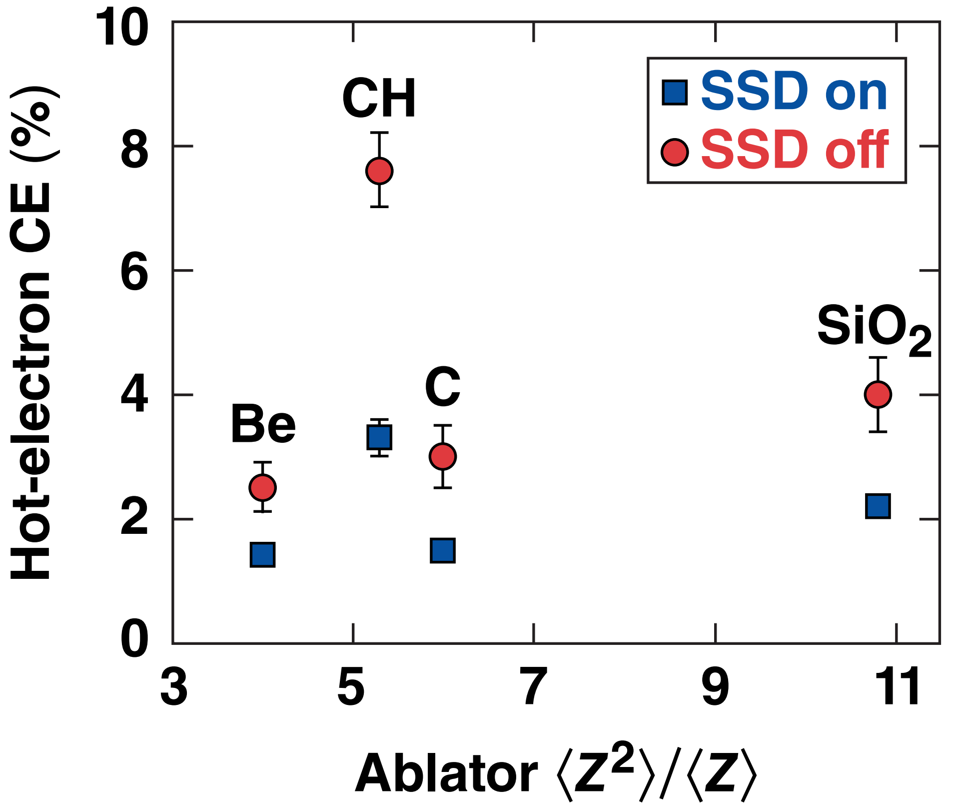
Hot-Electron Generation in Various Ablator Materials at Shock-Ignition–Relevant Laser Intensities



W. Theobald
University of Rochester
Laboratory for Laser Energetics

57th Annual Meeting of the American Physical Society Division of Plasma Physics
Savannah, GA
16–20 November 2015

Summary

Large amounts of hot electrons that enhance the shock formation are produced in CH ablators at $I = 6 \times 10^{15}$ W/cm^2

- Ablator materials other than CH (Be, C, SiO_2) produce fewer hot electrons and weaker shocks
- Stimulated Raman scattering is identified as the dominant hot-electron production process
- Particle-in-cell simulations qualitatively reproduce the high hot-electron production in plastic

E24526

Collaborators

R. Betti,[*,†] W. Seka,[*] A. Bose,[*,†] D. T. Michel, C. Stoeckl, and R. Yan[*]

Laboratory for Laser Energetics
*also Fusion Science Center
†also Departments of Mechanical Engineering and Physics
University of Rochester

