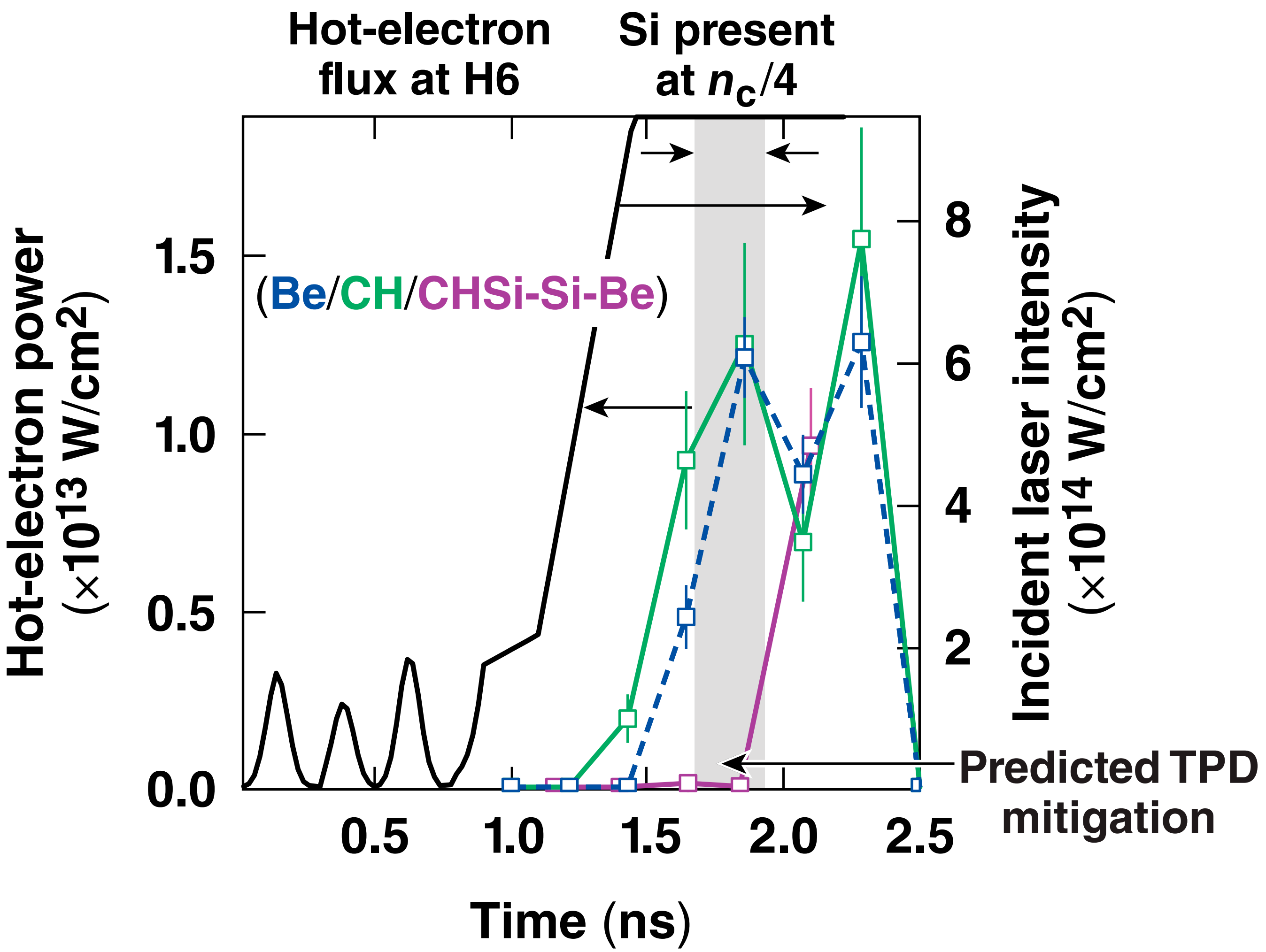
A Numerical Model for Hot-Electron Generation in Direct-Drive Implosions



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Summary

The new hot-electron package in *LPSE** enables hot-electron production caused by two-plasmon decay (TPD) to be computed in spherical implosions

- The recent "alternate ablator" campaign on OMEGA has been simulated with the laser–plasma instability (LPI) code *LPSE*
- The temporal behavior and strength of the hot-electron signatures are predicted to differ between the three ablator materials (CH, Be, and CHSi-Si-Be)
  - *LPSE* predicts the lowest hot-electron fraction in the Be-Si-CHSi target
  - Be and CH are predicted to be similar
- The goal of this campaign was to demonstrate hot-electron reduction in multilayer targets

TC12159

*Laser-plasma simulation environment (*LPSE*)

Collaborators

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LPSE is designed to perform large-scale simulations of laser–plasma interactions, where the three-dimensional geometry is essential

- *LPSE* computes TPD in the $n_c/4$ region of the corona
  - it is designed to compute the effect of multibeam instability*
- Laser irradiation can be very complex [standard OMEGA, OMEGA EP, and National Ignition Facility (NIF) beam geometries are built in]
- It uses an established model of TPD-driven electrostatic plasma turbulence**
  - hot electron production is computed using a novel hybrid-particle algorithm that integrates 10^7 to 10^8 particles taking advantage of hardware (GPU) acceleration
  - it is similar to the quasilinear model***

