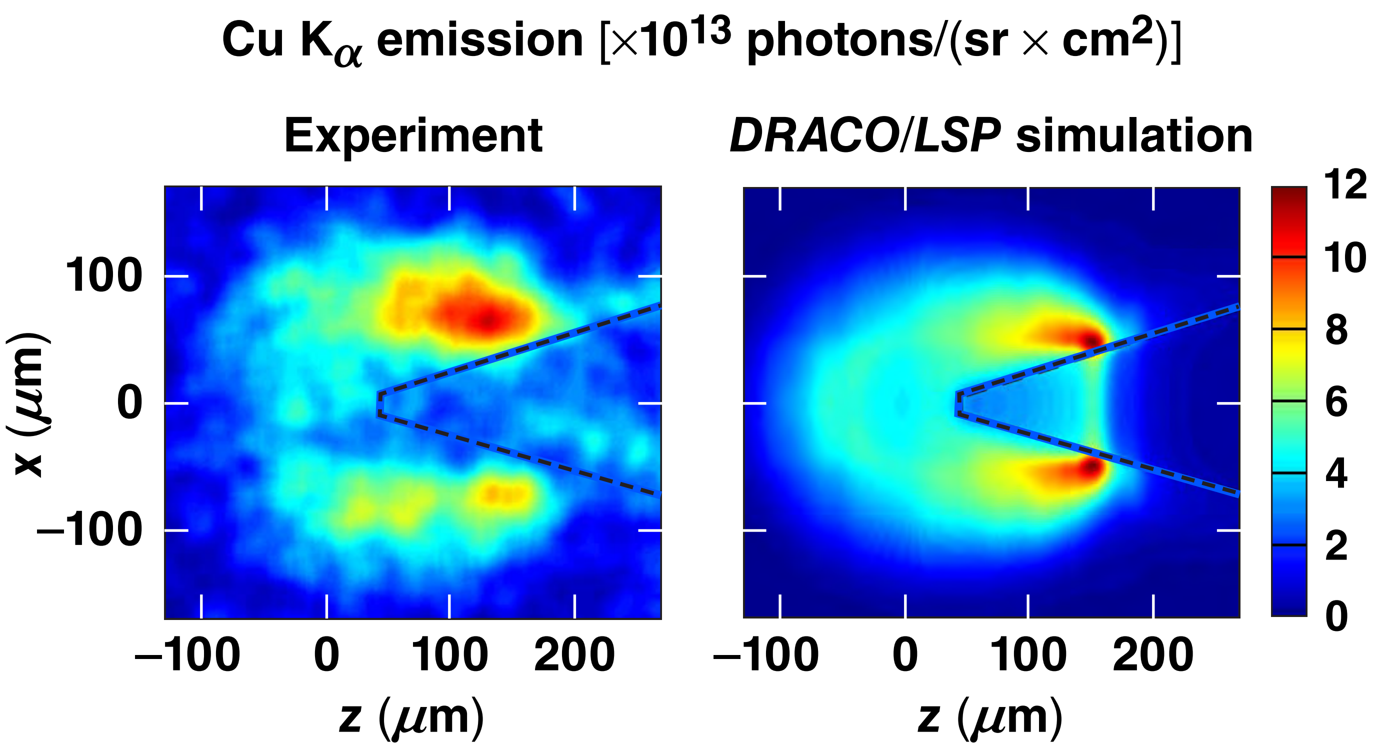
Simulations of Fuel Assembly and Fast-Electron Transport in Integrated Fast-Ignition Experiments on OMEGA



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Summary

*DRACO**/*LSP*** integrated simulations are used to study the performance of cone-in-shell fast-ignition targets

- *DRACO* simulations have been confirmed by 8.05-keV flash radiography of cone-in-shell implosions and shock breakout measurements
- *LSP* simulations explain the fast-electron transport in integrated OMEGA experiments using Cu-doped plastic shells
  - fast-electron–induced Cu K_{α} x-ray yield and spatial distribution are confirmed
  - ~2.5% of the total fast-electron energy is coupled to the core
    - hard fast-electron spectrum
    - large distance from the source to the core
    - large divergence

