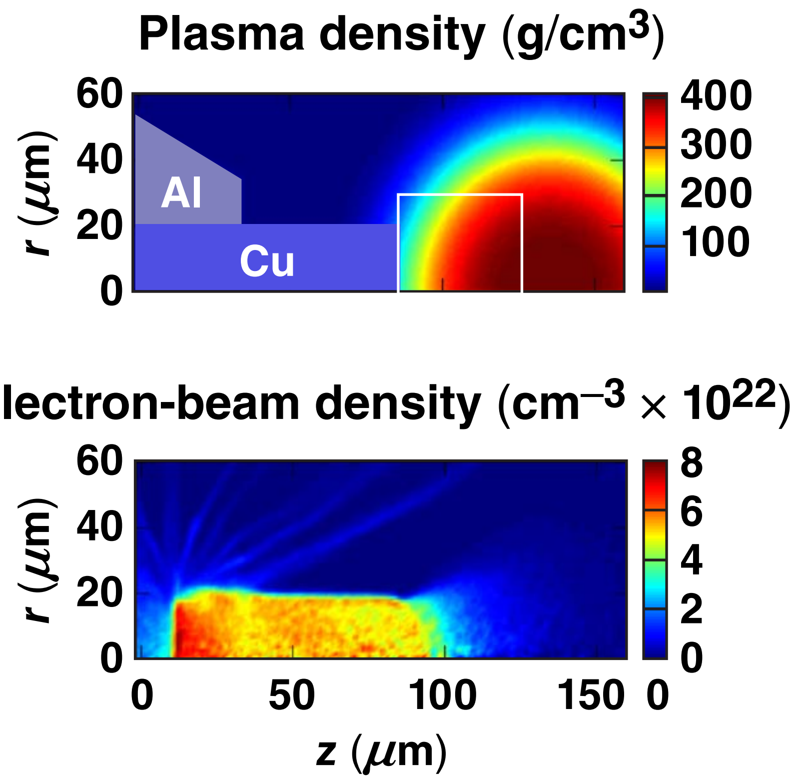
Controlling the Divergence of Laser-Generated Fast Electrons Through Resistivity Gradients in Fast-Ignition Targets



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Summary

Divergence of high-energy electron beams can be controlled through resistivity mismatch in fast-ignition targets

- *LSP** simulations predict collimation of high-energy electron beams by resistivity gradients
- Three cases have been modeled
  - Cu cone
  - Al cone with Cu insert in the cone tip
  - Al cone with a Cu wire attached to the cone tip
- Hot electrons are effectively collimated by resistivity gradients in the cone tip and in the wire, which increases their coupling to the core

TC9073

*D. R. Welch *et al.*, Phys. Plasmas 13, 063105 (2006).

Collaborators

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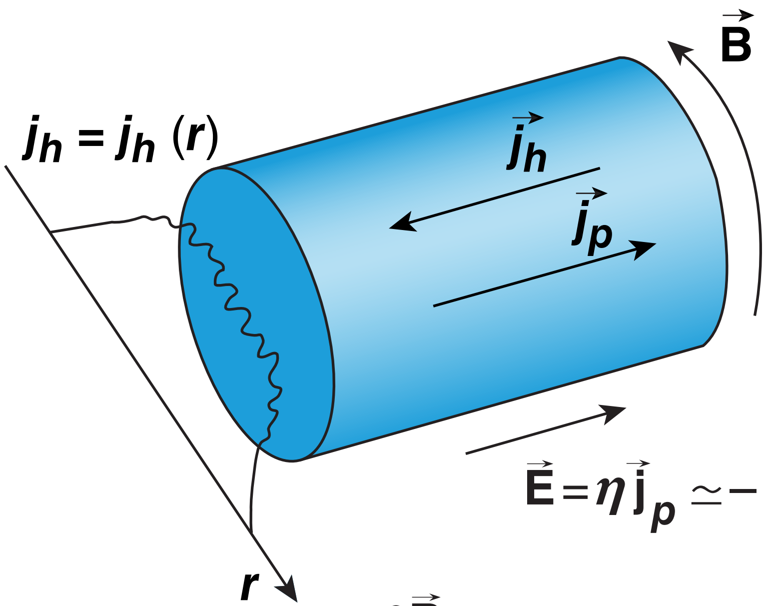
Self-generated resistive magnetic fields can control divergence of electron beams in plasmas*

