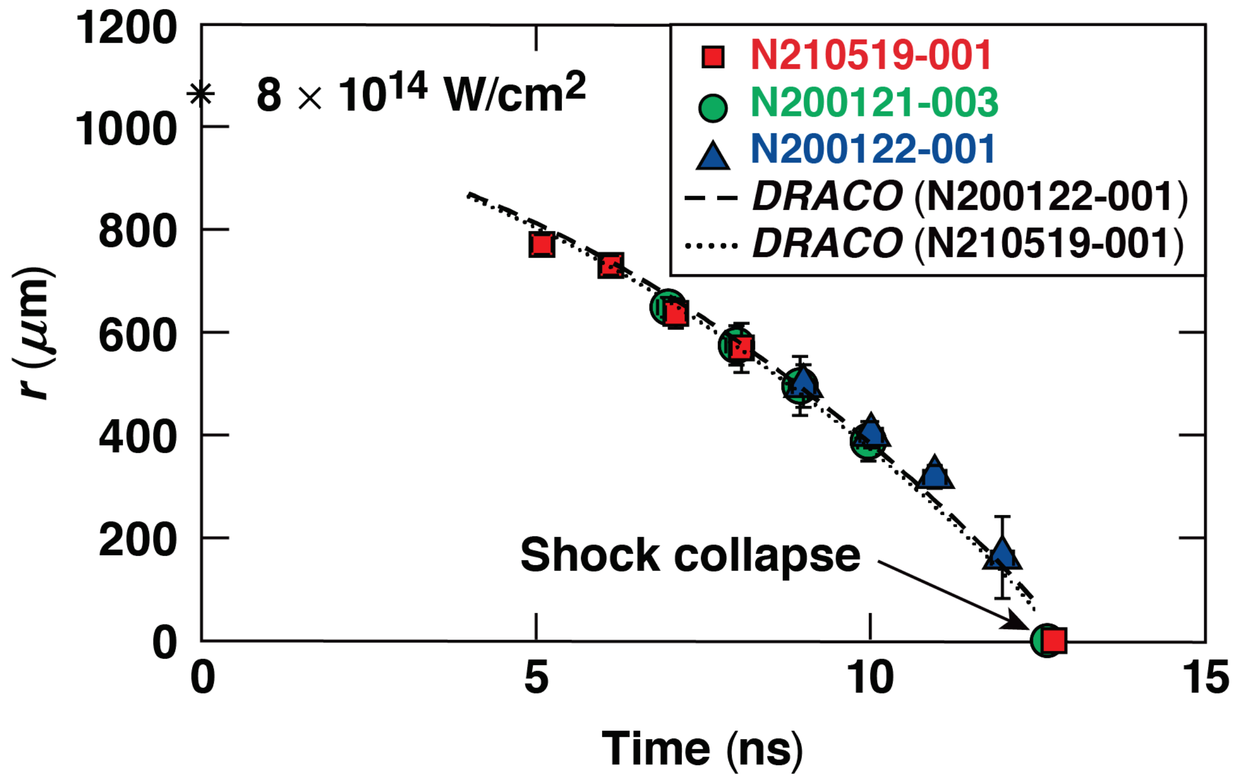
Laser-Direct-Drive Energy Coupling at 4 × 10^{14} W/cm^2 to 1.2 × 10^{15} W/cm^2 from Spherical Solid-Plastic Implosions at the National Ignition Facility



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Summary

Energy-coupling models are validated in the laser intensity range of 4×10^{14} W/cm^2 to 1.2×10^{15} W/cm^2 with PDD experiments of spherical solid-plastic targets on the NIF

- The measurements provide experimental shock trajectories and shock collapse time
- Agreement is obtained with the trajectories from 2-D *DRACO* radiation-hydrodynamics simulations using CBET* and nonlocal heat-transport models for three laser intensities
  - the inferred experimental shock velocity is 4±3% lower than the simulated velocity for 8×10^{14} W/cm^2

Future experiments will improve the measurement accuracy and field different laser pulse shapes. Similar experiments on OMEGA will test the scaling arguments of PDD implosions from OMEGA to the NIF.**

PDD: polar direct drive
NIF: National Ignition Facility
CBET: cross-beam energy transfer
* K. Anderson *et al.*, Bull. Am. Phys. Soc. 65, TO08.00009 (2020).
** C. Stoeckl *et al.*, UO04.00002, this conference.

Collaborators

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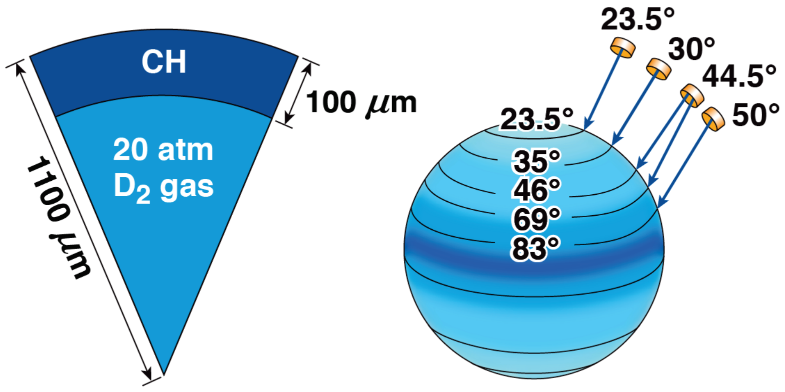
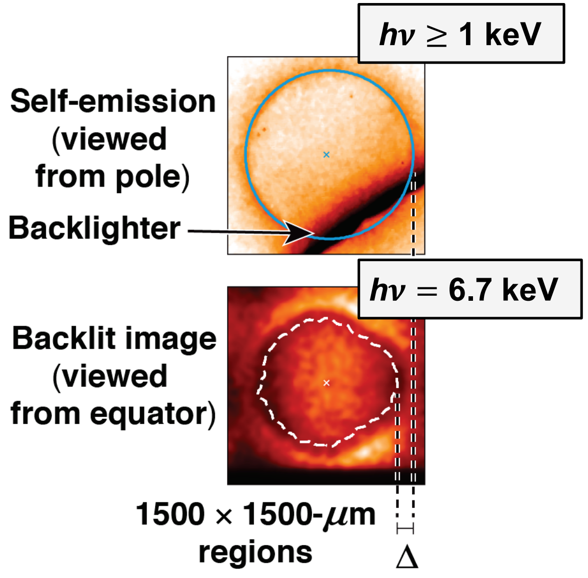
Previous NIF PDD energy-coupling experiments used shell-trajectory measurements inferred from coronal plasma emission and x-ray radiography*

