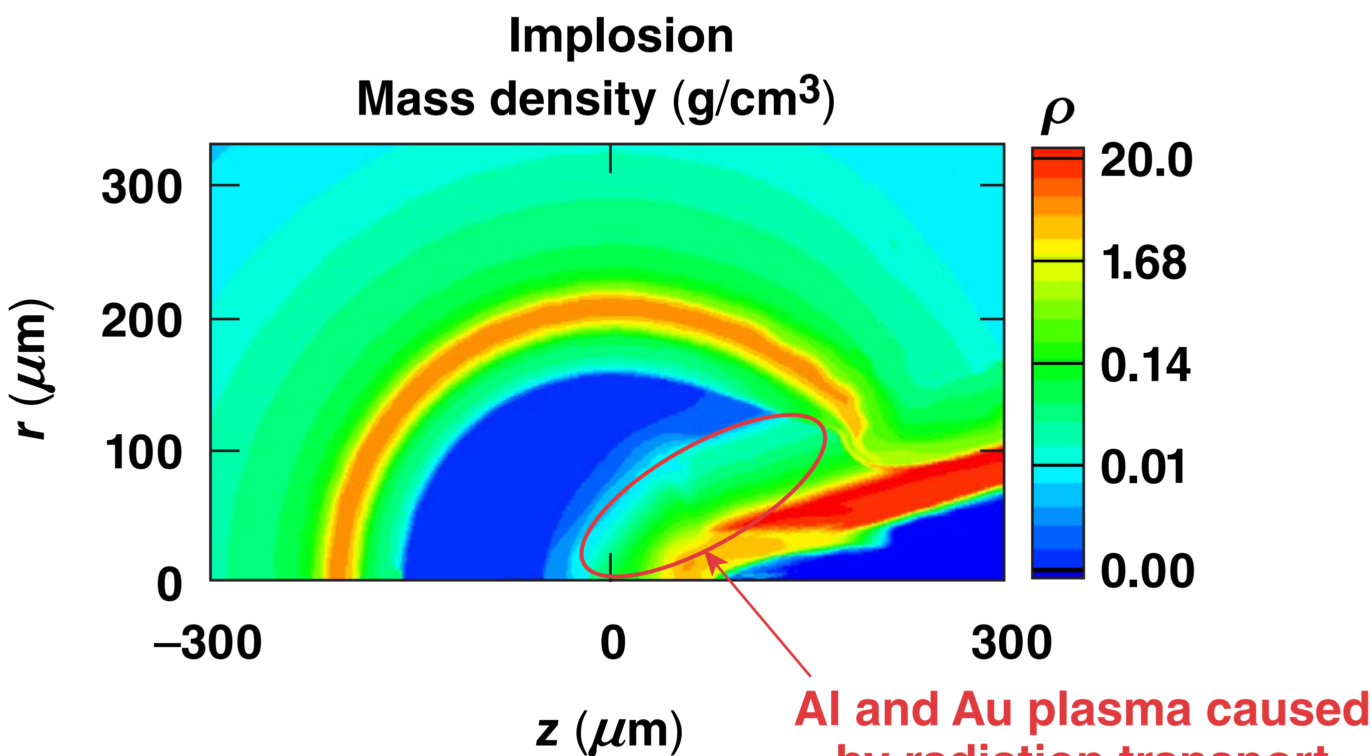
Simulations of Implosion and Core Heating for Integrated Cone-in-Shell Fast-Ignition Experiments on OMEGA



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Summary

Performance of cone-in-shell fast-ignition targets is studied using hybrid fluid and particle simulations of implosion and fast-electron transport

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- Implosion of cone-in-shell targets is simulated using the radiation–hydrodynamic code *DRACO**
- The hybrid particle-in-cell (PIC) code *LSP*** simulates the transport of fast electrons to the compressed core
- An aluminum cone tip is used to reduce the scattering losses of fast electrons
- A coupling efficiency of 1% to 4% of the petawatt laser pulse energy to the core is inferred from the simulations
- A neutron yield increase of 1 to 6 $\times$ 10^7 caused by fast electrons is predicted

*R.B. Radha *et al*., Phys. Plasmas 12, 056307 (2005).
**D.R. Welch *et al*., Phys. Plasmas 13, 063105 (2006).

