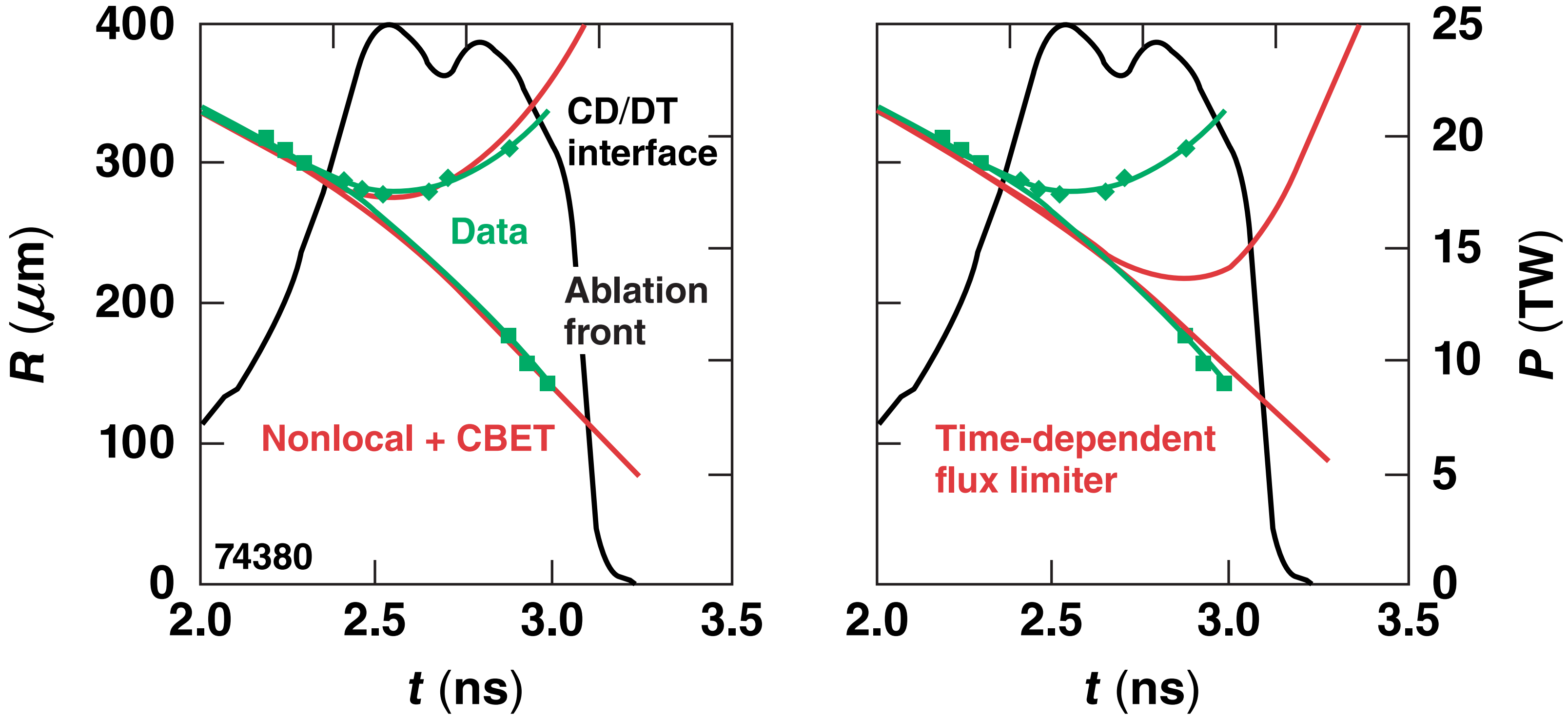
Constraining the Hydrodynamic Efficiency in Direct-Drive Cryogenic Implosions



D. T. Michel
University of Rochester
Laboratory for Laser Energetics

56th Annual Meeting of the
American Physical Society
Division of Plasma Physics
New Orleans, LA
27–31 October 2014

Summary

Nonlocal (NL) electron transport is required in 1-D *LILAC* simulations to reproduce the measured hydrodynamic coupling

