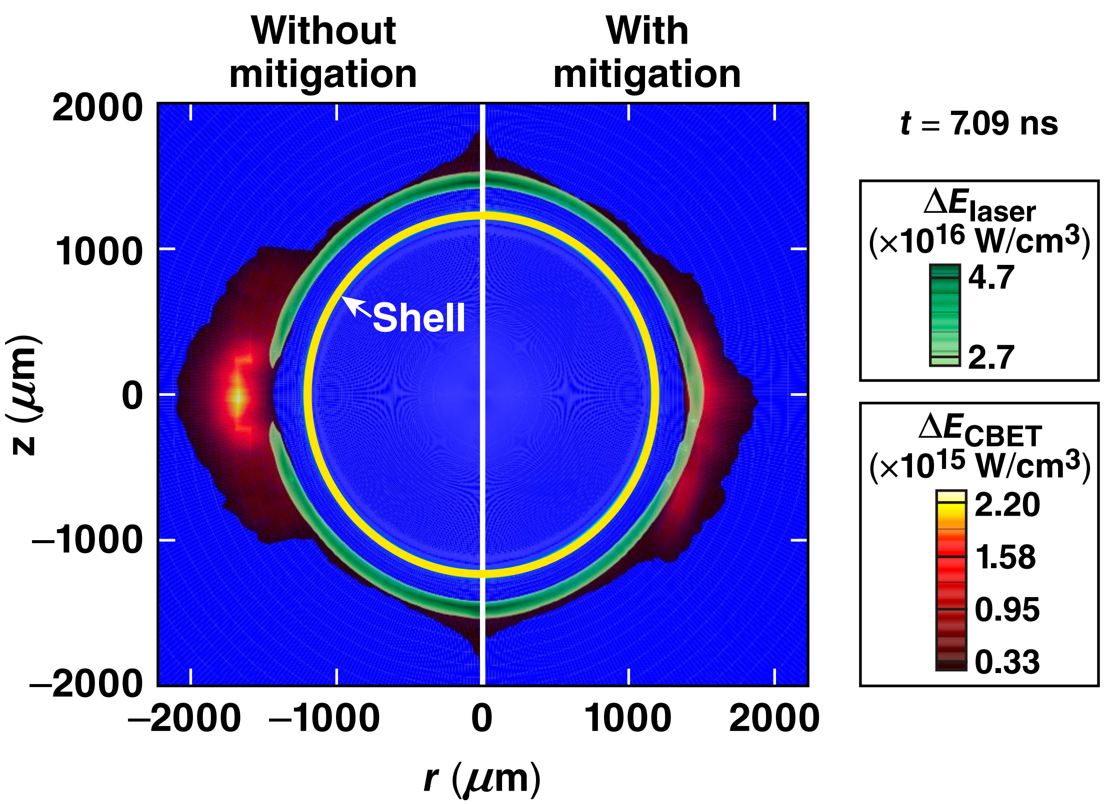
Cross-Beam Energy Transfer (CBET) Effect Integrated into the 2-D Hydrodynamics Code *DRACO*



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54th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Providence, RI
29 October–2 November 2012

Summary

DRACO provides self-consistent CBET calculations that predict angular-dependent effects in polar drive (PD)

- **The CBET effect increases scattered light through stimulated Brillouin scattering (SBS) of outgoing rays that remove energy from incoming rays**
- **The 2-D hydrodynamics code *DRACO* employs feedback control to maintain energy balance from CBET**
- **The NIF PD simulations demonstrate that beam-to-beam wavelength shift is a promising CBET mitigation strategy for typical targets**

Collaborators

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CBET modeling in *DRACO* employs an angular spectrum representation (ASR) approach with feedback control

