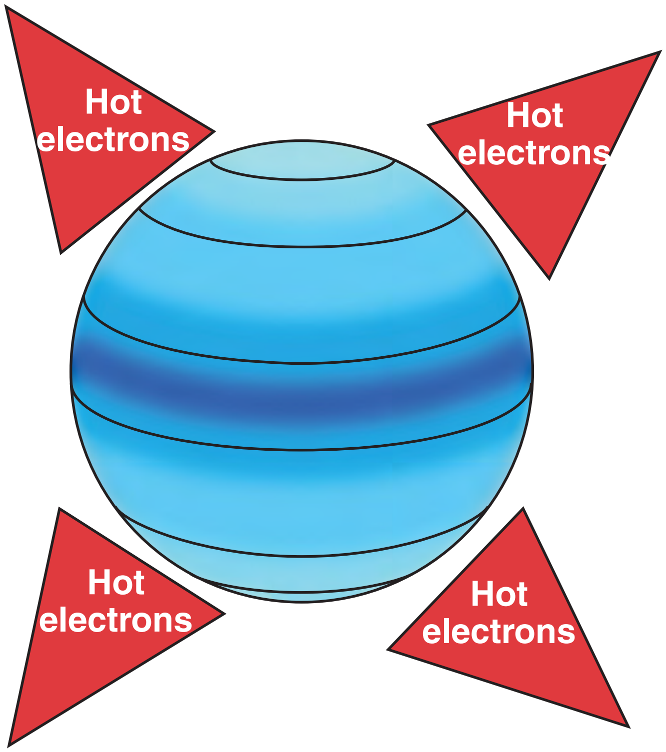
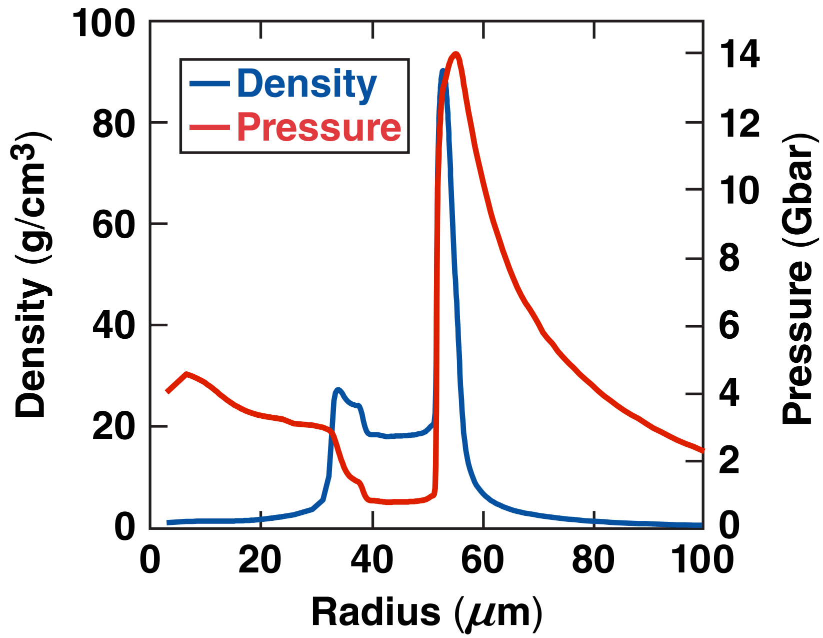
Electron Shock Ignition





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Summary

Ignition of slow targets is possible using laser-accelerated hot electrons to drive Gbar ignitor shocks

- OMEGA experiments show that up to 16% of the laser energy can be converted into hot electrons (T_{hot} ~ 30 to 40 keV) at intensities of ~10^{16} W/cm^2
- Ignition designs at V_i ~ 250 km/s and E_L ~ 100 kJ are developed with the ignitor shock driven by 30- to 40-keV hot electrons
- For high T_{hot} ~ 200 keV, ignition designs require massive targets (V_i ~ 100 km/s) with high-Z layers driven by $E_L \gtrsim$ 500 kJ