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Collaborators

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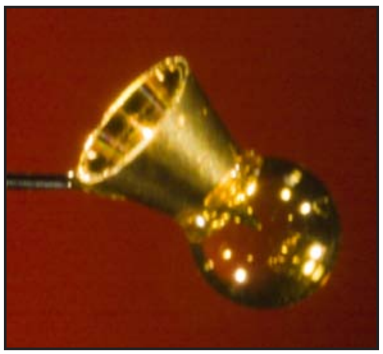
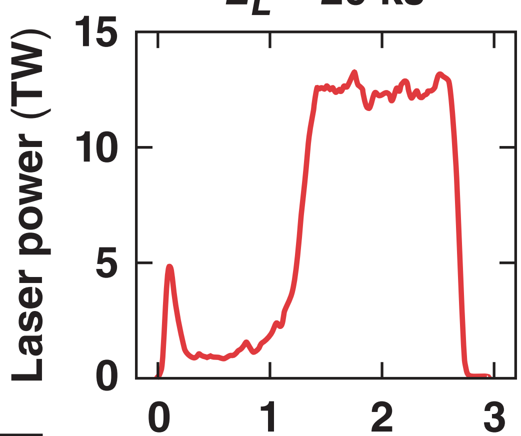
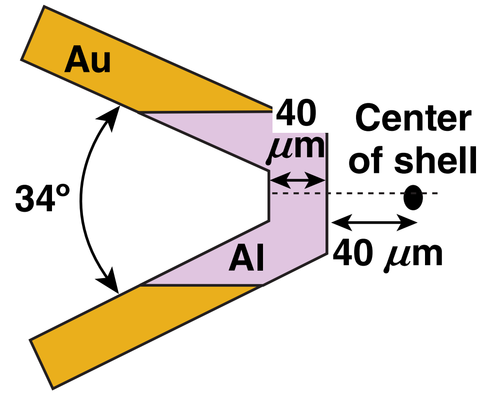
Integrated fast-ignition experiments with re-entrant cone targets are performed at the Omega EP Laser Facilities



Compression pulse
E_L = 20 kJ



Future cone tip design



Shell material	CD
Shell diameter	~870 μm
Shell thickness	~40 μm

- Improved OMEGA EP laser performance is expected
  - energy E_{EP} = 1.5 to 2 kJ
  - focal spot R_{80} = 15 μm
  - pre-pulse energy E_{pre} = 5 to 10 mJ

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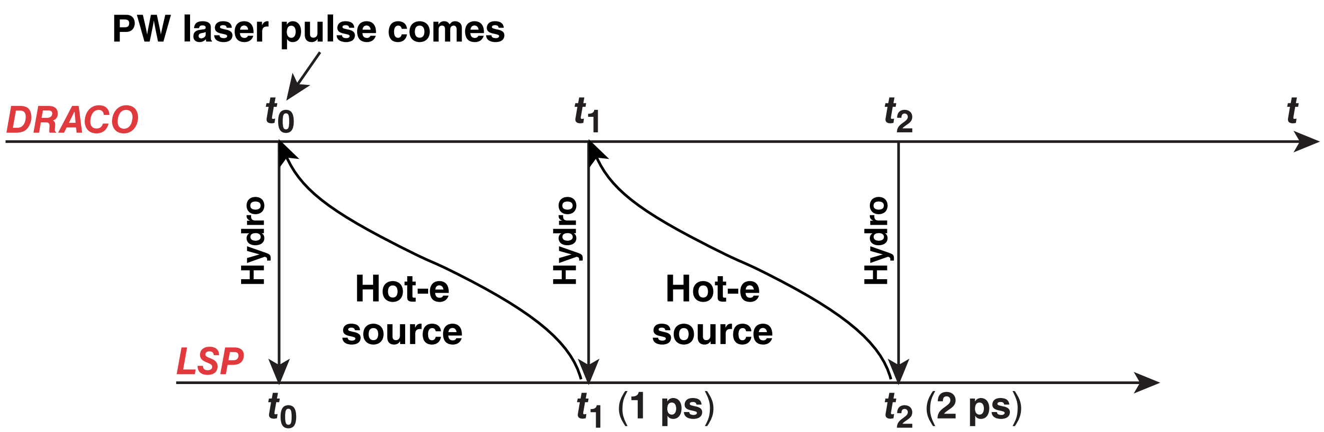
Performance of cone-in-shell targets is studied using *DRACO–LSP* integrated simulations