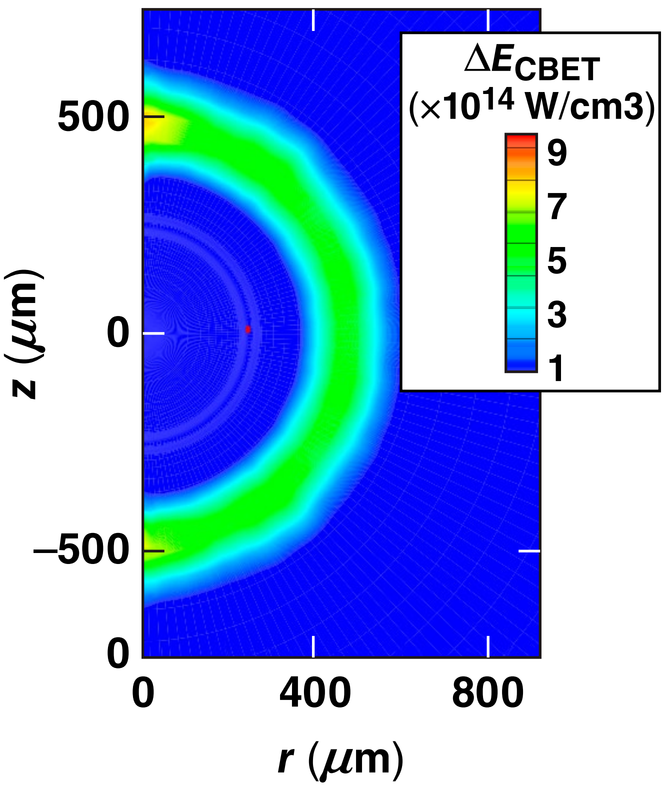
UR LLE

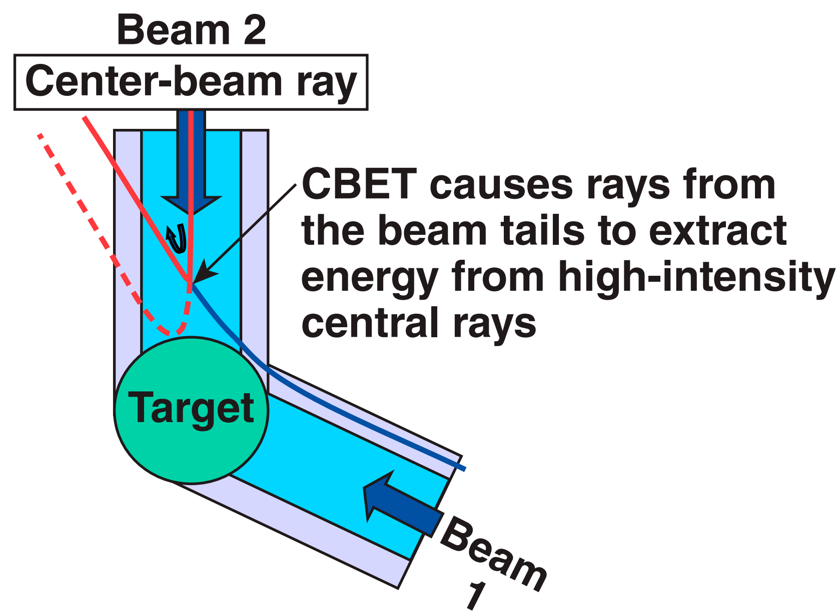
- The ASR captures the relevant wavelength, intensity, and direction information from all the beams that propagate through any cell
- Feedback through a PID-controller (proportional-integral-differential) loop provides vital control over CBET energy balance
  - the CBET equations conserve energy with feedback control; i.e., they lack energy depletion on their own*
  - feedback mimics the balanced energy flux from neighboring computational cells
- The ASR from the previous time step is used to increase convergence by providing an estimate for the current time step

*E. A. Williams *et al.*, Phys. Plasmas 11, 231 (2004).

Cross-beam energy transfer occurs nearly uniformly over the entire target for OMEGA direct drive

- **OMEGA direct drive offers a high amount of symmetry, which is reflected in the CBET gain power density (W/cm^3)**
- **The CBET effect can be successfully mitigated by reducing the beam diameter***



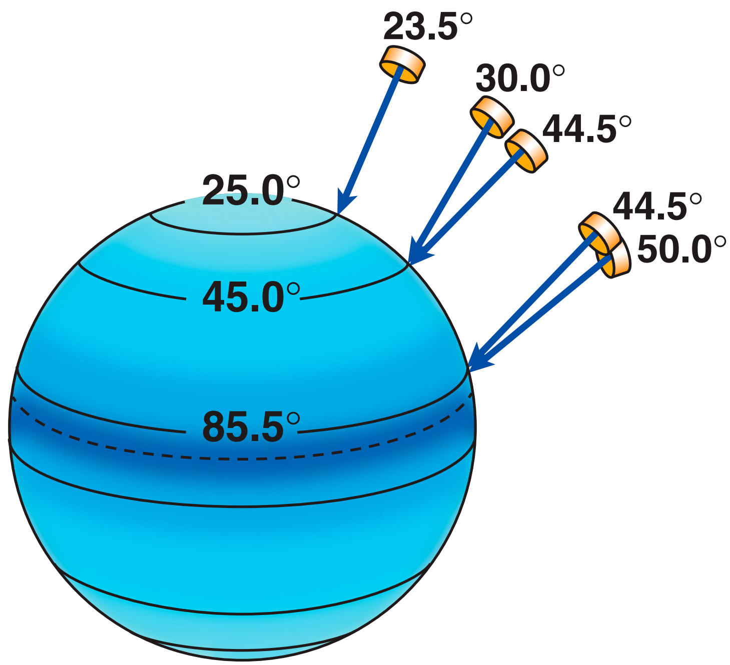


TC10214

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

NIF PD simulations including CBET produce polar-dependent CBET gain variations

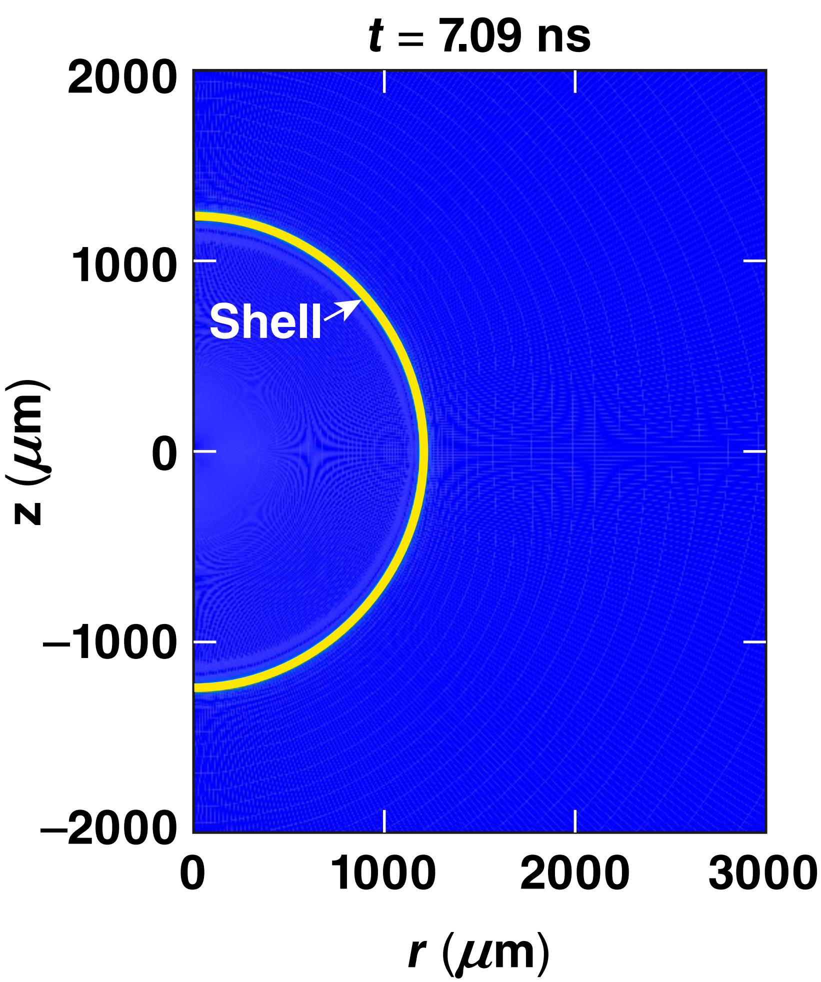
- PD employs the NIF indirect-drive ports to illuminate the target with modified spot shapes and transverse shifts to direct power towards the equator



