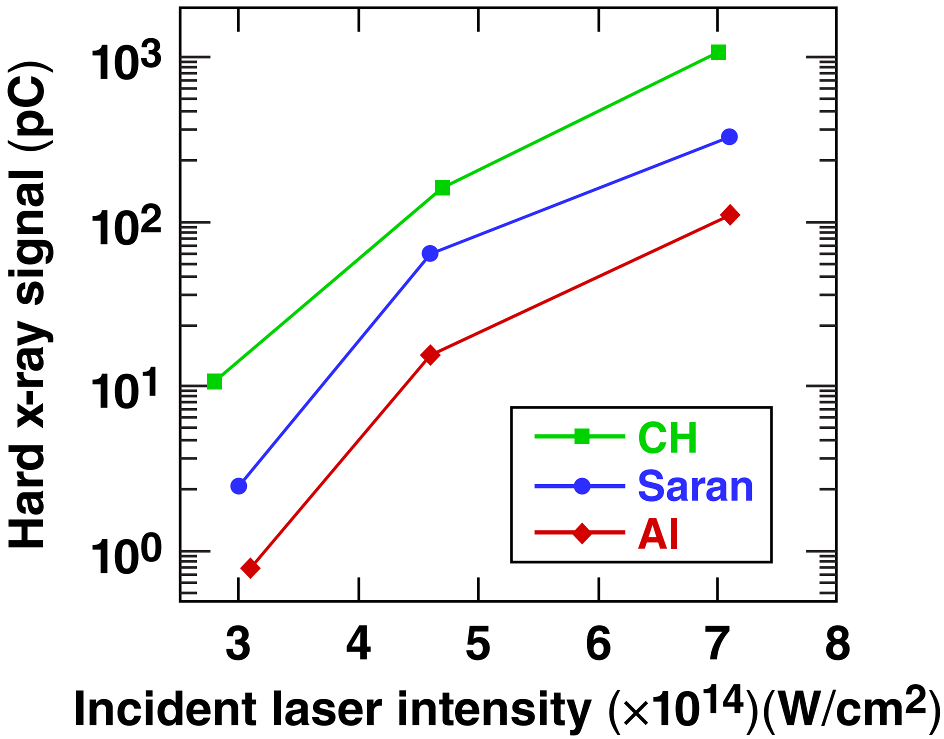
Analyses of Long-Scale-Length Plasma Experiments with Different Ablator Materials on the OMEGA EP Laser System



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Summary

Mitigating the two-plasmon-decay (TPD) instability in long-scale-length plasmas has been investigated with different ablators on OMEGA EP

- OMEGA EP is used to study laser–plasma-interaction (LPI) processes in NIF-scale plasmas
- NIF-scale-length plasmas (L_n ~ 300 to 400 μm) of CH, saran, and aluminum have been created with various beam energies available on OMEGA EP
- Fast-electron generation from TPD instability are reduced by a factor of 3 to 10 for saran and aluminum plasmas, compared to the CH case at the same intensity
- Two-dimensional *DRACO* simulations suggest that saran may be a better ablator for the direct-drive–ignition design since it balances TPD mitigation and hydro-drive efficiency

