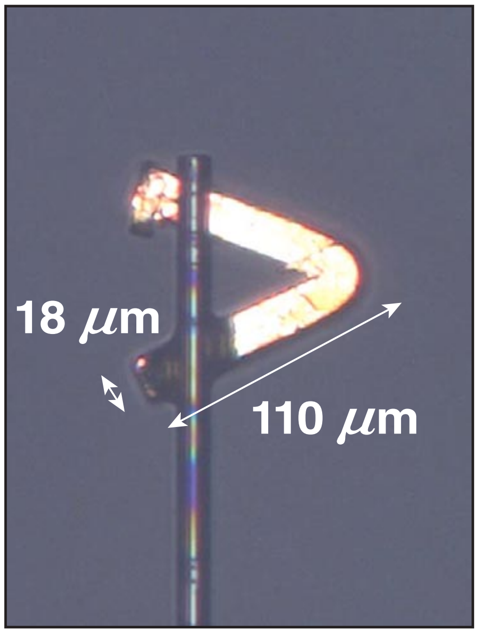
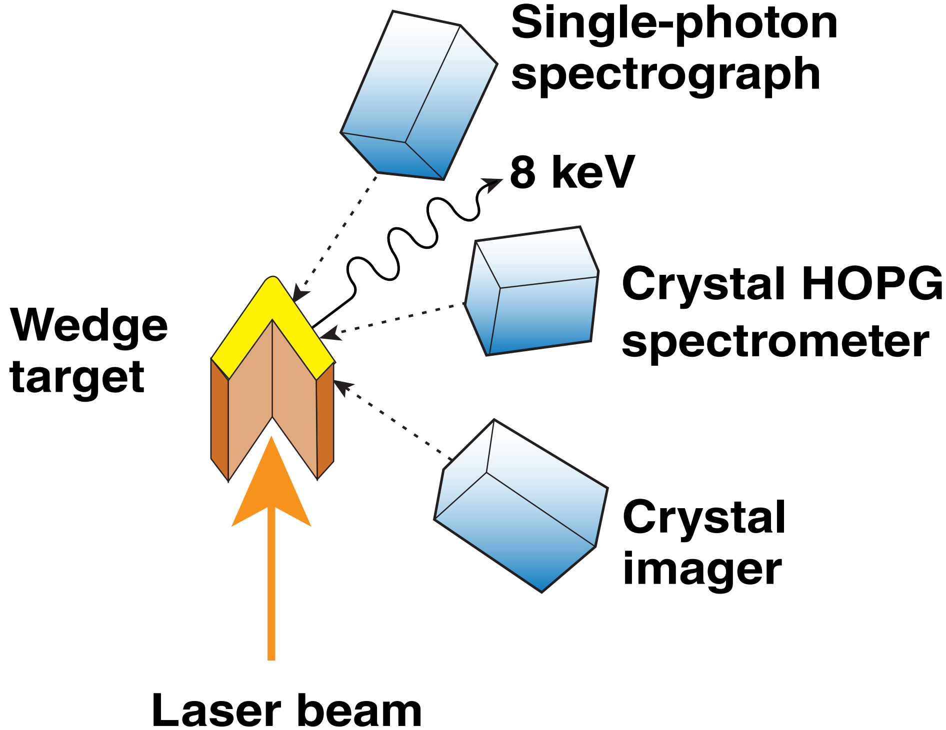
Intense Laser-to-Fast-Electron Coupling Efficiency in Wedge-Shaped Cavity Targets





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Division of Plasma Physics
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Summary

Intense lasers produce more hot electrons in narrow wedge-shaped cavity targets than on flat foils

- The K_α emission from solid Cu wedge-shaped, small-mass targets was measured for various opening angles and polarizations.
- The laser-to-fast-electron coupling efficency is higher with *p*-polarized light in wedge targets than with *s*-polarization.
- 2-D *OSIRIS* simulations are in agreement with the experimental data for *p*-polarization but not for *s*-polarization