- The increased energy delivered to the target compensates for reduced hydrodynamic efficiency
- A shim in the target shell compensates for the reduced equatorial hydro-efficiency

TC10215

The strongest CBET gain occurs the near the equator in NIF PD simulations



- The equatorial rings exchange the majority of CBET energy

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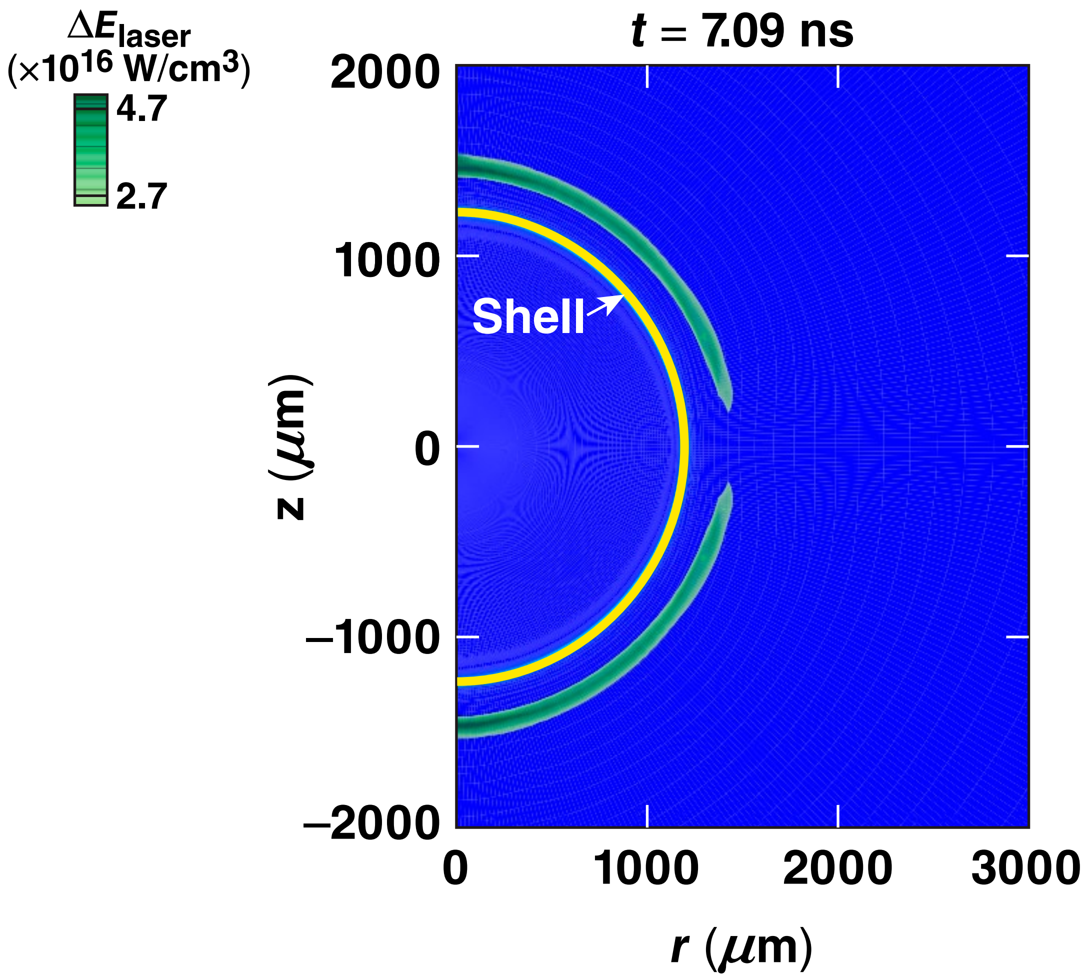

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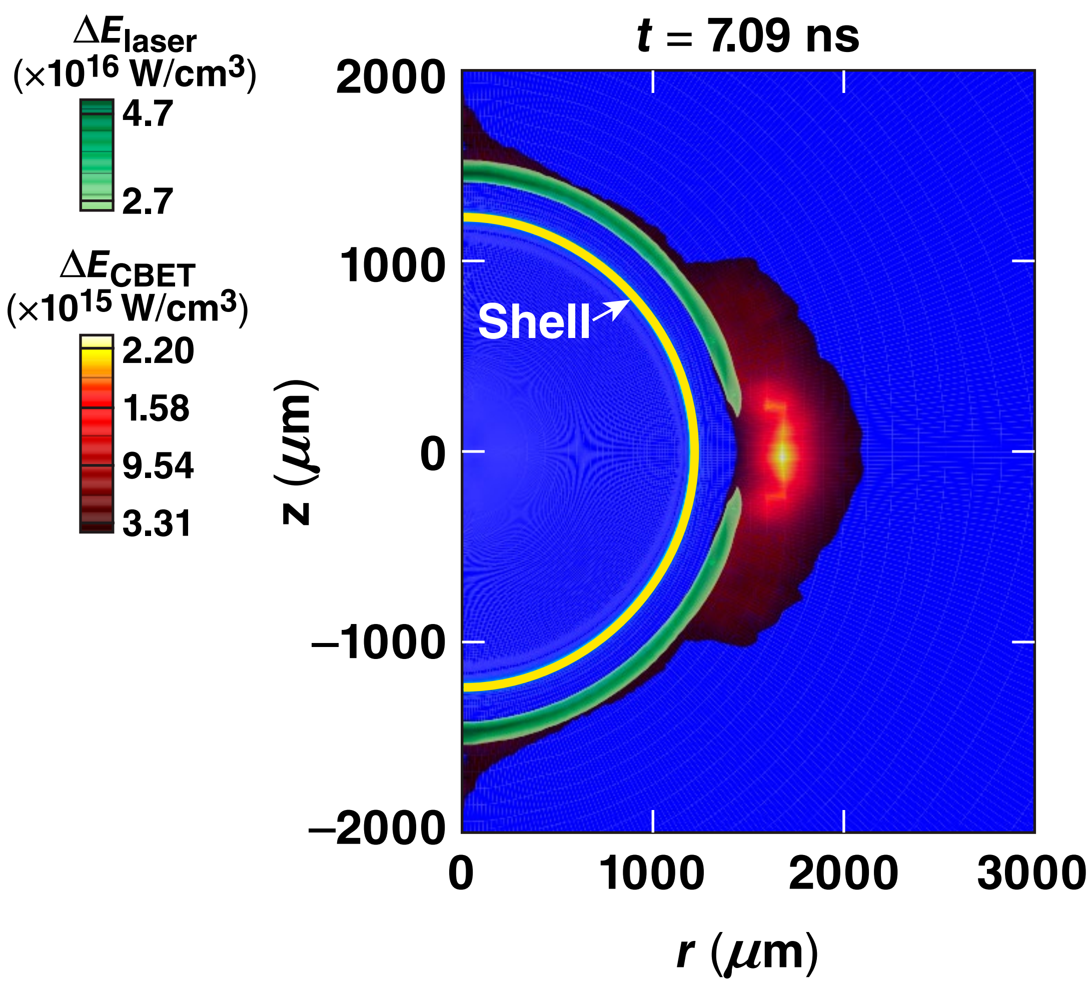

