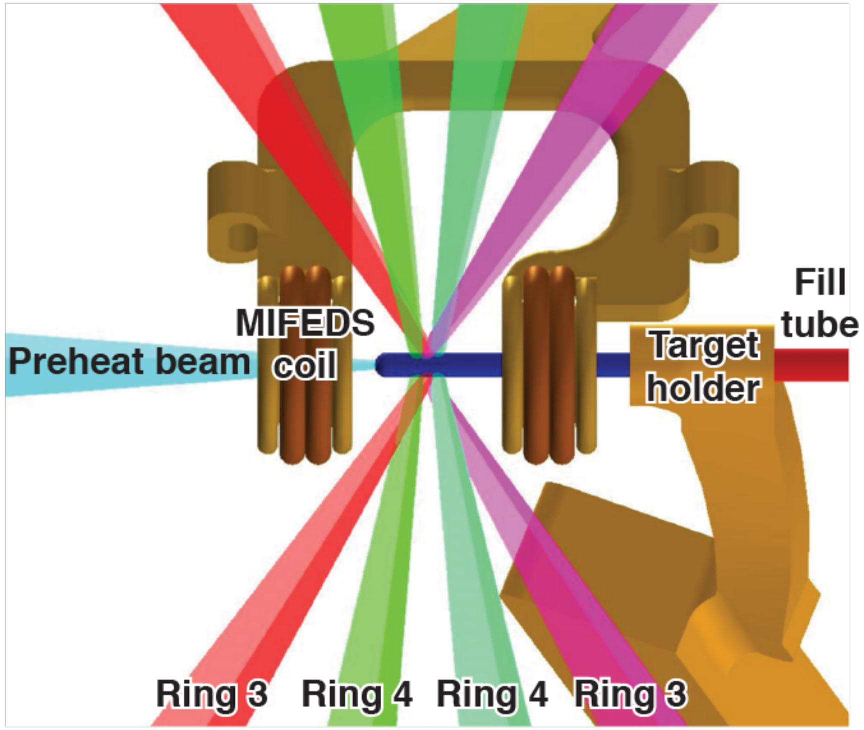
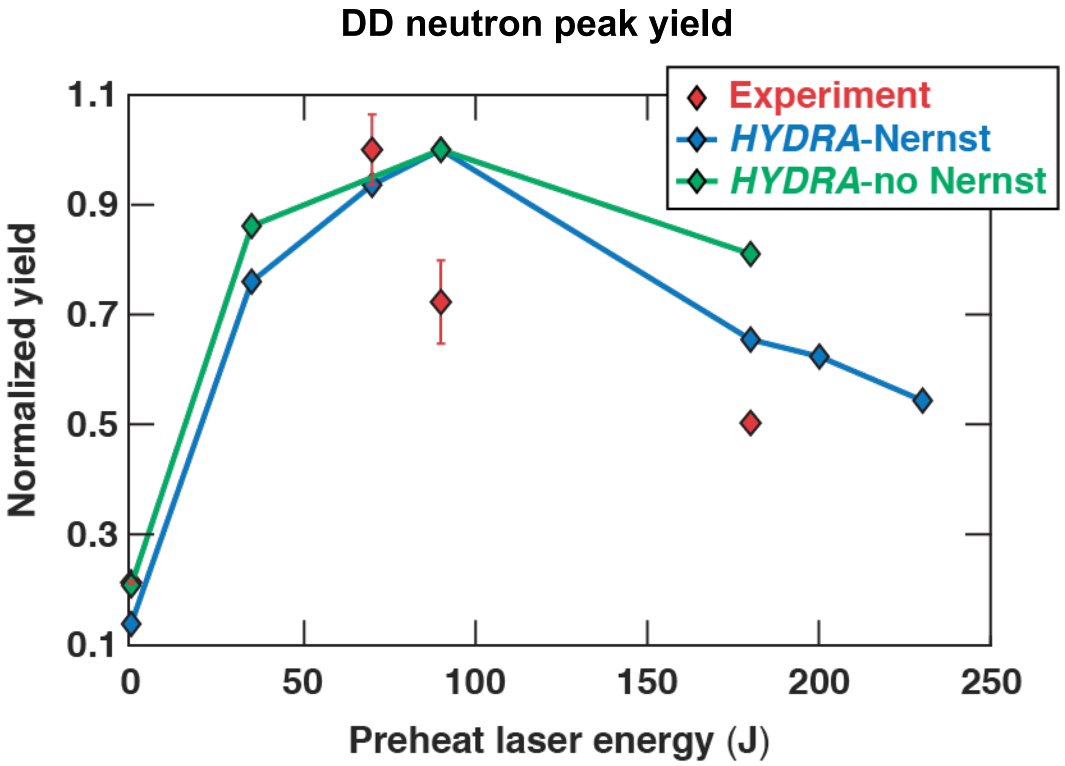
Simulations of Laser Preheat Effects on Yield in Mini-MagLIF Implosions at Omega



E25893



L. S. Leal
University of Rochester
Laboratory for Laser Energetics

62nd Annual Meeting of the American Physical Society
Division of Plasma Physics
9–13 November 2020

Three-dimensional *HYDRA* simulations of the mini-MagLIF at the Omega agree with experiments that there is an optimal laser preheat energy

- **Simulation including the Nernst effect capture the drop in normalized neutron yield from peak with preheat laser energy higher than optimal**
- **Neutron averaged radial profiles of density become less dominated by edge effects with increasing preheat laser energy**
- **A simple mix model shows that carbon mix can lead to neutron yield degradation and shift the optimal laser preheat energy**