Collaborators

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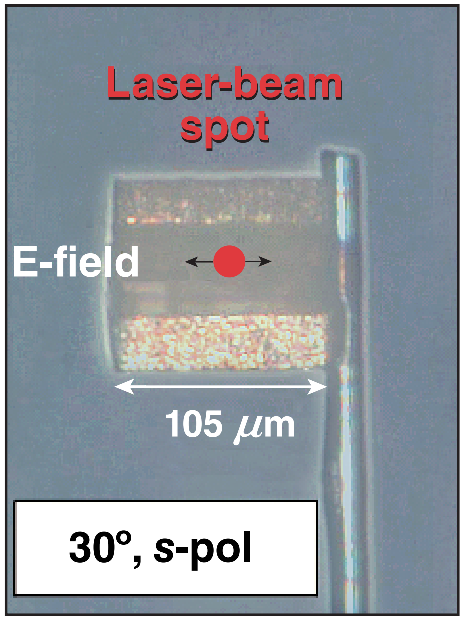
R. B. Stephens

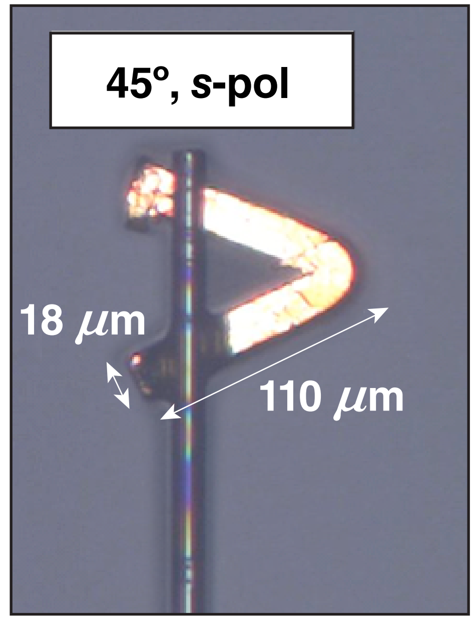
General Atomics

Wedge-cavity targets are used to study the fast-electron-conversion efficiency for 2-D cone-like target geometries

Front view



Side view



- **One-piece Cu targets with ~100 × 100 × 40-μm^3 volume and 30°, 45°, and 60° opening angles**
- **Radius of curvature (~1 μm) smaller than the focal-spot diameter**
- **Wedge target orientation sets laser polarization**

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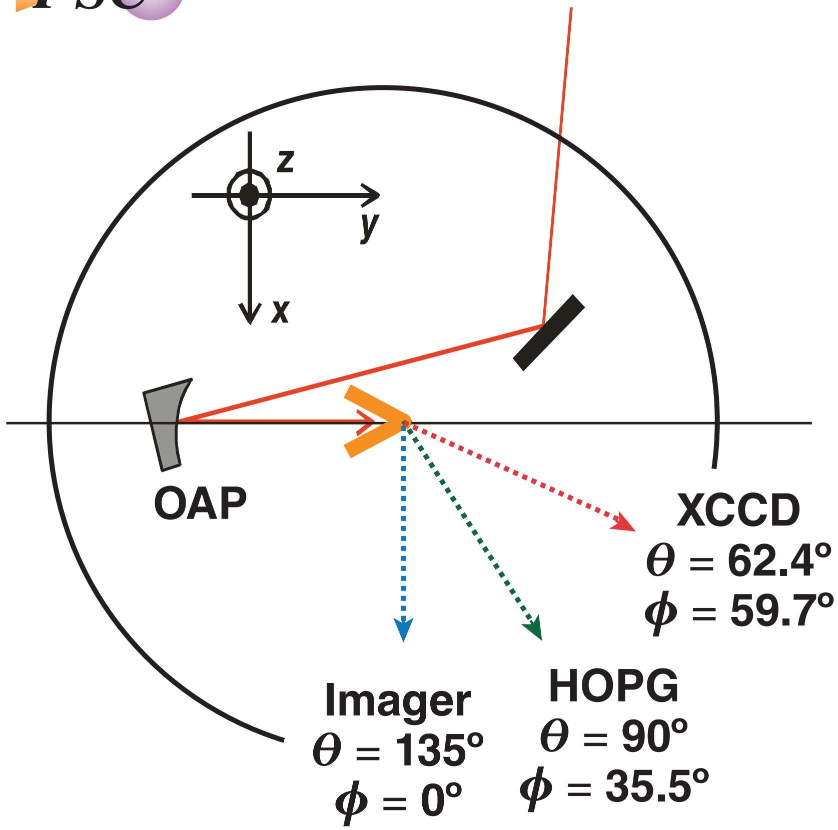
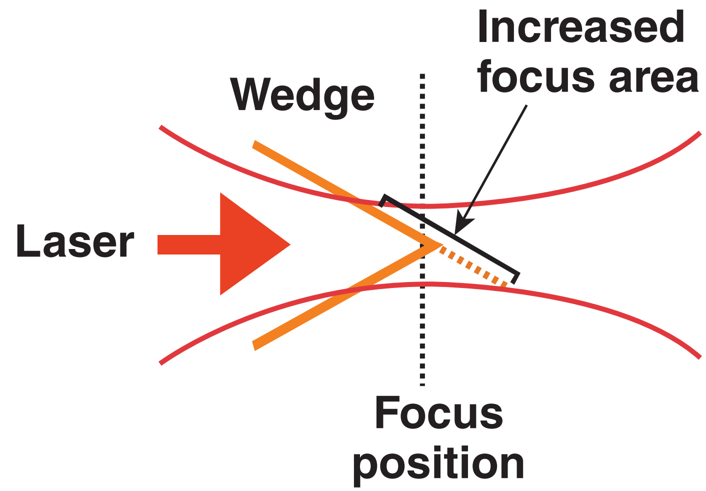
V. M. Ovchinnikov (JP6.00114).