- ***DRACO****
  - simulates the implosion in 2-D cylindrically symmetric geometry
  - uses Eulerian moving-grid scheme, 3-D ray trace, and radiation transport
- ***LSP*****
  - 2-D/3-D implicit hybrid-PIC code that calculates the target heating by fast electrons
  - coupled to the hydrodynamic code *DRACO* during the short-pulse interaction***



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***A.A. Solodov *et al*., Phys. Plasmas 15, 112702 (2008).

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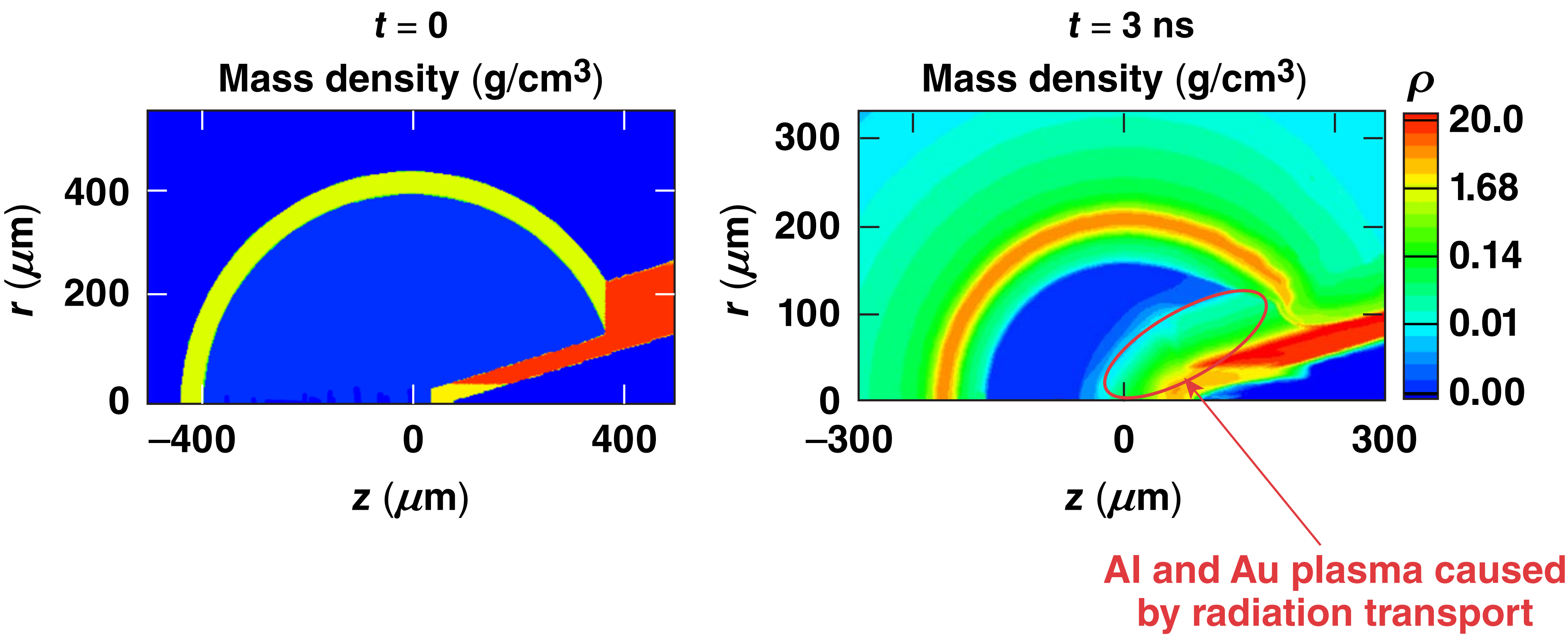
DRACO shows importance of radiation transport in modeling the implosion



