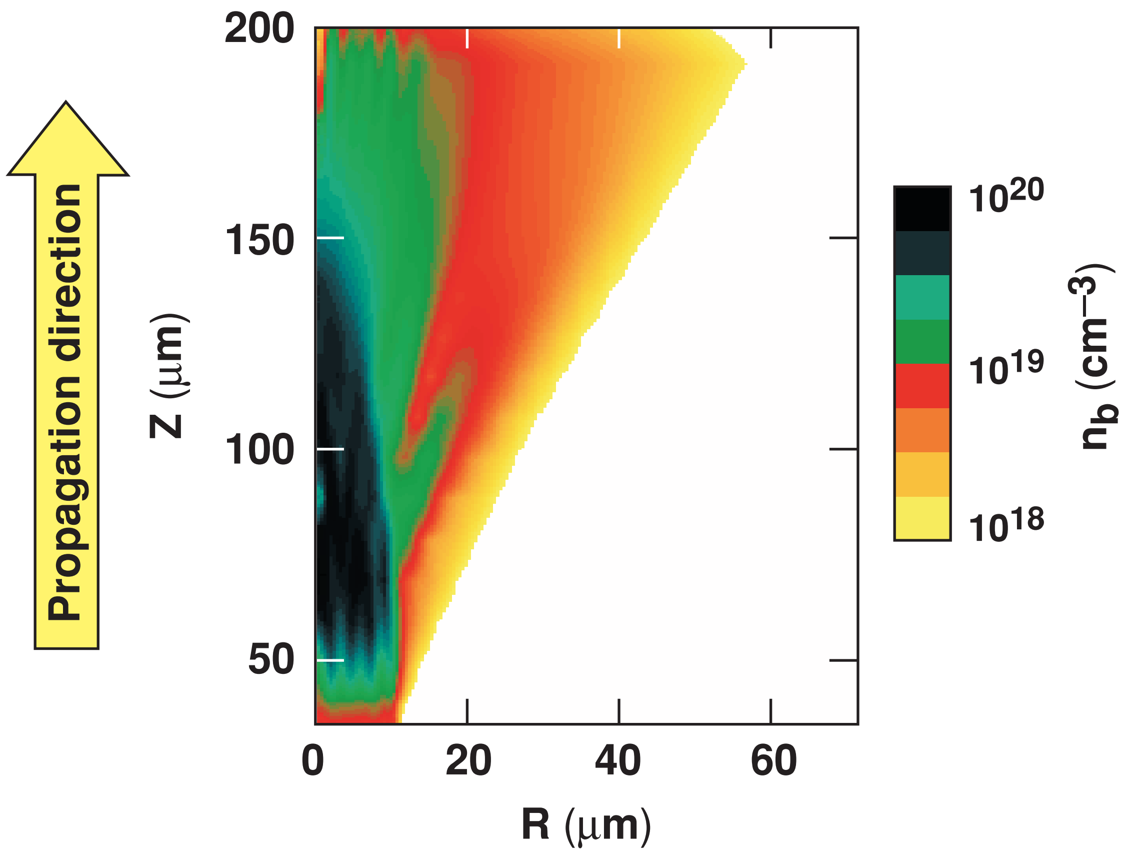
Intense Electron-Beam Transport in Dense, Cryogenic, DT, Fast-Ignition Fusion Targets



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Summary

The PIC/hybrid approach is a promising technique for modeling electron transport in very overdense plasmas

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- Two- and three-dimensional simulations of fast (1-MeV) electron beams have been made in imploded cryogenic fusion targets.
- The PIC/hybrid approach (LSP*) has several advantages over traditional PIC that allow large volumes of plasma to be simulated.
- A self-generated azimuthal magnetic field collimates the electron beam in 2-D, but not in 3-D.
- We observe filamentation of the beam current in both 2-D and 3-D.
  - Filamentation is shown to depend on the background plasma density and beam temperature.
- The target is primarily heated by the return current for the chosen conditions.

*D. R. Welch *et al.*, Nucl. Instrum. Methods Phys. Res. A 464, 134 (2001).