The experiments were performed on the Multi-Terawatt (MTW) Laser Facility at LLE





- Laser parameters: $\lambda = 1.053\ \mu$m
  5 J, 1 ps, 5-μm focus diameter
  (*f*/2 optics) 1×10^{19} W/cm^2 peak intensity
- Spatially and temporally averaged laser intensity on target: 2 to 5×10^{18} W/cm^2
- OPCPA amplification provides a high temporal contrast ($C > 10^8$)

Small-mass Cu targets are in the refluxing regime.*

*A. J. MacKinnon *et al*., Phys. Rev. Lett. 88, 215006 (2002);
J. Myatt *et al*., Phys. Plasmas 14, 056301 (2007);
P. M. Nilson *et al*., Phys Plasmas 15, 056308 (2008).

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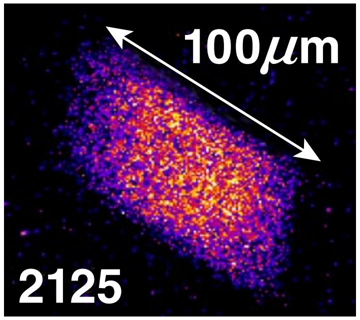
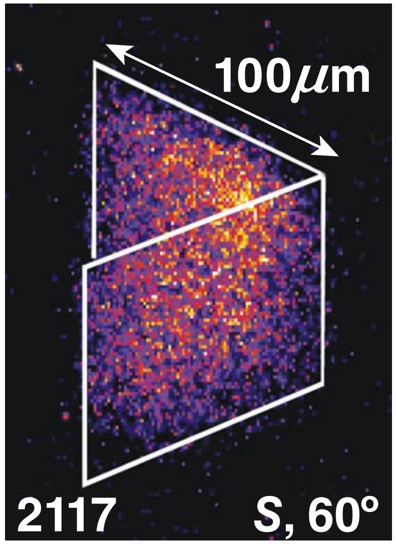
A spherical Bragg crystal imager recorded spatially resolved the Cu K_α emission

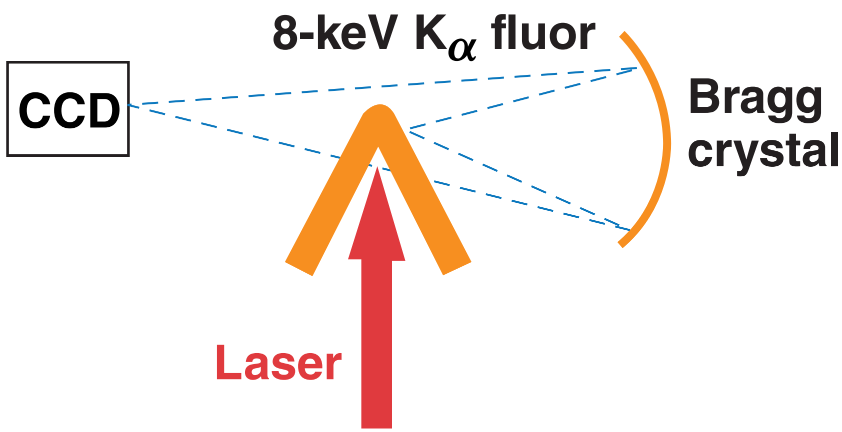
Flat Foil



Wedge



Homogeneous emission; indicates hot-electron refluxing in the targets.



