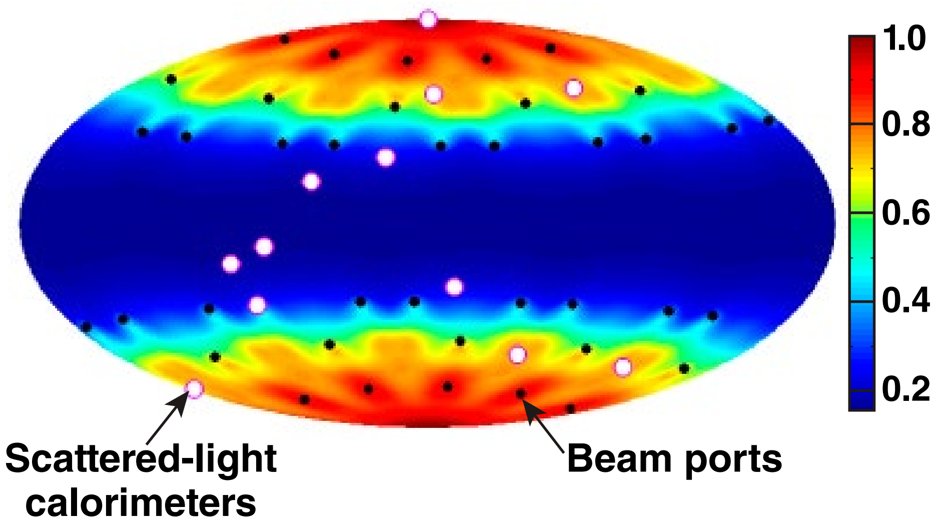
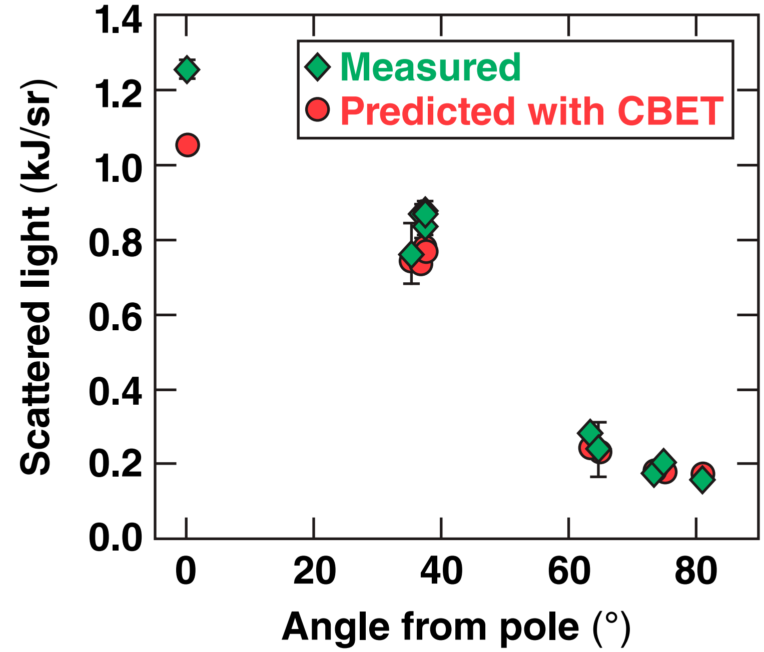
Modeling Cross-Beam Energy Transfer for Polar-Drive Experiments

Predicted scattered-light normalized distribution at wall



Measured and predicted energy collected by calorimeters



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Summary

Modeling suggests that cross-beam energy transfer (CBET) is significant during polar-drive (PD) implosions, but mitigation strategies exist

- Modeling predicts that CBET will reduce absorption of the laser energy by ~10% during PD implosions on OMEGA
  - this level is similar to that in symmetric 60-beam implosions
  - the equatorial ring is affected more than the other rings
- A reduction in absorption is predicted for the PD point design on the NIF
- CBET may be mitigated by reducing the ratio of the beam/target radii
  - smaller beam profiles reduce CBET but increase illumination nonuniformity

