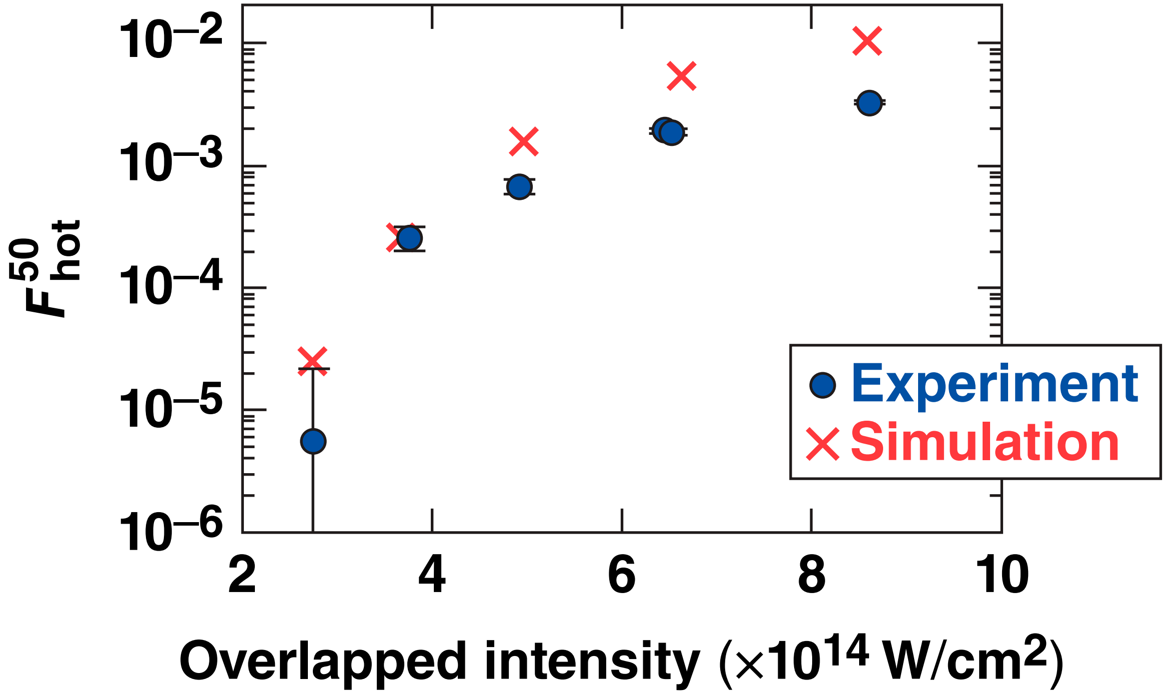
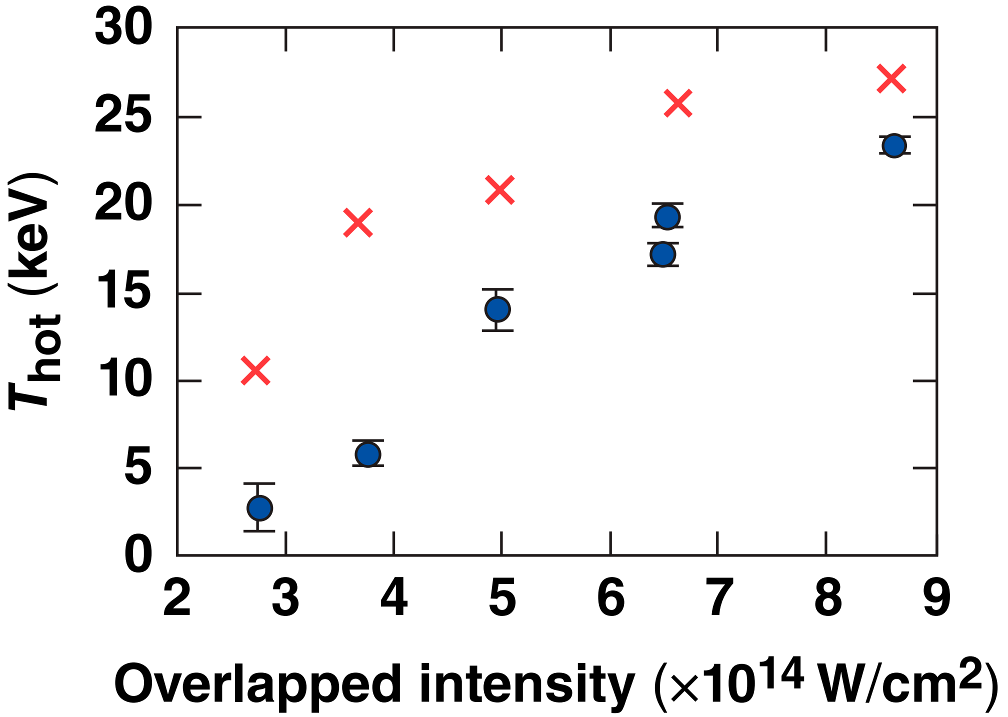
Modeling Hot-Electron Measurements in Multibeam Two-Plasmon–Decay Experiments

Fraction of incident laser energy converted into hot electrons



Hot-electron temperature



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Summary

Three-dimensional two-plasmon–decay (TPD) simulations were used to calculate hot-electron production in multibeam planar-target experiments on OMEGA

- Numerical TPD calculations were combined with hydrodynamic simulations to predict hot-electron production
- Simulations show good agreement with the temporally resolved hot-electron measurements and with the scaling of hot-electron production as a function of drive-beam intensity