NIF PDD implosion
(0.65 MJ, 1.2 × 10^{15} W/cm^2)



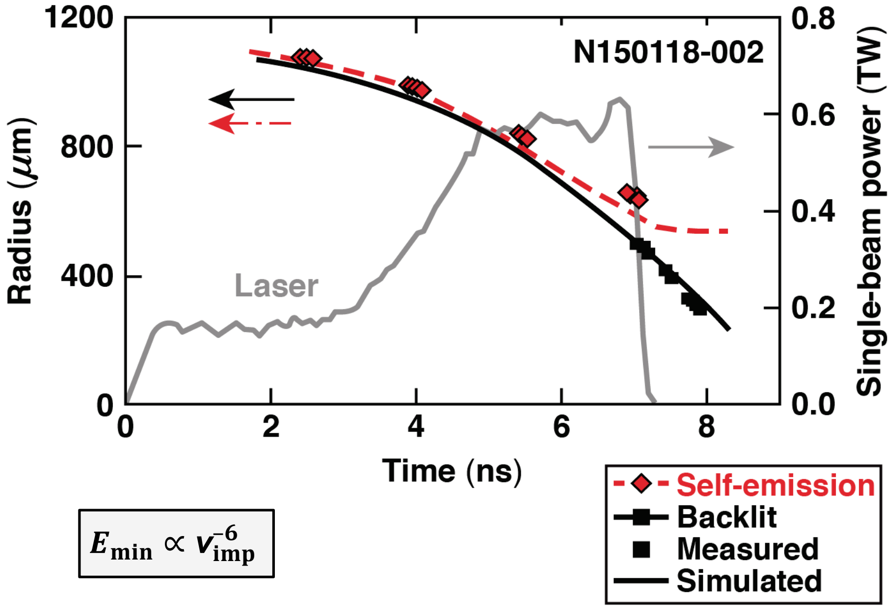
TC11724d

Measured gated x-ray images
(d*x* = 30 μm, d*t* = 100 ps)