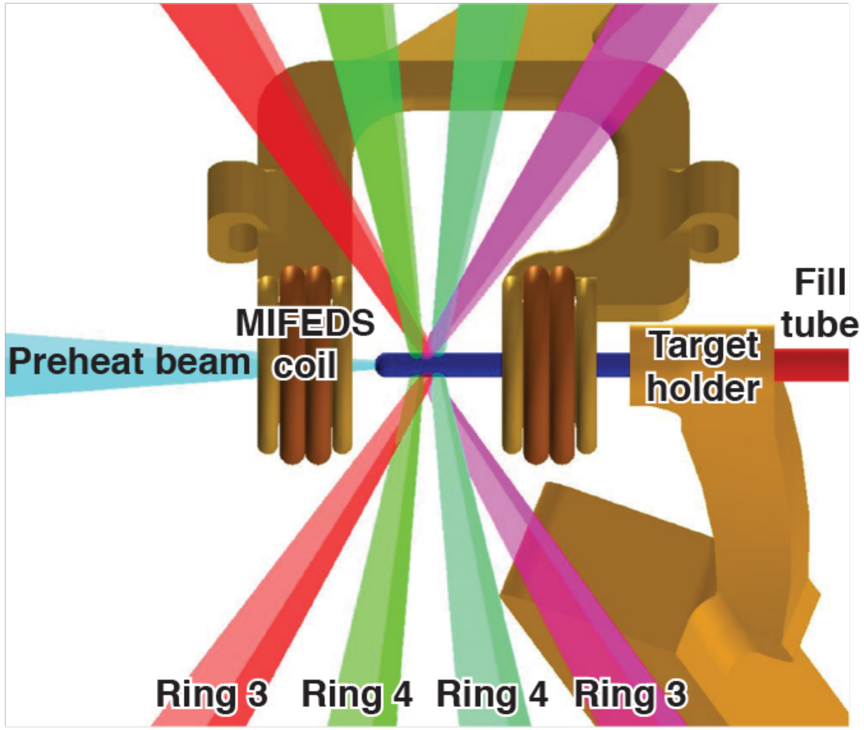
MagLIF: magnetized liner inertial fusion

Collaborators

A. V. Maximov, E. C. Hansen, J. R. Davies, D. H. Barnak, J. L. Peebles, A. B. Sefkow, and R. Betti

University of Rochester
Laboratory for Laser Energetics

Mini-MagLIF is a magneto inertial fusion concept at LLE that uses axial magnetic fields with laser-driven compression and preheat

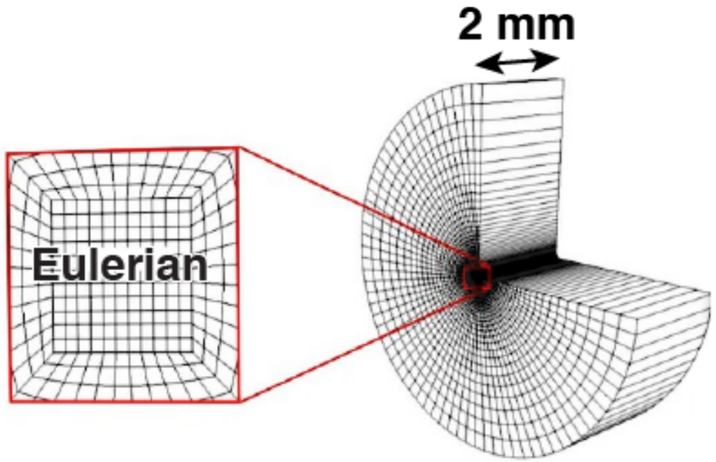


E25893

- 40 beams from OMEGA drive cylindrical targets that are 20-μm-thick shells with ~300-μm-radius
- The system can generate axial magnetic fields to the target in current MIFEDS generation up to 30 T
- Driver and preheat beams are 1.5-ns square-shaped pulses; the preheat laser begins 1 ns before driver

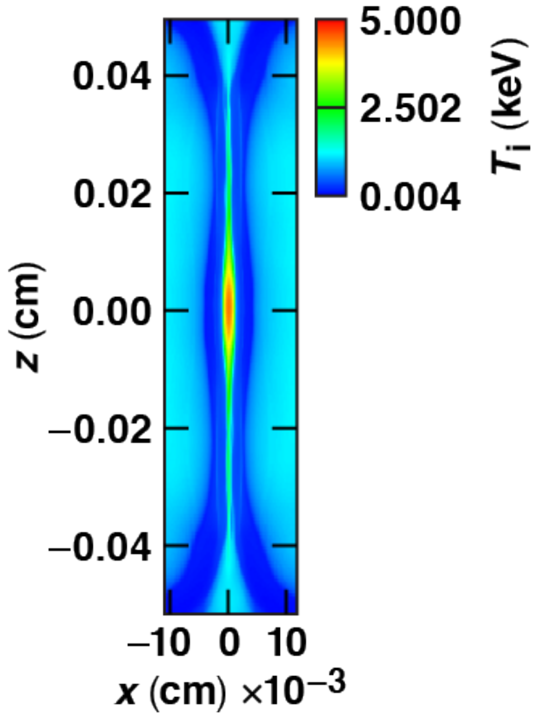
J. R. Davies *et al.*, Phys. Plasmas 24, 062701 (2017).

3D HYDRA simulations are used to study laser preheat effects in mini-MagLIF



TC15545

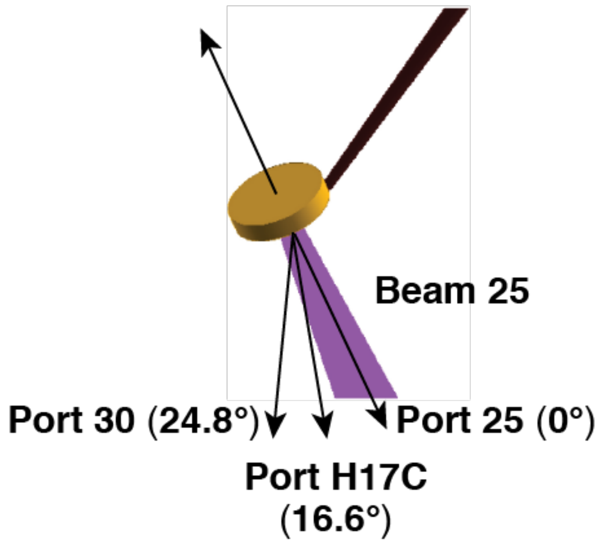
- **Simulations make use of butterfly mesh for hot spot of compression**