R. Nora

Lawrence Livermore National Laboratory

A. Casner and M. Lafon

CEA, DAM, DIF, Arpajon, France

X. Ribeyre, E. Llor-aisa, and A. Vallet

Centre Lasers Intenses et Applications, University of Bordeaux, Bordeaux, France

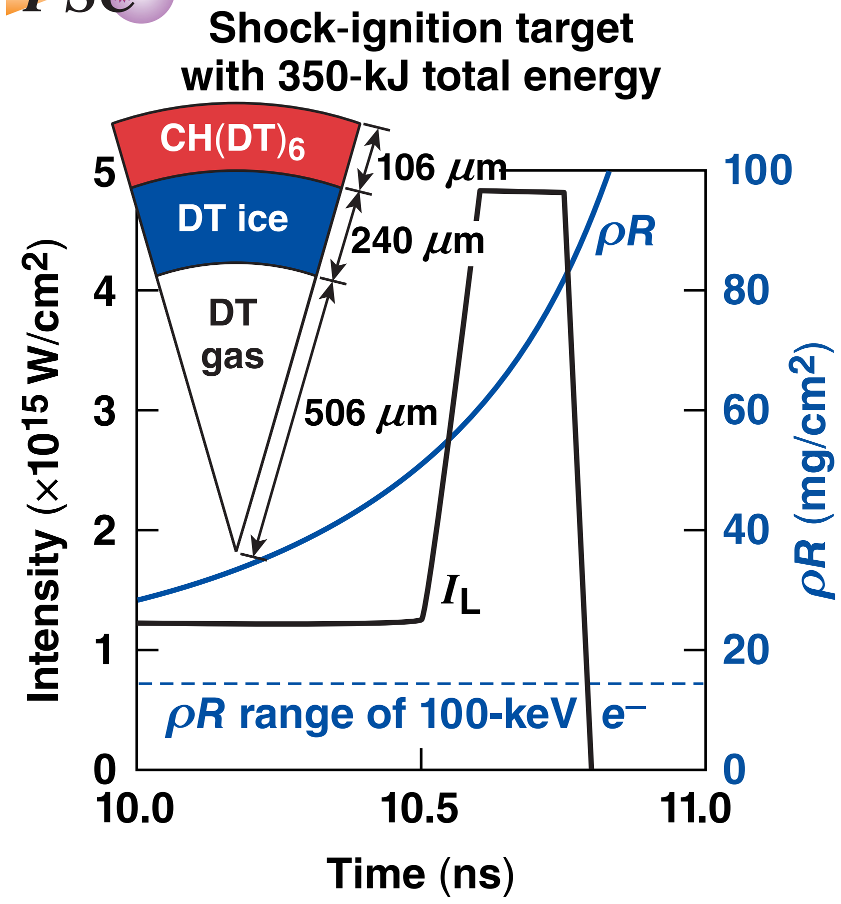
J. Peebles and F. N. Beg

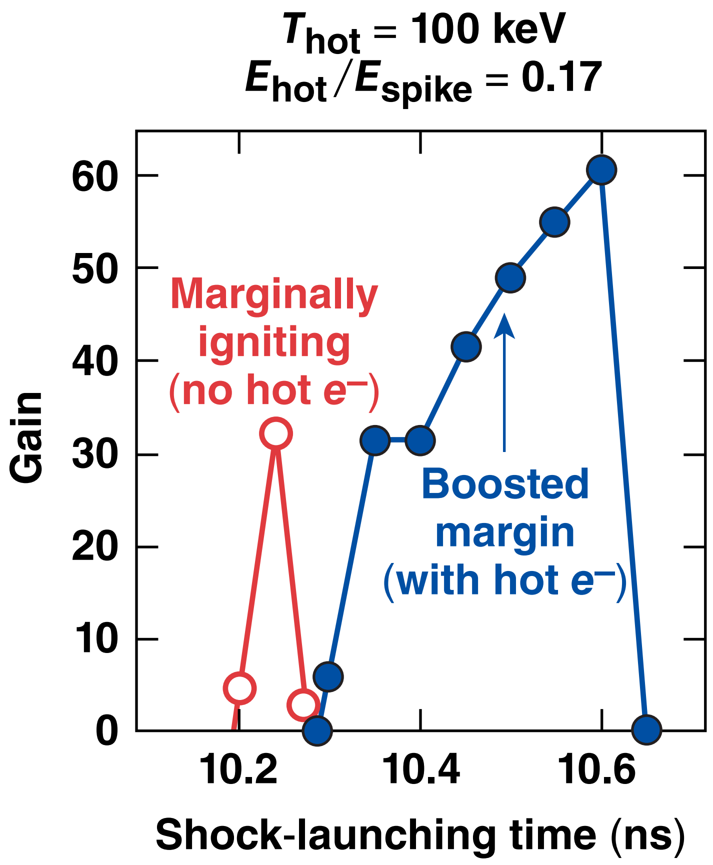
University of California, San Diego, La Jolla, CA

M. S. Wei

General Atomics, San Diego, CA

Hot electrons might help to improve the implosion performance in shock ignition





Hot electrons can contribute significantly to the shock formation*

$$P_{abl}\,(\text{Mbar}) \approx 175\,\rho_{g/cm^3}^{1/3}\,(\eta_{Le^-}\,I_{15})^{2/3}$$