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TC10216b

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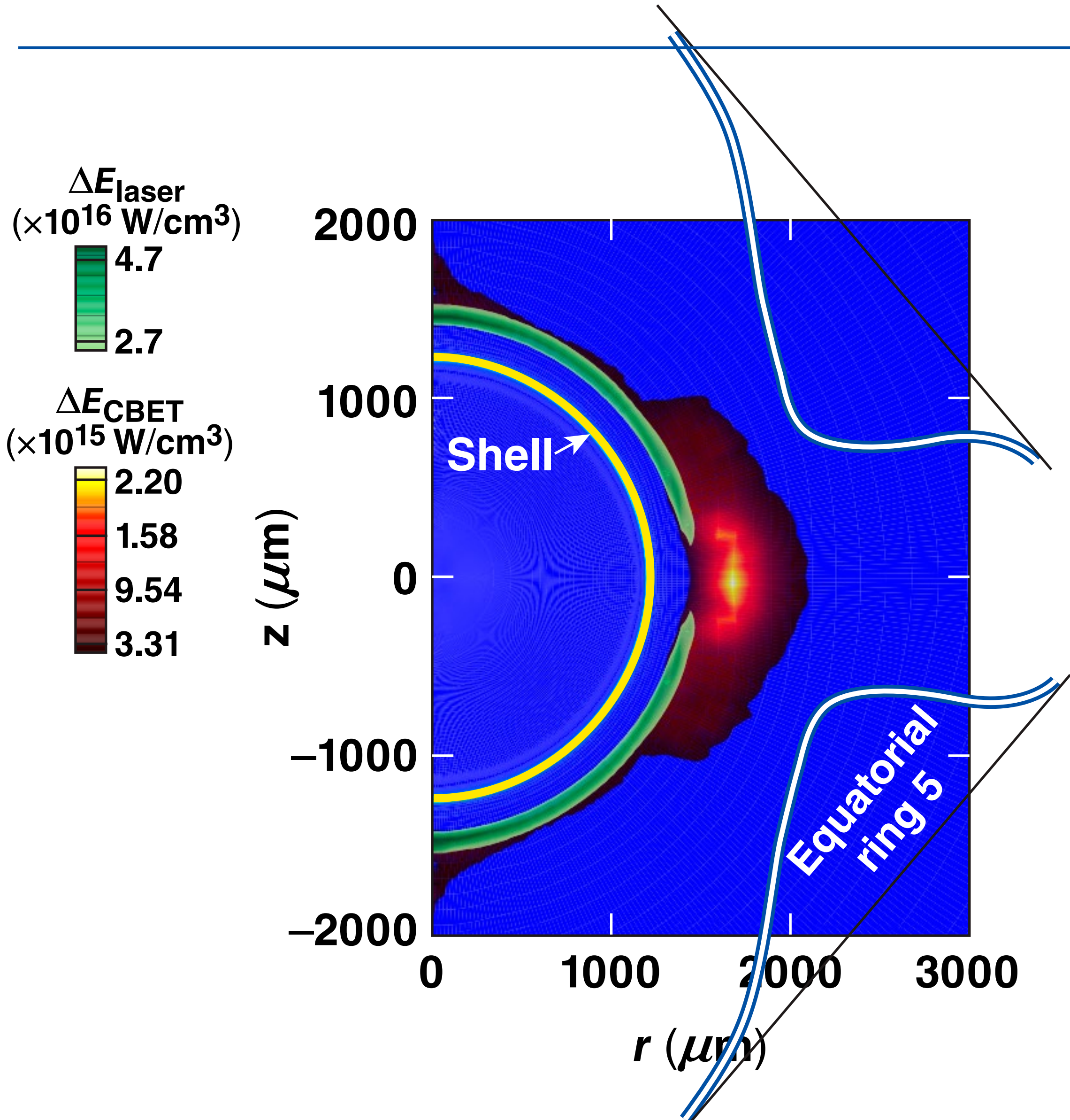

