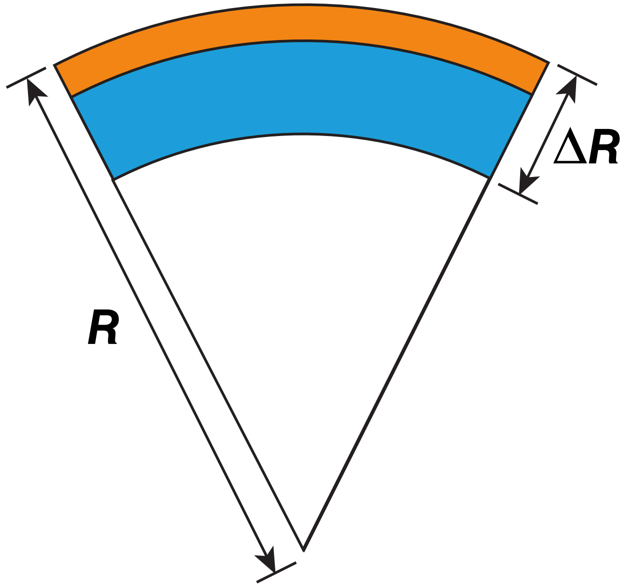
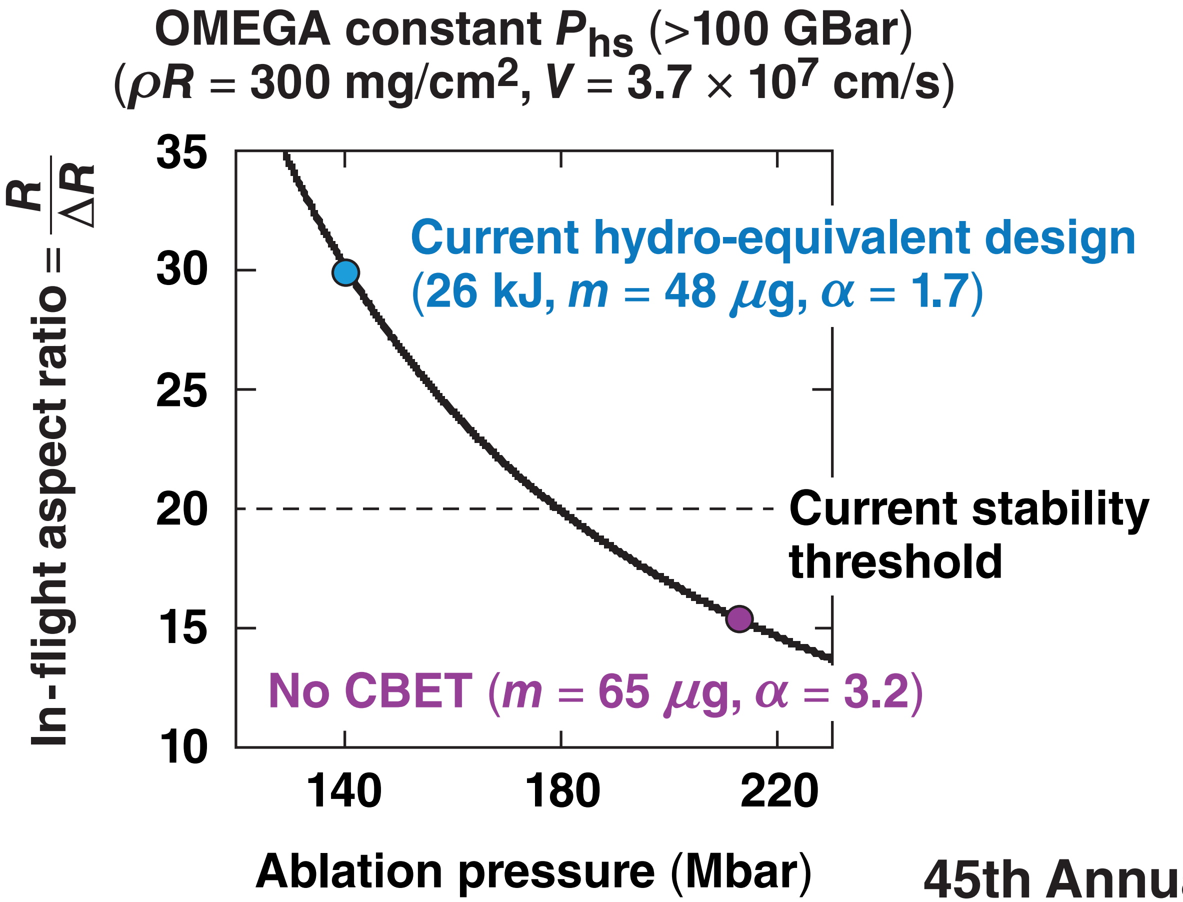
A Pathway to Ignition-Hydrodynamic-Equivalent Implosions on OMEGA Through the Reduction of Cross-Beam Energy Transfer





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Summary

Achieving hydrodynamic equivalence on OMEGA will require mitigating cross-beam energy transfer (CBET) and may require a multilayer target to reduce hot-electron preheat

- CBET reduces the ablation pressure by about 50% in hydro-equivalent designs
- Experiments have demonstrated CBET mitigation with reduced focal-spot size
- Three dimensional simulations suggest that reducing the laser spot size after the third picket (zooming) can recover the hot-spot pressure lost to CBET
- Multilayer targets reduce hot electrons and improve hydrodynamic efficiency

Collaborators

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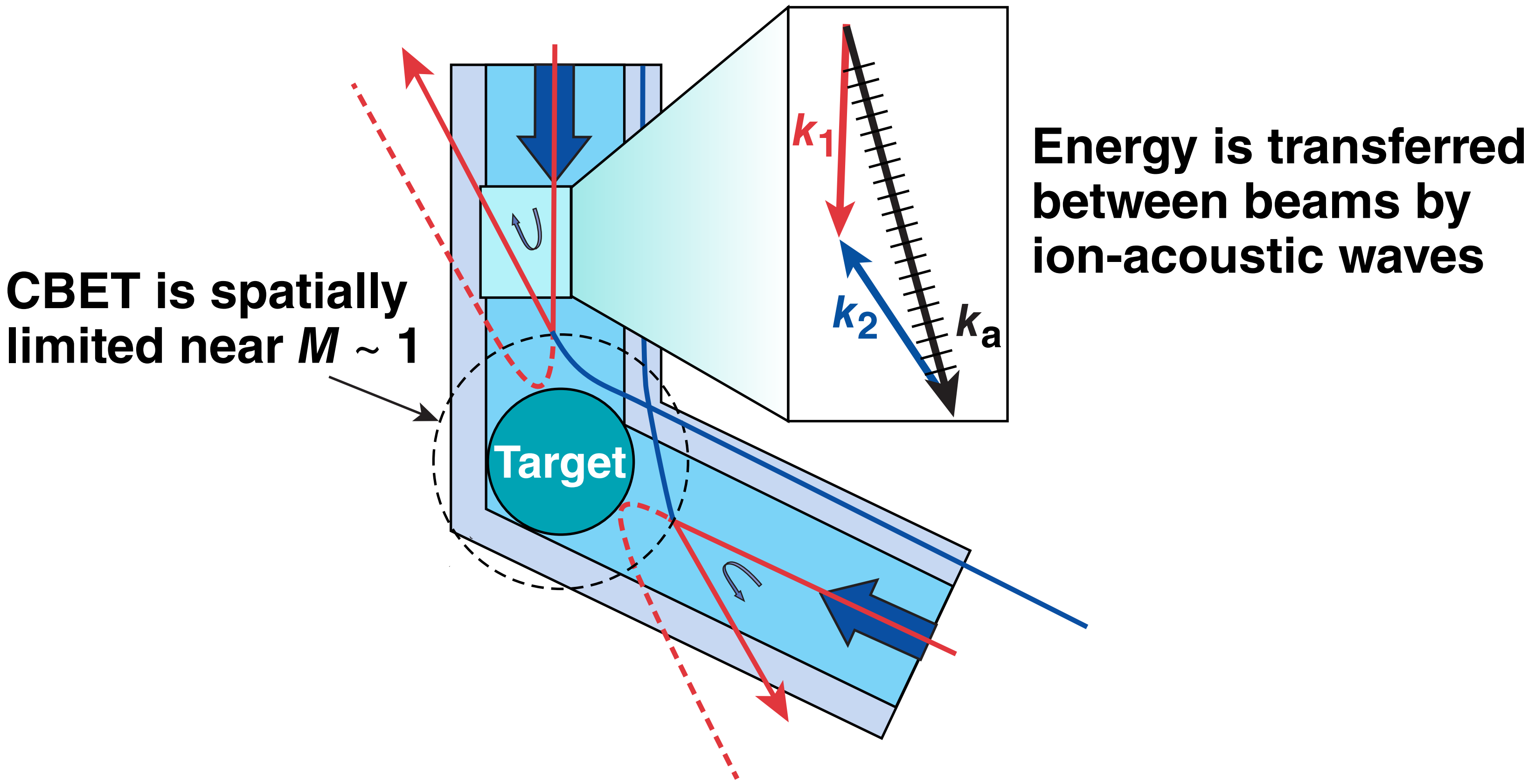
CBET reduces the energy coupled to the fusion capsule by transferring energy from the incident light to the outgoing light



