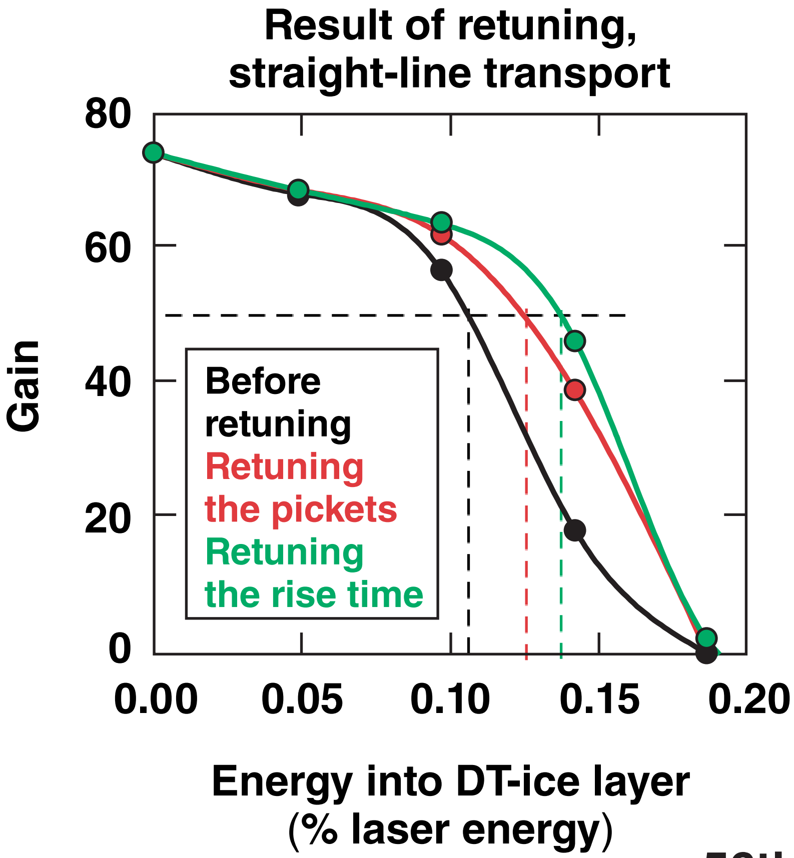
Limits on the Level of Fast-Electron Preheat in Direct-Drive–Ignition Designs



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

Summary

Fast-electron preheat in excess of 0.2% of the laser energy reduces the 1-D gain by 30%

- Optimized high-gain ignition targets are sensitive to preheat
- Fast electrons will increase preheat and reduce gain
- The gain reduction is dependent on the fast-electron-transport model
- Preheat effects from the fast electrons can be slightly reduced by reoptimizing the ignition targets

Collaborators

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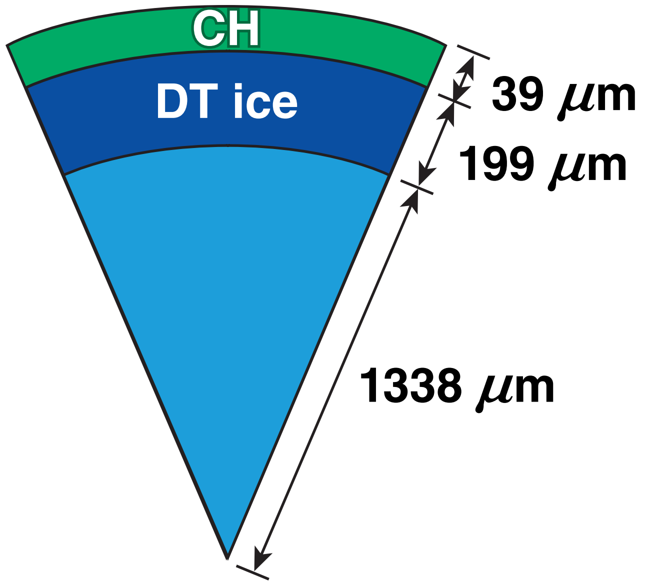
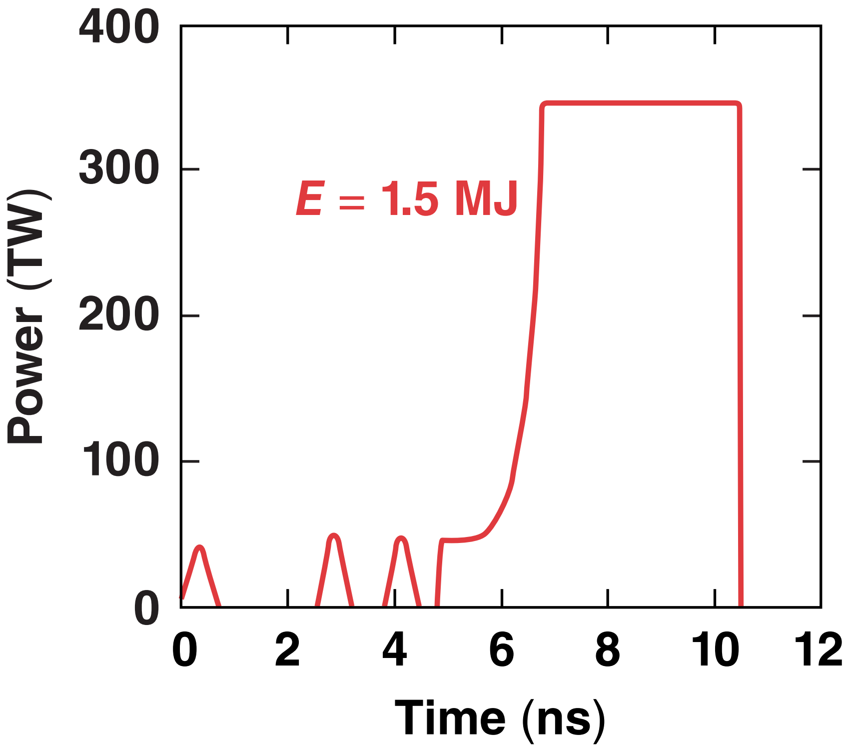
Optimal target implosions* have low preheat, which leads to high energy gains on the National Ignition Facility (NIF) laser