$\rho_{g/cm^3}^{1/3}$: target mass density

η_{Le^-}: conversion efficiency

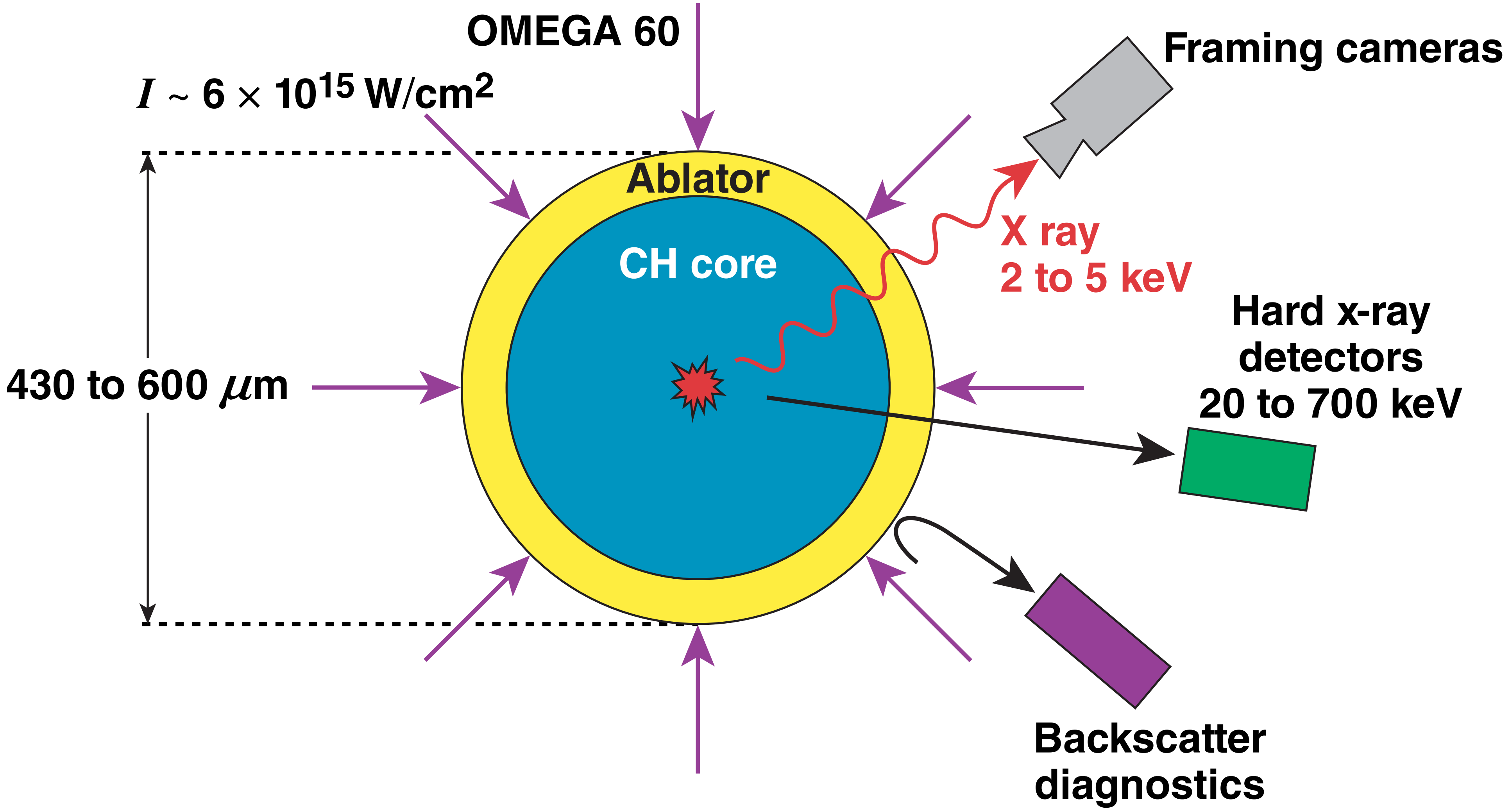
If the ρR is high enough, hot electrons are stopped in the outer regions of the shell, increasing the shock pressure and the target gain.**

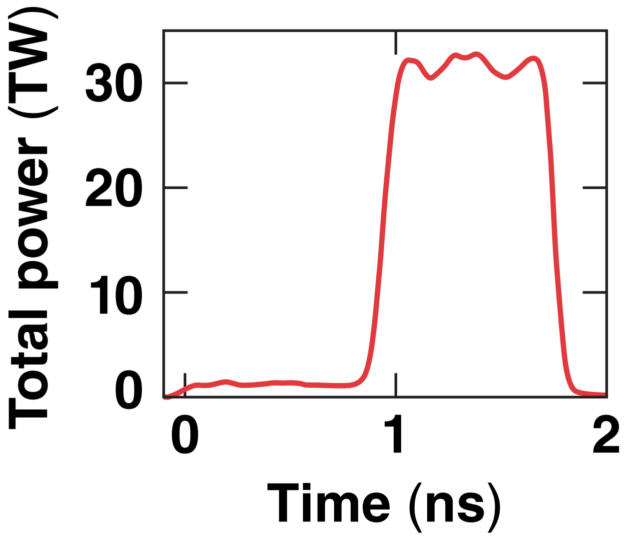
* S. Gus'kov *et al.*, Phys. Rev. Lett. 109, 255004 (2012); X. Ribeyre *et al.*, Phys. Plasmas 20, 062705 (2013); A. R. Piriz *et al.*, Phys. Plasmas 19, 122705 (2012).

** R. Betti *et al.*, J. Phys.: Conf. Ser. 112, 022024 (2008).

TC7870I

The spherical strong shock (SSS) platform* was developed to study the formation of shocks and hot electrons in solid targets with various ablators

