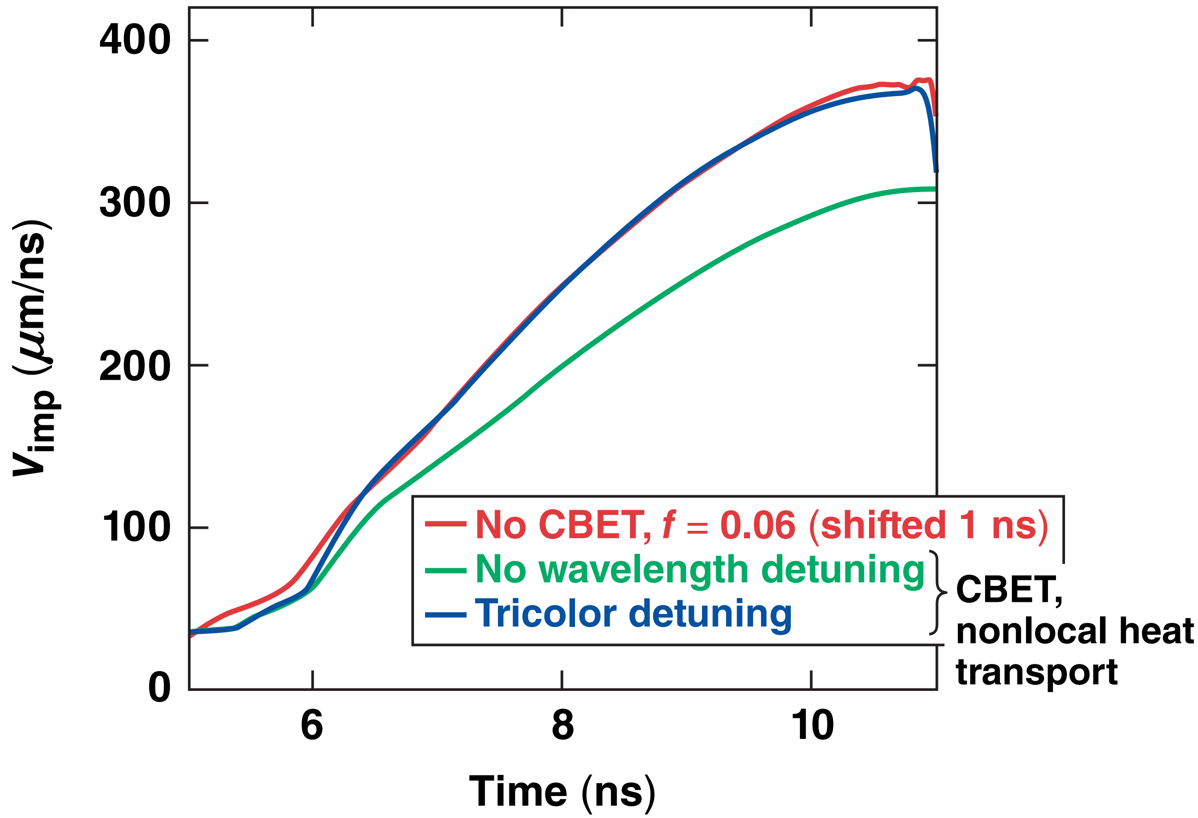
# A Polar-Drive Alpha-Heating Platform for the National Ignition Facility





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Summary

# Three-color detuning cross-beam energy transfer (CBET) mitigation achieves ignition-relevant implosion velocities

- Tricolor detuning restores over half the drive energy lost to CBET
- Nonlocal electron transport increases the hydrodynamic efficiency, offsetting the decrease in drive energy caused by CBET
- A polar-drive target design, with an implosion velocity of 370 $\mu$m/ns, is predicted to demonstrate alpha heating with a neutron yield of $2 \times 10^{16}$