Collaborators

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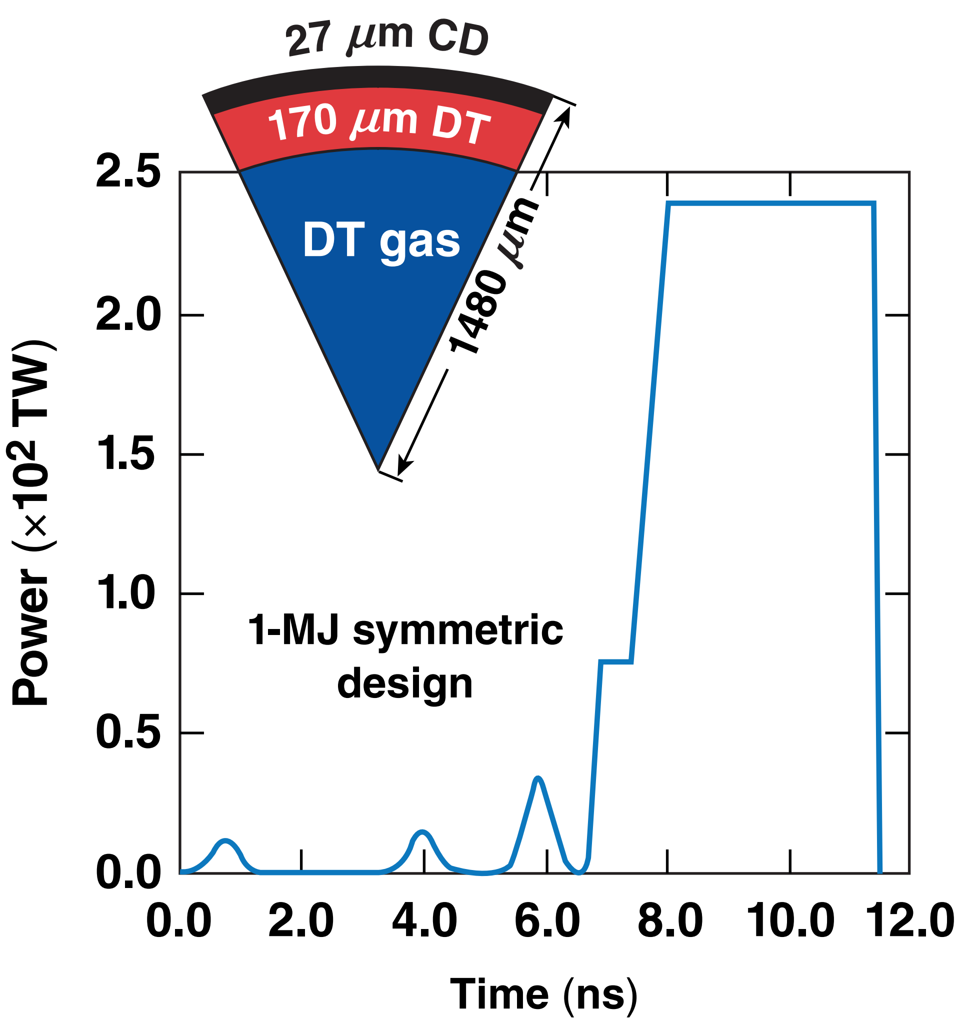
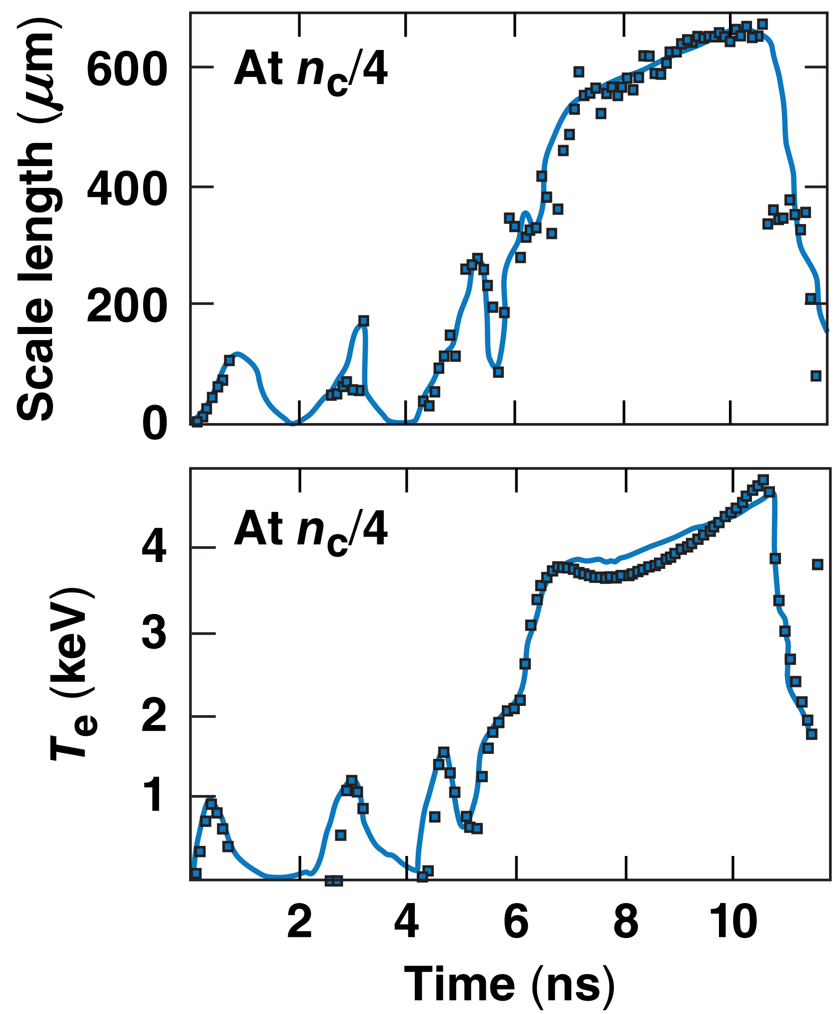
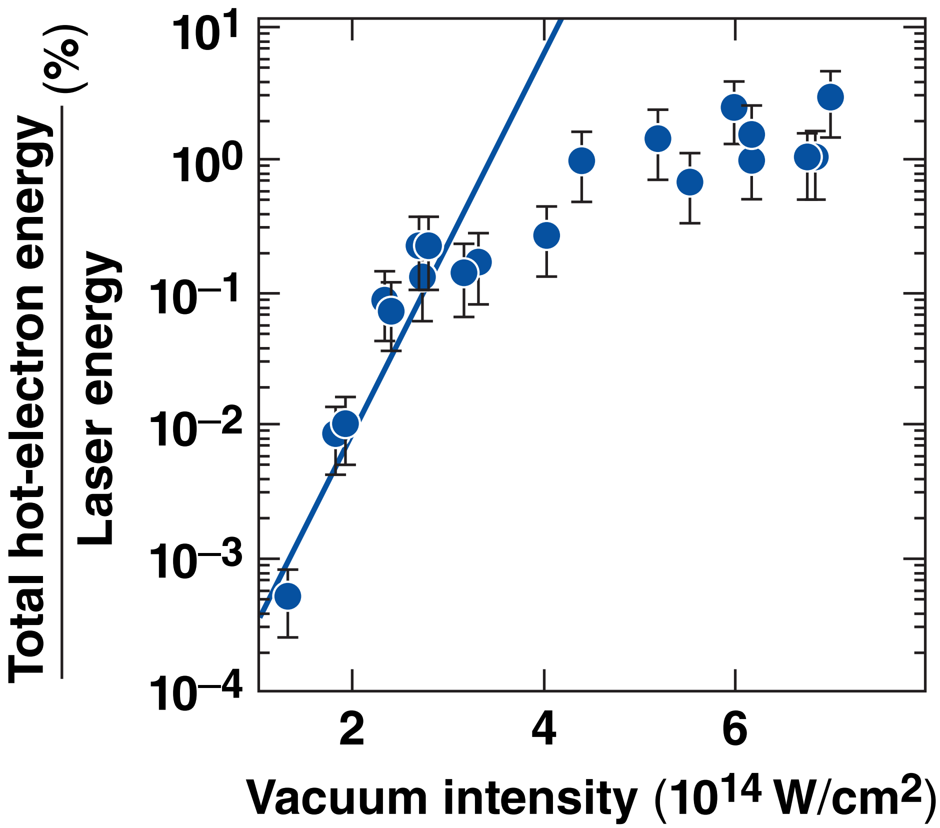
Direct-drive NIF designs require accurate assessments of LPI processes in long-scale-length plasmas





TC9392

Hot electrons from TPD have been measured in long-scale-length (L_n ~ 400 μm) plasma experiments with plastic-CH targets*



*D. H. Froula, B. Yaakobi, S. X. Hu, P.-Y. Chang, R. S. Craxton, D. H. Edgell, R. Follett, D. T. Michel, J. F. Myatt, W. Seka, R. W. Short, A. Solodov, and C. Stoeckl, Phys. Rev. Lett. 108, 165003 (2012).