- Cone material absorbs radiation emitted in the corona and thermally expands
- Cone can fill up with aluminum plasma if the tip is thinner than 35 μm

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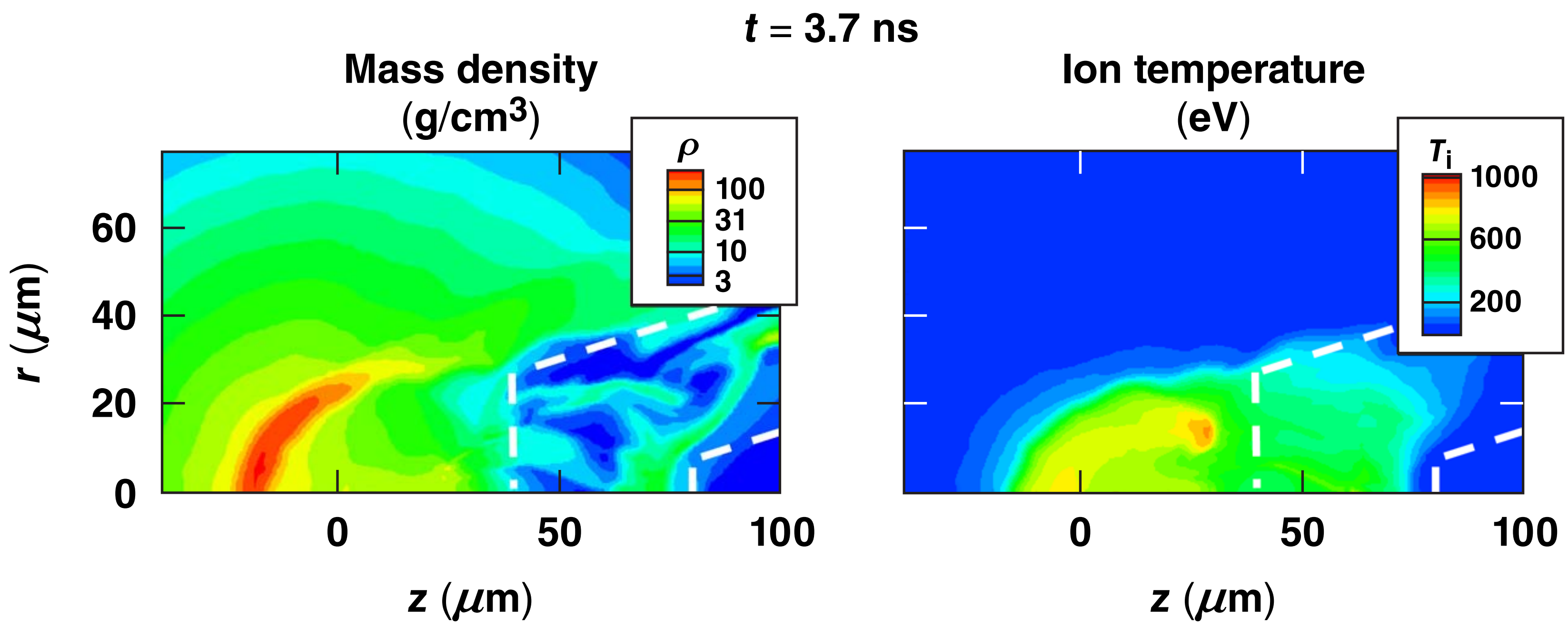
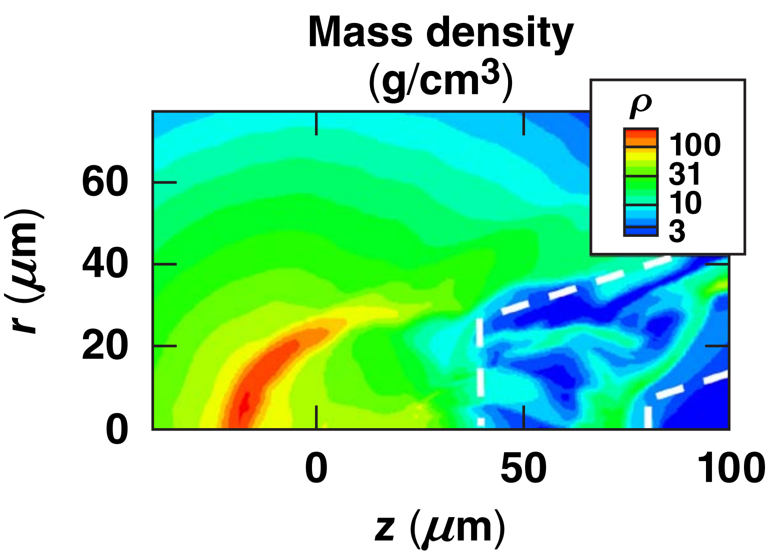
DRACO predicts an asymmetric fuel assembly with a hot spot facing the cone tip

