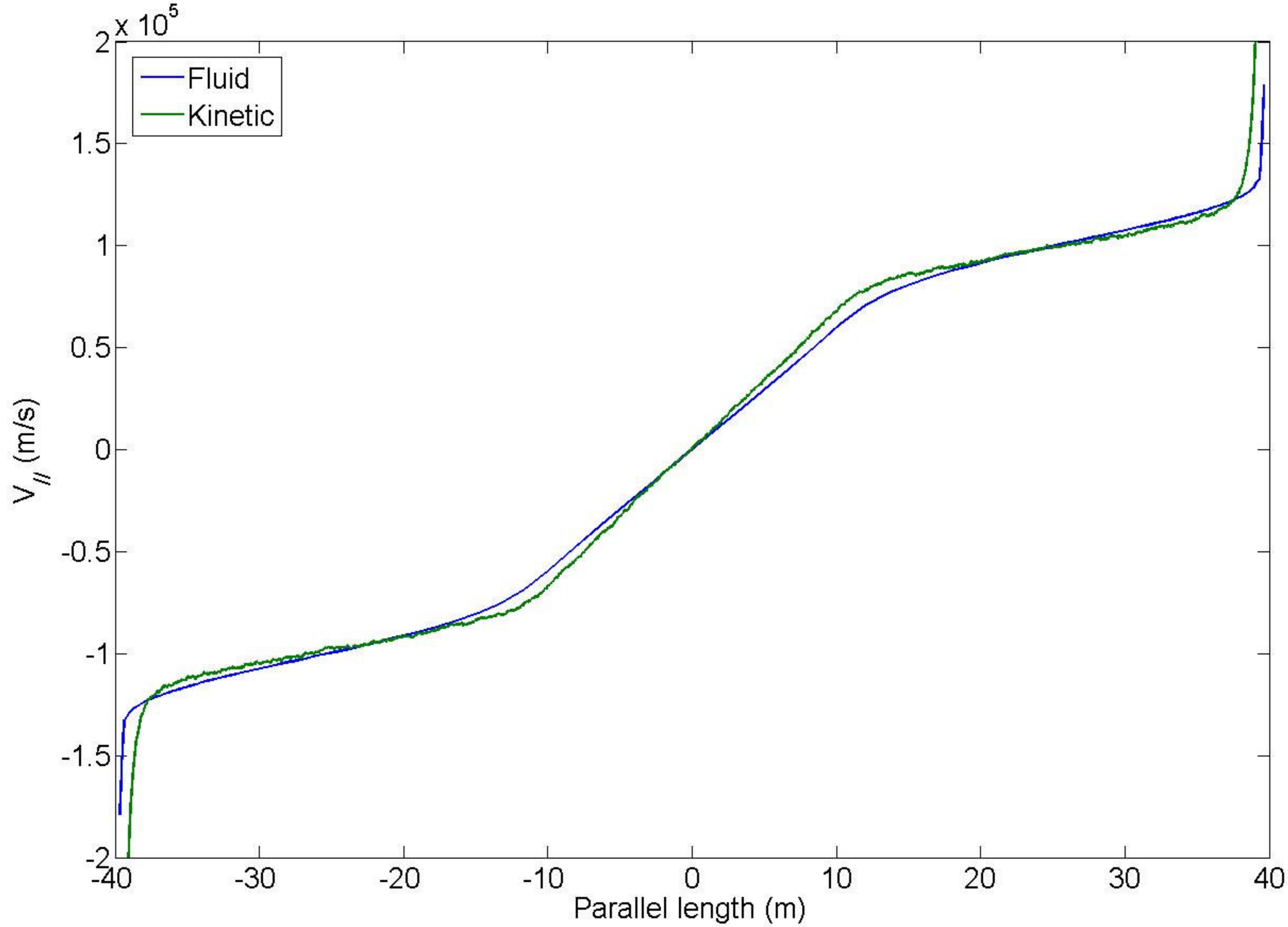


Conclusions

- Three different cases running in parallel (two reported in some detail here)
- All of them show similar un-correct behaviour
  - Not a time step problem
  - Not an internal iteration problem
- Other possible candidates:
  - A spatial resolution problem ➔ To be investigated
  - A numerical instability ➔ To be investigated
  - …