TC15546

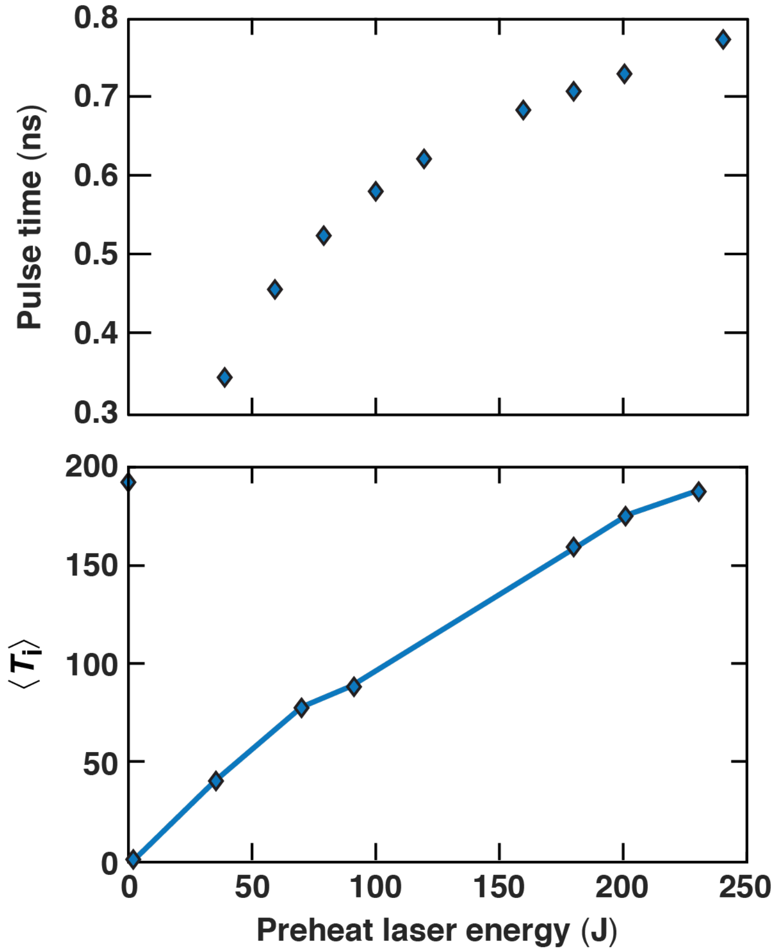
* E. C. Hansen *et al.*, Phys. Plasmas 27, 062703 (2020).
M. M. Marinak *et al.*, Phys. Plasmas 8, 2275 (2001).

The effect of the window in experiments is included into simulations through modification of the preheat laser pulse



TC12451d

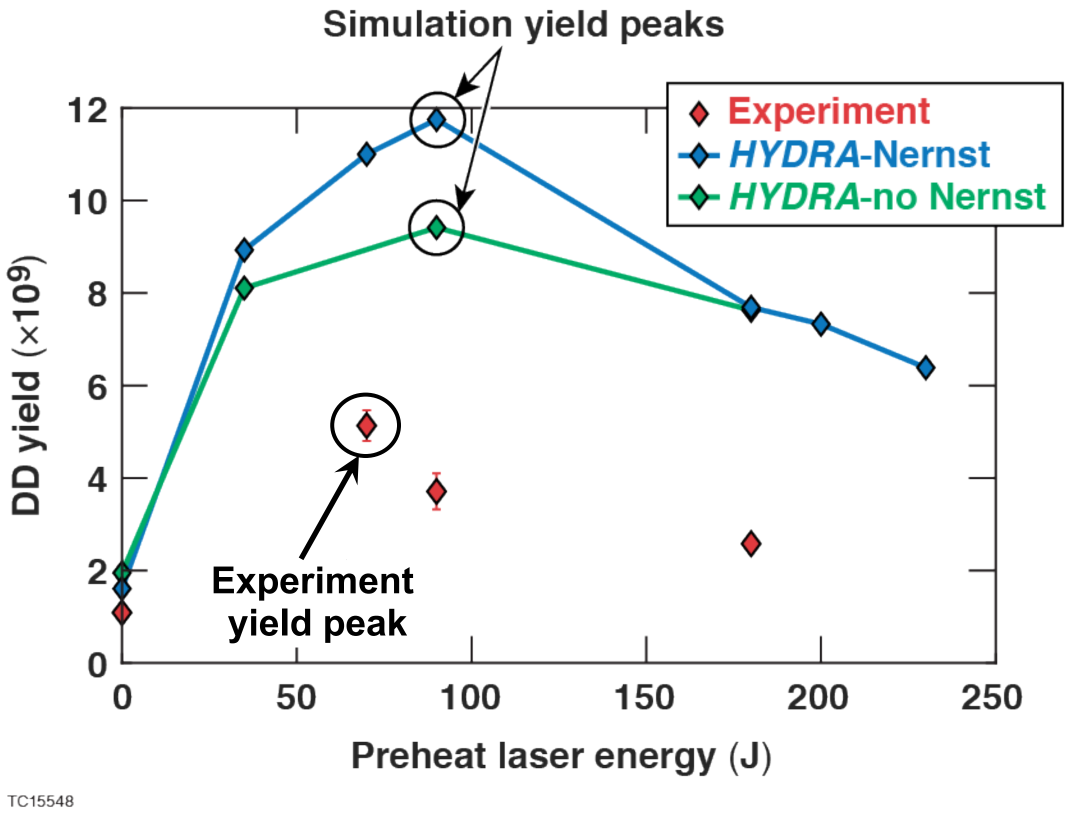
- The calorimeter measured the energy absorbed in foils similar to the window
- Pulse time length in fuel is determined from experiments*

