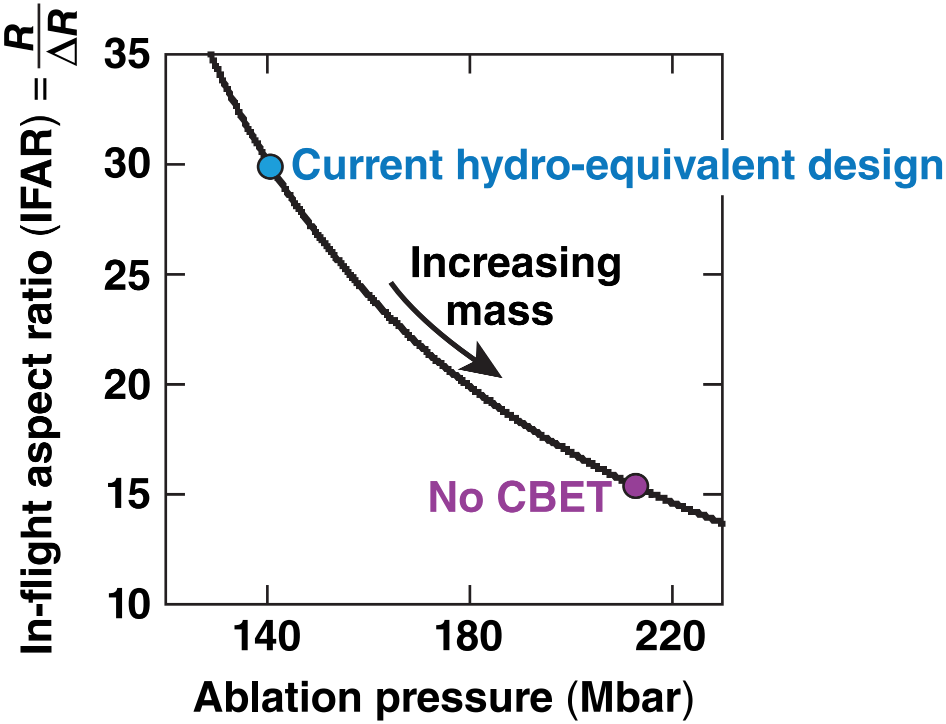
A Pathway to Ignition-Hydrodynamic-Equivalent Implosions in OMEGA Direct Drive Through the Reduction of Cross-Beam Energy Transfer



OMEGA ignition hydro-equivalent conditions

$$V_{imp} \propto \frac{P_a}{M(\Delta R)} = 3.7 \times 10^7 \text{ cm/s}$$

$$P_{hs} \propto \frac{P_a^{1/3} \times V^3}{\alpha} > 100 \text{ Gbar}$$

$$\rho R \propto \frac{P_a^{2/3}}{\sqrt{\alpha}} = 300 \text{ mg/cm}^2$$

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Summary

Reducing cross-beam energy transfer on OMEGA will allow for more-stable ignition-relevant implosions

- Cross-beam energy transfer (CBET) reduces the ablation pressure, requiring less-stable implosions to reach $\rho R = 300$ mg/cm^2 and 3.7×10^7 cm/s
- CBET can be mitigated by reducing the diameter of the laser beams during the main drive
- A zooming phase plate is proposed to produce large-diameter laser spots during the pickets and small-diameter laser spots during the drive

Collaborators

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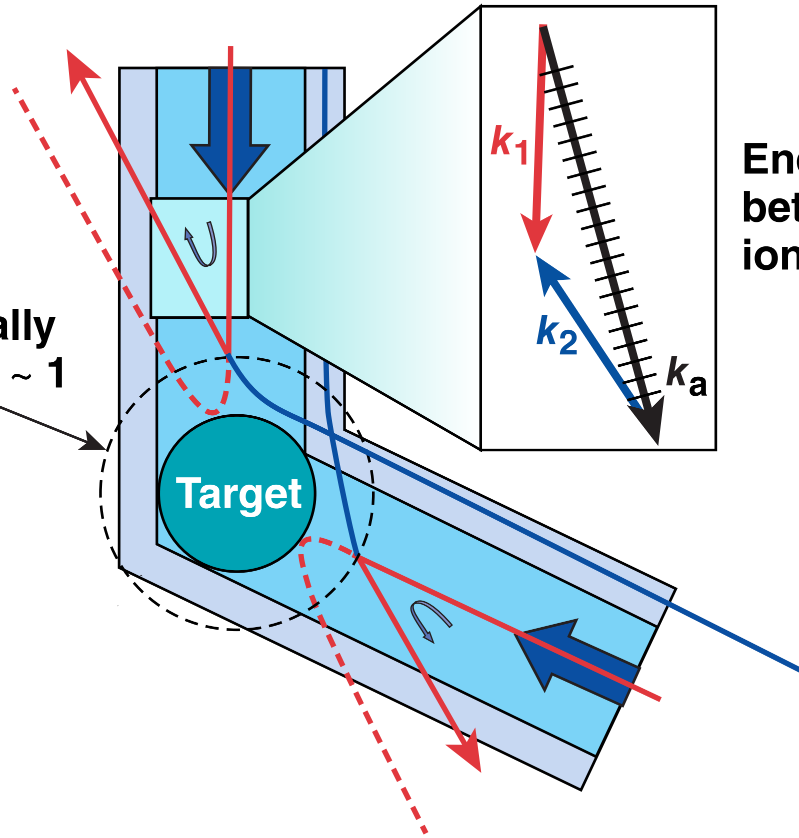
CBET reduces the energy coupled to the fusion capsule by transferring energy from the incident light to the outgoing light