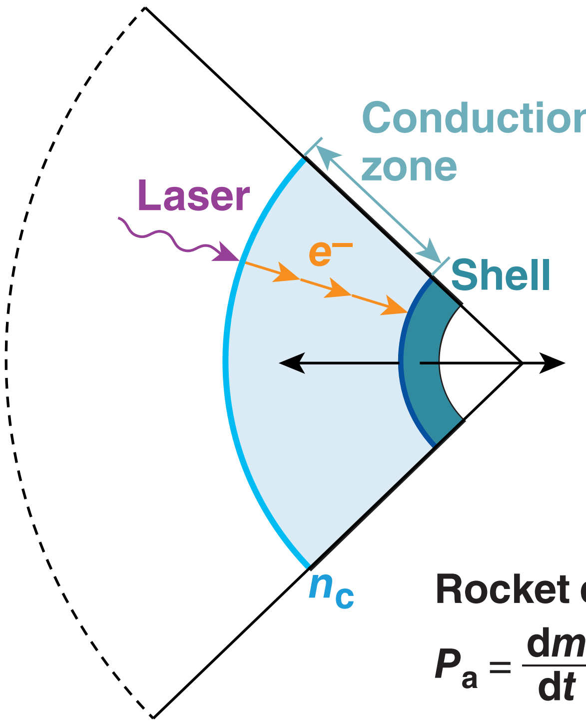
- The self-emission x-ray imaging measures the hydrodynamic coupling (implosion velocity and mass ablation rate)
- The mass ablation rate is underestimated when using a time-dependent flux limiter adapted to match the experimental shell trajectory
- *LILAC* with NL and CBET accurately models the hydrodynamic coupling, reproducing both the transfer of the laser energy to the plasma (absorption) and of the plasma energy to the kinetic energy of the shell

Collaborators

**T. C. Sangster, V. N. Goncharov, A. Davis, I. V. Igumenshchev,
R. Epstein, V. Yu. Glebov, S. X. Hu, D. D. Meyerhofer, W. Seka,
A. Shvydky, C. Stoeckl and D. H. Froula**

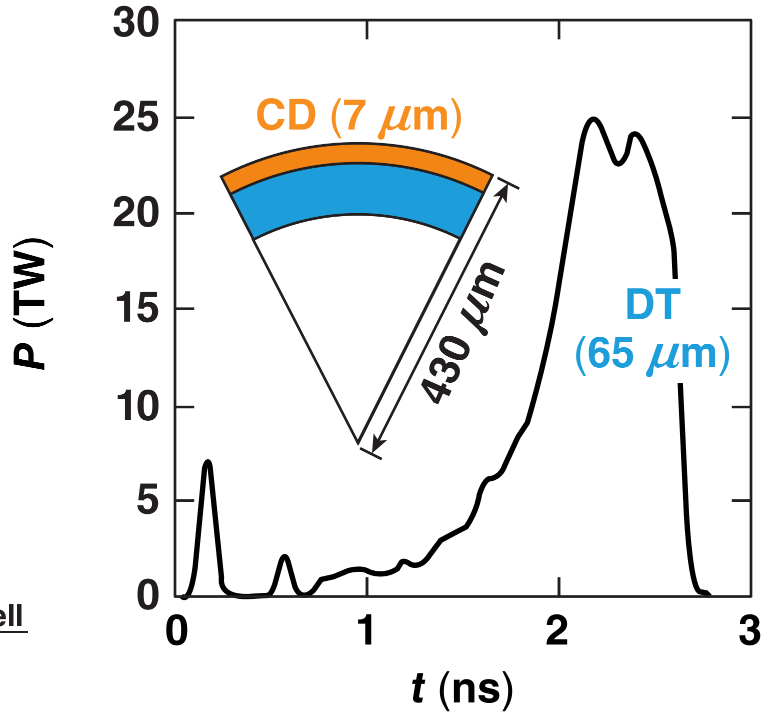
University of Rochester
Laboratory for Laser Energetics

Direct-drive inertial confinement fusion implosions are driven by laser energy absorbed near the critical density and transported by electrons to the ablation surface



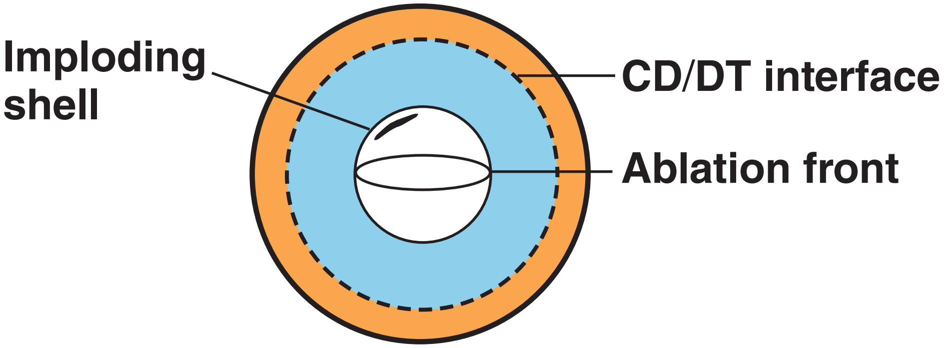
Rocket effect:

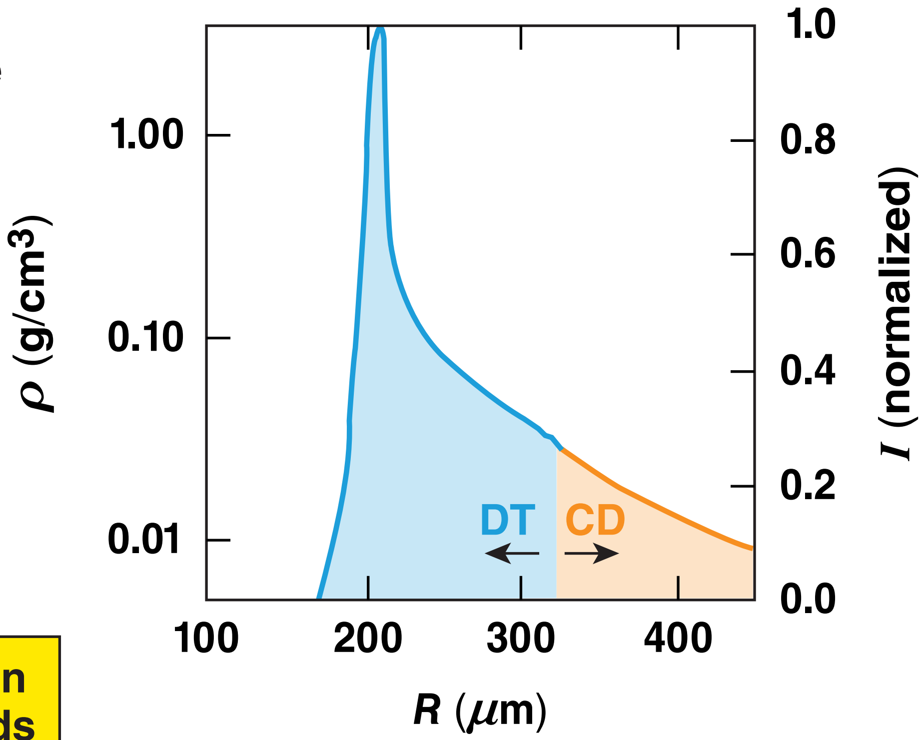
$$P_a = \frac{dm}{dt} V_{ex} = M \frac{dV_{shell}}{dt}$$



Measurements of the trajectory (V_{shell}) and the CD burnthrough $[(dm/dt), M]$ constrain the coupling physics in direct-drive implosions.

Self-emission x-ray imaging provides a tool to study shell velocity and mass ablation rate in cryogenic implosions





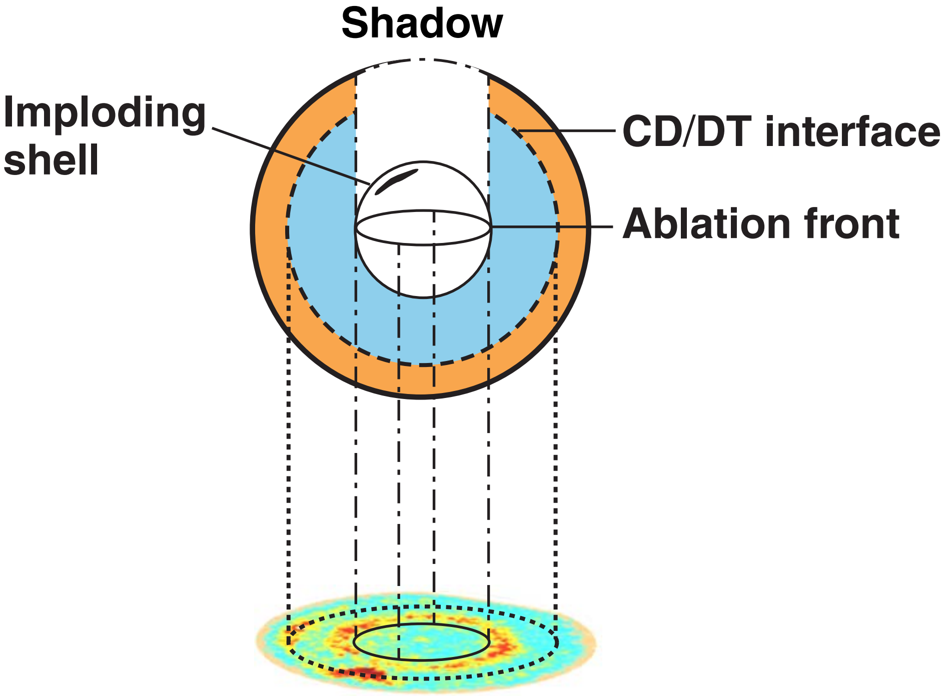
The DT peak corresponds to the ablation front,* whereas the CD peak corresponds to the position of the CD/DT interface in the coronal plasma.