ADDITIONAL SLIDES

Steady State Velocities



$\alpha_e = 0.12$

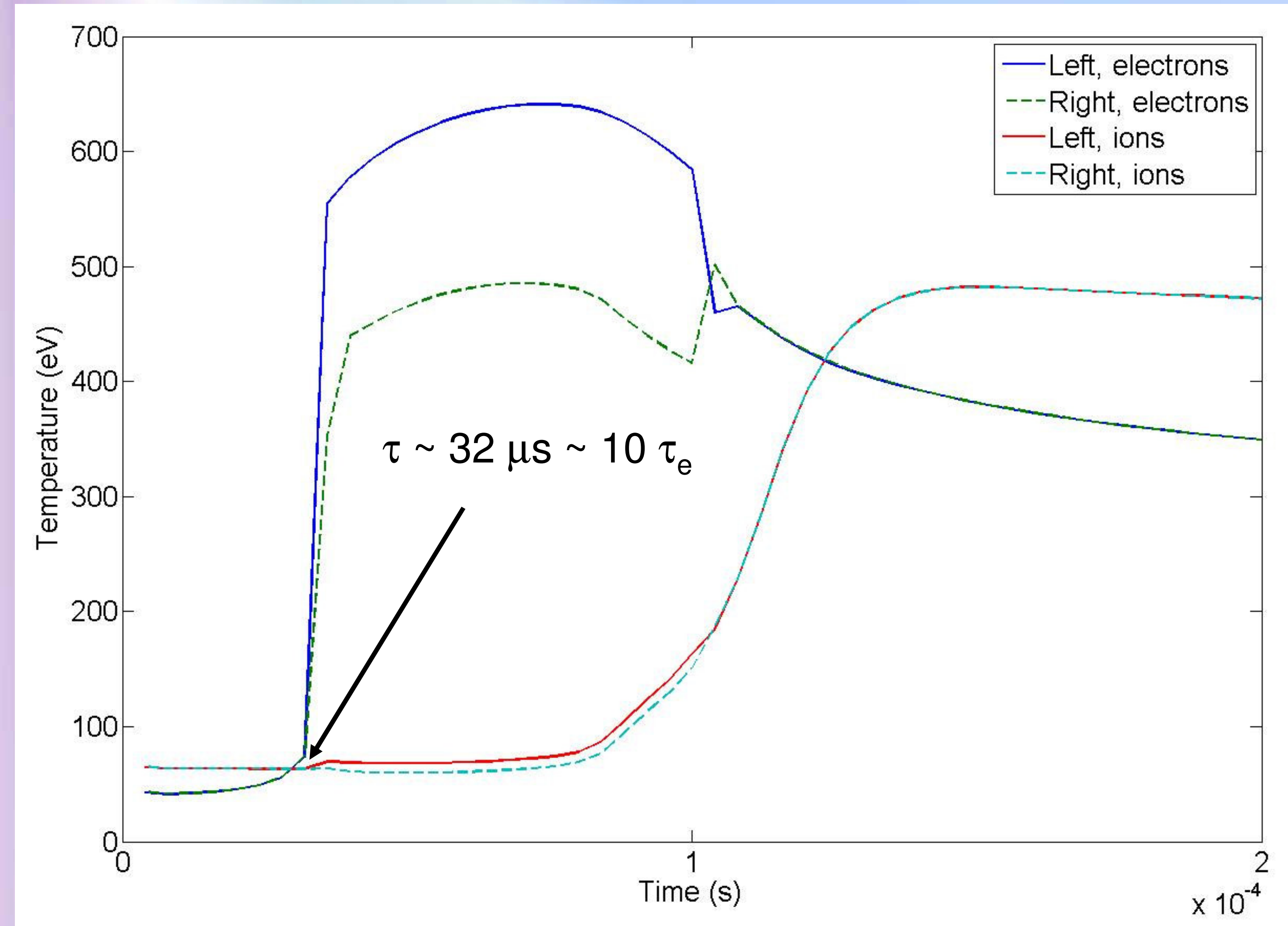
$\alpha_i = 0.2$

$\beta = 0.46$

$\gamma_e = 3.8$

$\gamma_e = 5.5$

Target Temperatures



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$\gamma_e = 3.8$

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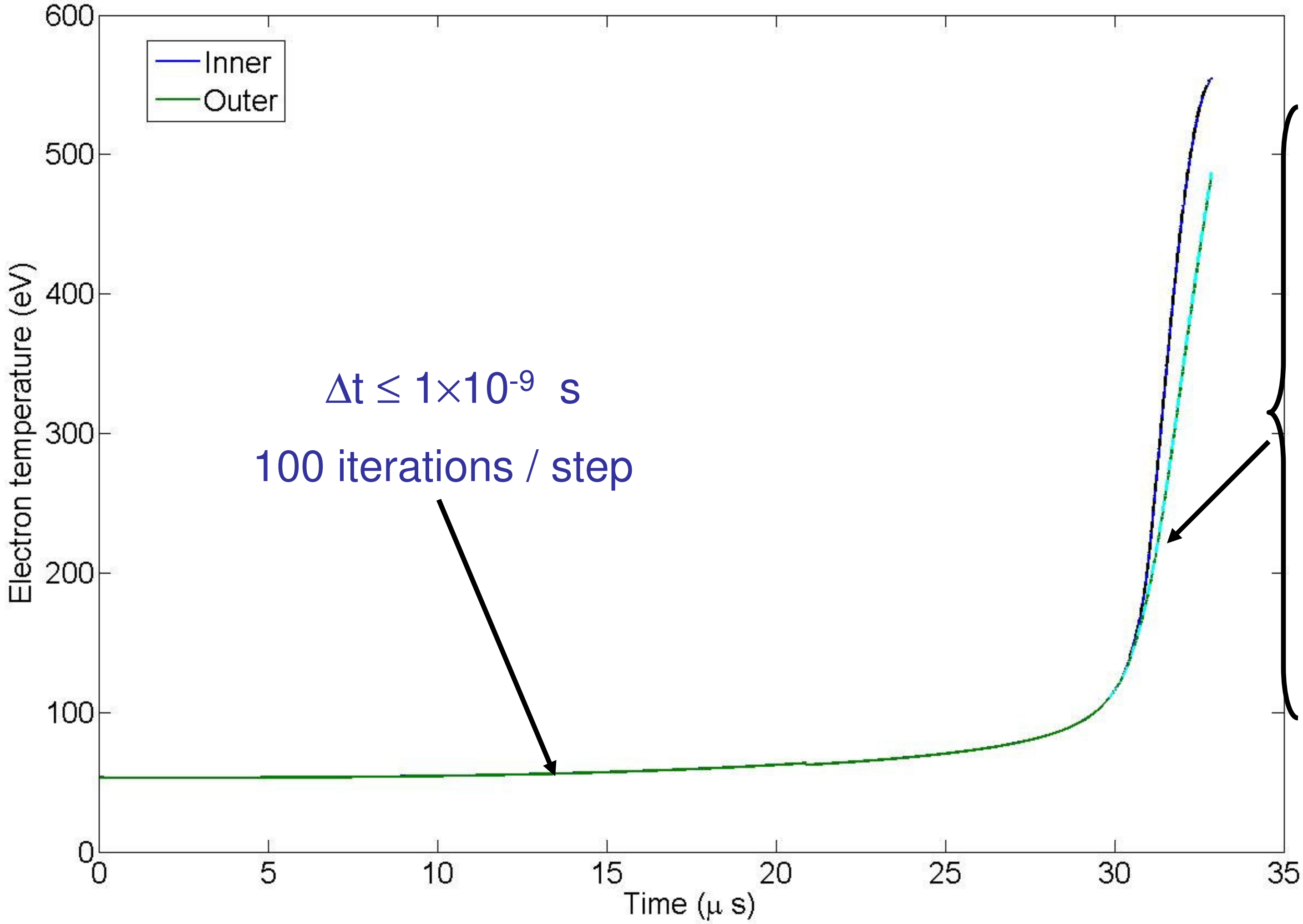
Electron Temperature Traces

$\alpha_e = 0.12$ $\alpha_i = 0.2$ $\beta = 0.46$ $\gamma_e = 3.8$ $\gamma_e = 5.5$



$\Delta t \leq 3\times10^{-10}$ s

100 iterations / step

$\Delta t \leq 3\times10^{-11}$ s

100 iterations / step

$\Delta t \leq 3\times10^{-10}$ s

1000 iterations / step

Time Dependent Parameters

Table of time dependent boundary conditions and flux limiters coefficients, first half ELM (time in μs)

	0<t<1.125	t<2.250	t<3.0	t<9.0	t<26.25	t<45.0	t<63.75	t<82.5
α_e	0.12	0.14	0.14	0.14	0.14	0.125	0.031	0.0185
α_i	0.1	0.128	0.199	0.228	0.24	0.297	0.338	0.316
β	0.46	0.441	0.422	0.409	0.308	0.164	0.235	0.303
γ_e	2.20	11.9	51.5	51.4	16.9	4.74	3.33	2.38
γ_i	3.80	4.04	3.05	4.05	3.74	4.17	6.70	9.73