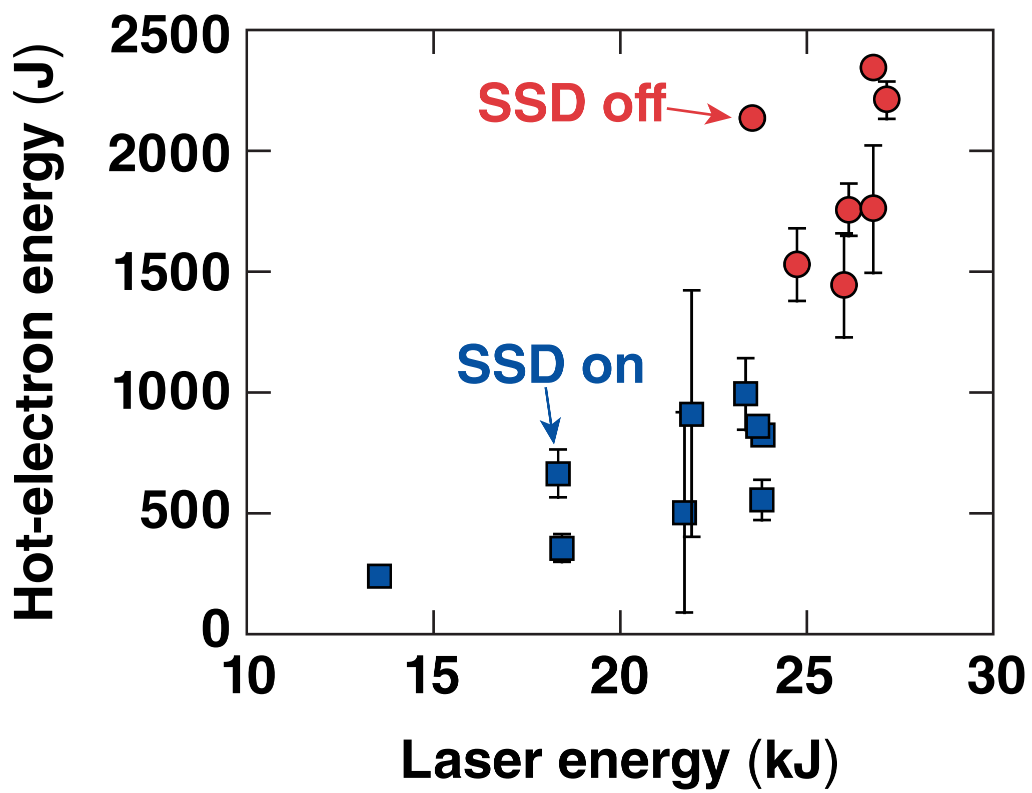


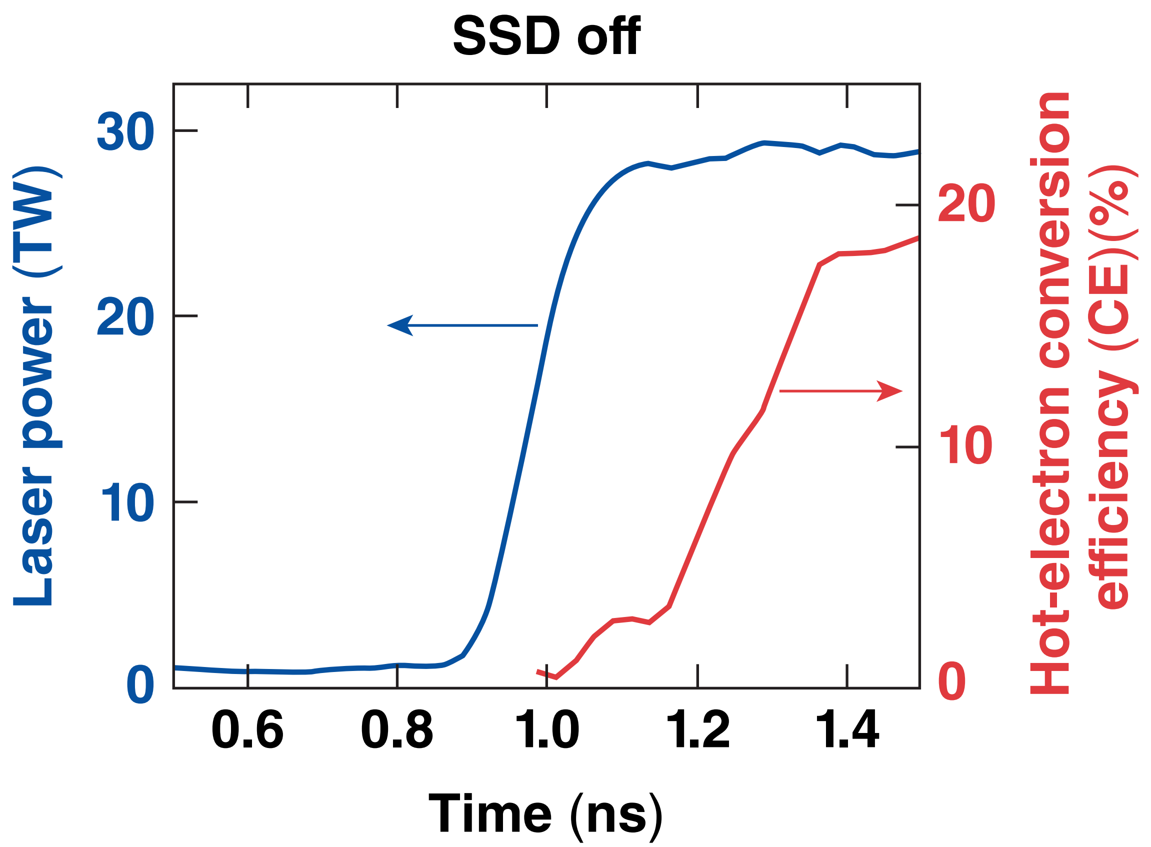


*R. Nora *et al*., Phys. Rev. Lett. 114, 045001 (2015);
W. Theobald *et al*., Phys. Plasmas 22, 056310 (2015).