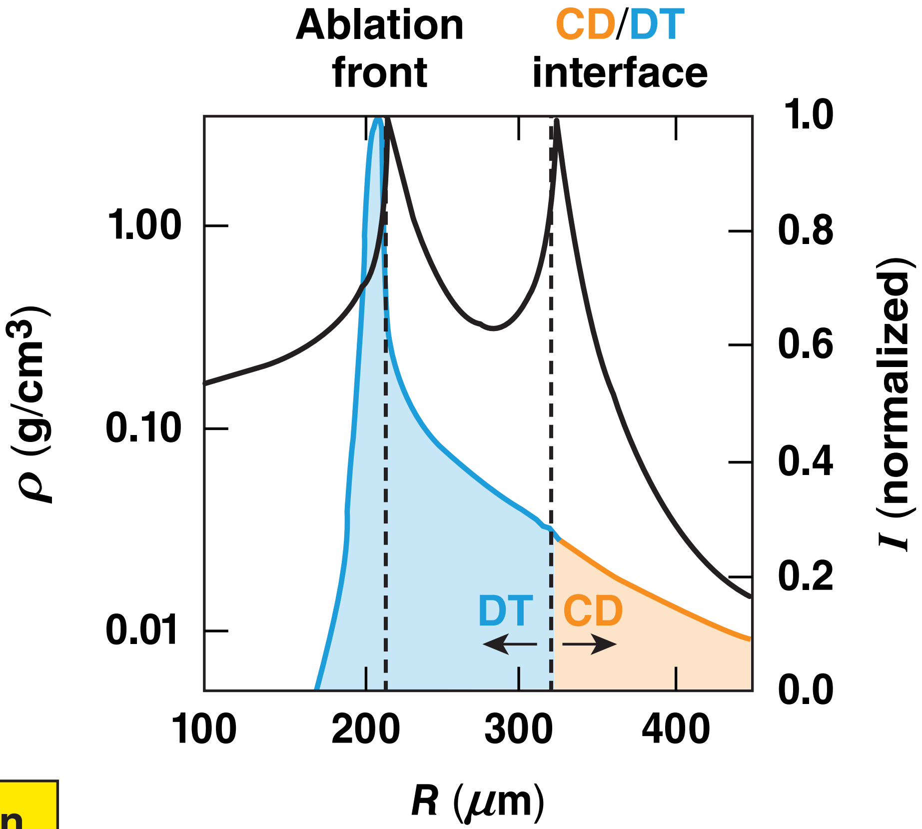
E23547

---

*D. T. Michel *et al.*, Rev. Sci. Instr. 83, 10E530 (2012).

Self-emission x-ray imaging provides a tool to study shell velocity and mass ablation rate in cryogenic implosions





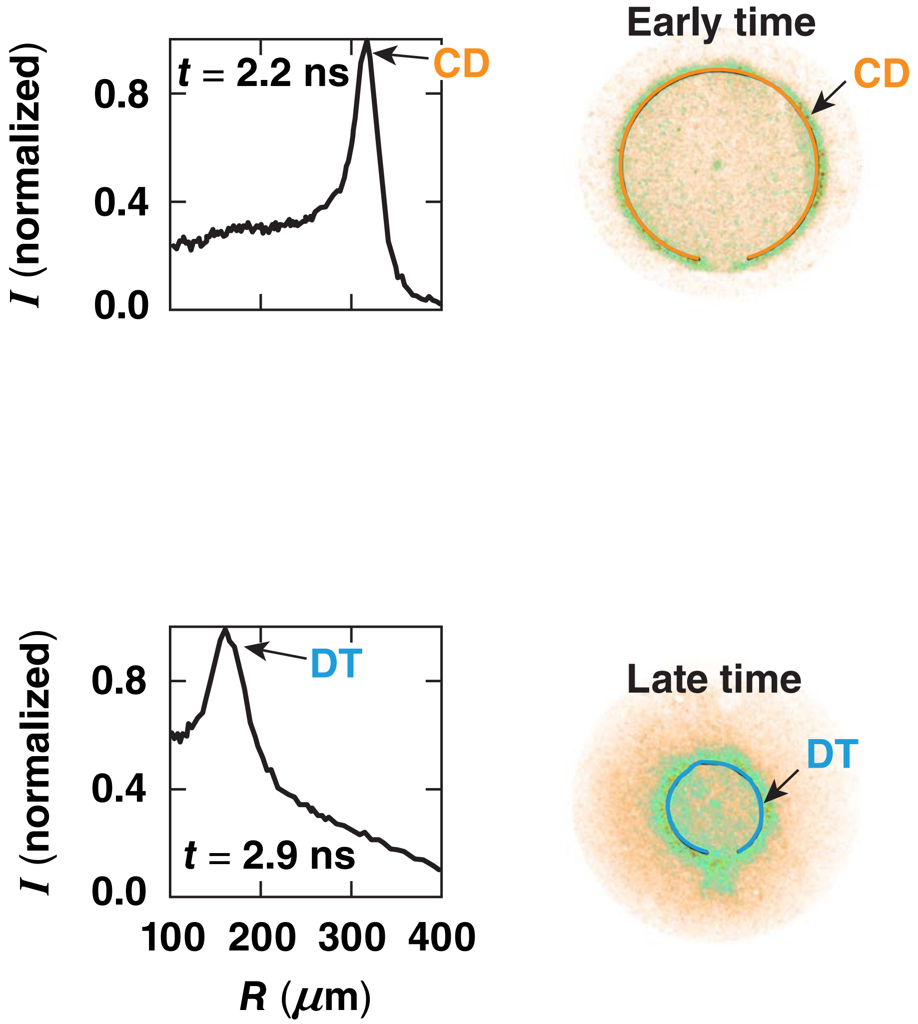
The DT peak corresponds to the ablation front,* whereas the CD peak corresponds to the position of the CD/DT interface in the coronal plasma.

