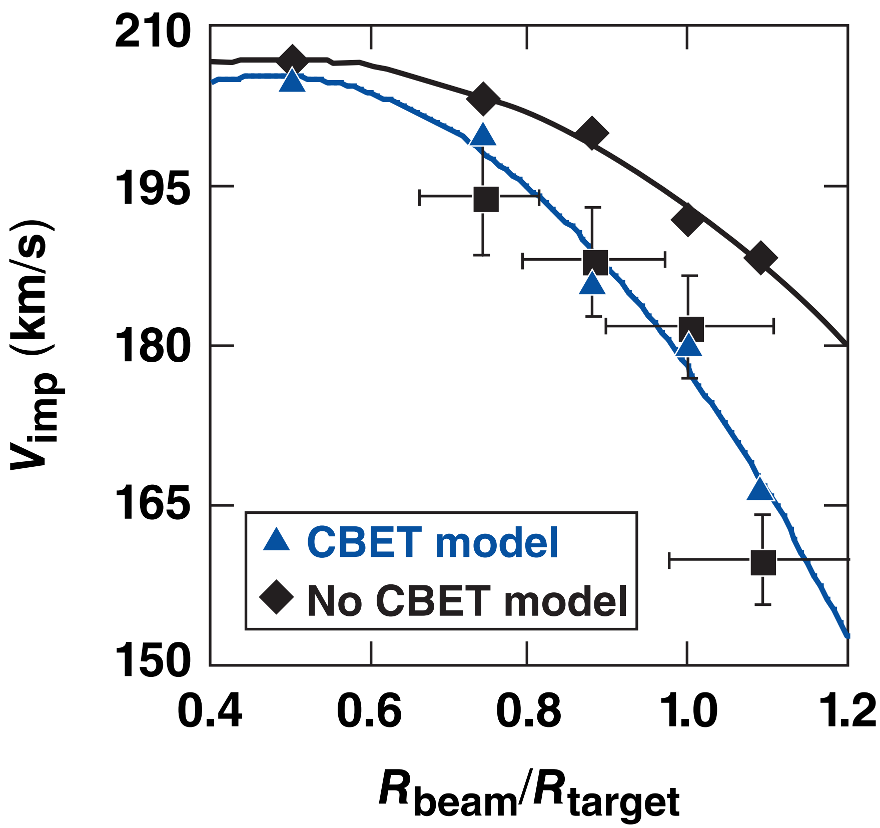
Mitigation of Cross-Beam Energy Transfer in Direct-Drive Implosions



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42nd Annual Anomalous Absorption Conference
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Summary

Reducing the radius of the laser spots mitigates cross-beam energy transfer (CBET)

- All measurements are consistent with the reduction of CBET when the laser spot size is reduced
- A 20% reduction in spot size leads to a
  - 17% increase in implosion velocity
- A two-state zooming of spot diameter is proposed to smooth the laser imprint and reduce cross-beam energy transfer

Cross-beam energy transfer modeling is required to match the experimental observables (scattered light, implosion velocity, and bang time).

Collaborators

UR LLE

I. V. Igumenshchev, D. T. Michel, D. H. Edgell, R. Follett, J. H. Kelly,
T. J. Kessler, W. Seka, D. D. Meyerhofer, V. N. Goncharov, and J. F. Myatt

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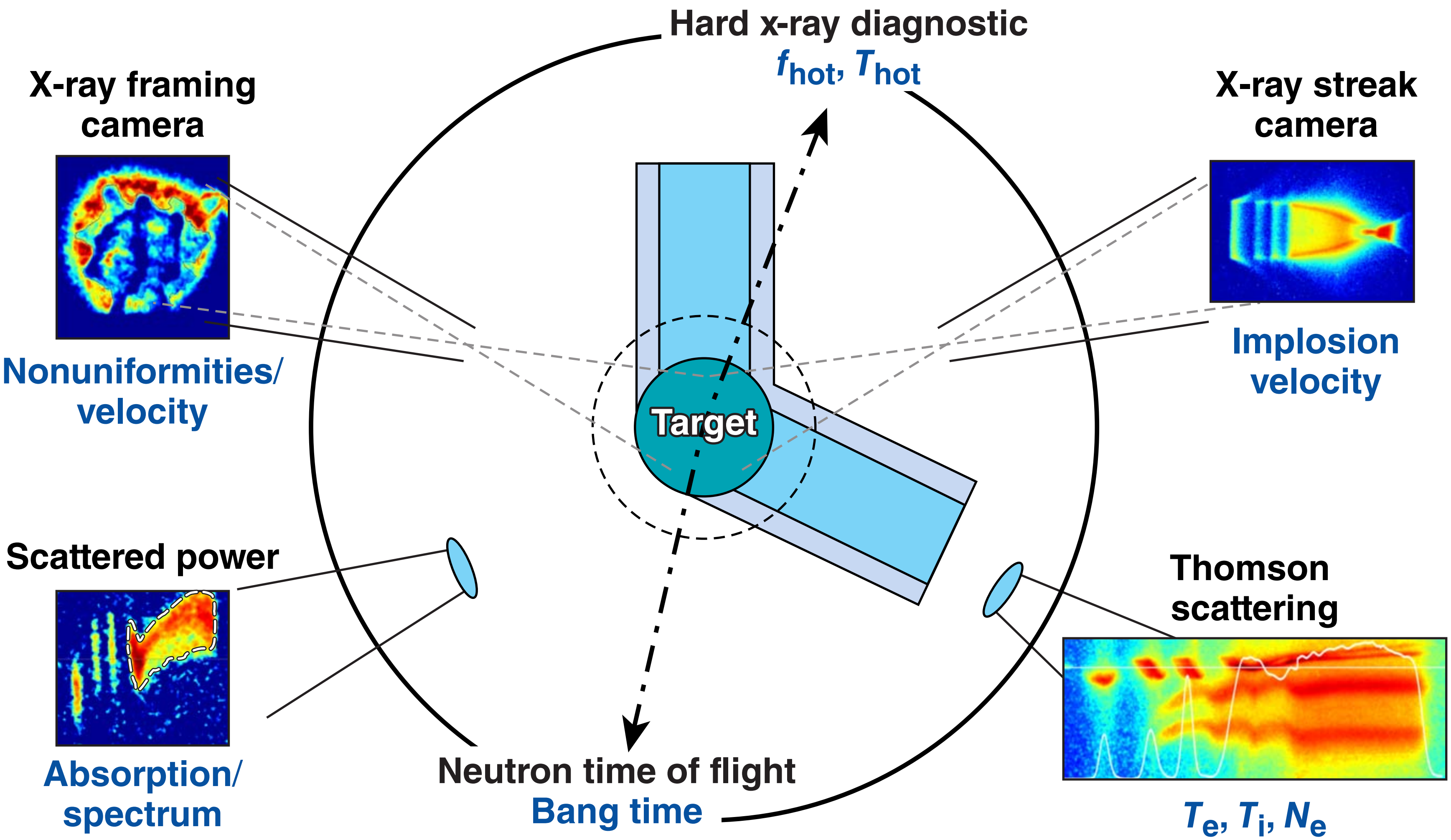
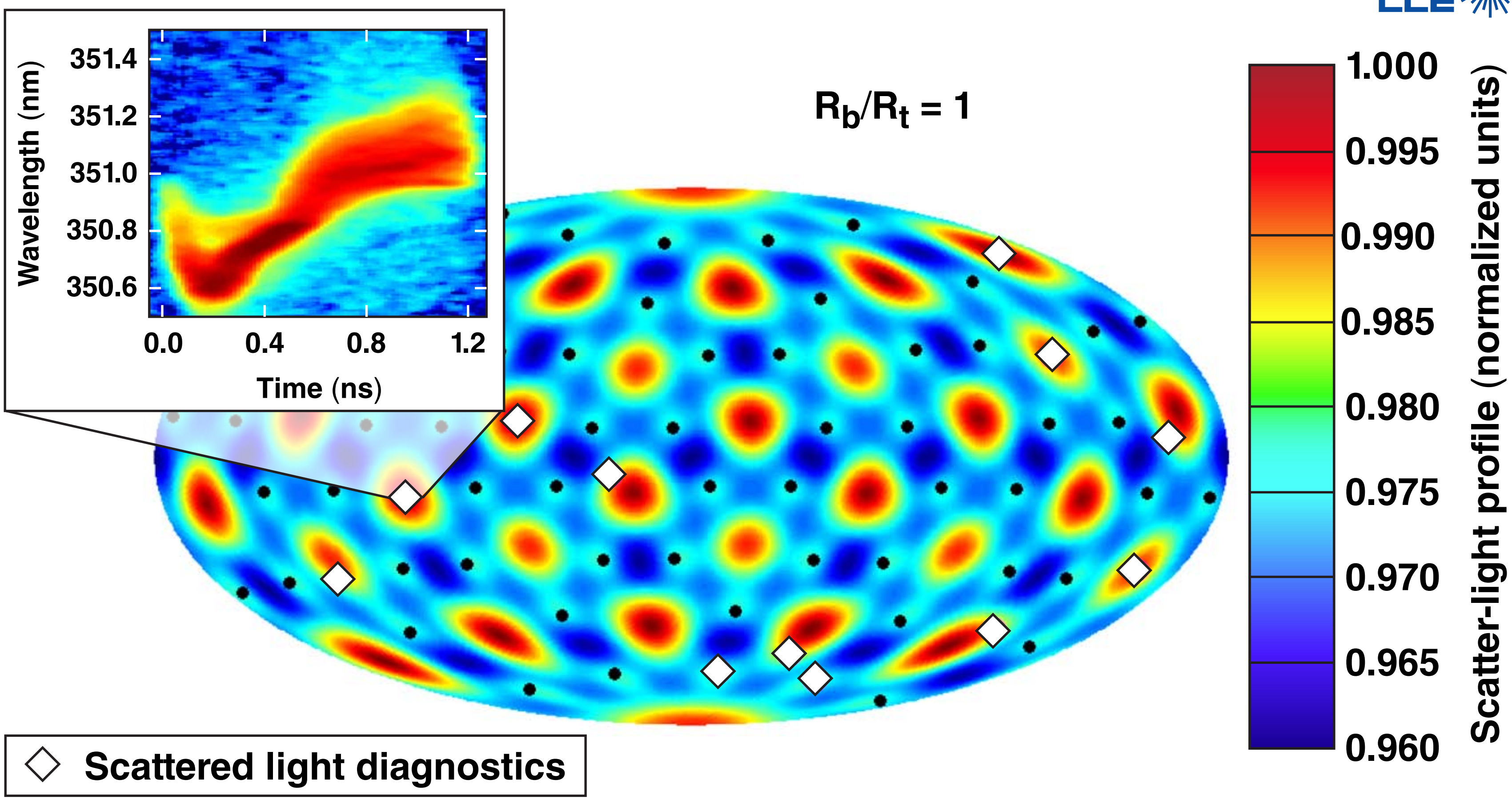
Low-adiabat, direct-drive–implosion experiments are well diagnosed on the OMEGA Laser System