TC10027

Mitigating the TPD instability is important for reducing the possibility of compression reduction by hot electrons

- The TPD-threshold parameter* is defined as,

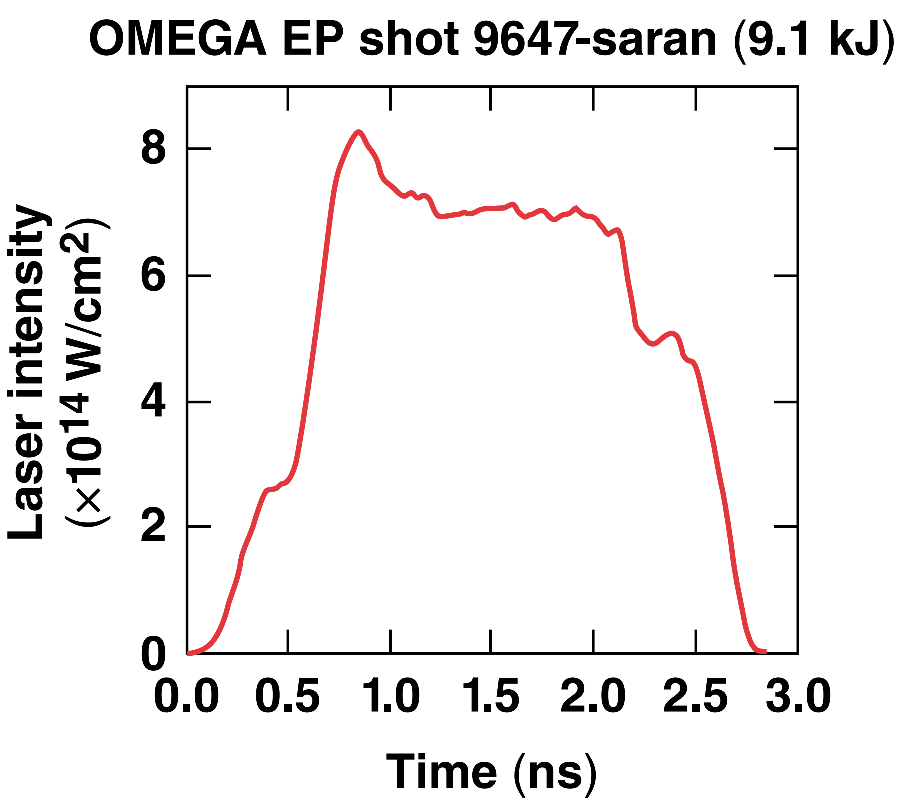
$$\eta = \frac{I_q\,(10^{14}\ \mathrm{W/cm^2}) \times L_n\,(\mu\mathrm{m})}{230 \times T_e\,(\mathrm{keV})}$$

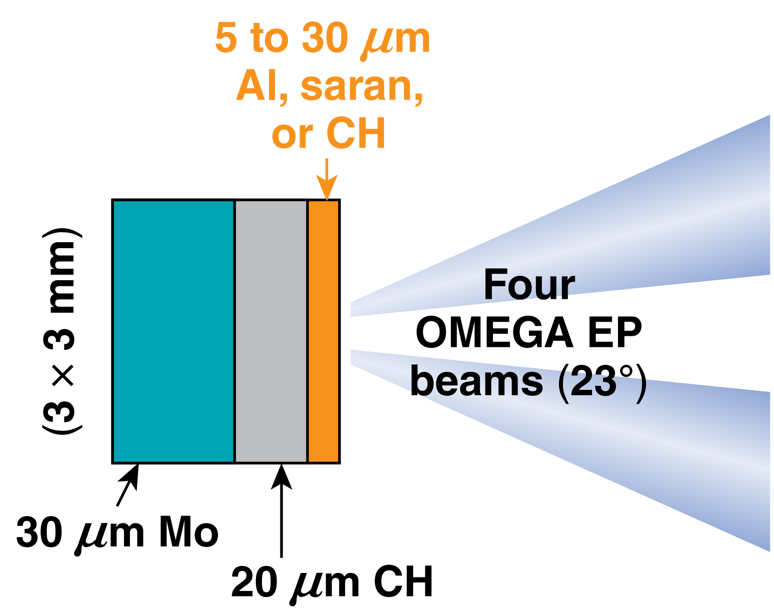
- Long-scale-length plasmas ($L_n > 400\ \mu$m) are inevitable in direct-drive–ignition implosions on the NIF
- The TPD threshold parameter could be decreased by reducing I_q, increasing T_e, and decreasing L_n
- Ablator materials with $\langle Z \rangle$ larger than the typical plastic-CH ($\langle Z \rangle \sim 3$ to 3.5) may have advantages of suppressing TPD-instability as a result of
  - more absorption so that less intensity reaches quarter-critical regime
  - hot-electron temperature at the quarter-critical regime
  - scale-length can be reduced