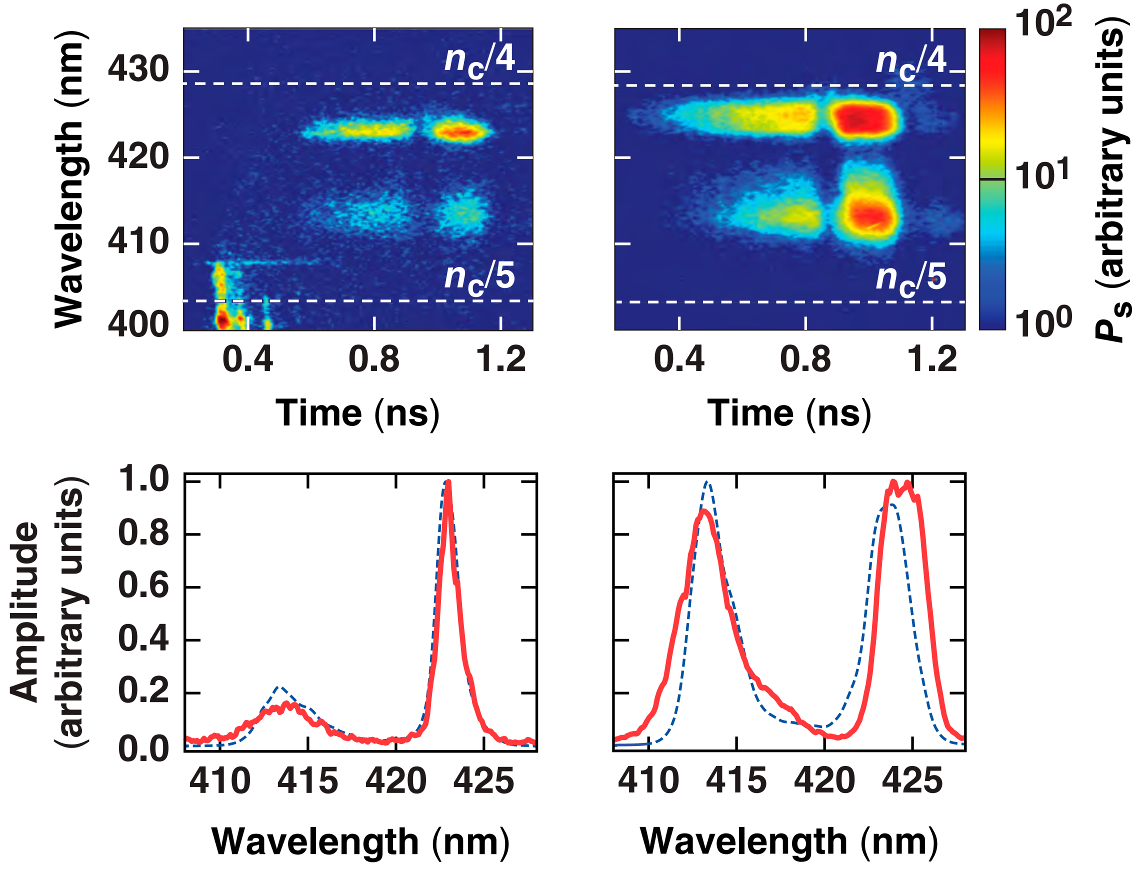
*J. F. Myatt *et al*., Phys. Plasmas 21, 055501 (2014).
**D. F. DuBois, D. A. Russell, and H. A. Rose, Phys. Rev. Lett. 74, 3983 (1995); D. A. Russell and D. F. DuBois, Phys. Rev. Lett. 86, 428 (2001);
***J. F. Myatt *et al*., Phys. Plasmas 20, 052705 (2013).

LPSE quantifies hot-electron production (energetics and spectral properties) relevant to inertial confinement fusion (ICF) experiments at the Omega Laser Facility and on the NIF

- Other diagnostic signatures of TPD in OMEGA experiments can be computed
  - Thomson scattering
  - hard x rays
  - half-harmonic emission

- Predictions have been made for FY15 NIF experiments by A. A. Solodov**

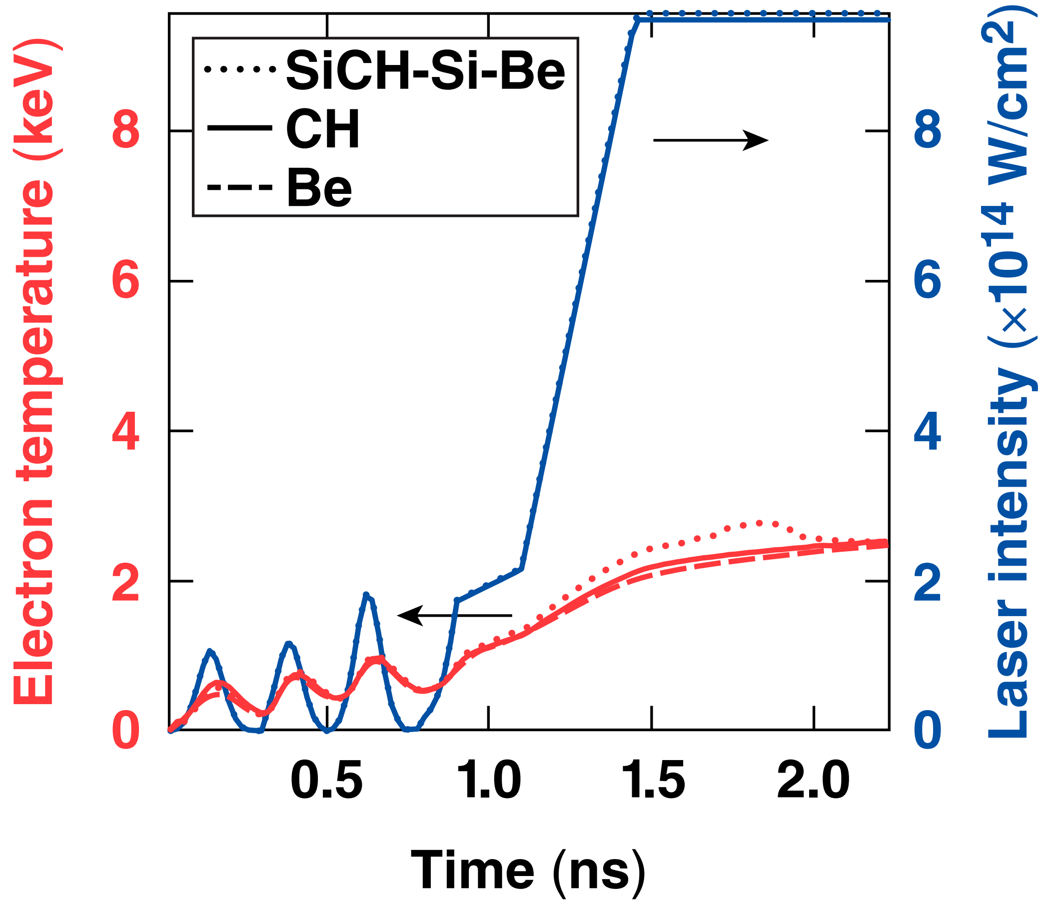
Thomson scattering from TPD waves [comparison with *LPSE* (blue lines)]*