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

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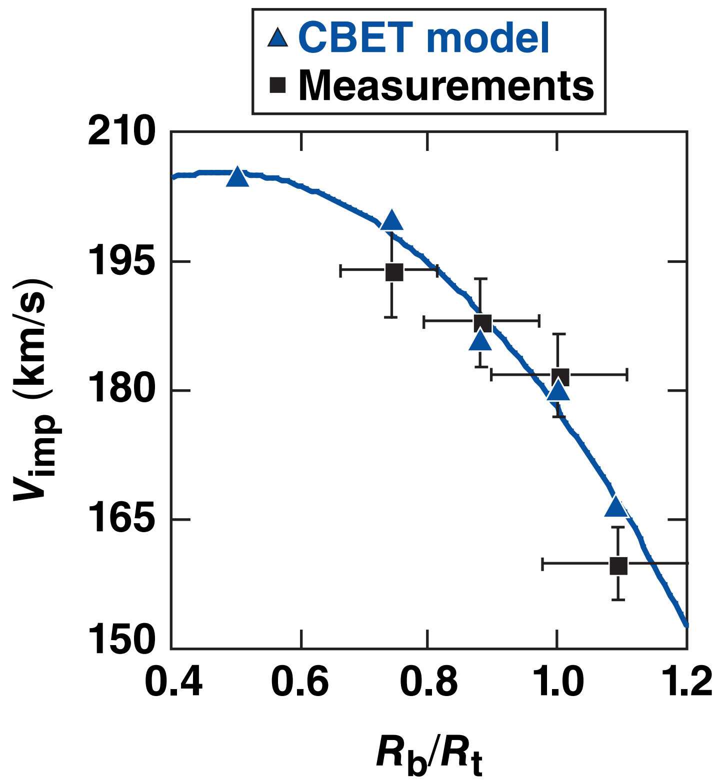
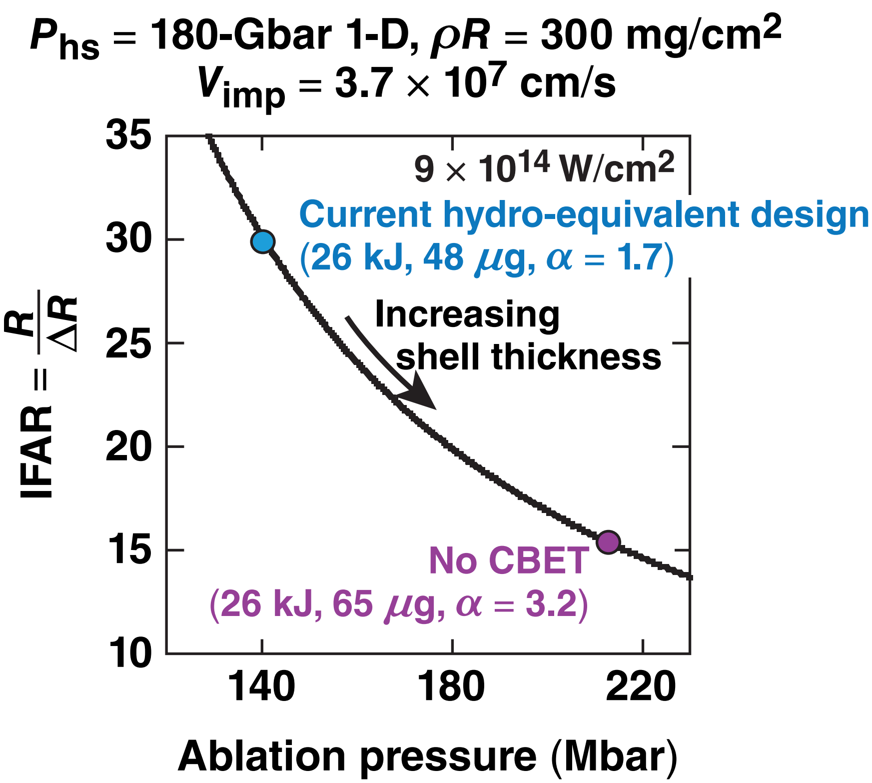
CBET reduces the ablation pressure by 50% in hydro-equivalent OMEGA designs