TC10028

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

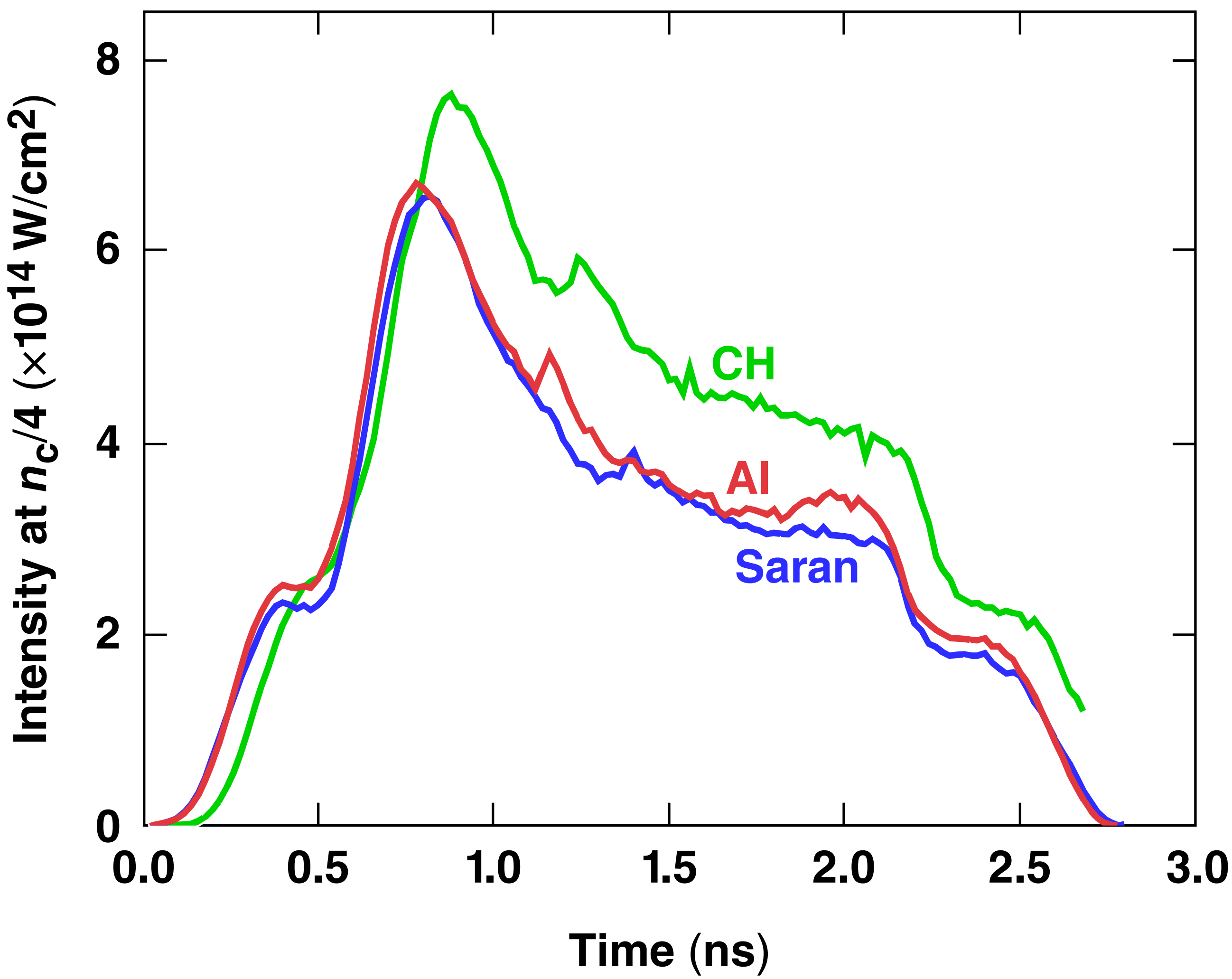
Experiments on OMEGA EP use large (1-mm) DPP's to create long-scale-length plasmas with Mo-CH-ablator "sandwich" targets