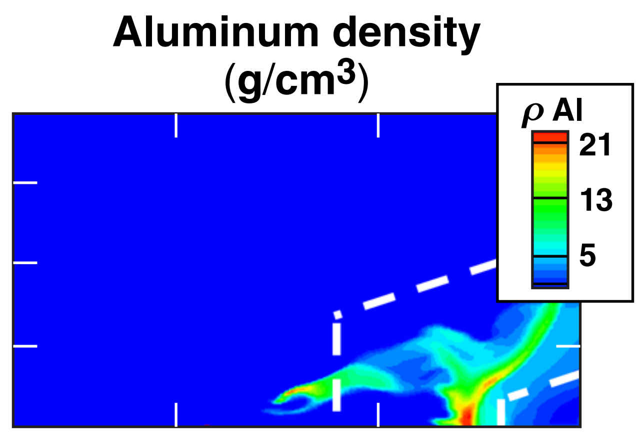


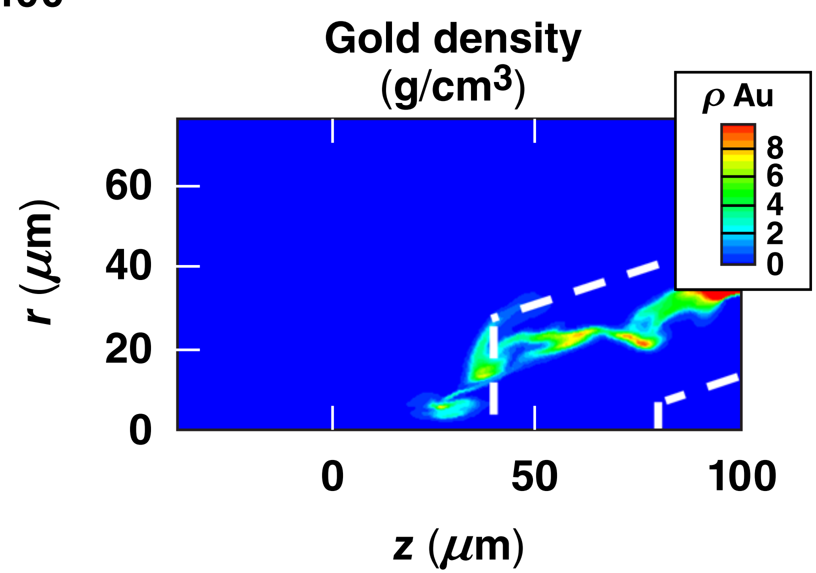
- ρR = 0.48 g/cm^2 in –*z* direction, 85% of 1-D ρR
- Implosion neutron yield is 10^8 (4×10^6 in experiments*)
- The temperature needs to be reduced by 1.65 in the simulation to match the experimental neutron yield
- 3-D hot-spot mix can reduce the temperature

*W. Theobald *et al*., Phys. Plasmas 18, 056305 (2011).