E22457c

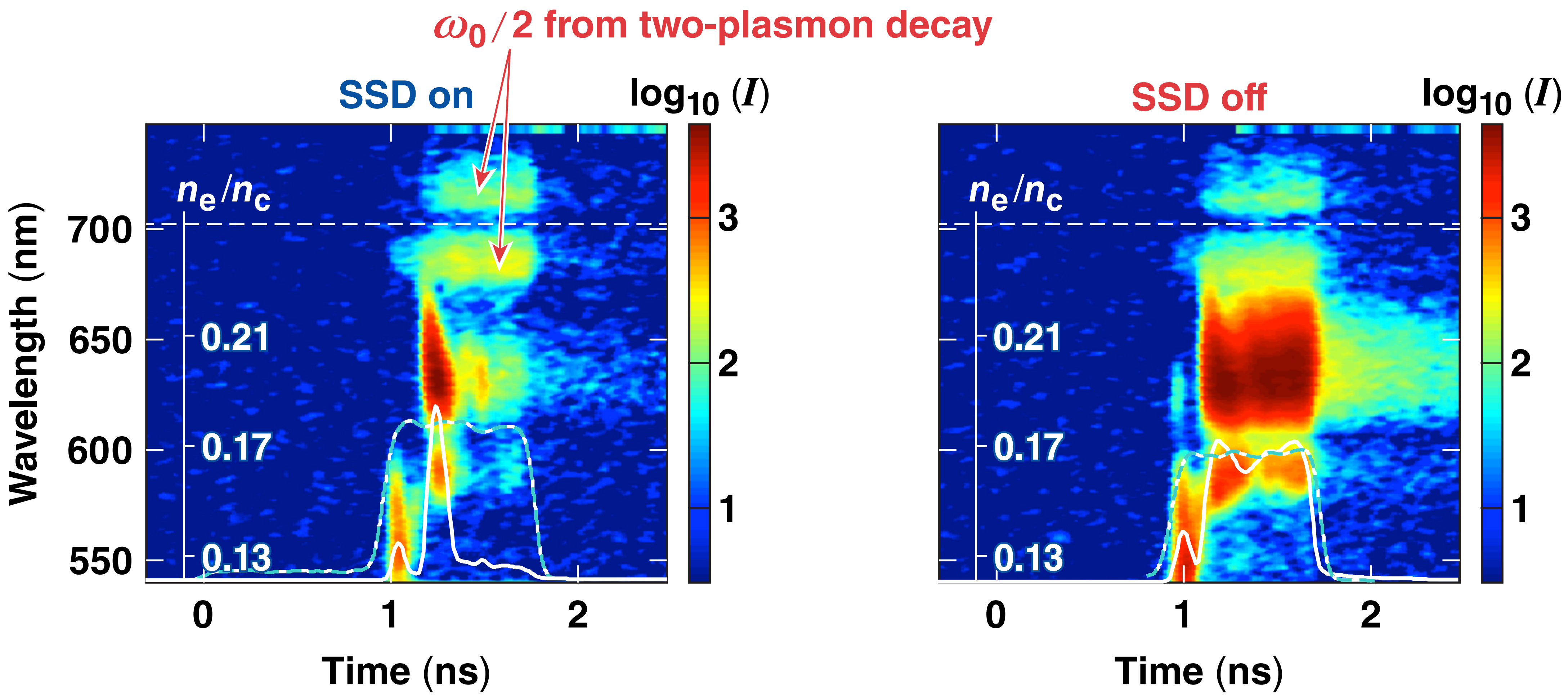
More than 15% of the instantaneous laser energy is converted into hot electrons in plastic ablators when smoothing by spectral dispersion (SSD) is turned off





E24379a

Stimulated Raman scattering (SRS) is the dominant hot-electron production process