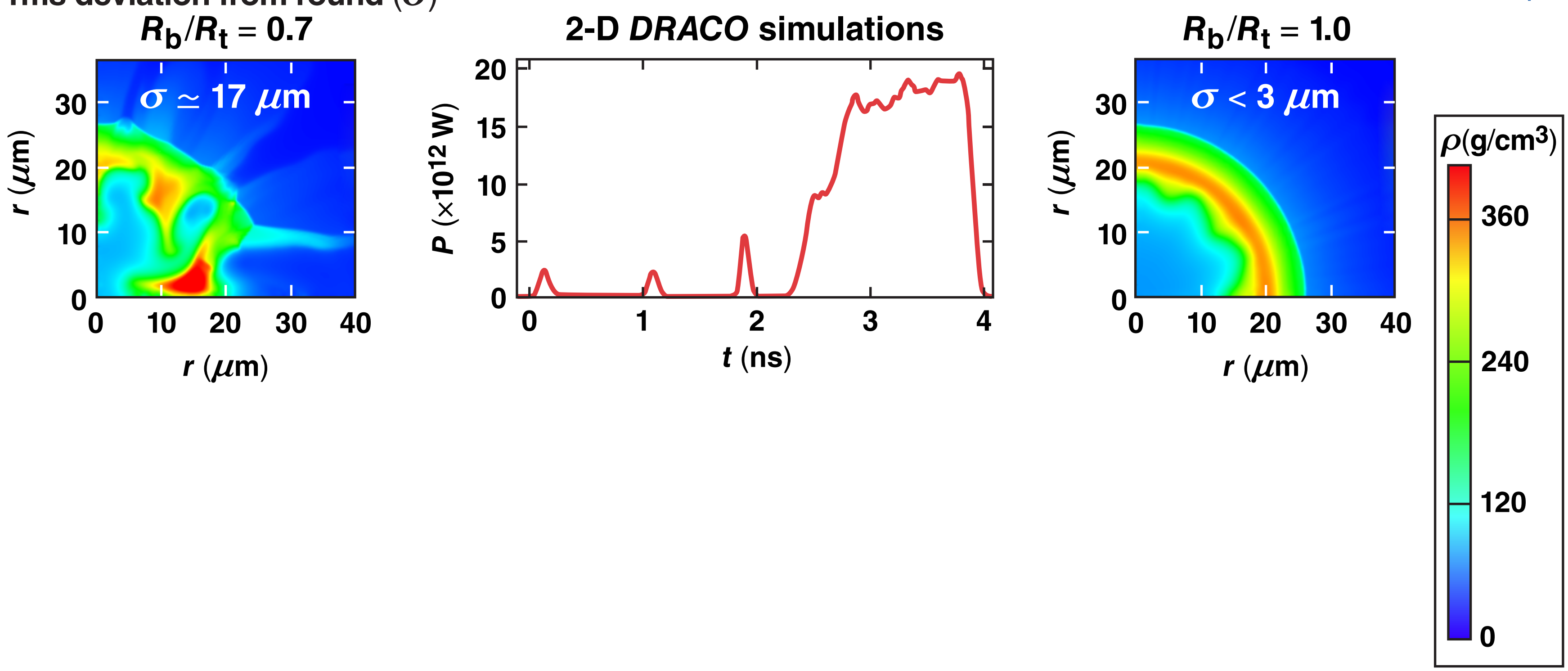
Experiments have demonstrated that CBET can be mitigated by reducing the energy that propagates past the target.

E23469

*V. N. Goncharov *et al*., Phys. Plasmas 21, 056315 (2014).

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

rms deviation from round (σ)



S. P. Obenschain *et al*., Phys. Plasmas 3, 2098 (1996); A. J. Schmitt *et al*., Phys. Plasmas 11, 2716 (2004); I. V. Igumenshchev *et al*. Phys. Rev. Lett. 110, 145001 (2013).

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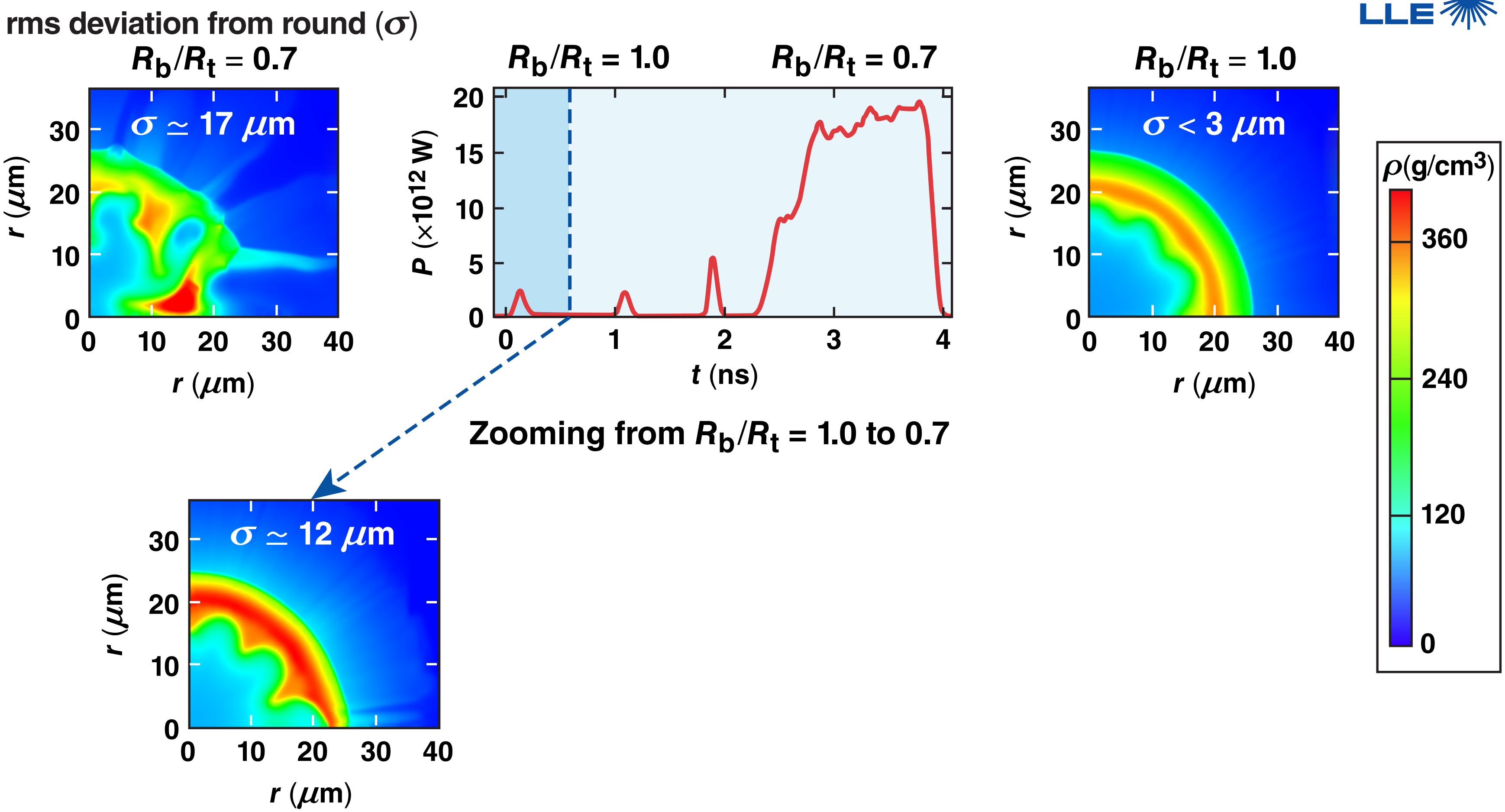

