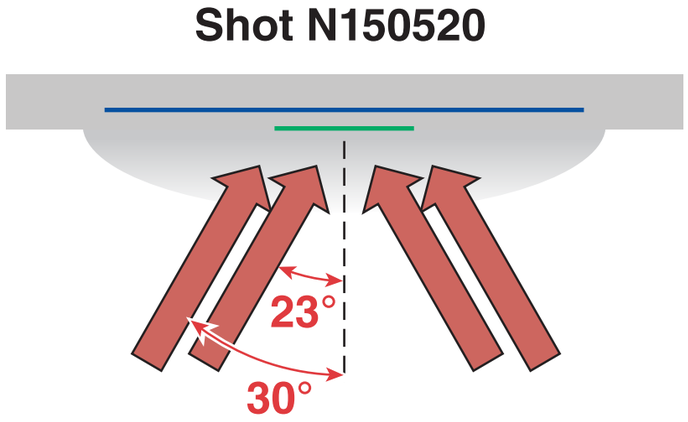
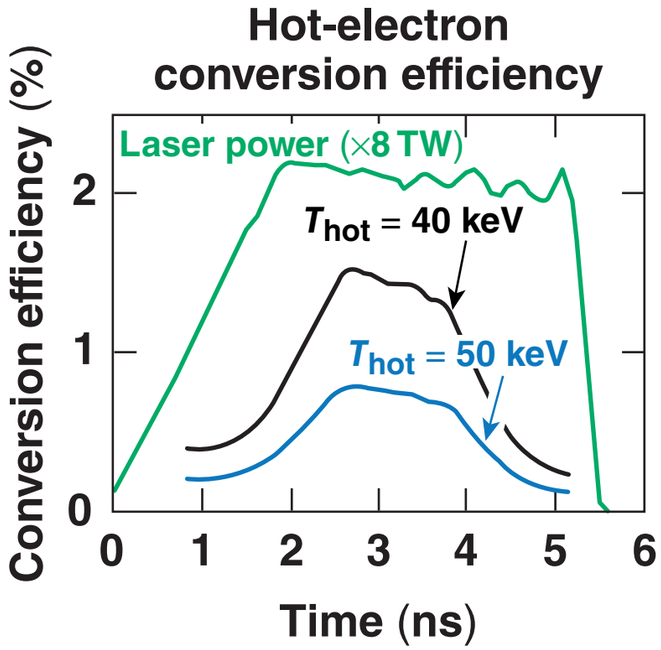
Modeling Two-Plasmon–Decay Experiments at Direct-Drive Ignition-Relevant Plasma Conditions at the National Ignition Facility





A. A. Solodov
University of Rochester
Laboratory for Laser Energetics

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Summary

A new planar-target experimental platform was developed to investigate the impact of two-plasmon decay (TPD) in direct-drive (DD)–ignition designs

- Planar experiments at the National Ignition Facility (NIF) studied the beam angle-of-incidence dependence of TPD
- A laser-energy conversion efficiency of ~1% into hot electrons with T_e = 40 keV to 50 keV was found
- The beam angle of incidence did not have a strong effect on TPD

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Collaborators

M. J. Rosenberg,[1] J. F. Myatt, R. Epstein,[2] S. P. Regan, W. Seka,
J. Shaw, and M. Hohenberger

University of Rochester
Laboratory for Laser Energetics

J. W. Bates

Naval Research Laboratory

J. D. Moody, J. E. Ralph, D. P. Turnbull, and M. A. Barrios

Lawrence Livermore National Laboratory

[1]M. J. Rosenberg *et al*., NO5.00006, this conference.
[2]R. Epstein *et al*., NO5.00008, this conference.

Planar NIF experiments explore TPD in more extreme conditions than OMEGA and current NIF polar-direct-drive experiments

UR LLE

Coronal conditions predicted by *DRACO* radiation–hydrodynamic simulations

Parameters at $n_c/4$ surface	OMEGA*	Current NIF DD**	Ignition NIF DD***	Planar NIF
I_L (W/cm^2)	$<4 \times 10^{14}$	4.5×10^{14}	8 to 10 $\times 10^{14}$	6 to 9 $\times 10^{14}$
L_n (μm)	<350 μm	350 μm	600 μm	550 to 600 μm
T_e (keV)	<2.5 keV	3.5 keV	5 keV	3.2 keV

*S. X. Hu *et al.*, Phys. Plasmas 20, 032704 (2013).
**M. Hohenberger *et al.*, Phys. Plasmas 22, 056308 (2015).
***T. J. B. Collins *et al.*, Phys. Plasmas 19, 056308 (2012).