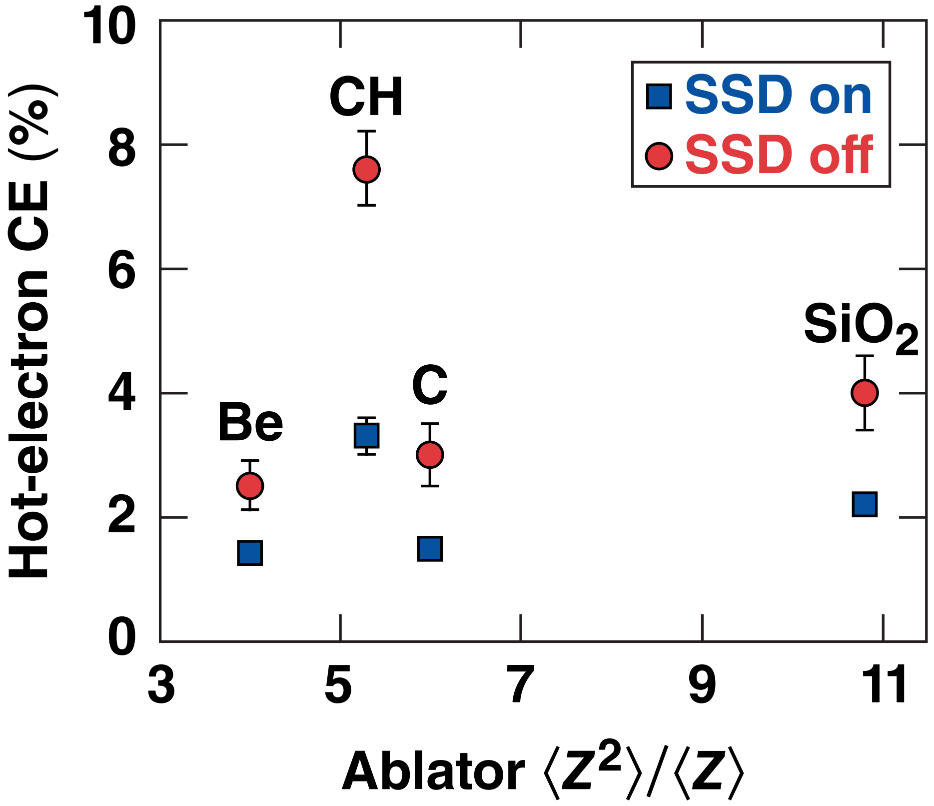


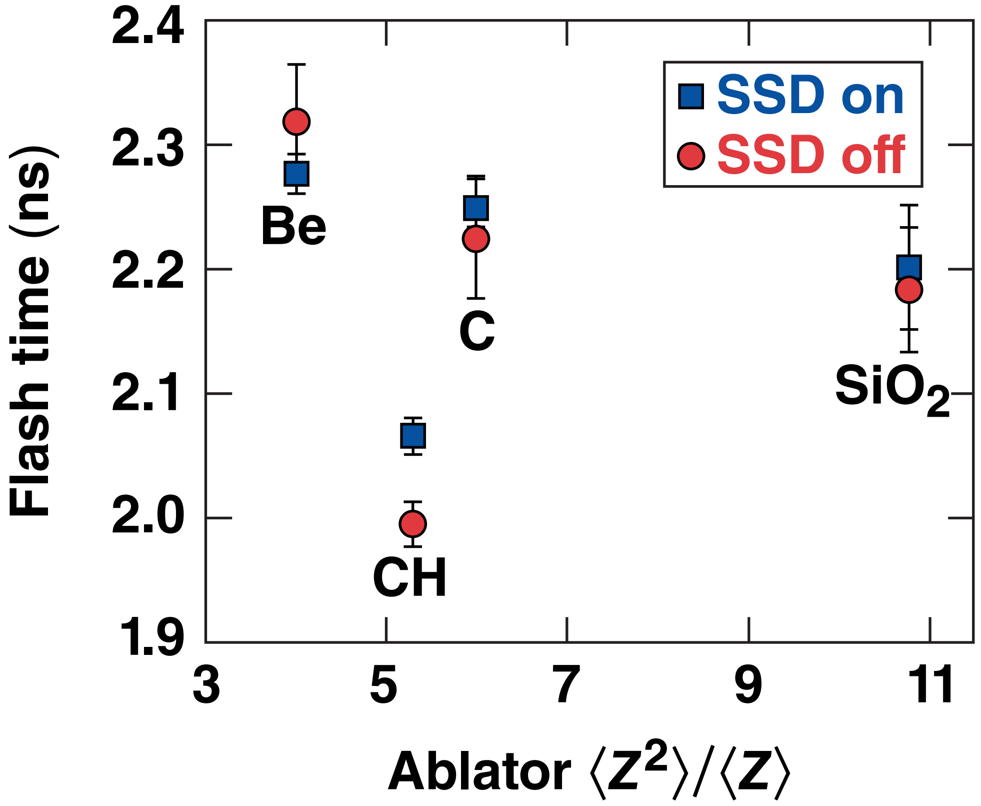
E_{SRS} (arbitrary units) = 291

E_{SRS} (arbitrary units) = 1563

E23226d

More hot electrons are produced in plastic, which correlates with an earlier flash time