E20335b

Light scattered from the target uniformly illuminates the chamber wall

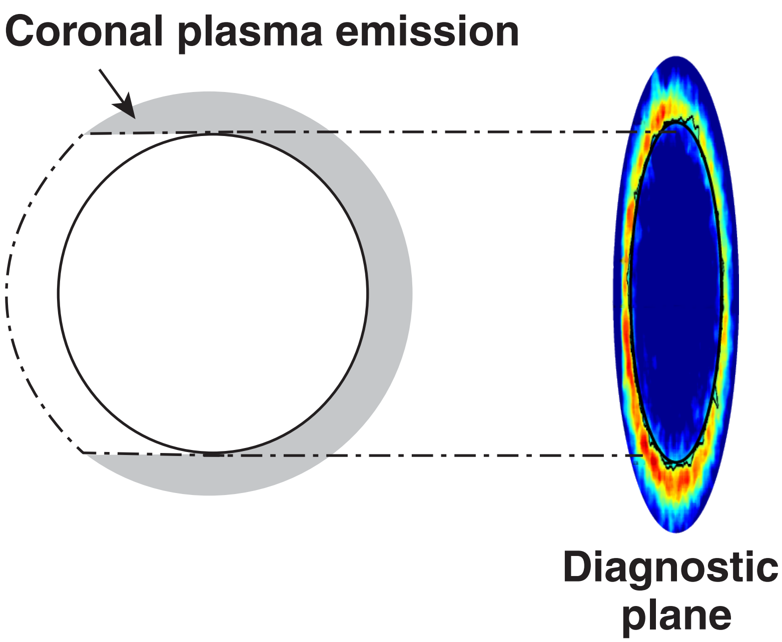


The scattered power is recorded at many locations around the OMEGA target chamber to measure the total absorption (5% accuracy).

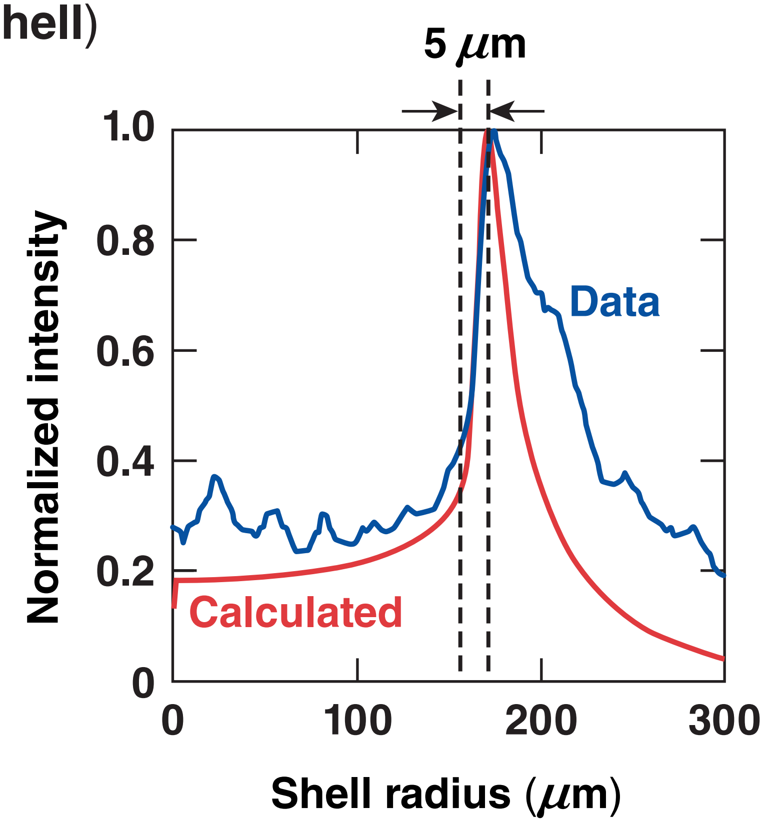
*D. Edgell, "Mitigation of Cross-Beam Energy Transfer in Polar-Drive Implosions," this conference.