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

Collaborators

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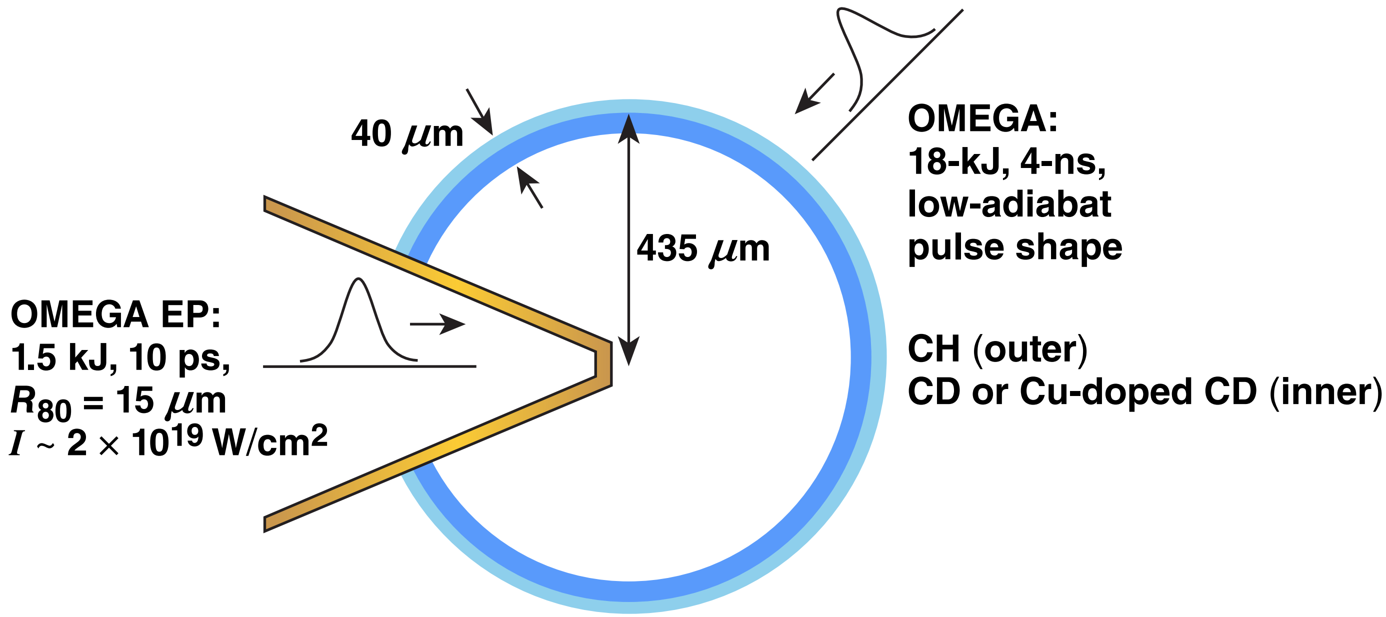
General Atomics

Integrated fast-ignition experiments with re-entrant cone-in-shell targets are performed at the Omega Laser Facility



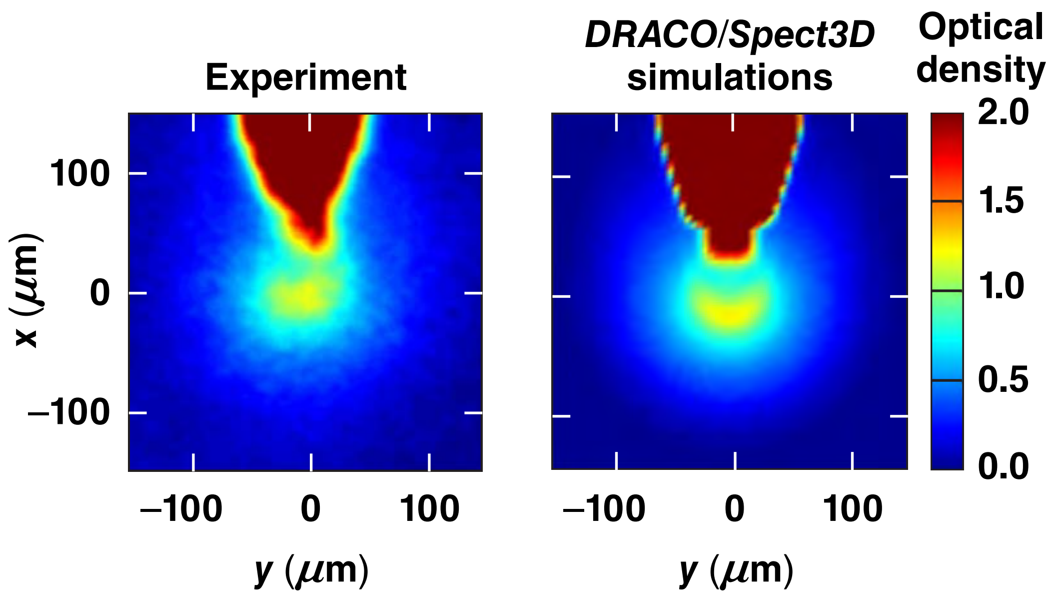
- A spherical crystal imager* (SCI) is used to obtain a spatial distribution of Cu K_α x rays induced by fast electrons in the imploded core