Collaborators

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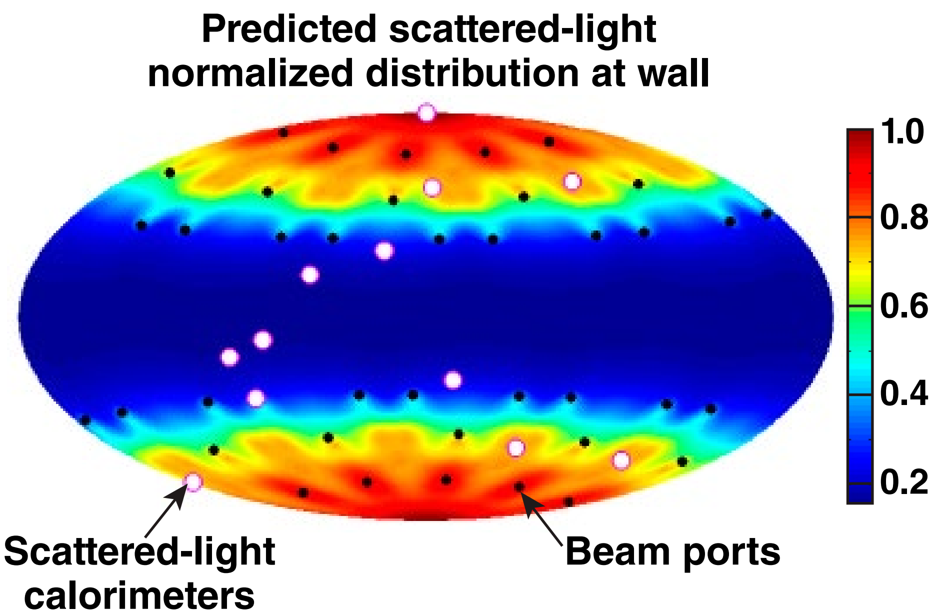
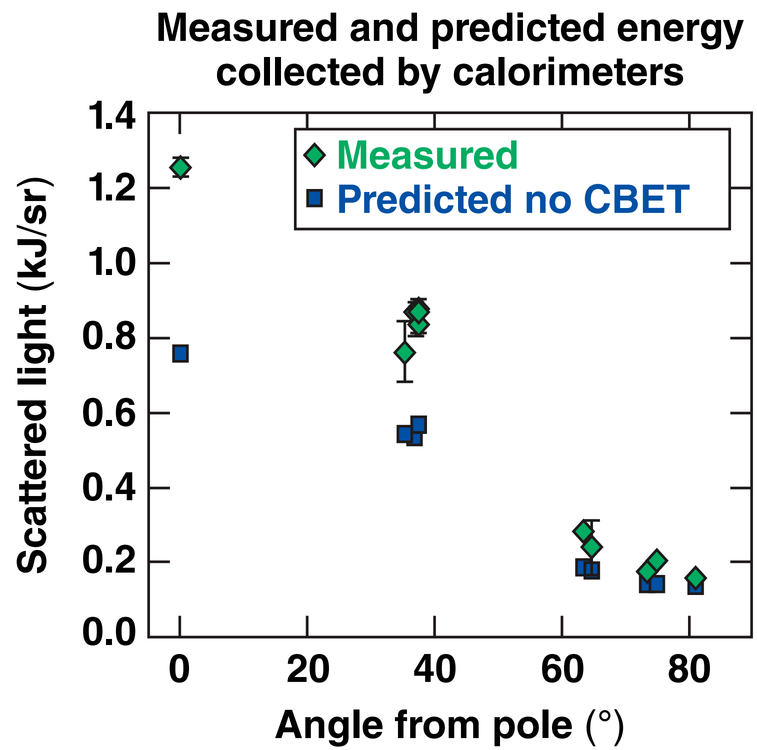
CBET is modeled using our scattered-light simulation code with a 3-D PD geometry

- Plasma parameters taken from 2-D *DRACO* hydrocode calculations (without CBET)
- Beam profiles are divided into many beamlets and ray tracing is used to calculate their paths and Doppler shifts
- CBET calculated* in 3-D for all beamlet crossings using all beams
  - intensity, absorption, and transfer along each beamlet solved iteratively
- Incorporation of CBET into *DRACO* is an ongoing effort**
- Modeling has been benchmarked using PD implosions on OMEGA

*I. V. Igumenshchev *et al*., Phys. Plasmas 17, 122708 (2010).
**J. A. Marozas *et al*., Bull. Am. Phys. Soc. 56, 241 (2011).
For more details about CBET modeling, see also talk by J. A. Marozas, UO5.00003, this conference.