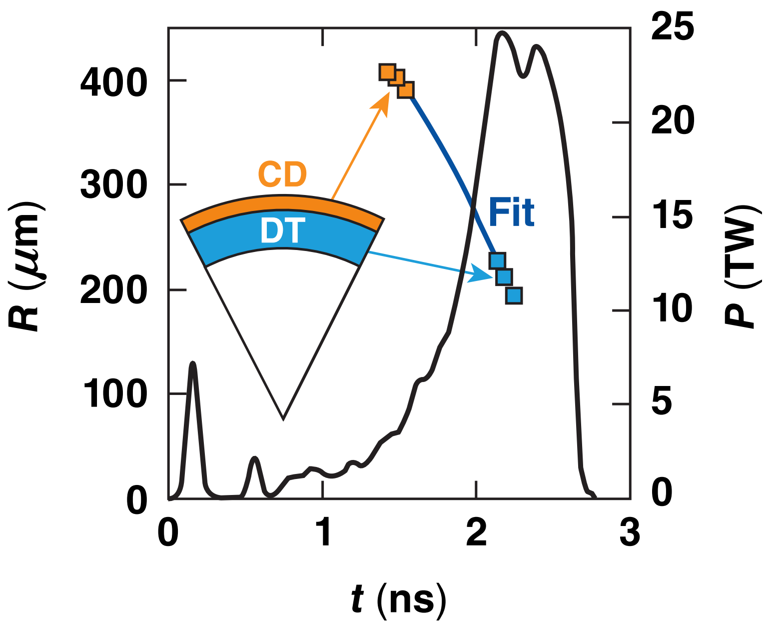
E23547a

---

*D. T. Michel *et al*., Rev. Sci. Instr. 83, 10E530 (2012).

In cryogenic implosions, the shell trajectories are measured from the CD emission (early time) and the DT emission (late time)