CBET reduces the most hydrodynamically efficient portion of the incident laser beams.

I. V. Igumenschev *et al*., Phys. Plasmas, 16, 082701 (2009).

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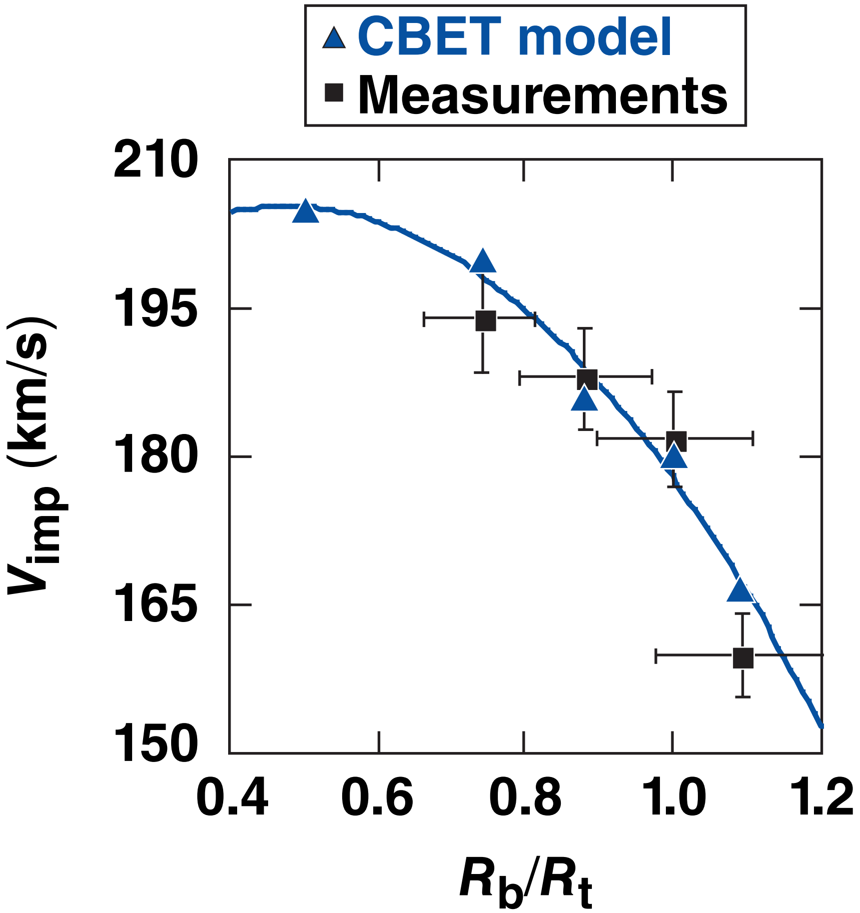
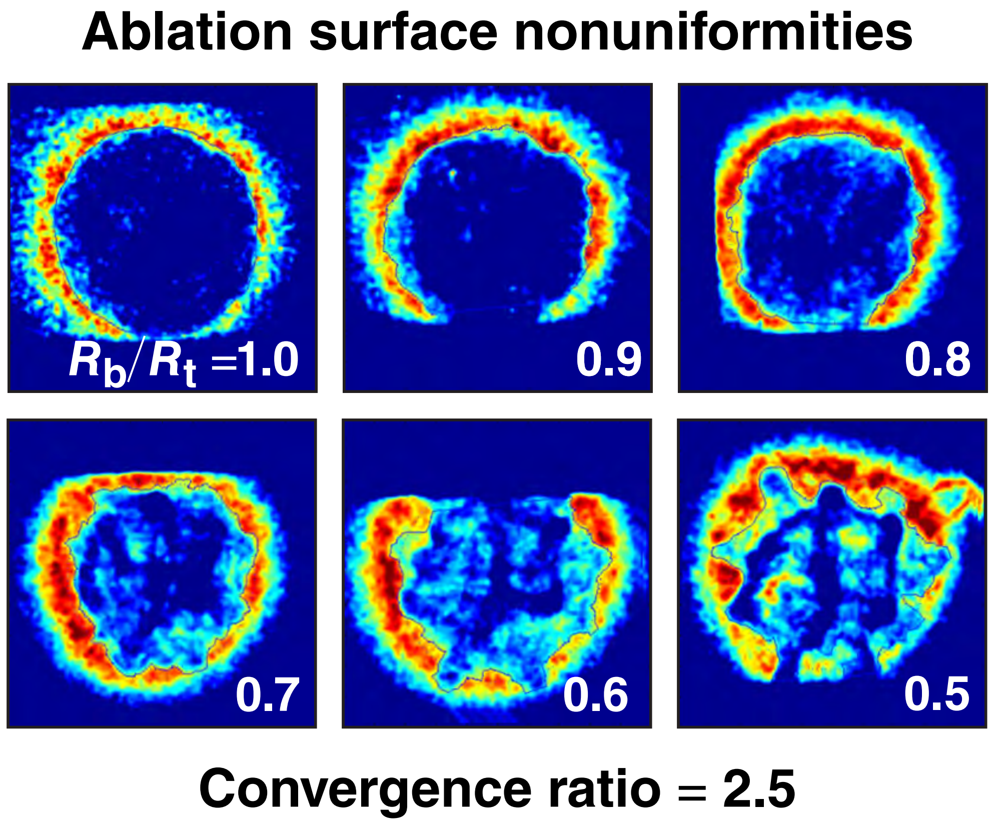
Experiments have demonstrated that CBET can be mitigated by reducing the energy that propagates past the target*





Reducing the diameter of the beams by 30% recovers most of the velocity lost to CBET, but the target performance was significantly compromised by nonuniformities.

*D. H. Froula *et al.*, Phys. Rev. Lett. 108, 125003 (2012).