TC11725e

Shell trajectory

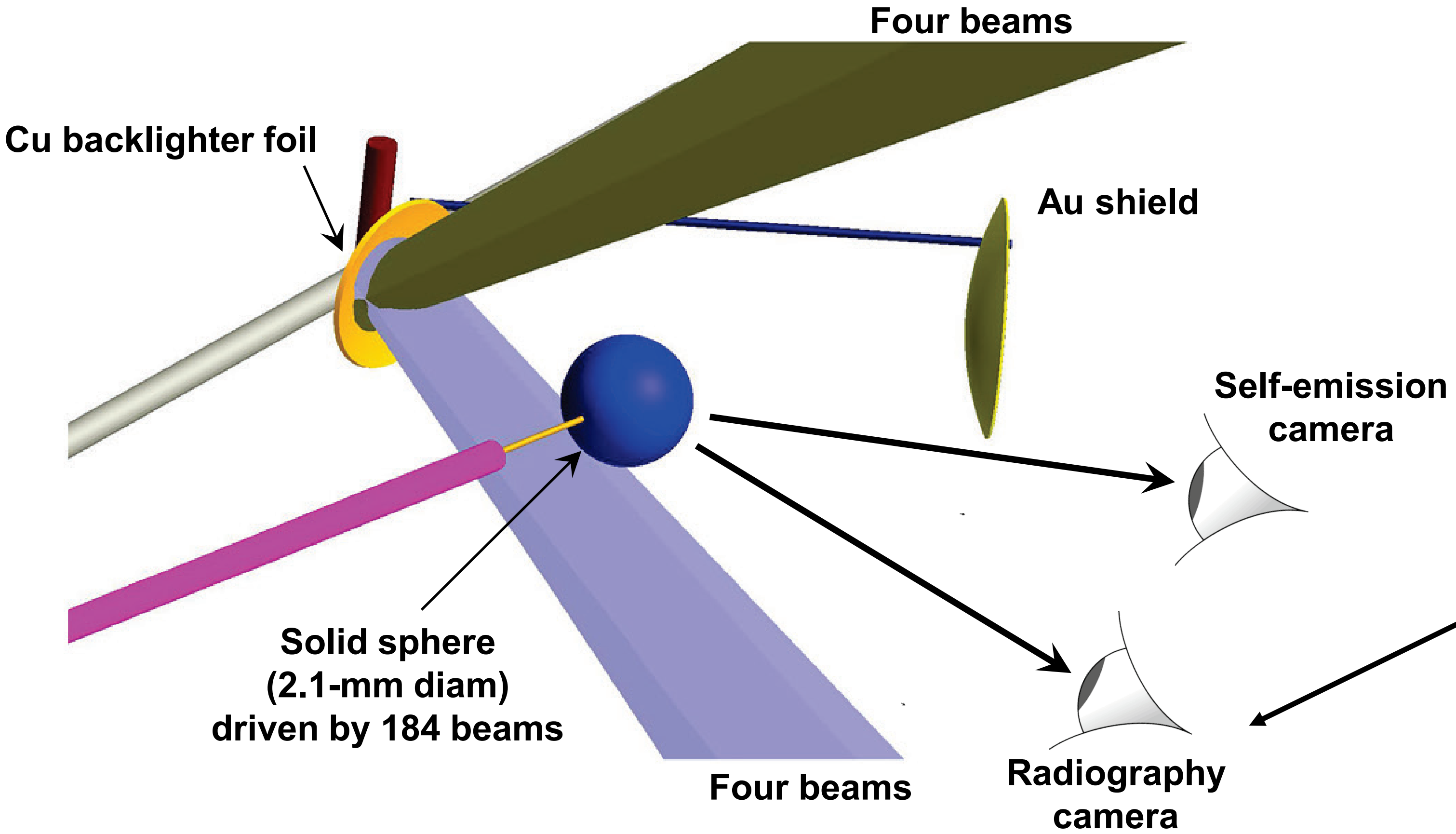


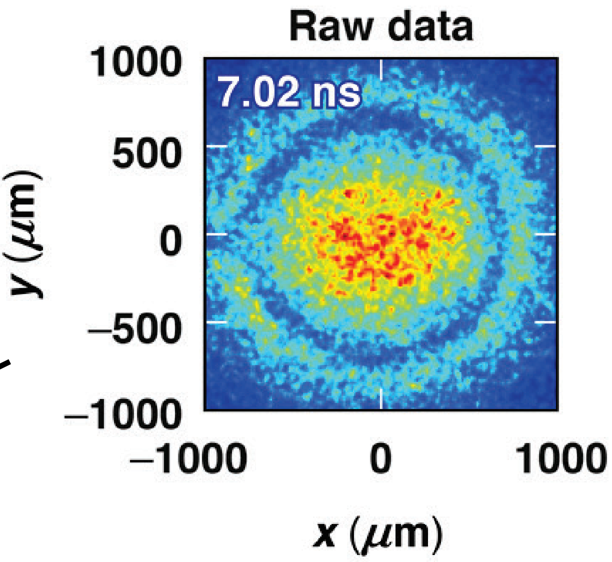
TC12730b

Backlit image: Indicates match in modeled and measured v_{imp} within 1%*
Self-emission: Indicates a 9% overprediction of v_{imp} attributed to laser imprint and subsequent Rayleigh–Taylor growth.*

* P. B. Radha *et al.*, Phys. Plasmas 23, 056305 (2016).
E_{min}: minimum fuel energy required for ignition
V_{imp}: implosion velocity

Energy-coupling experiments relevant to LDD ignition-target designs are being conducted on the NIF using a spherical, solid-plastic target*