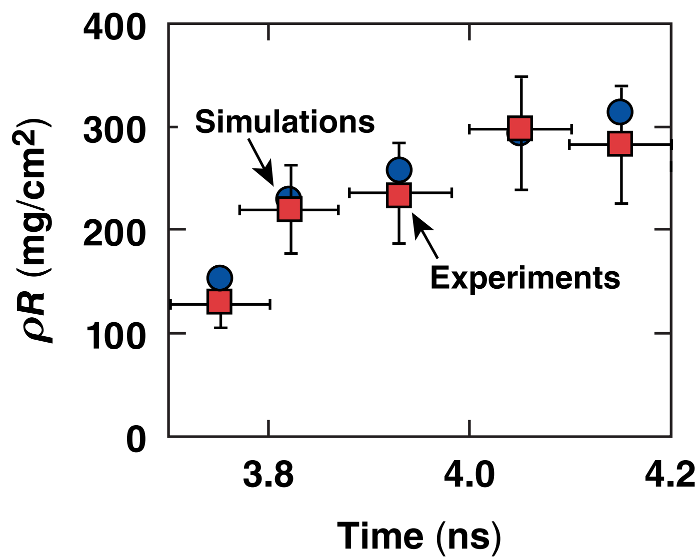
TC10047b

*C. Stoeckl *et al.*, Rev. Sci. Instrum. 83, 10E501 (2012).

DRACO simulations of the compressed core areal density agree with the experiments

