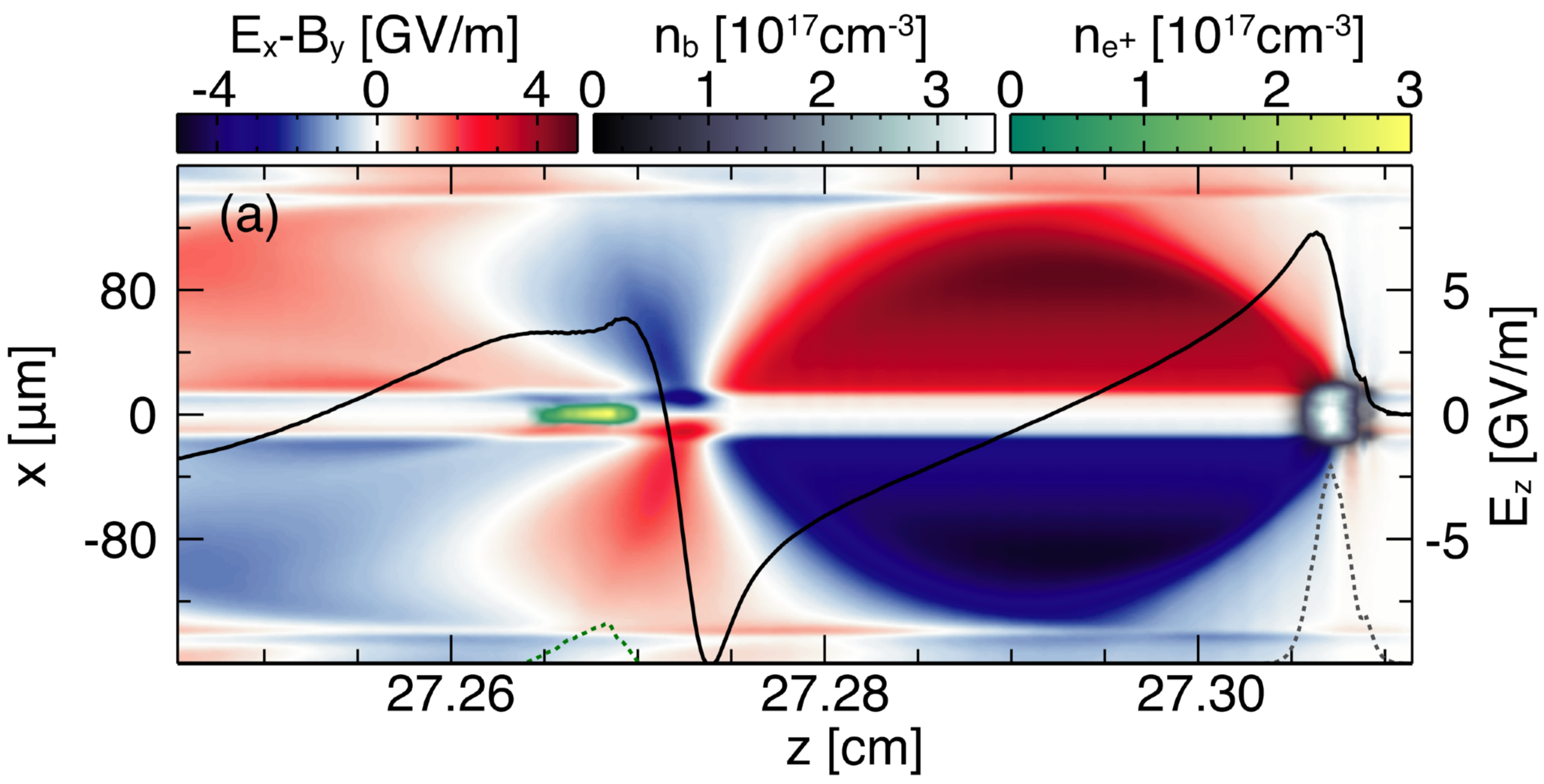
Q&A: electron and positron acceleration in self-generated, thin, warm hollow plasma channels

T. Silva, J. Vieira

on behalf of our collaborators

GoLP / Instituto de Plasmas e Fusão Nuclear
Instituto Superior Técnico, Lisbon, Portugal

epp.tecnico.ulisboa.pt || **golp**.tecnico.ulisboa.pt



Stable positron acceleration over 27cm propagation

Q&A

Q: Is shadowgraphy adequate for thin wall diagnostics?

A: Progress on E324 is essential to demonstrate that it can diagnose the channel - E324 plans to work on a similar regime as ours (low-density plasma). Thus, we cannot confirm, at this moment, if shadowgraphy will be adequate, but we hope so.

Q: Which diagnostics is used?

A: ***To demonstrate the channel generation and to characterize it***

- Shadowgraphy is an important diagnostic for this goal if it proves to be an adequate diagnostic for the thin channel; if it is not, we can still use a probe e- beam to verify the channel formation.
- Probe electron beam (the same/similar that drives the wakefield in the channel) gets an imprint of the channel size (modifies the beam profile to a flat-top distribution which matches the channel diameter). The high-resolution DTOTR will likely be used for this measurement.