X-ray self-emission is used to measure the shell trajectory and nonuniformities

- A steep gradient in emission is created by the rapid increase in density at the ablation surface (optically thick shell)



Absorption length for 1 keV is 10 to 15 μm for 1 g/cc CH

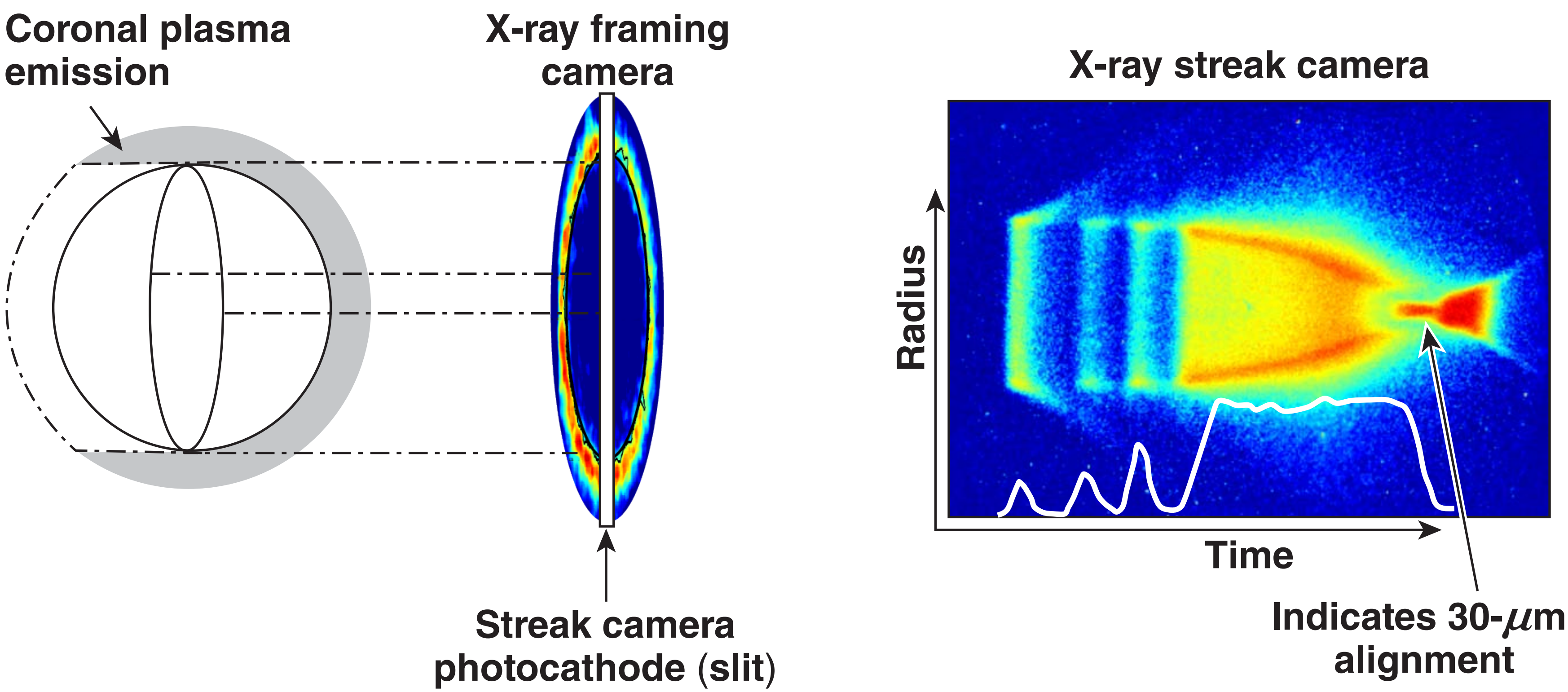


The shell radii on OMEGA are measured with an accuracy of 1 μm and velocity is measured to within 2%.

* D. T. Michel *et al.*, "Shell Trajectory Measurements from Direct-Drive Experiments," to be published in Review of Scientific Instruments.

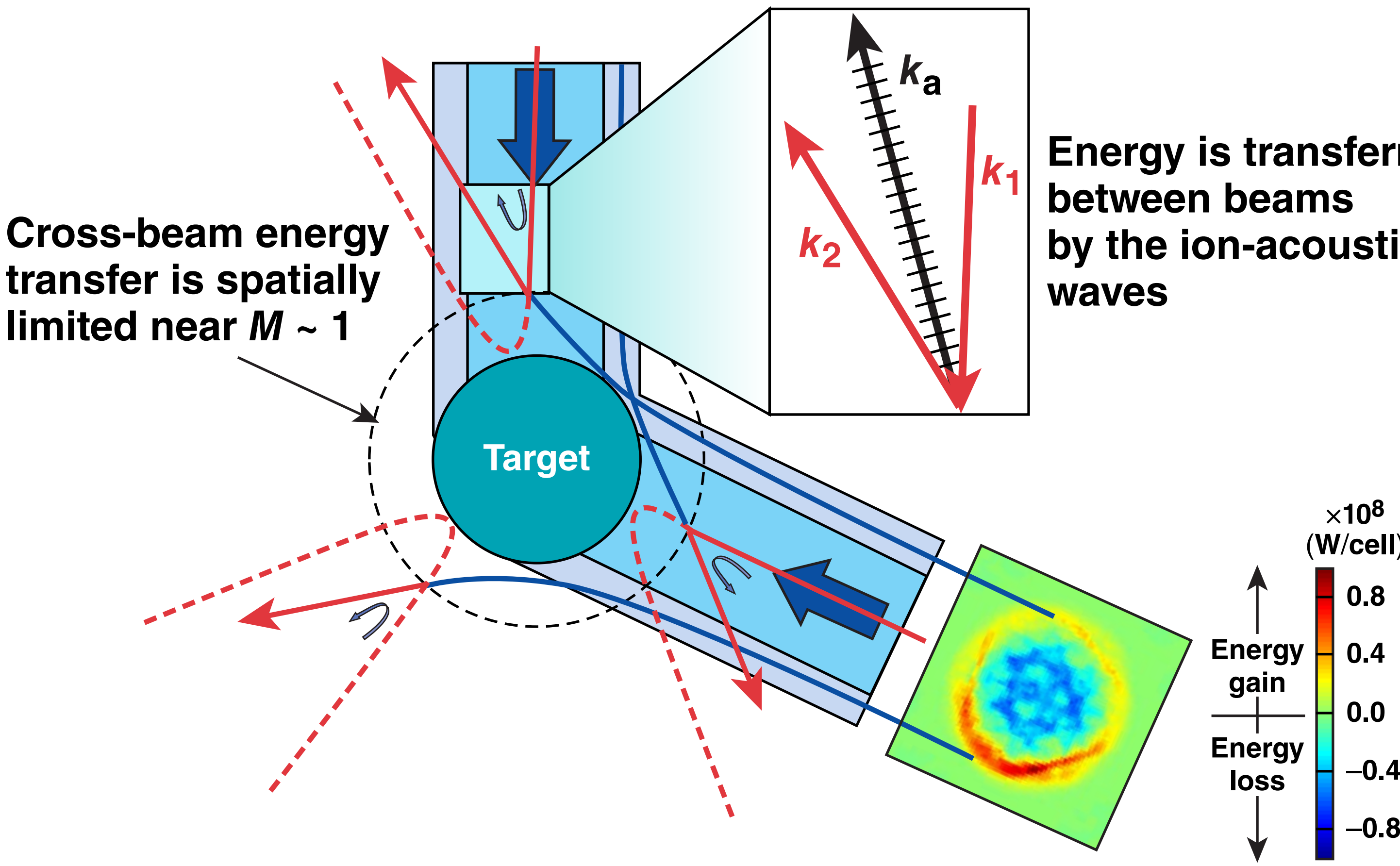
E21313

This technique is adapted to a streak camera to provide absolute timing



These diagnostics are used to measure the shell trajectory and infer the hydrodynamic efficiency.