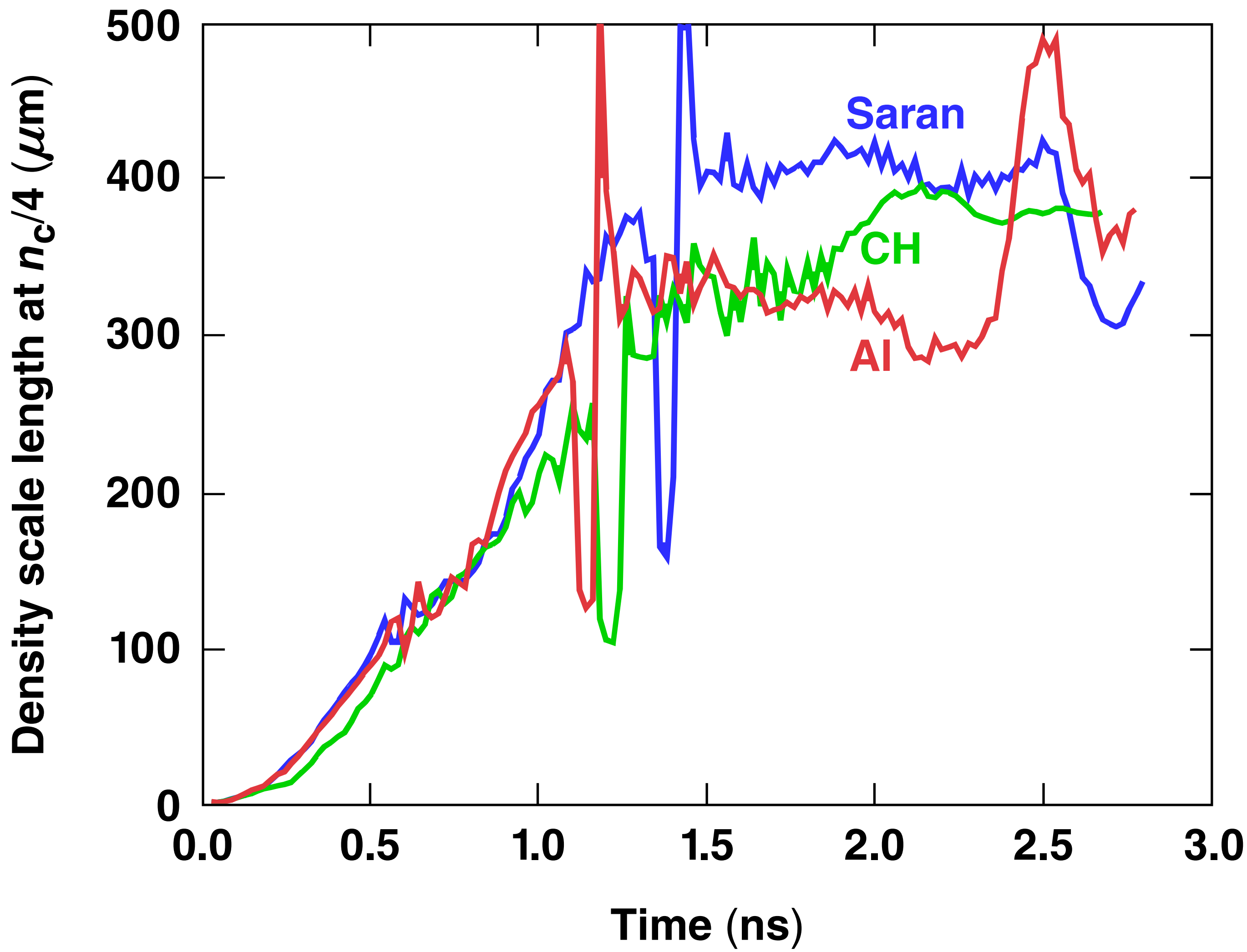
TC10030

DRACO simulations show lower laser intensities at $n_c/4$ for Saran and Al in contrast to CH



TC10029

DRACO simulations show different density-scale-length L_n at $n_c/4$ for Saran and Al in comparison with CH



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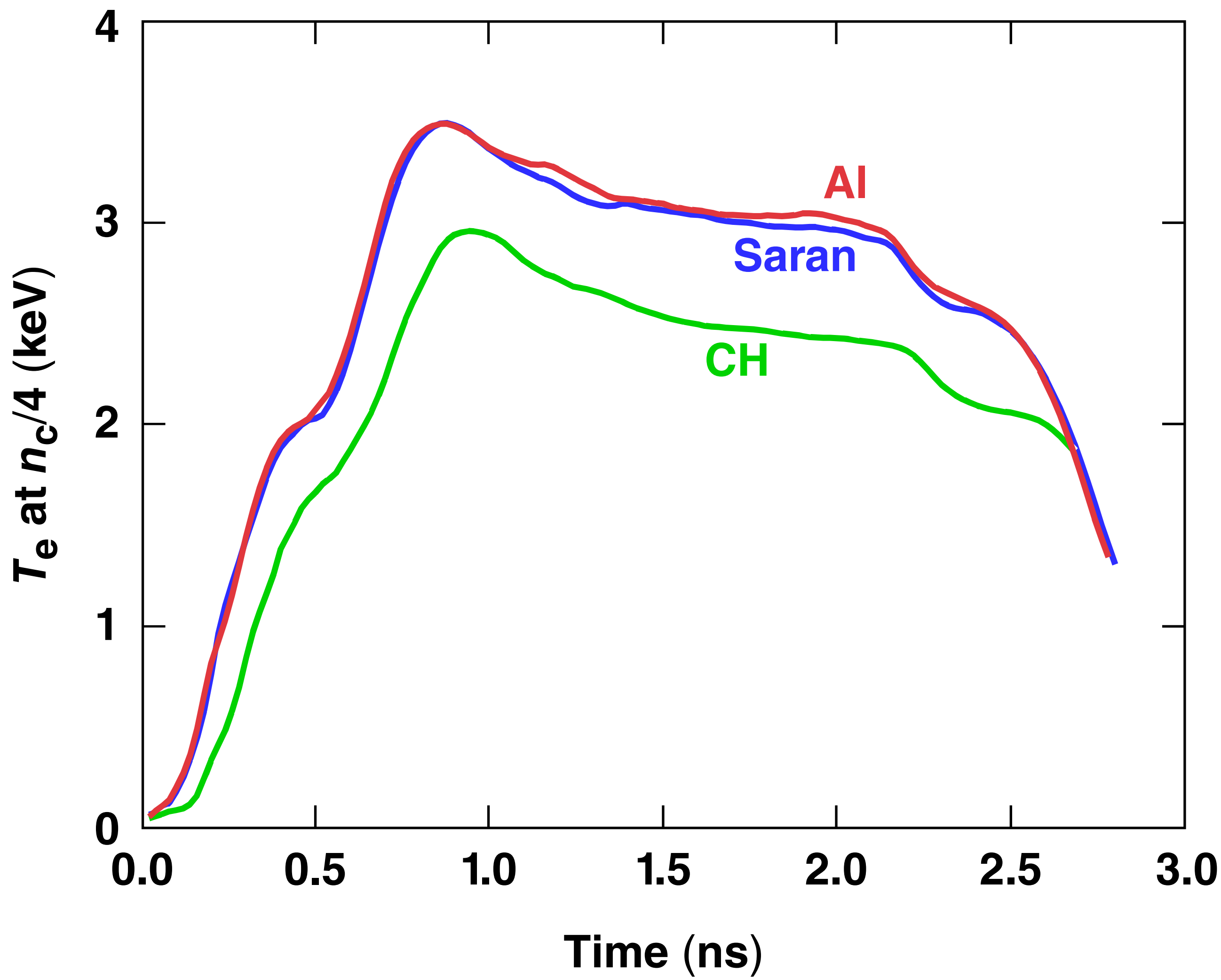
The temperature at $n_c/4$ is higher for Saran and Al when compared to the CH case



