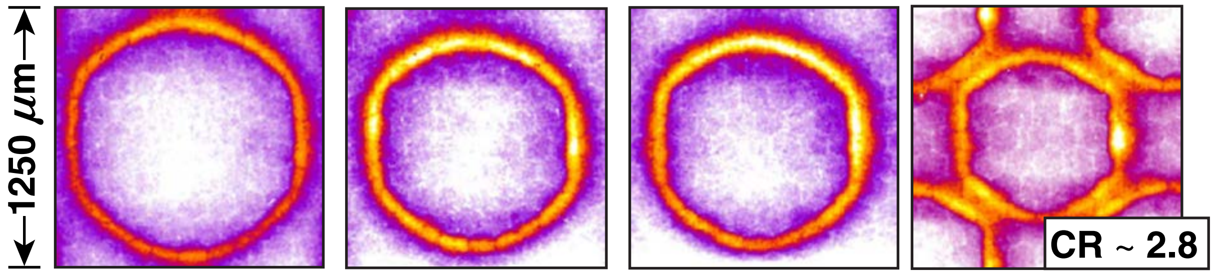
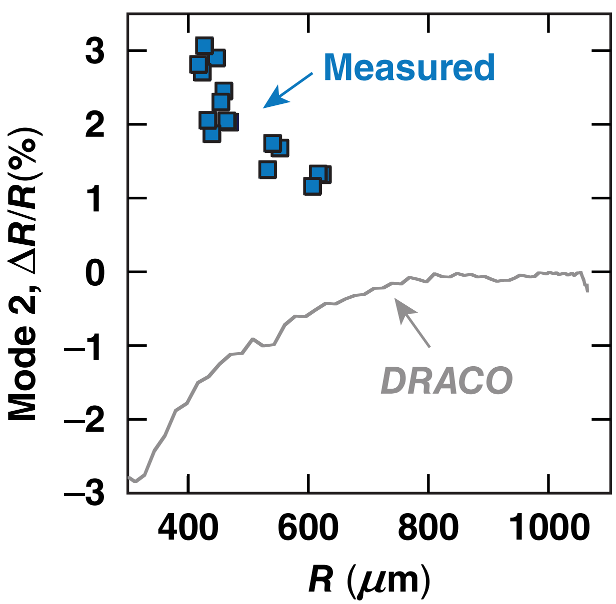
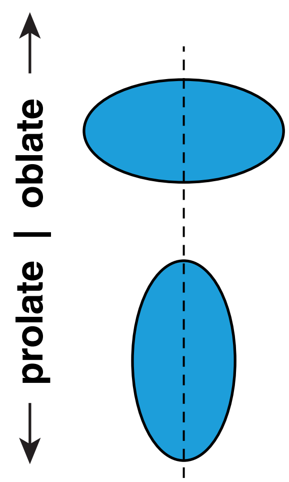
Cross-Beam Energy Transfer in Polar-Drive Implosions on OMEGA and the NIF

NIF implosion N130128-001-999



Shell trajectory Mode 2





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Summary

Modeling polar-drive (PD) implosions without cross-beam energy transfer (CBET) does not accurately predict the drive or the shell symmetry

- PD implosions are modeled using the 2-D *DRACO* hydrodynamic code a flux limiter and without CBET
- Calculations using a CBET postprocessor suggest that
  - CBET will significantly reduce the absorption
  - the beams pointed at the equator will be most affected
- The drive in PD implosions is diagnosed using shell trajectory and scattered-light measurements
  - many, but not all, drive observables are consistent with the CBET predictions
- Inclusion of nonlocal electron transport and CBET in hydrocode modeling may improve the predictions*

*J. A. Marozas *et al*., this conference.