Collaborators

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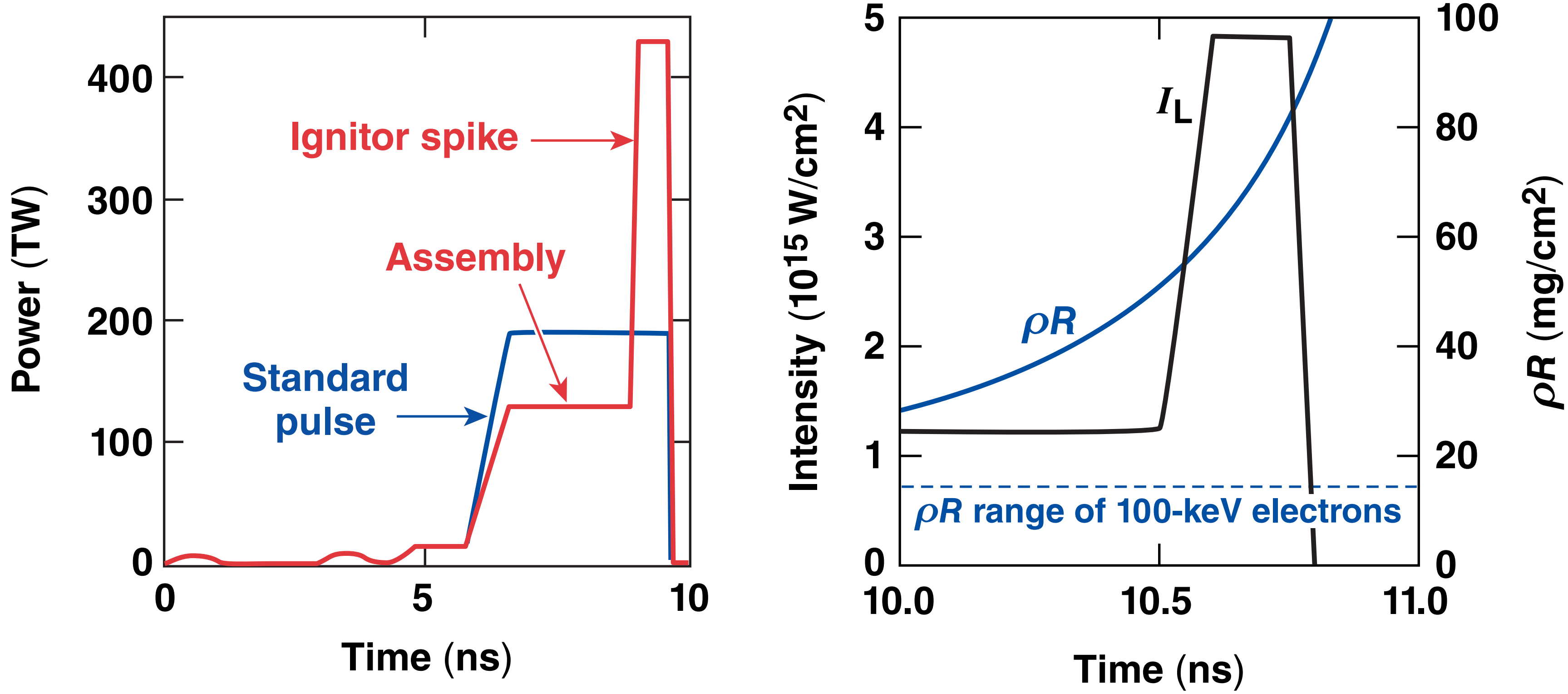
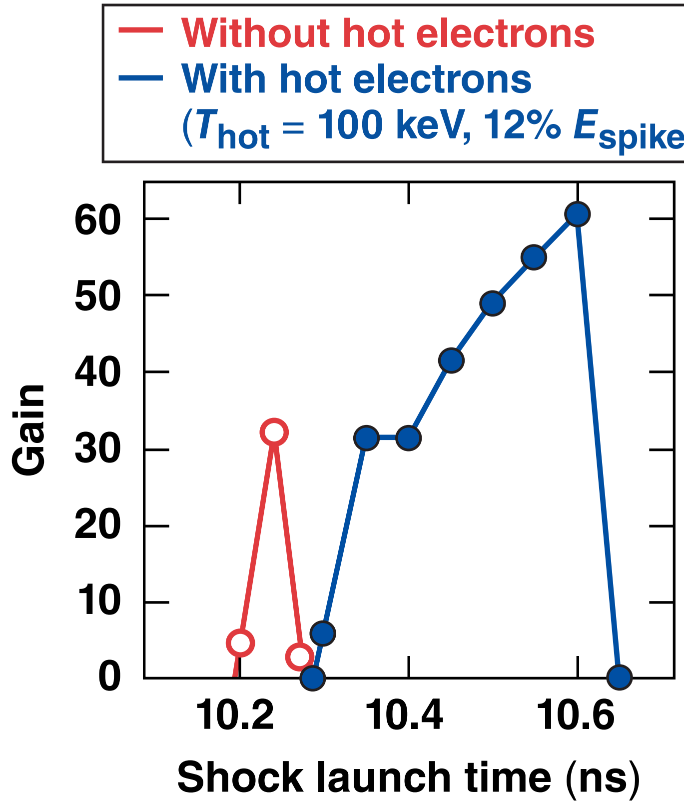
In shock ignition, the spike intensity exceeds the laser–plasma instability (LPI) threshold, producing hot electrons



