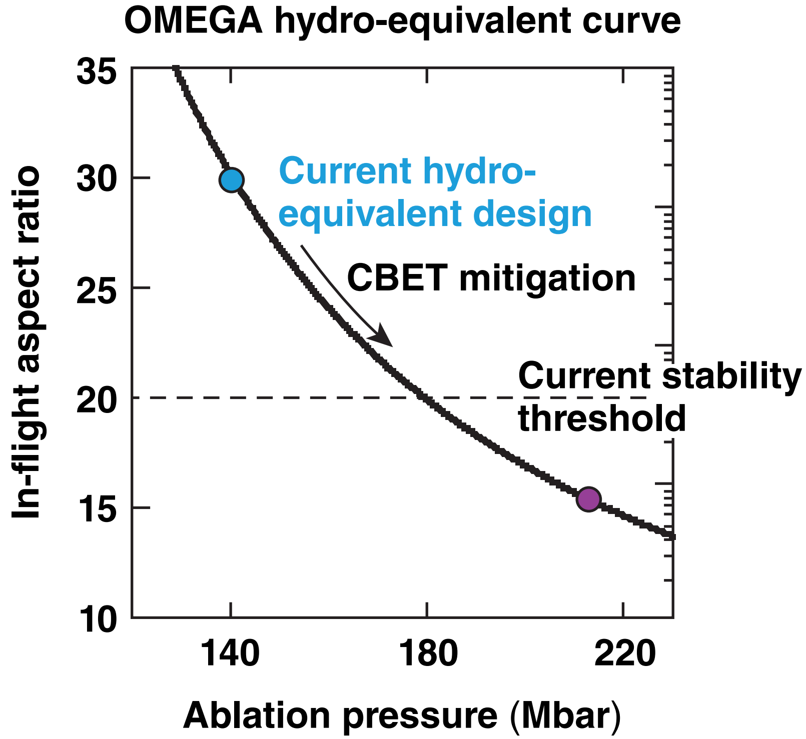
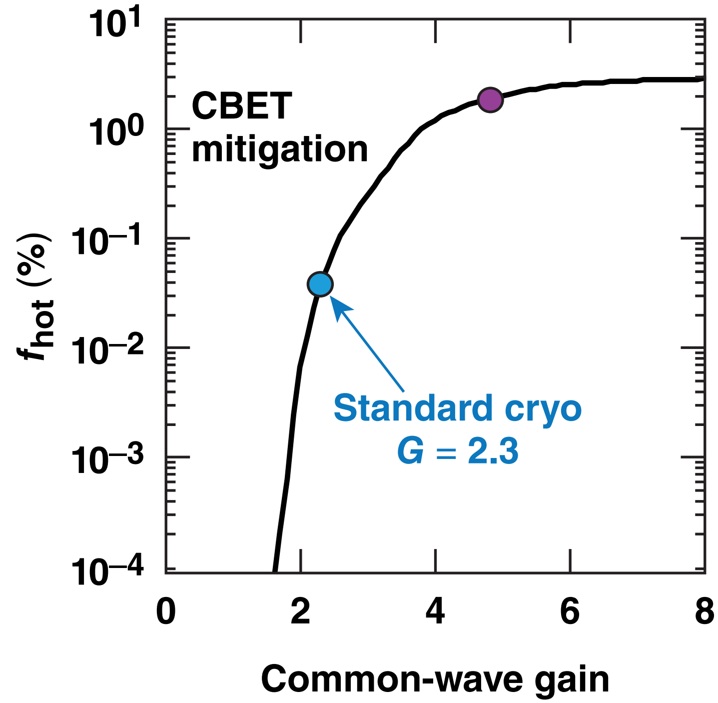
Empirical Scaling of Hot Electrons with the Two-Plasmon–Decay Common-Wave Gain





D. H. Edgell
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

Two-plasmon–decay (TPD) common-wave scaling makes it possible to predict hot-electron production for experimental designs