Collaborators

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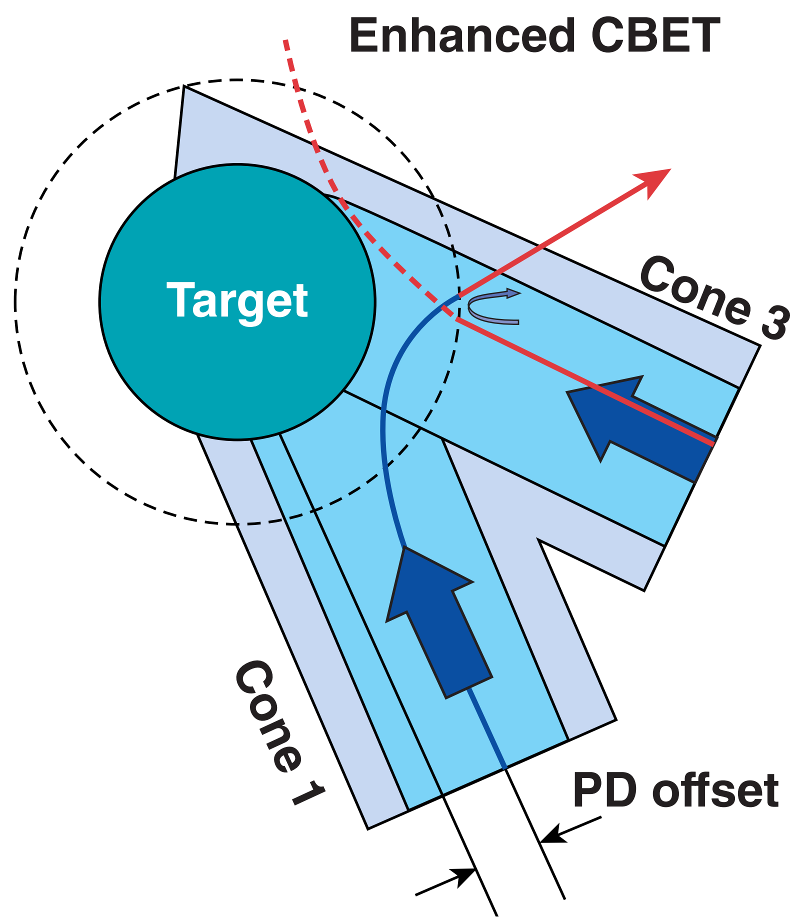
Direct-drive experiments at the National Ignition Facility (NIF) require nonsymmetric PD geometry

- Beams must be repointed toward the equator to uniformly implode; as a result, the center of the beam profile
  - refracts more
  - penetrates into the coronal plasma less
  - is absorbed less
- This results in more energy from one beam crossing other beams and more opportunity for laser energy to bypass the high-absorption region



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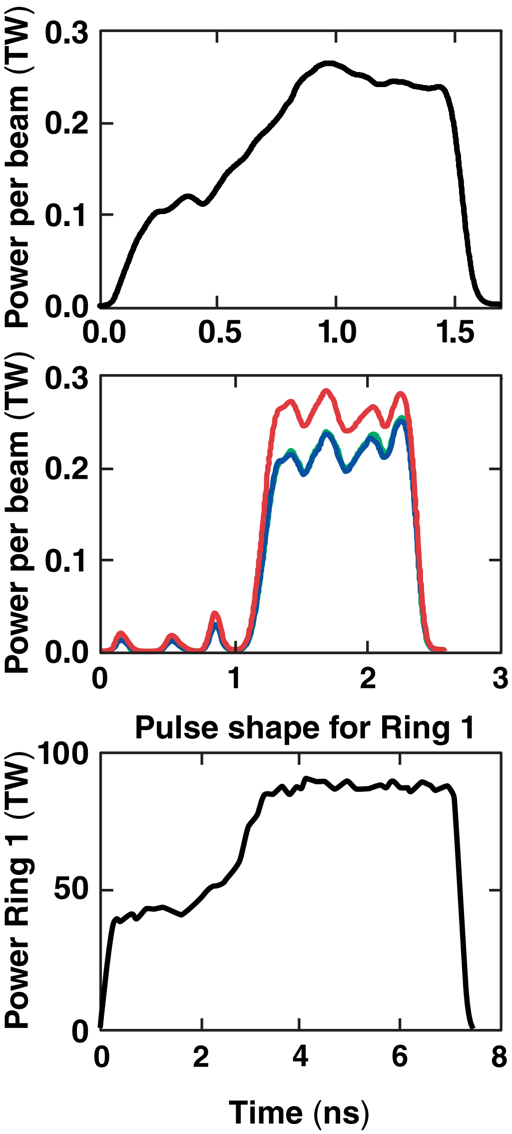
CBET for 3-D PD geometry is examined using a scattered-light postprocessing code

- Inclusion of CBET into 2-D *DRACO* is ongoing* but not yet available for the implosions studied for this talk
- The CBET postprocessor
  1. takes the predicted coronal plasma from 2-D *DRACO* with an $f = 0.06$ flux limiter
  2. uses a 3-D ray trace to calculate the paths, Doppler shifts, and crossings of many beamlets for each PD beam
  3. calculates CBET iteratively for one beam in each ring
- As a postprocessor, the predictions cannot be self-consistent with the hydrodynamics but are useful for estimating the importance of CBET