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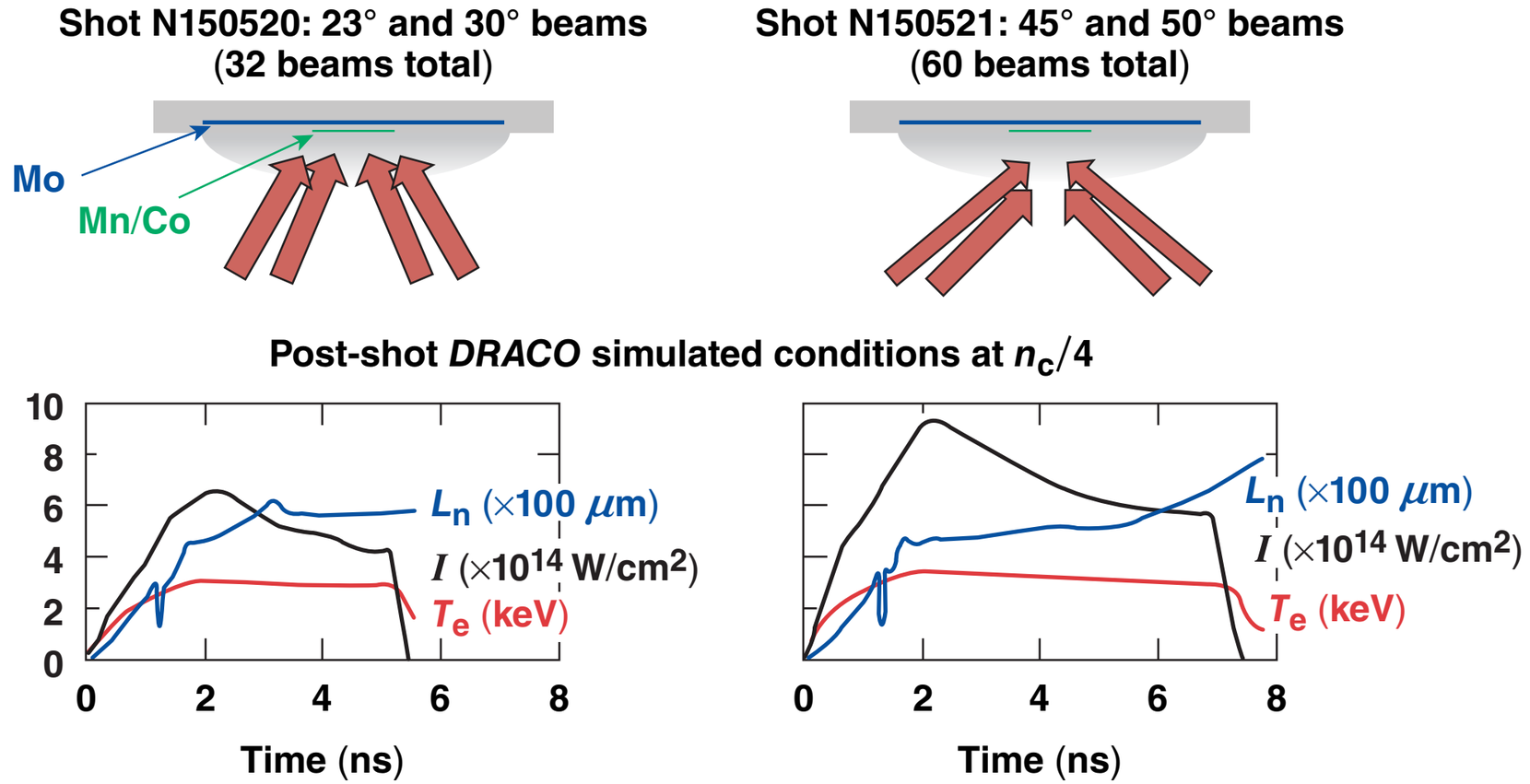
Two planar experiments were fielded on the NIF to study the beam angle-of-incidence dependence of TPD



The empirical TPD threshold is exceeded in this experimental design: $\eta = I_{14}\, L_{n,\mu m}/(230\, T_{e,keV}) \sim 4$ to 5.