# Collaborators

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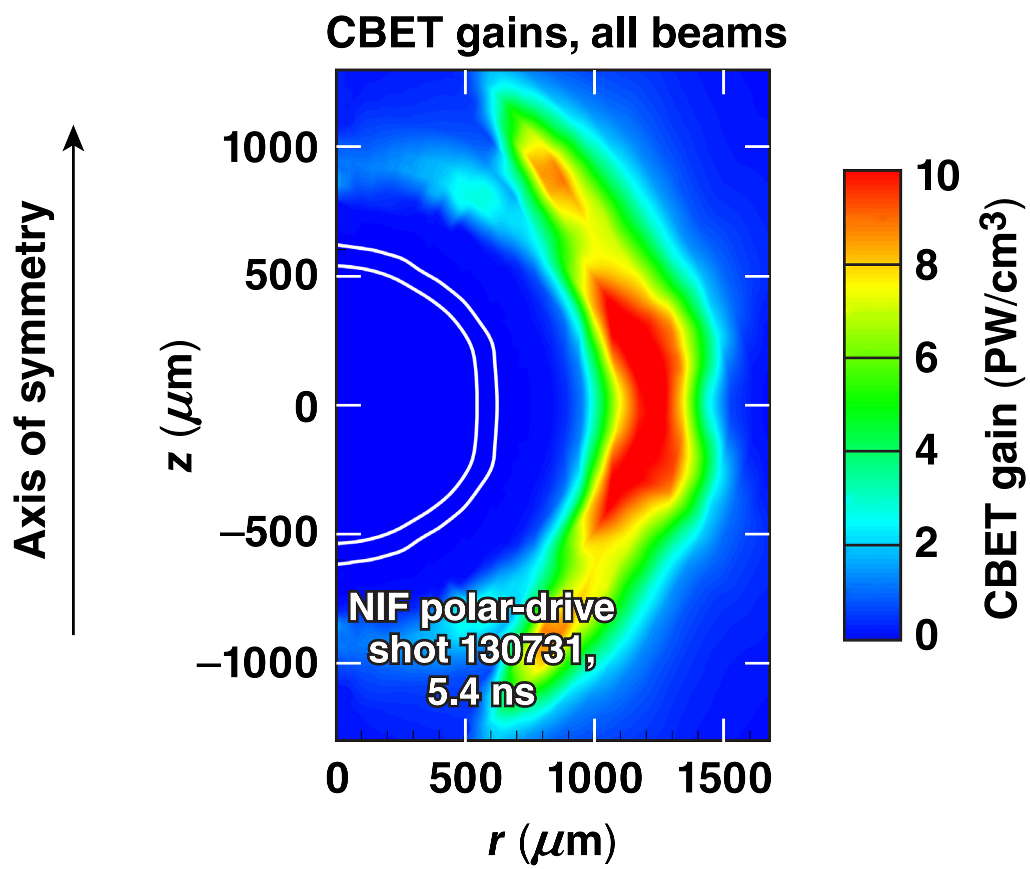
# The majority of CBET* occurs over the equatorial region in polar drive