1-D gain = 74



Picket power and timing, and the rise time of the drive portion of the pulse, control the preheat in the DT ice.

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*T. J. B. Collins, J. A. Marozas, and P. W. McKenty, Bull. Am. Phys. Soc. 57, 155 (2012).

The fast electrons in *LILAC* are transported using either a straight-line method or a diffusion model

- The energy distribution of 40- to 50-keV electrons spans the two transport regimes; the two models bracket the uncertainty in the transport model
- In the straight-line model, the electrons are created with a 90° half-angle divergence, directed into the target,* and lose energy according to the stopping power derived by C. K. Li and R. D. Petrasso** and A. A. Solodov†
- In the diffusion model, flux limiting is replaced by a streaming description of the long mean-free-path electrons‡

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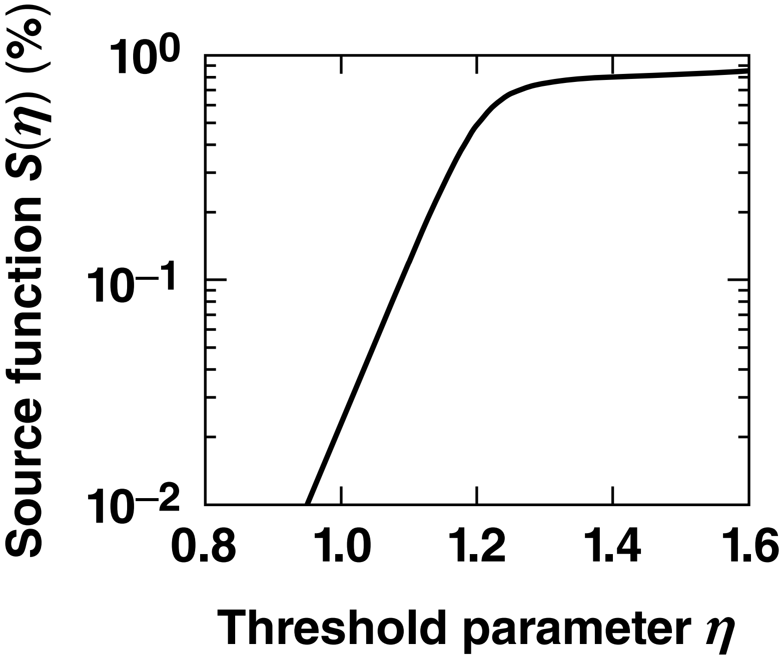
*B. Yaakobi *et al*., Phys. Plasmas 20, 092706 (2013).
**C. K. Li and R. D. Petrasso, Phys. Rev. E 70, 067401 (2004).
†A. A. Solodov and R. Betti, Phys. Plasmas 15, 042707 (2008).
‡J. Delettrez and E. B. Goldman, Laboratory for Laser Energetics, University of Rochester, Rochester, NY, LLE Report No. 36 (1976).