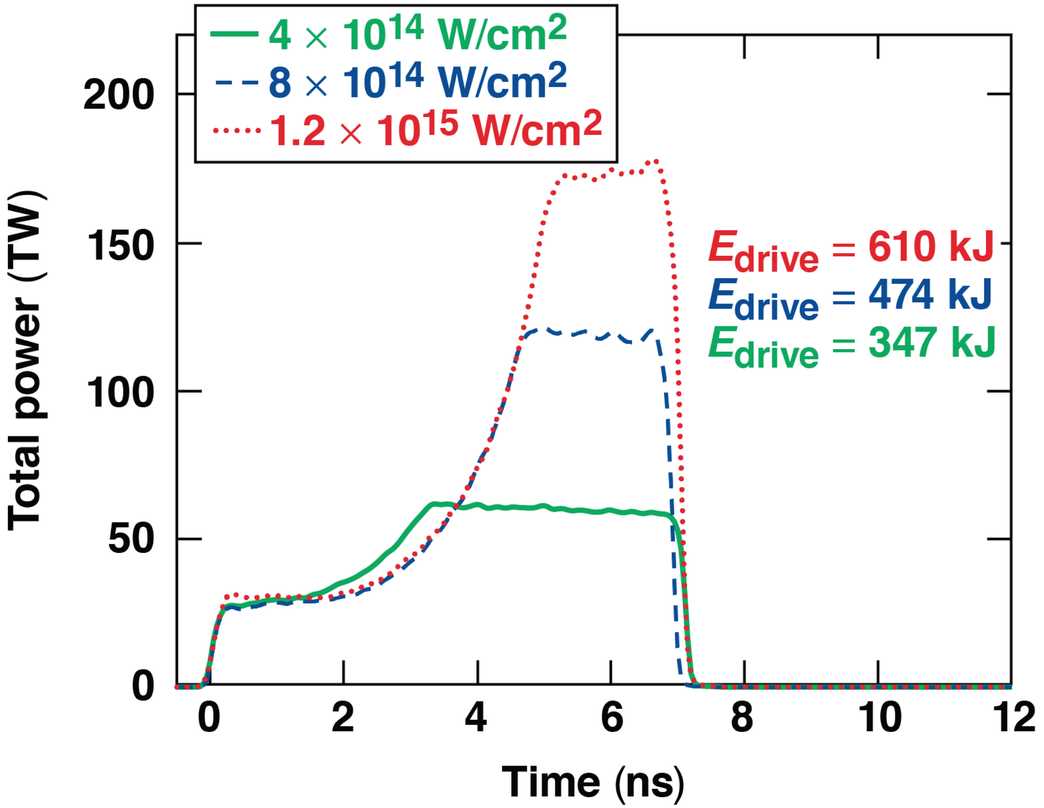


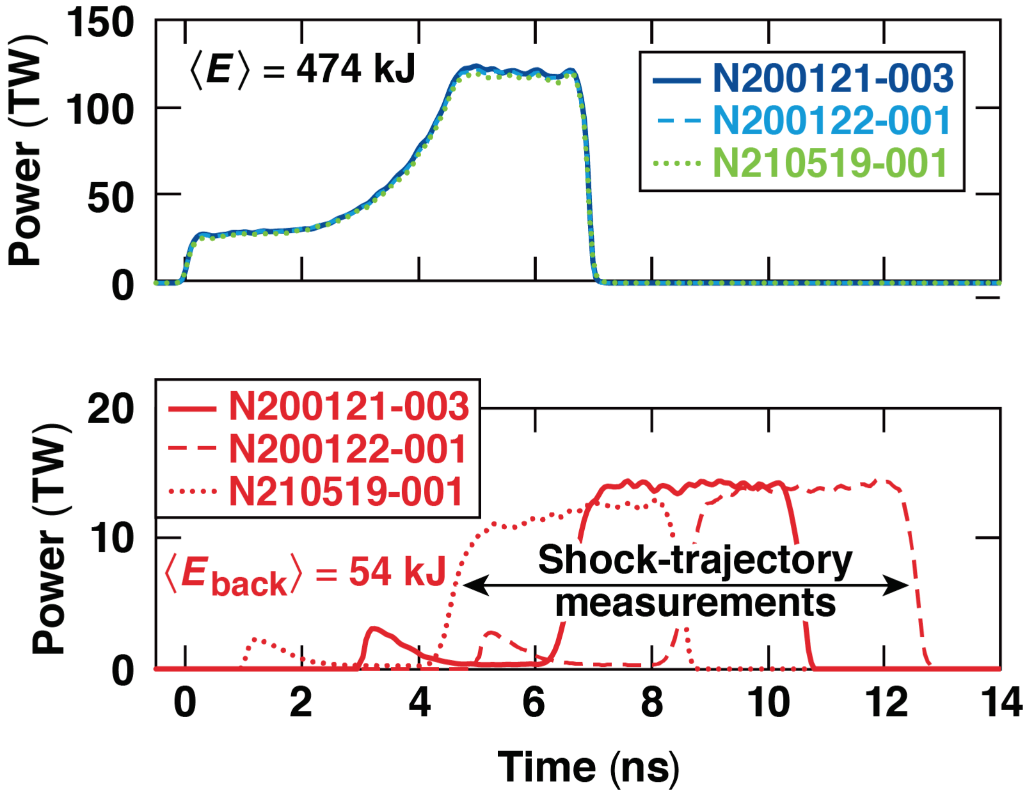
Solid spheres offer the advantage of quantifying energy coupling without the challenges from hydrodynamic instabilities of thin-shell implosions.

LDD: laser direct drive

*S. P. Regan *et al.*, Bull. Am. Phys. Soc. 65, BO09.00011 (2020).

One hundred eighty-four NIF laser beams irradiated the target in a PDD geometry with different laser pulse shapes





E29787

The shock trajectory was recorded during and after the main drive over a ~7-ns time window for a peak intensity of 8×10^{14} W/cm^2.