Aluminum and gold filling the shell during the implosion are compressed into a small region between the cone tip and the hot spot







Aluminum and gold in front of the cone tip can help to collimate fast electrons.

LSP simulates fast-electron transport from the cone tip to the core

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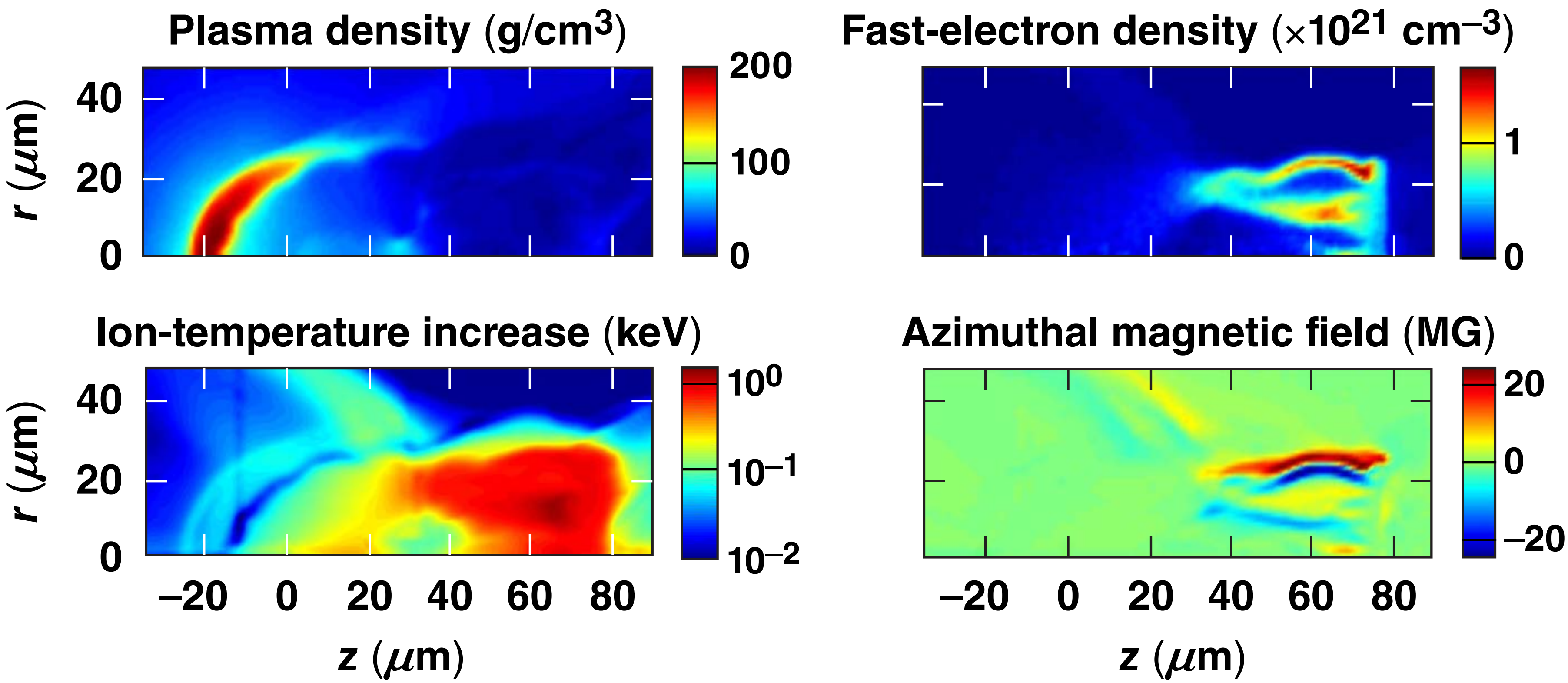
- Fast electrons are injected at the inner cone-tip surface
- OMEGA EP pulse energy E_{EP} = 1.5 kJ is assumed
- Sensitivity of core heating and neutron yield increase to variations in fast-electron divergence, temperature, and conversion efficiency is studied
- Recent *OSIRIS* PIC simulations* of fast-electron generation in the OMEGA EP pre-plasma suggest that fast electrons reaching the cone tip have
  - divergence half-angle of ~30°
  - 10% to 20% of the laser pulse energy
  - wide energy spectrum with 40% below 1 MeV

*J. Li *et al.*, this conference.