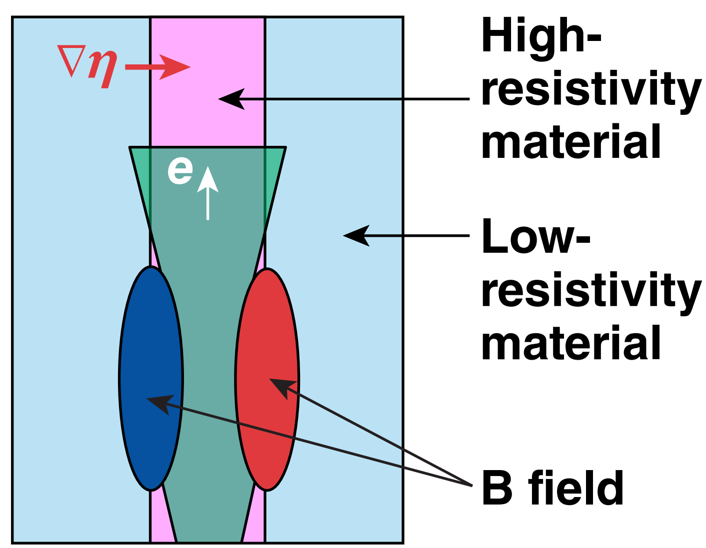


$$\vec{E} = \eta \vec{j}_p \simeq -\eta \vec{j}_h$$

$$\frac{\partial \vec{B}}{\partial t} = -\nabla \times \vec{E}$$

$$\frac{\partial \vec{B}}{\partial t} = \eta \nabla \times \vec{j}_h + \nabla \eta \times \vec{j}_h$$