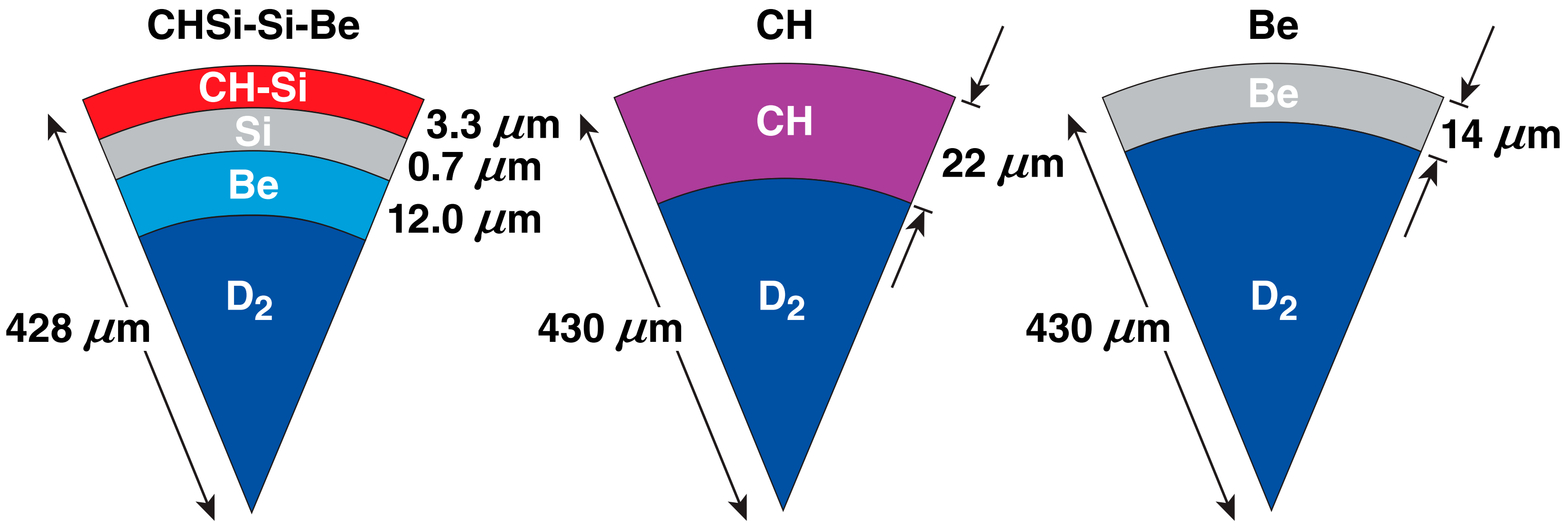


*R. K. Follett *et al*., Phys. Rev. E 91, 031104 (2015).
** T. M. Rosenberg *et al*., this conference.

Three spherical implosions experiments were simulated with *LILAC* to obtain the hydrodynamic variables as a function of time (CBET,* but no TPD)