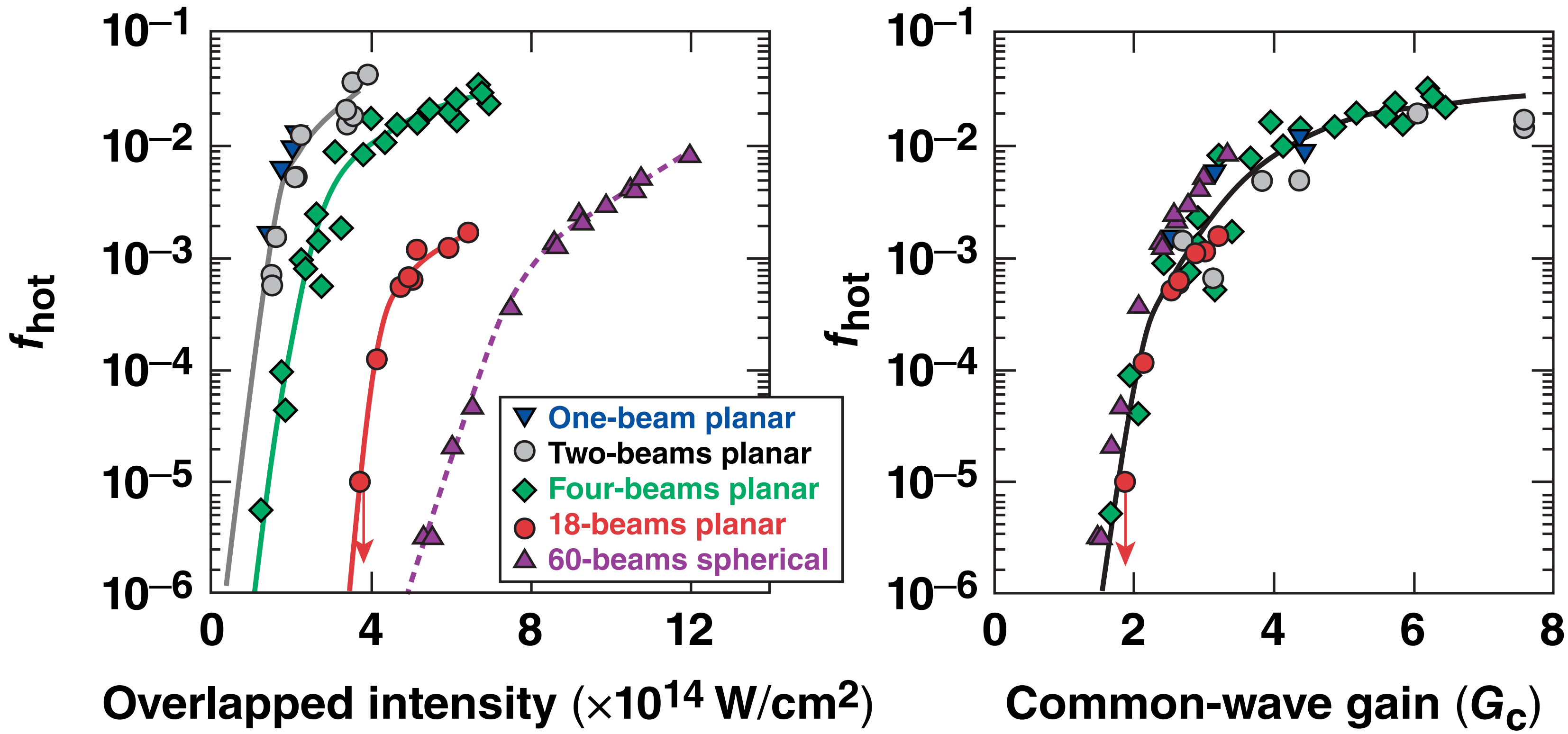
- Hot-electron production from TPD in OMEGA and OMEGA EP experiments scales empirically with the TPD common-wave gain
- If cross-beam energy transfer (CBET) must be mitigated to achieve ignition hydrodynamic equivalence on OMEGA then TPD mitigation will likely be required
- The scaling predicts that TPD mitigation with mid-Z layers will sufficiently reduce the hot-electron production

Collaborators

I. V. Igumenshchev, D. T. Michel, J. F. Myatt, D. H. Froula,
R. J. Henchen, and V. N. Goncharov

University of Rochester
Laboratory for Laser Energetics

The common-wave gain provides a useful empirical scaling that unifies the different experimental geometries