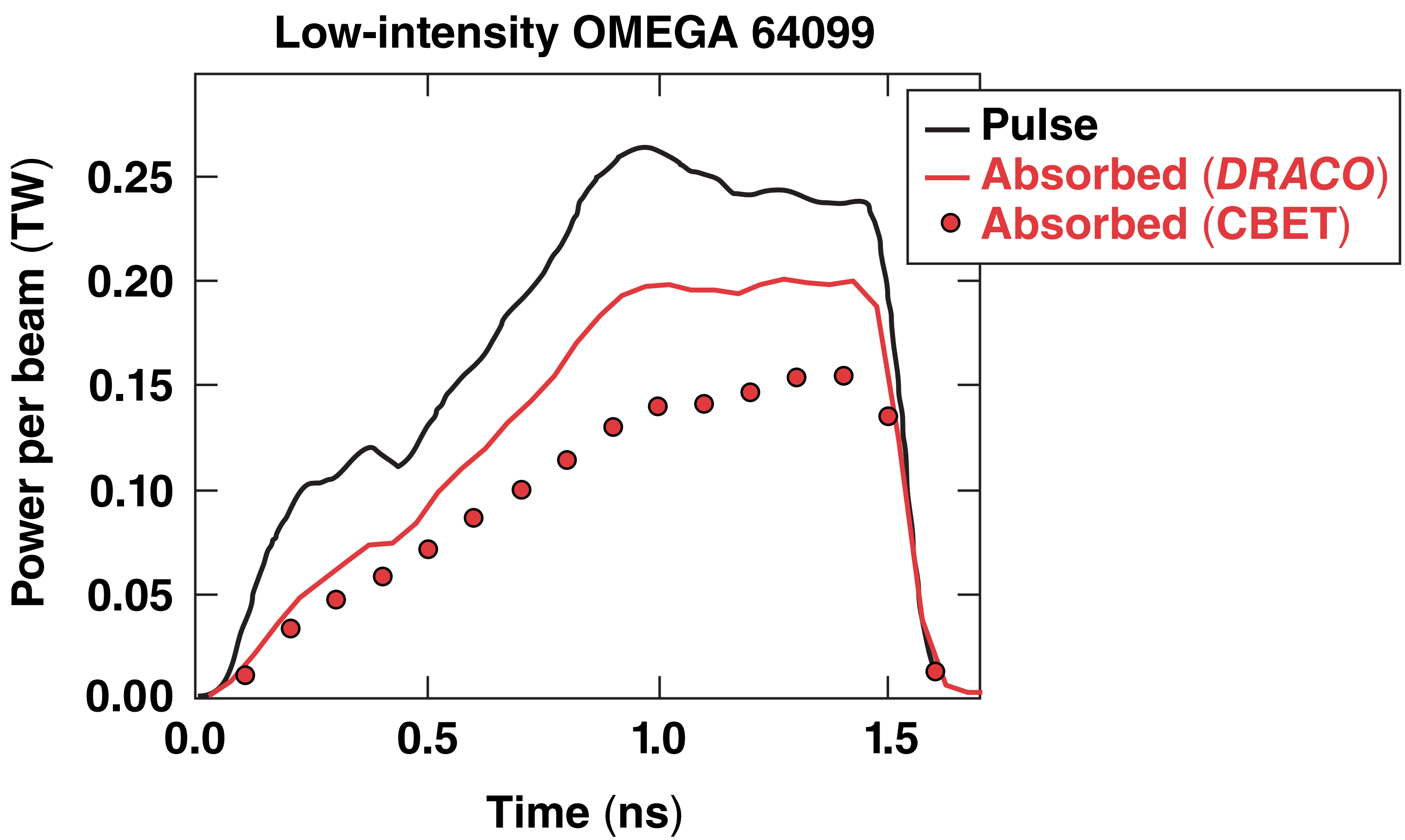
*J. A. Marozas *et al*., this conference.