- 8.05-keV Cu-K_α flash radiography of cone-in-shell implosions*



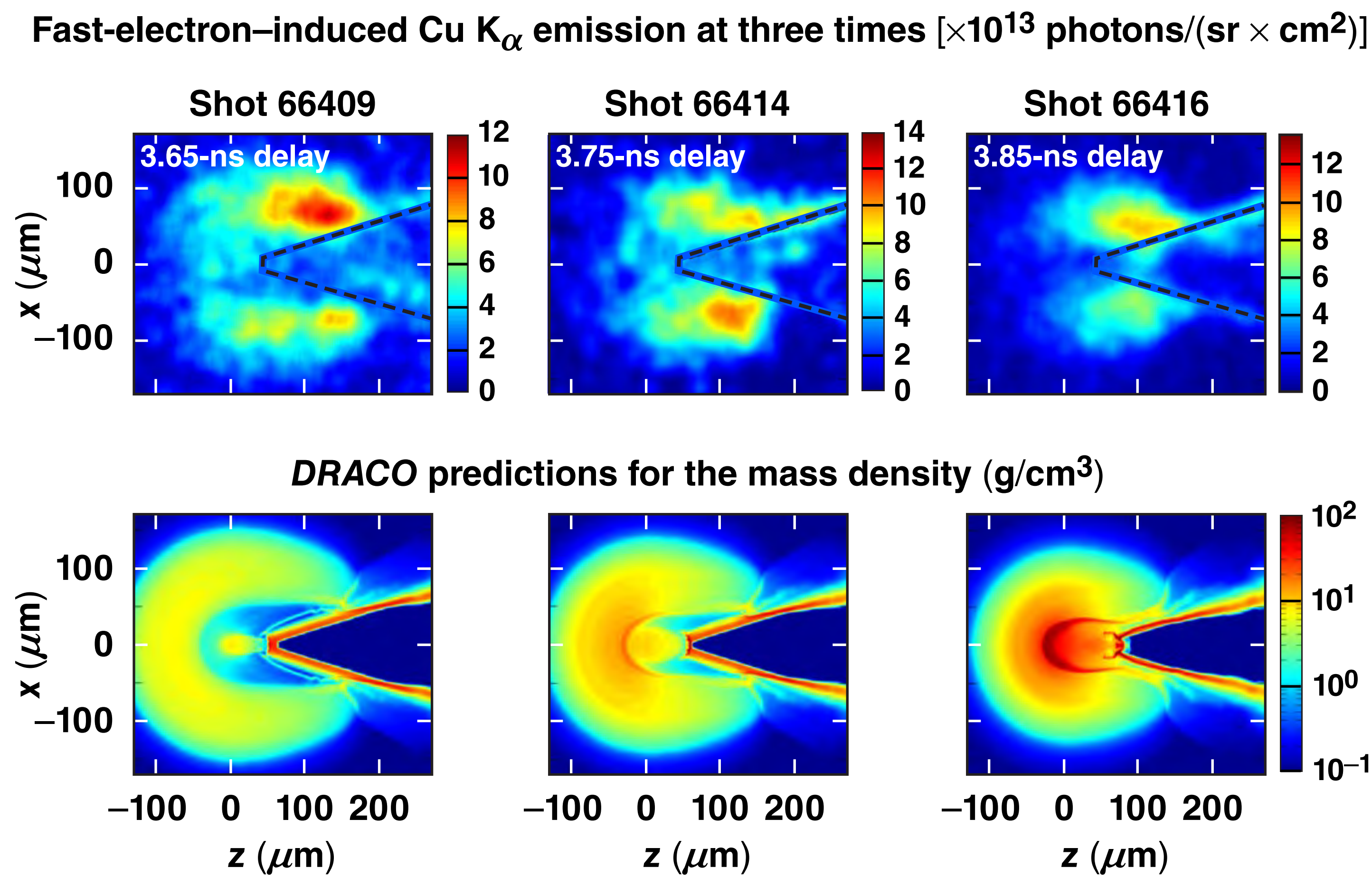


- Cone-tip breakout time agrees in the experiments and simulations*

*W. Theobald *et al*., Bull. Am. Phys. Soc. 57, 115 (2012);
A. A. Solodov *et al*., Bull. Am. Phys. Soc. 57, 29 (2012).

TC10328a

CD shells with Cu dopant have been used to characterize the transport of fast electrons in the integrated experiments*



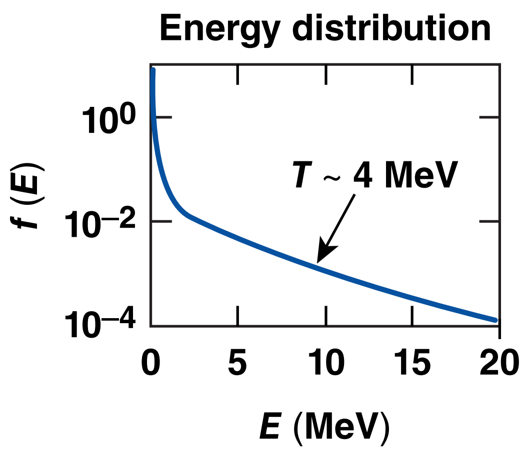
- E_{EP} = 500 J, τ = 10 ps, E_{pre} = 20 mJ (low contrast)

*L. C. Jarrott *et al.*, YO5.00004, this conference

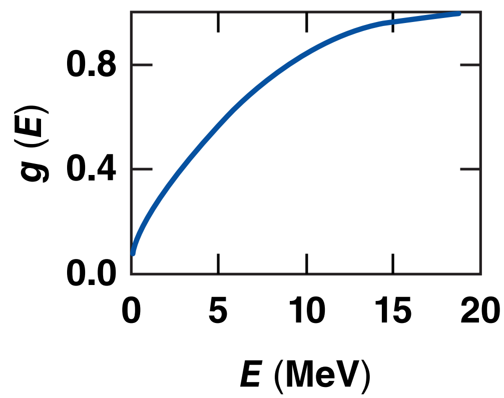
TC11031

LSP simulations of fast-electron transport in the implosion plasma have been performed

- The energy spectrum of fast electrons is predicted by particle-in-cell (PIC) simulations* of OMEGA EP pulse propagation in the laser pre-plasma