For low-enough energy, hot electrons are stopped in a narrow outer layer of the imploding shell.

R. Betti *et al*., Phys. Rev. Lett. 98, 155001 (2007);
L. J. Perkins *et al*., Phys. Rev. Lett. 103, 045004 (2009);
X. Ribeyre *et al*., Plasma Phys. Control. Fusion 51, 1 (2009);
M. Lafon *et al*., Phys. Plasmas 17, 052704 (2010);
A. J. Schmitt *et al*., Phys. Plasmas 17, 042701 (2010).

Hot electrons produced during the spike can improve the implosion performance



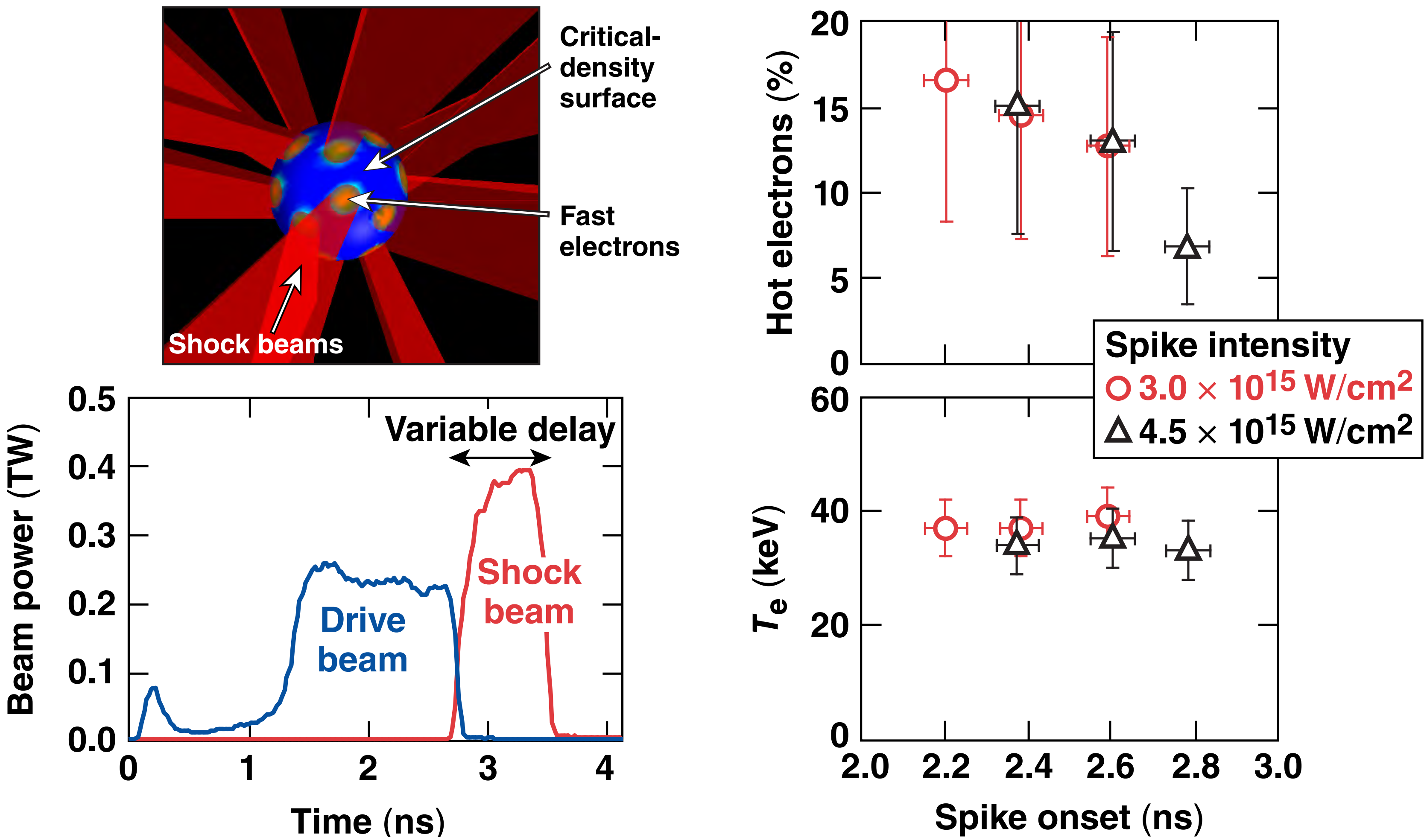
$$P_{hot} \approx 175\left(\eta_{L\rightarrow e}\ I_L^{15}\right)^{1/3}\ \rho_{g/cm^3}^{1/3}\ \text{Mbar}\ ^*$$