CBET for three different PD implosions is investigated in this talk

- **OMEGA PD at low intensity: shot 64099**
  - 3×10^{14} W/cm^2, 16.6 kJ
  - 40 beams pointed into three rings
  - 870-μm target diameter, 605-μm FWHM beams
- **OMEGA PD at high intensity: shot 68205**
  - 1×10^{15} W/cm^2, 13.5 kJ
  - 40 beams pointed into three rings
  - 600-μm target diameter, 308-μm FWHM beams
- **NIF PD at low intensity: shot N130128-001-999**
  - 4×10^{14} W/cm^2, 344 kJ
  - 196 beams pointed into five rings
  - 2200-μm target diameter



The CBET model predicts the total absorbed power will be significantly reduced during PD implosions



- The total absorption is reduced from 82% to 61%

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CBET is predicted to reduce absorption in all rings for all three PD geometries

	OMEGA		OMEGA		NIF	
Shot	64099 at 1.2 ns		68205 at 2.0 ns		N130128	
	No CBET	CBET	No CBET	CBET	No CBET	CBET
Ring 1	83.7	71.8	84.3	59.6	91.3	85.4
Ring 2	80.5	61.6	84.2	56.9	93.1	74.2
Ring 3	80.8	55.0	82.0	48.3	95.6	65.1
Ring 4	–	–	–	–	90.0	62.4
Ring 5	–	–	–	–	82.0	58.2
Total (%)	81.5	60.9	83.0	52.9	89.1	67.6

The predicted reduction in absorption caused by CBET is greater for the beams repointed toward the equator (higher ring numbers).

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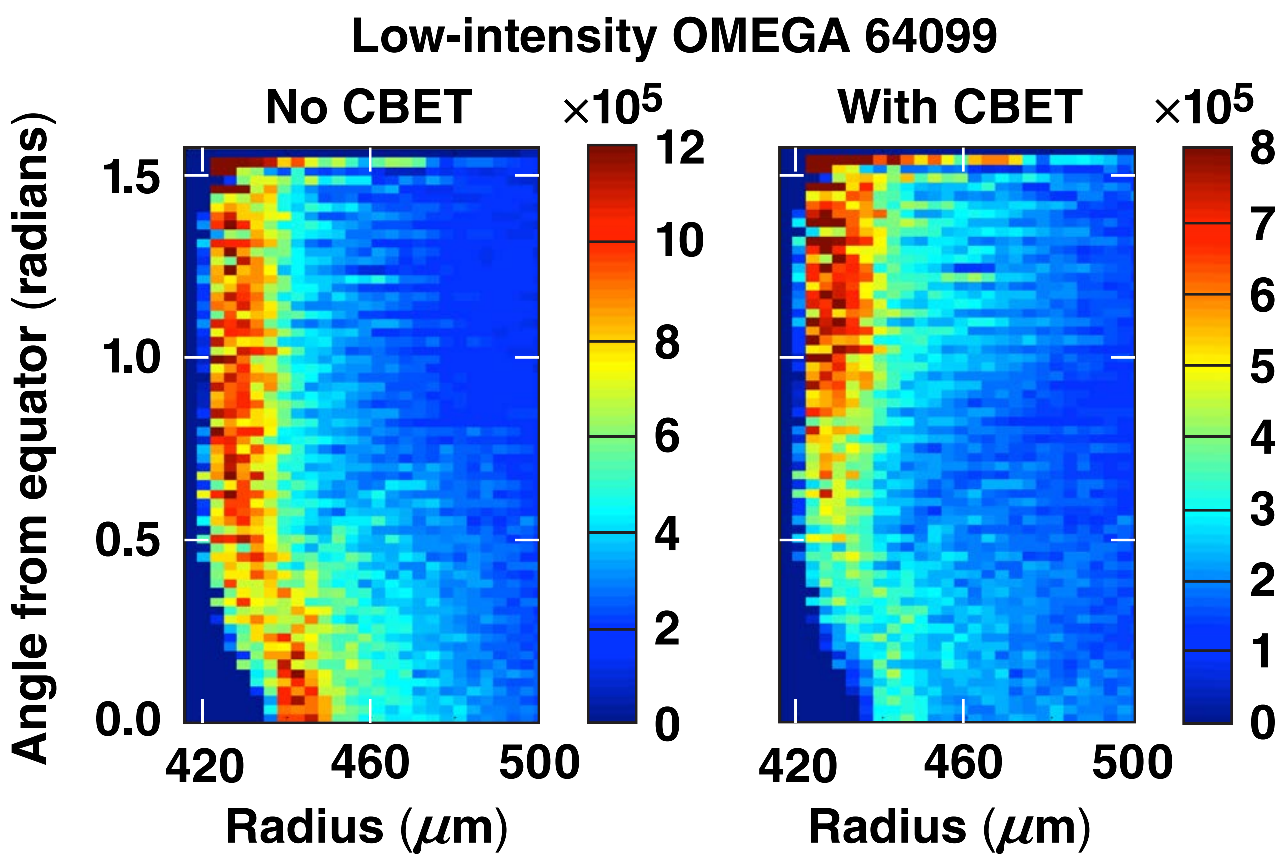
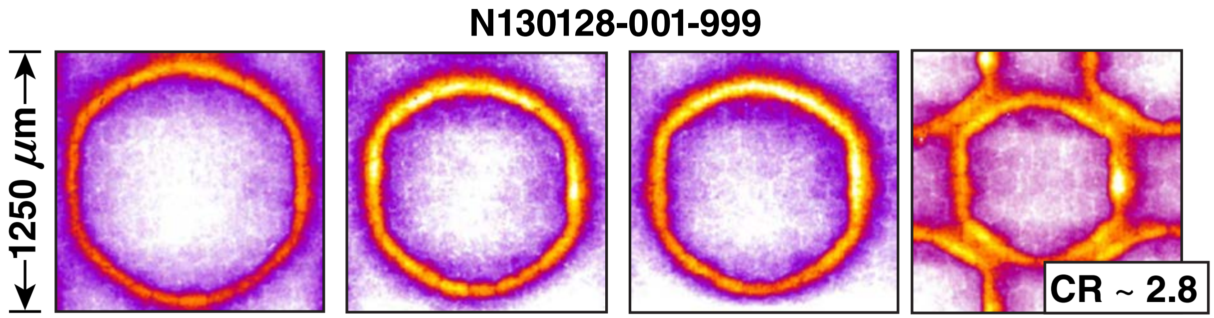
CBET is predicted to reduce the energy deposited near the equator