- Electron collimation by B fields generated by resistivity gradients*

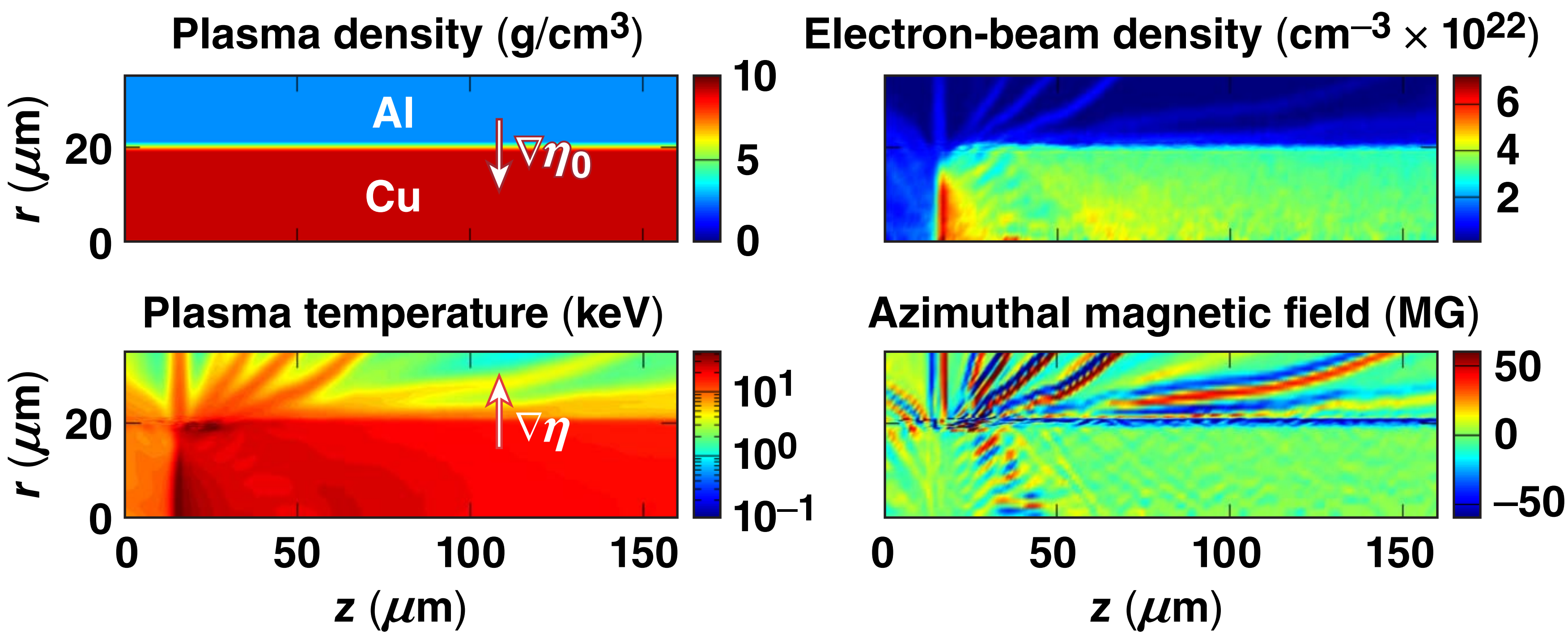


TC9074

*A. P. L. Robinson and M. Sherlock, Phys. Plasmas 14, 083105 (2007).

A thin Cu fiber embedded in Al effectively collimates a highly divergent 15-kJ electron beam in the *LSP* simulation

- Simulation for a 7-ps, 2-MeV mean-energy, 67° half-angle electron beam



- Even though $\nabla\eta$ changed direction due to fiber heating, collimation is maintained because $|\eta\nabla \times \vec{j}_h|$ becomes greater than $|\nabla\eta \times \vec{j}_h|$

Collimated electrons contain 65% of the beam energy.