Integrated scattered-light distribution from OMEGA PD implosions support the CBET predictions





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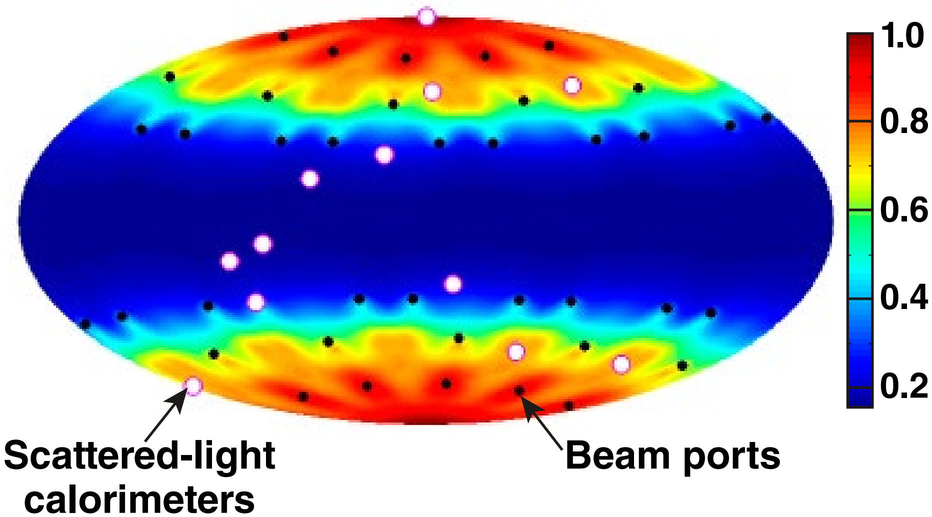
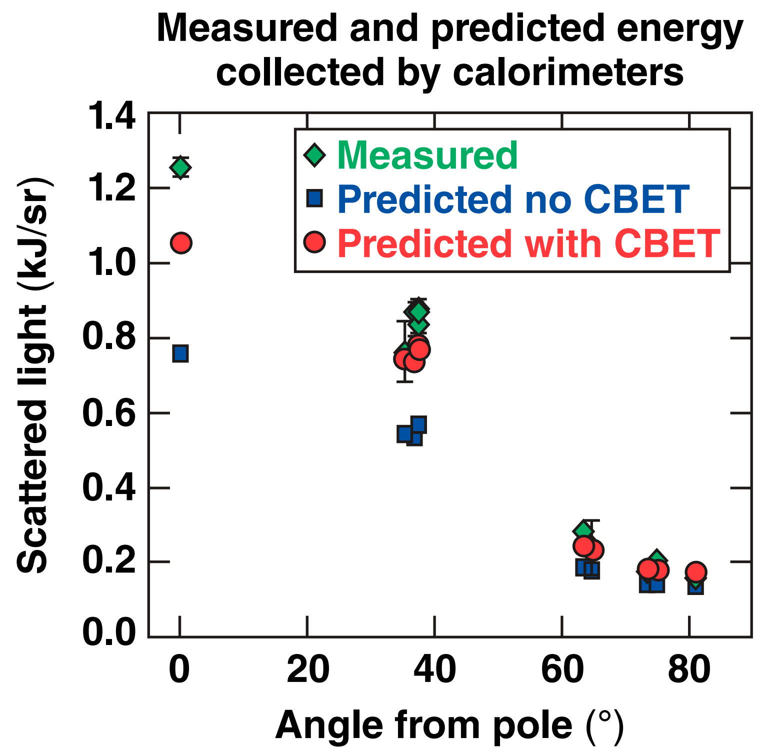
Integrated scattered-light distribution from OMEGA PD implosions support the CBET predictions





Planned scattered-light calorimeters on NIF will be essential measurements for PD implosions.