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TC10216c

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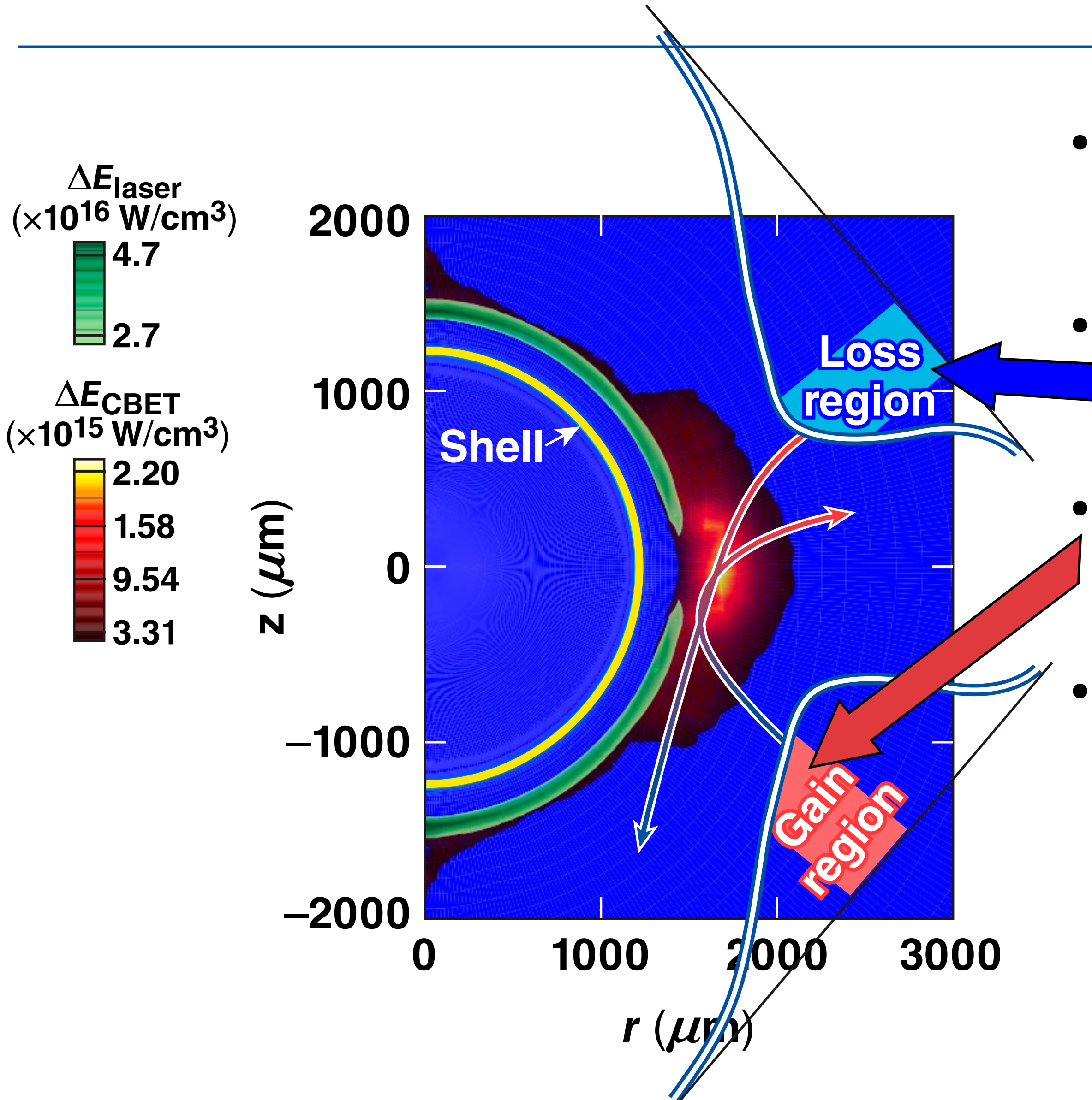
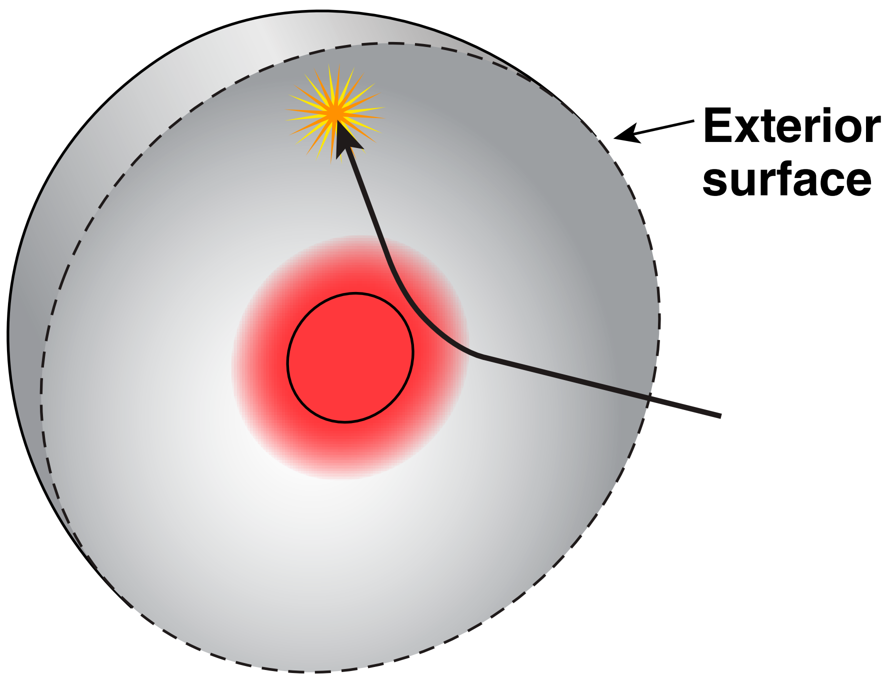


- The equatorial rings exchange the majority of CBET energy
- The CBET-loss ray energy scatters toward the opposite pole
- The CBET-gain ray energy scatters toward the opposite equator
- Making spots smaller while attempting to deliver energy to the equator is not a viable mitigation scheme

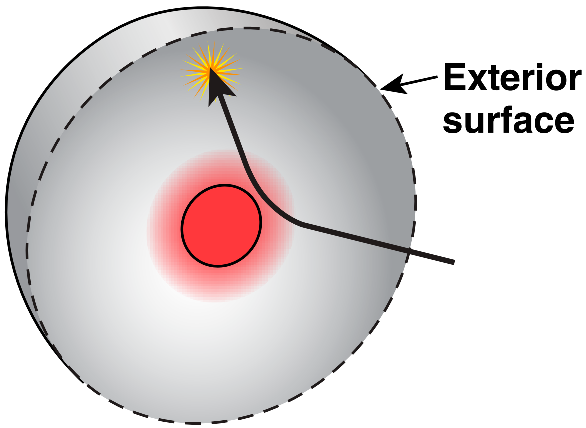
TC10216d

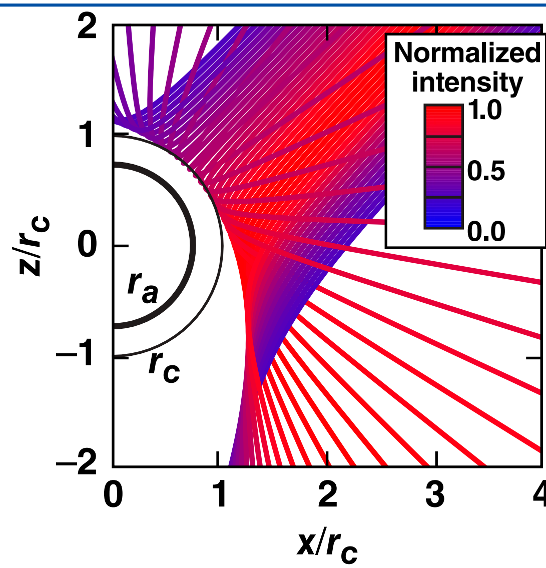
The ray energy gained or lost as a result of CBET is accumulated during propagation and collected on a scattering screen