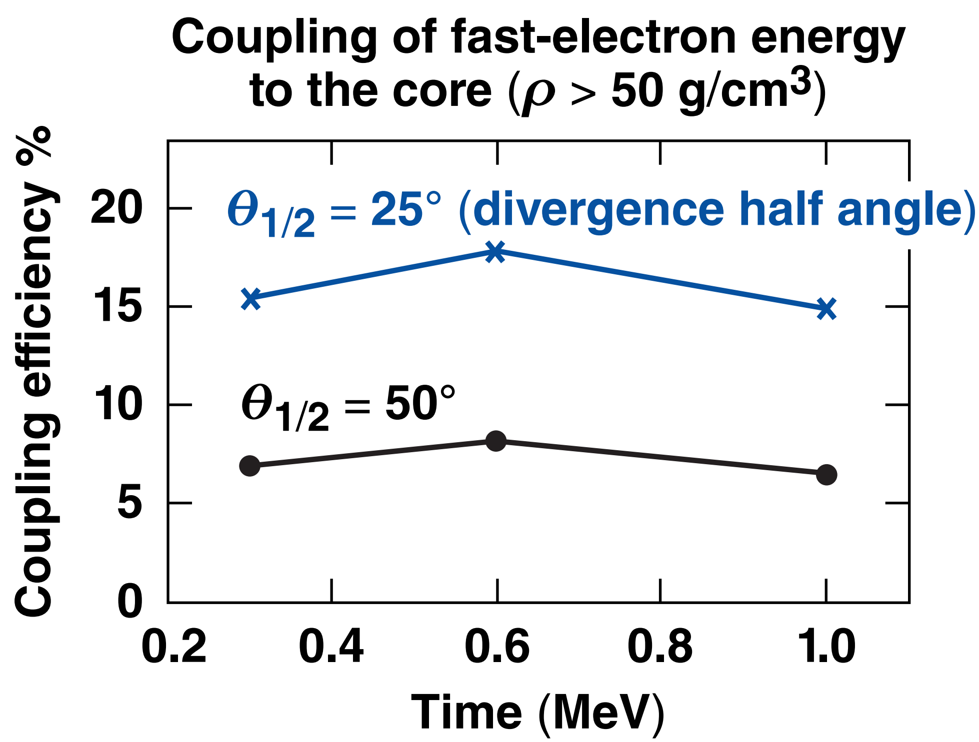
LSP simulates fast-electron transport and core heating

Simulation for electron temperature T = 0.6, divergence half-angle $\theta_{1/2}$ = 35°, conversion efficiency η_L = 0.15