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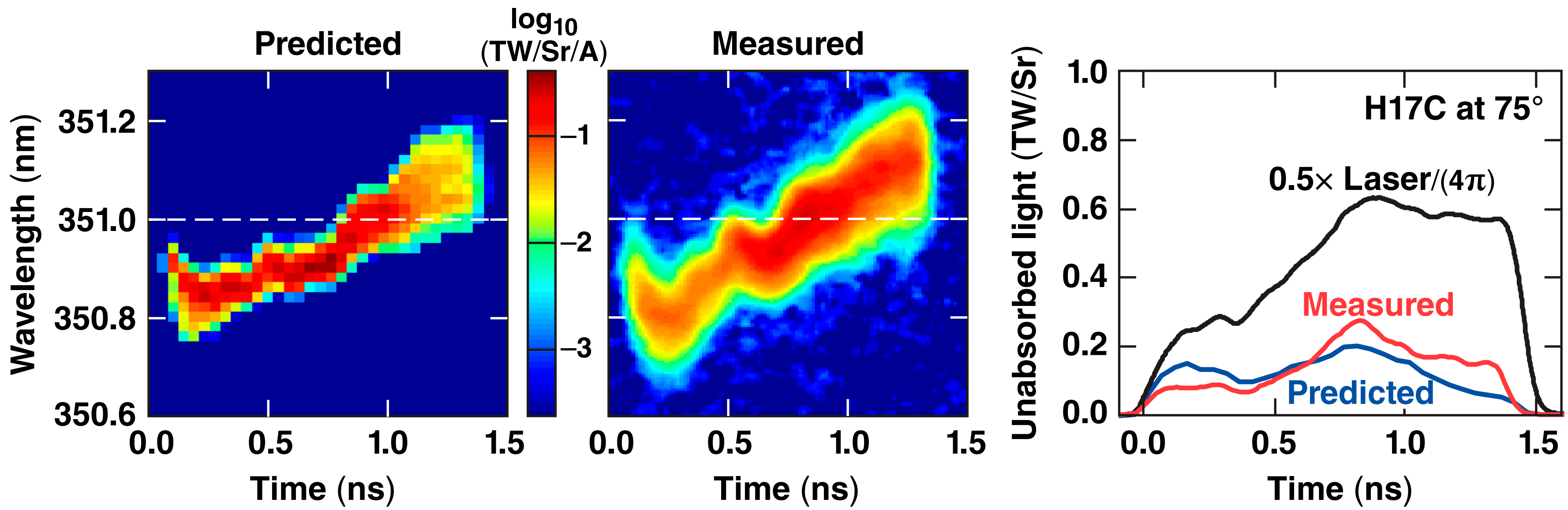
CBET modeling of the time-dependent scattered light spectrum reproduces the observed features



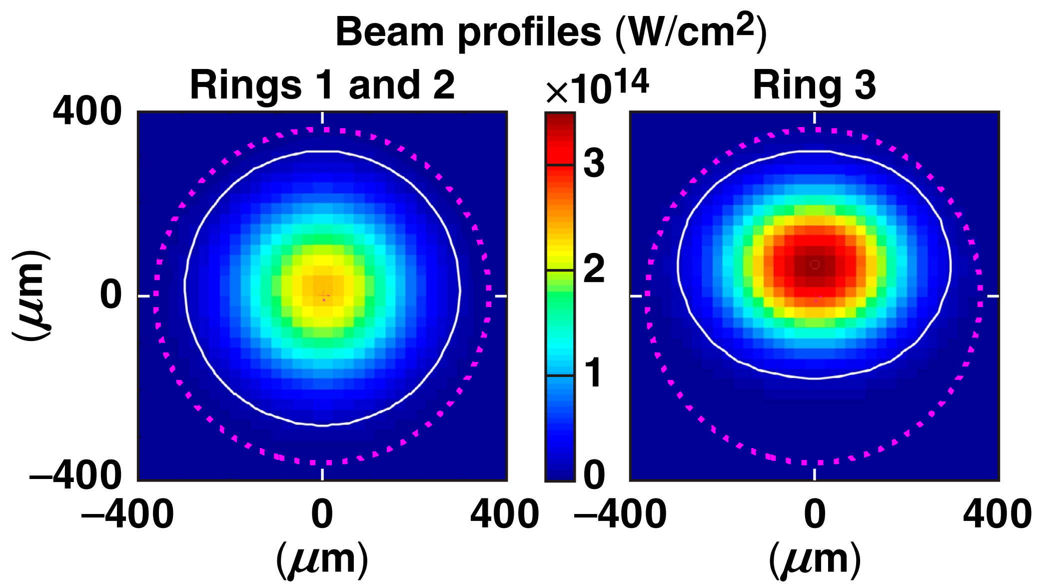
- Details of the predicted spectra will likely match the observations even better with CBET incorporated into the hydrocode plasma profile predictions

A ~10% reduction in absorption caused by CBET is predicted for upcoming optimized PD implosions on OMEGA*