TC10377

The ray energy gained or lost as a result of CBET is accumulated during propagation and collected on a scattering screen

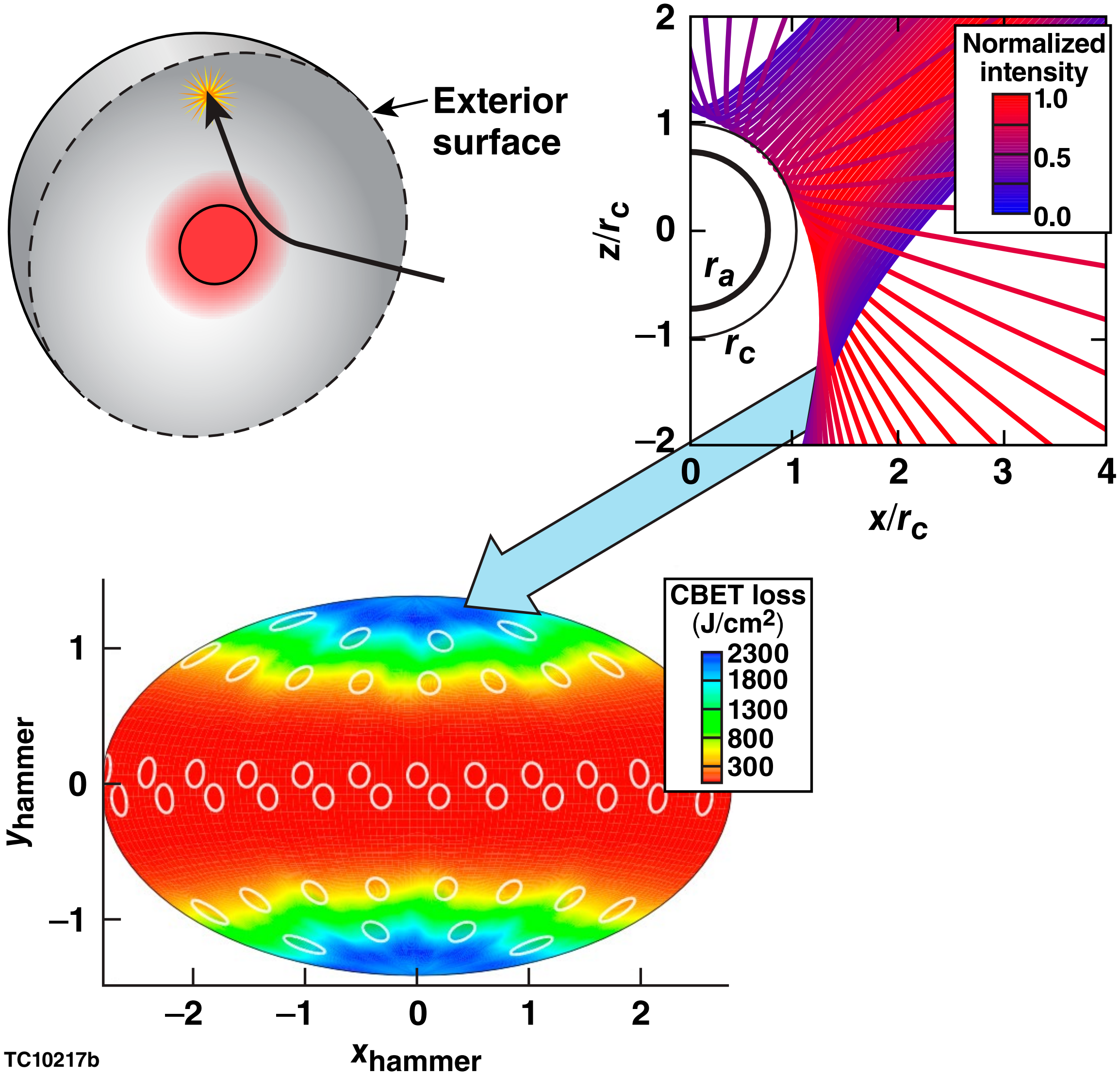




- The primary sources of CBET gain are the equatorial rings; the polar and mid-latitude rings contribute a much smaller portion (25%)

TC10217a

The ray energy gained or lost as a result of CBET is accumulated during propagation and collected on a scattering screen