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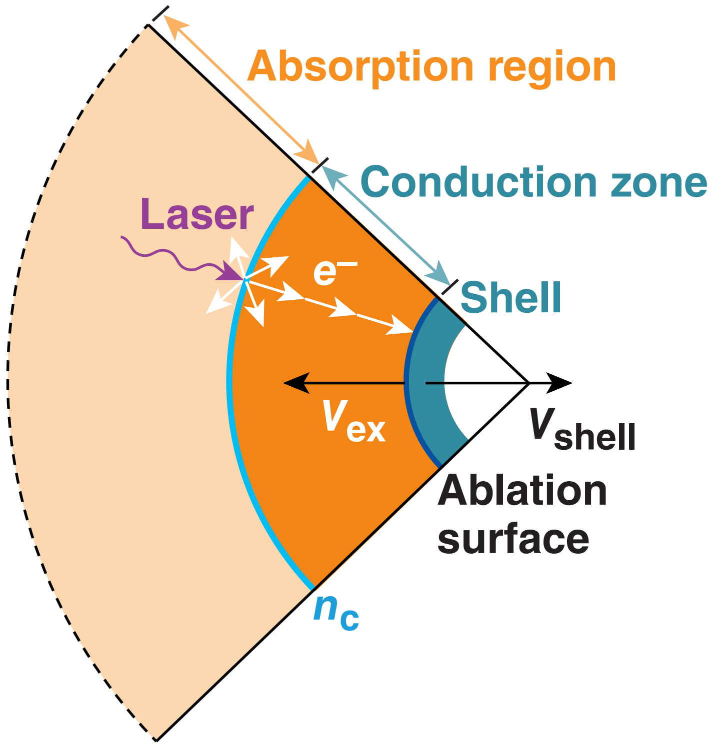
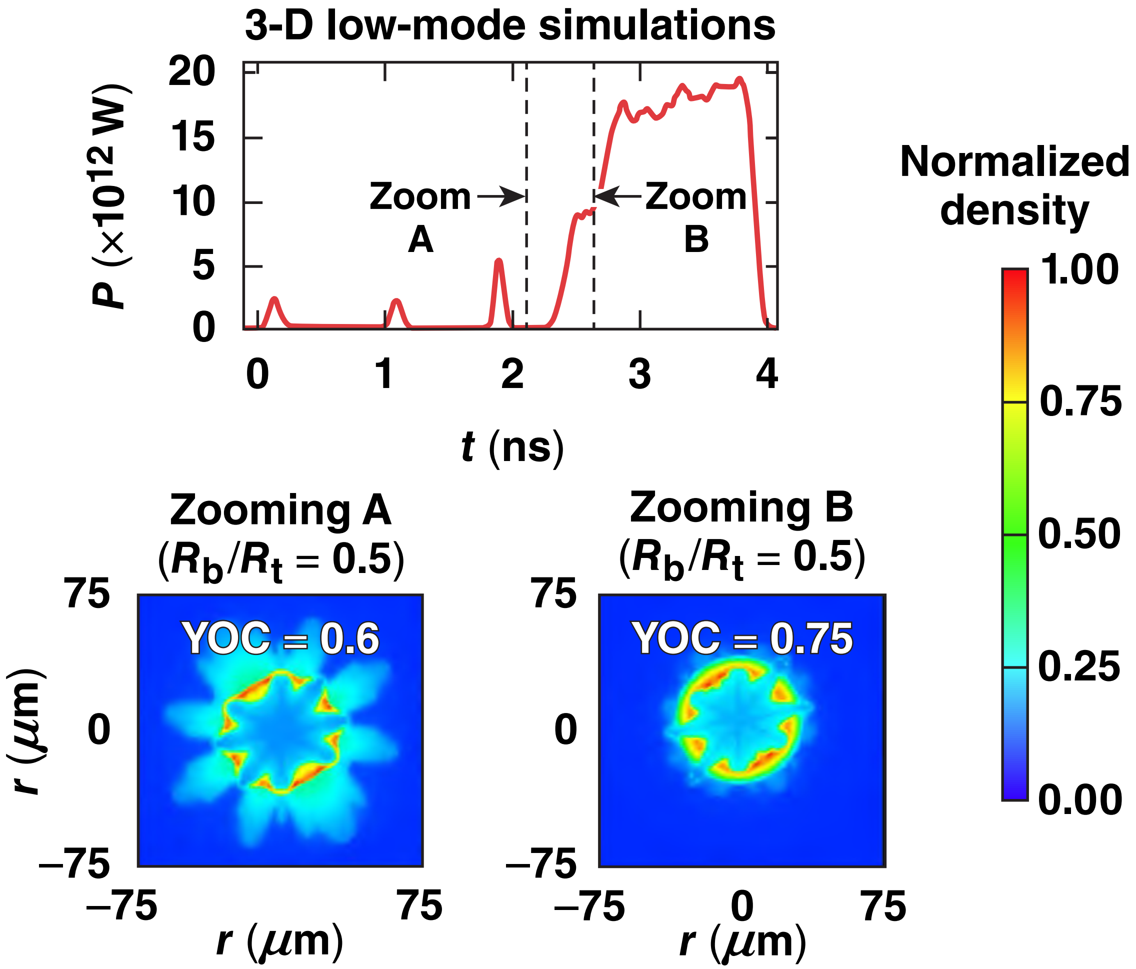
To reduce the laser spot without introducing nonuniformities, the diameter of the laser beams must be reduced after a sufficient conduction zone has been developed