$\eta_{L\rightarrow e}$ = conversion efficiency

For moderate T_{hot}, hot electrons increase the ignitor shock pressure and improve the target gains.

R. Betti *et al*., J. Phys., Conf. Ser. 112, 022024 (2008);
A. R. Piriz *et al*., Phys. Plasmas 19, 122705 (2012).
*S. Gus'kov *et al*., Phys. Rev. Lett. 109, 255004 (2012);
X. Ribeyre *et al*., Phys. Plasmas 20, 062705 (2013).

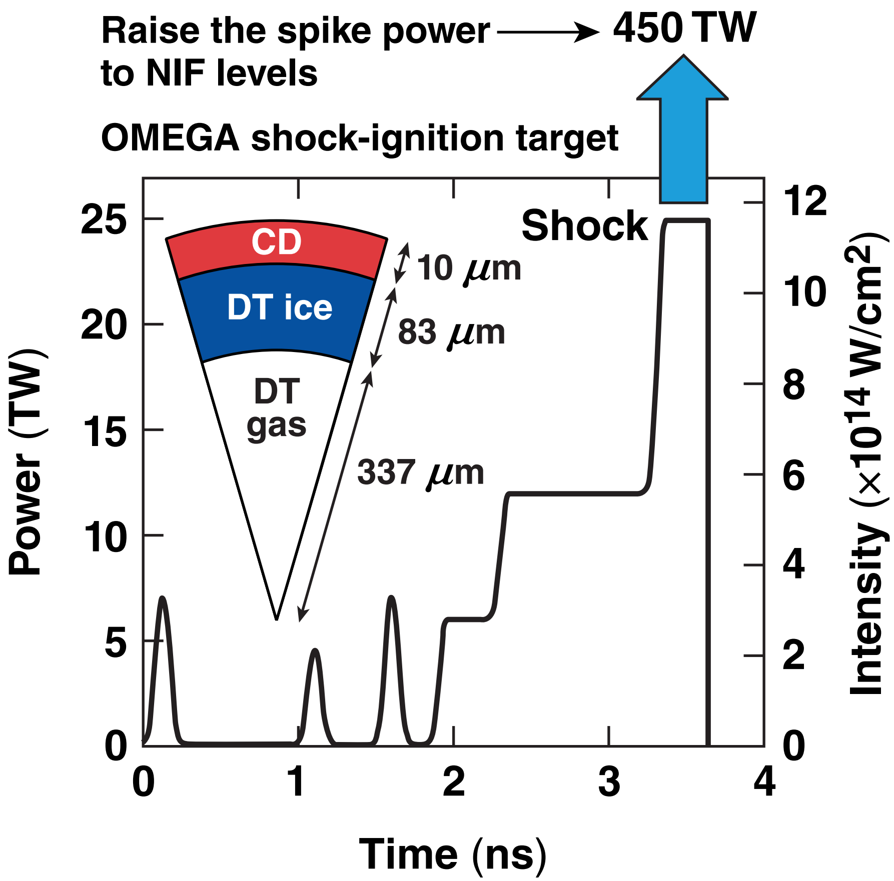
Up to 16% of the shock-beam energy was converted into hot electrons in OMEGA 40 + 20 experiments