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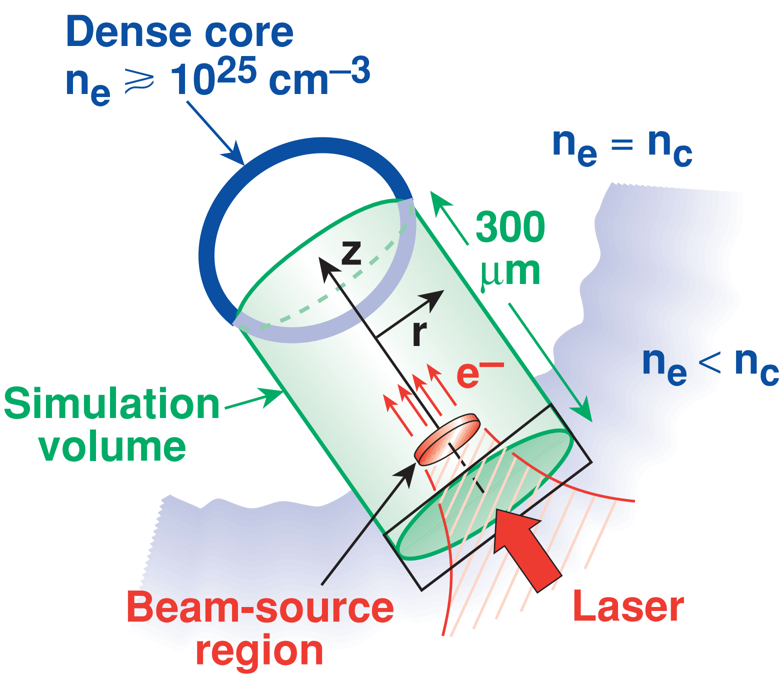
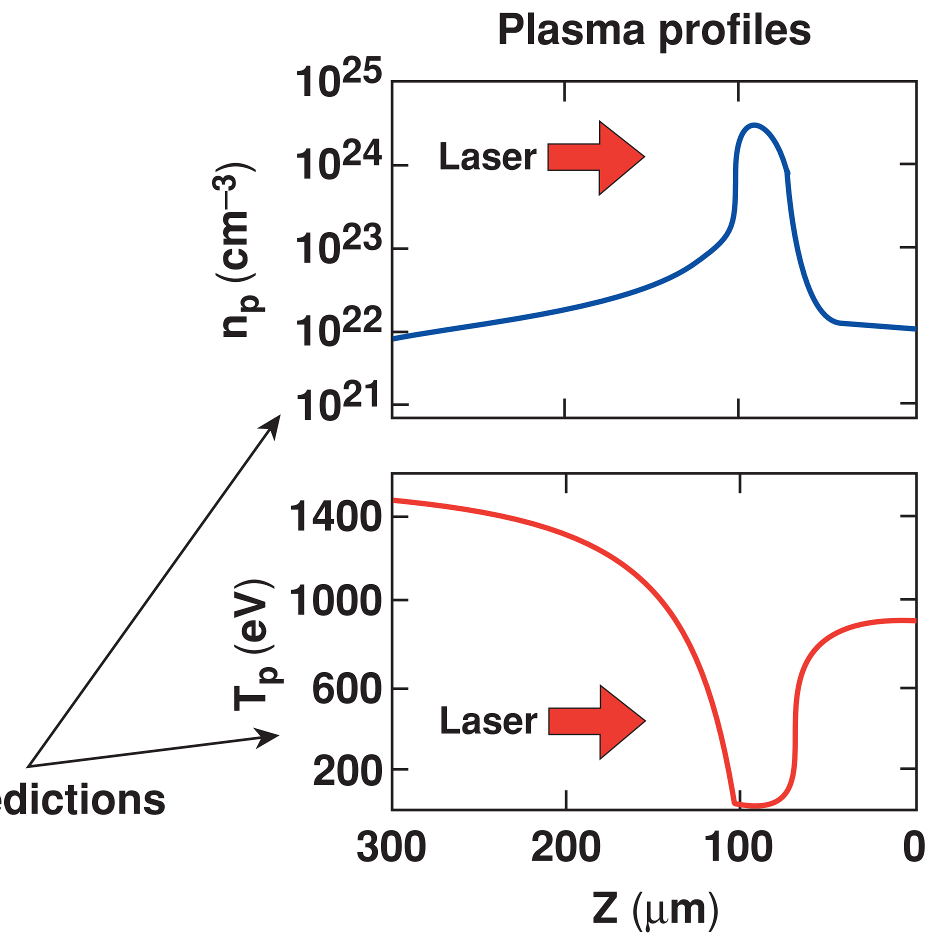
We treat the fast-electron transport but not the generation mechanism