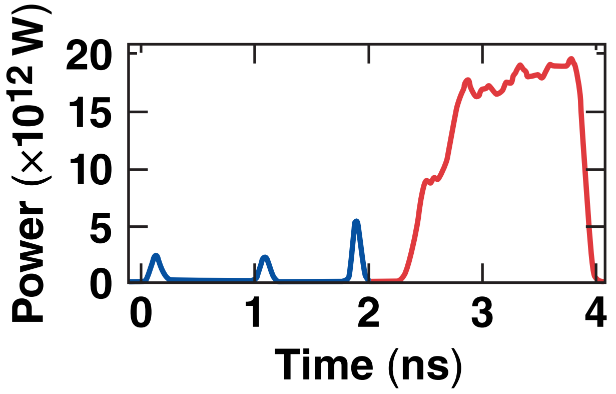


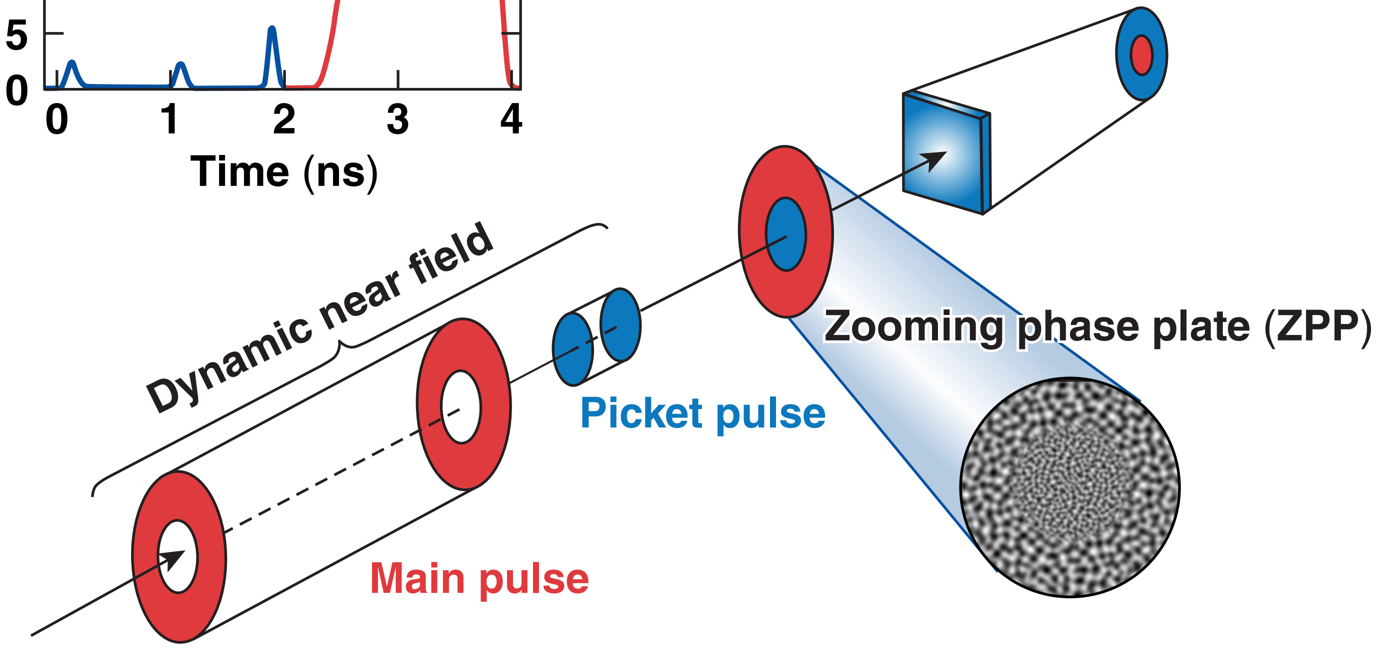


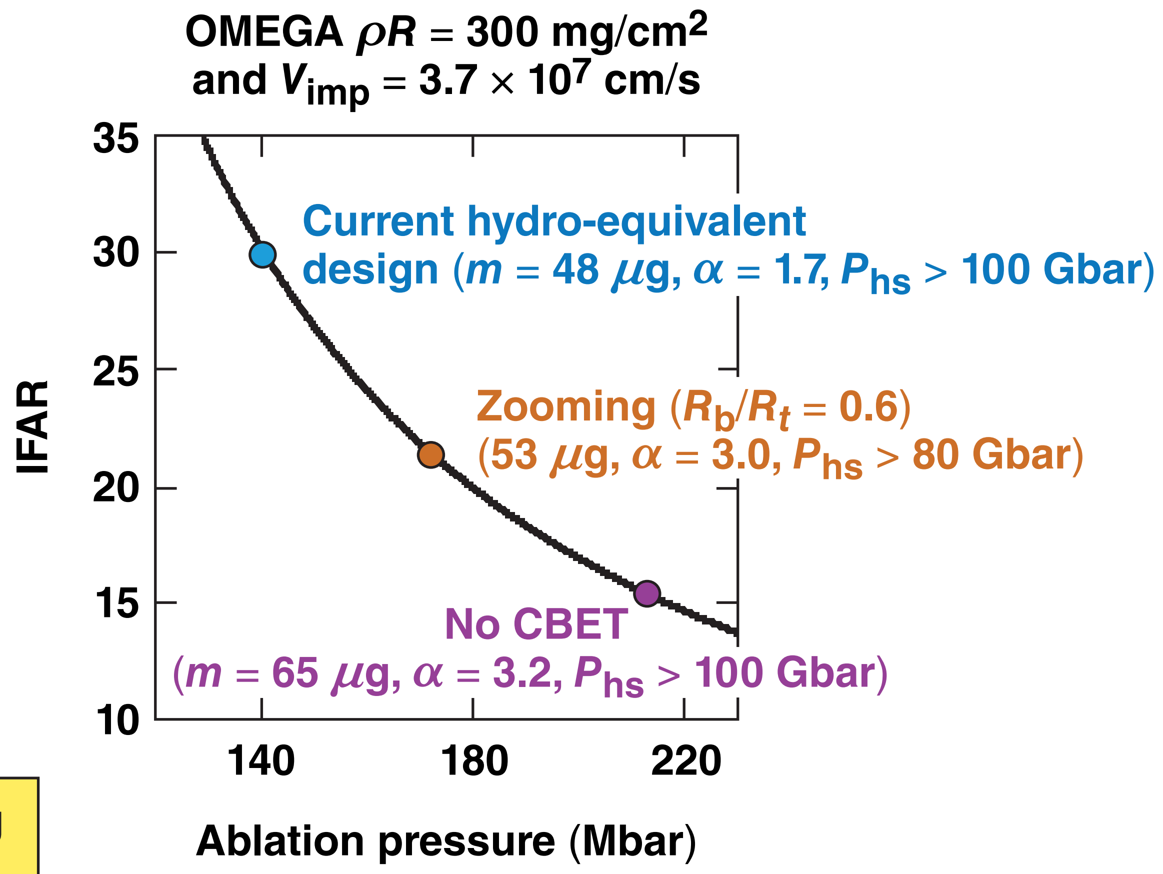
Three-dimensional simulations suggest that zooming after the third picket can recover the hot-spot pressure lost to CBET.

*I. V. Igumenshchev *et al*. Phys. Rev. Lett. 110, 145001 (2013).

Coaxial zooming is being implemented on OMEGA using a multipulse driver and a radially varying phase plate*





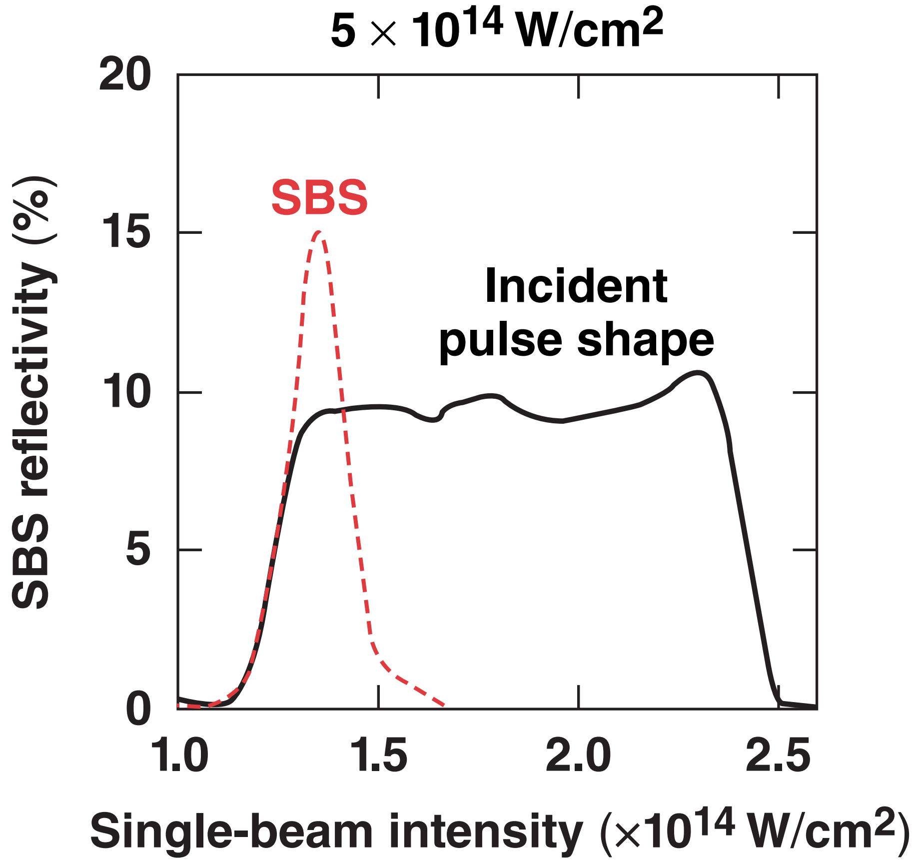


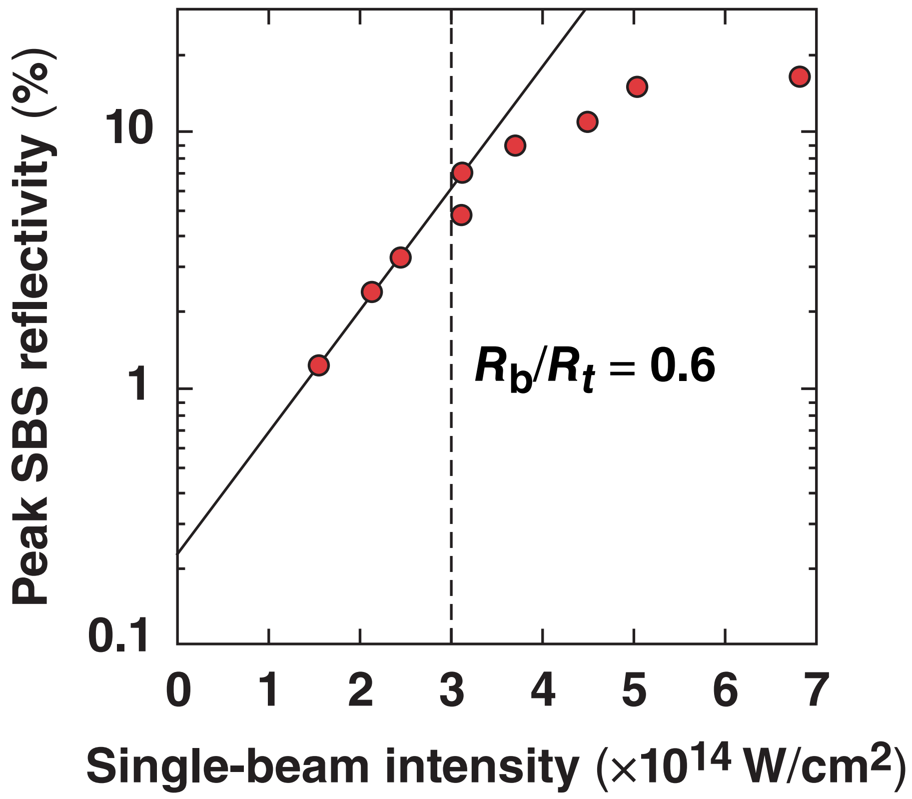
- There are three concerns with zooming that are being investigated
  - single-beam stimulated Brillouin scattering (SBS)
  - increased power spectrum
  - increased hot-electron fraction