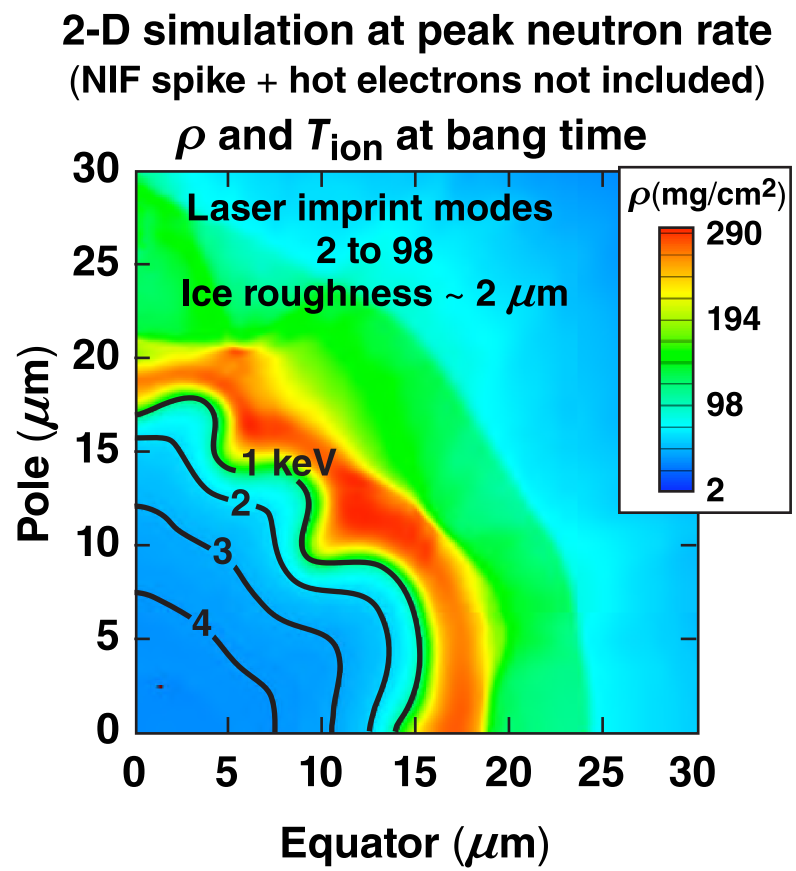


W. Theobald *et al.*, Phys. Plasmas 19, 102706 (2012).

TC11035

Electron shock ignition is applied to OMEGA targets by adding a power spike with National Ignition Facility (NIF) power levels