Demonstrate wakefield excitation in the channel

- Shots with and without a wakefield driver can help distinguish the wakefield driver spectrum (thus corroborating the channel generation and characterize the fields driven on the channel). The spectrum here will likely be measured with the LFOV or CHER.

Demonstrate BBU free e- and e+ acceleration

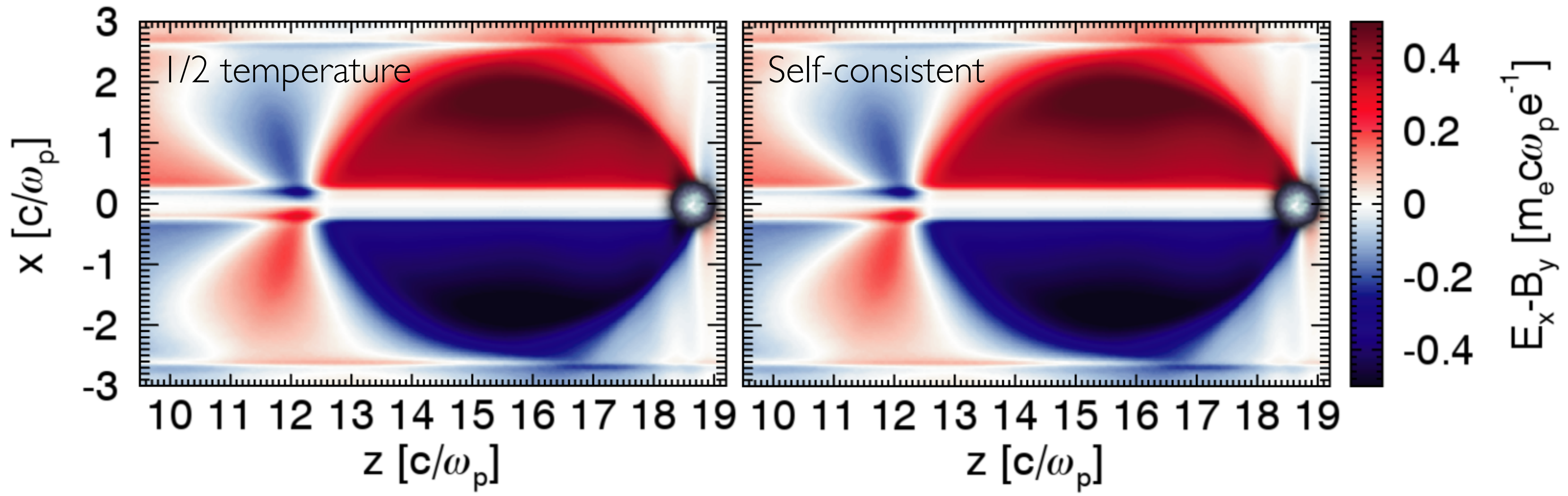
- Spectrum (from the LFOV or CHER) to measure accelerating gradients.
- Emittance (butterfly technique) to verify quality acceleration for e- and e+ (DTOTR).

Q&A

Q: How sensitive is the effect to the electron temperature?

A: Let us explain the role of the electron temperature first.

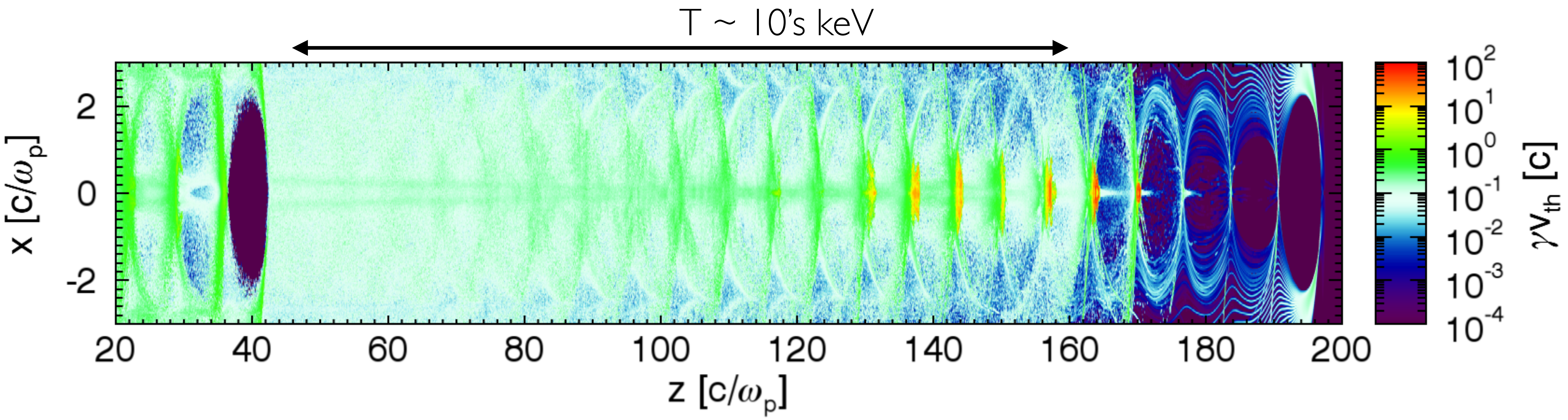
- If the plasma is cold, the second bubble is void of electrons (similar to standard blowout), thus is inefficient for e+ acceleration.
- If the plasma is warm, the channel can radially capture electrons near the axis in the second bubble.
- Temperature requirement is a function of the wakefield amplitude.
- Preliminary simulations artificially reducing the electron temperature by a factor of 2 showed similar results to the self-consistent.
- If the plasma temperature is lower (higher) in experiments than the predicted by simulation, one could decrease (increase) the wakefield driver charge to allow for e+ favorable regimes.