- Large contrast in plasma density



- Plasma profiles are *DRACO* predictions for an $\alpha = 3$ implosion.

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Electron-beam parameters are relevant to future fast-ignition studies on OMEGA EP

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- An electron beam is generated by promotion from background over a 20-μm spot with a pulse duration of 10 ps.
- FI-relevant parameters are chosen for the beam source

$$n_b = 2 \times 10^{20}\, \eta_{eff} \frac{I}{10^{19}\,\mathrm{Wcm^{-2}}} \frac{1\,\mathrm{MeV}}{\varepsilon_b} \mathrm{cm^{-3}}$$

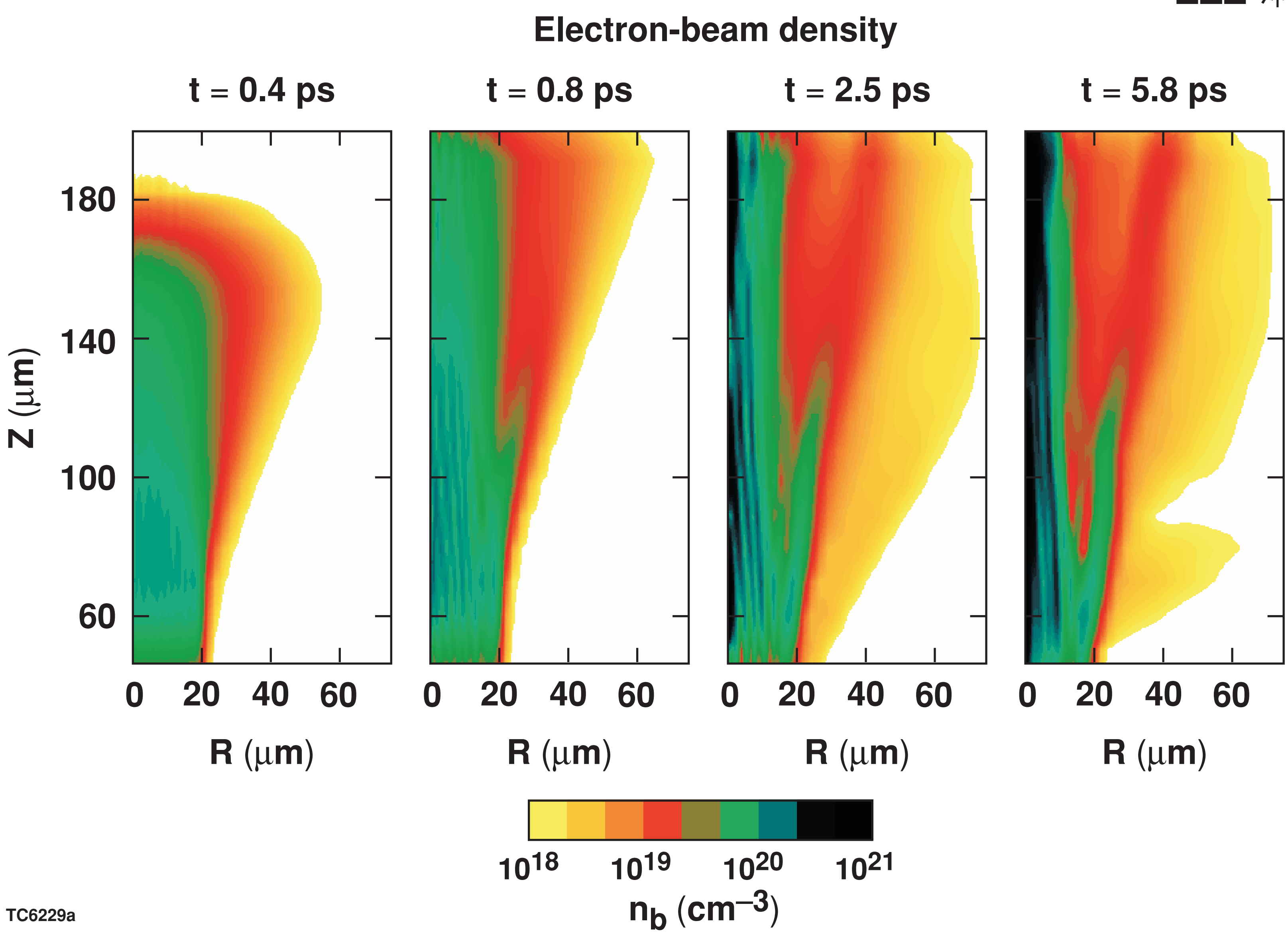
- Unlike simulations in near-critical plasmas, the beam is "weak" in the sense that $n_b/n_e << 1$