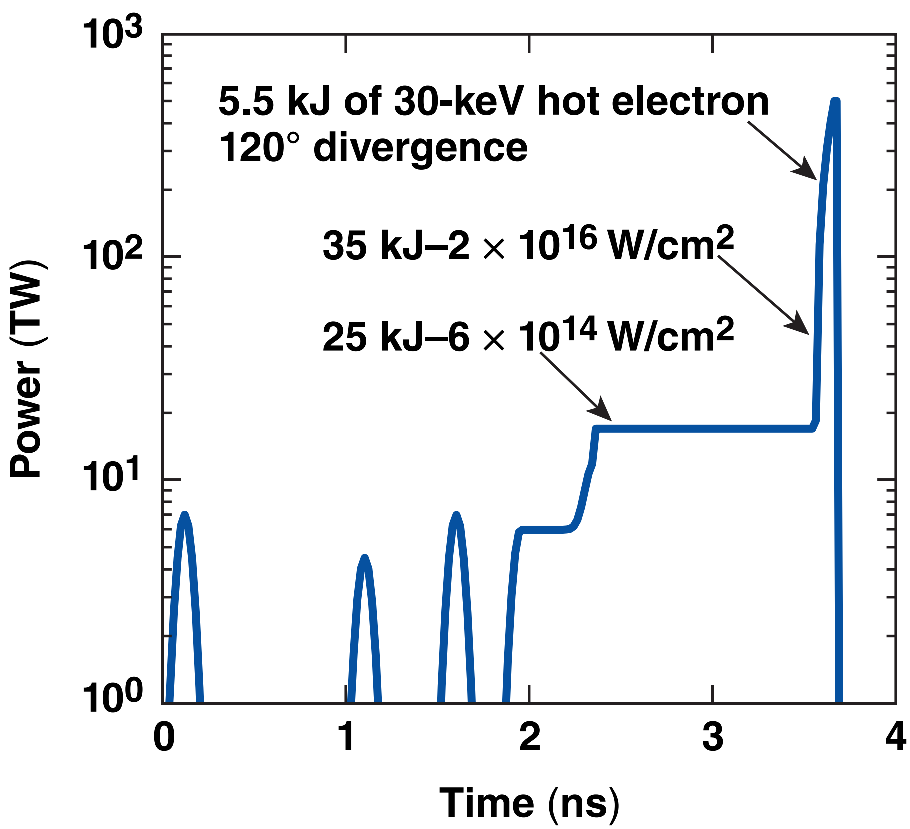
R. Nora *et al.*, Bull. Am. Phys. Soc. 56, 327 (2011).

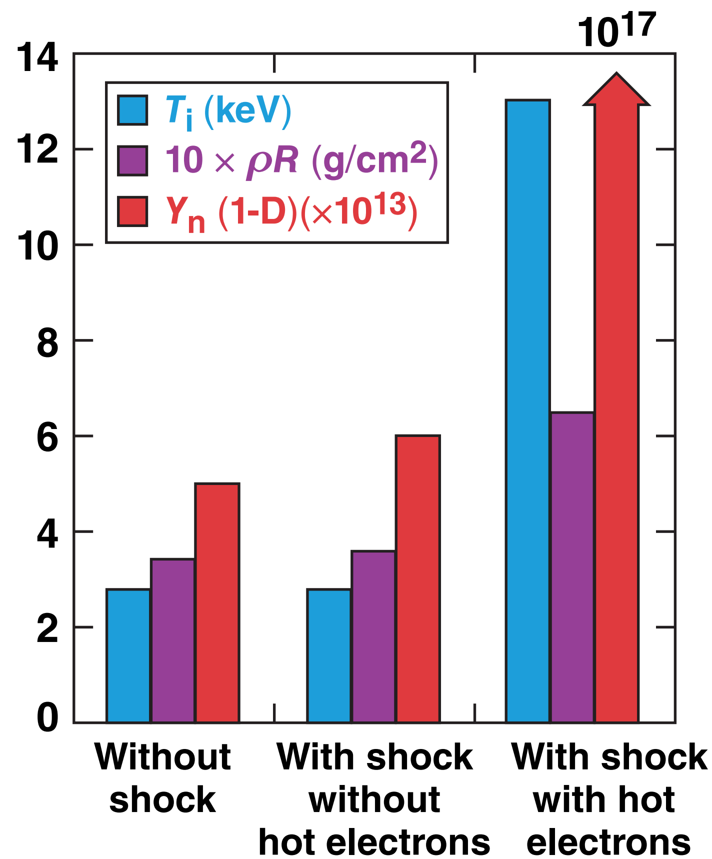
TC11036

UNIVERSITY of ROCHESTER

The hot-electron–driven shock ignites the OMEGA target with a 1-D gain of 5.7

Target specifications: IFAR* = 15, V_i = 270 km/s, $\langle \alpha \rangle$ = 3, E_L = 60 kJ