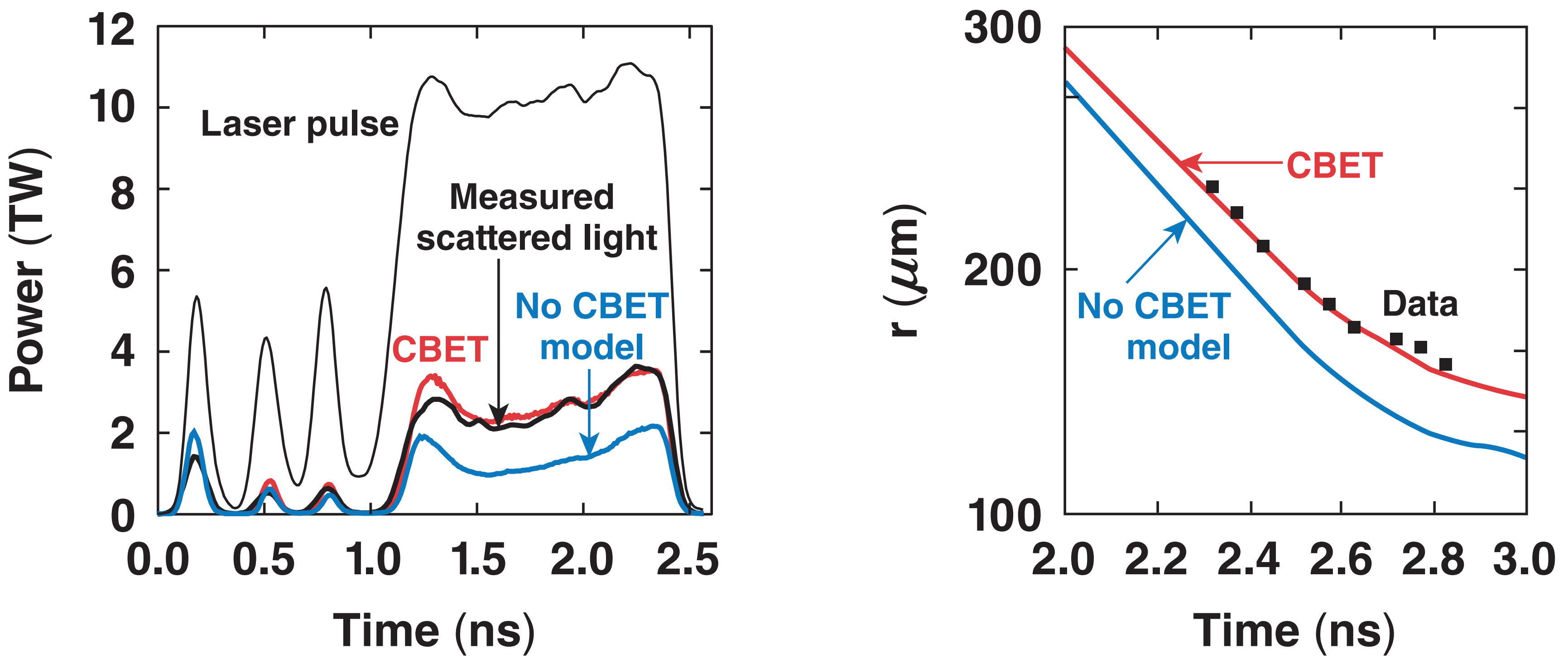
Cross-beam energy transfer (CBET) reduces the energy coupled to the fusion capsule



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

P. Michel *et al.*, Phys. Rev. Lett. 102, 025004 (2009).
J. F. Myatt *et al.*, Phys. Plasmas 11, 3394 (2004).
W. Seka *et al.*, Phys. Plasmas 15, 056312 (2008).

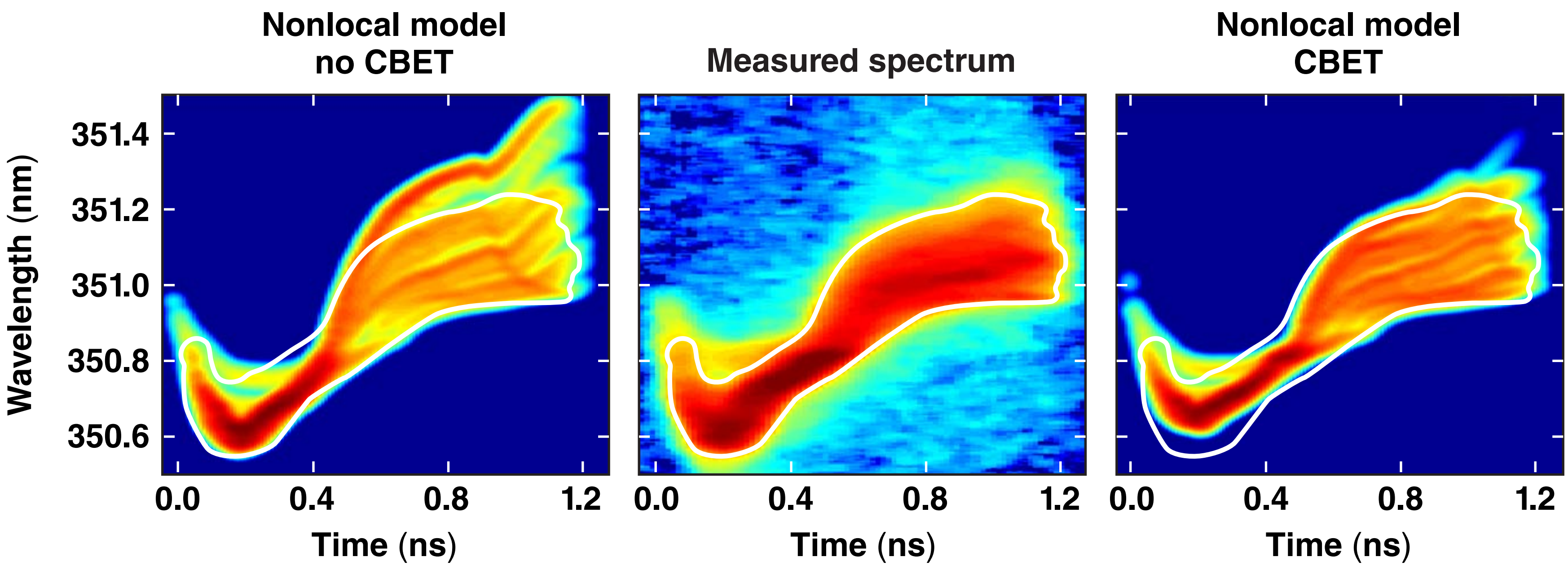
Cross-beam energy transfer modeling is required to match the experimental observables (scattered light, implosion velocity, and bang time)



E21315

*I. V. Igumenshchev *et al.*, Phys. Plasmas 19, 056314 (2012).

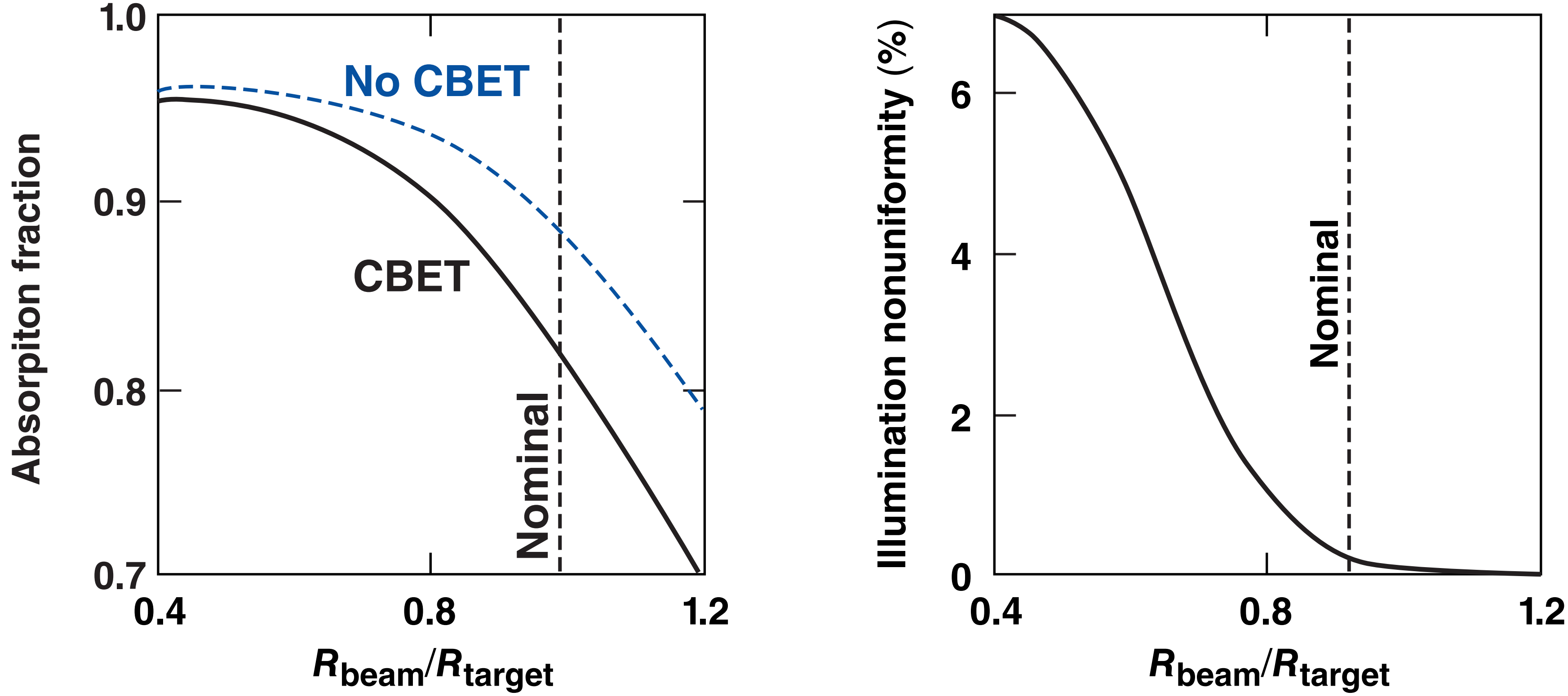
The scattered-light spectrum provides a measure of the underdense plasma conditions



The scattered-light spectrum demonstrates the need to include CBET and nonlocal modeling.