$$I_b = 30\, \eta_{eff} \frac{I}{10^{19}\,\mathrm{Wcm^{-2}}} \frac{A_{spot}}{300\,\mu\mathrm{m}^2} \left(\frac{1\,\mathrm{MeV}}{\varepsilon_b}\right) \mathrm{MA}$$

$$I_b >> I_{Alfvén} = 17\gamma\beta\ \mathrm{kA}$$

- Self-generated fields are therefore important for transport.

In 2-D, r-z geometry, the electron beam breaks into filaments and contracts radially



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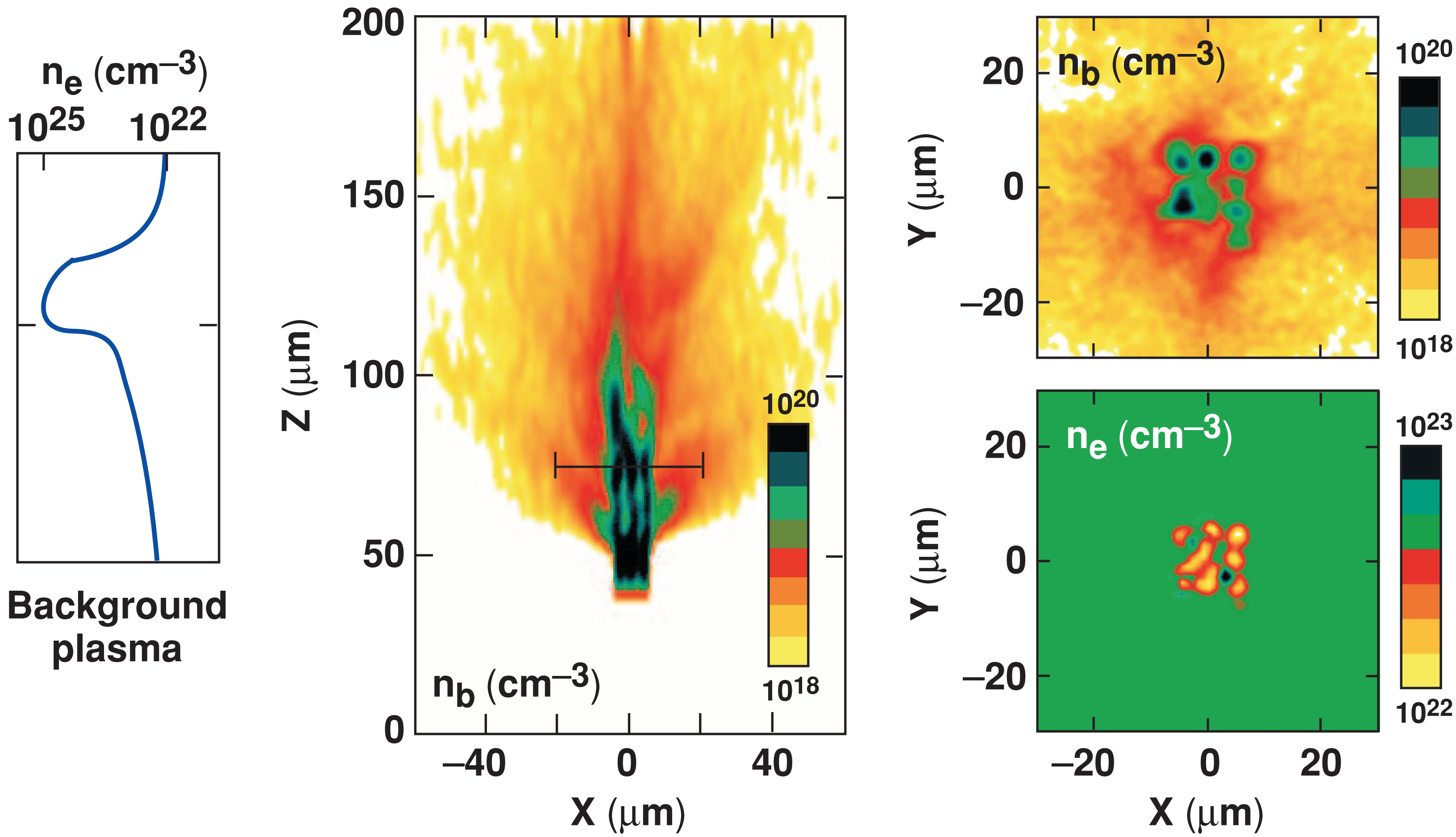
In three dimensions the electron beam breaks up into filaments