*In-flight aspect ratio

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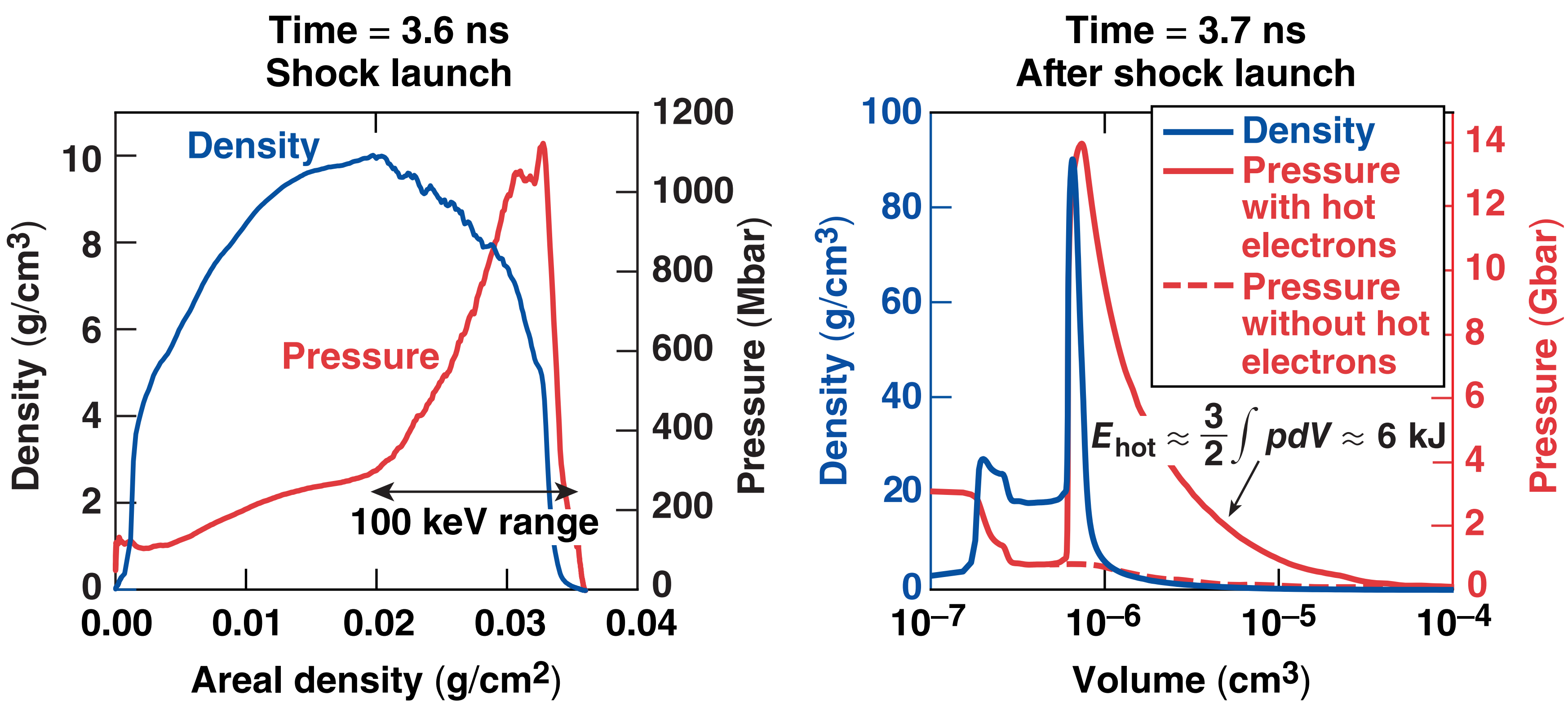
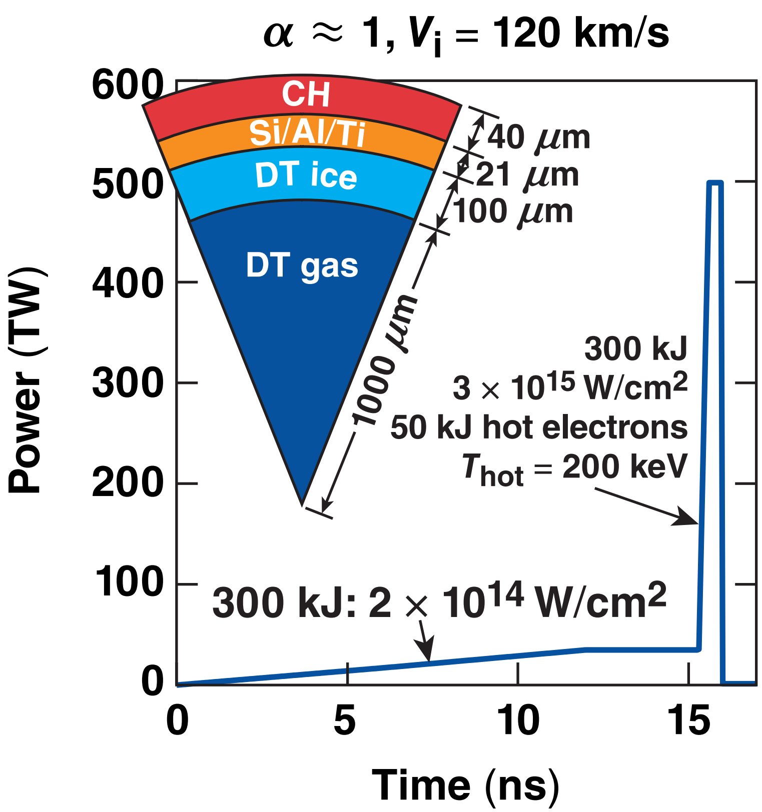
The ~6 kJ of hot-electron energy drives a ~10-Gbar shock that ignites the hot spot with large margins