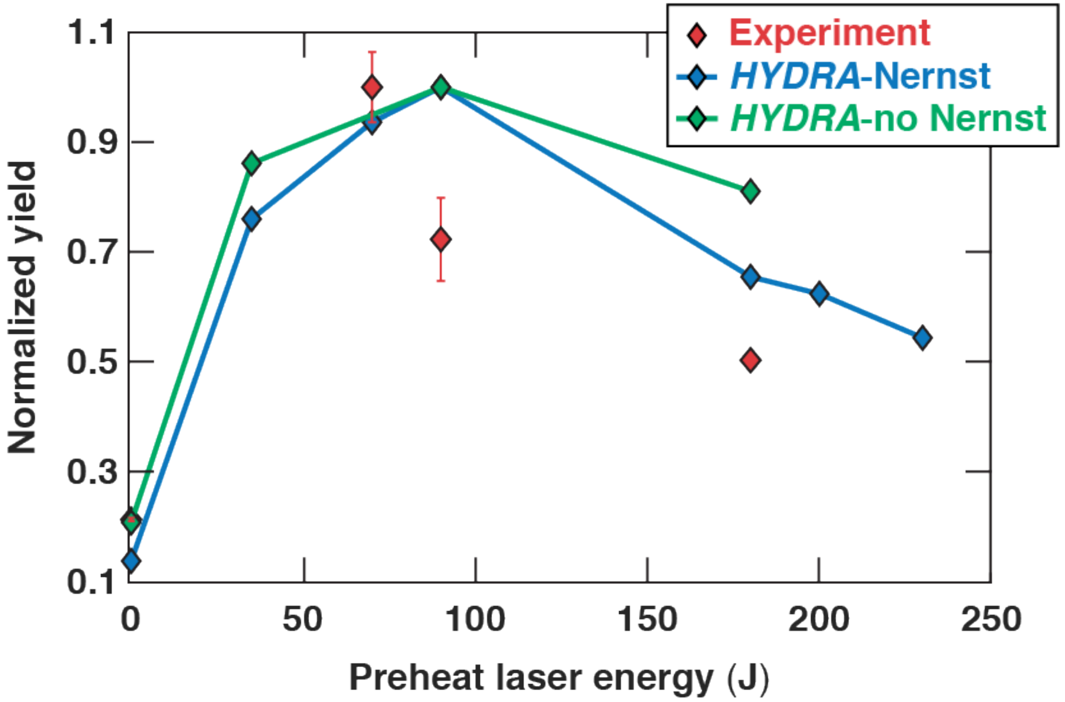


TC15547

* J. R. Davies *et al.*, Phys. Plasmas 25, 062704 (2018).

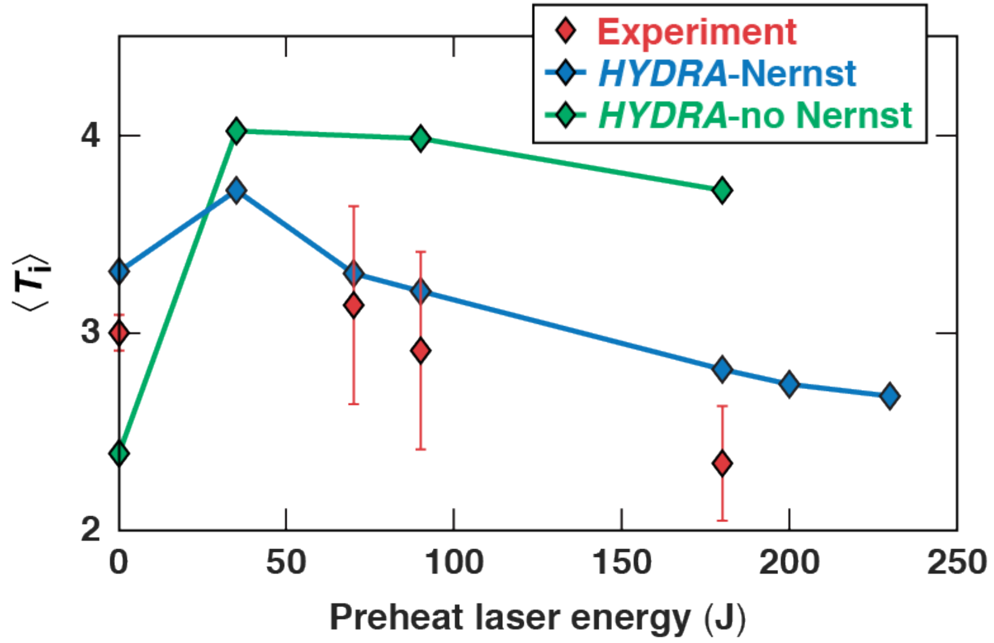
Simulations show trend of DD neutron yield mitigation when increasing laser preheat energy past optimum