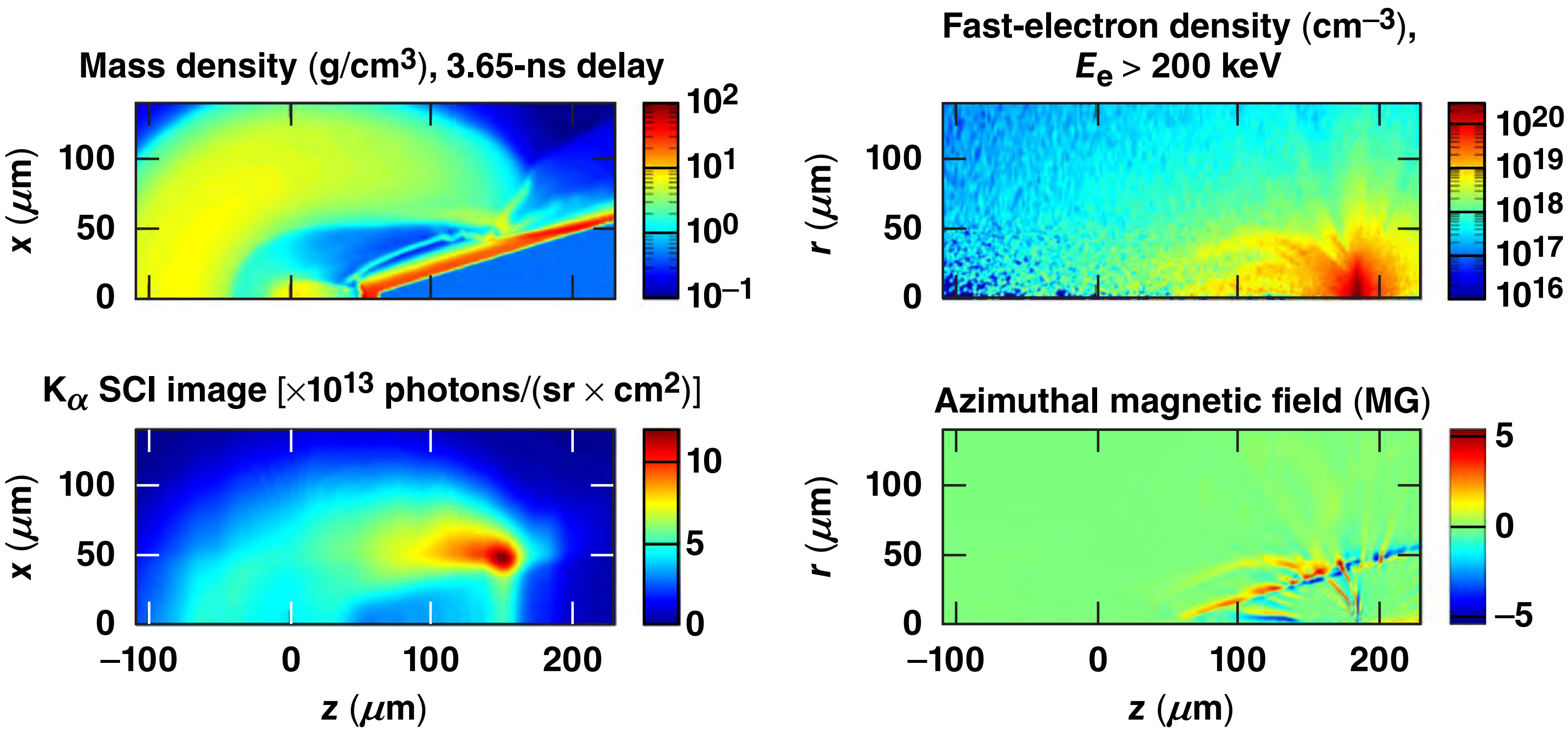
$$g(E) = \int_0^E f(E')E'dE' \Big/ \int_0^\infty f(E')E'dE'$$



- Isotropic angular distribution of fast electrons is assumed
- Fast-electron–induced Cu K_α emission and propagation through the imploded core is modeled**
- The total energy of fast electrons is ~30% of E_{EP} = 500 J, inferred from comparing the K_α yield in the experiments to the simulations