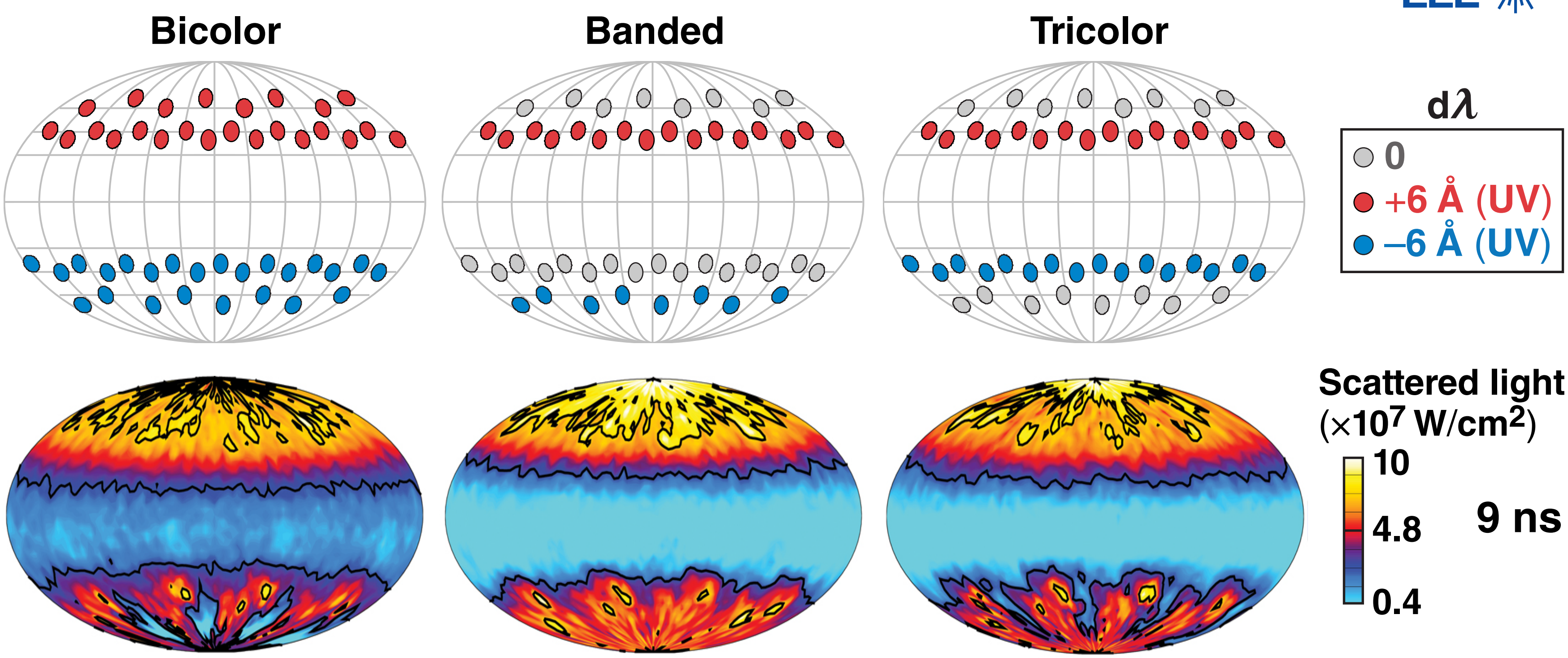

- CBET reduces the laser drive by as much as 30%, making CBET mitigation the most-important design issue
- Laser wavelength detuning is used for power balance in indirect-drive experiments; for direct drive it is used for CBET mitigation

- Detuning the laser wavelength in each hemisphere changes the location of the CBET resonance region; the interaction region vanishes only in the large detuning limit

TC11765

*J. A. Marozas *et al*., NO4.00014, this conference; P. W. McKenty *et al*., NO4.00015, this conference.

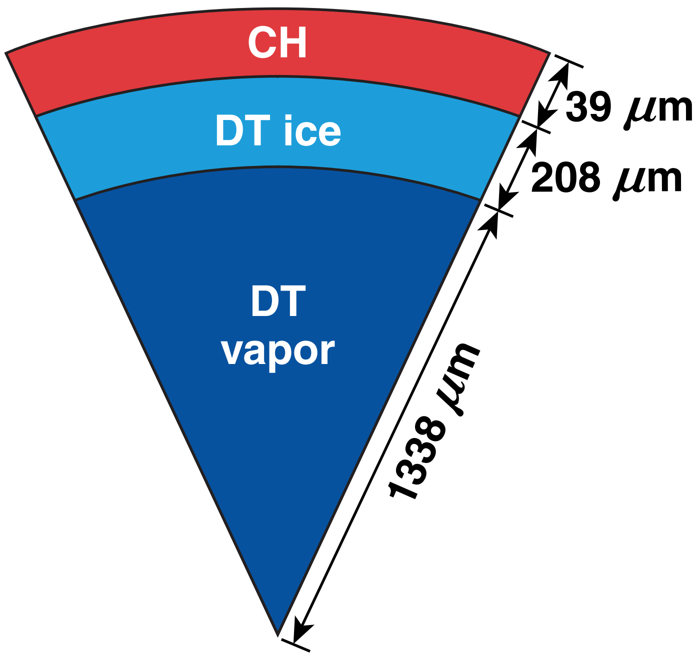
# Three wavelength detuning strategies were explored for CBET mitigation