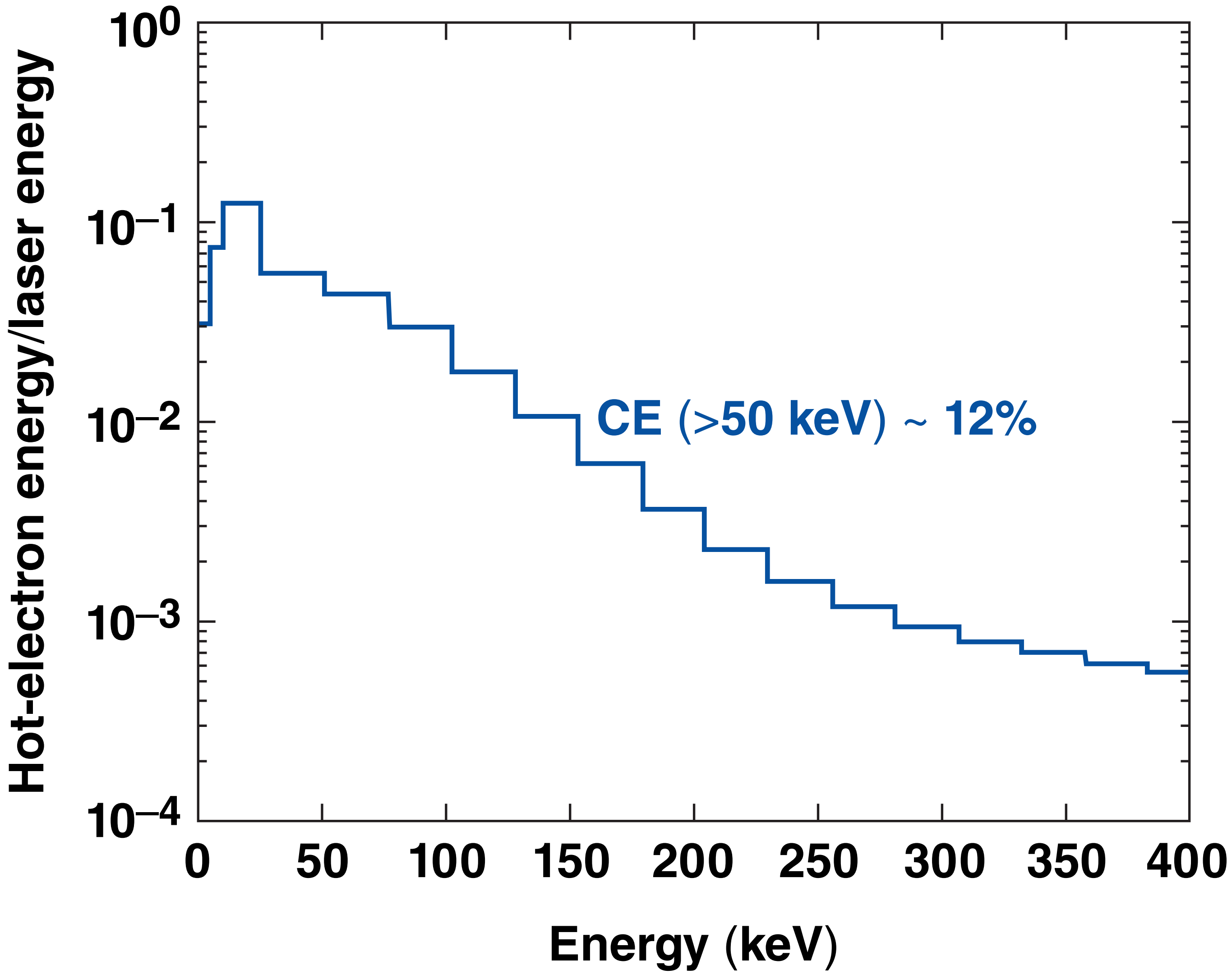




- Hot-electron temperatures are ~60 to 80 keV and are independent of the ablator material and SSD

E24380a

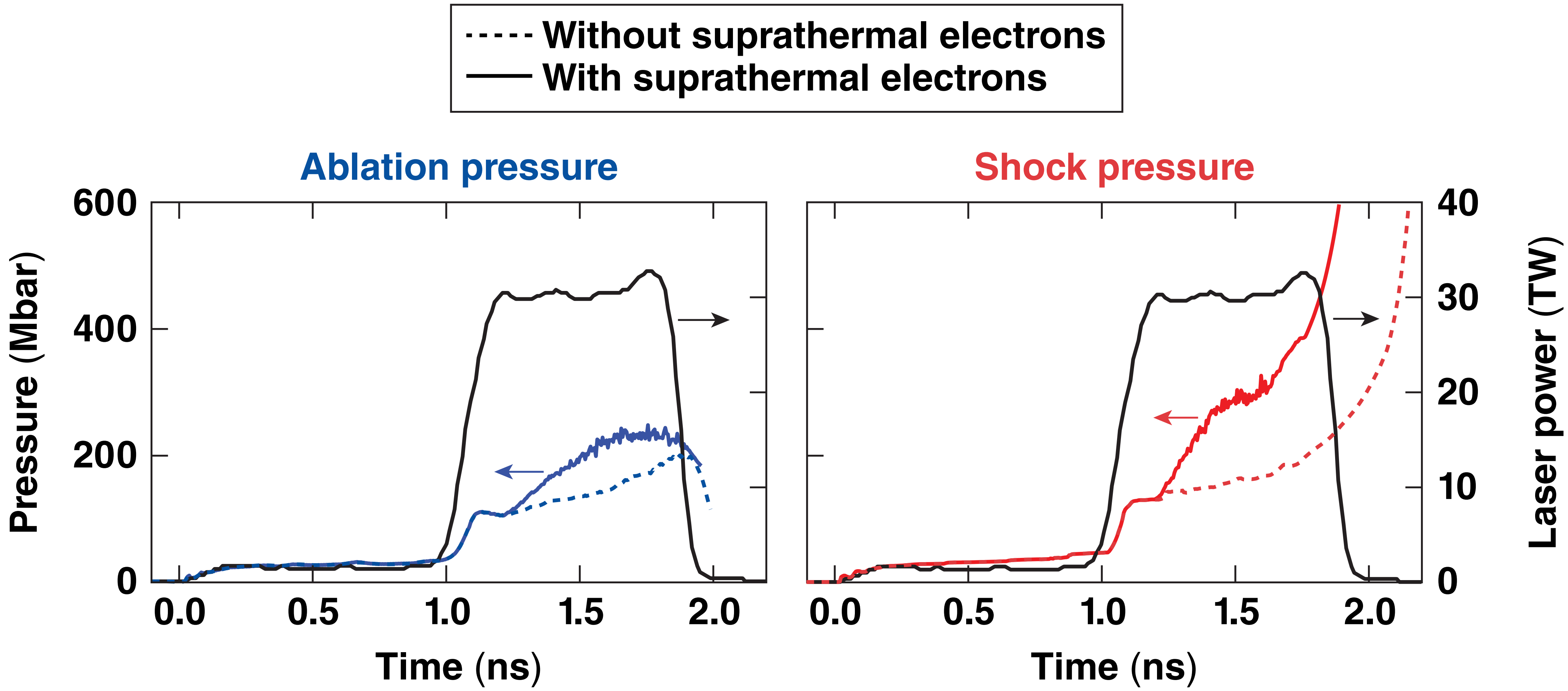
Particle-in-cell simulations qualitatively reproduce the high hot-electron production in plastic