In both models, the fast-electron source tracks the conditions at the quarter-critical surface during the pulse

- The energy source scales as F_{fast} $S(\eta)$, where F_{fast} is a free parameter and $\eta = I_{14} \times L\ (\text{mm}) / [233 \times T(\text{keV})]$ is the threshold parameter*

- The electrons are created at the quarter-critical surface with the temperature $T_h = 8.0 \times I_{14} - 22.0$ (keV), a fit to OMEGA experiments

- Using this source function replicates well the measured temporal hard x-ray emission**



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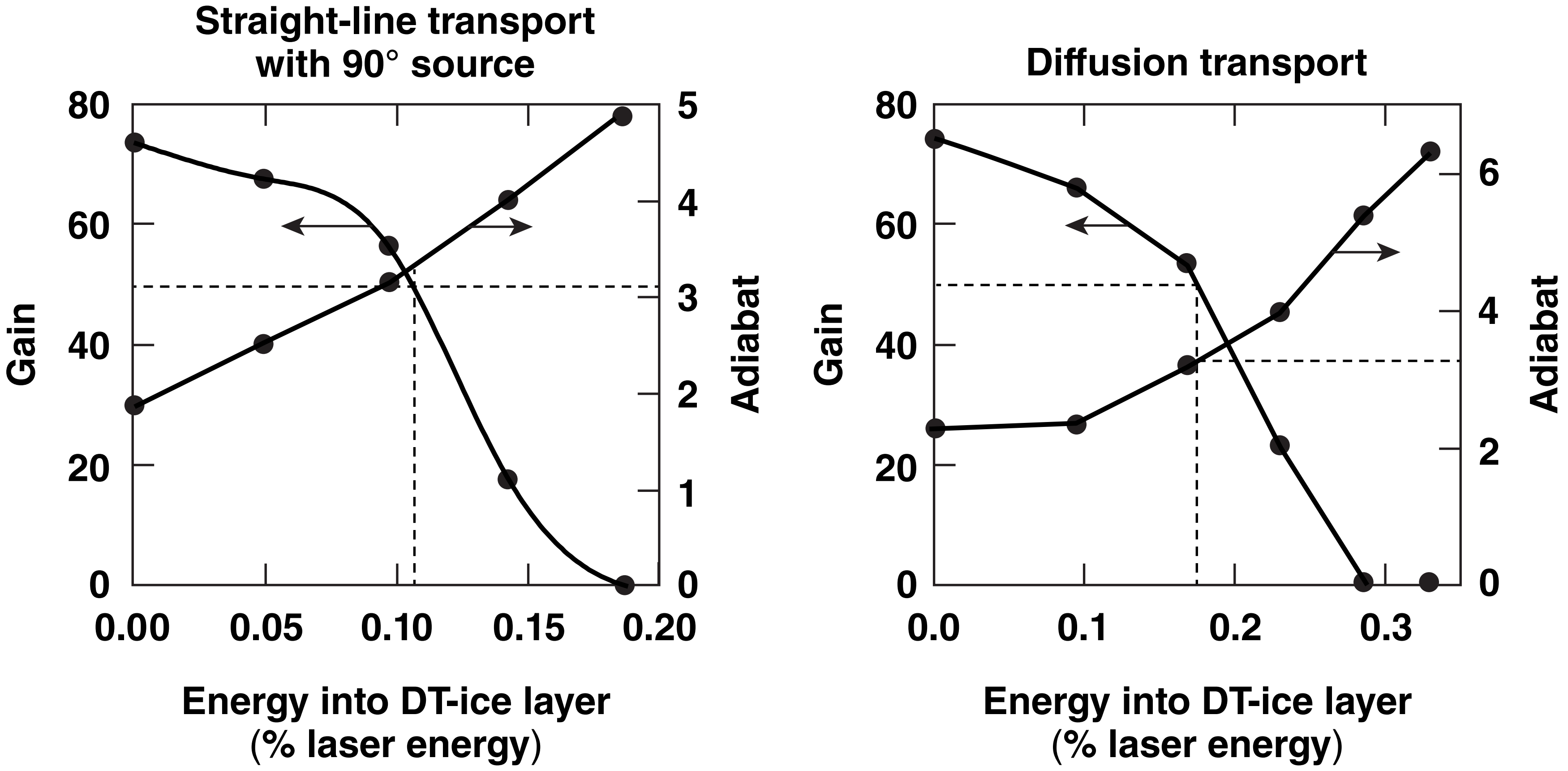
*A. Simon *et al*., Phys. Fluids 26, 3107 (1983).

**J. A. Delettrez *et al*., Bull. Am. Phys. Soc. 53, 248 (2008).

Ice-layer preheat from fast electrons must be kept below 0.1% to 0.18% of the laser energy to maintain 30% of the 1-D gain



- The higher preheat limit in the diffusion model is caused by differences in the spatial energy deposition by the fast electrons

TC11482

The optimizing code *TELIOS** was used to reduce the effects of fast-electron preheat

- *TELIOS* uses the downhill simplex method (Nelder–Mead method) to optimize the gain from *LILAC* runs by varying target and pulse parameters
- Two adjustments were carried out to compensate the preheat from fast electrons by reducing the preheat from shocks
  - picket timing and power
  - rise time of the main pulse
- The drive portion of the pulse is kept constant