Collaborators

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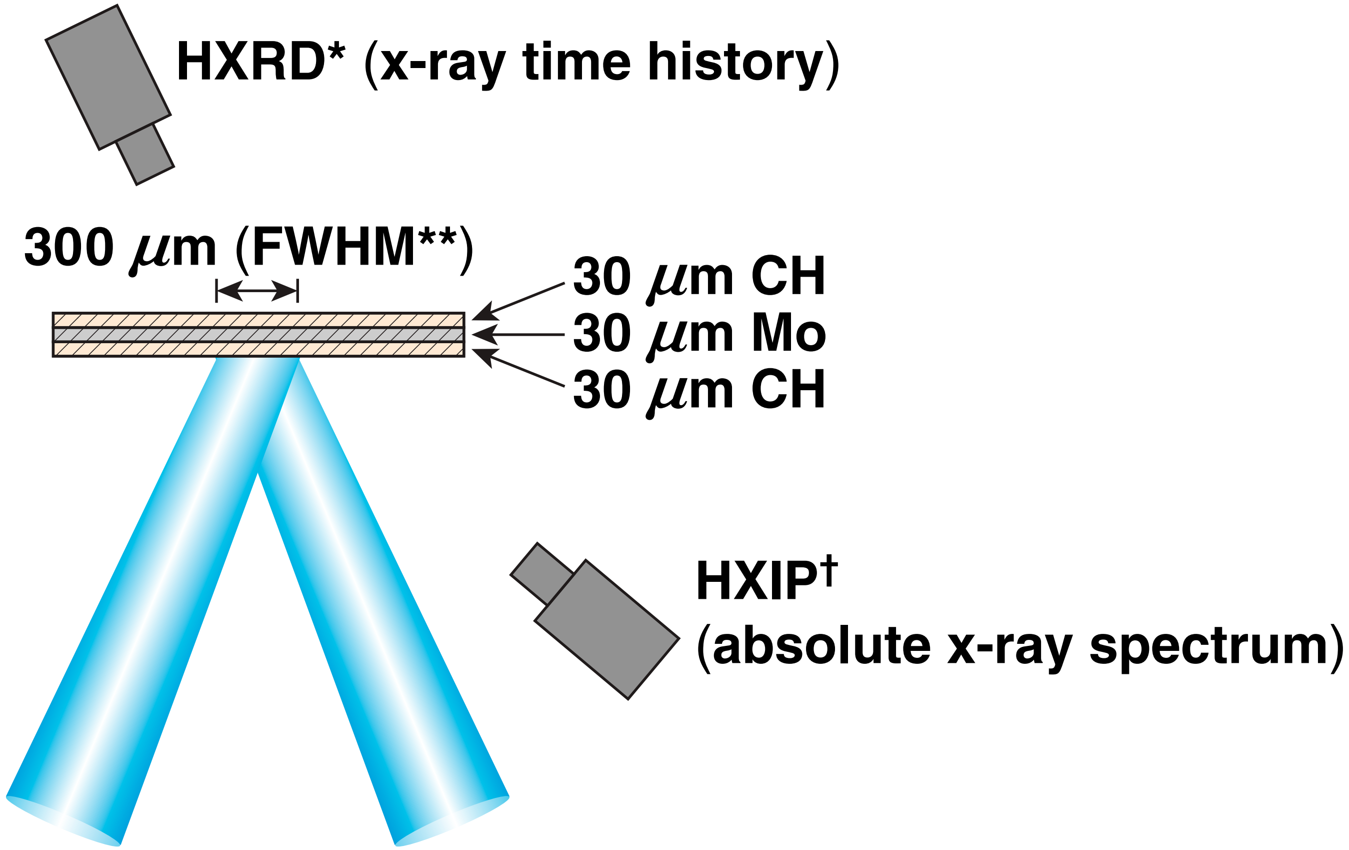
Hard x-ray detectors were used to measure the hot-electron distribution

Experimental configuration



3ω (351-nm) drive beams
0.4 to 1 kJ in 1 ns ($I_{\text{overlap}} = 3$ to 9×10^{14} W/cm^2)

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* HXRD: hard x-ray detector
** FWHM: full width at half maximum
† HXIP: hard x-ray image-plate spectrometer

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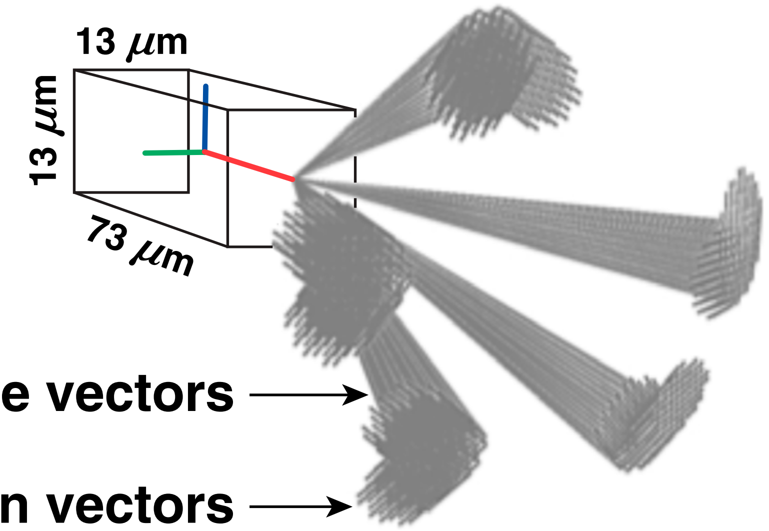
LPSE solves a pair of equations that model the coupling between the envelope of high-frequency-electrostatic perturbations and low-frequency-density perturbations*