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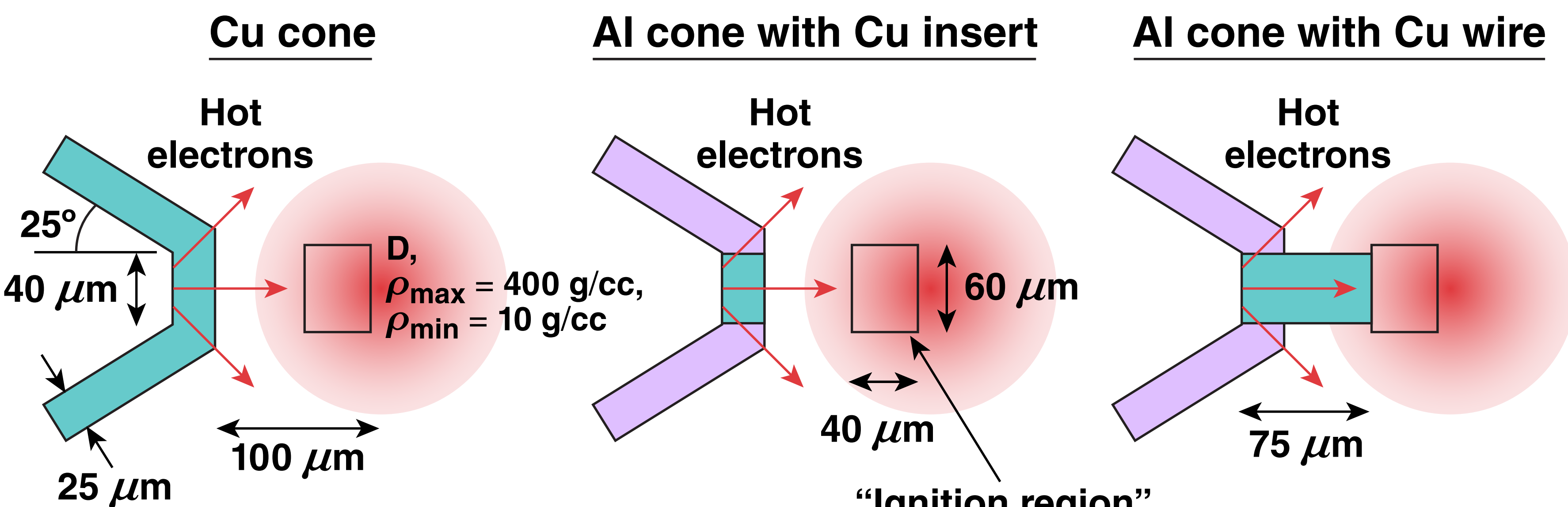
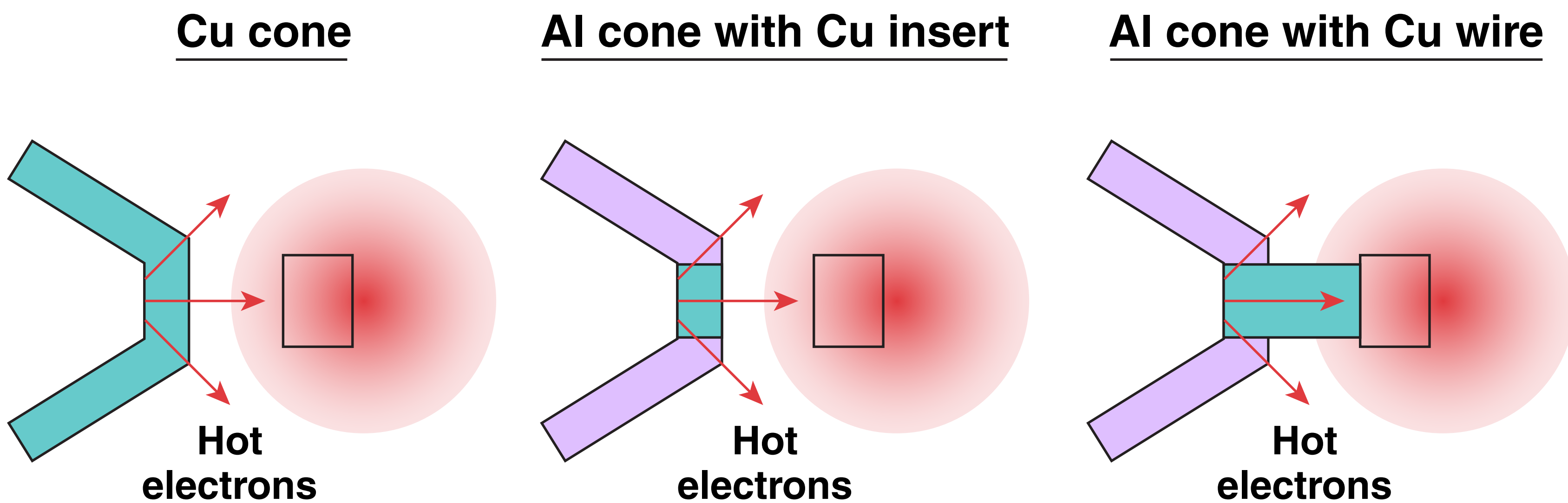
Electron transport in fast-ignition targets using materials with different resistivities has been modeled with *LSP*