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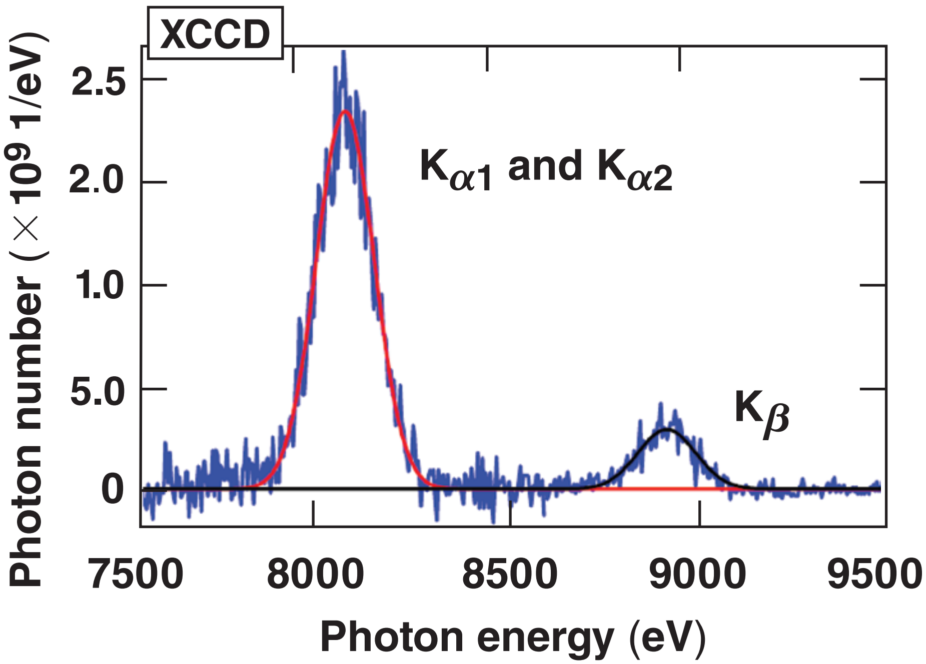
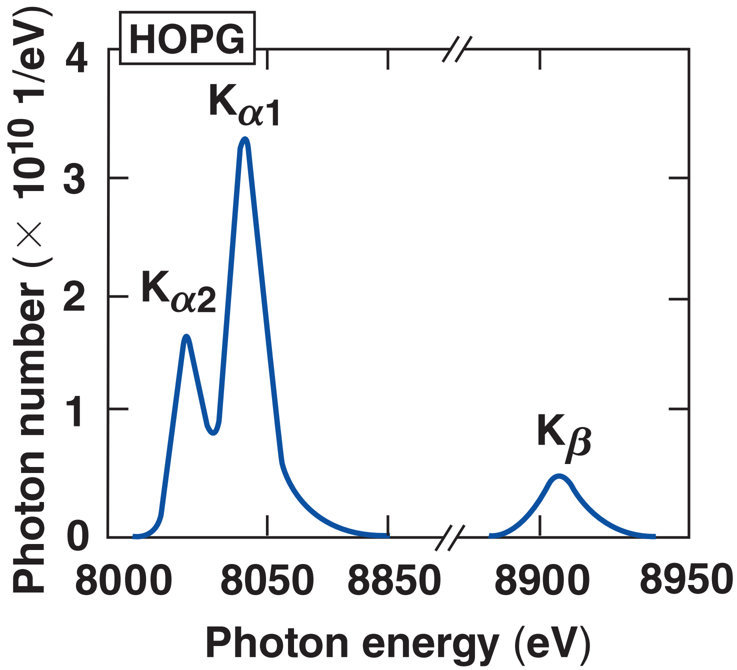
The single-hit CCD and the HOPG provide absolute photon numbers to infer the conversion efficiency*