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TC10217b

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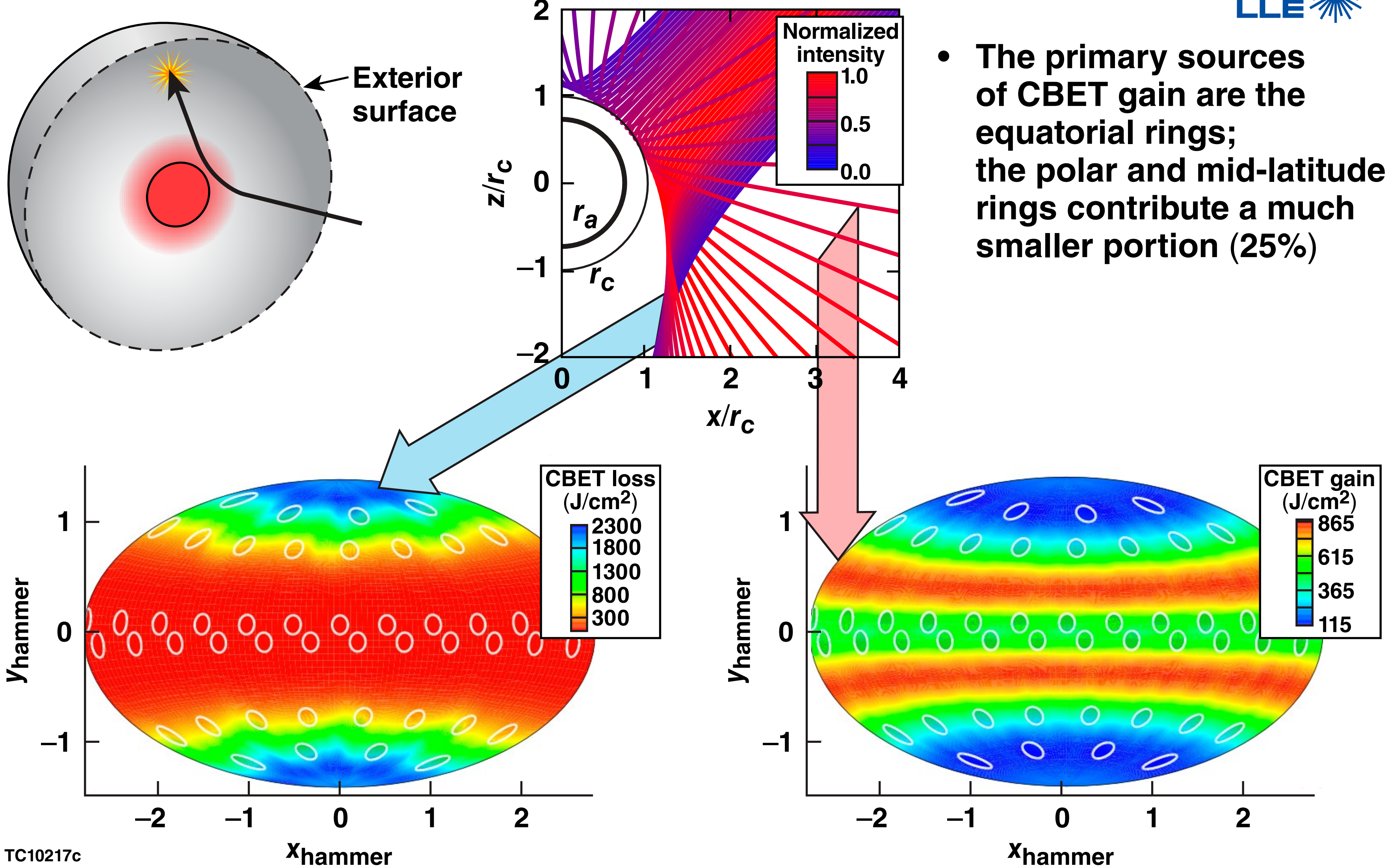
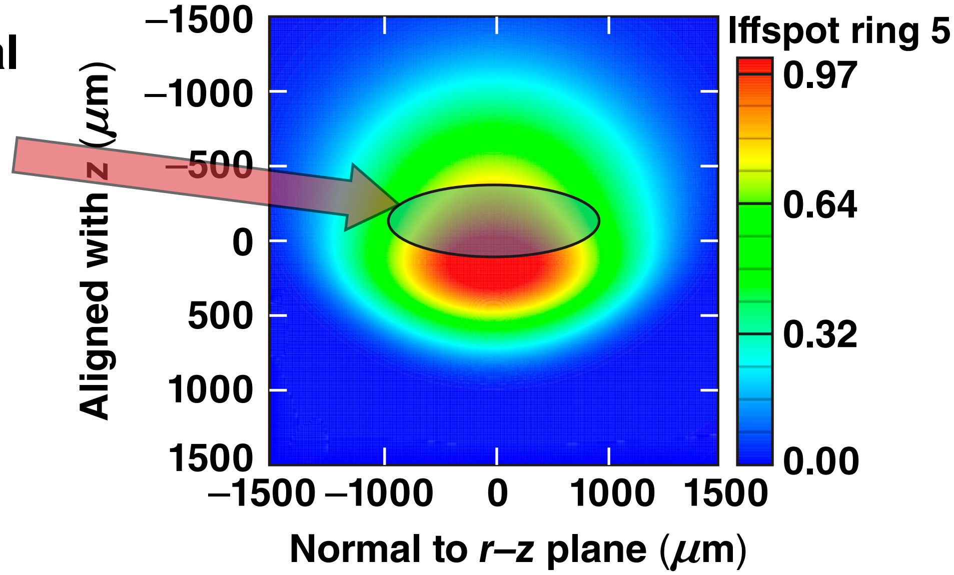


- The primary sources of CBET gain are the equatorial rings; the polar and mid-latitude rings contribute a much smaller portion (25%)

TC10217c

The scattered equatorial CBET gain originates from the interior of the spot

- **The effect of CBET from the central portion of the spot cannot be mitigated via a spot shape change because this energy is required to drive the target**
- **However, a wavelength change can be used to shift the CBET resonance condition***