$$\overbrace{\nabla\cdot\left[2i\omega_{\mathrm{pe}}\left(\partial_t+\underbrace{\nu_{\mathrm{e}}}_{\text{Hybrid-particle evolution}}\right)+3v_{\mathrm{te}}^2\nabla^2-\omega_{\mathrm{pe}}^2\frac{\delta N}{n_0}\right]\vec{E}}^{\text{Electron plasma wave propagation in an inhomogeneous plasma}}=\overbrace{\omega_{\mathrm{pe}}^2\nabla\cdot\left(\frac{\delta n}{n_0}\vec{E}\right)}^{\text{Coupling to ions}}+\overbrace{\frac{e}{4m_{\mathrm{e}}}\nabla\cdot\left[\nabla\left(\vec{E}_0\cdot\vec{E}^*\right)-\vec{E}_0\nabla\cdot\vec{E}^*\right]}^{\text{Coupling to drive beams}}+\underbrace{S_E}_{\text{Thermal fluctuations}}$$

$$\underbrace{\left[\partial_t^2+2\nu_{\mathrm{i}}\nabla_t-c_s^2\nabla^2\right]\delta n}_{\text{ion-acoustic wave propagation}}=\underbrace{\frac{\nabla^2\left|\vec{E}+\vec{E}_0\right|^2}{16\pi m_{\mathrm{i}}}}_{\text{Ponderomotive force}}$$

***LPSE* geometry**



Drive-beam wave vectors →

Polarization vectors →

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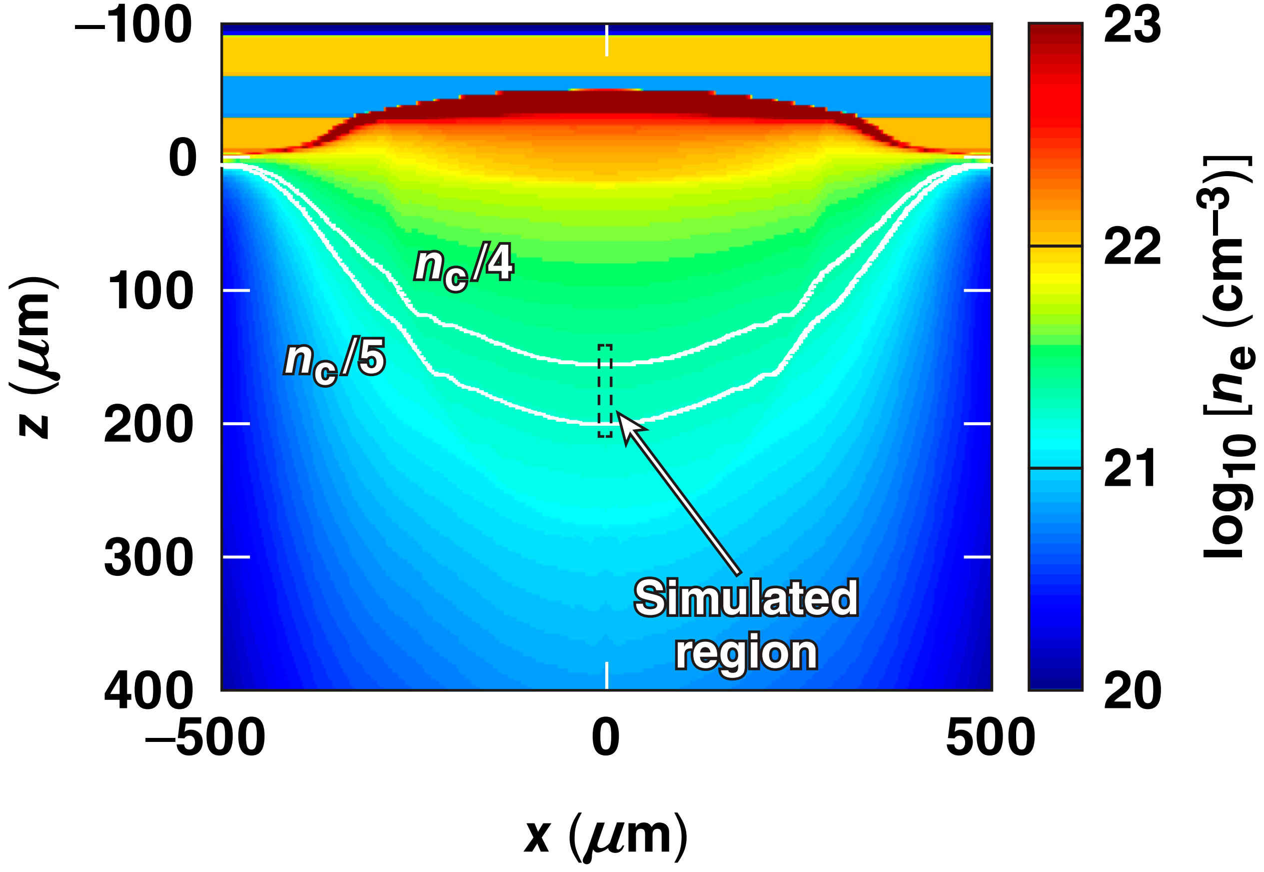
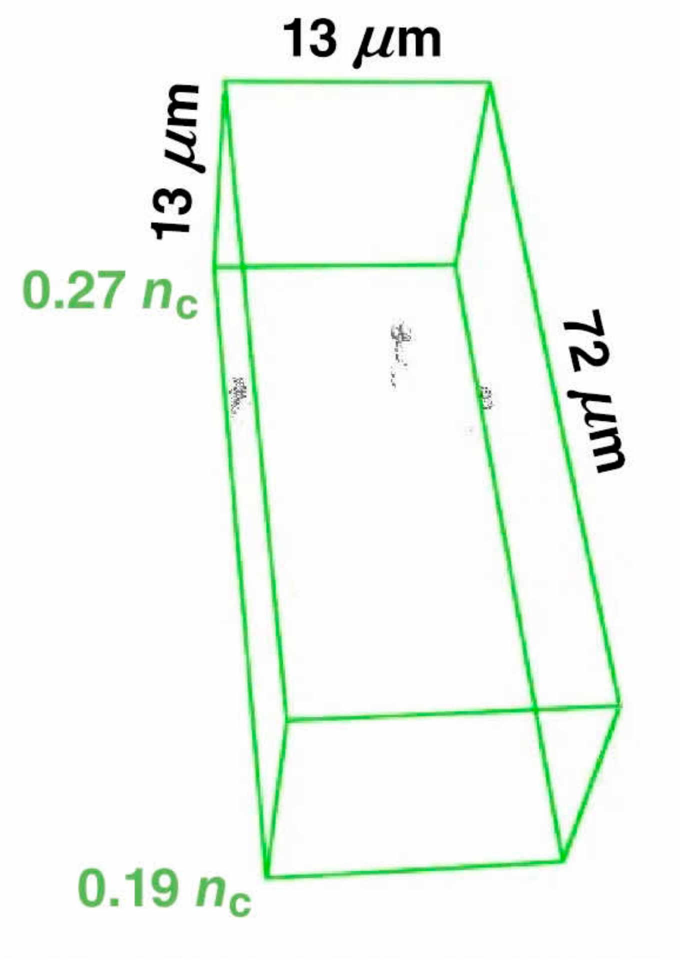
*J. F. Myatt, NO5.00002, this conference.