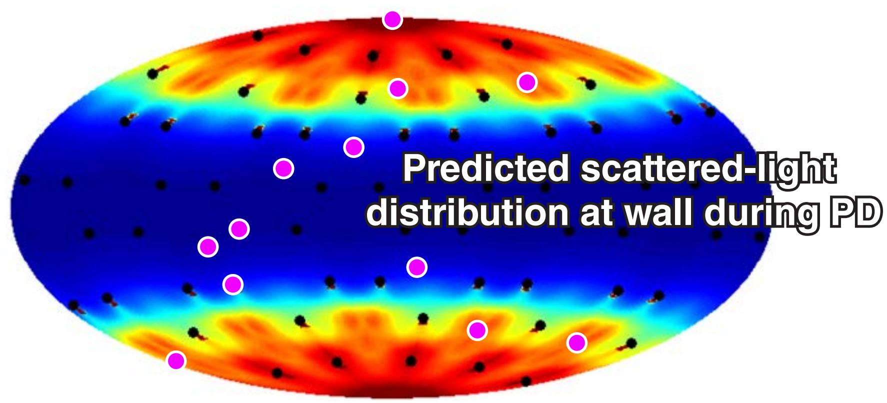
- Reduced absorption at the equator is also predicted in NIF and high-intensity OMEGA PD implosions

Reduced drive at the equator would result in a more-oblate implosion than predicted.

The drive during PD is diagnosed using shell trajectory and scattered-light measurements