- The coronal temperature is predicted to increase in the Be-Si-CHSi target
- the TPD threshold increases according to the simple IL/T scaling





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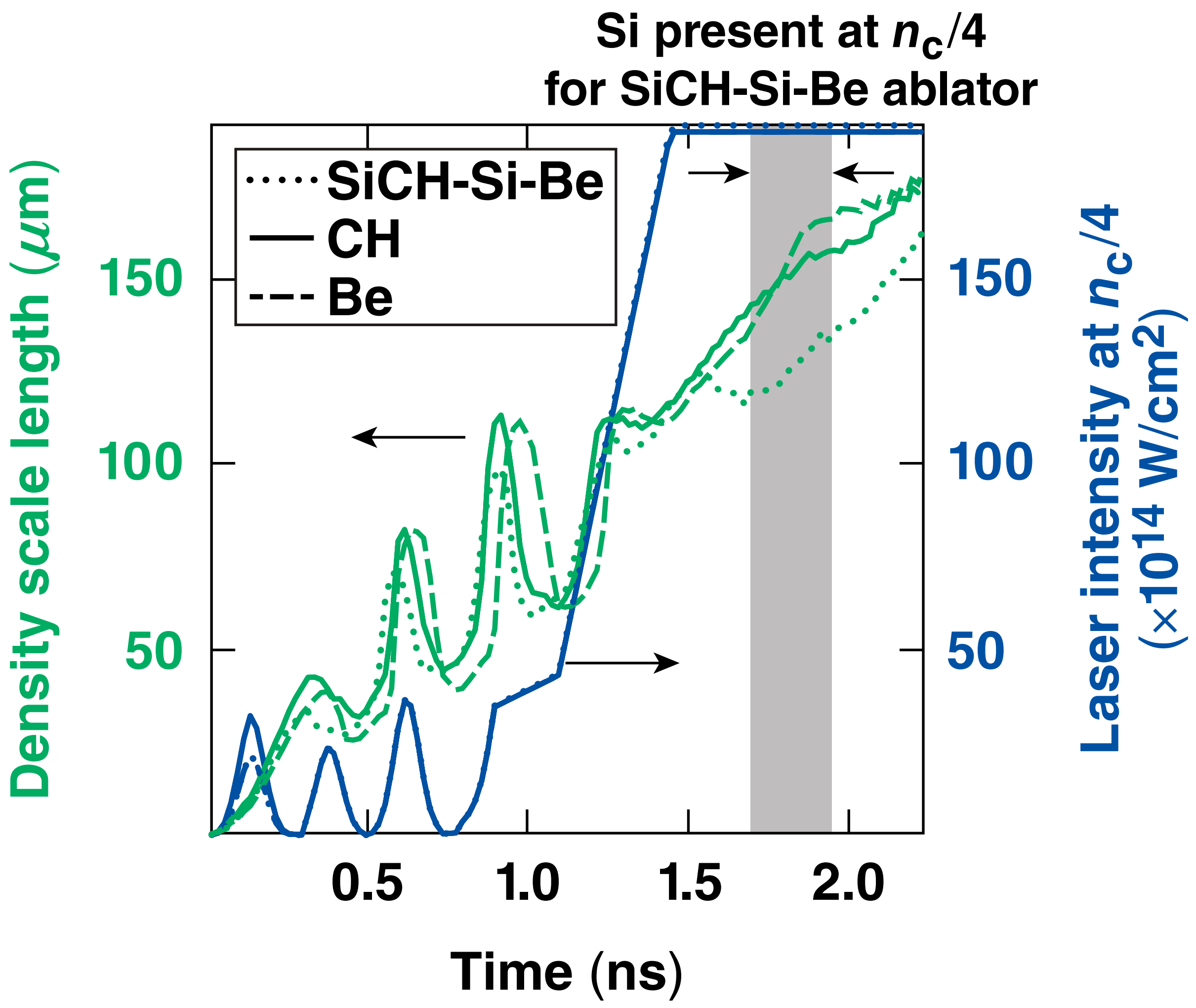
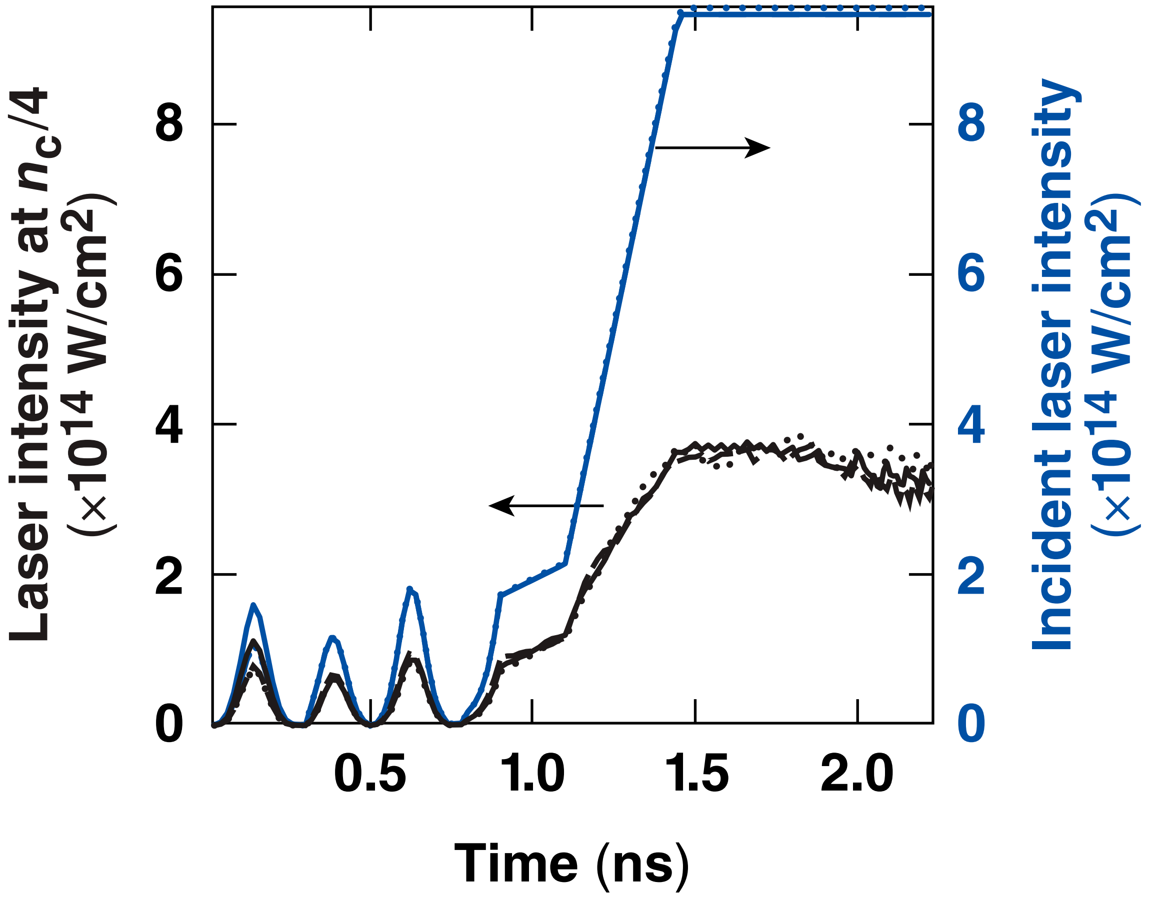
*Cross-beam energy transfer