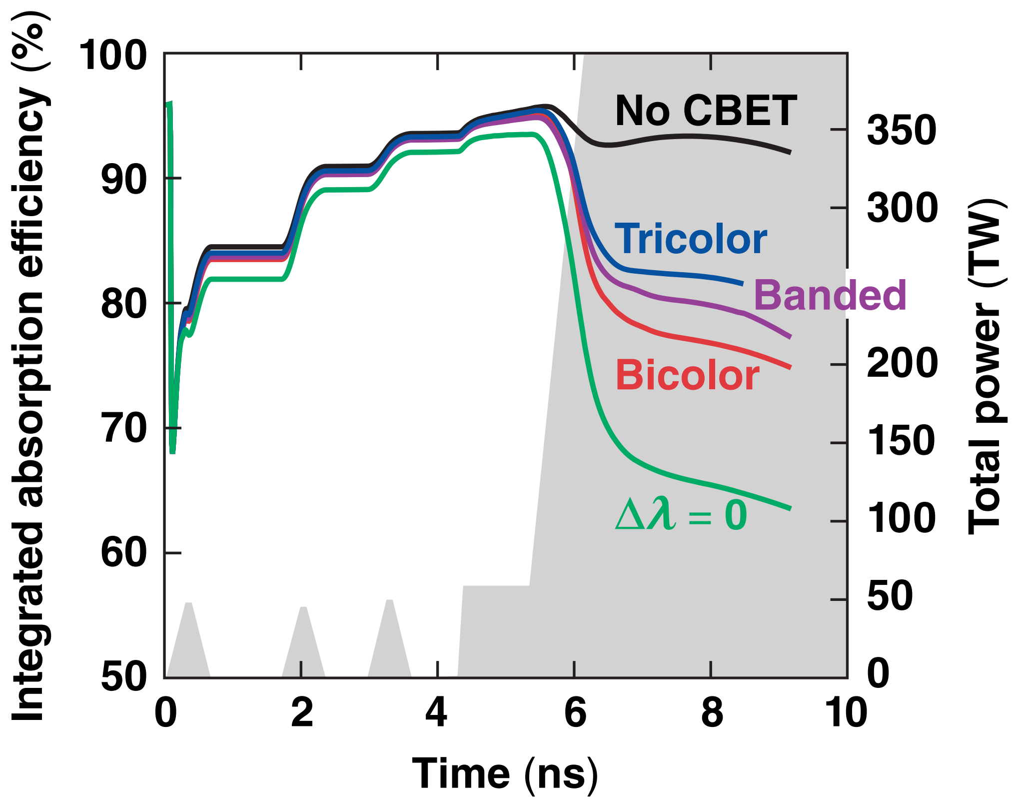



- Banded and tricolor detuning have less scattered light at the equator because of reduced intrahemispherical CBET and less scattering of the polar beams
- Tricolor detuning has less scattered light at the poles because of reduced interhemispherical CBET and less scattering of the equatorial beams
- The sign $\Delta\lambda$ determines whether the interaction region moves radially in or out; this introduces a north–south asymmetry and a significant $\ell = 1$ perturbation

# Tricolor detuning restores over half of the absorbed energy lost to CBET

- **Tricolor detuning not only reduces interhemispherical CBET but also reduces CBET within each hemisphere**