Two-dimensional hydrodynamic simulations were used to calculate the input parameters for the *LPSE* simulations

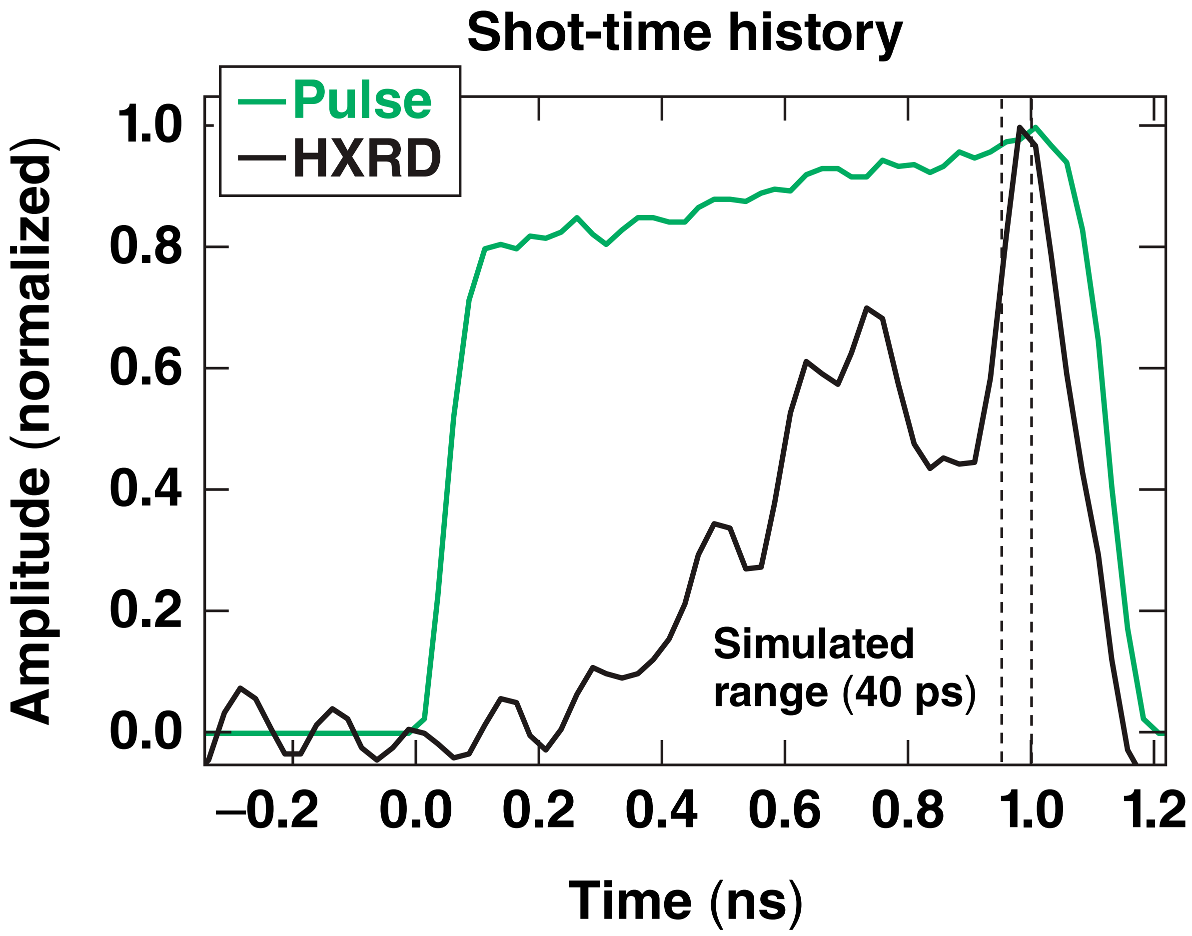
Density profile (*DRACO*)