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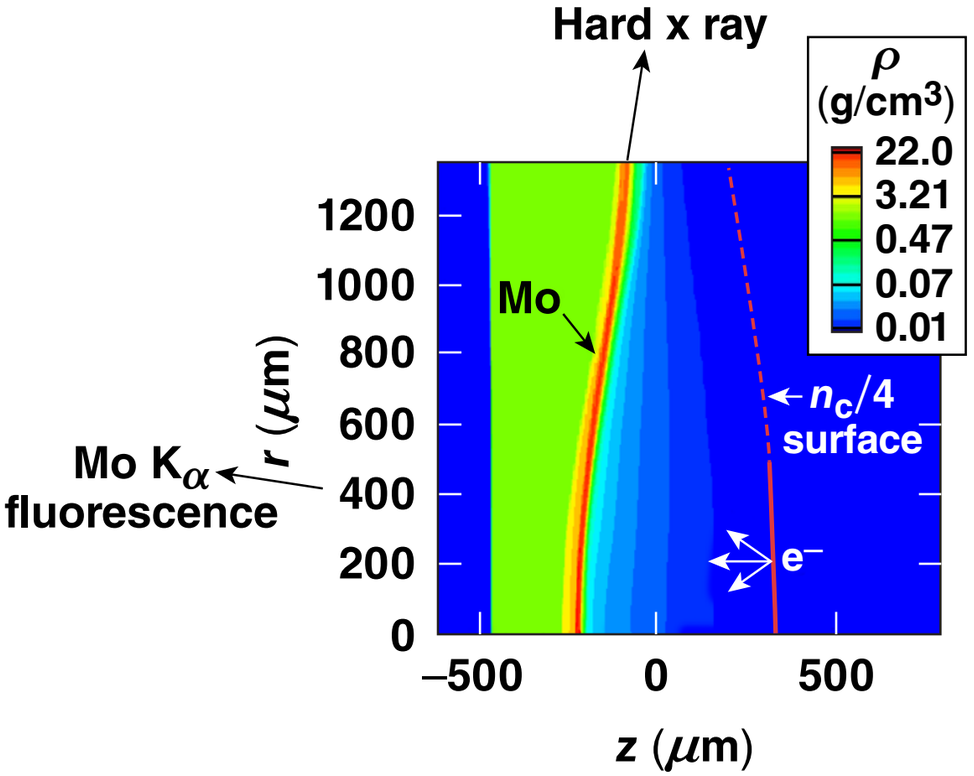
Laser-energy-to-hot-electron conversion efficiency and x-ray spectra were computed using Monte Carlo *EGSnrc** simulations



- *EGSnrc* models the hot-electron transport, hard x-ray emission, and Mo K_α fluorescence
- Plasma profiles are taken from *DRACO* simulations
- Hot electrons are injected
  - at $n_c/4$ surface ($r < 500$ μm)
  - isotropic in the forward 2π solid angle
  - temperature T_{hot} = 40 to 50 keV from the hard x-ray spectra

*I. Kawrakow *et al.*, NRC, Ottawa, Canada, NRCC Report PIRS-701 (May 2011).