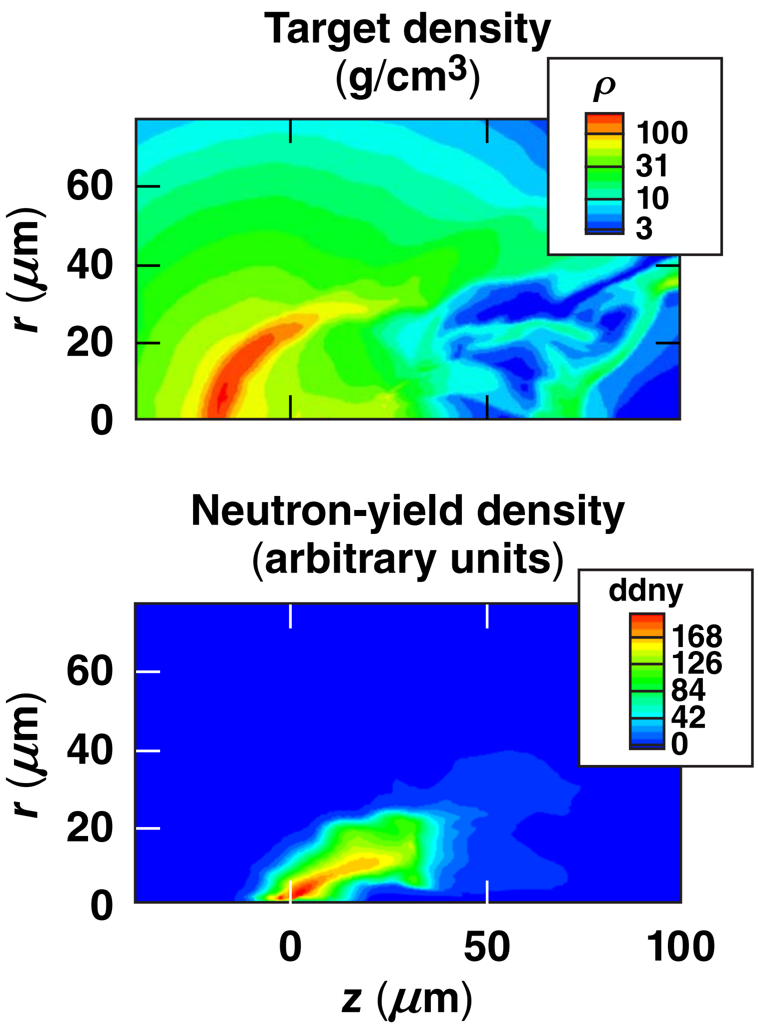
Fast electrons are collimated by magnetic fields generated caused by the resistivity gradients.

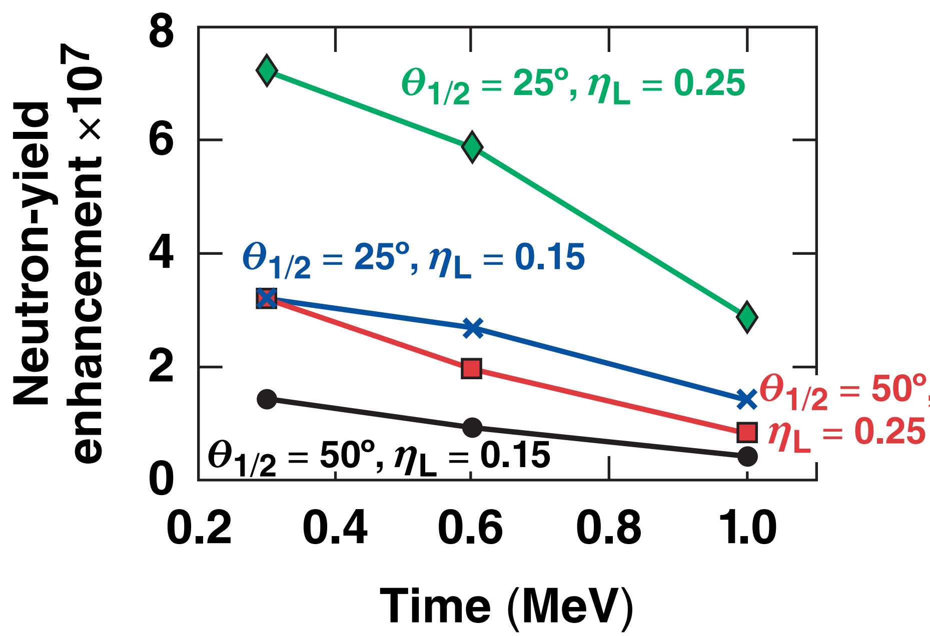
LSP predicts that 6% to 18% of fast-electron energy is coupled to the core (1% to 4% of the laser energy)



- Assumes 15% to 25% conversion efficiency to fast electrons reaching the cone tip

Neutron-yield increase by 1 to 6 × 10^7 is predicted by *DRACO/LSP* simulations





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Summary/Conclusions

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