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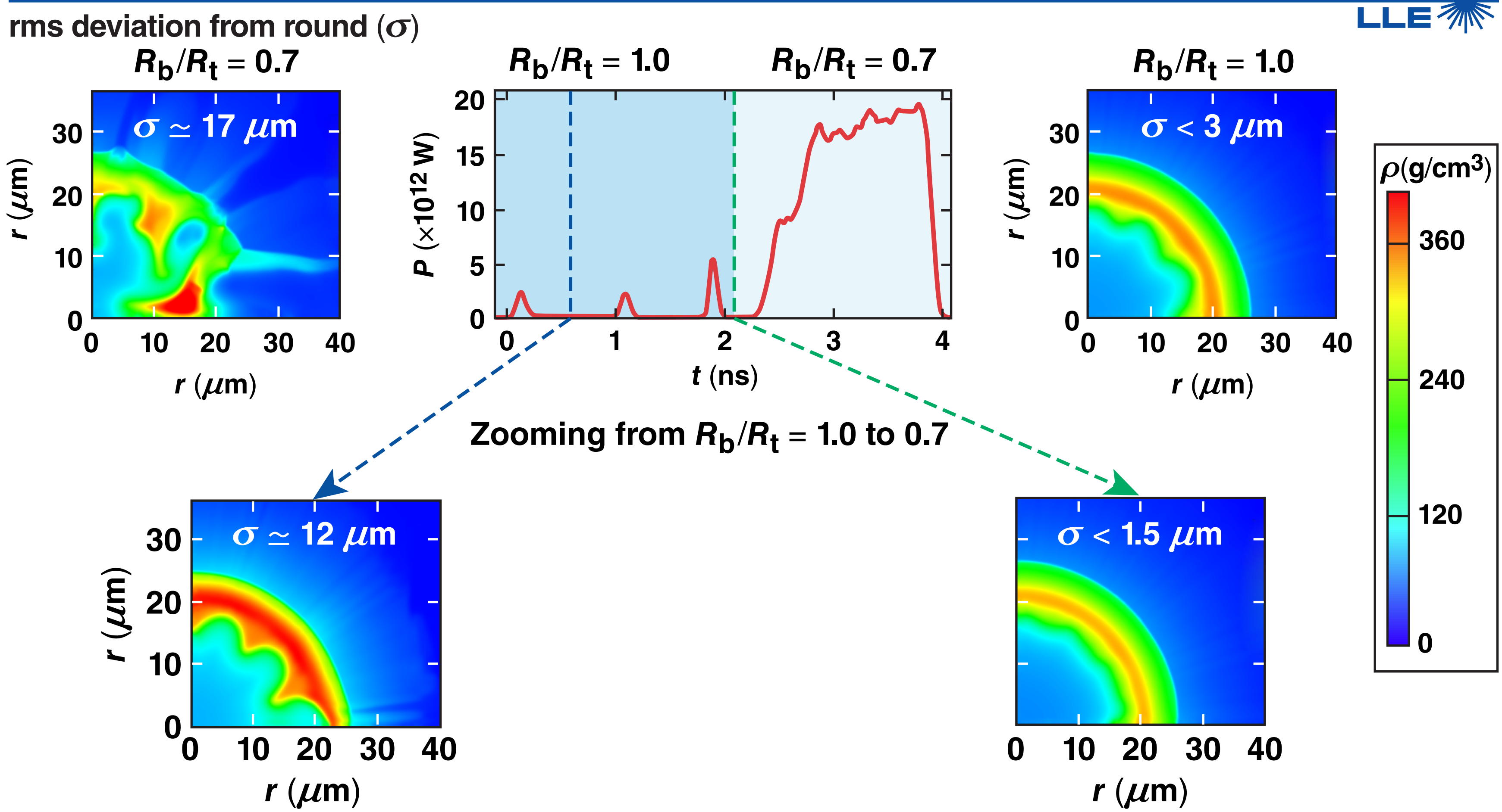

Zooming* after the third picket is predicted to maintain good low-mode uniformity.

*S. P. Obenschain *et al*., Phys. Plasmas 3, 2098 (1996); A. J. Schmitt *et al*., Phys. Plasmas 11, 2716 (2004); I. V. Igumenshchev *et al*. Phys. Rev. Lett. 110, 145001 (2013).