E22039f

*D. H. Froula *et al.*, Phys. Plasmas 20, 082704 (2013).

To investigate single-beam SBS, a small spot was used to scale the intensity





The experiments suggest the R_b/R_t must remain above 0.6 to keep single-beam SBS below 5%.

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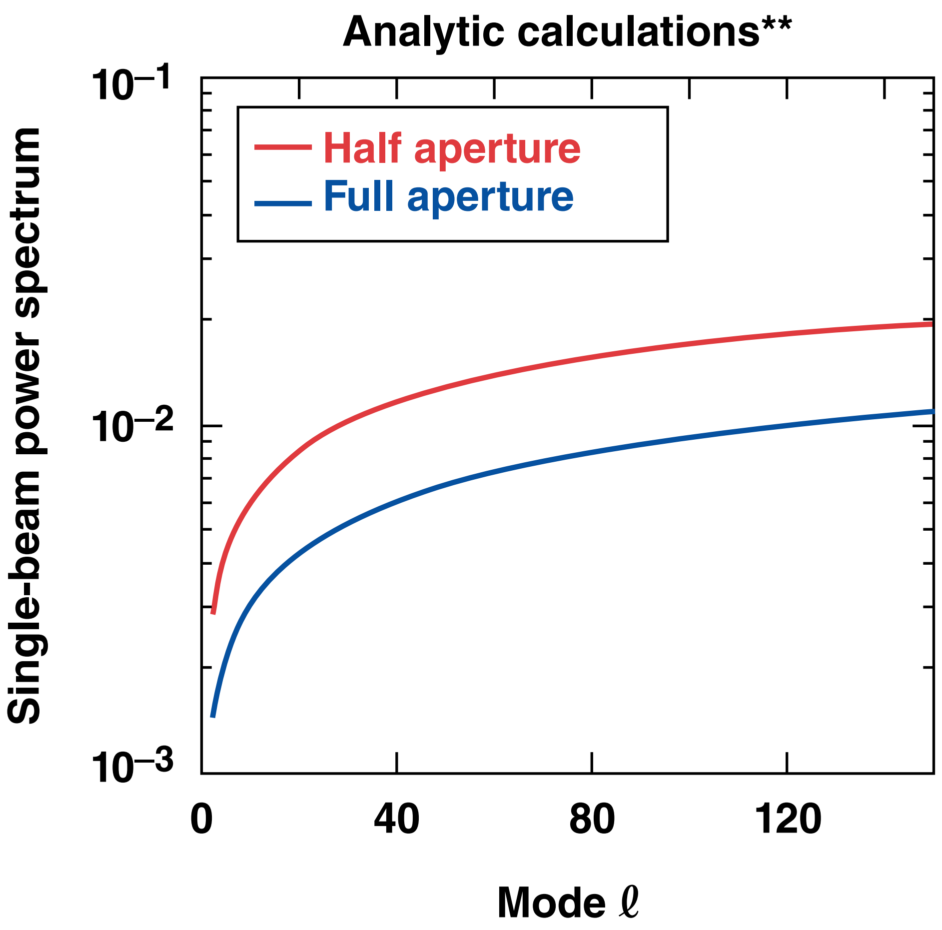
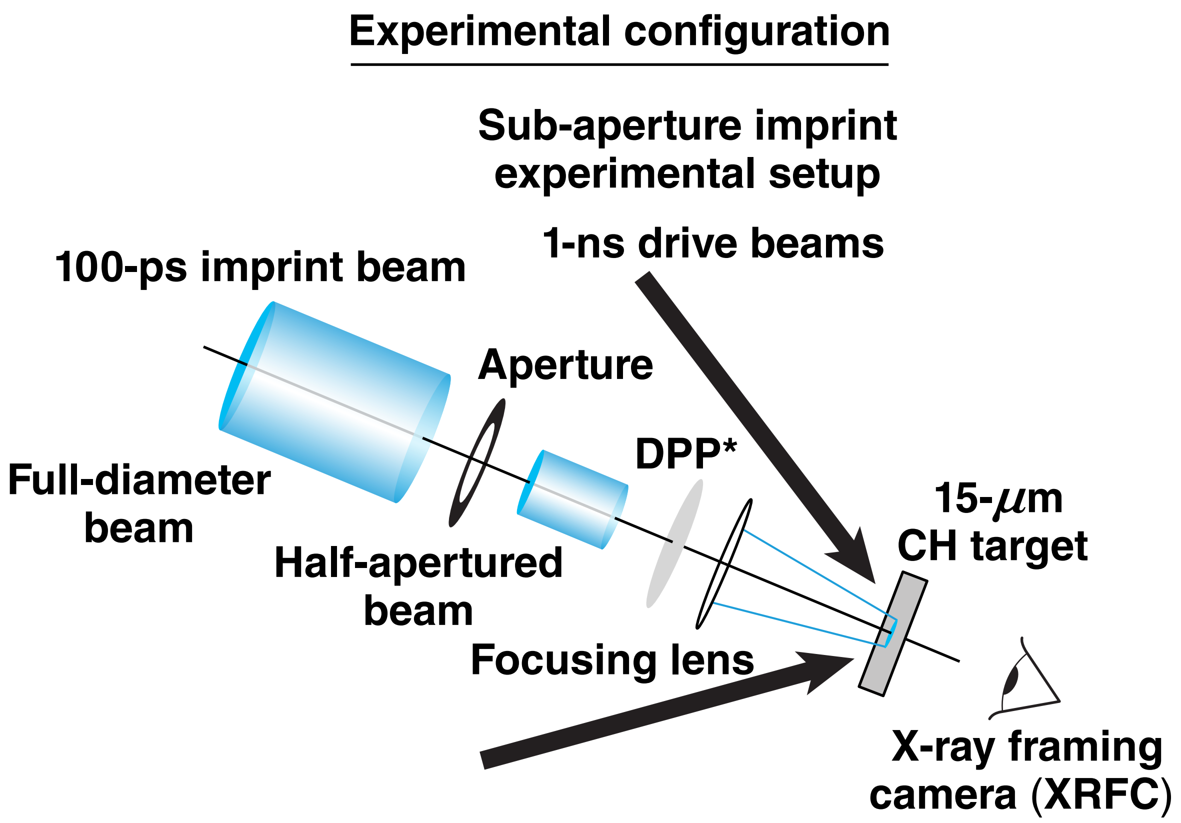
To investigate the increased power spectrum, planar Rayleigh–Taylor experiments were performed with a sub-aperture beam