Ring	Absorption no CBET	Absorption with CBET
1	85%	82%
2	85%	78%
3	84%	69%
Total	85%	75%

at 2 ns

PD distributed phase plates (DPP's), optimized pointing



- This level is similar to that in symmetric 60-beam implosions
- This is consistent with observed ~180 ps bang-time delays in PD implosions
- Equatorial third ring most affected by CBET

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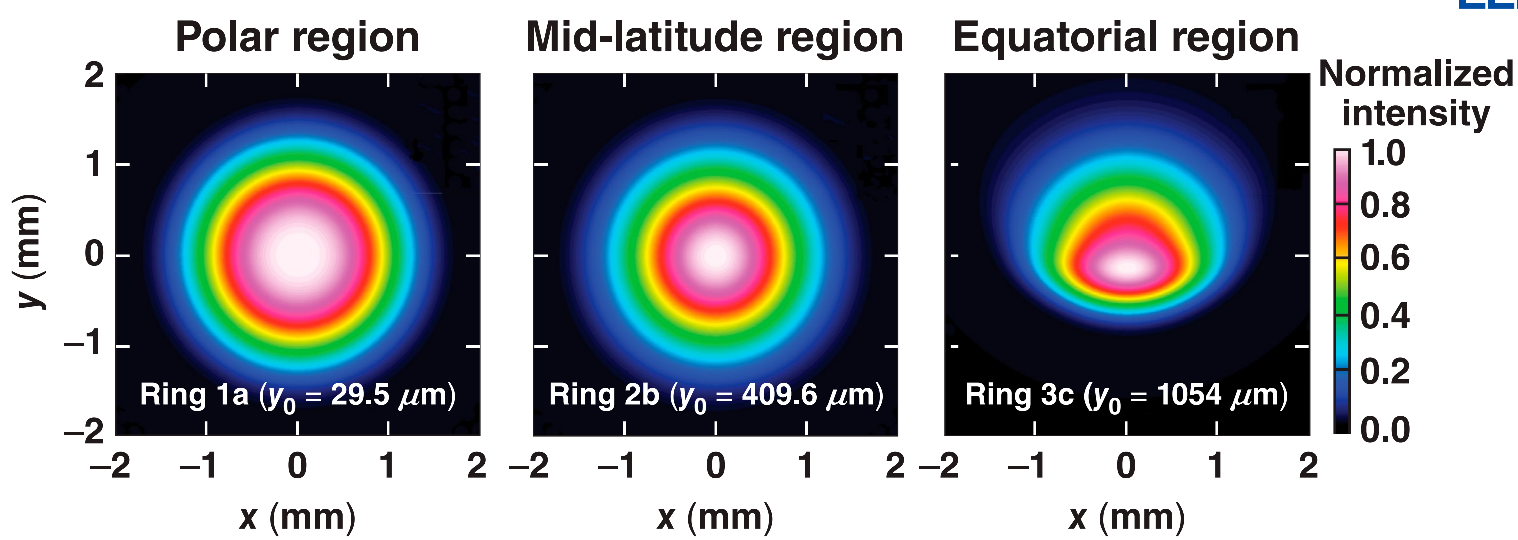
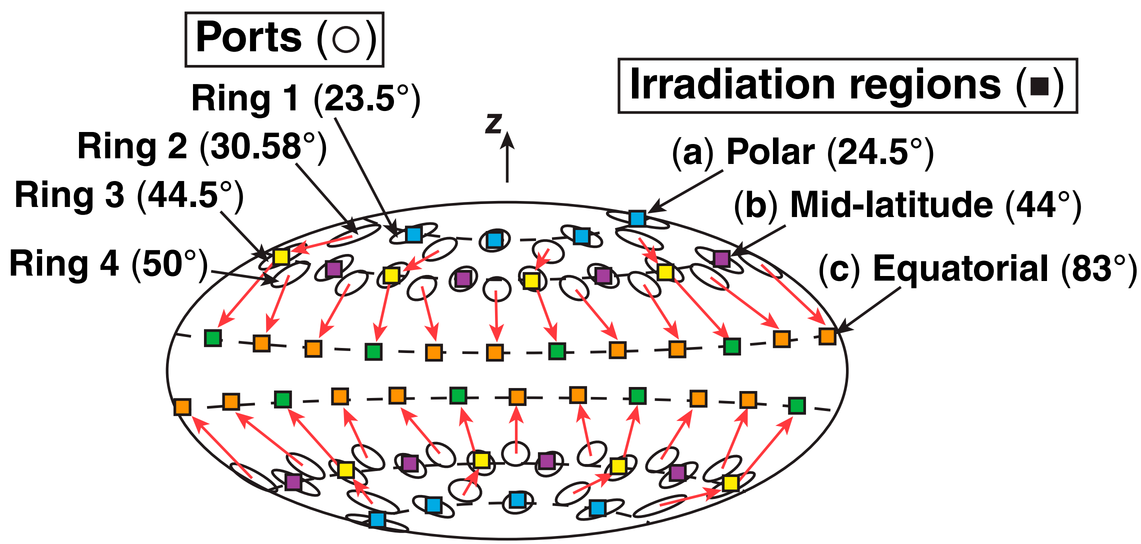
*P. B. Radha, NI2.00006, this conference