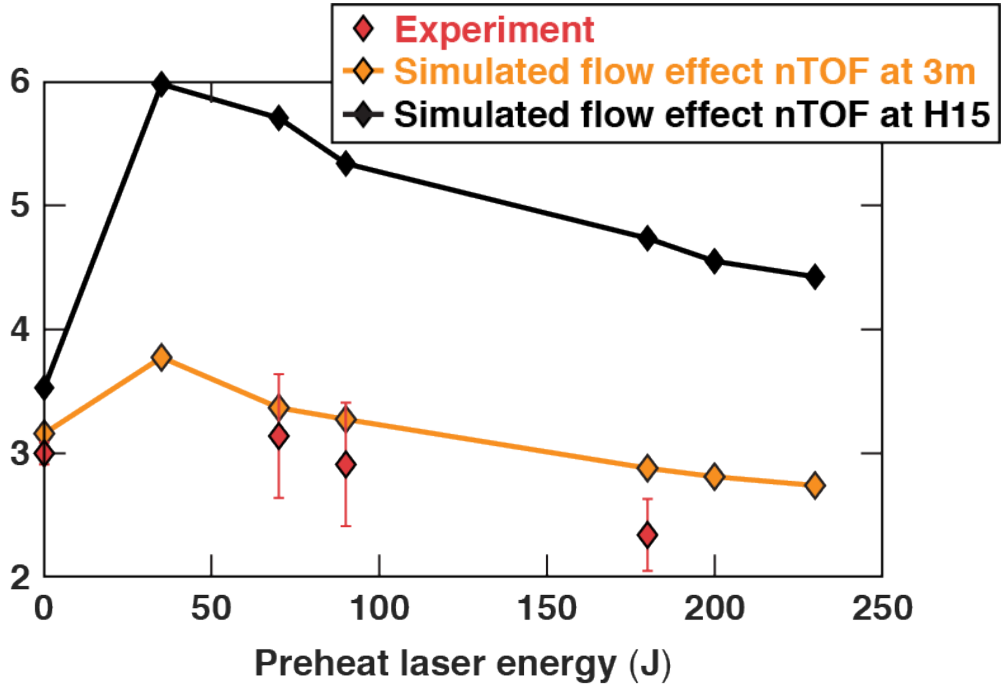




$$\frac{\partial \vec{B}_{\mathrm{Nernst}}}{\partial t} = c\nabla\times\boldsymbol{\beta}_{\wedge}\cdot\nabla T_{\mathrm{e}}$$

The neutron-averaged ion temperature at bang time follows a similar trend, but is higher than in experiments



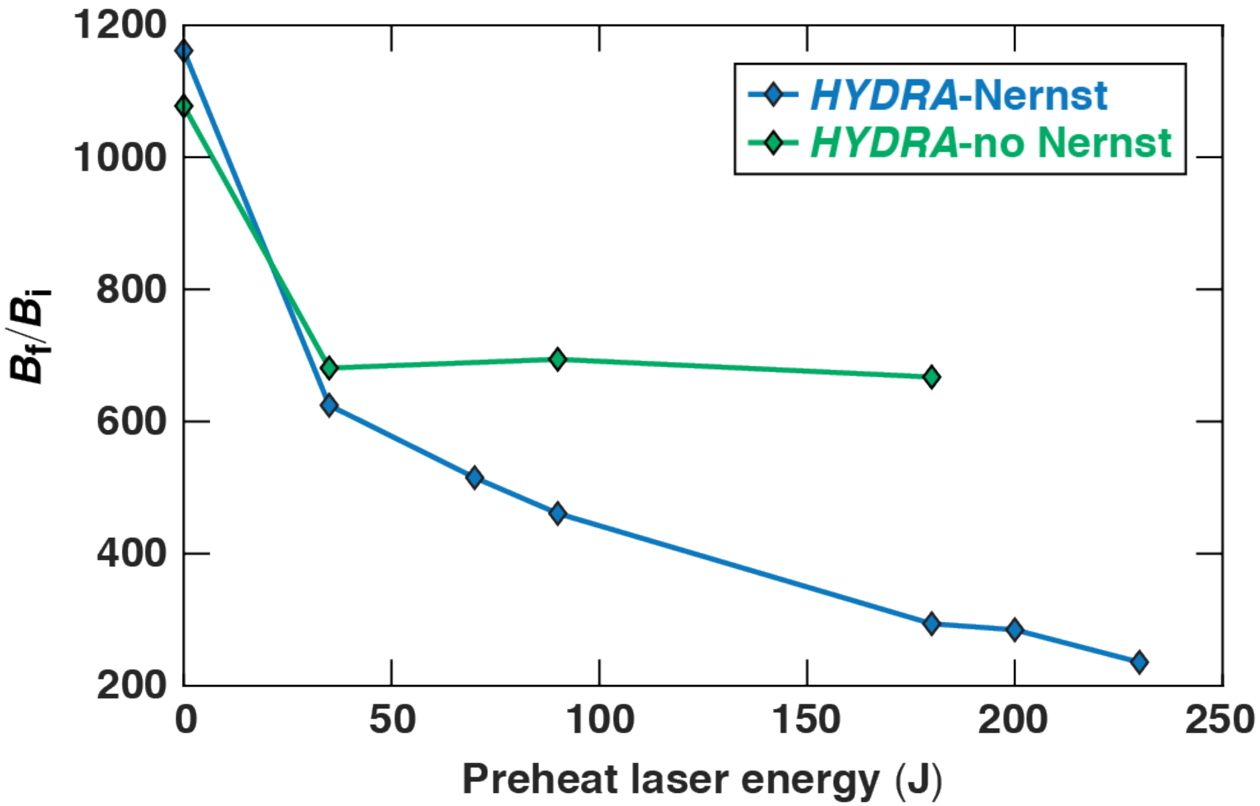


TC15549

Simulations without Nernst effect plateau with increasing laser preheat energy

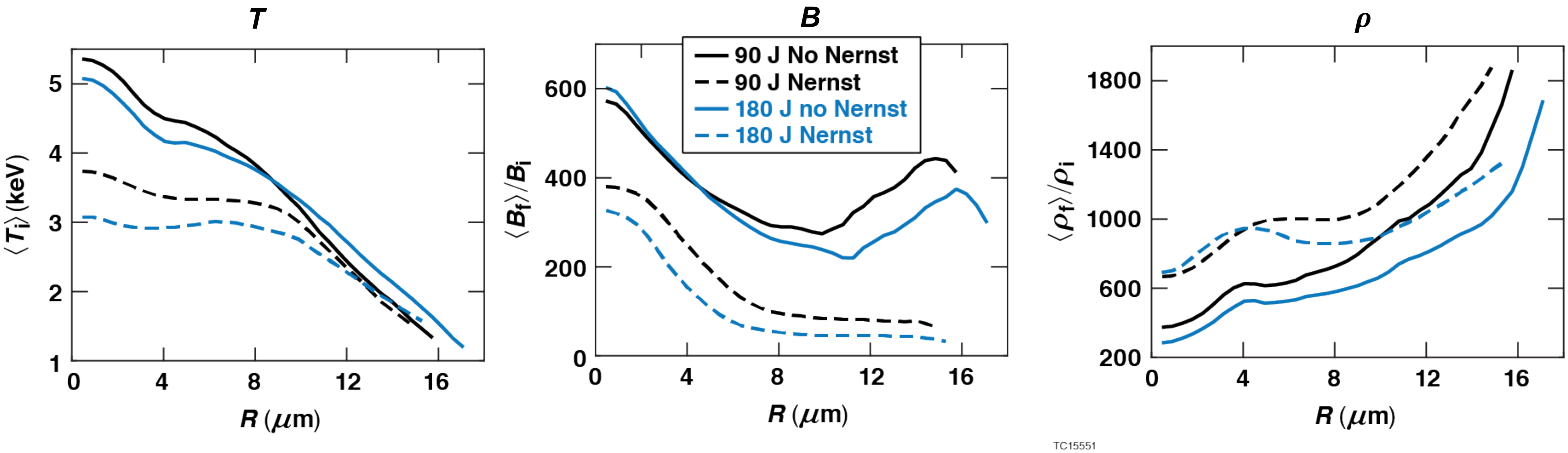
Plasma flow increases the ion temperatures that are inferred from measurements