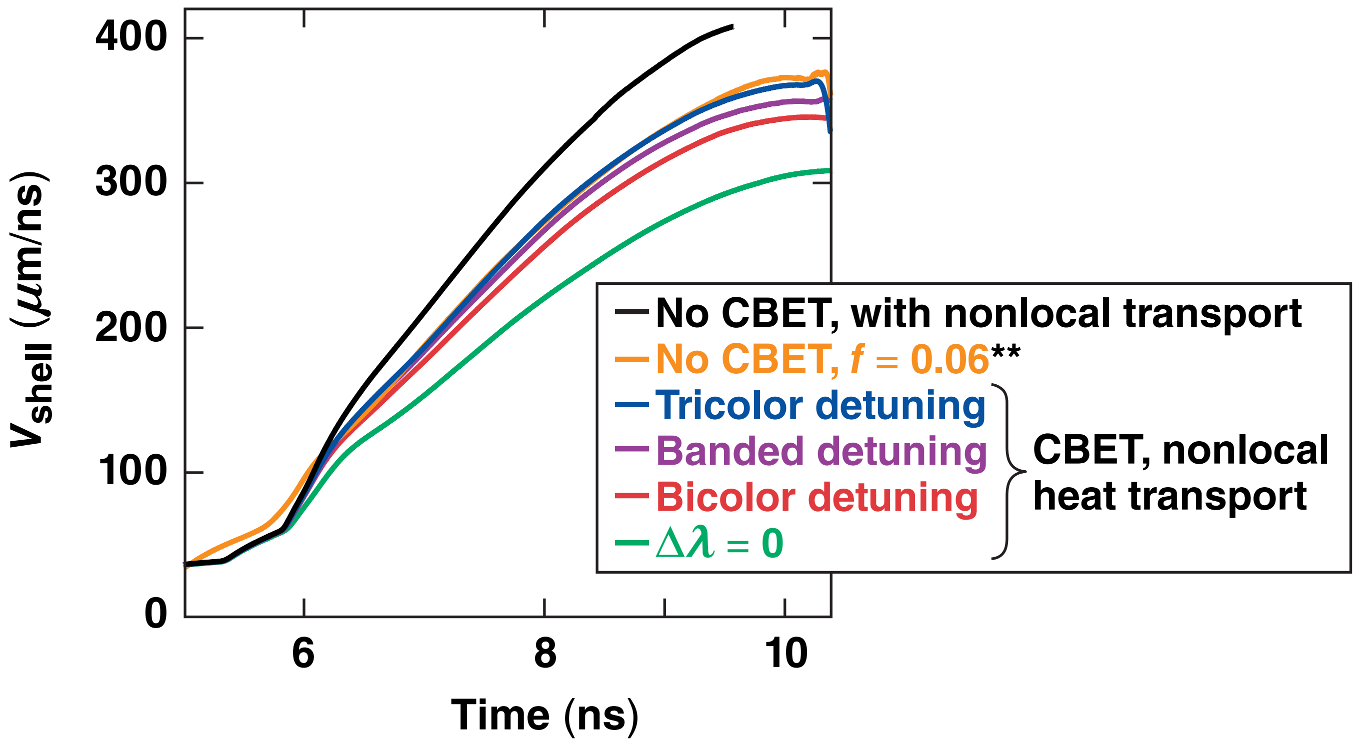




- **This design uses phase plates relevant to polar-drive ignition**

TC11530

# The loss of absorbed energy is offset by the increase in hydrodynamic efficiency caused by nonlocal heat transport

- Nonlocal electron transport is modeled with the implicit Schurtz–Nicolaï–Busquet (iSNB) model*
- Tricolor detuning achieves an implosion velocity comparable to that of the original point design as simulated without CBET or nonlocal heat transport




* G. P. Shurtz, Ph. D. Nicolaï, and M. Busquet, Phys. Plasmas 7, 4238 (2000); D. Cao *et al.*, UP8.00084, this conference.

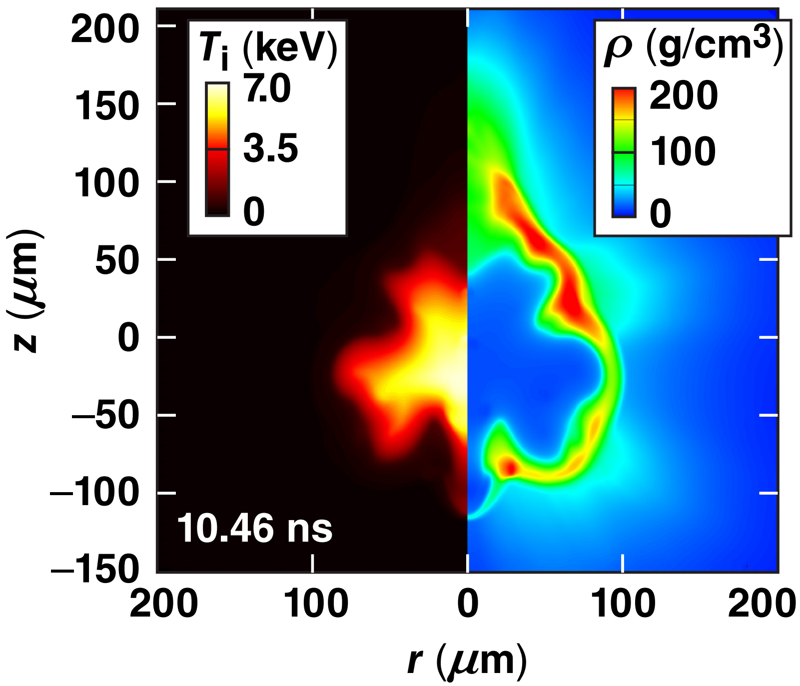
** T. J. B. Collins *et al.*, Phys. Plasmas 19, 056308 (2012).