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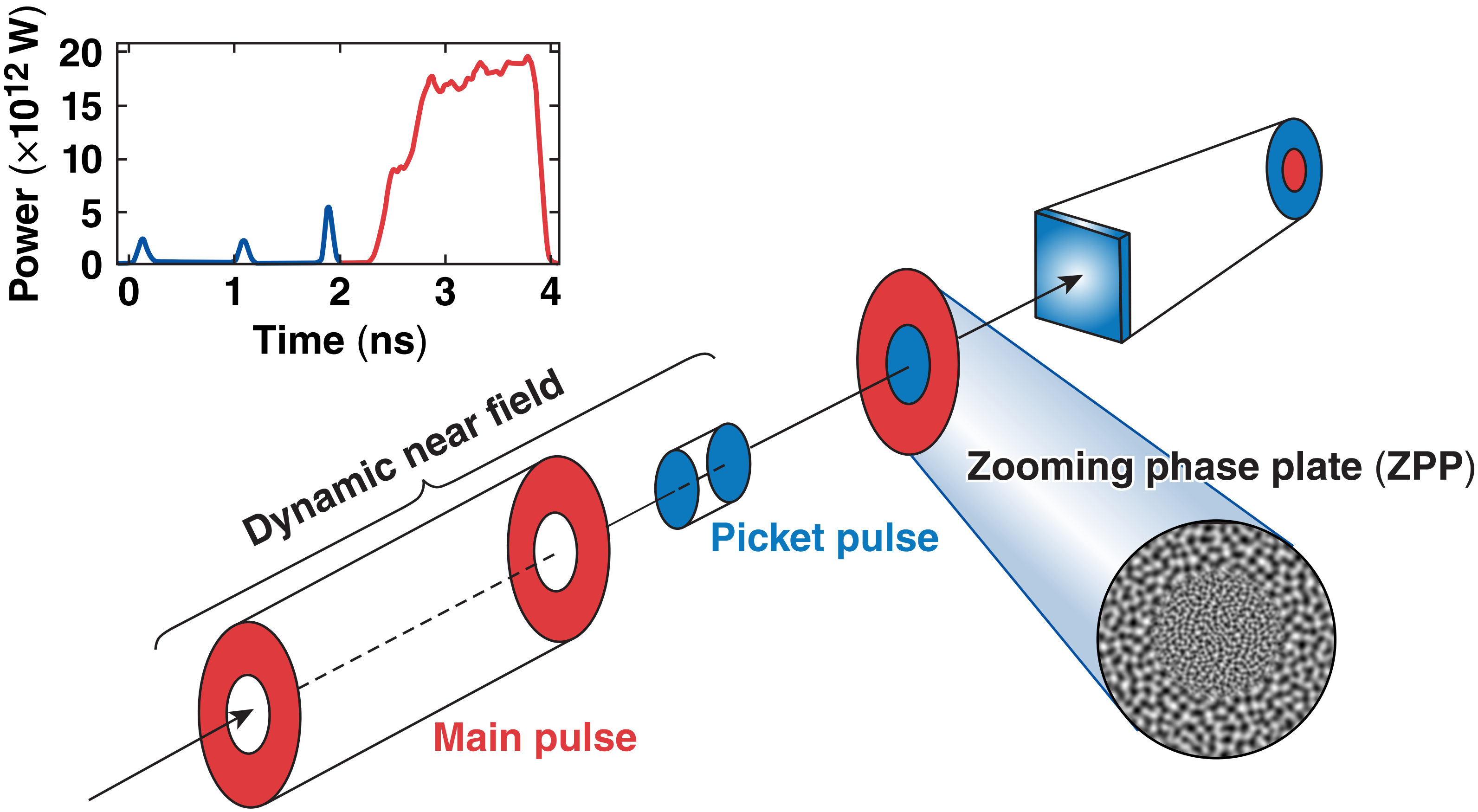
Zooming can be implemented on OMEGA using a radially varying phase plate and a dynamic near field