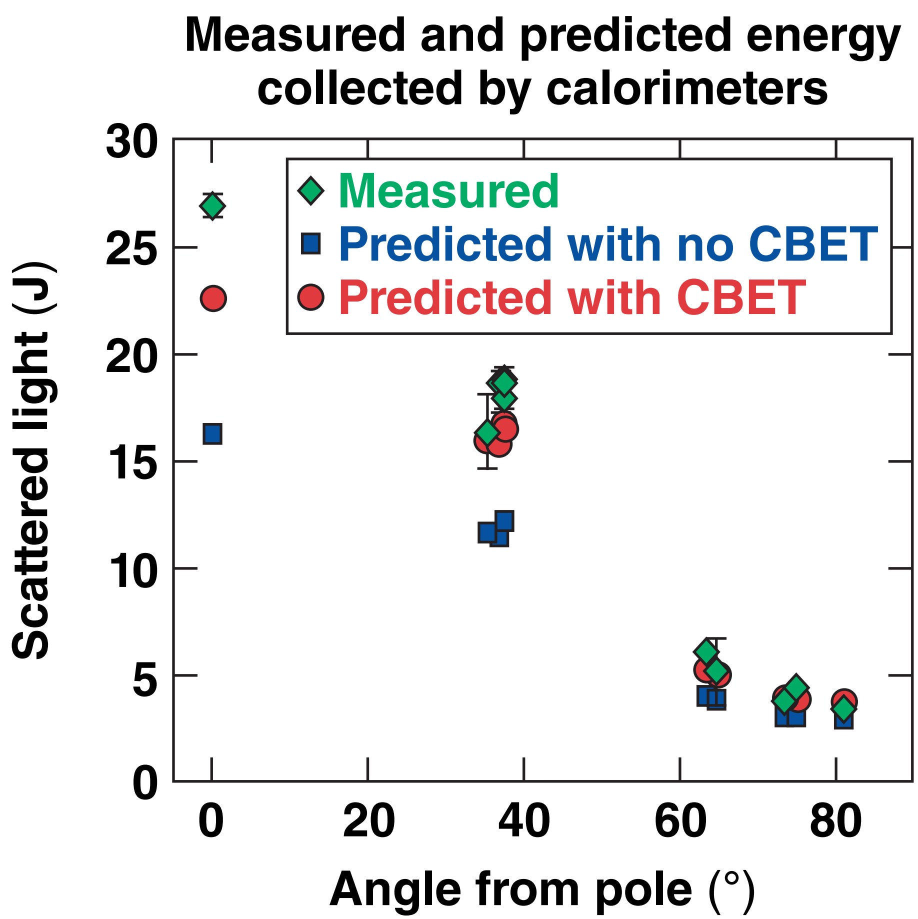
- X-ray framing camera (XRFC) self-emission images give the shell trajectory during NIF and OMEGA implosions
- Scattered-light measurements on OMEGA give the overall laser absorption



Locations of scattered-light calorimeters on OMEGA

Comparison of these measurements with predictions provide a gauge to the drive-modeling accuracy.

In low-intensity PD implosions on OMEGA, CBET is required in the modeling to predict the measured scattered light



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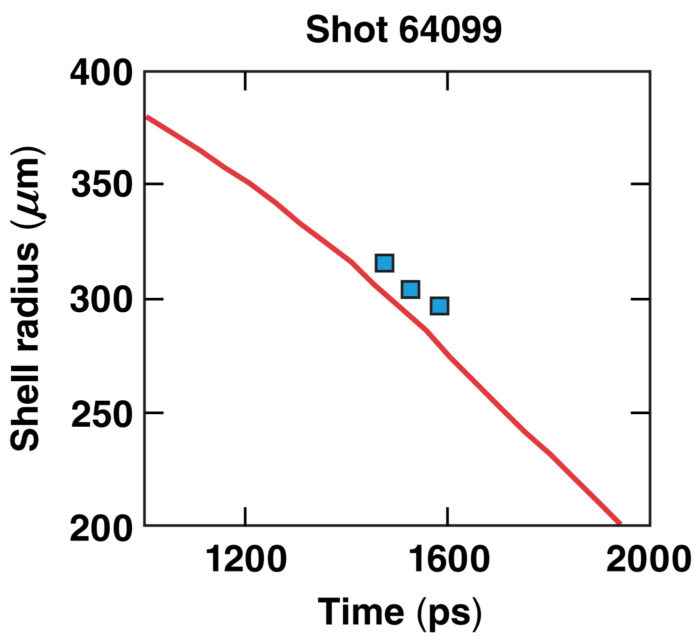
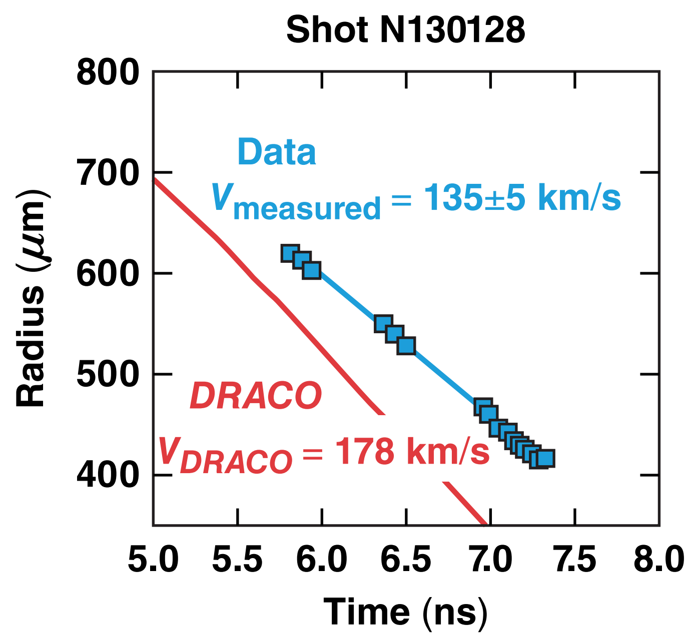
In low-intensity PD implosions, the measured shell velocity is lower than the *DRACO* prediction without CBET