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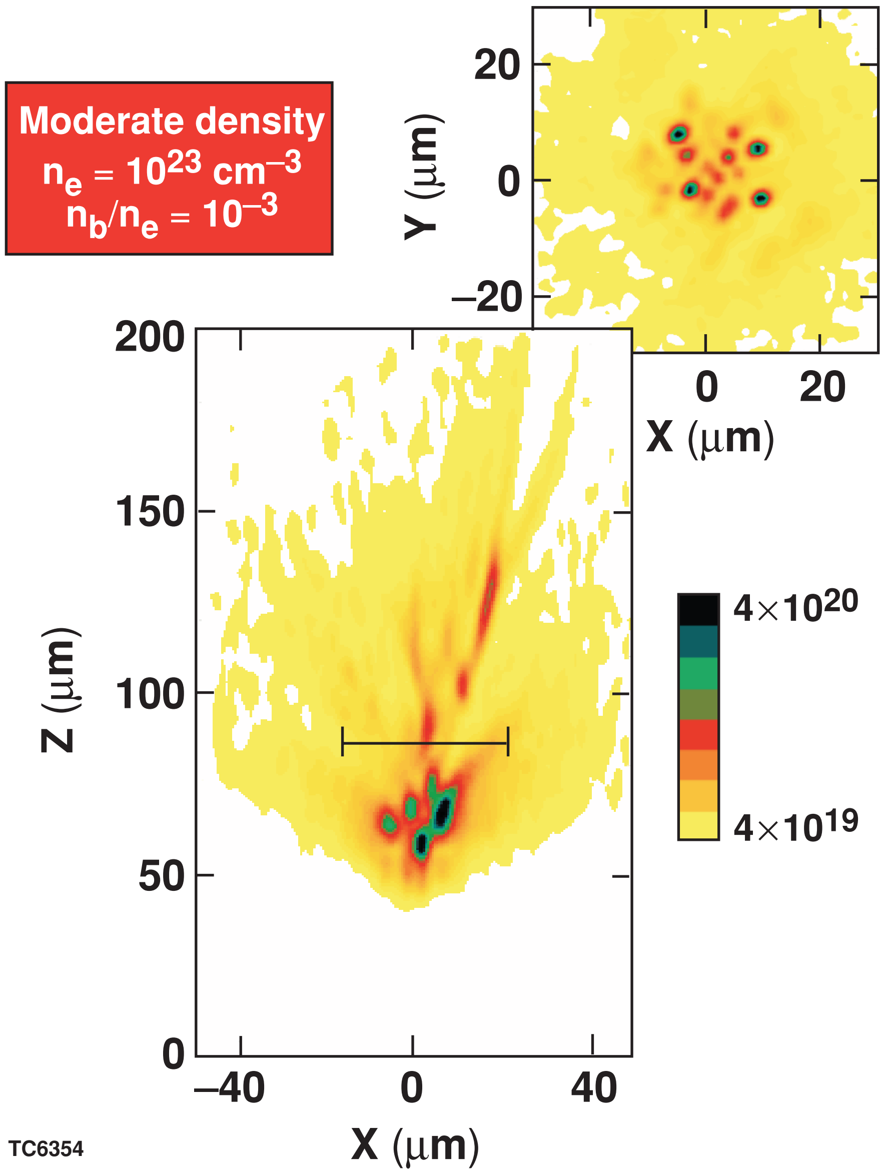