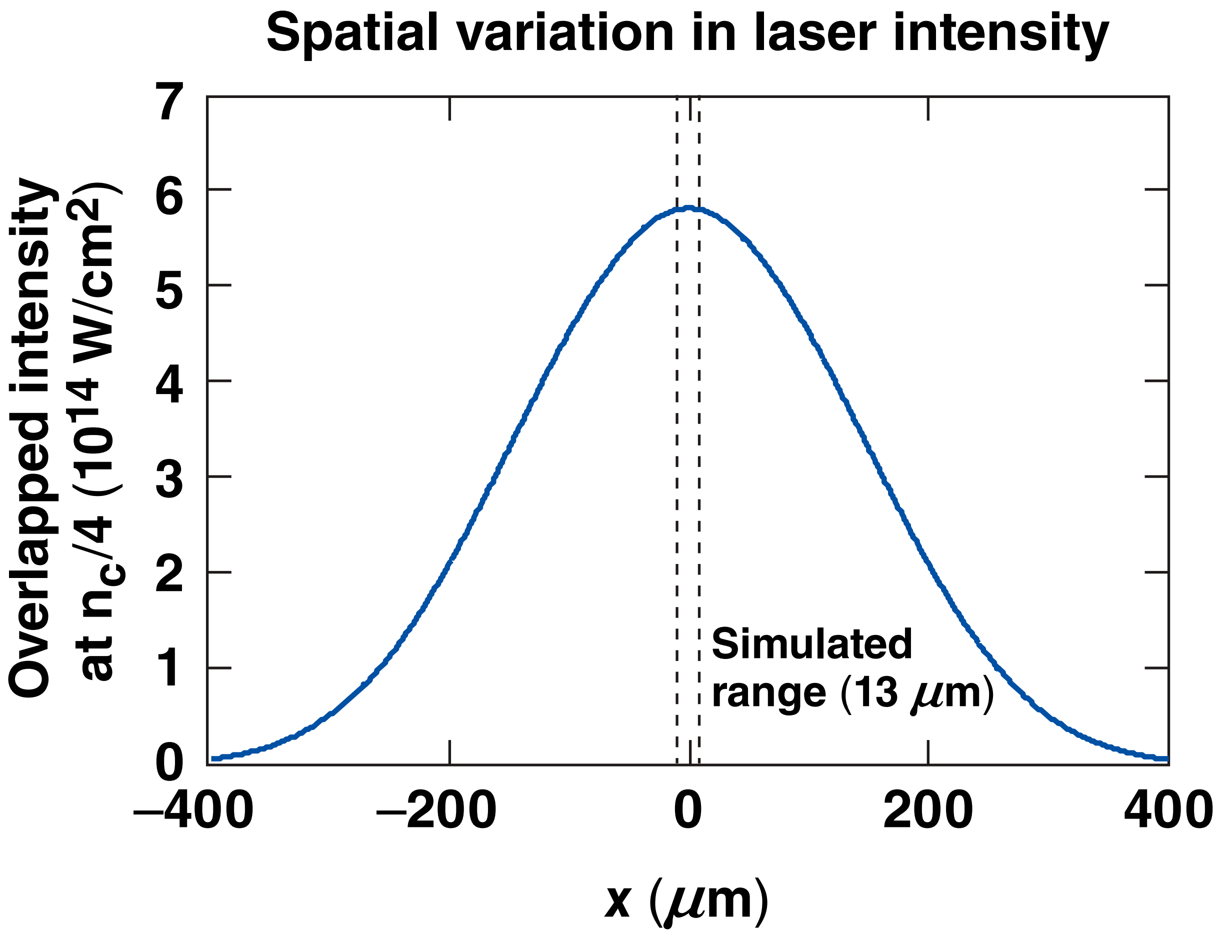


LPSE geometry
(isosurfaces of electric potential)



To make a direct comparison between hot-electron measurements and simulations, it is necessary to account for spatial and temporal variations present in the experiment