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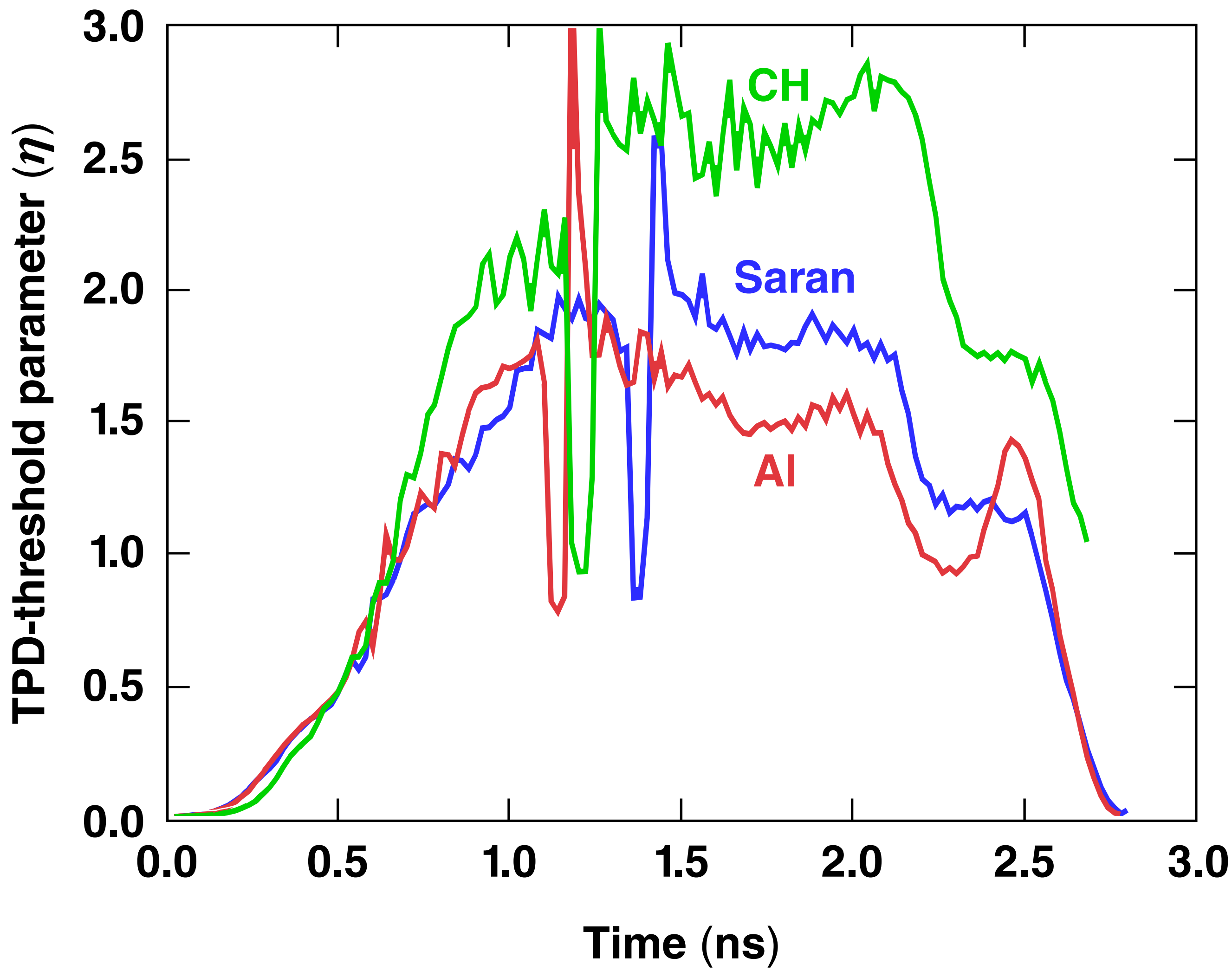
Finally, the TPD-threshold parameters (η) are smaller for saran and Al when compared to the CH case