*DPP = distributed phase plate

**R. Epstein, J. Appl. Phys. 82, 2123 (1997).

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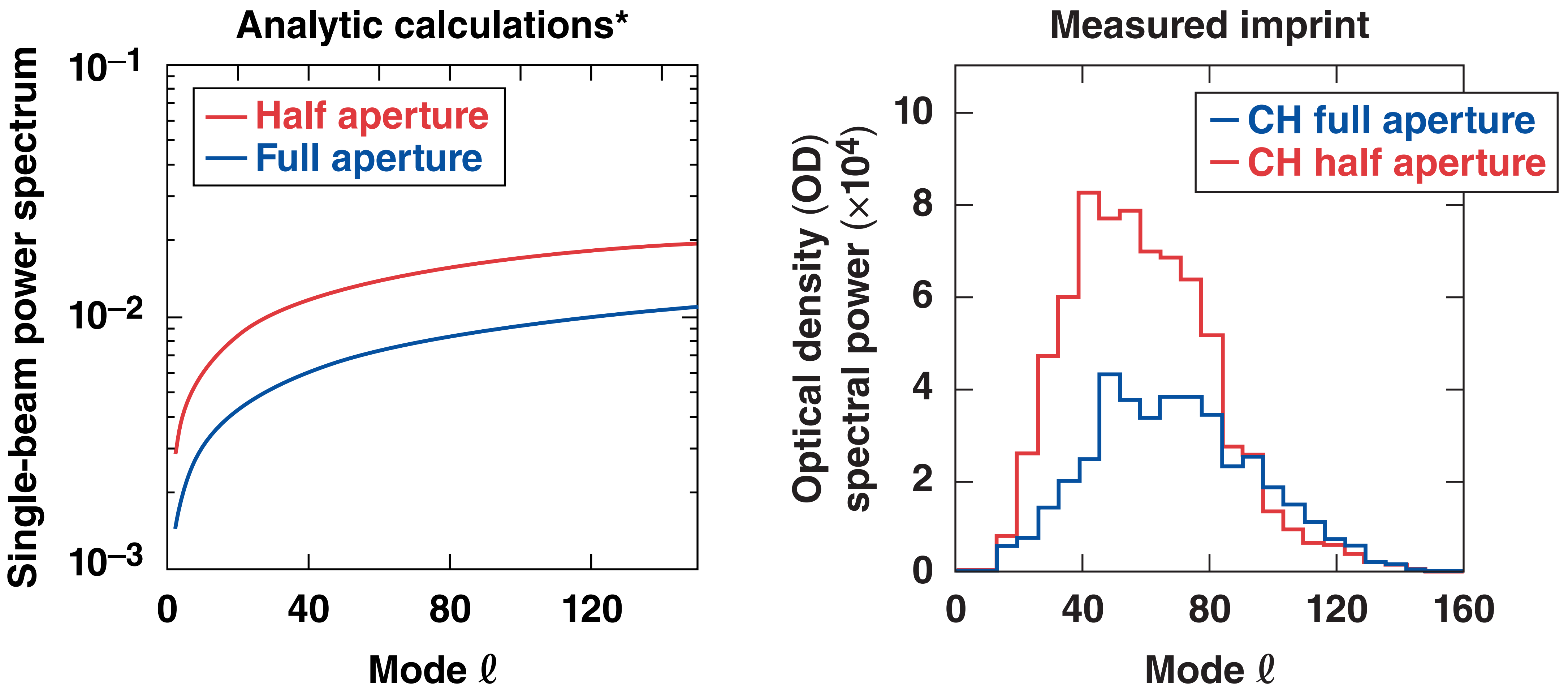
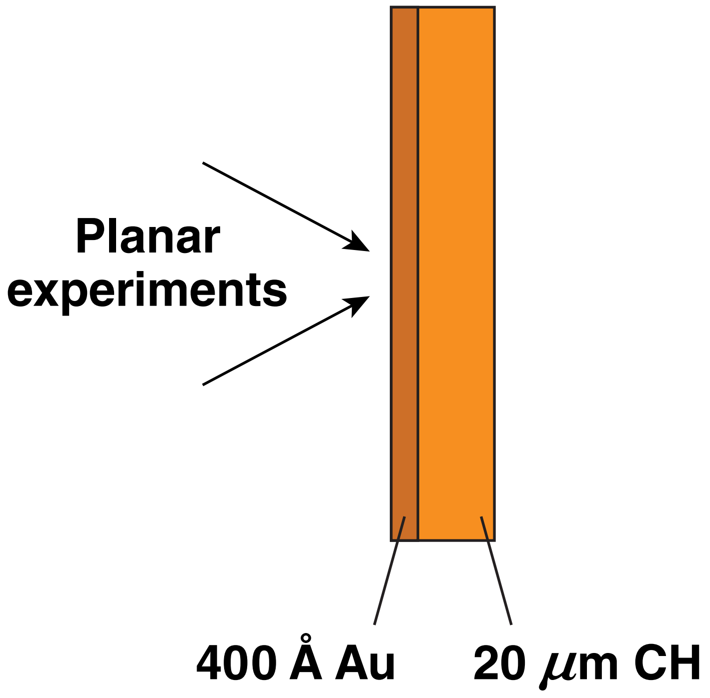
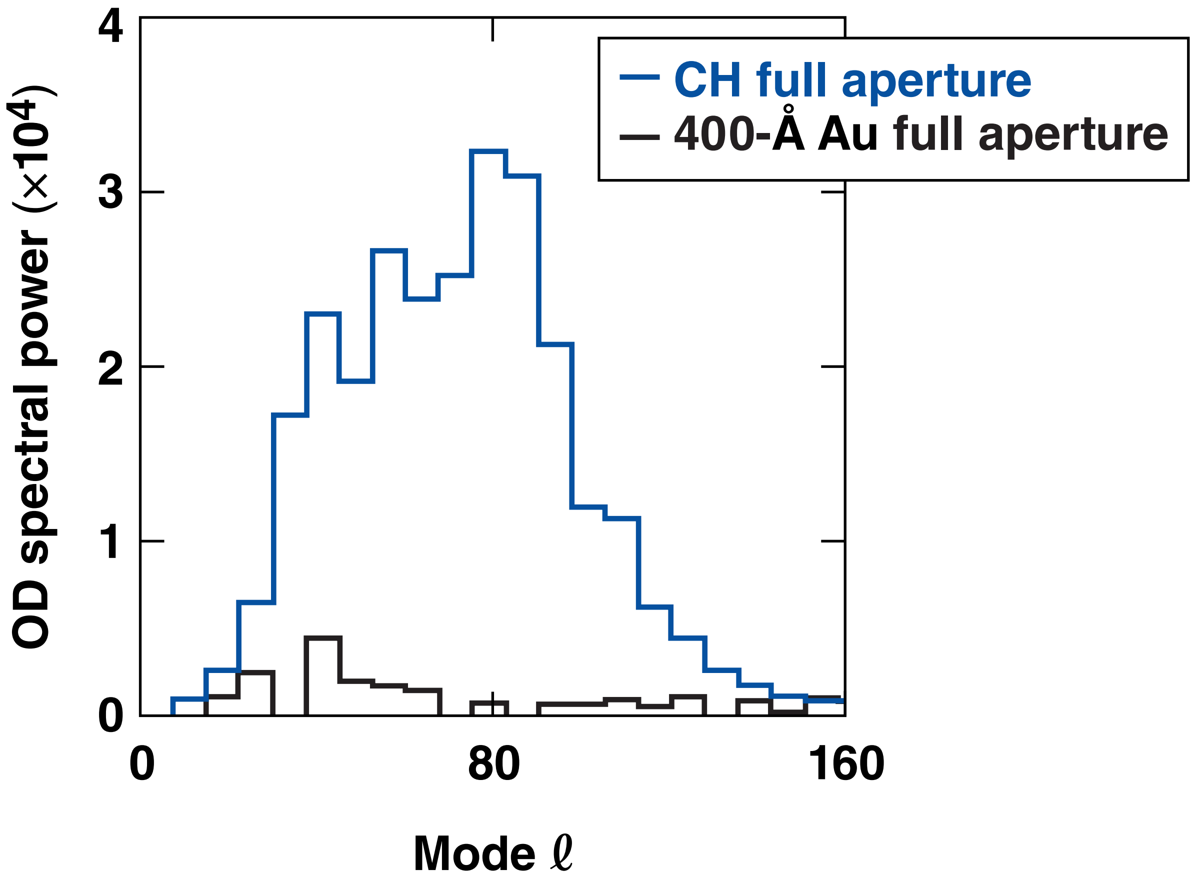
The Rayleigh–Taylor growth was measured to be larger with the sub-aperture beam



*R. Epstein, J. Appl. Phys. 82, 2123 (1997).