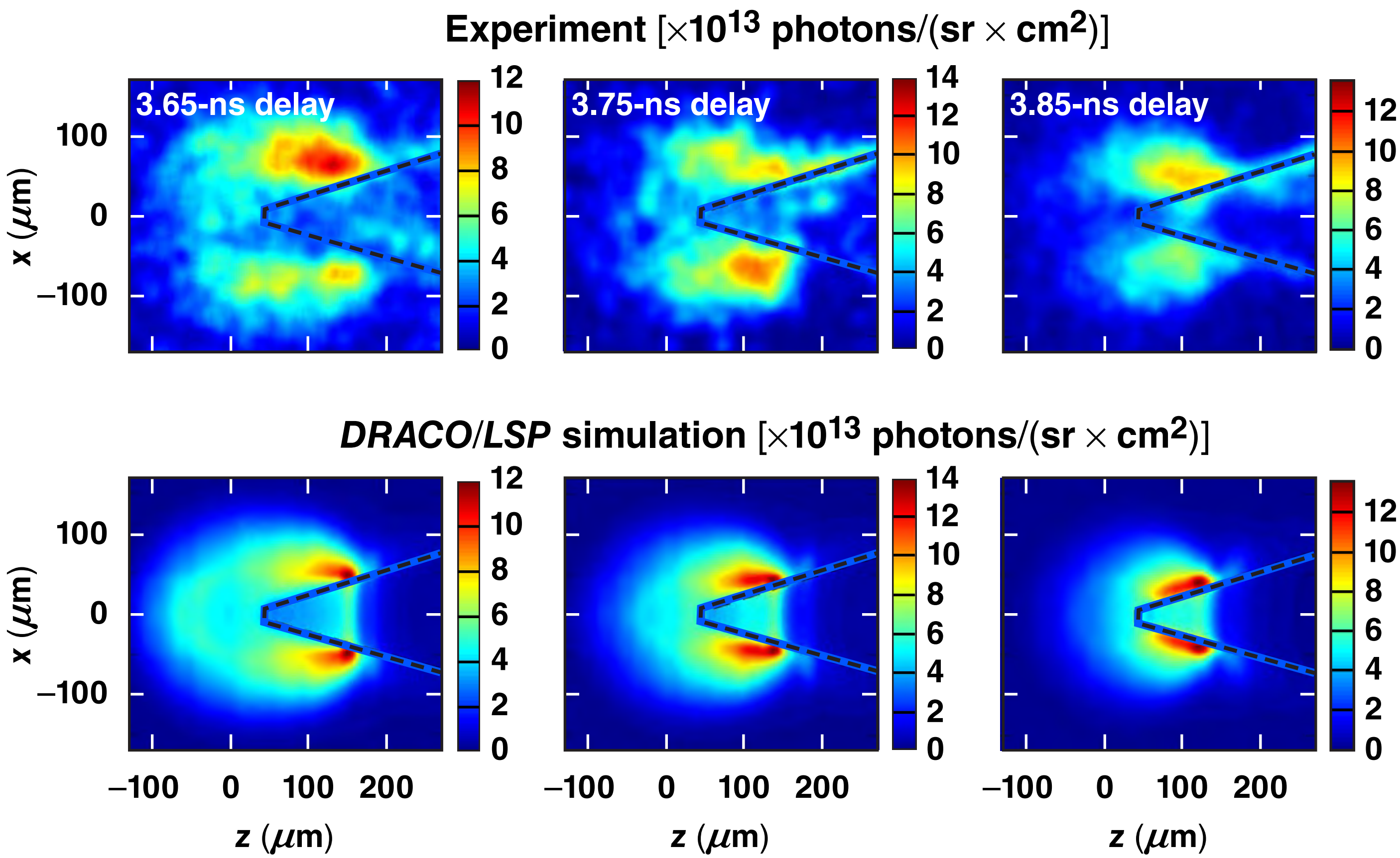
* J. Li *et al*., Phys. Plasmas 20, 052706 (2013); B. Qiao *et al*., YO5.00005, this conference.
**Plasma temperature-dependent collection efficiency of the SCI is from H. Sawada *et al*., Phys. Plasmas 19, 103108 (2012).

LSP simulates the fast-electron transport and Cu K_α emission



- Hard fast-electron spectrum, large distance from the source to the core, and large divergence explain a weak coupling of fast electrons to the core (ρ_{cd} > 1 g/cm^3): 2.5% of the total fast-electron energy

K_α-emission images agree in the experiments and simulations



Yield = 1.9×10^{10} ph/sr   Yield = 2.2×10^{10} ph/sr   Yield = 1.5×10^{10} ph/sr

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Summary/Conclusions

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The fuel assembly can be improved by optimizing the compression pulse and evacuating air from the shell

- Air removal reduces the mass of the hot spot and the pressure on the cone tip; the fuel stagnates closer to the target center
- Compression pulse picket is optimized:
  - picket power is reduced to account for an increased absorption (~50%) predicted by the nonlocal thermal transport model*
  - with an optimized picket, the shell implodes on a lower adiabat and less fuel is injected by the shocks into the hot spot

Gas pressure	Picket	Cone tip	Δt (ps)	ρR_{break} (mg/cm^2)	ρR_{max} (mg/cm^2)
0.8-atm air	Current	15-μm Au	300	80	300
Vacuum	Optimized	15-μm Au	140	360	600
Vacuum	Optimized	60-μm Al	80	500	600

*V. N. Goncharov *et al*., Phys. Plasmas 15, 056310 (2008).