TC11529

# A robust target design has been developed that is predicted to demonstrate alpha heating

- The hot-spot temperature and uniformity are sufficient to generate significant alpha-deposition yield
- This design operates on an adiabat of ~3 to reduce hydrodynamic instability
- This lowers the growth factor for mode $\ell = 100$ by 82%

| Design properties | Alpha-burning design |
|---|---|
| $V_{imp}$ ($\mu$m/ns) | 370 |
| $E_{laser}$ (MJ) | 1.5 |
| Peak power (TW) | 433 |
| In-flight aspect ratio (IFAR) | 23 |
| In-flight $\alpha$ | 3 |
| Peak $\rho R$ (g/cm$^2$) | 1.6 |
| Peak $T_i$ (keV) | 6.3 |
| Neutron yield | $2.4 \times 10^{16}$ |

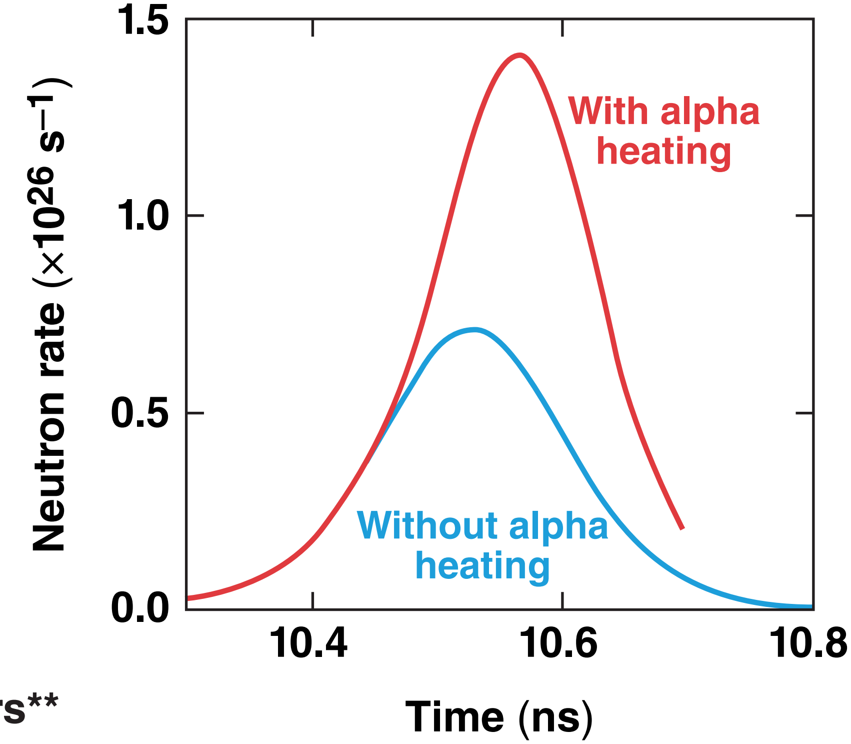



Simulated with CBET, nonlocal heat transport, and long-wavelength nonuniformities

TC11531

# The ion temperatures achieved are sufficient to demonstrate "bootstrap" heating

- The areal density and peak ion temperature, while insufficient to produce a sustained burn wave, do generate alpha-deposition neutron yield comparable to the neutron yield generated by compression alone
- $E_{\alpha}/E_{tot} \sim 0.5$, $Y_{\alpha}/Y_{no\ \alpha} \sim 1.7$
- The target implosion speed can be further increased by
  - increasing incident laser energy from 1.5 MJ to 1.8 MJ*
  - reducing the spot size to 85% of the target radius, increasing the absorbed laser energy by 6%
  - increasing the coronal electron temperature using moderate-*Z* ablators**




**A high-gain, low-adiabat design is being developed based on the robust alpha-burning design.**

* J. A. Marozas *et al.*, 44th Anomalous Absorption Conference, Estes Park, CO (2014).
** M. Lafon *et al.*, JO4.00011, this conference.

TC11570

# Three-color detuning cross-beam energy transfer (CBET) mitigation achieves ignition-relevant implosion velocities

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- A polar-drive target design, with an implosion velocity of 370 $\mu$m/ns, is predicted to demonstrate alpha heating with a neutron yield of $2 \times 10^{16}$
- A second design with a low adiabat is being toned for ignition