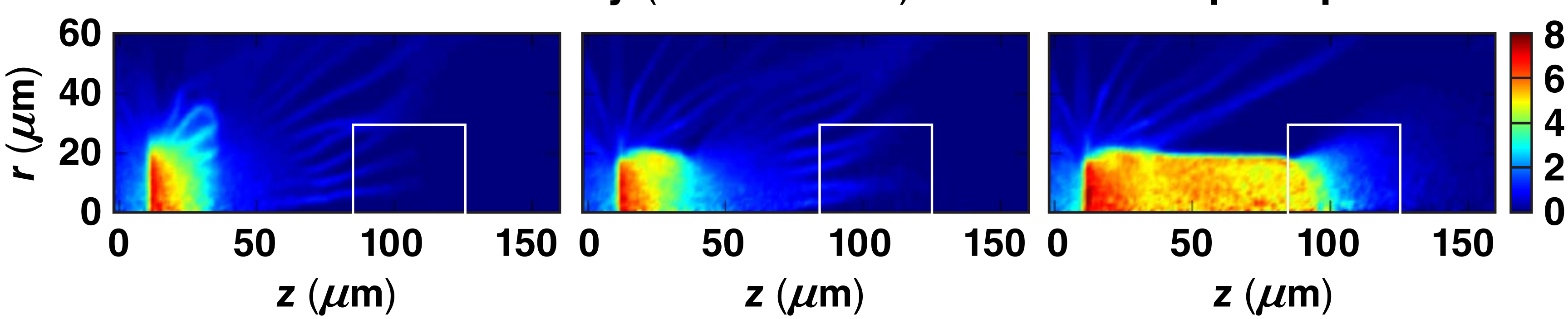


- Electron beam: E_{tot} = 40 kJ, τ = 10 ps, r_0 = 20 μm, T_{hot} = 1.6 MeV, $\theta_{1/2}$ = 67°
- Ionization and radiative cooling are modeled
- Energy coupled to the "ignition region" is calculated and compared in the simulations

Electrons are effectively collimated by resistivity gradients in the cone tip and in the wire



Electron-beam density ($cm^{-3} \times 10^{22}$) at the time of peak power



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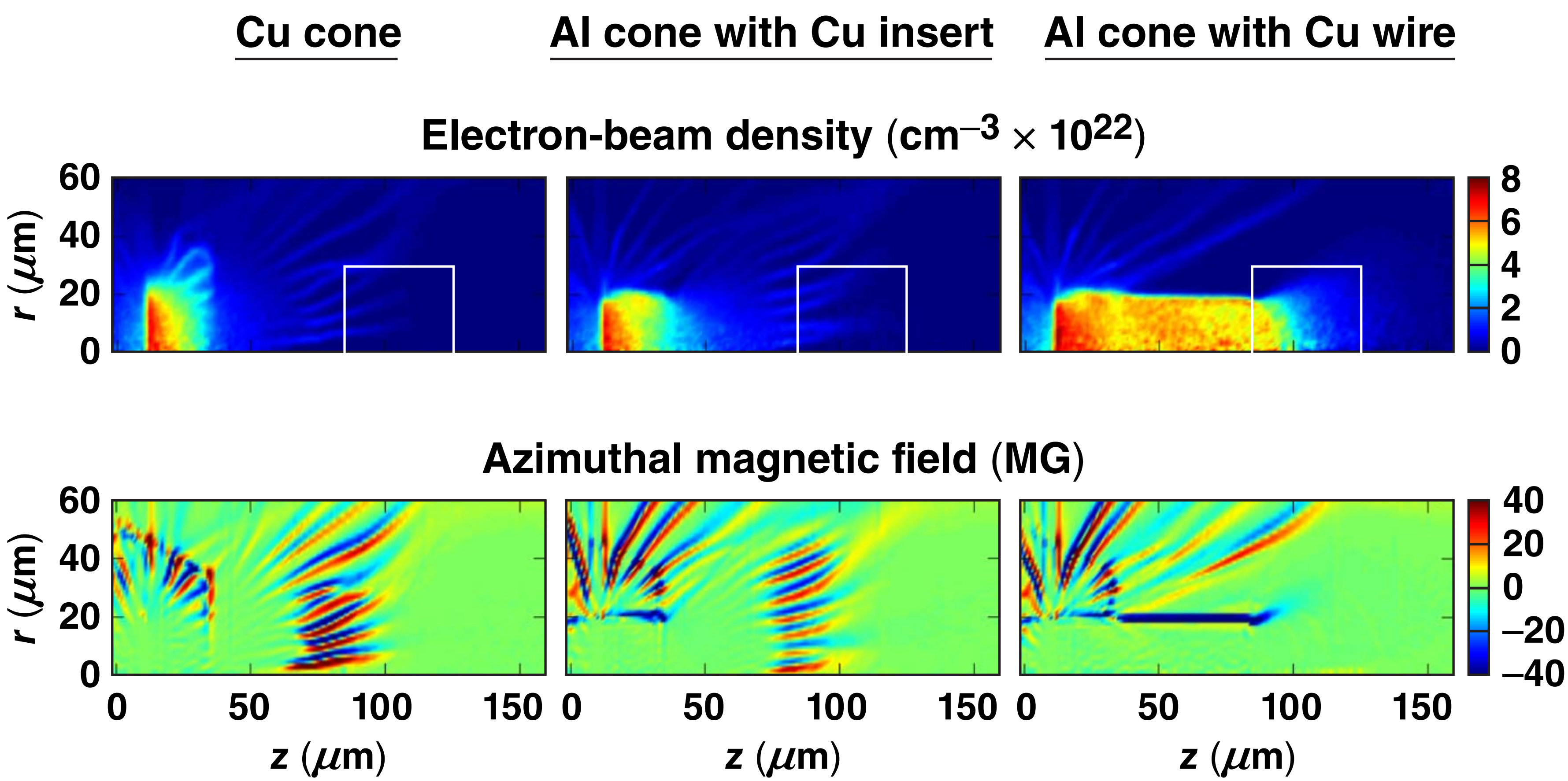
Hot-electron divergence is controlled by a resistive magnetic field