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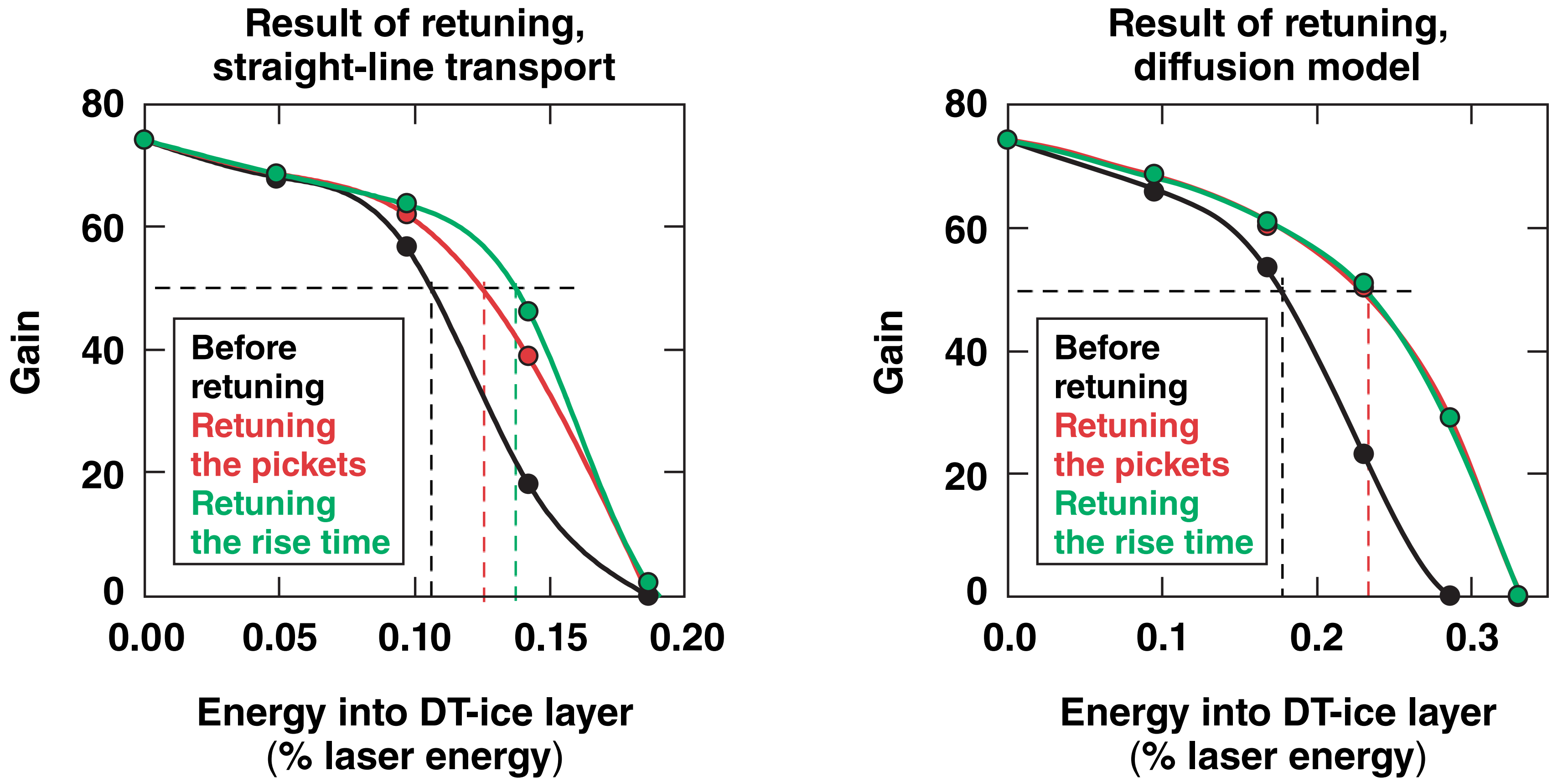
*T. J. B. Collins *et al*., Phys. Plasmas 19, 056308 (2012).

Gain improvements by optimizing the picket power and timing were about 30% for both models



Both retuning methods yield comparable gain improvement, reducing the shock preheat by the same amount.

TC11484

Summary/Conclusions

Fast-electron preheat in excess of 0.2% of the laser energy reduces the 1-D gain by 30%

- Optimized high-gain ignition targets are sensitive to preheat
- Fast electrons will increase preheat and reduce gain
- The gain reduction is dependent on the fast electron transport model
- Preheat effects from the fast electrons can be slightly reduced by reoptimizing the ignition targets
- Fast-electron preheat can also be reduced by using multilayer ablators*

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*M. Lafon *et al*, JO4.00011, this conference;
D. H. Edgell *et al*, PO4.00002, this conference.