Magnetic-field compression is reduced with higher preheat laser energy when Nernst effect is included in simulations



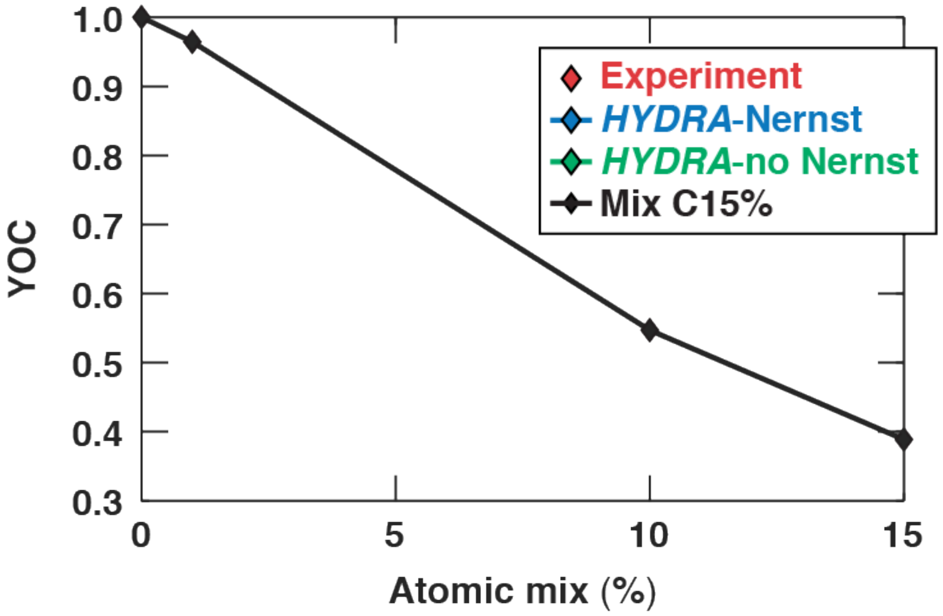
TC15550

Radial profiles of neutron-averaged quantities show that including Nernst effect can alter their shape at bang time

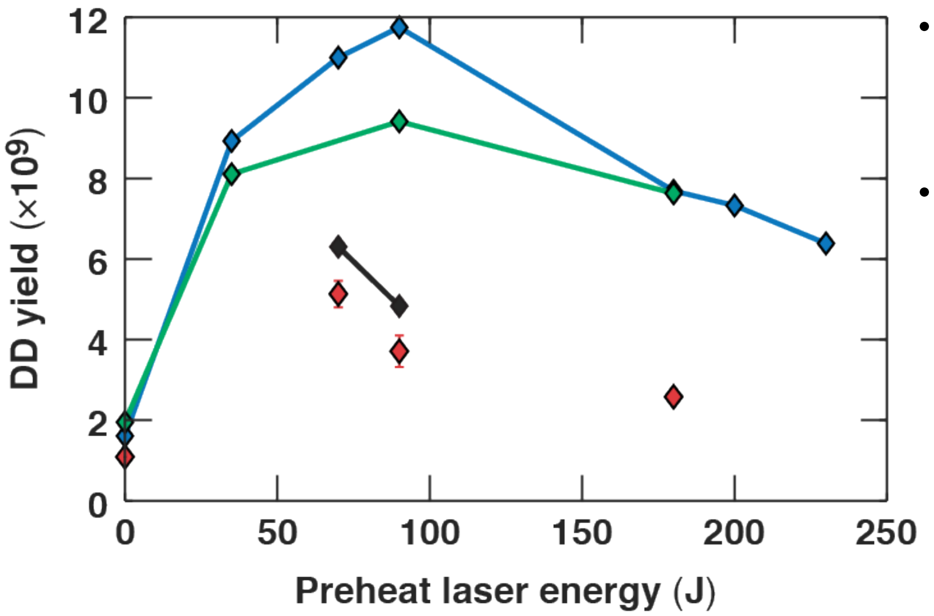


The radial profile of fuel density becomes less dominated by edge effects with increasing laser preheat energy when including Nernst effect.

Including uniform carbon mix into the fuel lowers neutron yield



TC15552



- The simulation has the fuel region where D_2 is uniformly mixed with C
- The mass of D_2 is kept constant

The mix can shift optimal preheat laser energy.