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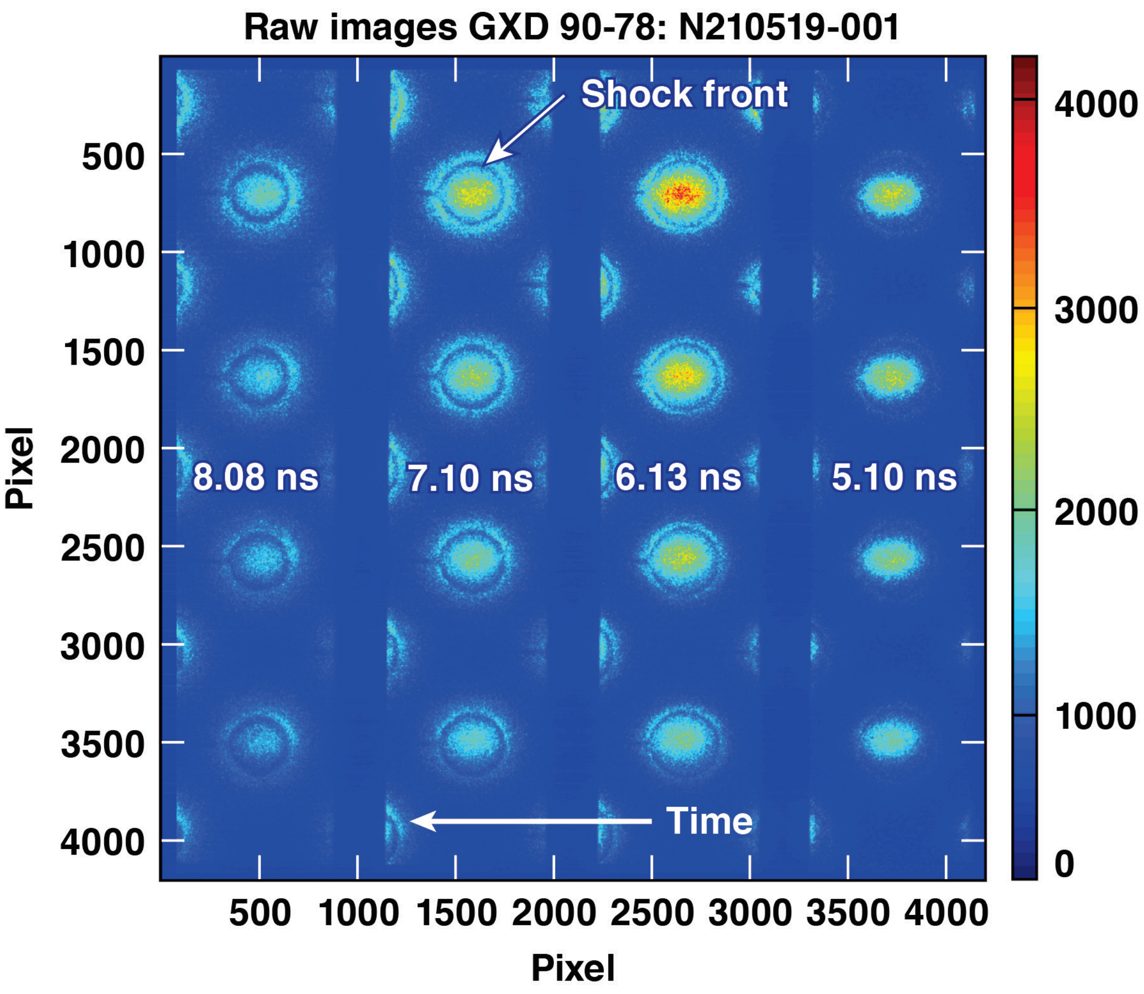
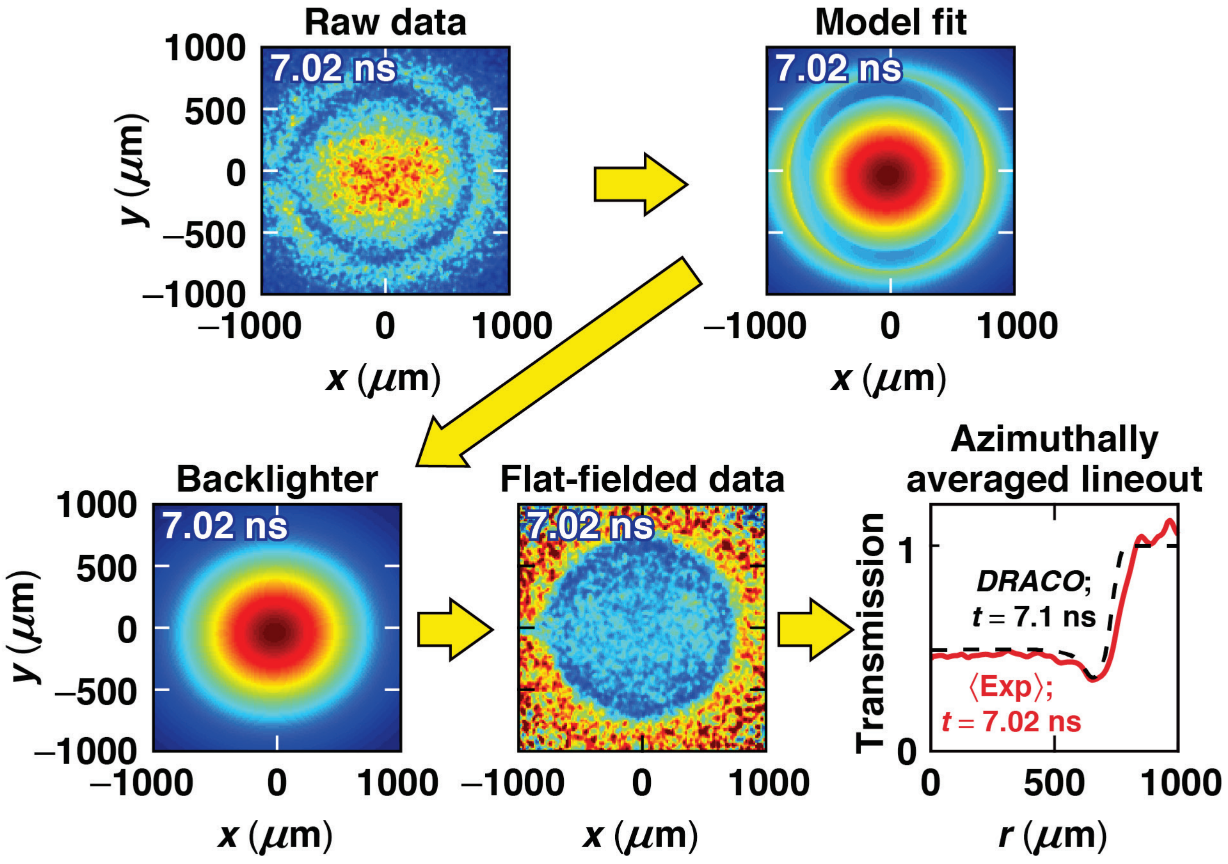
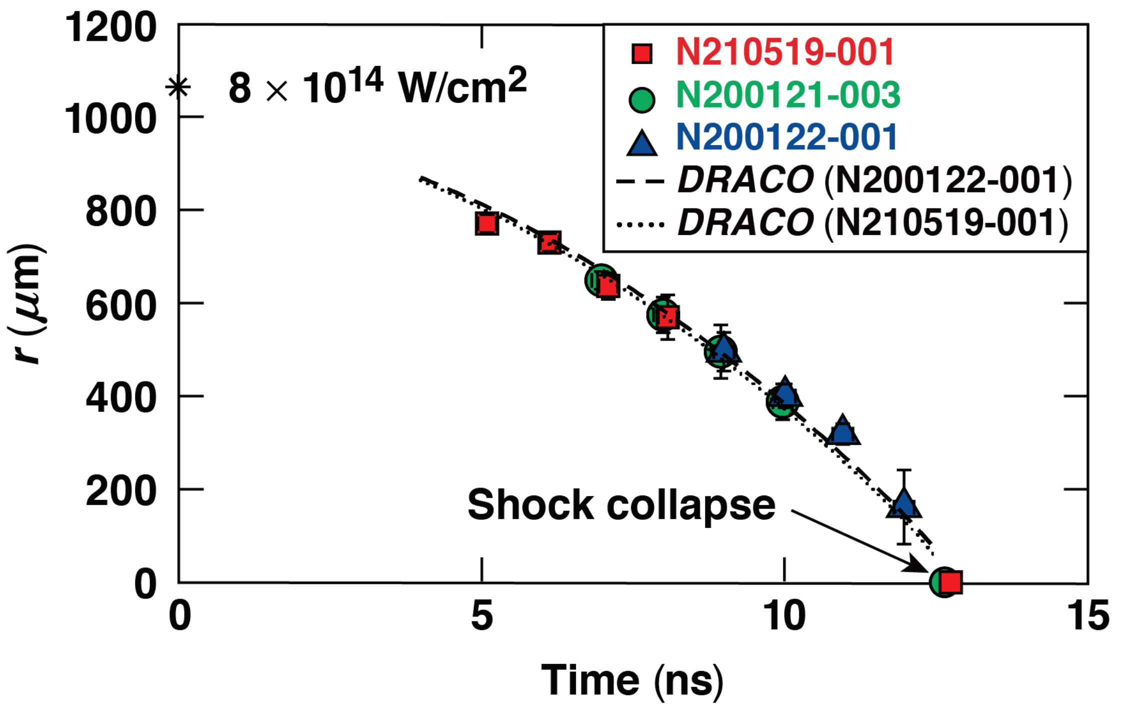
The trajectory was recorded using a pinhole array imager on an x-ray framing camera with ~100-ps temporal and ~30-μm spatial resolution