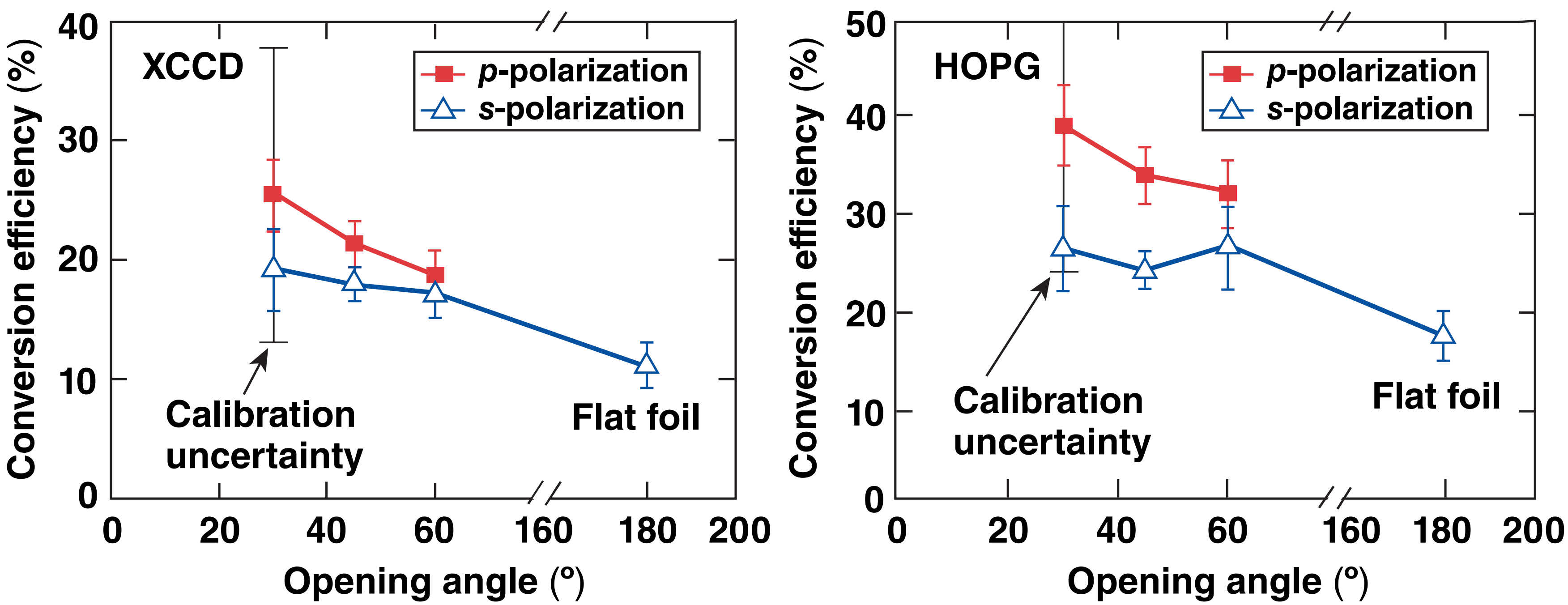




- K-photon generation calculated as in an infinite medium
- Relativistic K-shell-ionization cross sections included
- Classical slowing-down approximation (CSDA)
- Exponential hot-electron distribution with ponderomotive scaling

*W. Theobald *et al*., Phys. Plasmas 13, 043102 (2006).
P. M. Nilson *et al*., Phys. Plasmas 15, 056308 (2008).

The conversion efficiency of laser-to-fast-electron energy depends on wedge opening angle and laser polarization



Fast-electron-conversion efficiency increases for the narrow wedge targets compared to flat foils.