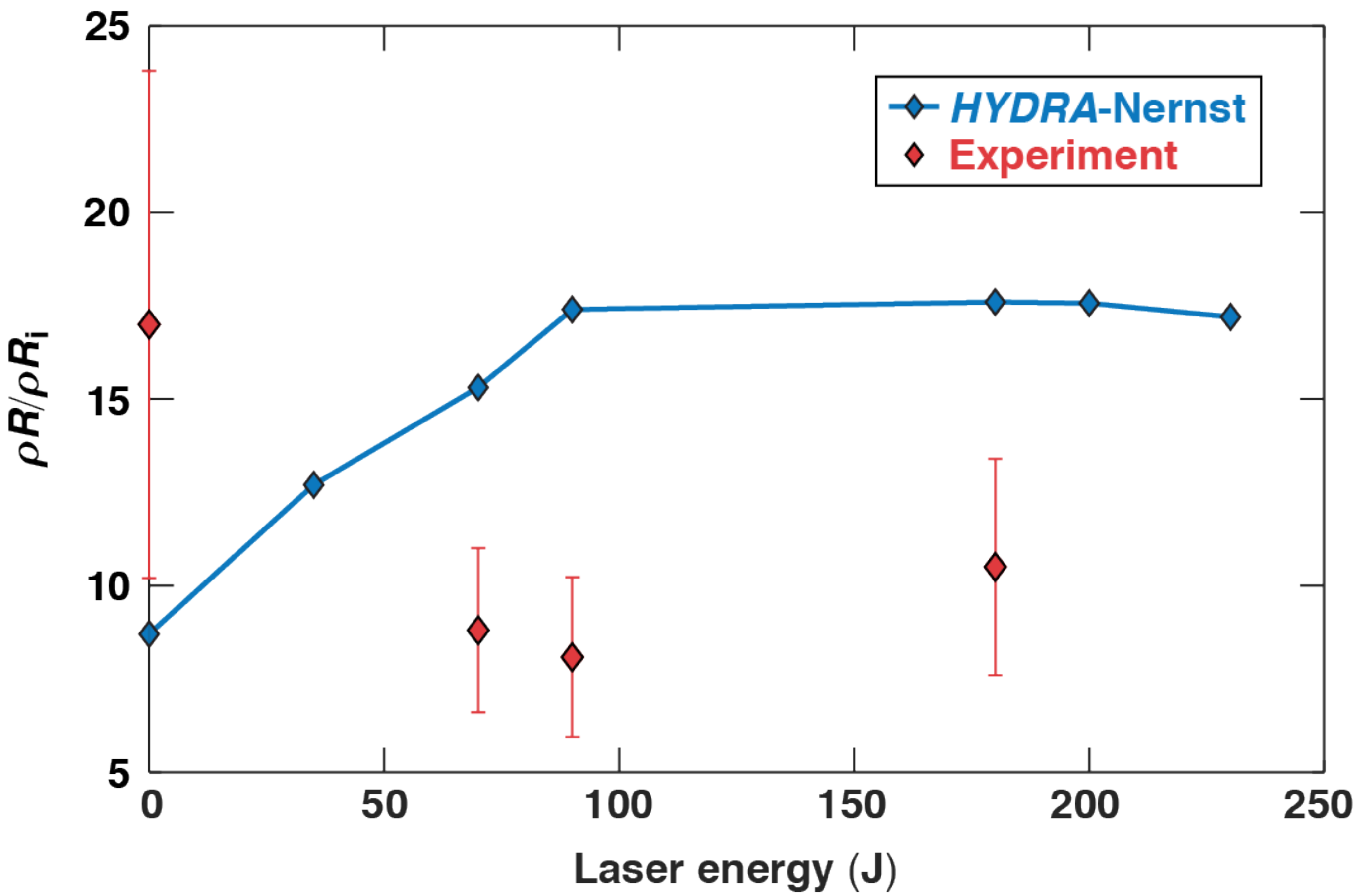
YOC: yield over clean

Three-dimensional *HYDRA* simulations of the mini-MagLIF at the Omega agree with experiments that there is an optimal laser preheat energy

- Simulation including the Nernst capture the drop in normalized yield from peak with preheat laser energy higher than optimal
- Neutron averaged radial profiles of density becomes less dominated by edge effects with increasing preheat laser energy
- A simple mix model shows that carbon mix can lead to yield degradation and shift the optimal laser preheat energy