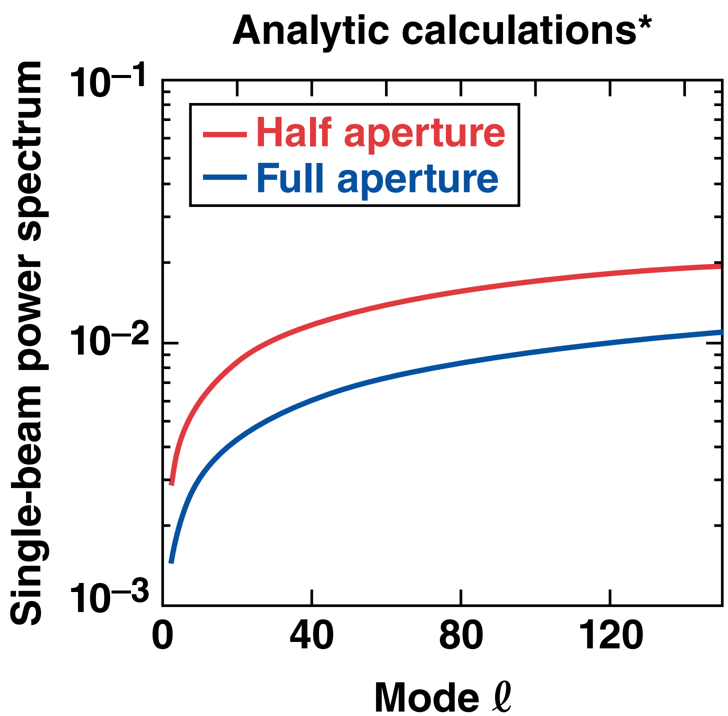


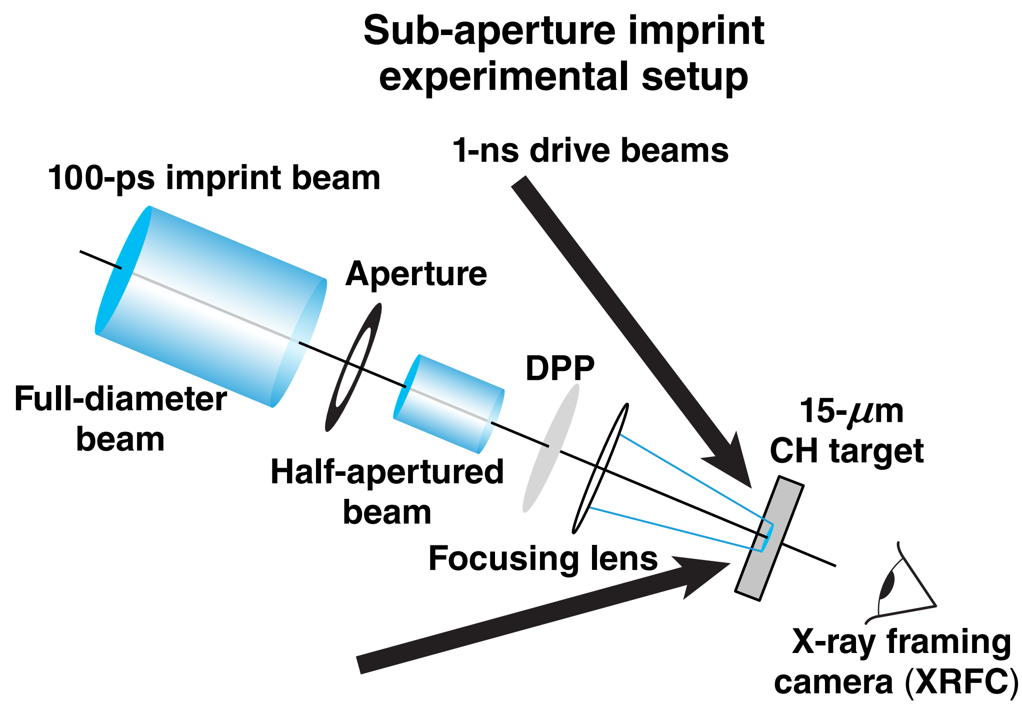
E22039b

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

The smaller-diameter laser beams used during the pickets increase the imprint power spectrum over the modes with the highest Rayleigh–Taylor growth rates

UR LLE



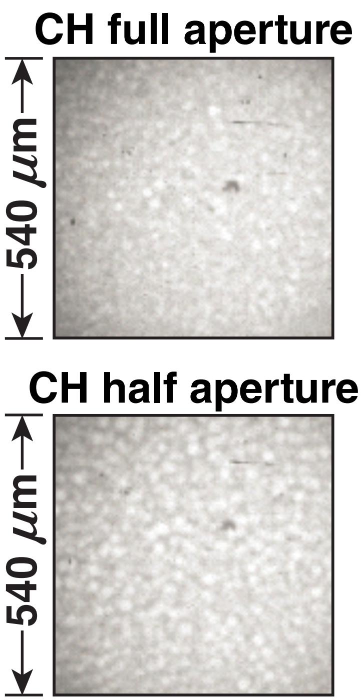


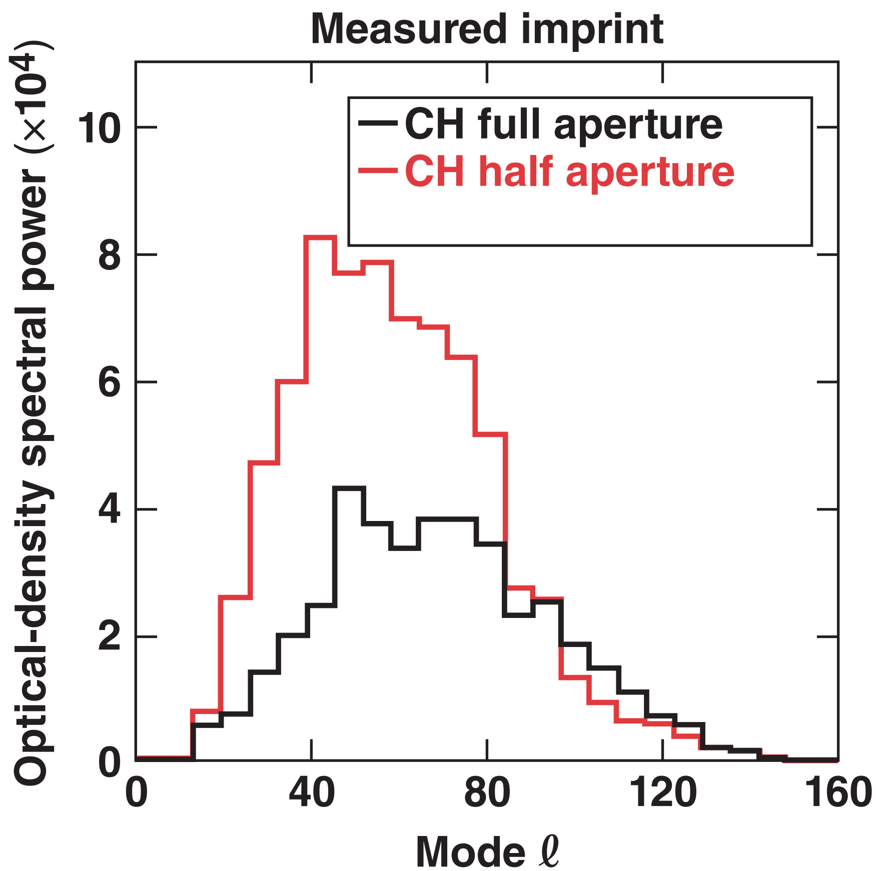
The effect of an increased imprint power spectrum resulting from the reduced beam diameters was tested in planar experiments.