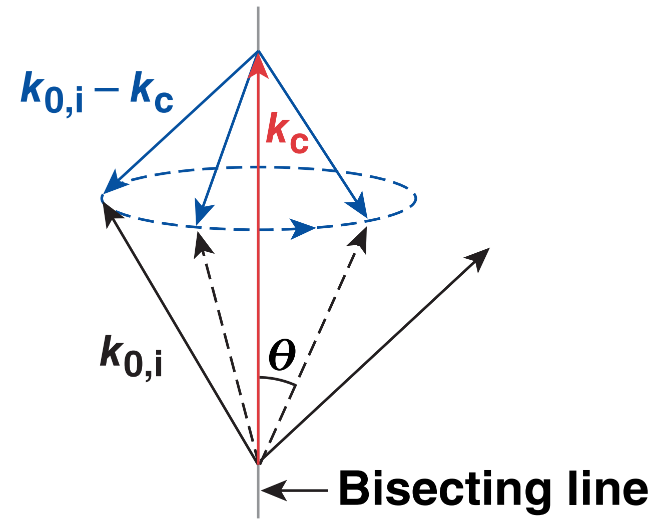
The common-wave gain can be used as a scaling metric for target design.

E21699n

A hydrocode postprocessor calculates maximum common-wave gain on the quarter-critical surface

- Linear theory shows that a resonant electron plasma wave (EPW) is shared by multiple beams in the region bisecting the wave vectors of the beam*
- Three-dimensional ray tracing finds the common-wave gain from all groups of three or more beams group at each point on the surface
- To predict hot-electron yields, the maximum gain over the entire surface is assumed to dominate

Multibeam common-wave region



Intensity at $n_c/4$ that contributes to the dominant mode

$$G_c \approx \frac{I_{\Sigma}(\mathrm{W/cm^2})L_n(\mu\mathrm{m})}{T_e(\mathrm{keV})} \times 10^{-16}$$

*D. T. Michel *et al.*, Phys. Rev. Lett. 109, 155007 (2012).

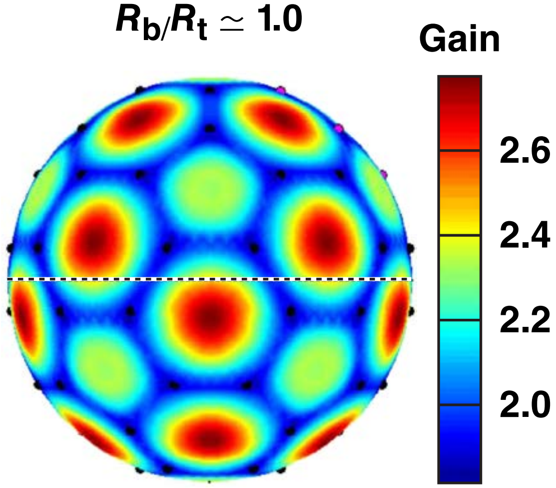
E23225a

CBET mitigation strategies based on reduced beam size are being evaluated for implementation on OMEGA

- Typically in CBET, the edge seed of outgoing beams takes energy from the center of ingoing beams
- Reducing the beam radius increases absorption and the target drive as well as the maximum common-wave gain caused by the higher intensities