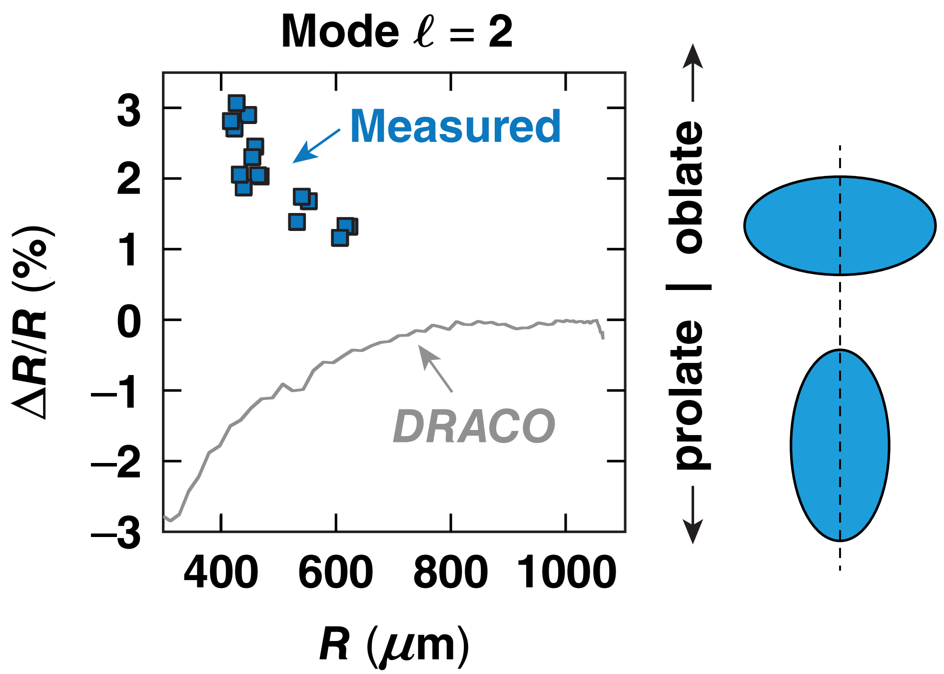


* V_{imp} averaged over 600 ps

- In OMEGA shot 64099
  - the shell trajectory is delayed from predictions
- In NIF shot N130128
  - the maximum shell velocity was 25% less than predicted by *DRACO*
  - shell trajectories are delayed by several hundreds of picoseconds compared to predictions

E22198

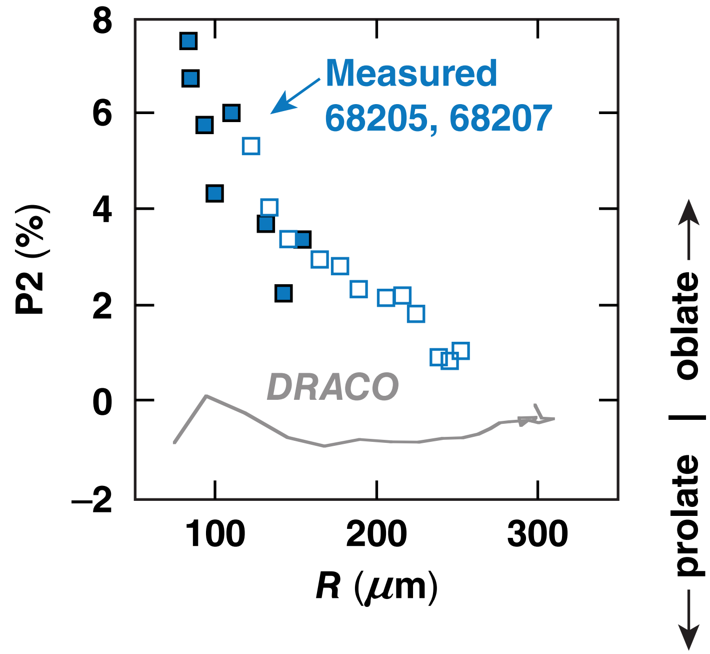
In low-intensity PD implosions on the NIF, the shell is more oblate than predicted by *DRACO* without CBET