Adding a thin high-Z layer is measured to reduce the Rayleigh–Taylor growth over the modes of concern*

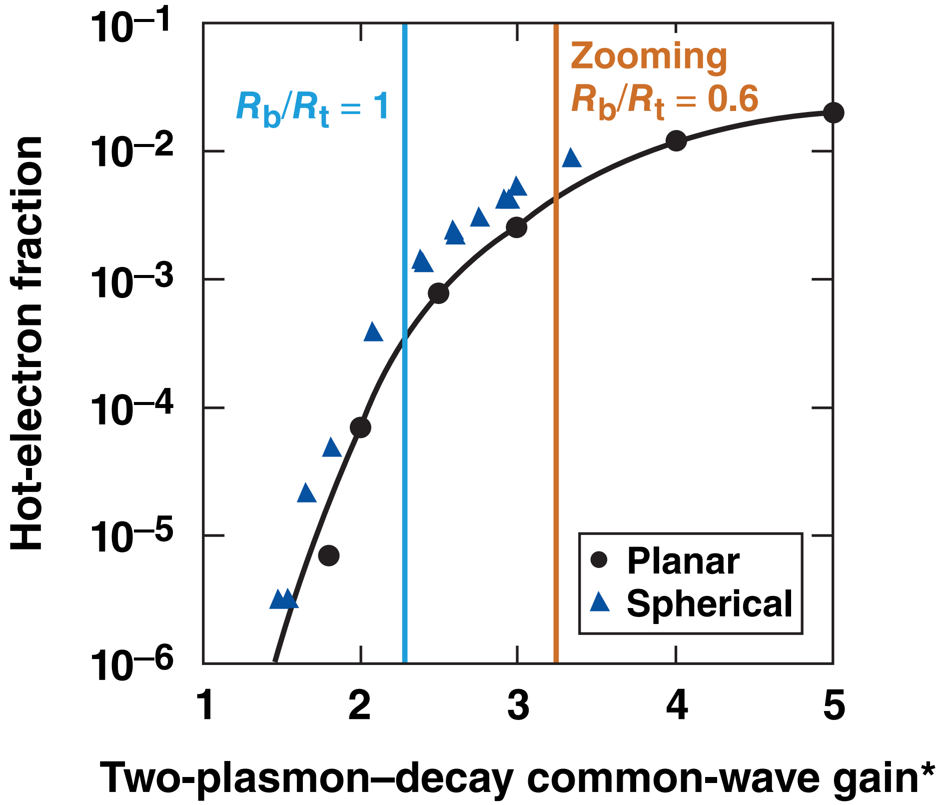


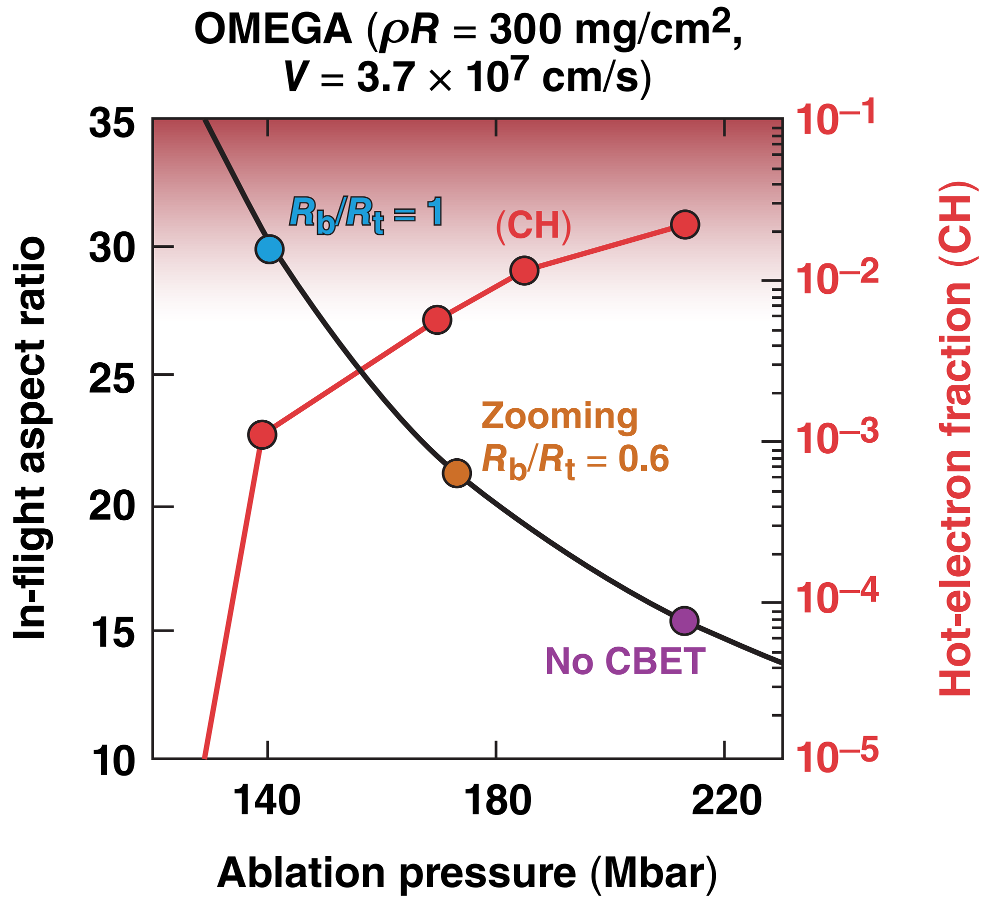


E22168c

*S. P. Obenschain *et al*., Phys. Plasmas 3, 2098 (1996).

Two-plasmon–decay experiments suggest that mitigating CBET will increase the hot-electron fraction by a factor of 5





Current cryo experiments show no evidence of hot-electron preheat, but simulations suggest a factor of two increase will degrade the areal density.