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

E22168a

The sub-aperture imprint power spectrum was measured to produce increased imprint levels over the mid-frequency modes



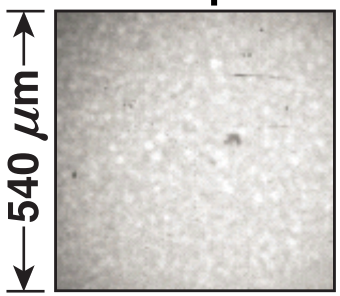


E22927b

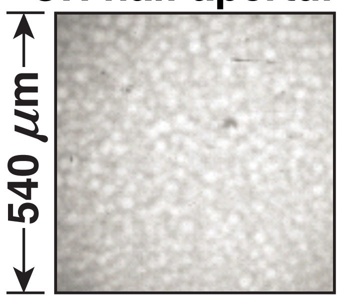
X rays from a thin, high-Z layer (600-Å Pd) were used to reduce the imprint*

UR LLE

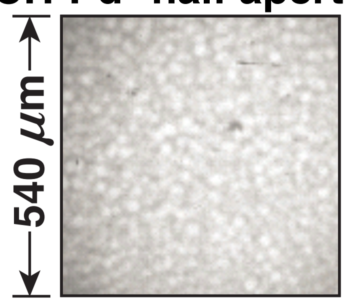
CH full aperture



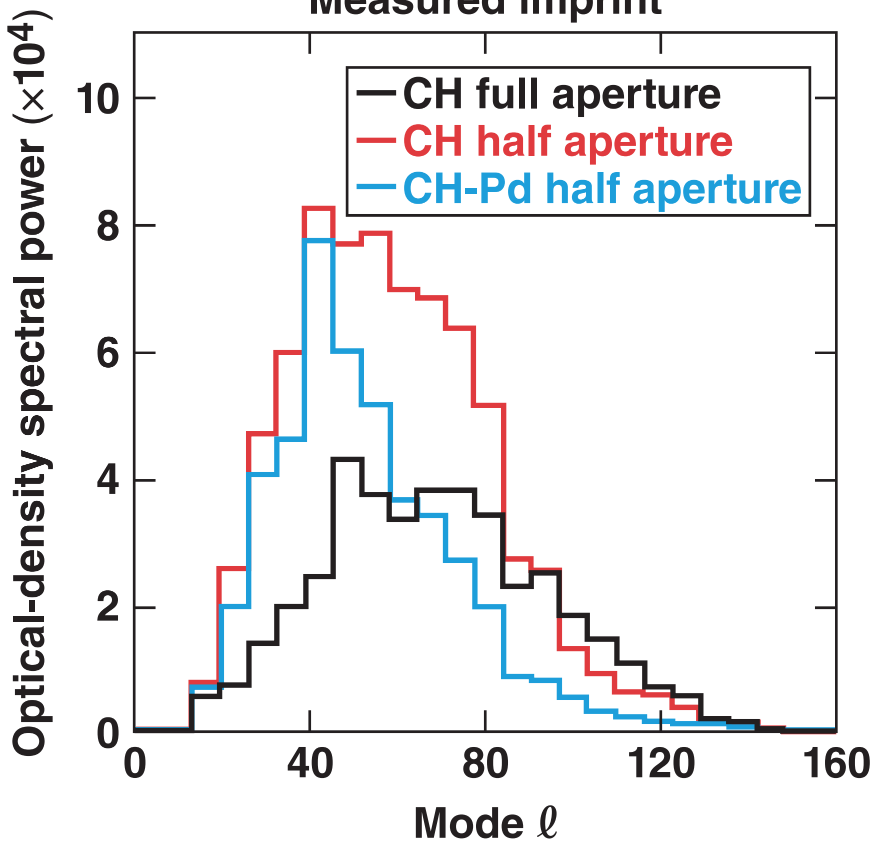
CH half aperture



CH-Pd* half aperture



Measured imprint



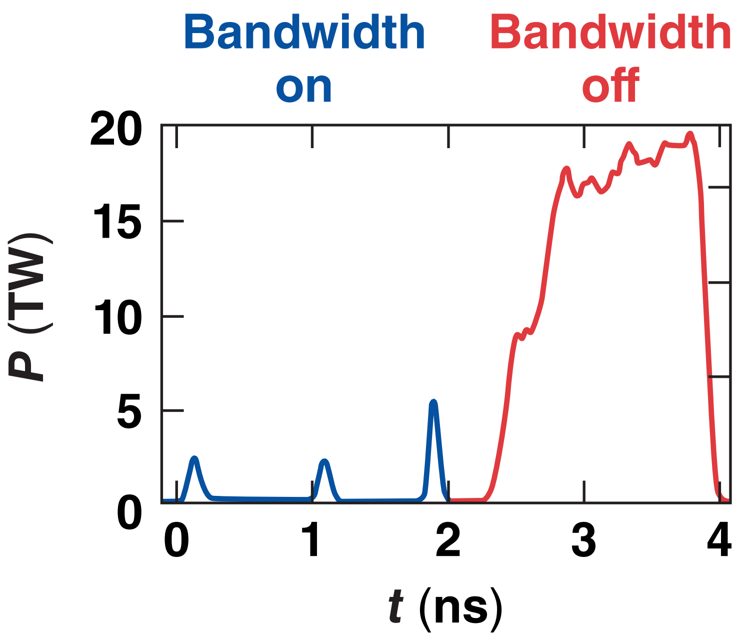
Recent results suggest that thicker Pd or 400 Å of gold will supress the low-mode laser imprint.

*S. P. Obenschain *et al*., Phys. Plasmas 3, 2098 (1996); M. Karasik *et al*., Bull. Am. Phys. Soc. 58, 370 (2013).