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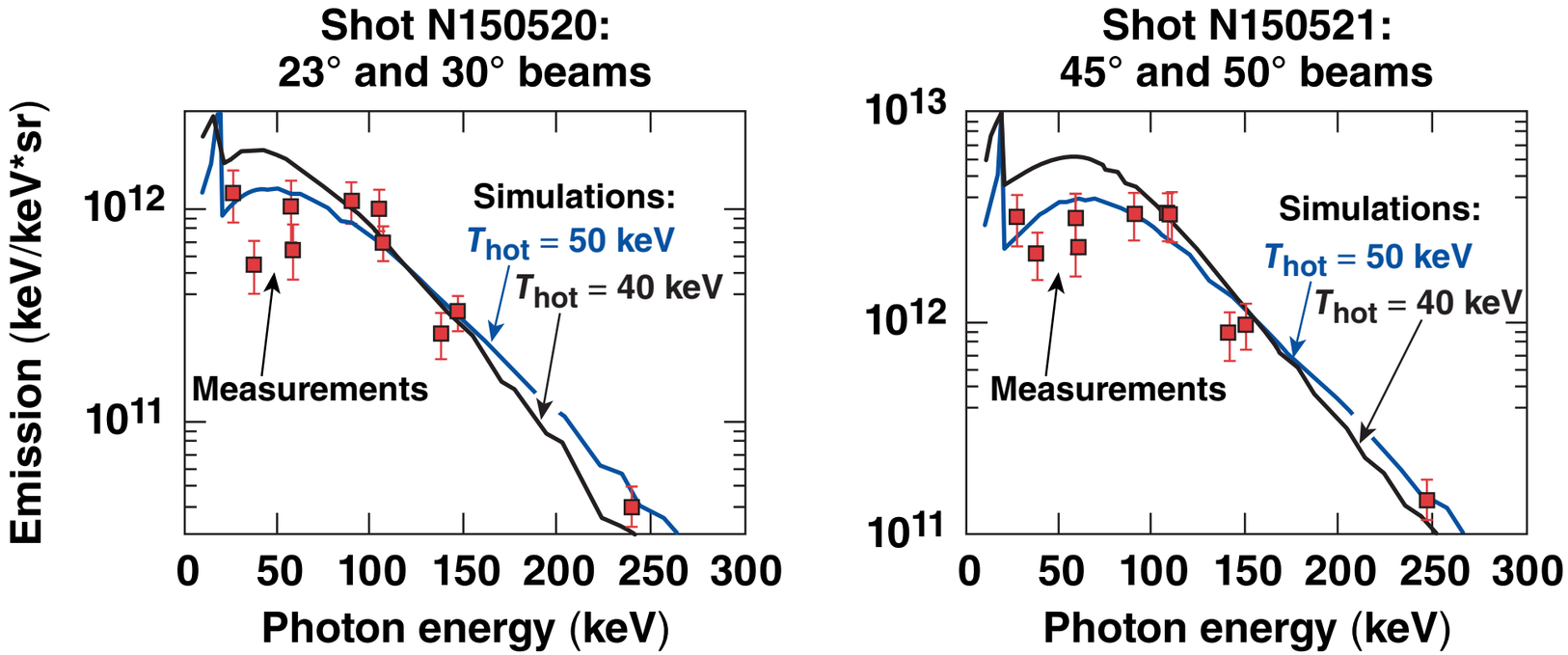
Measured and simulated time-integrated hard x-ray spectra compare well



Time-integrated hard x-ray spectra indicate T_{hot} = 40 to 50 keV, consistent with TPD.