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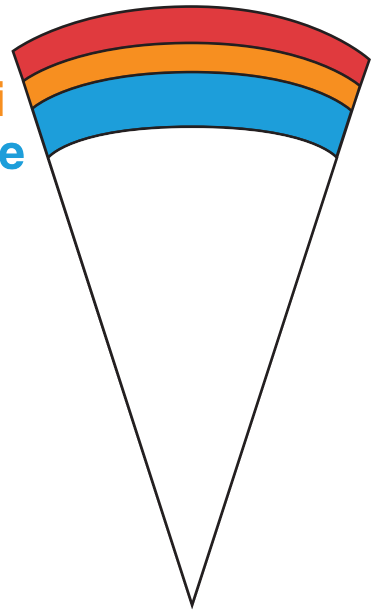
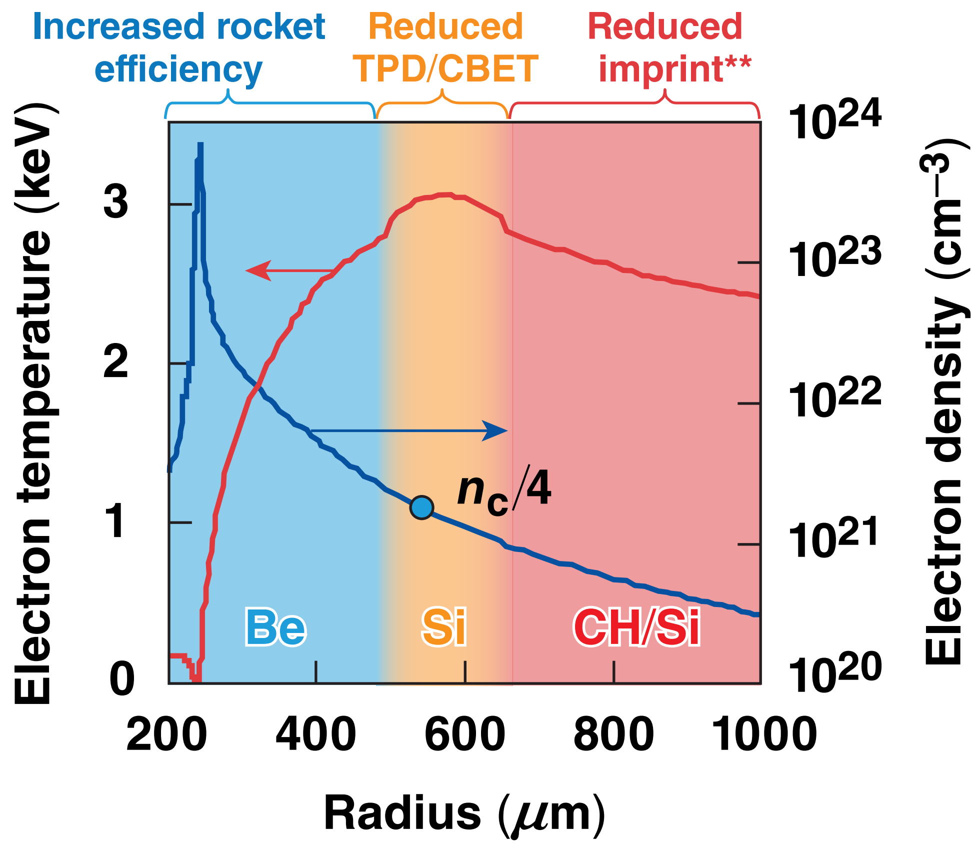
Multilayer targets were designed to increase hydrodynamic efficiency, reduce laser–plasma instabilities, and lower the Rayleigh–Taylor growth



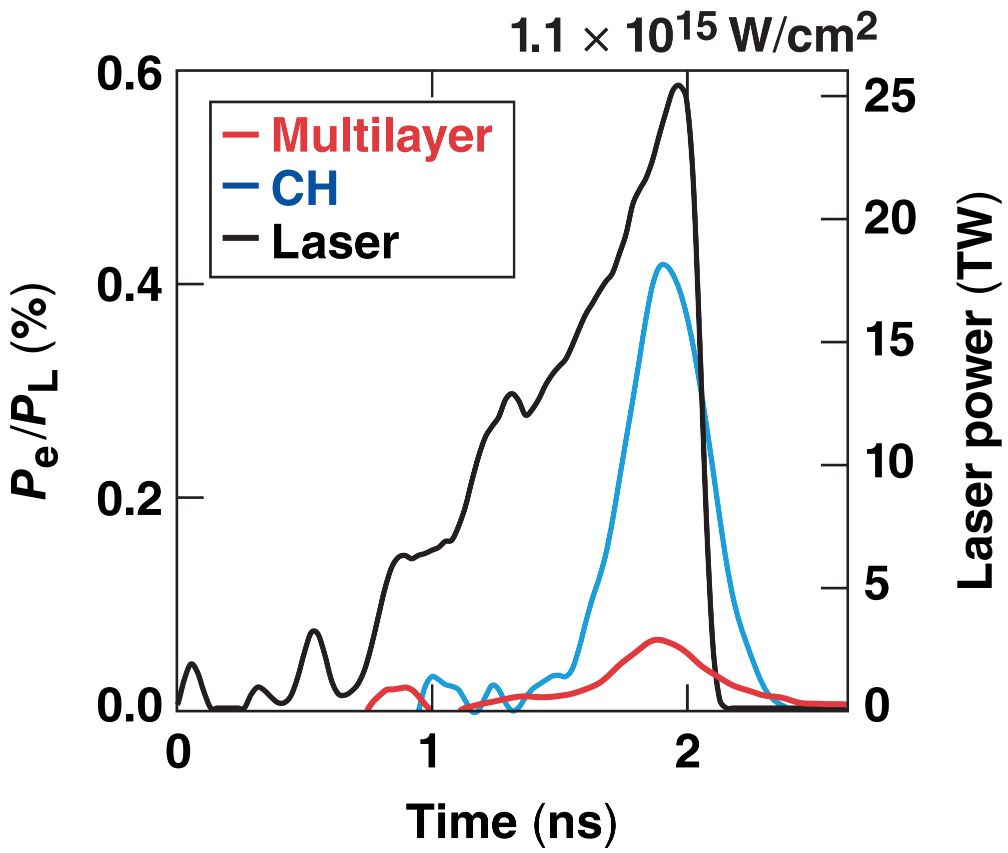


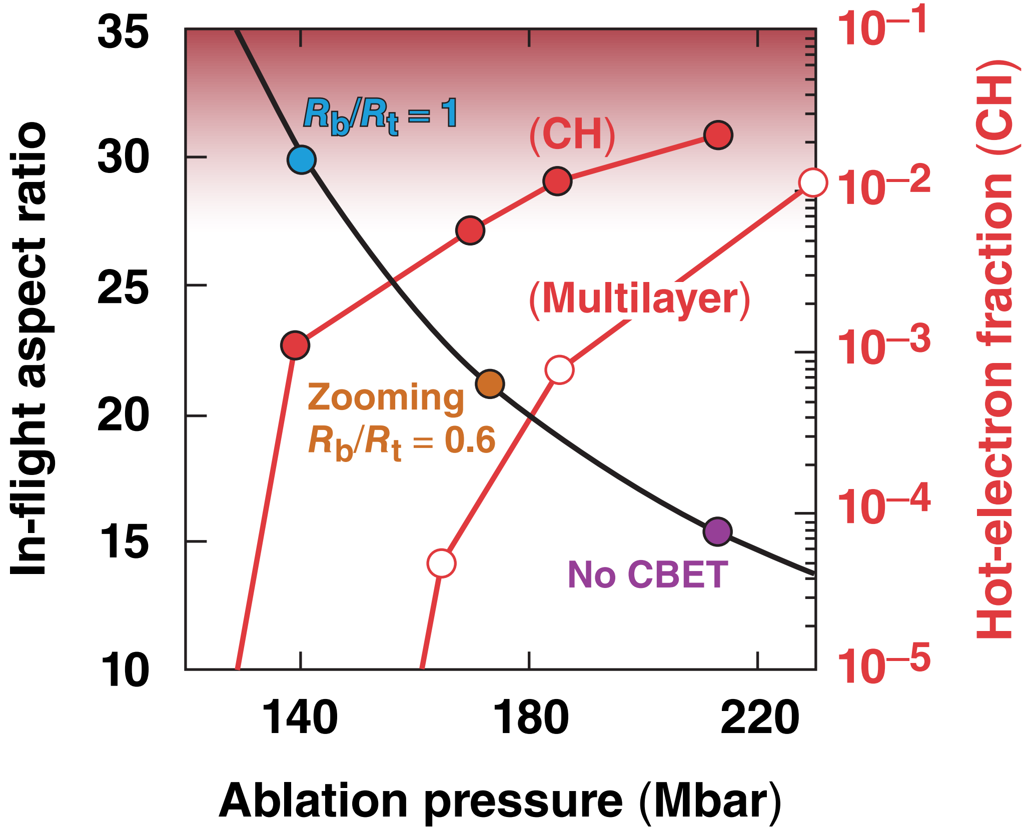
The layer thicknesses are optimized to have increased laser absorption at $n_c/4$ (Si higher T_e) and increased ablation in Be (higher A/Z).

* V. N. Goncharov *et al*., Phys. Plasmas 21, 056315 (2014).
**S. X. Hu *et al*., Phys. Rev. Lett. 111, 123003 (2013); G. Fiksel *et al*., Phys. Plasmas 19, 062704 (2012).

E22920d

The increased electron temperature in the multilayer targets reduces the hot-electron fraction by a factor of 8





The hot-electron fraction is reduced by a factor of 8 in multilayer compared to CH targets.

E22929c

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

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