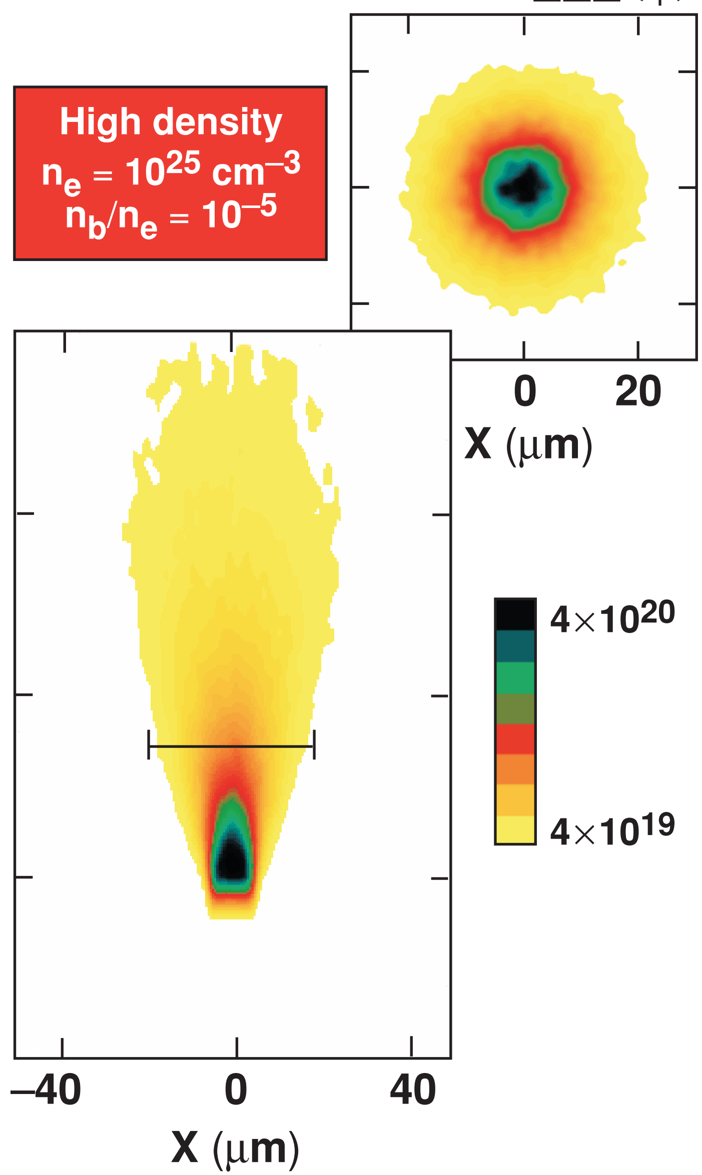
Homogeneous simulations show that beam filamentation depends on the plasma density