E19907a

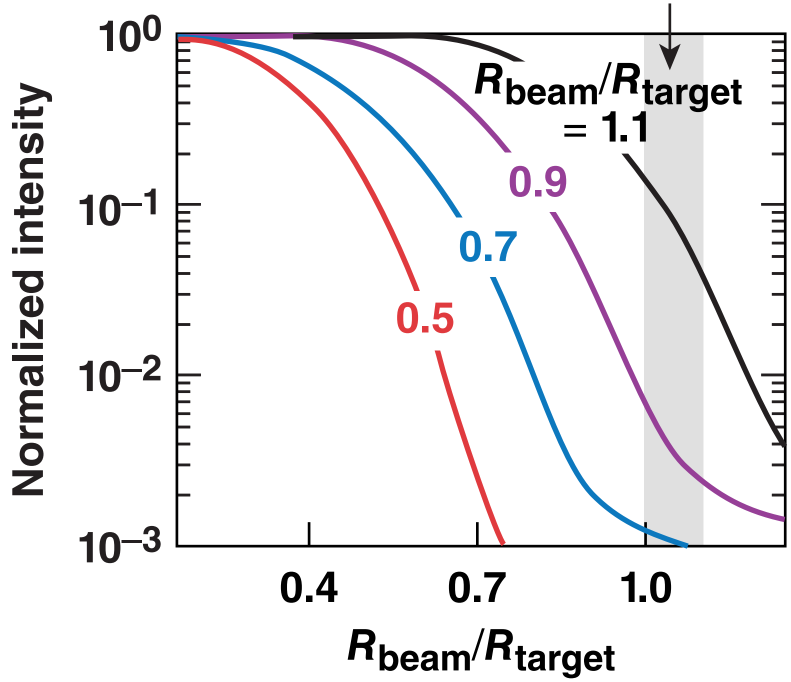
Removing the energy bypassing the target will reduce cross-beam energy transfer at the cost of increased illumination nonuniformities

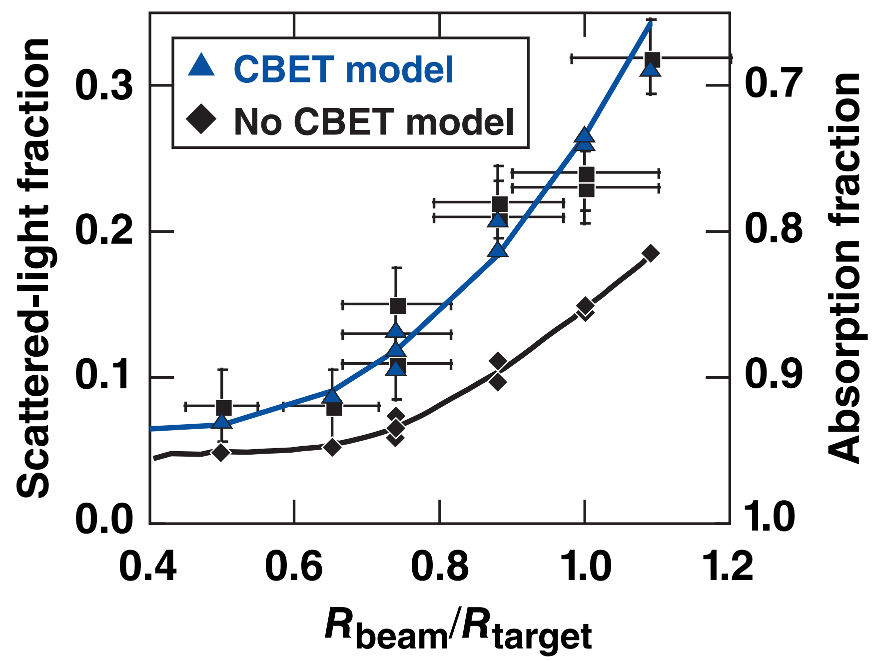


E21316

*I. V. Igumenshchev *et al*., Phys. Plasmas 19, 056314 (2012).

Experiments on OMEGA employed various diameter laser beams to reduce cross-beam energy transfer



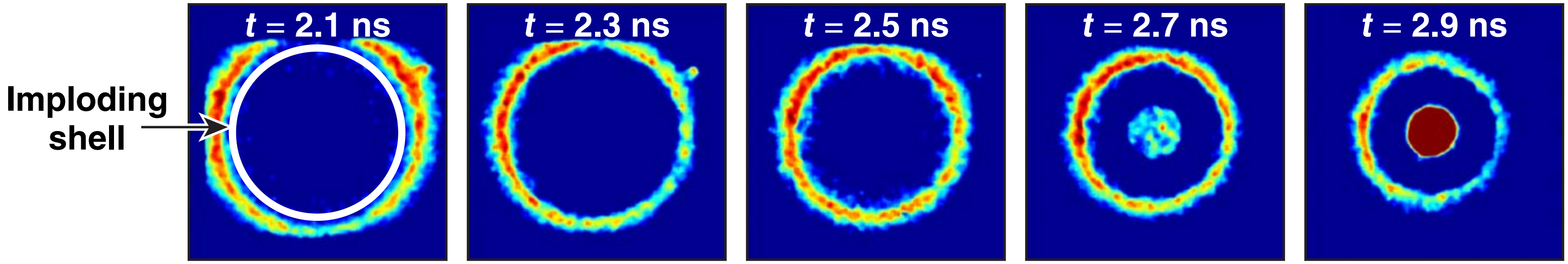


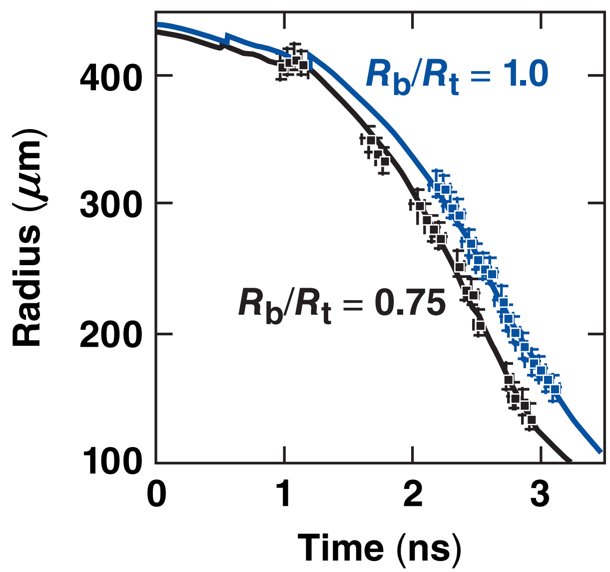
A 20% reduction in beam radius results in a 15% increase in the laser absorption.