The PD ignition point design* for the NIF has been studied using the CBET model





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*T. J. B. Collins *et al.*, Phys. Plasmas 19, 056308 (2012); T. J. B. Collins, JO4.00010, this conference

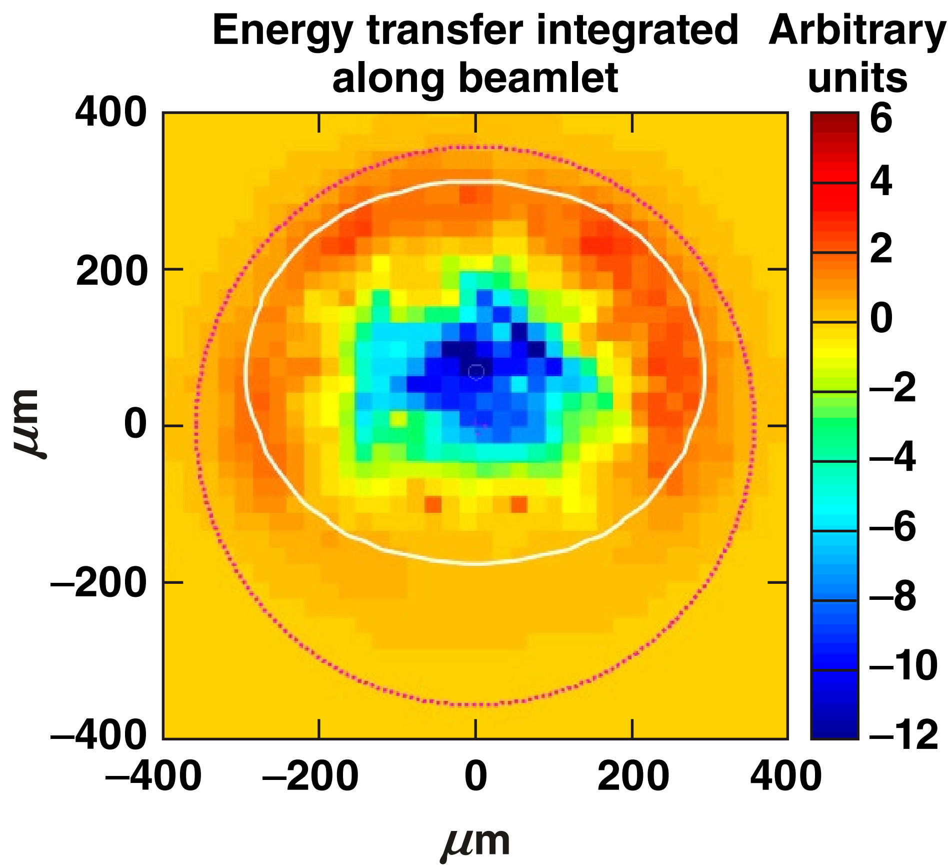
Preliminary results suggest ~20% reduction in absorption as a result of CBET for PD on the NIF

- The NIF PD implosions seem more sensitive to CBET than OMEGA
  - quads treated as single beams with quadruple intensity
  - pointing offsets are larger
    - some beams are offset azimuthally as well as toward the equator

Ring	Absorption no CBET	Absorption with CBET
1a	95%	88%
2b	95%	80%
3b	92%	90%
3c	90%	59%
4c	92% 89%	55% 60%
Total	92%	72%