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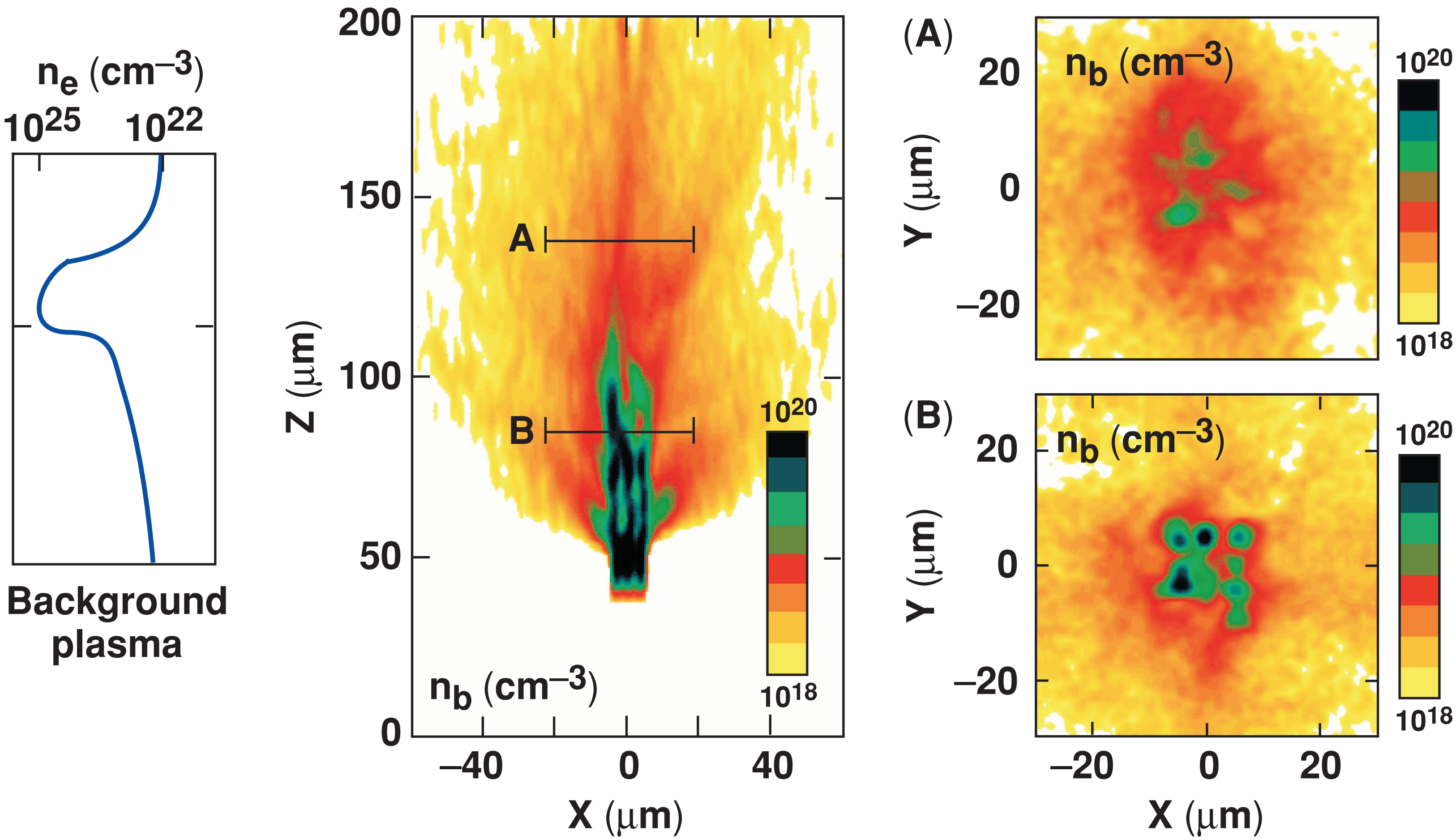
The filaments are smoothed-out in the high density shell