TÉCNICO LISBOA

Q: Is there numerical heating in the simulations? If so, how can this be improved?

A: Numerical heating is typically associated with simulation cells larger than the Debye length. Taking typical values of $T = [1,\ 20]\ keV$, $\lambda_{De} = \frac{v_{th}}{c} c/\omega_p = [0.044,\ 0.2]\ c/\omega_p$, while our grid resolution is $dx = dy = dz = 0.02\ c/\omega_p$.



- We also made a convergence test for particles-per-cell (1, 2, 4, 8) limited by the 3D nature of the simulations (comparison of the e-density on the next page).
- By those estimate, we believe our simulations are free of numerical heating. We will further confirm it with other diagnostics.

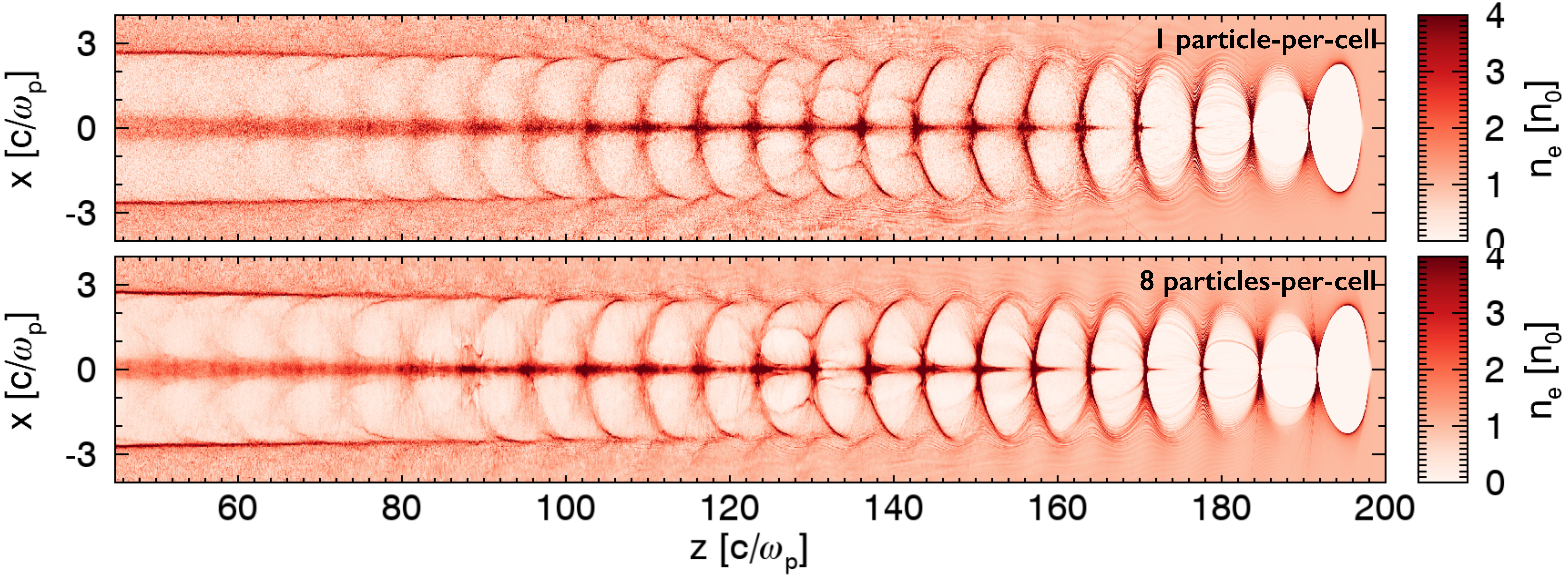
Q: Collisional effects

A: Electron-ion collision frequency $\nu_{ei} = 9.19 \times 10^6 \times n[10^{16} cm^{-3}] \times Z^2 \times T[keV]^{-3/2}\ s^{-1}$

For $n = 10^{16} cm^{-3},\ Z = 1,\ T = 1keV \rightarrow \tau_{ei} \sim 10^{-7} s$ much larger then the ion dynamics we are following (ps scale)

We also performed PIC simulations for E224 experiment (slightly different setup) with collisions, and we found no changes compared to collisionless simulations

Q&A


1 particle-per-cell
8 particles-per-cell
x [c/ωp]
z [c/ωp]
ne [n0]
3
0
-3
60
80
100
120
140
160
180
200
0
1
2
3
4