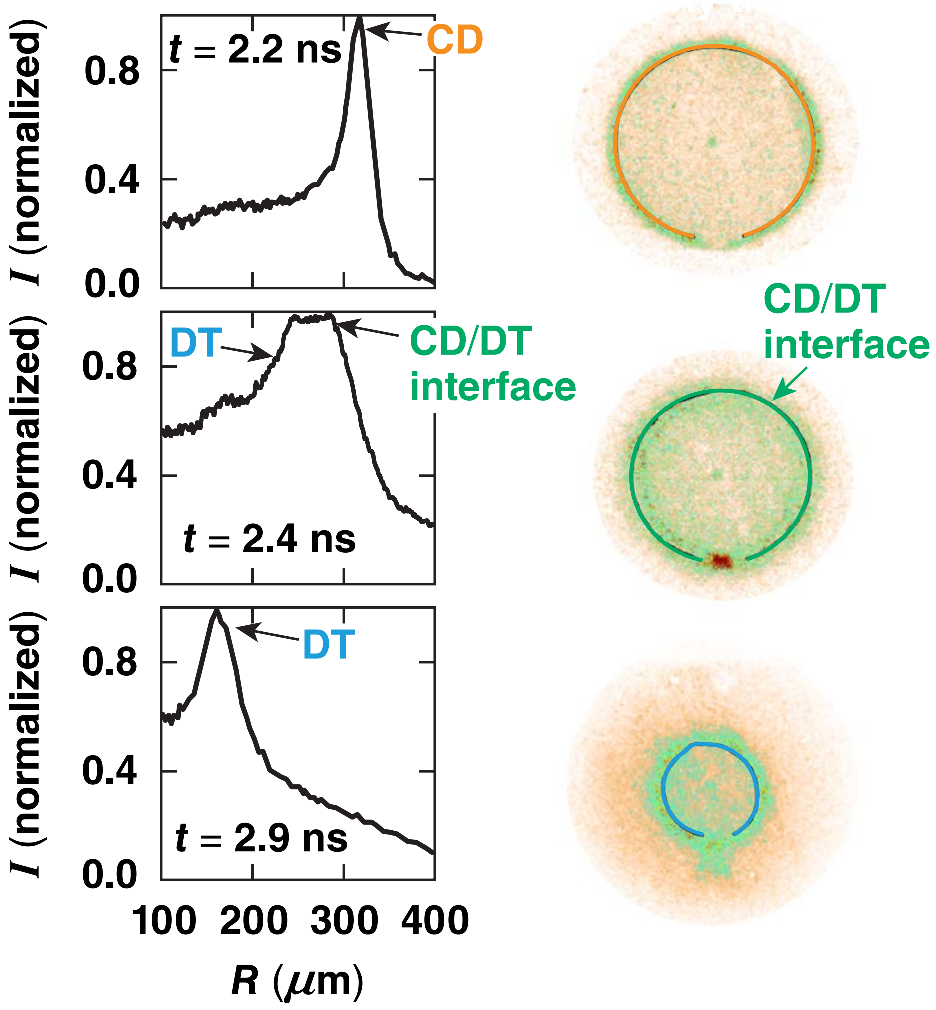


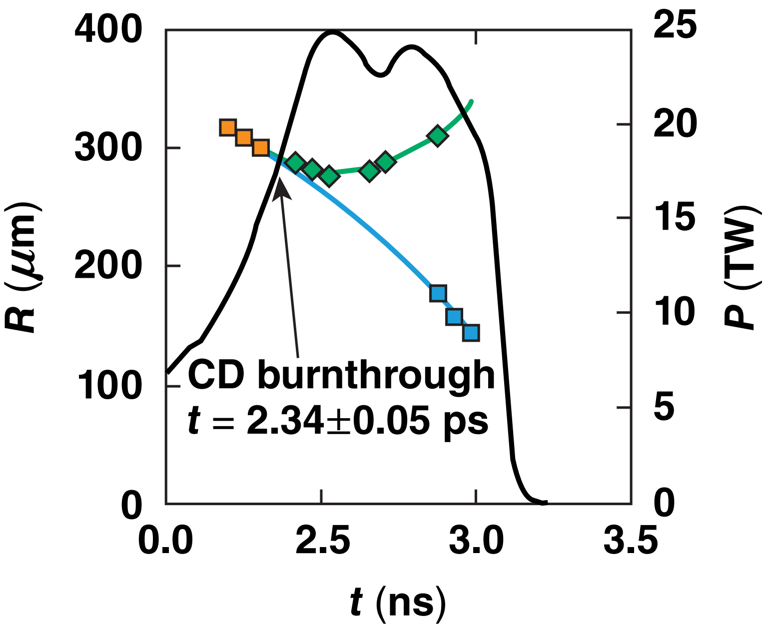


E23045b

Mass Ablation Rate

The simultaneous measurement of the trajectory and the CD/DT interface makes it possible to determine the CD burnthrough time*