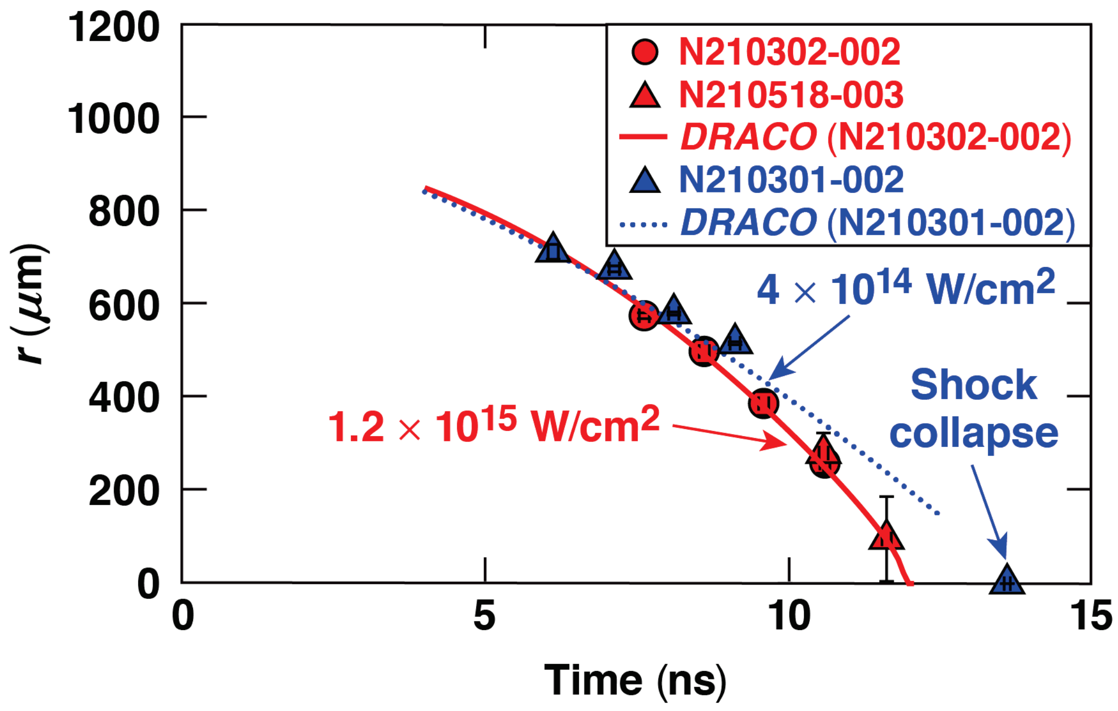


E29888

Two-dimensional *DRACO* simulations using CBET and nonlocal heat-transport models* accurately predict the energy coupling diagnosed with shock-trajectory measurements