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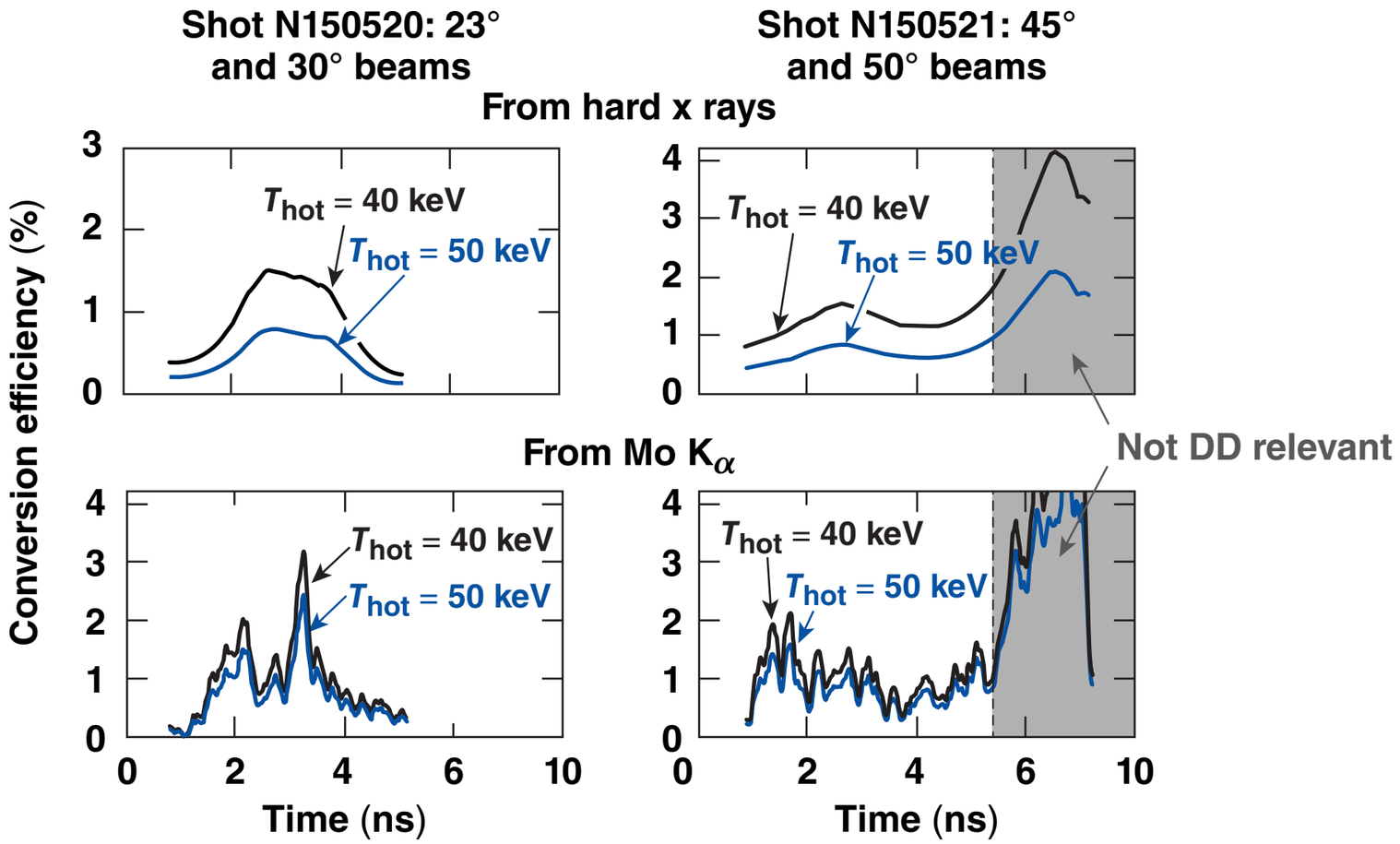
Absolute hard x ray and Mo K_α emission levels indicate the laser-energy-to-hot-electron conversion efficiency is ~1% in both shots



- The overall conversion efficiency is 0.5% to 1.0% (T_{hot} = 40 to 50 keV) in shot N150520 and 0.7% to 1.3% in shot N150521 (during the first 5 ns)

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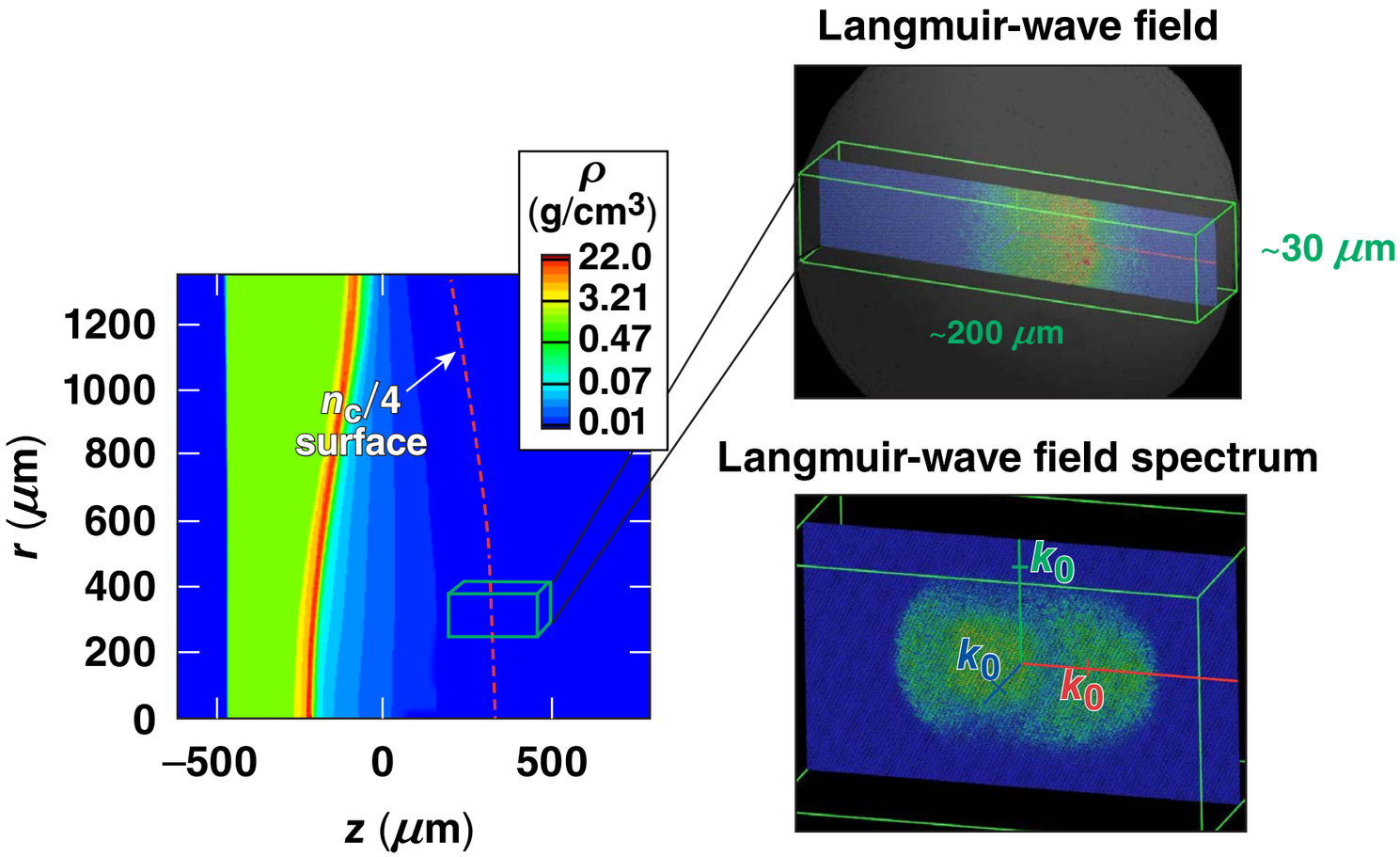
The 3-D laser-plasma simulation code *LPSE** models TPD in the experiments