Shot 63311, SG4's, 900-μm CH on Mo, SG1018, 29.4 kJ

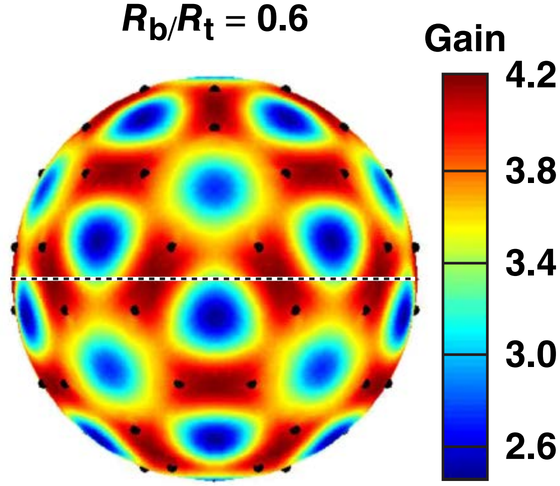
$R_b/R_t \simeq 1.0$



G_{max} = 2.8
f_{hot} = 0.08%
Absorption = ~55%

Shot 70010, PPD-DDPs, 866-μm CH, SG1018, 29.6 kJ

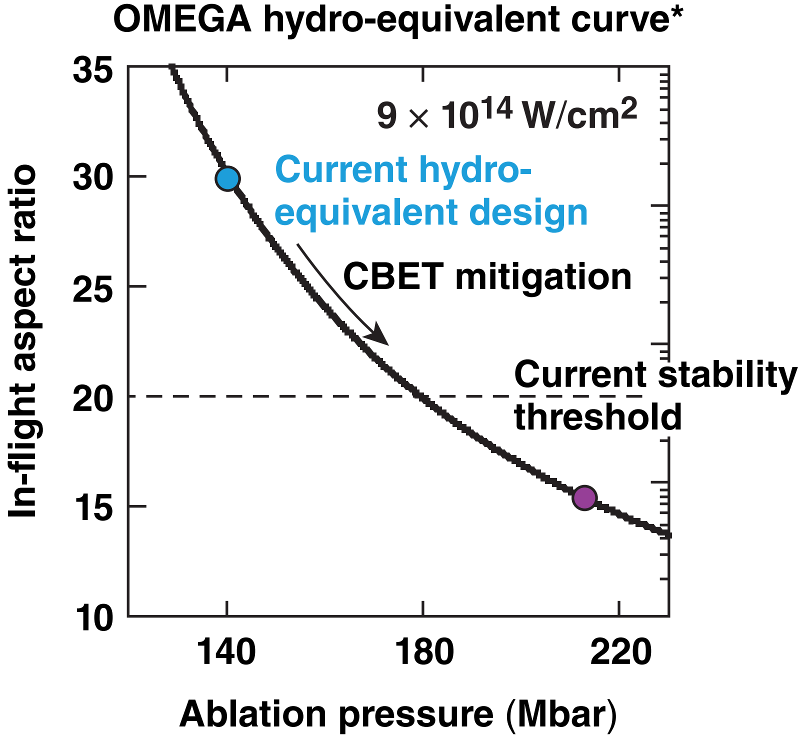
R_b/R_t = 0.6

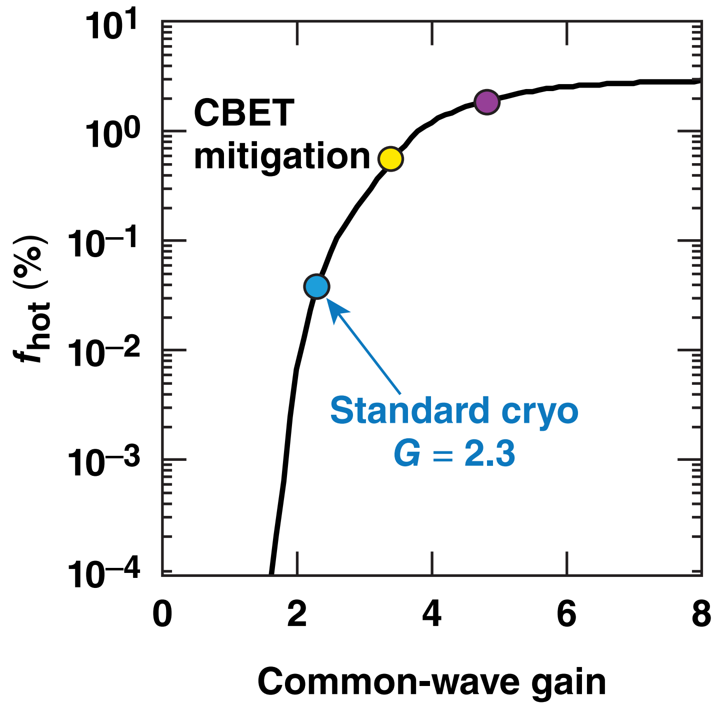


G_{max} = 4.2
f_{hot} = 0.9%
Absorption = 63%

E23422

Reduced-beam-size CBET mitigation schemes on OMEGA will likely require TPD mitigation