E29885

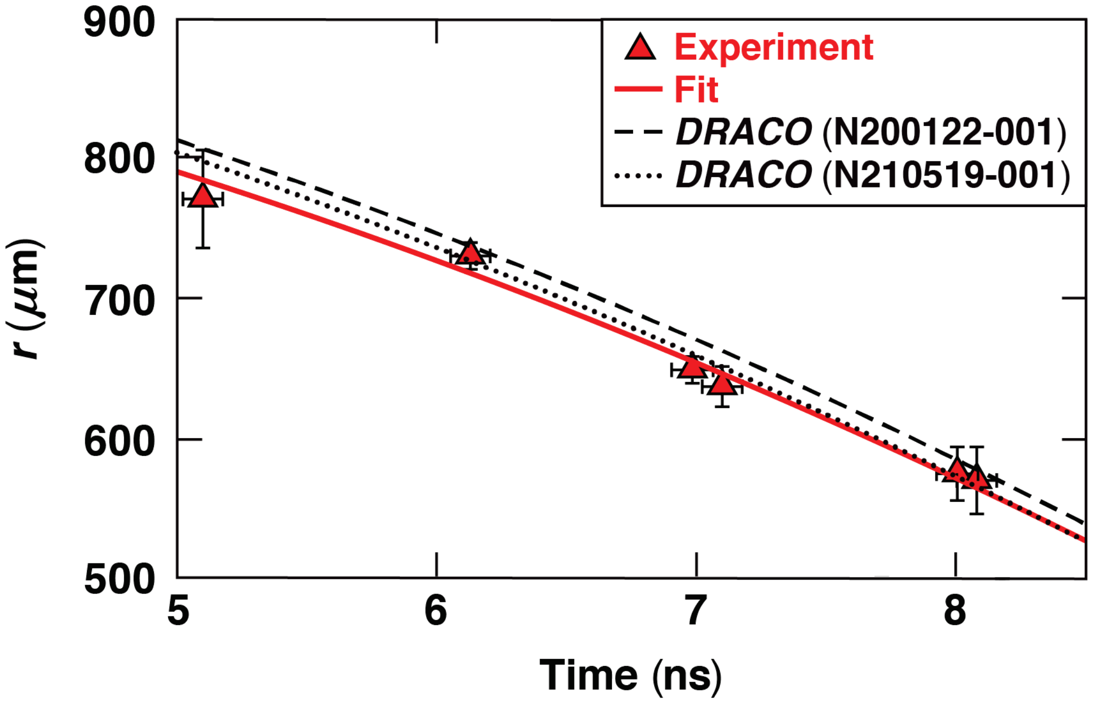


E29889

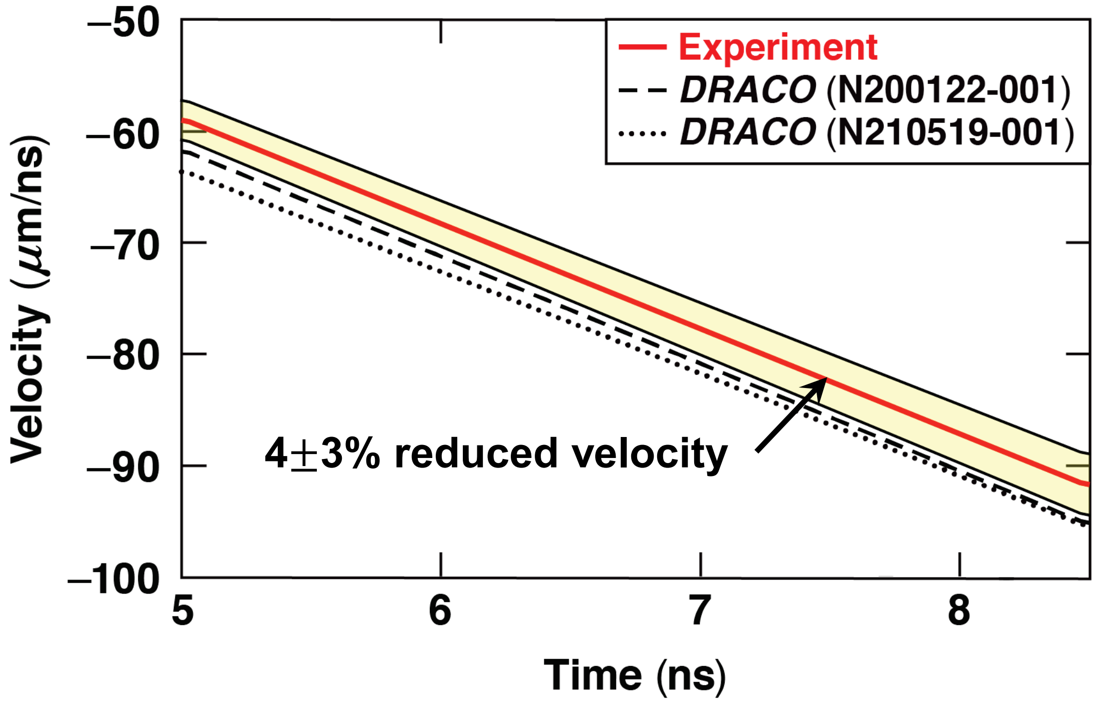
The simulations were post-processed with *Spect3D* and take the instrument response function into account.**

* R. Bahukutumbi *et al.*, UO04.00001, this conference.
** J. J. MacFarlane *et al.*, High Energy Density Phys. 3, 181 (2007).

A slightly reduced experimental shock velocity is inferred for 8 × 10^{14} W/cm^2 compared to simulations



E29933



E29934

Future experiments will improve the measurement accuracy and field different pulse shapes.