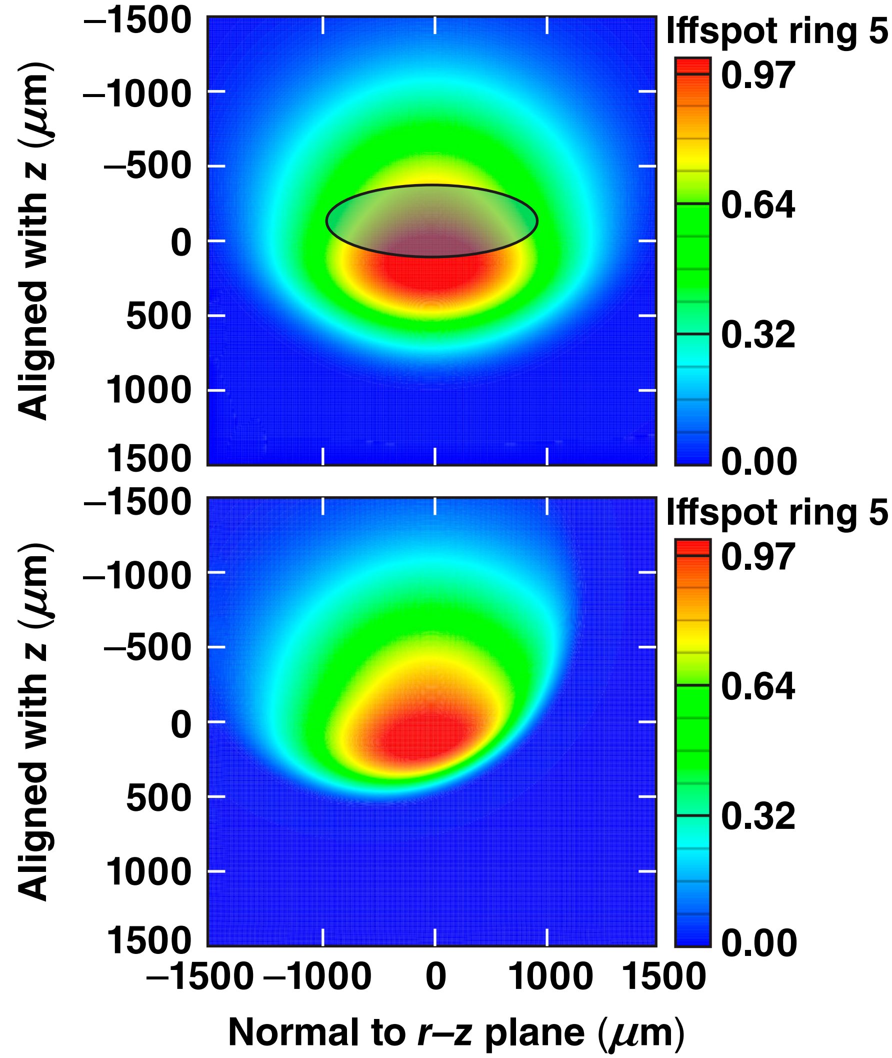


TC10378

*NIF IDI: P. Michel *et al.*, Phys. Plasmas 17, 056305 (2010).
1-D *LILAC* CBET: I. V. Igumenshchev *et al.*, Phys. Plasmas 19, 056314 (2012).

The scattered equatorial CBET gain shows the important probe rays originate in the center of the spot

- **The effect of CBET from the central portion of the spot cannot be mitigated via a spot shape change because this energy is required to drive the target**
- **However, a wavelength change can be used to shift the CBET resonance condition***
- **A modest amount of CBET reduction can be achieved by applying an additional aperture to the equatorial spots to reduce the light that goes over the horizon because of lateral repointing**



TC10378a

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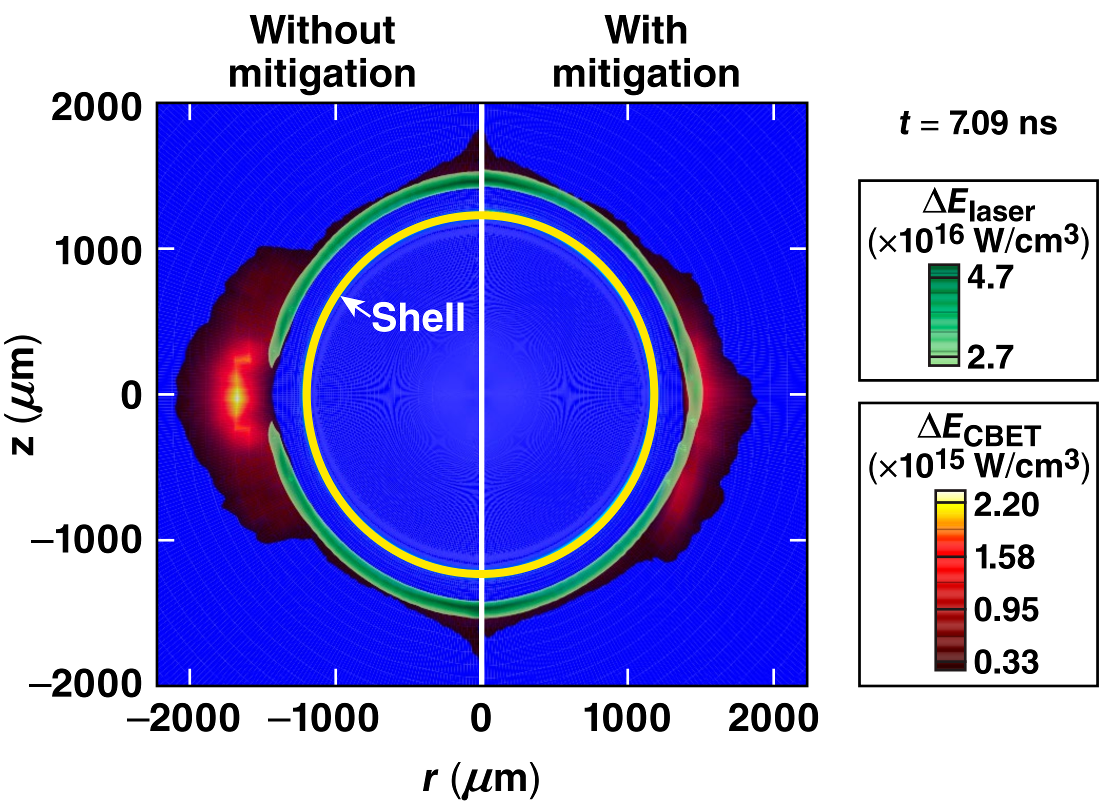
The static spot shape and wavelength shift mitigation schemes recover most of the lost equatorial energy density



- A UV wavelength shift of 12 Angstroms was applied as +6Å in one hemisphere and –6Å in the other
- Other mitigation schemes are being investigated
  - $N > 2$ wavelengths at $-3Å < \lambda_{UV} < 3Å$
  - shim compensation for decreased equatorial drive
  - repointing and spot shape control

TC10379

Summary/Conclusions

DRACO provides self-consistent CBET calculations that predict angular-dependent effects in polar drive (PD)

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- **The 2-D hydrodynamics code *DRACO* employs feedback control to maintain energy balance from CBET**
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