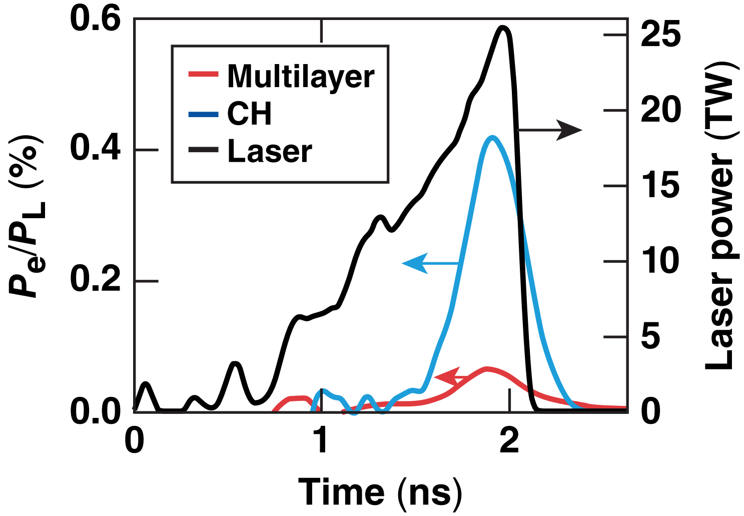


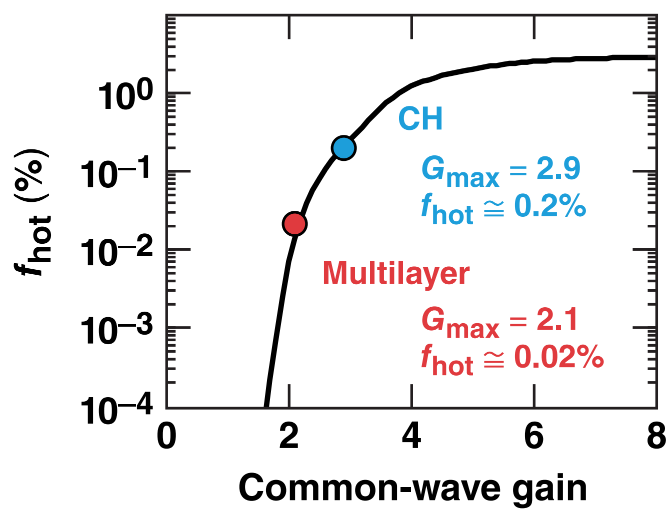
Multilayer mid-Z targets have shown promise for TPD mitigation.

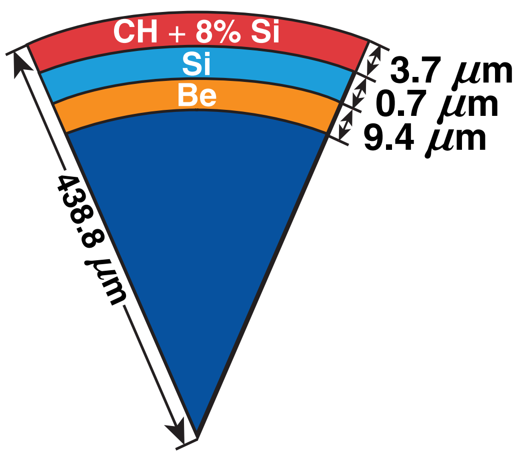
E23423

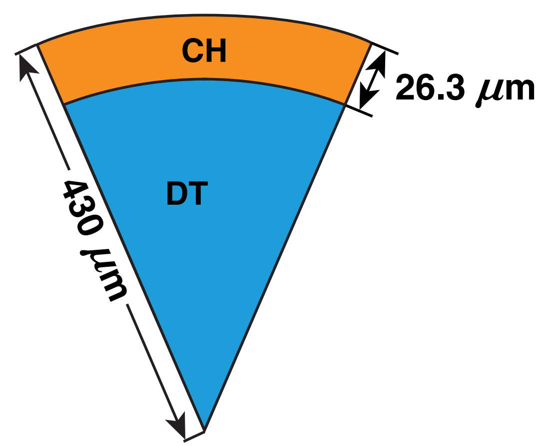
D. H. Froula *et al.*, NO4.00013, this conference.