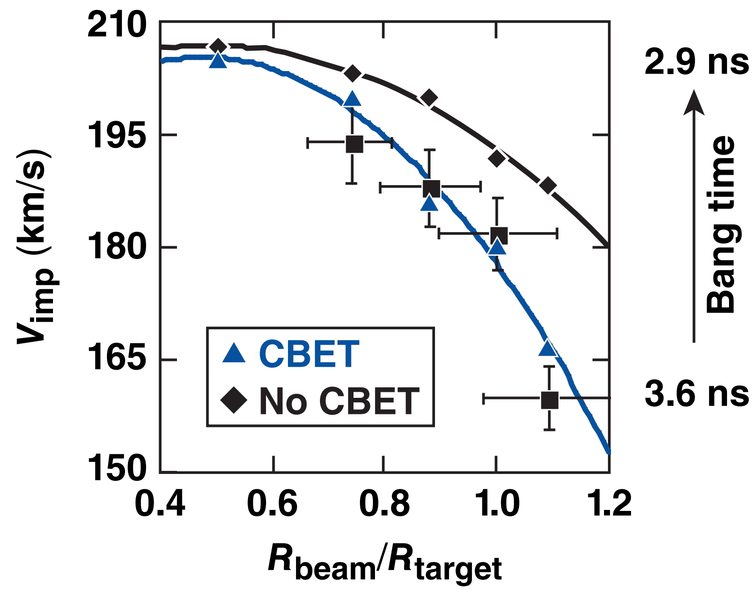
E20145c

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

The shell trajectory measurements* distinguish between the different models in the hydrocodes







A 20% reduction in beam radius results in a 15% increase in absorption and a 17% increase in implosion velocity.

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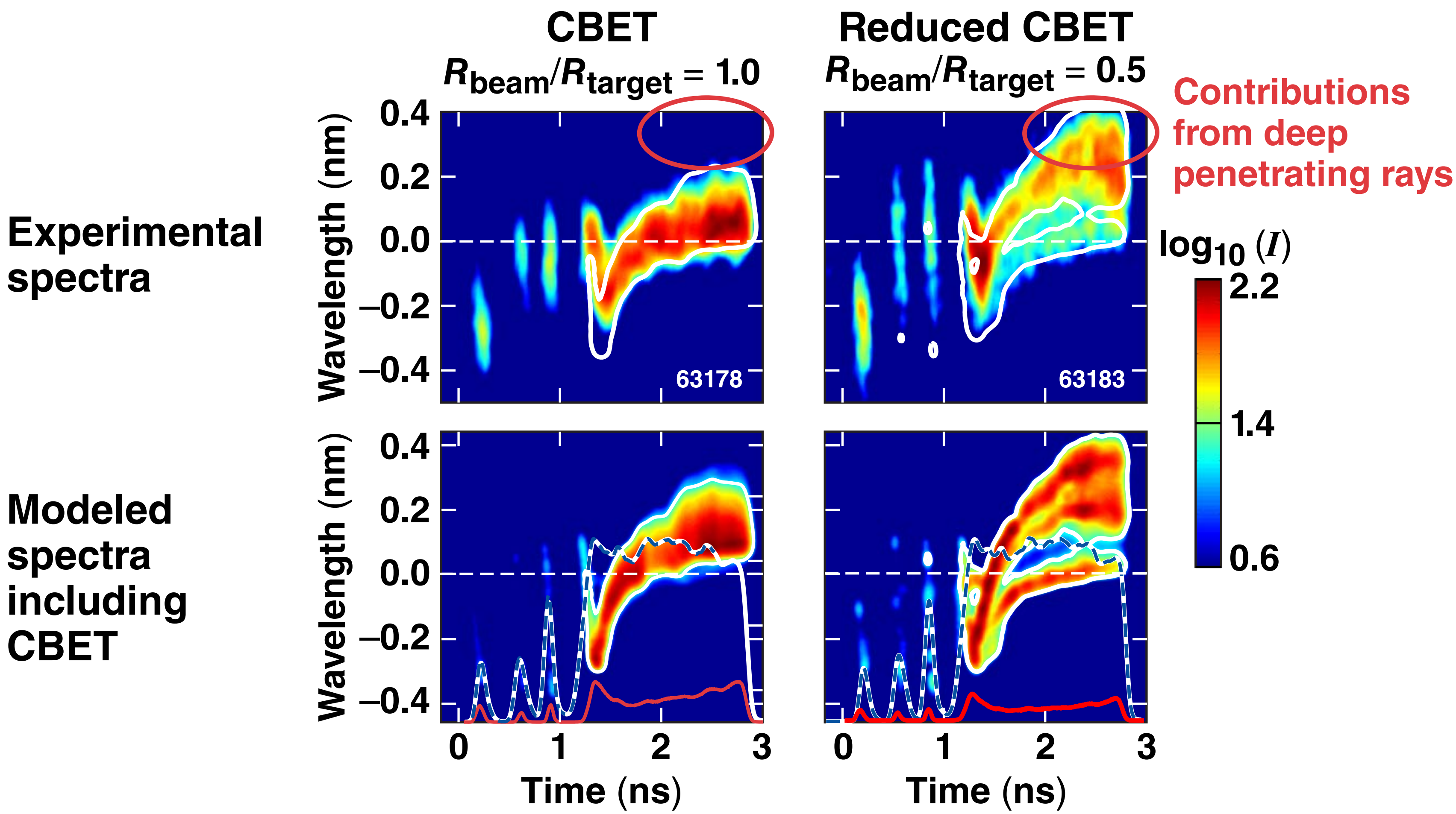
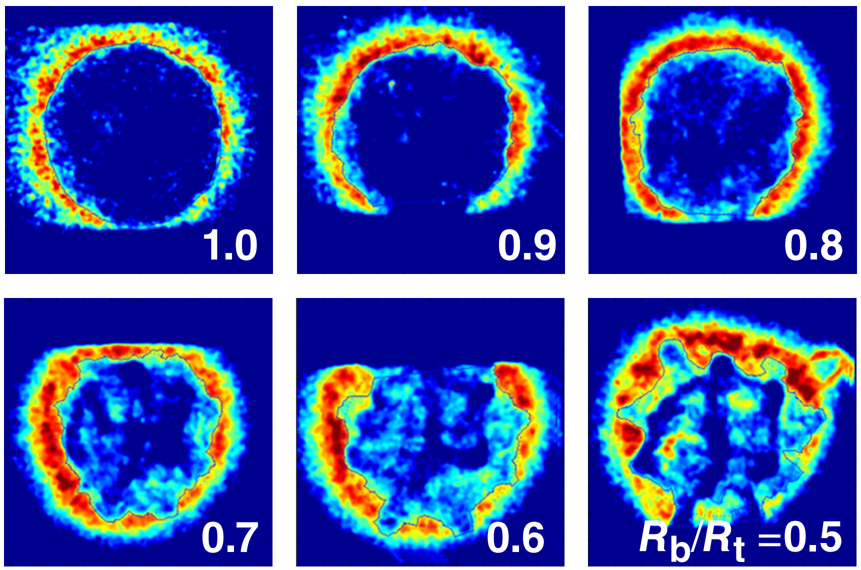
E20337b

This increased hydro-efficiency is a result of increased coupling of the near-radial rays that penetrate to the critical surface and reduced CBET

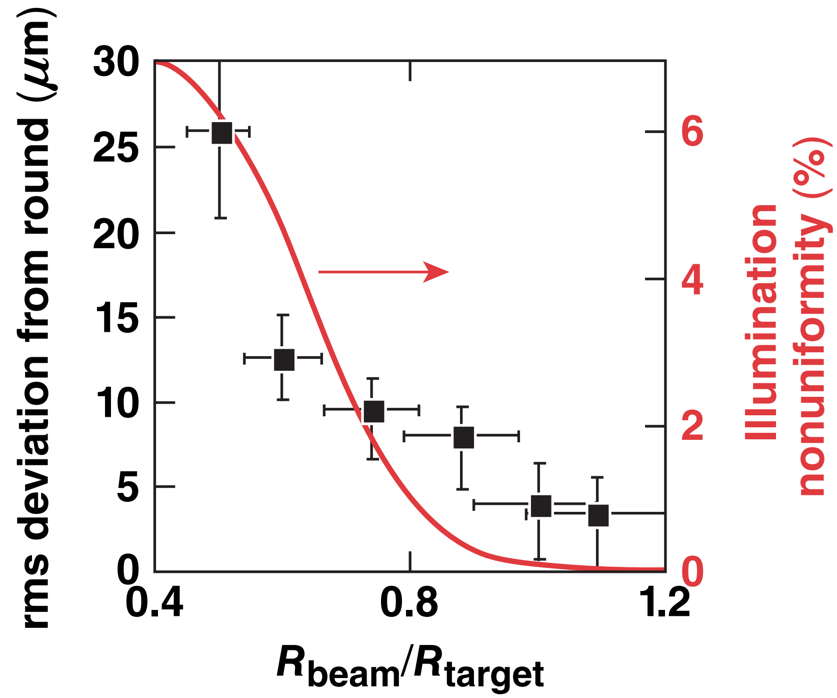


E20481c

Reducing the overlapped illumination uniformity results in nonuniformities on the imploding shell