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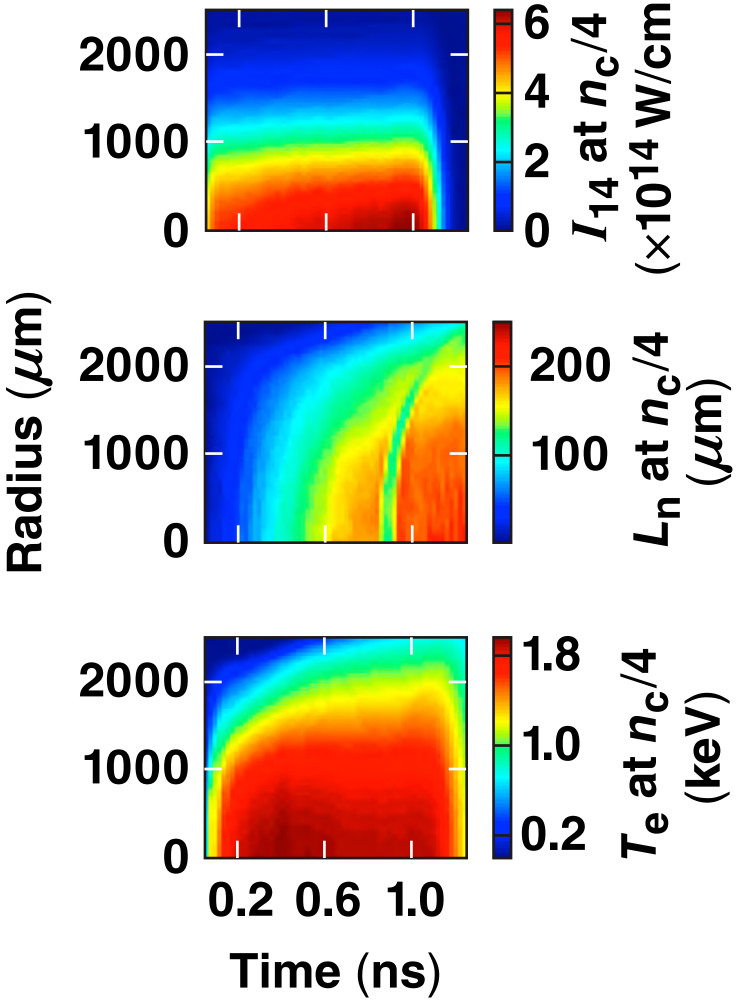
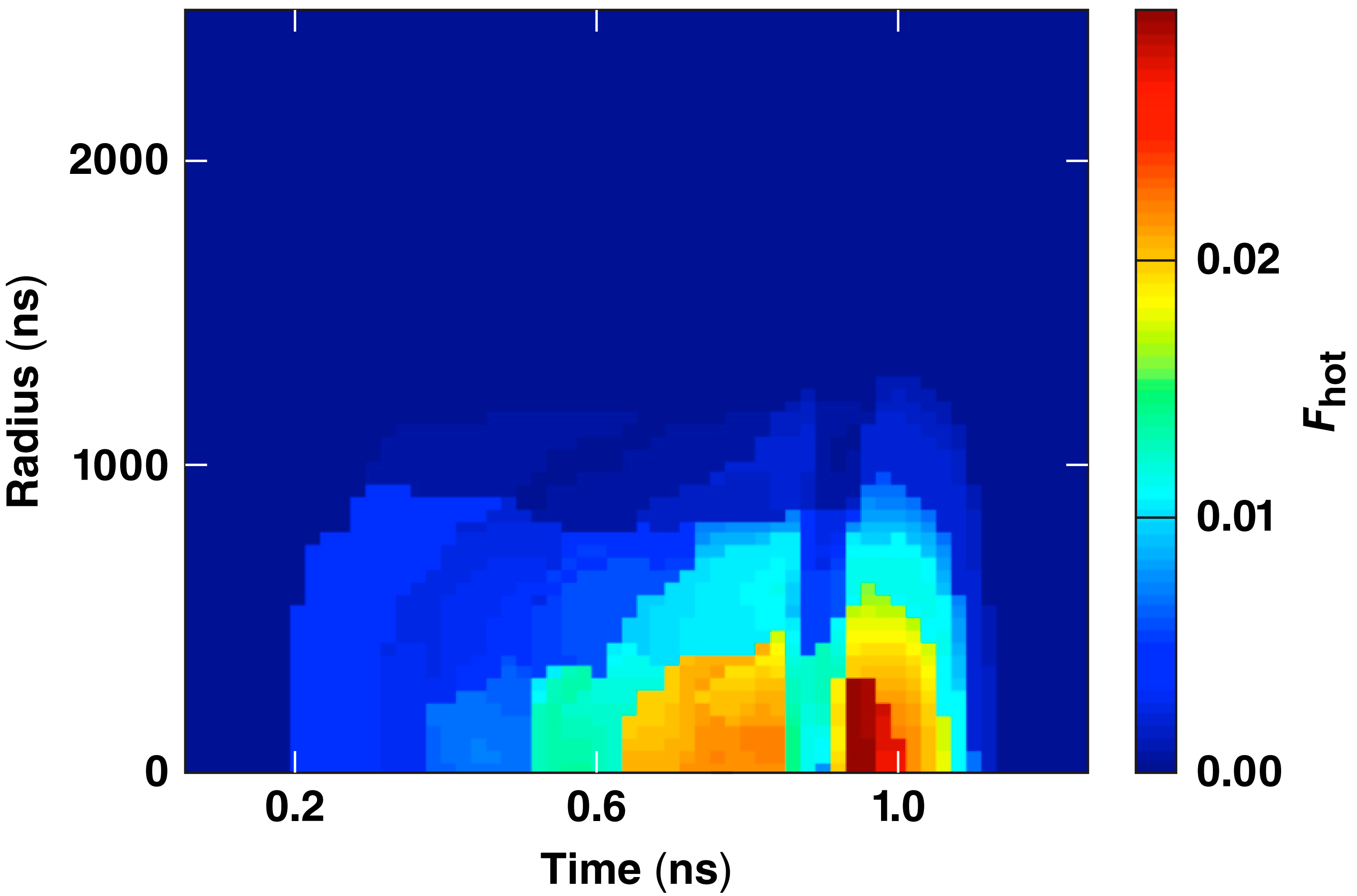
Predicted hot-electron fractions were generated using plasma conditions from *DRACO* simulations