The Si layer reduces the density scale length at the $n_c/4$ surface





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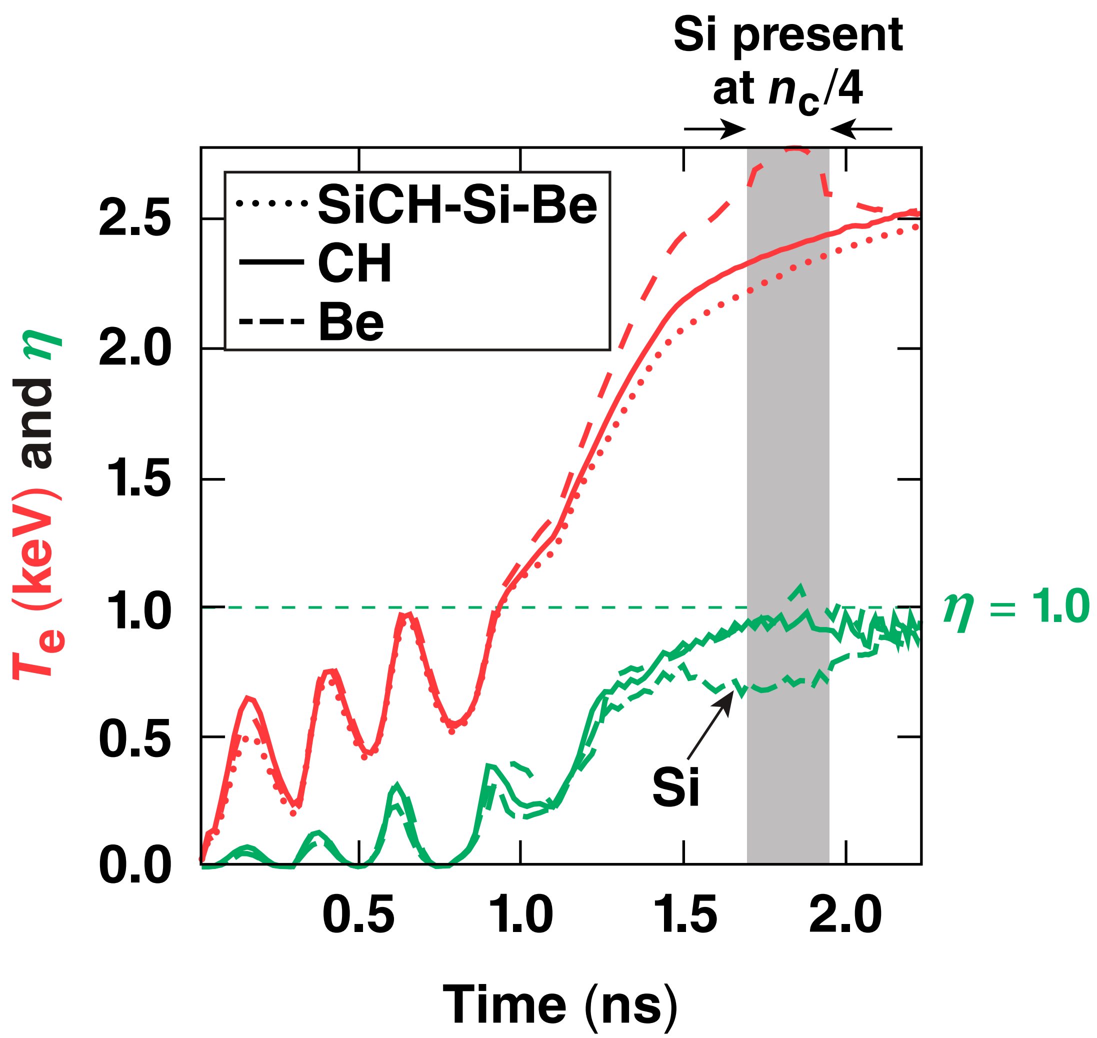
Based on *LILAC* predicted scale lengths, temperatures, and intensities, the Be-Si-CHSi target is expected to excite the least TPD