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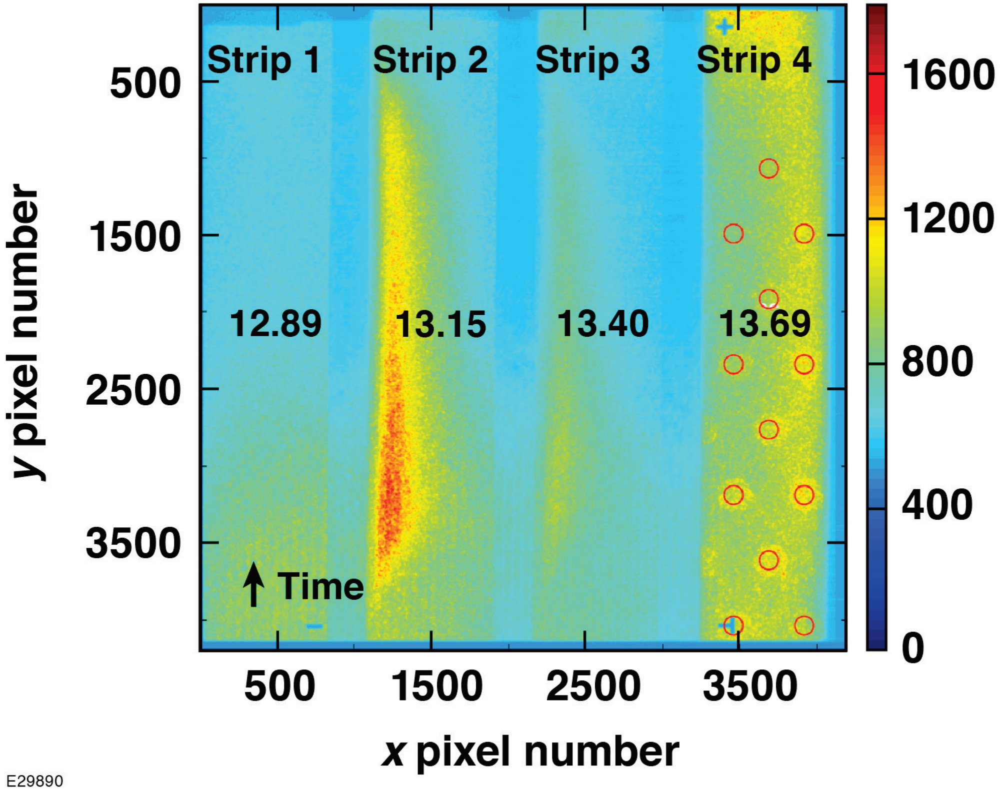
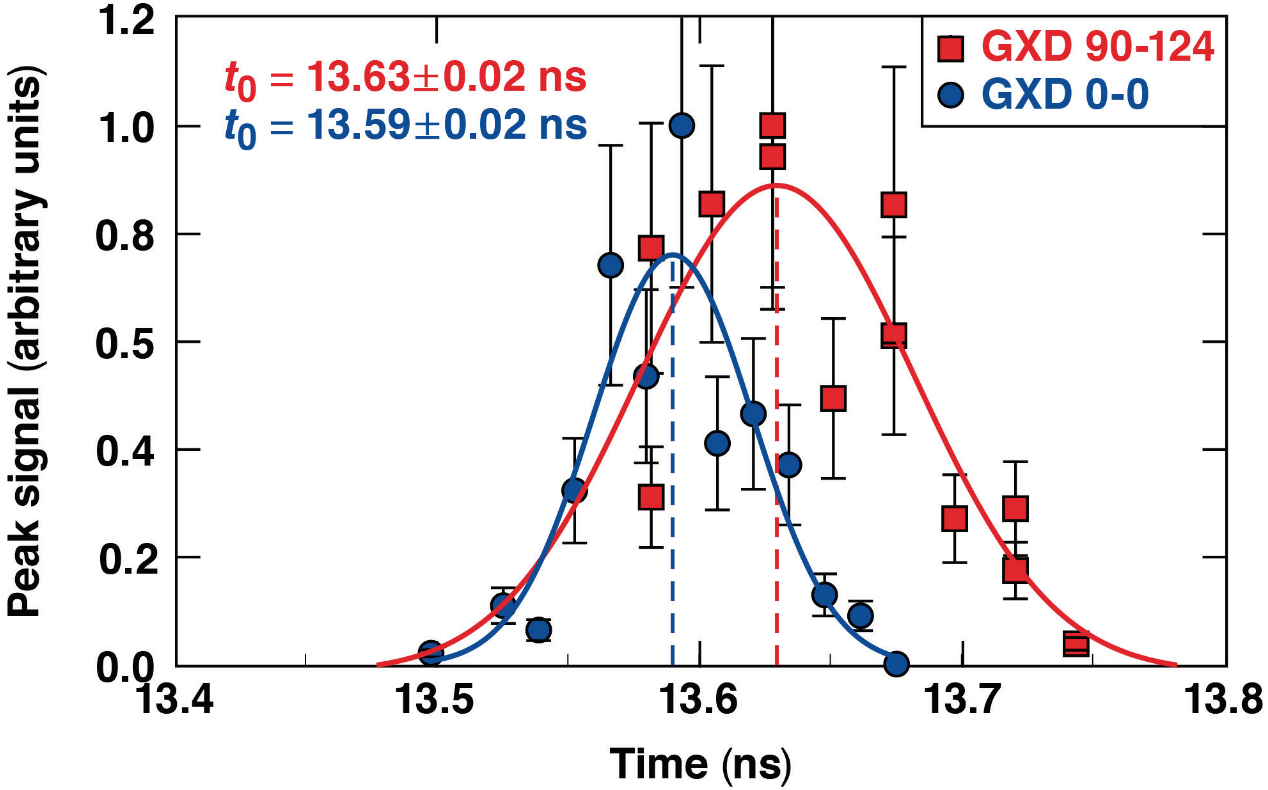
The arrival time of the shock in the center of the sphere was measured at 4×10^{14} W/cm^2 from the x-ray flash created by the shock collapse

Raw image GXD 0-0: N210301-002



Flash time: N210301-002



E29890

The x-ray flash time from both diagnostics is in agreement, providing an average value of 13.61±0.05 ns, which will be compared to radiation-hydrodynamic simulations.