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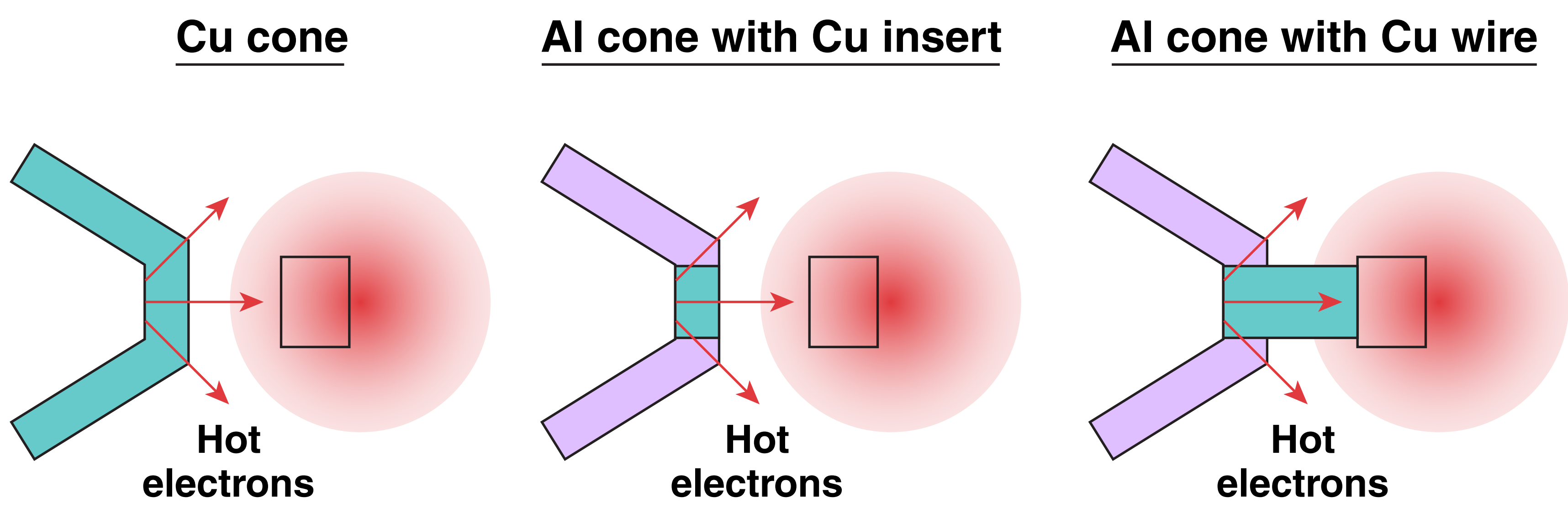
Resistive collimation significantly improves electron coupling to the core



Energy coupled to the "ignition region"		
2.7 kJ (7%)	4.5 kJ (11%)	18 kJ (45%)

- Resistive collimation can be especially useful for targets with thick cone tips
- Hydrodynamic simulations are required to determine survivability of the wire during the implosion

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Summary/Conclusions

Divergence of high-energy electron beams can be controlled through resistivity mismatch in fast-ignition targets

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