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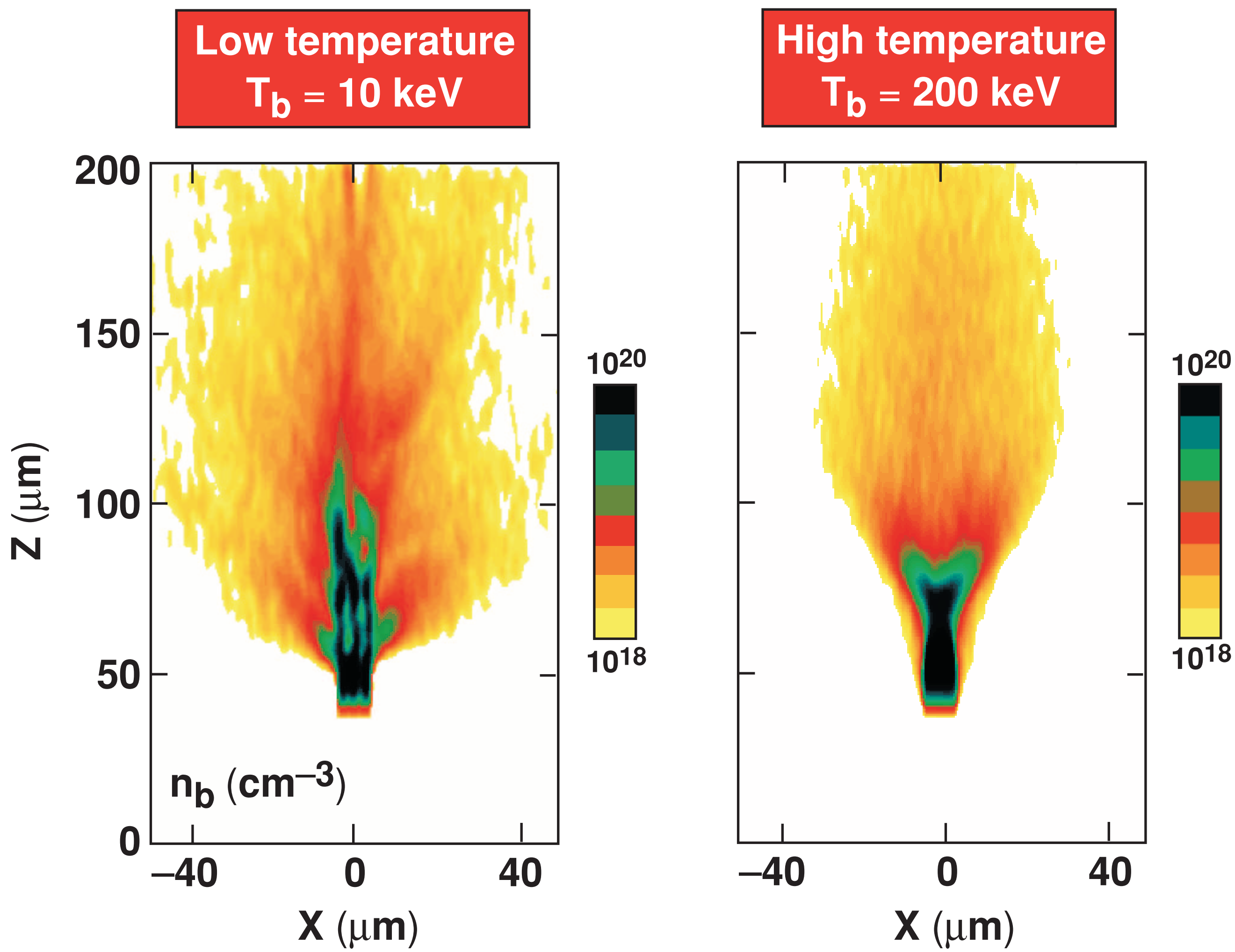
Filamentation is suppressed by a large beam "temperature"



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Summary/Conclusions

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