E22927d

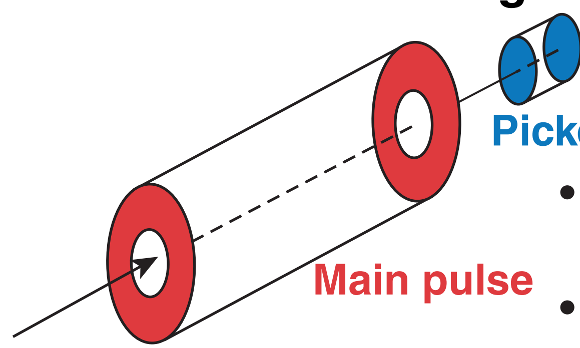
A multipulse driver line is currently being implemented on OMEGA to support CBET mitigation projects

Dynamic bandwidth reduction



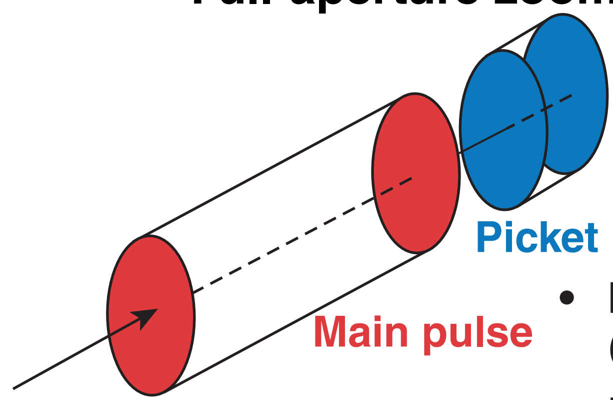
Dynamic near field

Coaxial zooming



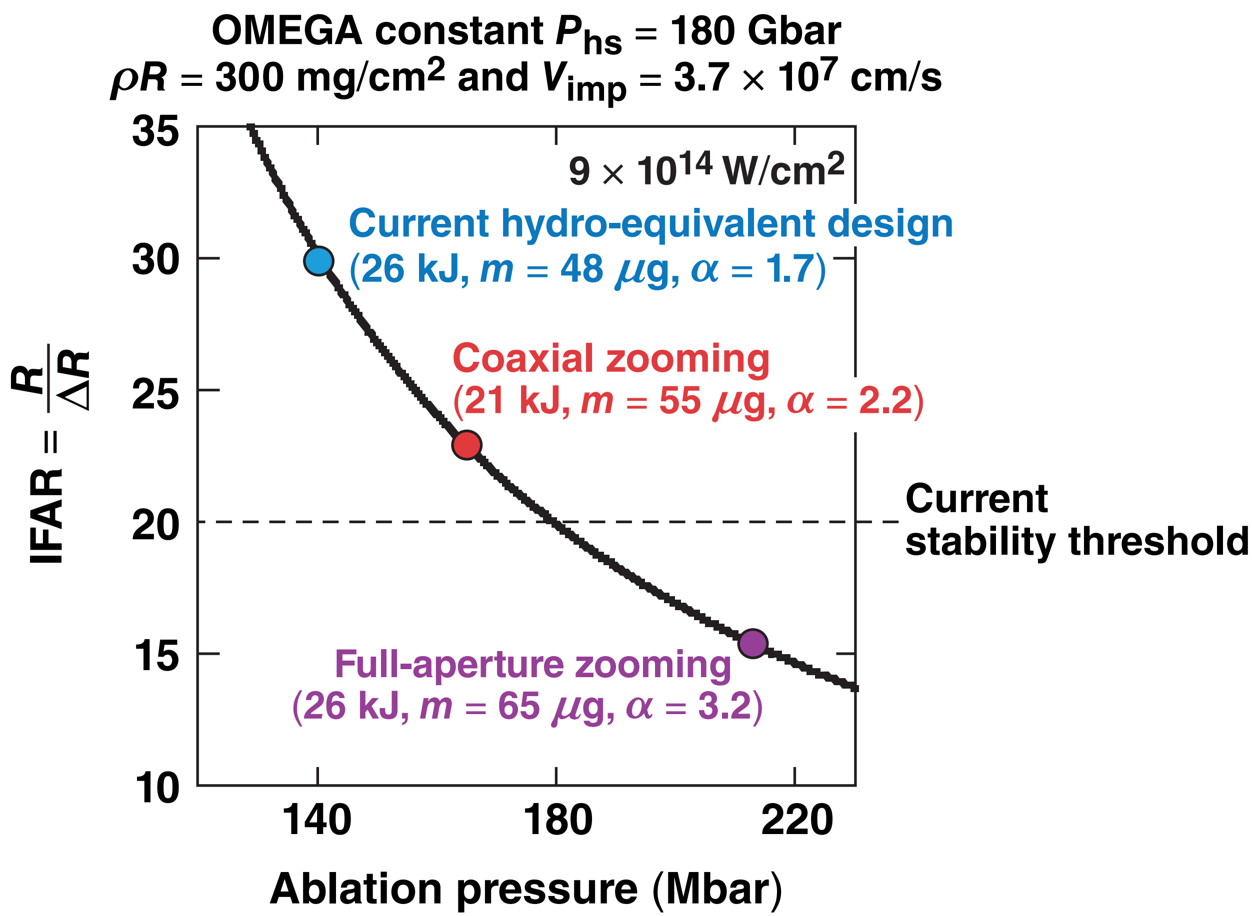
- Limited energy (21 kJ)
- Reduced smoothing

Full-aperture zooming



- Full energy (28 kJ)
- Enhanced smoothing

Full-aperture zooming provides a viable path to hydro-equivalence on OMEGA



A full-aperture zooming scheme (that will maintain excellent smoothing) is being developed that uses bandwidth to control the focal-spot size.

E22929a

Summary/Conclusions

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