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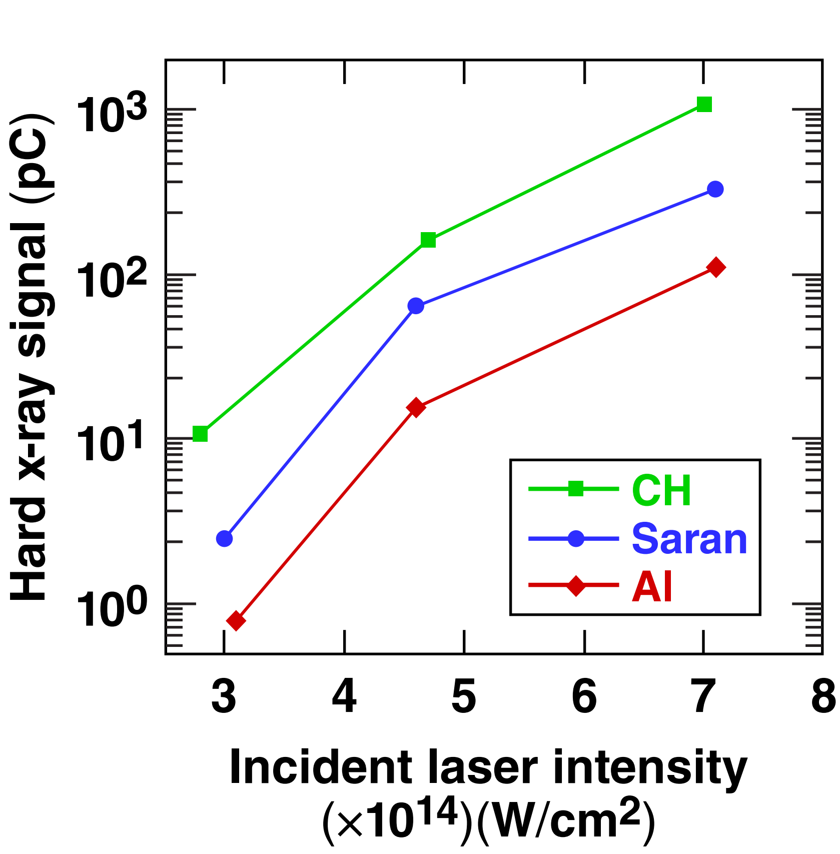
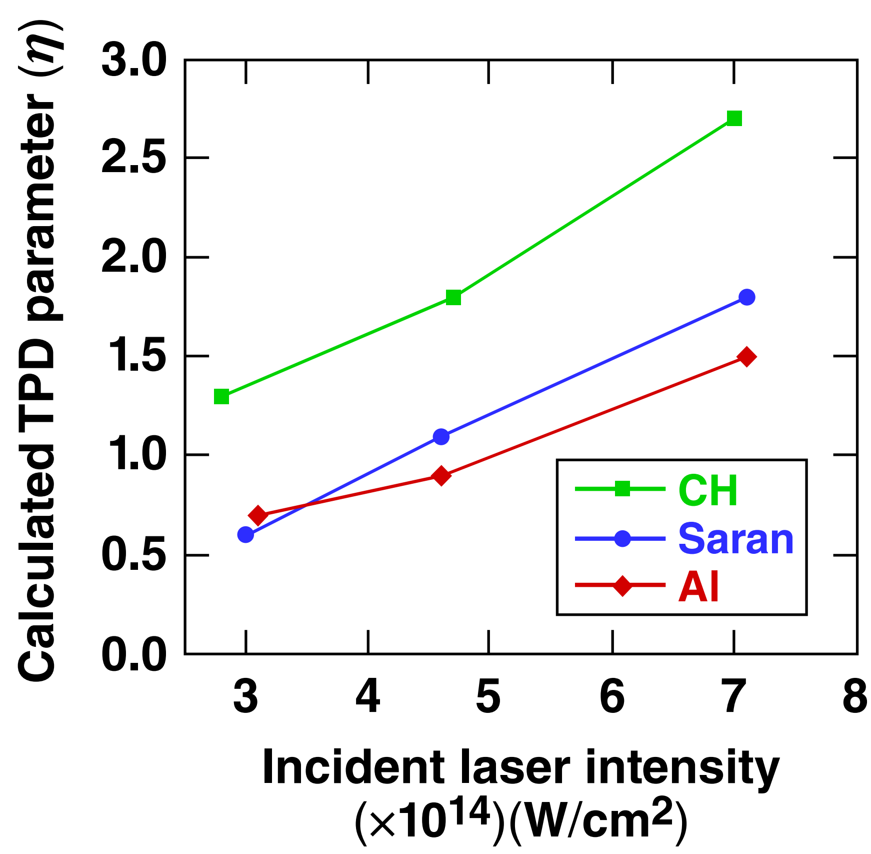
Experimental results have shown a factor of 3 to 10 reduction in TPD-induced hot-electron signals for saran ($\langle Z \rangle = 8$) and aluminum ($Z = 13$) compared to the CH-ablator case





TC10031

The hydro-drive efficiency must be considered when fighting/mitigating TPD instability in long-scale-length plasmas

- Although mid-/high-Z ablators can suppress the hot-electron generation from TPD instability, they may not be efficient for hydro drive because thermal conduction in plasmas is scaled with $1/Z$
- Radiation loss and radiative preheat are among the concerns when high-$\langle Z \rangle$ ablators are considered for direct-drive–ignition designs
- A balance between TPD-instability mitigation and maintaining an acceptable hydro-efficiency must be made

Optimal mid-Z (= 3 to 8) ablators can not only mitigate TPD instability, but also give acceptable hydro-efficiency