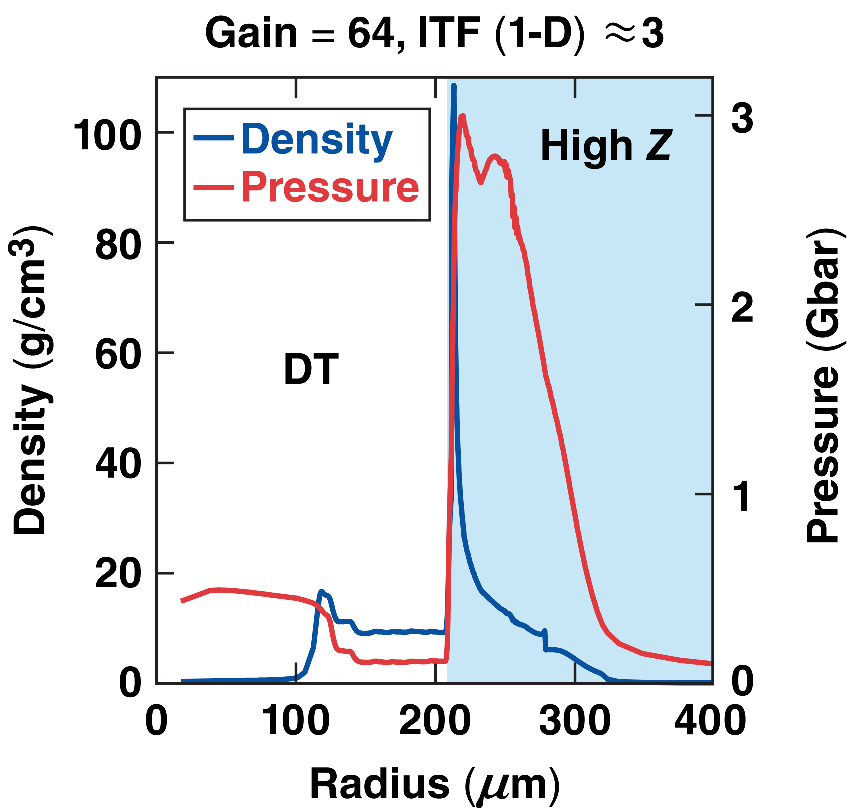


The OMEGA-sized target ignites with an ignition threshold factor (ITF) (1-D) ≈ 3

TC11009

For high hot-electron temperatures (~200 keV), ignition targets require high-Z layers to stop the hot electrons





TC11038

Summary/Conclusions

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