Convergence ratio = 2.5

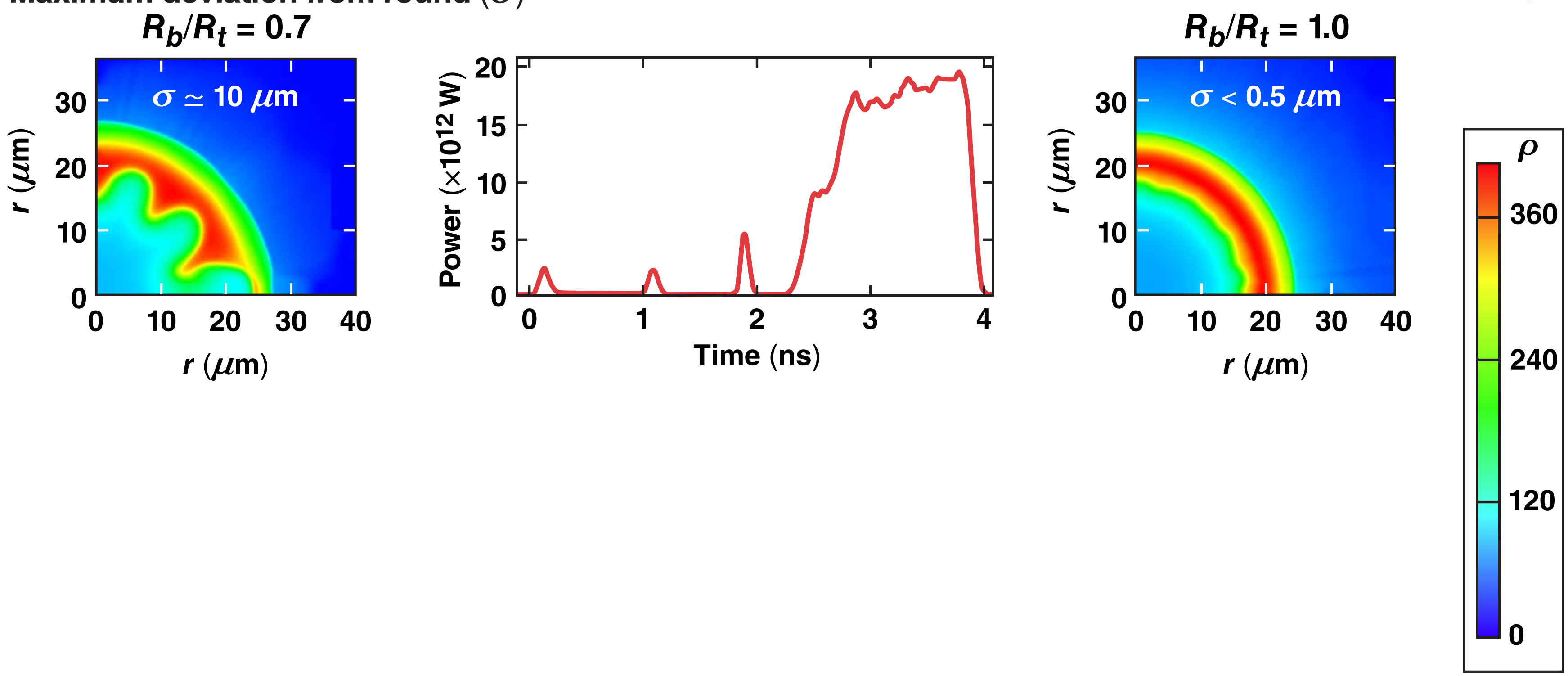


Nonuniformities are measured when cross-beam energy transfer is mitigated.

U1265c

A two-state zooming is proposed to smooth laser imprint and reduce CBET during the main drive

Maximum deviation from round (σ)



E21317a

A two-state zooming is proposed to smooth laser imprint and reduce CBET during the main drive

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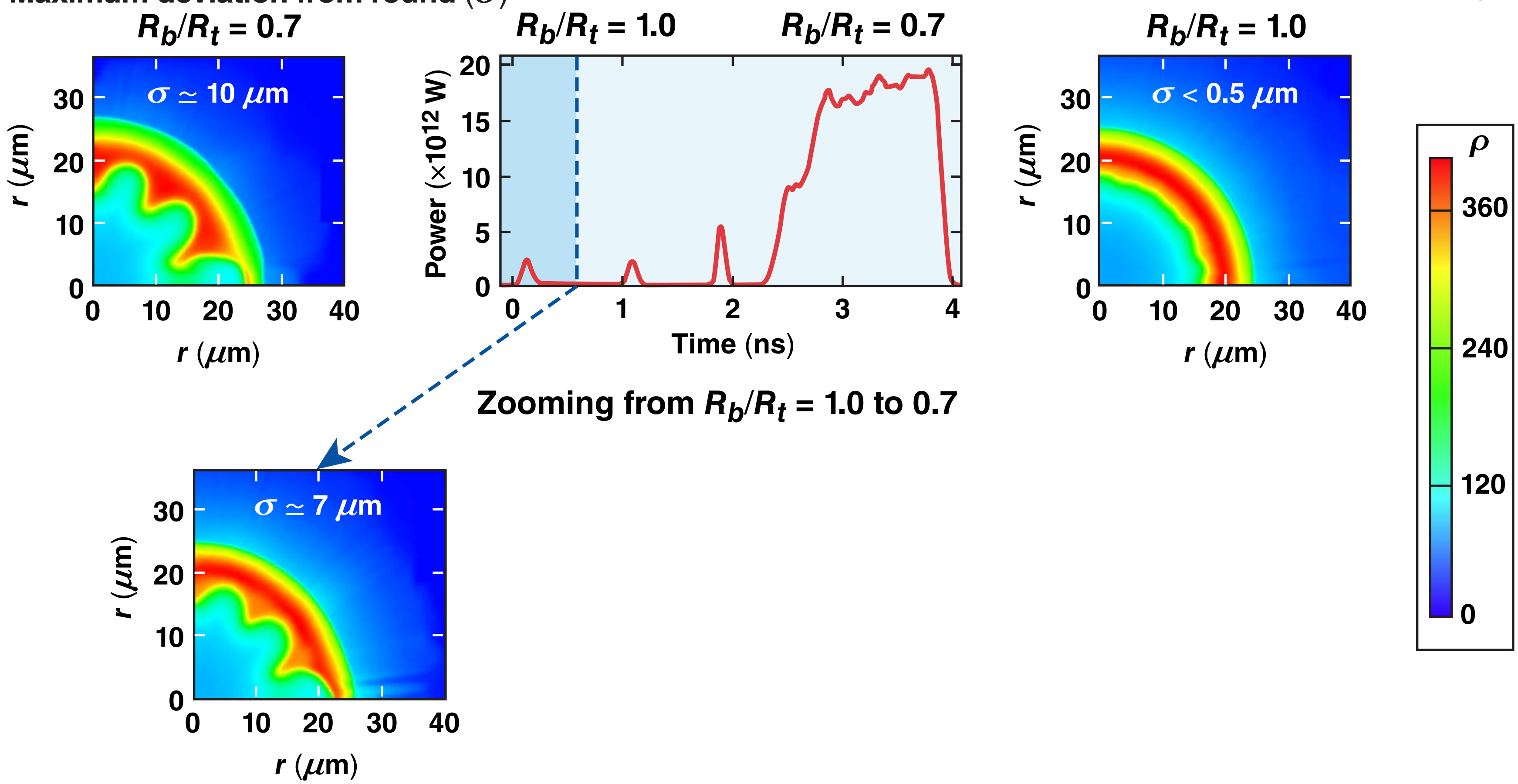