- The "strength" of TPD should depend on the quantity $\frac{IL_\text{n}}{T_\text{e}}$
- Linear threshold parameter for a single beam $\eta = \frac{I_{14}\,L_{\text{n},\mu\text{m}}}{230\,T_{\text{e, keV}}}$*
- IL/T_e varies little during the main pulse because temperature increases compensate for the scale length



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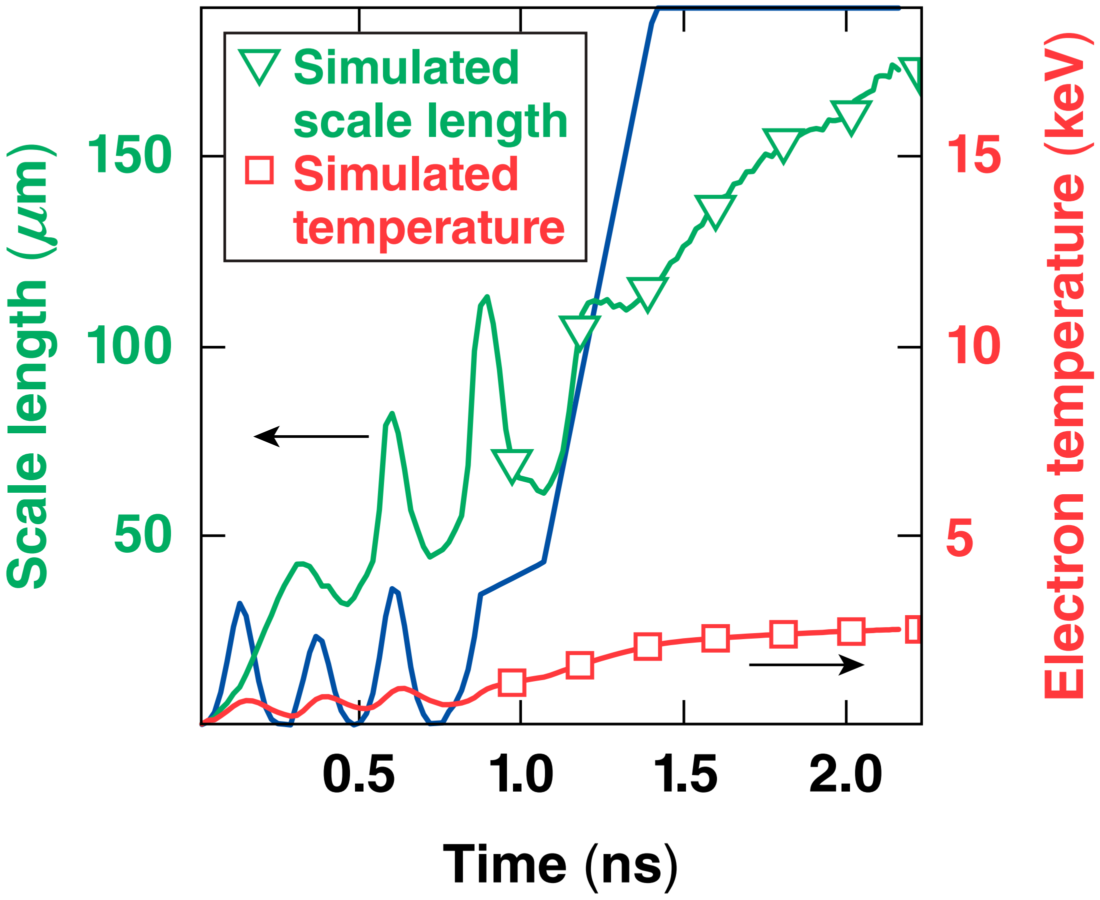
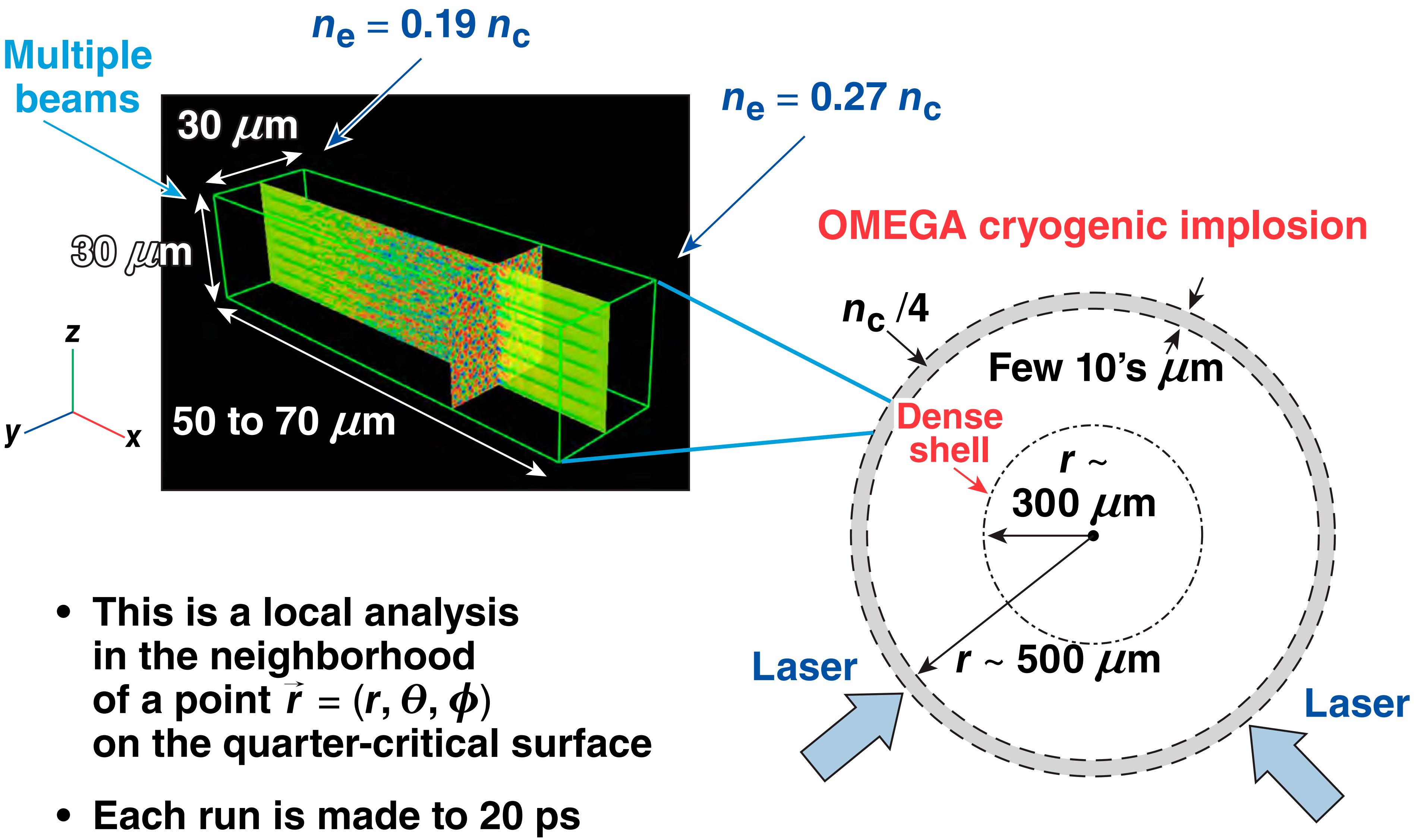
*A. Simon *et al*., Phys. Fluids 26, 3107 (1983).