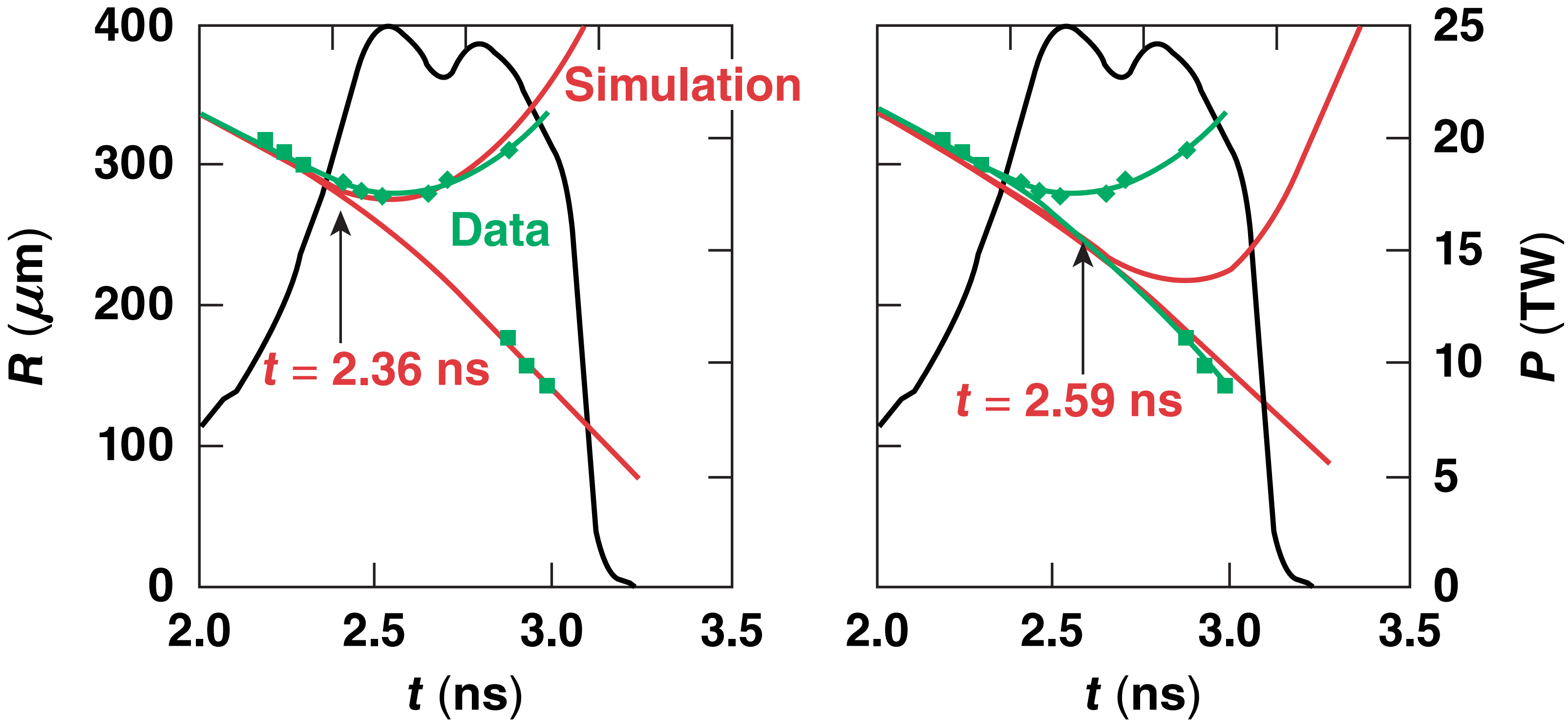
The CD burnthrough corresponds to the time when the CD/DT interface separates from the ablation front.

---

*A. K. Davis *et al.*, Rev. Sci. Instr. 85, 11D616 (2014).

E23045c

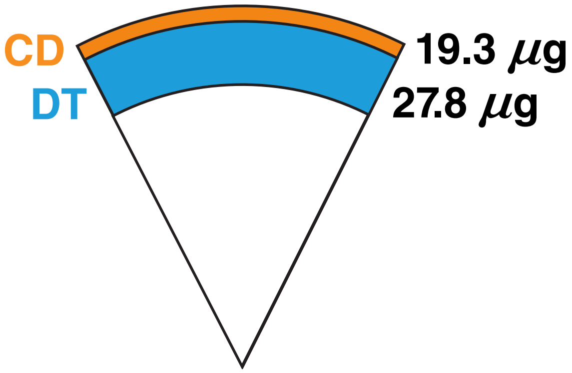
Shell trajectories and CD burnthrough are reproduced by *LILAC* simulations when including CBET and NL

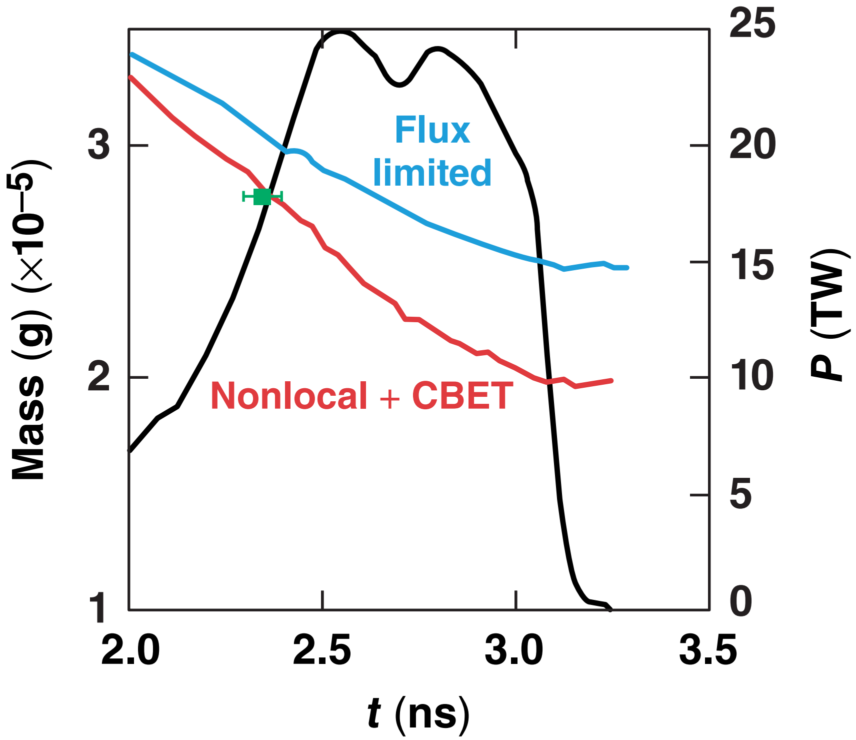


When matching shell trajectory, time-dependent flux-limiter simulations predict a burnthrough time 250 ps later than in the experiment.