E21317b

A two-state zooming is proposed to smooth laser imprint and reduce CBET during the main drive

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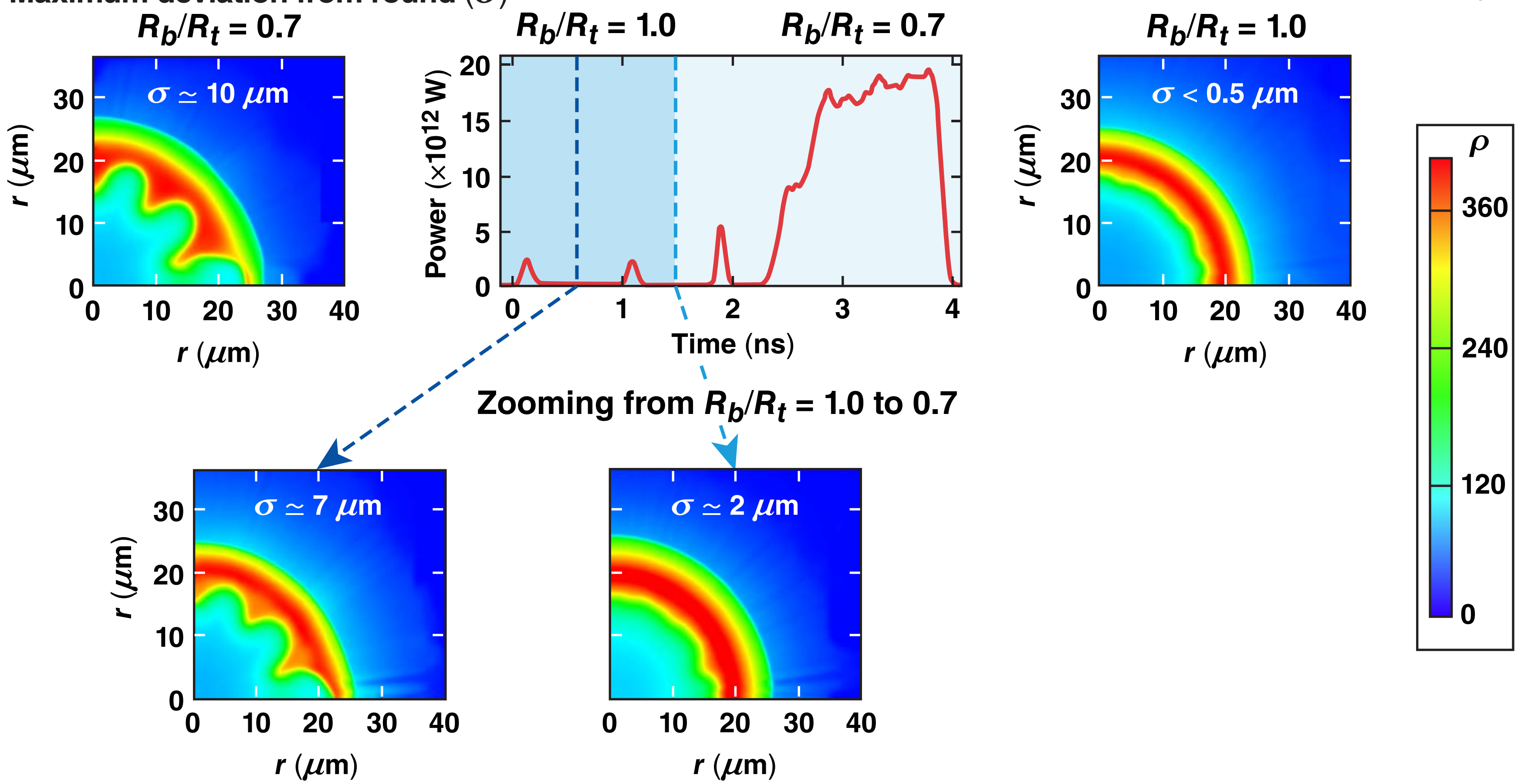

E21317c

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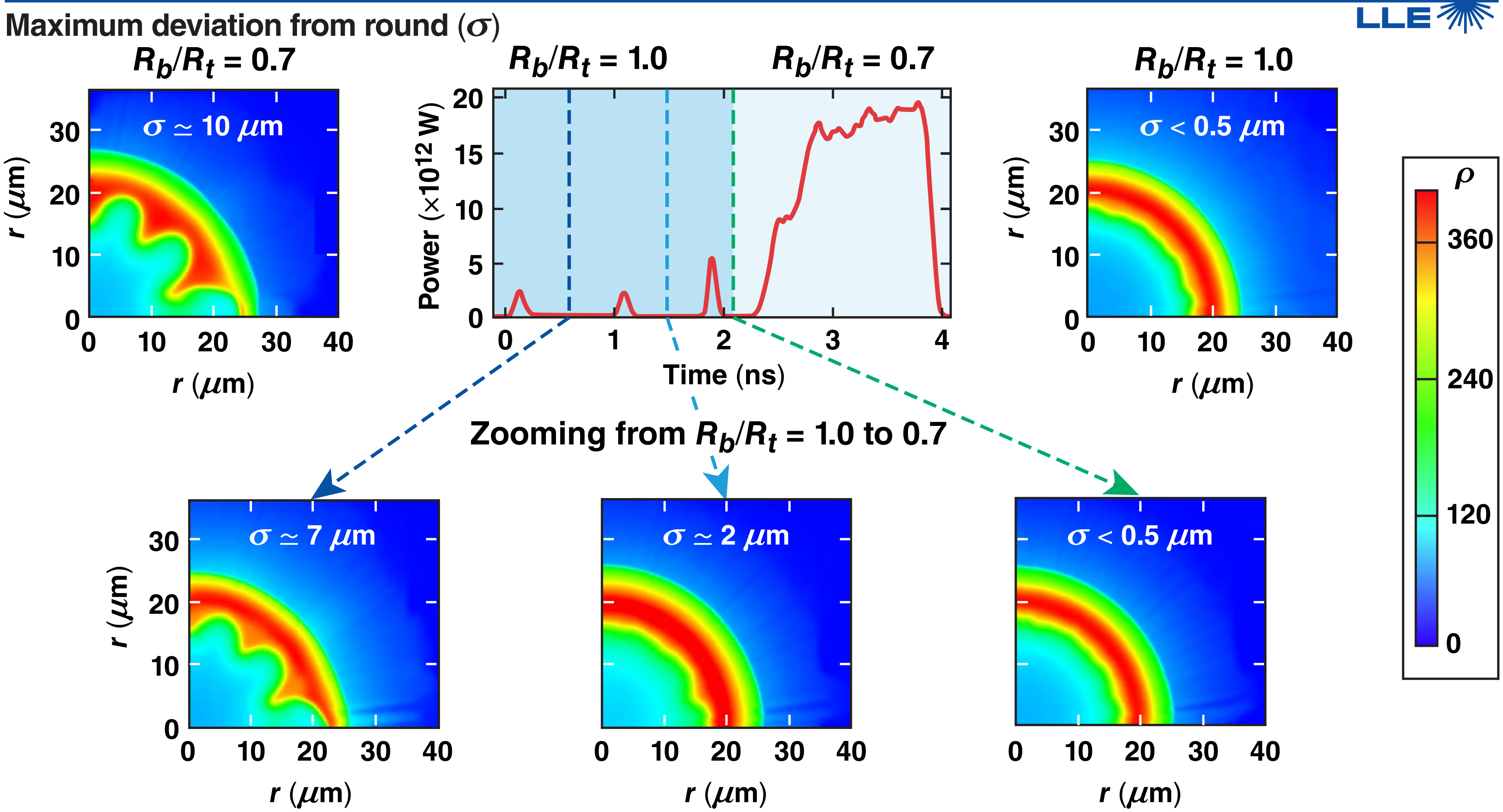

Zooming and dynamic bandwidth reduction will increase the effective energy on target by 30% in OMEGA implosion experiments.

E21317

Summary/Conclusions

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E21311