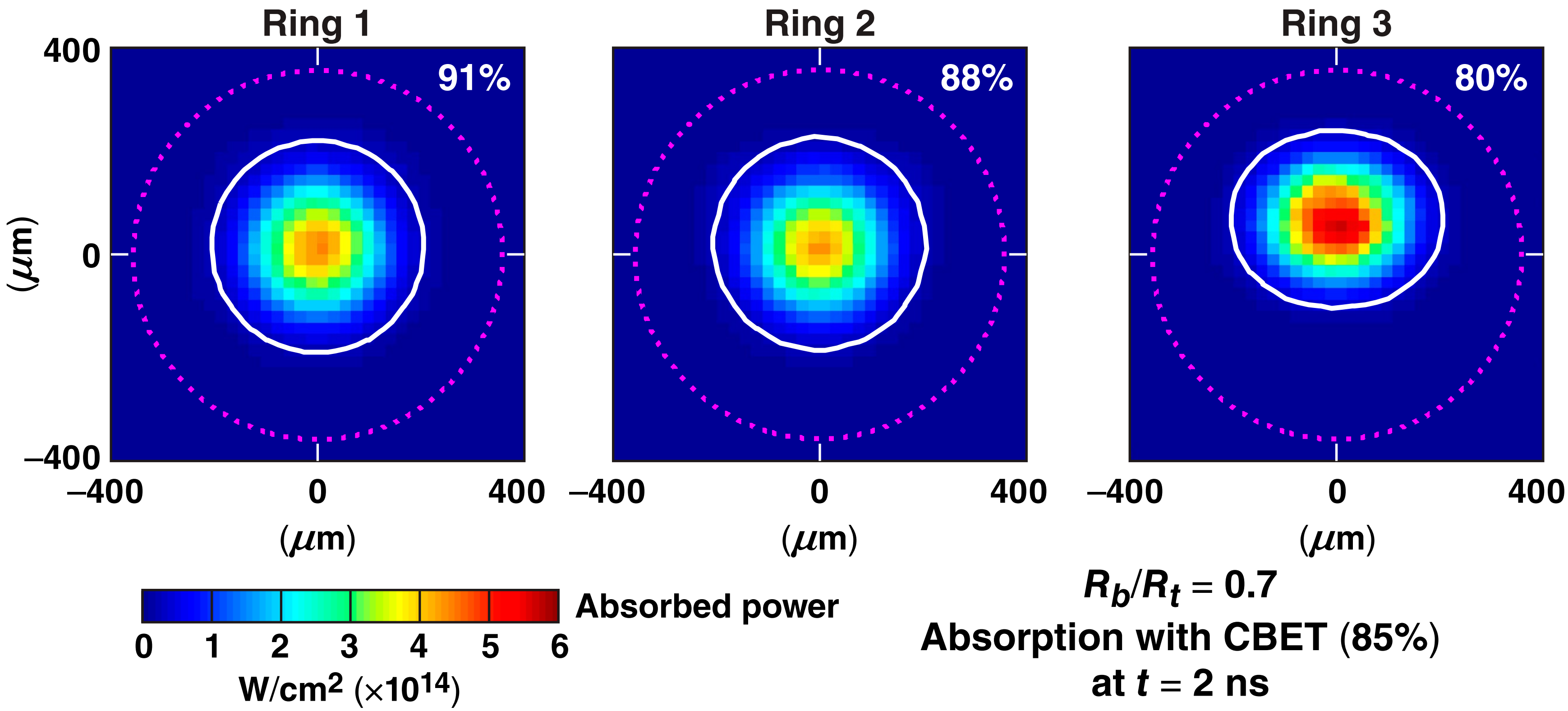
CBET may be mitigated by using a smaller laser beam spot size

- In CBET the edge regions of the beam profiles steal energy from the centers
  - if we remove this edge region by making the spot smaller we may reduce the effects of CBET
- Experiments* in symmetric-drive implosions with reduced beam/target radius support this



* I. V. Igumenshchev *et al*., Phys Plasmas 19, 056314 (2012).
D. H. Froula *et al*., Phys. Rev. Lett. 108, 125003 (2012).

Using a smaller spot size recovers the 85% total absorption of the no-CBET predictions in PD



R_b/R_t = 0.7
Absorption with CBET (85%)
at t = 2 ns

This could be an effective CBET mitigation strategy for PD, but it must be balanced with increasing illumination asymmetries and possible LPI issues with decreasing beam size.

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