Experimental tests of multilayer targets produced many fewer hot electrons than CH targets









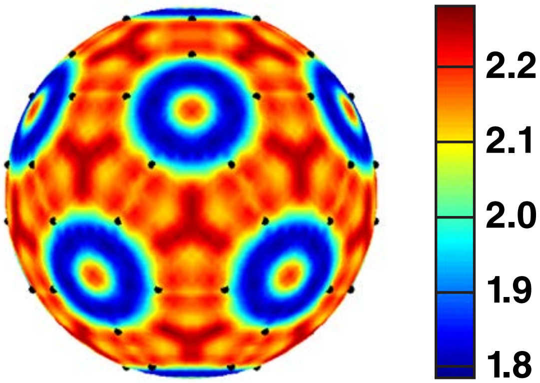
- A mid-*Z* layer (Si) embedded in the target shell is designed to increase the coronal temperature at quarter critical to reduce the two-plasmon–decay produced hot electrons

TC11238a

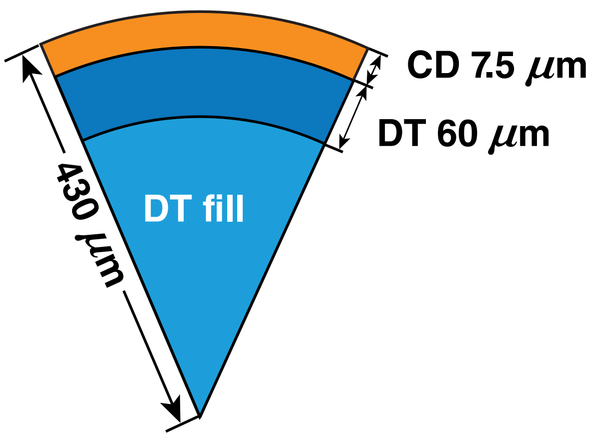
Mid-Z multilayers are predicted to significantly reduce hot-electron production

UR LLE

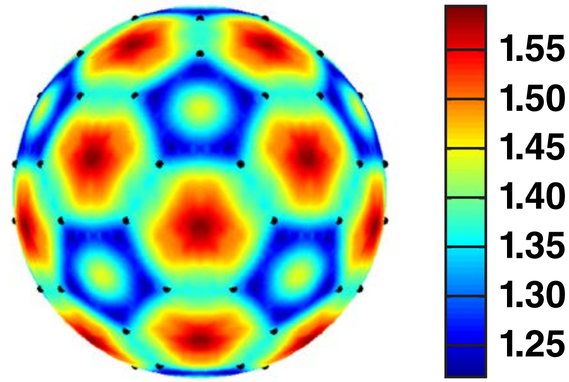
Standard cryo design
SG4s, 26 kJ



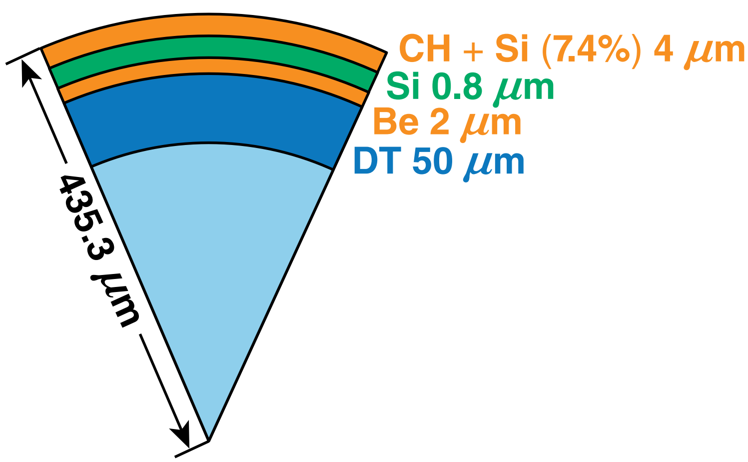
G_{max} = 2.3
f_{hot} → 0.035%



Multilayer cryo design
SG4s, 25 kJ



G_{max} = 1.6
f_{hot} → 10^{-4}%



E23091a

Summary/Conclusions

Two-plasmon–decay (TPD) common-wave scaling makes it possible to predict hot-electron production for experimental designs

UR LLE

- Hot-electron production from TPD in OMEGA and OMEGA EP experiments scales empirically with the TPD common-wave gain
- If cross-beam energy transfer (CBET) must be mitigated to achieve ignition hydrodynamic equivalence on OMEGA then TPD mitigation will likely be required
- The scaling predicts that TPD mitigation with mid-Z layers will sufficiently reduce the hot-electron production