Plasma parameters at $n_c/4$
(from *DRACO* simulations)



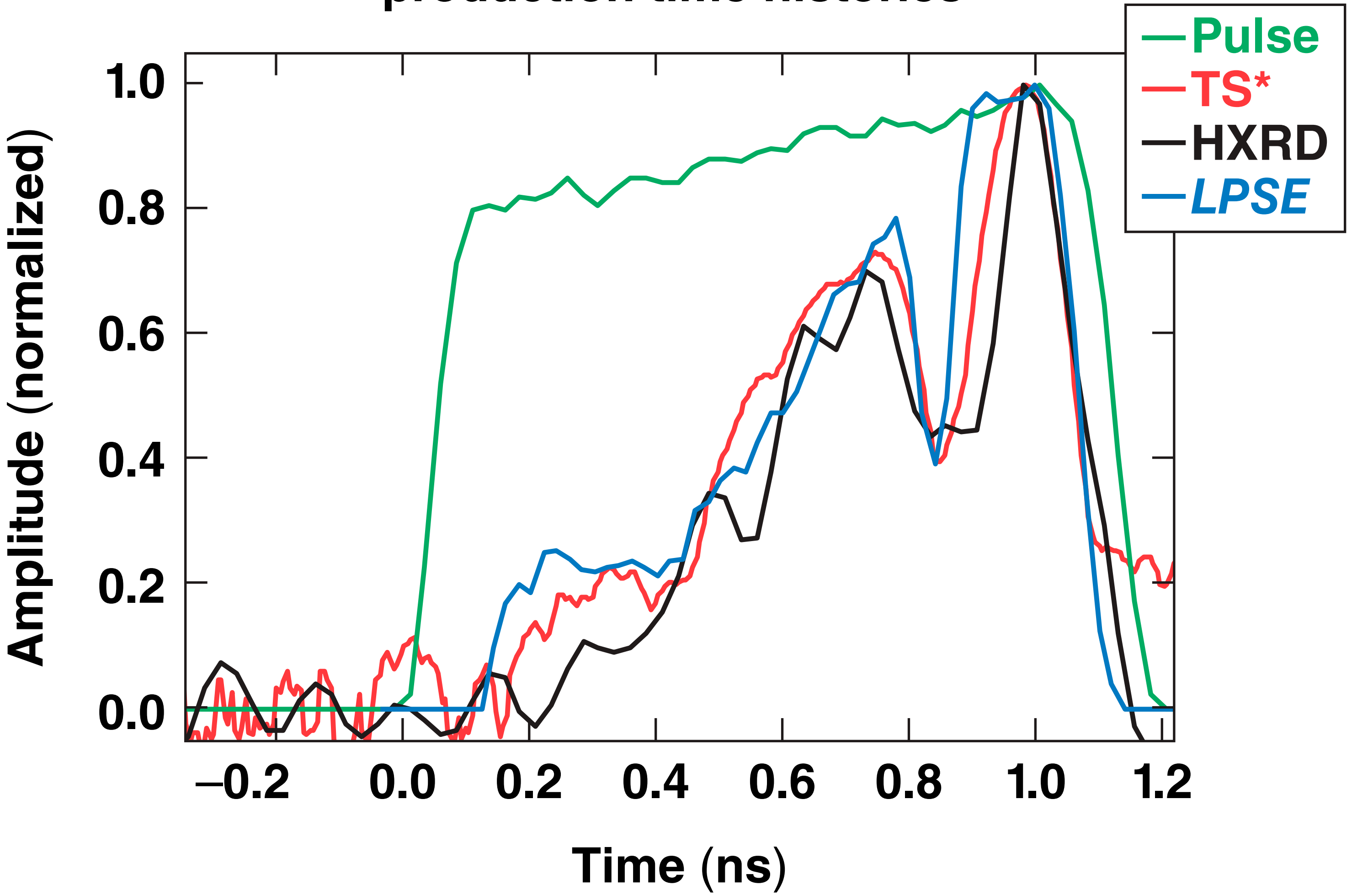
Spatially and temporally varying F_{hot} prediction



The predicted spatially averaged hot-electron production is in good agreement with time-resolved HXRD measurements

$$\left\langle F_{\text{hot}} \right\rangle_r = \frac{\int F_{\text{hot}}(r,t) I(r,t) r dr}{\int I(r,t) r dr}$$