E23550

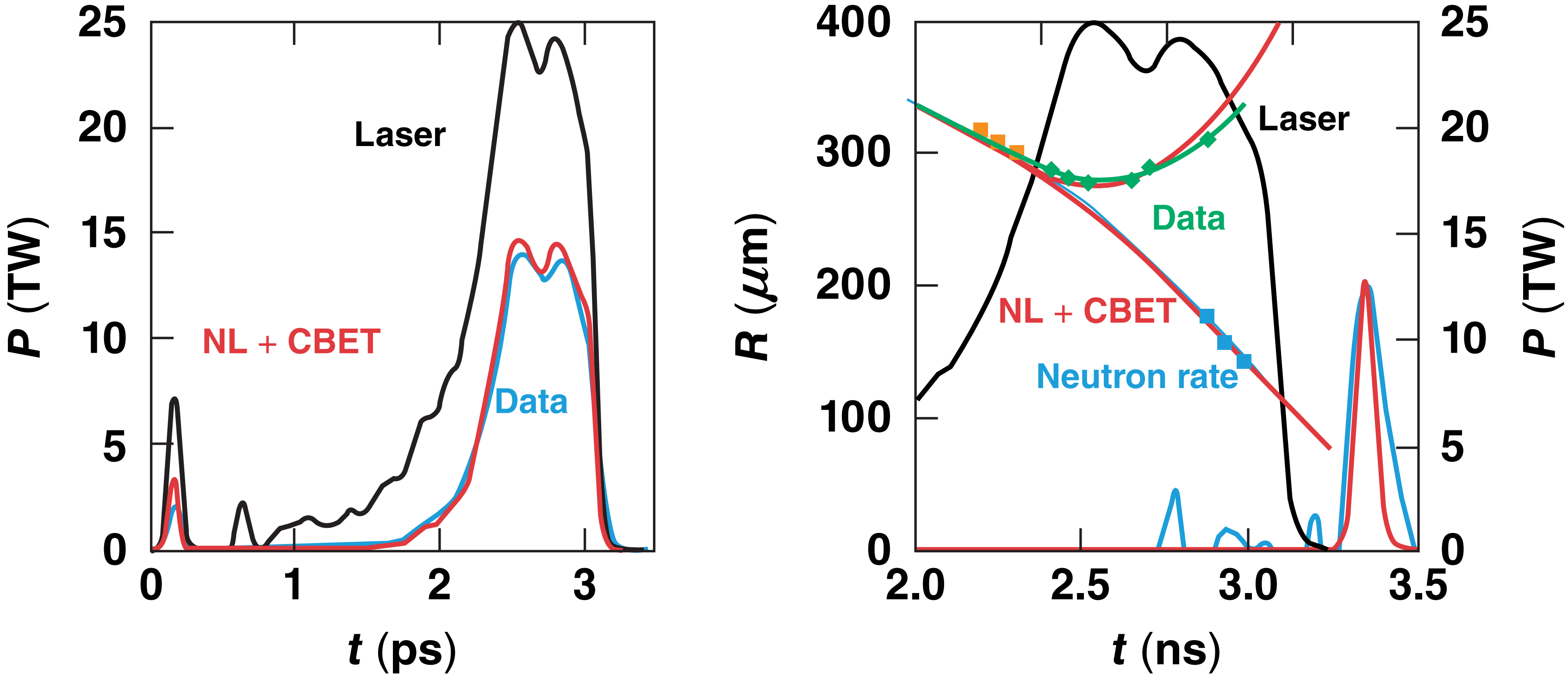
At the burnthrough time, the remaining mass of the shell corresponds to the initial mass of the DT





When matching shell trajectory, time-dependent flux-limiter simulations overestimate the shell mass and the kinetic energy by 26%.

LILAC simulations that include NL and CBET reproduce both the absorption and the kinetic energy of the shell



The code accurately models the hydrodynamic coupling in cryogenic implosions.

Summary/Conclusions

Nonlocal (NL) electron transport is required in 1-D *LILAC* simulations to reproduce the measured hydrodynamic coupling

- The self-emission x-ray imaging measures the hydrodynamic coupling (implosion velocity and mass ablation rate)
- The mass ablation rate is underestimated when using a time-dependent flux limiter adapted to match the experimental shell trajectory
- *LILAC* with NL and CBET accurately models the hydrodynamic coupling, reproducing both the transfer of the laser energy to the plasma (absorption) and of the plasma energy to the kinetic energy of the shell