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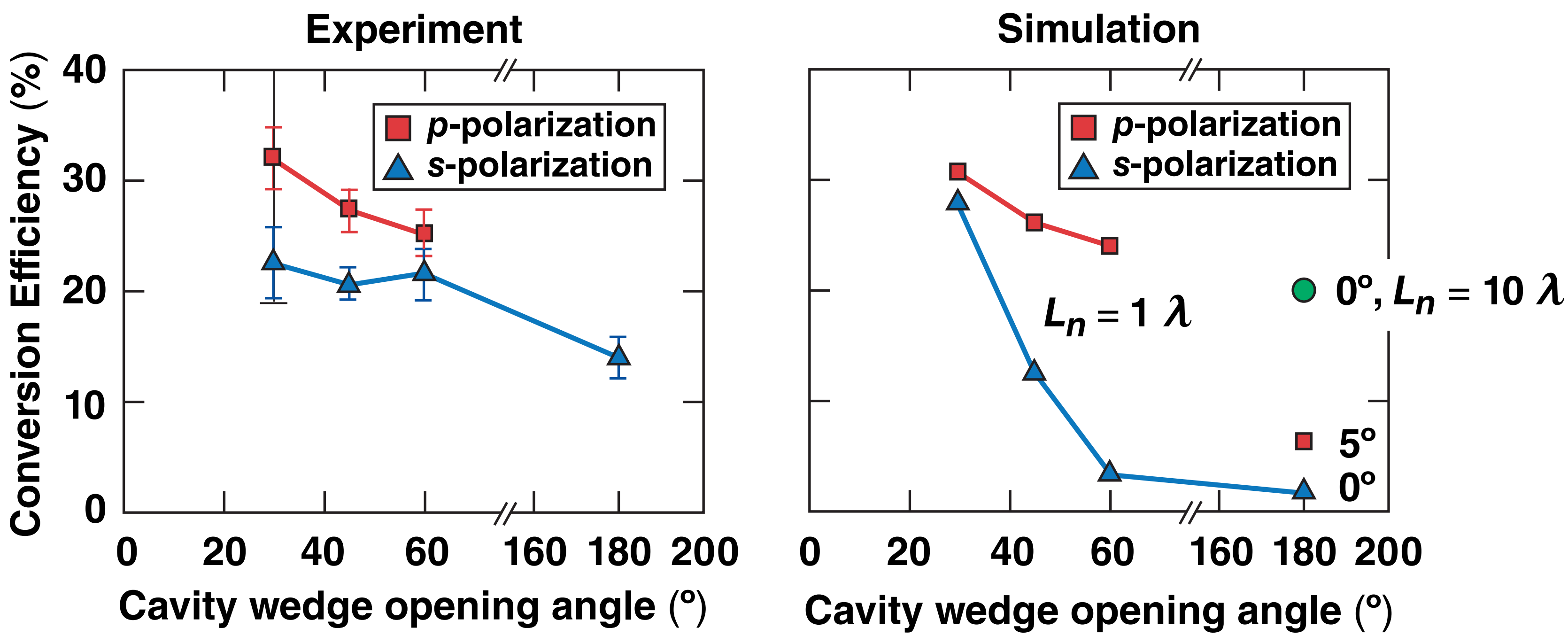
Two-dimensional *OSIRIS** simulations are in agreement with the experimental data for *p*-polarization but not for *s*-polarization



p-polarization absorption is higher than *s*-polarization due to resonance absorption/Brunel absorption.

E17443

*R. A. Fonseca *et al.*, in *Computational Science–ICCS 2002* (Springer, Berlin, 2002), p. 343.

Summary/Conclusions

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- The K_α emission from solid Cu wedge-shaped, small-mass targets was measured for various opening angles and polarizations.
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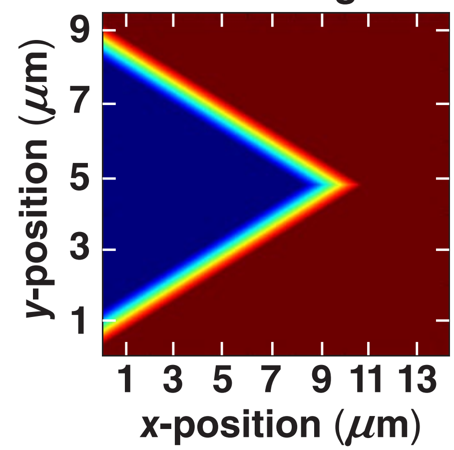
E17439