Each target is simulated by *LPSE* to quantify the hot-electron production

- The simulations take advantage of the separation between hydro and LPI time scales
- The duration of the implosion is broken up into several runs chosen to sample the main pulse (markers)
- The hydrodynamic variables are "frozen" over the duration of the *LPSE* simulation



The 3-D simulation volume is determined by the density scale length at the chosen time



- This is a local analysis in the neighborhood of a point $\vec{r} = (r, \theta, \phi)$ on the quarter-critical surface
- Each run is made to 20 ps

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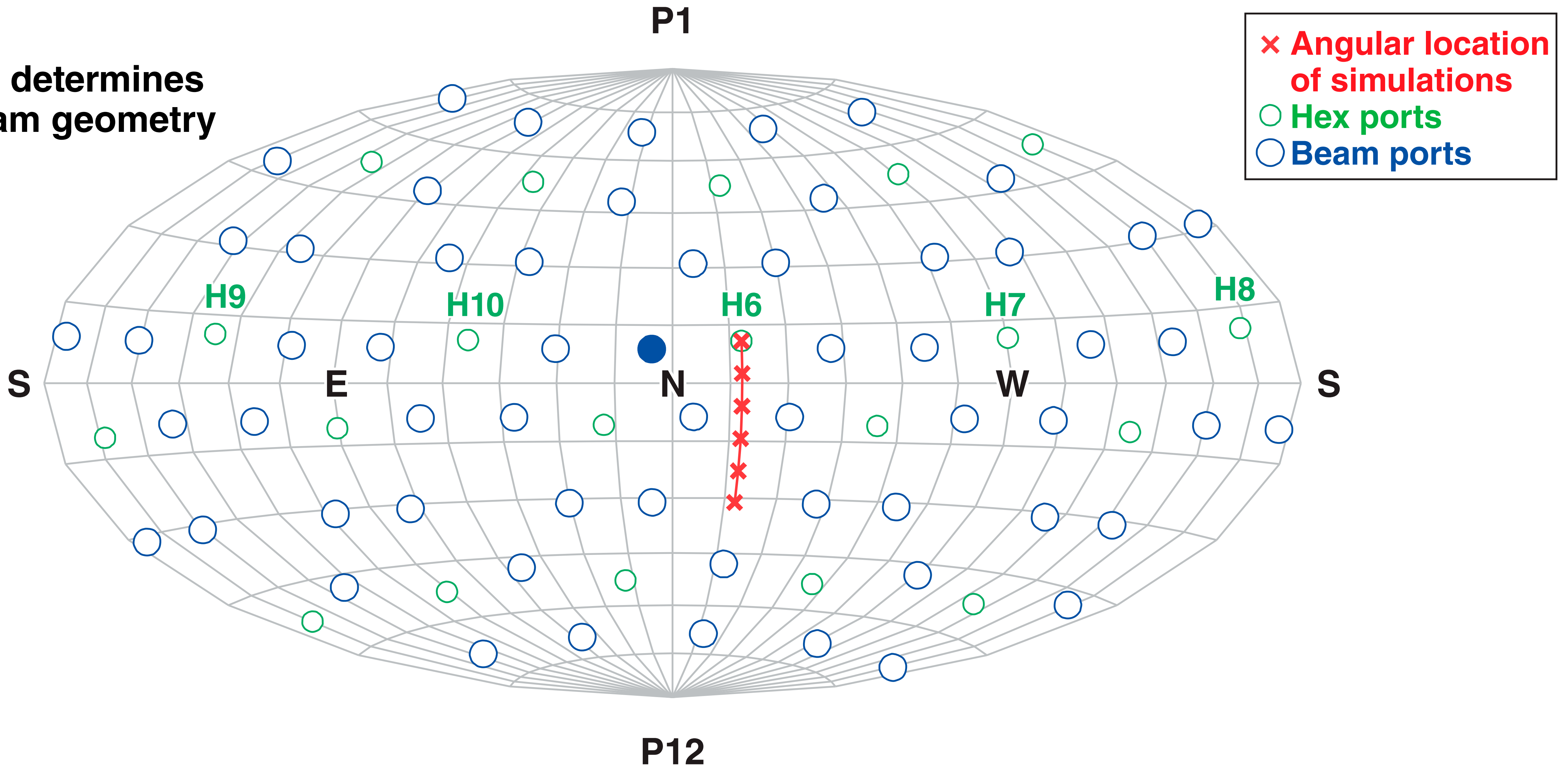
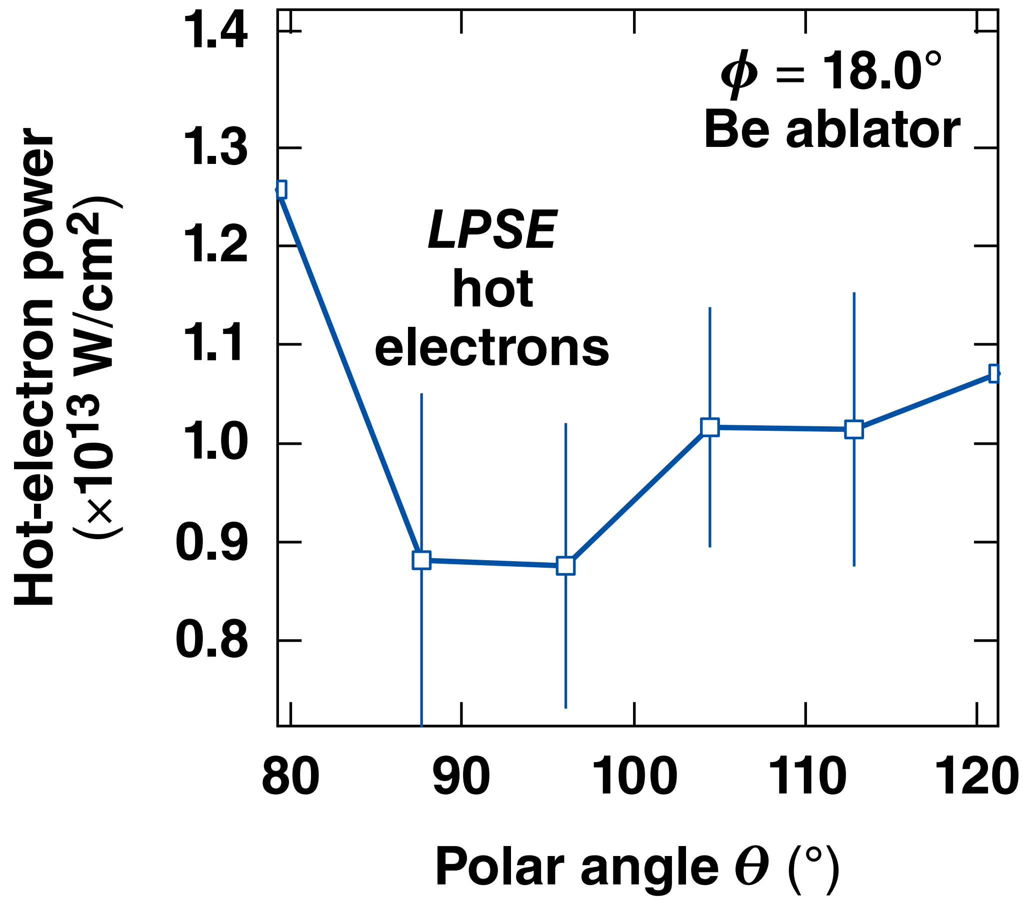
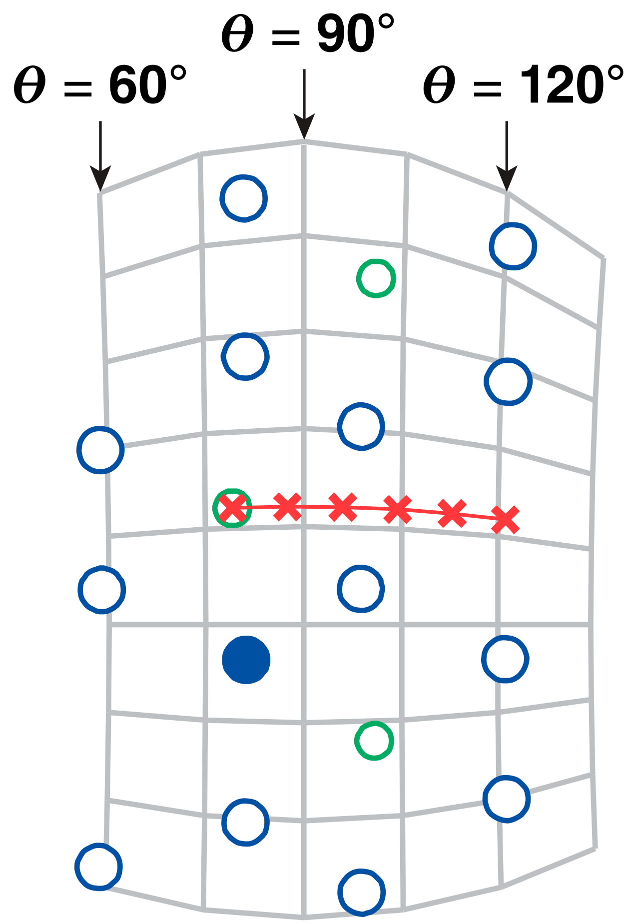
For each simulated time, six different locations near the $n_c/4$ surface were computed [using a distributed polarization rotator (DPR) model]

- **The location determines the laser beam geometry**



For all cases (tangentially focused SG5) TPD hot electrons are preferentially generated at the hex centers*