Measured and predicted hot-electron–production time histories



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*TS: Thomson scattering

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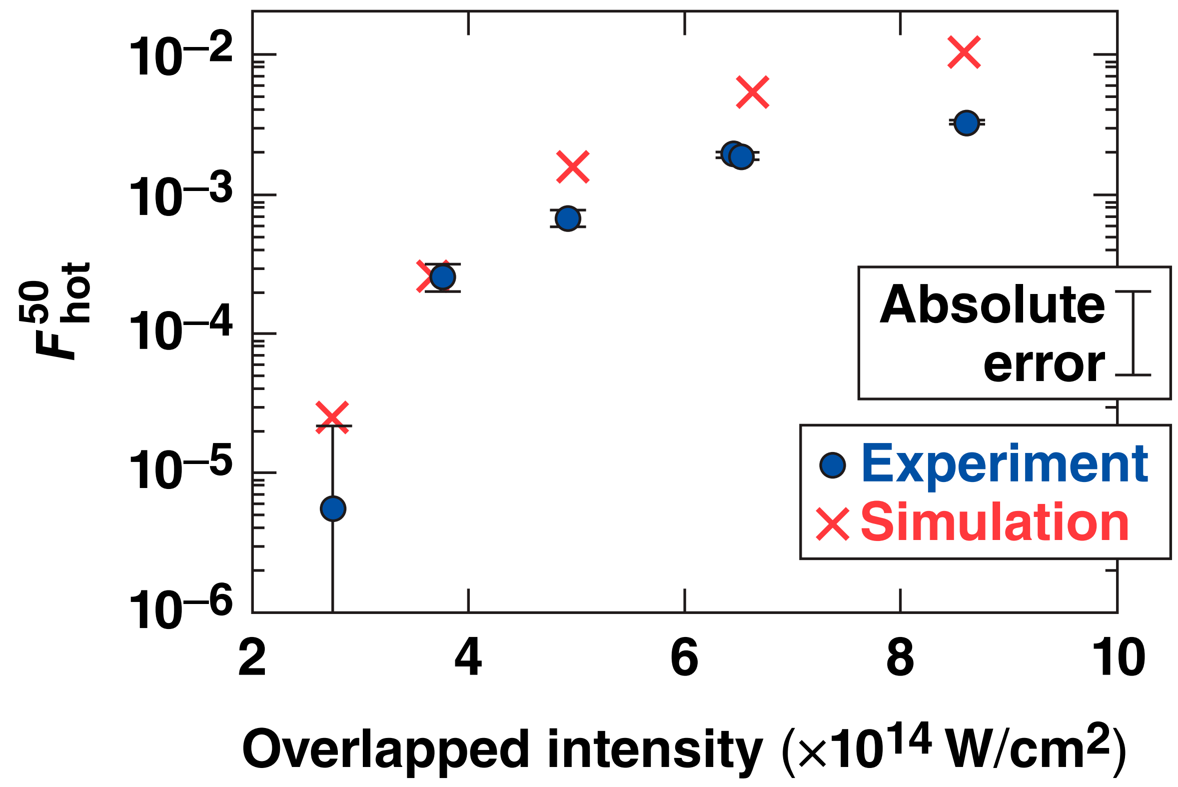
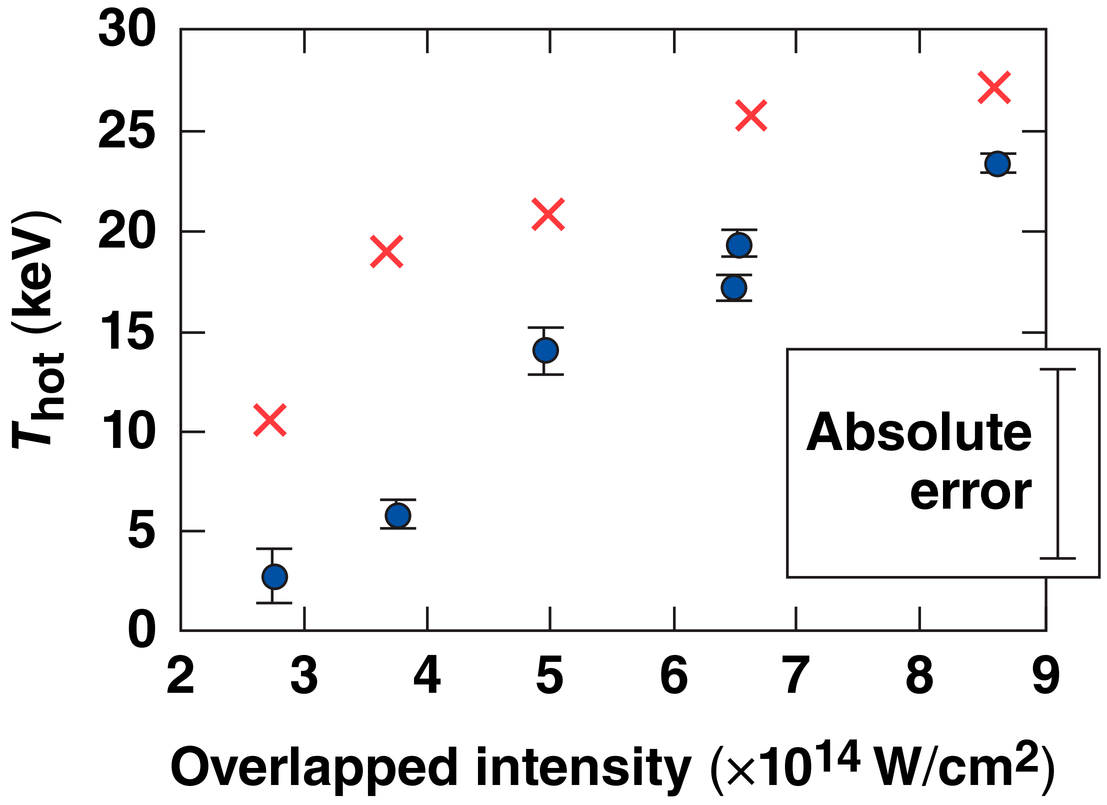
LPSE reproduces the observed scaling in hot-electron temperature and fraction

$$\langle F_{\text{hot}} \rangle = \frac{\int dt \int F_{\text{hot}}^{LPSE}(r,t)I(r,t)rdr}{\int dt \int I(r,t)rdr}$$

Fraction of incident laser energy converted into hot electrons



Hot-electron temperature



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Summary/Conclusions

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