*OSIRIS** 2-D PIC simulations were performed for the wedge targets

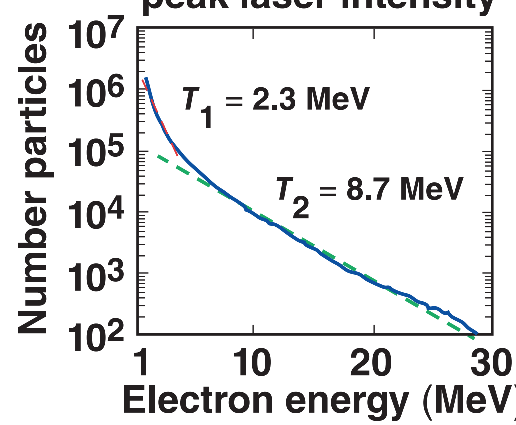
- Laser pulse: $I = 10^{19}$ W/cm^2, 1 ps, 4-μm focus, Gaussian profiles in space and time
- Transversal: periodic boundary condition for both fields and particles

  Longitudinal: thermal boundary conditions for particles and open boundary for fields
- Linear-density ramp to 10 n_{cr} in 0.1 μm to 10 μm
- The total laser absorption into electrons with kinetic energy above 8 keV was calculated

Initial density profile of 45° target



Wedge, 30°, *p*-pol, peak laser intensity



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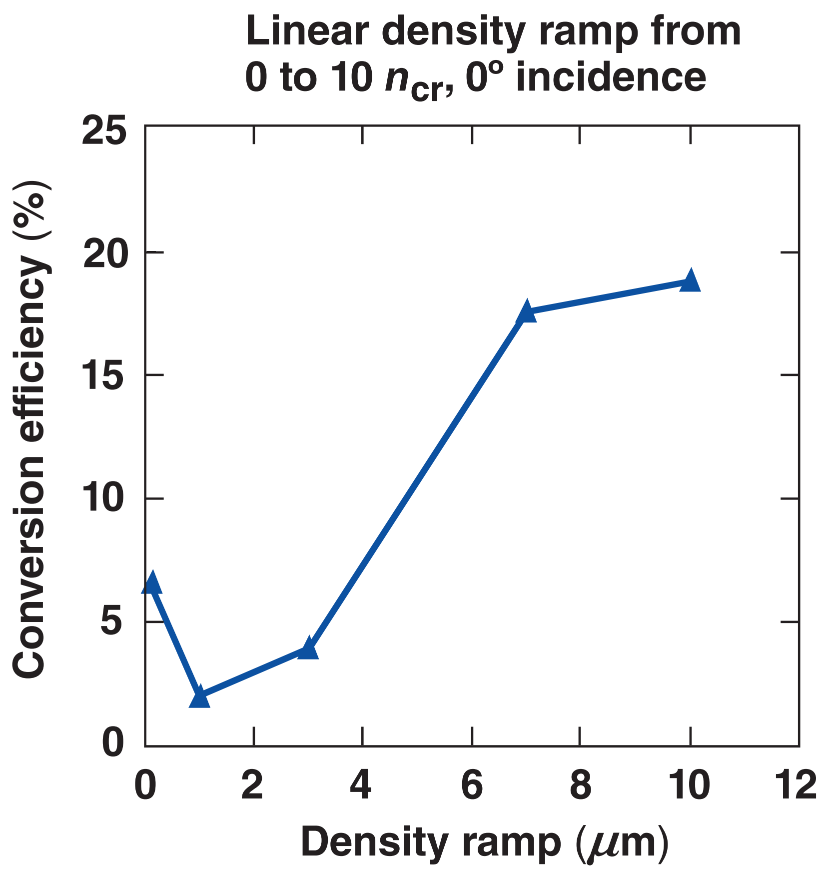
*R. A. Fonseca *et al*., in *Computational Science–ICCS 2002* (Springer, Berlin, 2002), p. 343

Low-density plasma generation from laser prepulses plays an important role in fast-electron generation



- 2-D *OSIRIS* simulations yield higher conversion efficiency for longer density ramps:
  - 1-D hydro simulations with laser prepulse show that the angle of incidence affects the plasma profile
  - Larger angles produce a steeper profile between critical and tenth-critical density
- The plasma scale length might change with wedge angle
  - 2-D *DRACO* hydro simulations will be carried out to assess pre-plasma in the cavity

E17445