- This is broadly consistent with Seka's observations*

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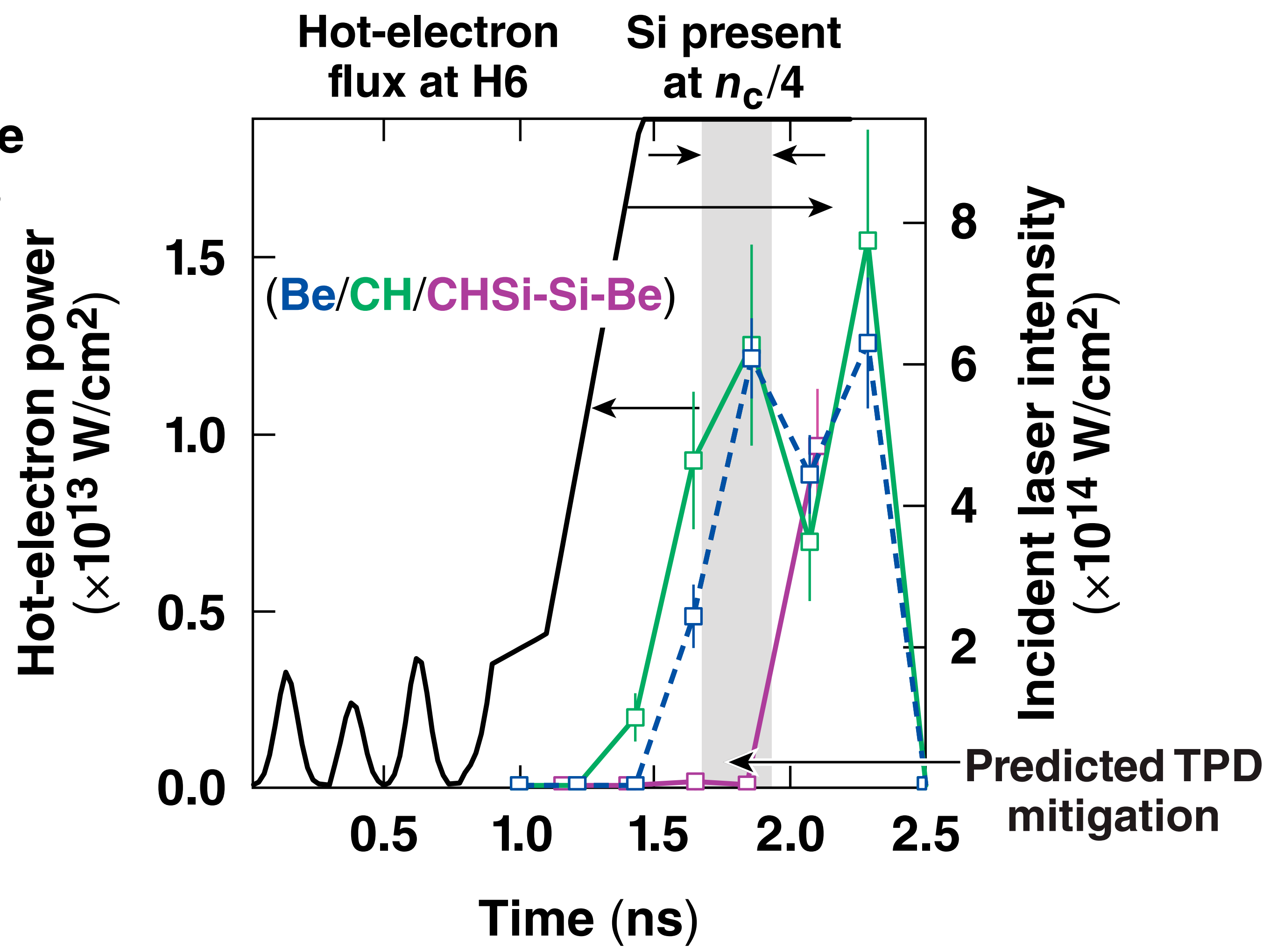
*W. Seka *et al*., Phys. Rev. Lett. 112, 145001 (2014).

The absolute time-dependent hot-electron power has been computed for each ablator type

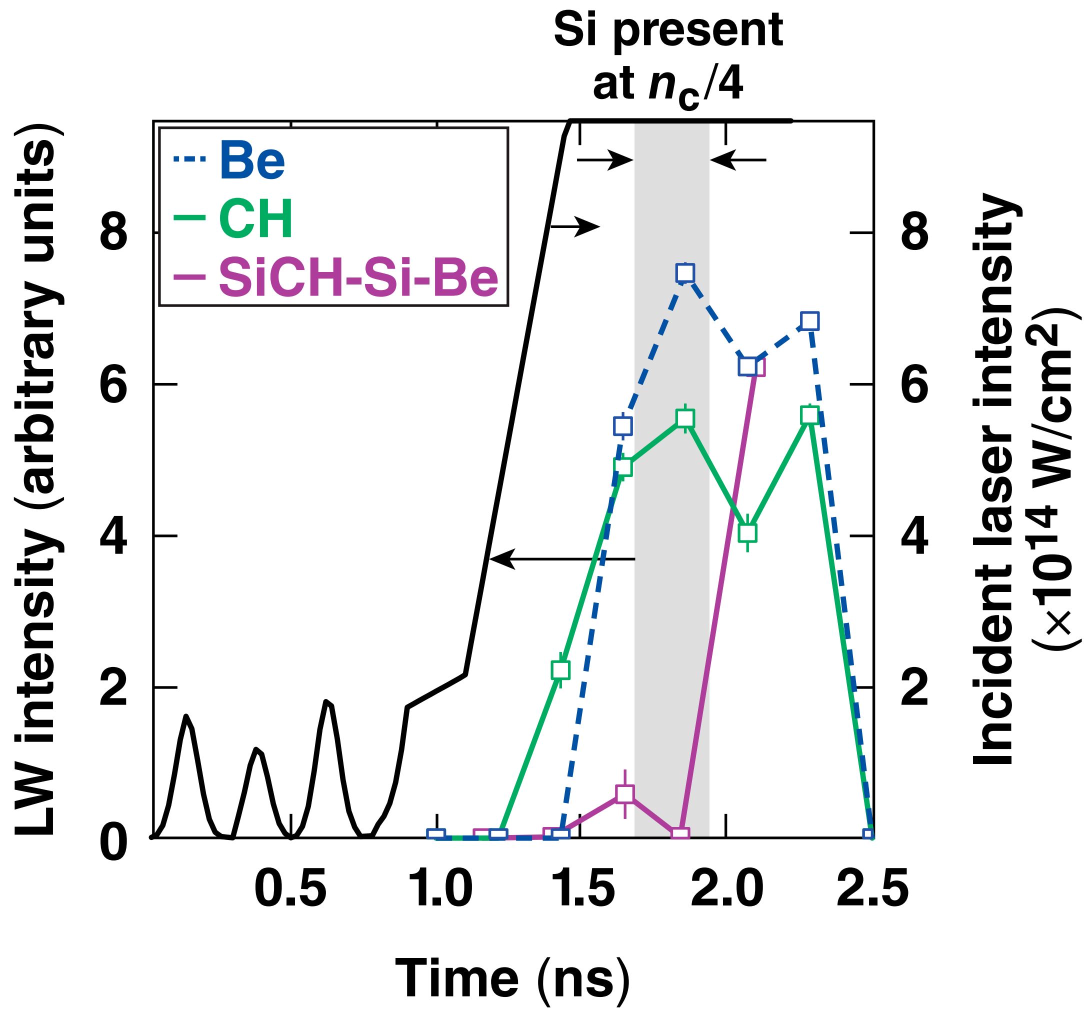
- CH and Be targets produce similar hot-electron fluxes



Hot-electron power is strongly reduced in the CHSi-Si-Be design when Si is present at the $n_c/4$ surface.

The Langmuir wave (LW) intensity shows differences between Be and CH that are not seen in hot electrons

- The reasons are caused by differences in the acoustic damping rate
- This effect might be observable with Thomson scattering**



*J. F. Myatt *et al.*, Phys. Plasmas 20, 052705 (2013).
**R. K. Follett *et al.*, this conference.

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