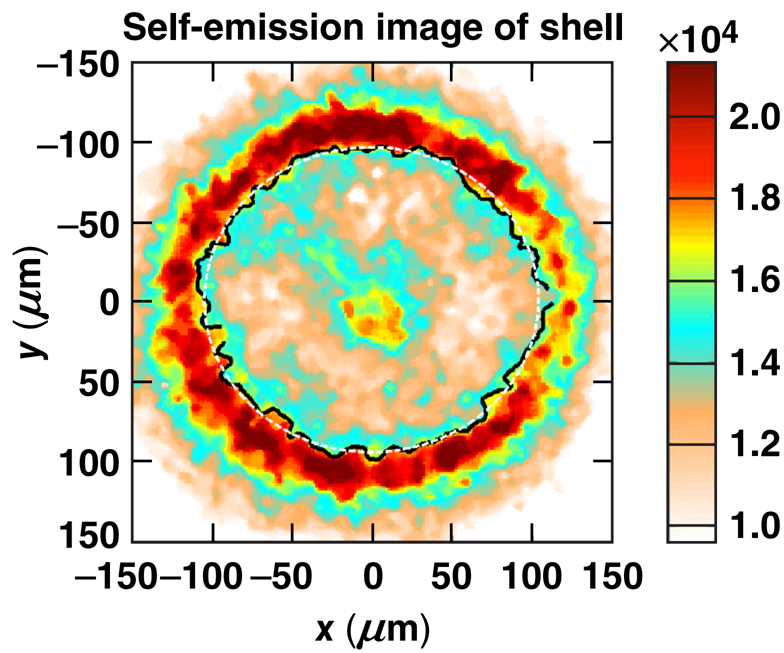


- Modes 3, 4, 6 are well predicted by *DRACO* without CBET

This is consistent with the reduction in energy deposited at the equator predicted by the CBET model.

For high-intensity PD implosions on OMEGA, the shape is more oblate than predicted



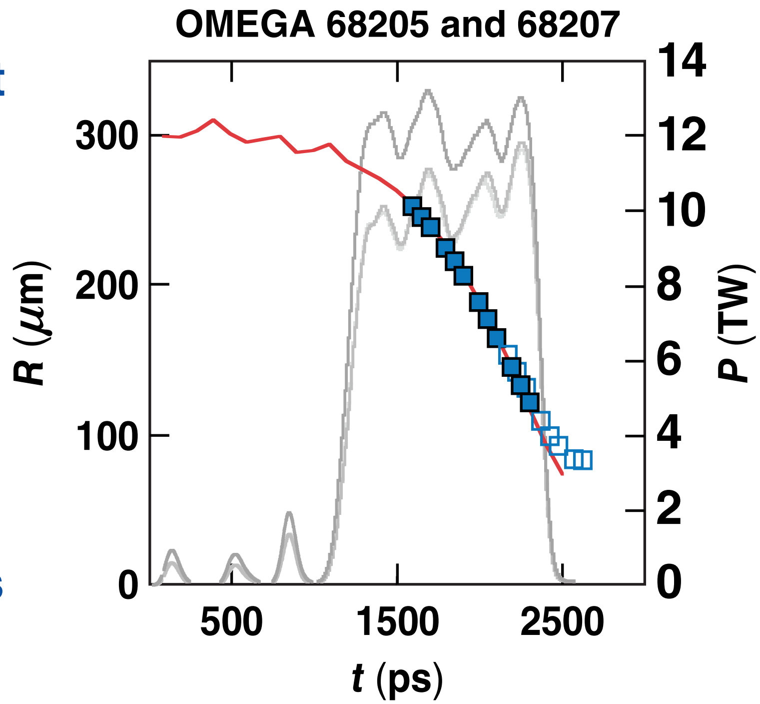


This is consistent with the reduction in energy deposited at the equator predicted by the CBET model.

E22200

Modeling without CBET reproduces some drive observables in high-intensity PD on OMEGA

- The *mean* predicted shell trajectory is in good agreement with measurements, but
  - the implosion is more oblate than predicted
  - the CBET postprocessor predicts significantly reduced absorbed power
- For symmetric implosions, inclusion of nonlocal electron transport and CBET in PD modeling improves the predictions



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Modeling polar-drive (PD) implosions without cross-beam energy transfer (CBET) does not accurately predict the drive or the shell symmetry

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- The drive in PD implosions is diagnosed using shell trajectory and scattered-light measurements
  - many, but not all, drive observables are consistent with the CBET predictions
- Inclusion of nonlocal electron transport and CBET in hydrocode modeling may improve the predictions*

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