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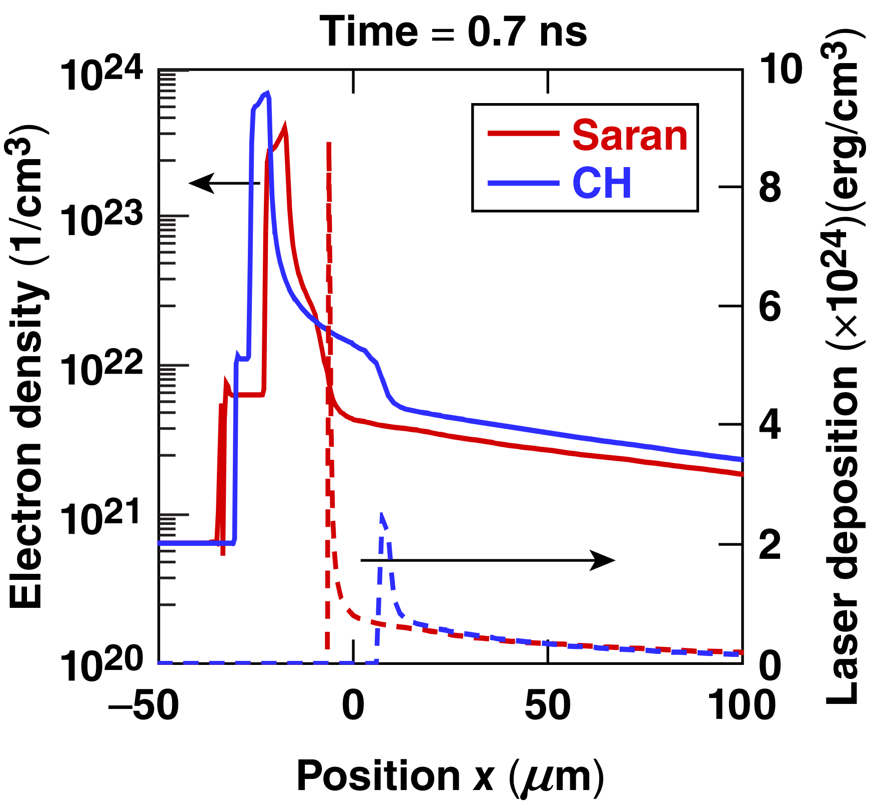
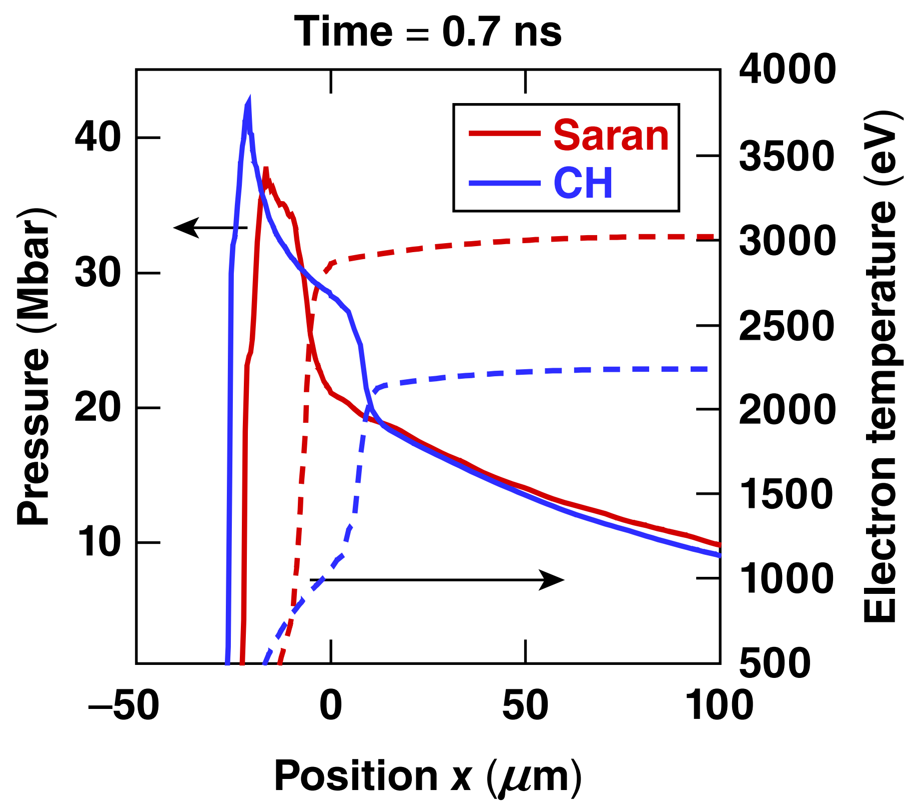
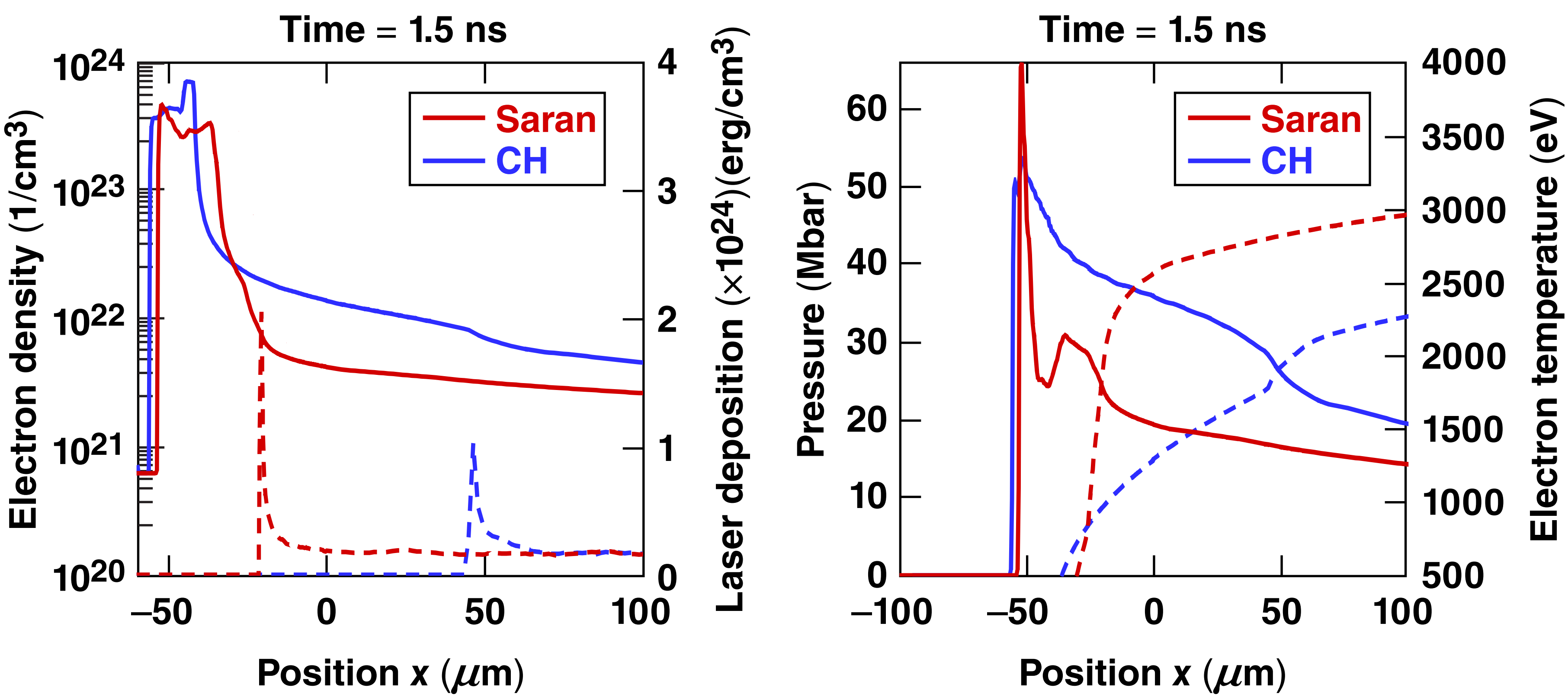




Early time of drive: saran ablator gives only ~10% lower drive pressure.

TC10036

DRACO simulations show that saran may be a better ablator for both mitigating TPD instability and maintaining acceptable hydro-efficiency



The small shock-front position difference (~2 μm) indicates the acceptable drive efficiency of a saran ablator.

TC10037

Summary/Conclusions

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