*J. F. Myatt *et al.*, NO5.00002, this conference.

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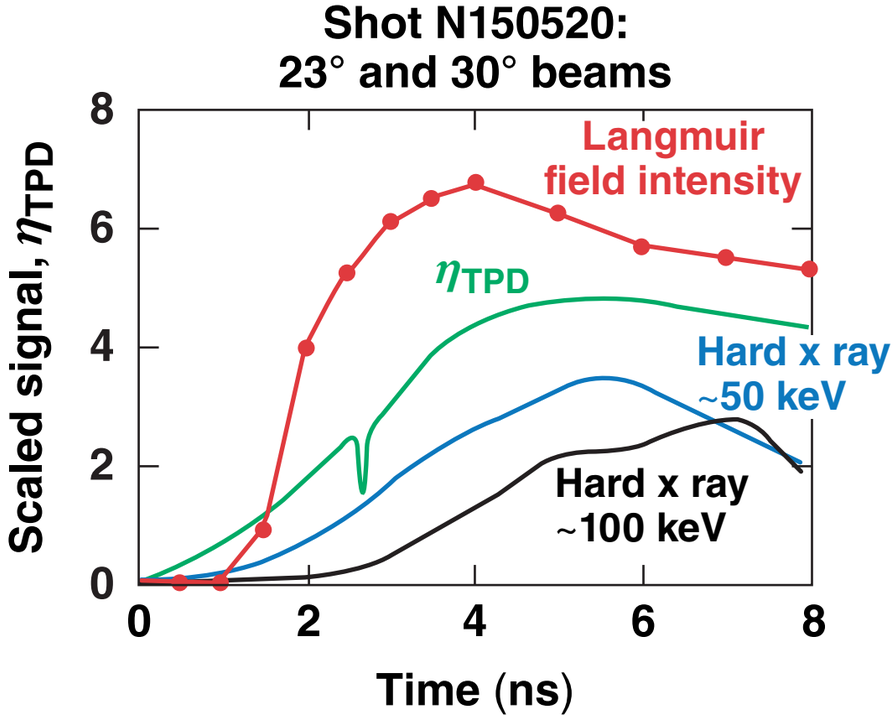
LPSE simulations confirm the onset of TPD when the threshold parameter $\eta \sim 1$



- *LPSE* shows a similar onset of TPD for the 45° and 50° shot
- *LPSE* overestimates the hot-electron production
- The mechanisms of TPD saturation such as pump depletion are being implemented in *LPSE*

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