E24527

Courtesy of R. Yan

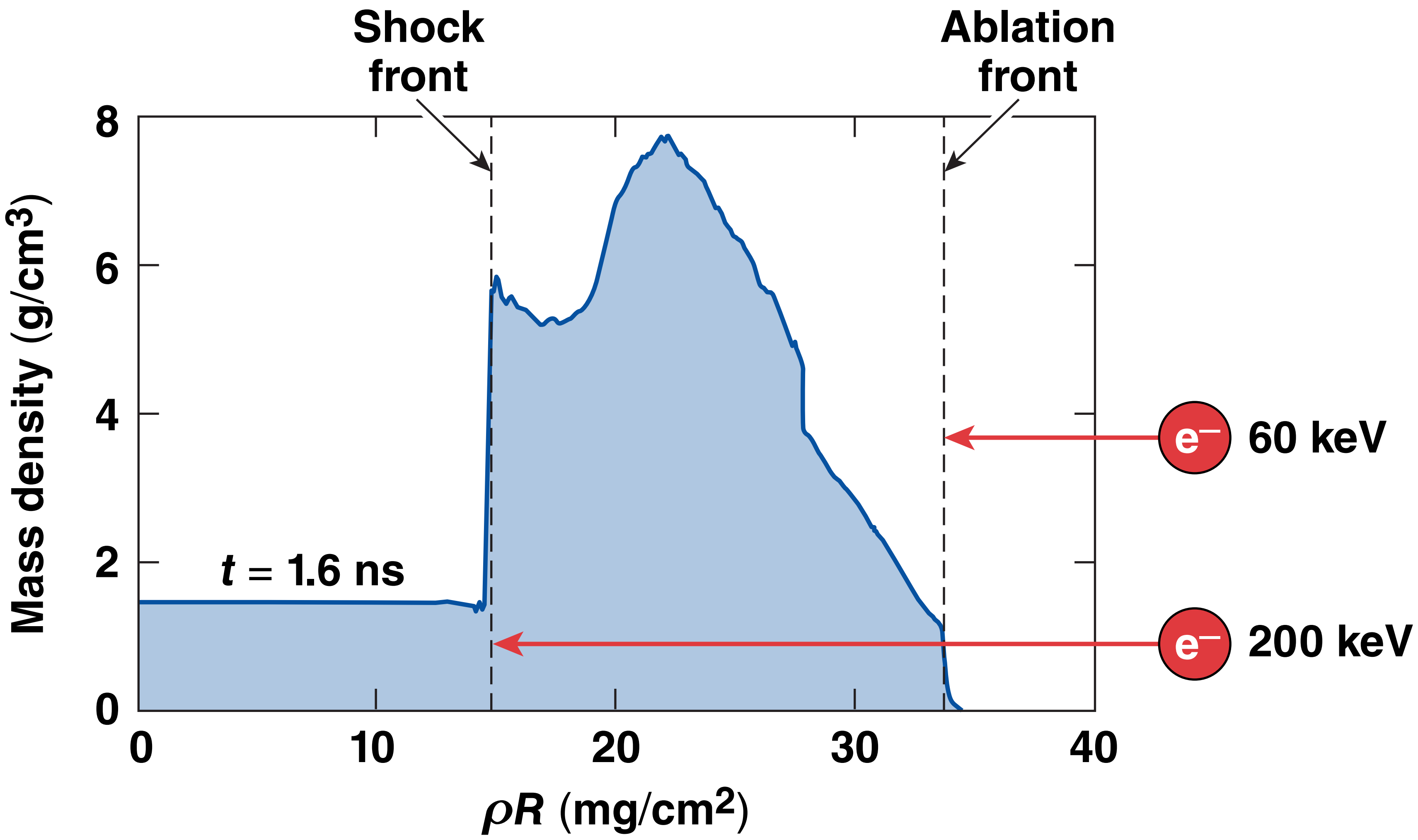
The shock and ablation pressures are significantly enhanced by the deposition of suprathermal electrons



TC11474b

*R. Nora *et al.*, Phys. Rev. Lett. 114, 045001 (2015).

One-dimensional simulations show that the majority of the suprathermal electron energy is deposited between the ablation front and shock front



TC11706b

Large amounts of hot electrons that enhance the shock formation are produced in CH ablators at $I = 6 \times 10^{15}$ W/cm^2

- Ablator materials other than CH (Be, C, SiO_2) produce fewer hot electrons and weaker shocks
- Stimulated Raman scattering is identified as the dominant hot-electron production process
- Particle-in-cell simulations qualitatively reproduce the high hot-electron production in plastic