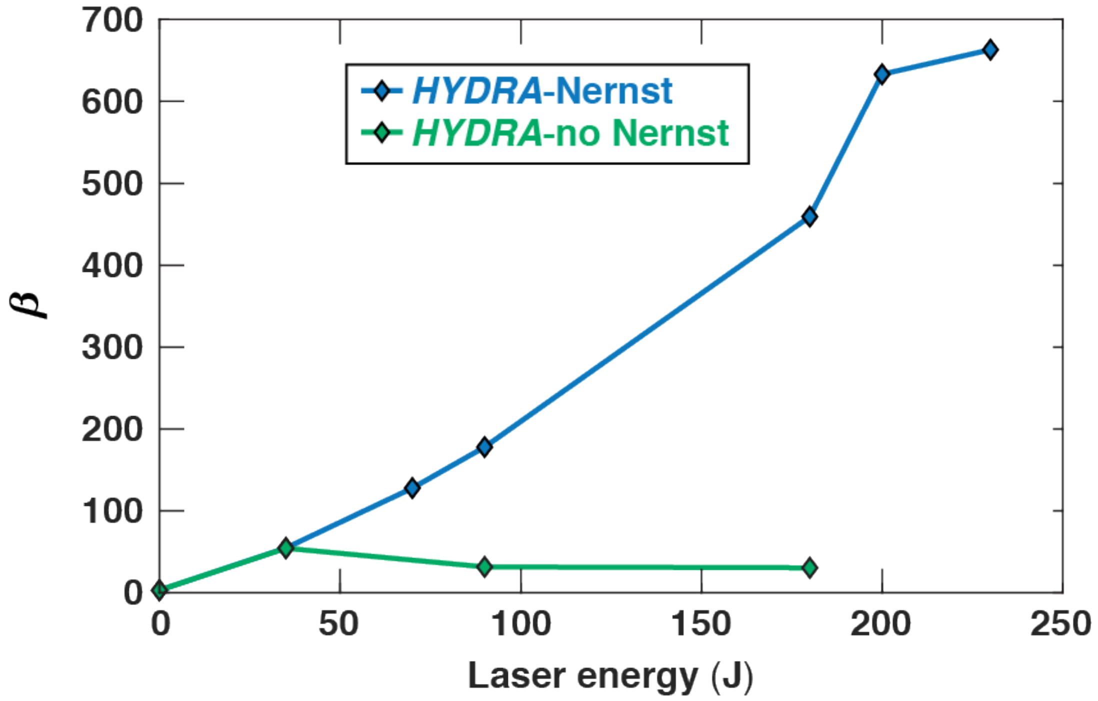
Backup

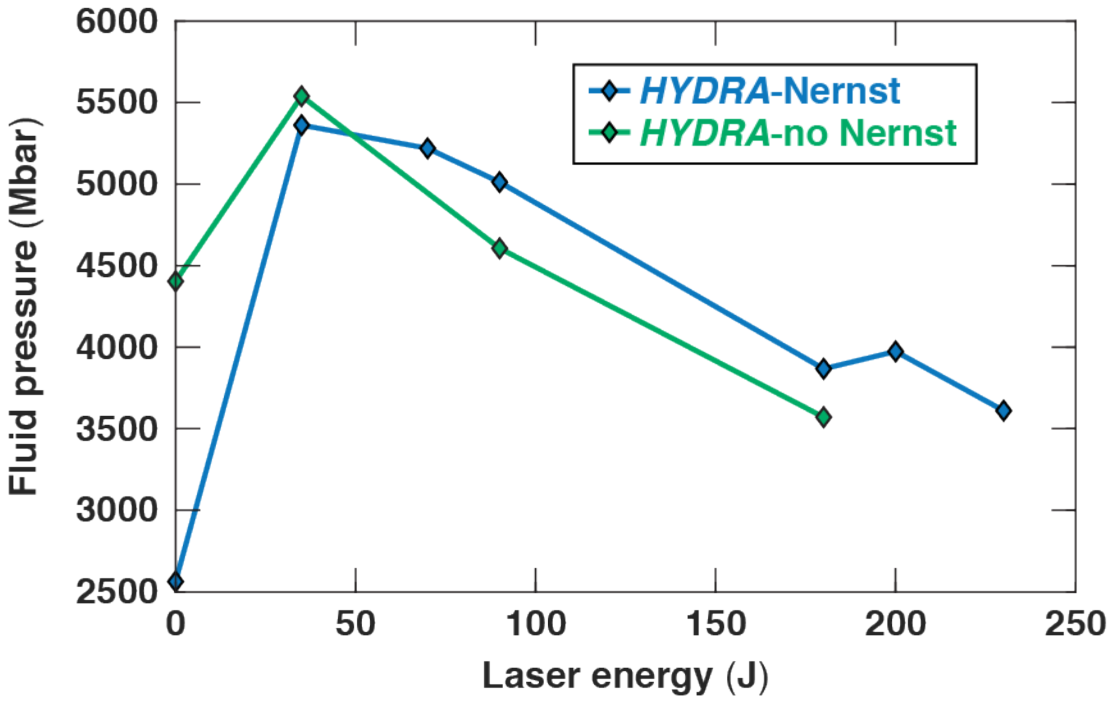
Fuel areal density in the simulation plateaus, which does not currently agree with experiments



TC15553

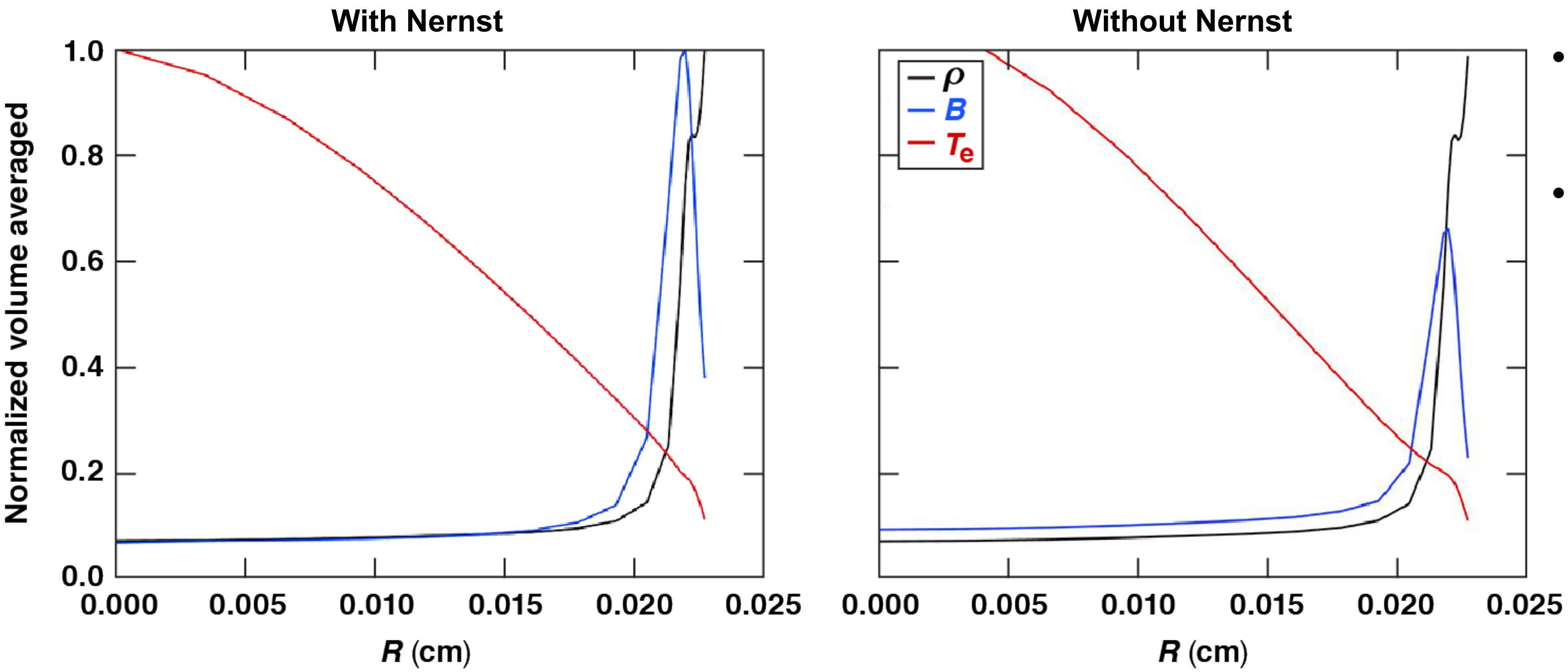
Plasma beta and pressure





TC15562

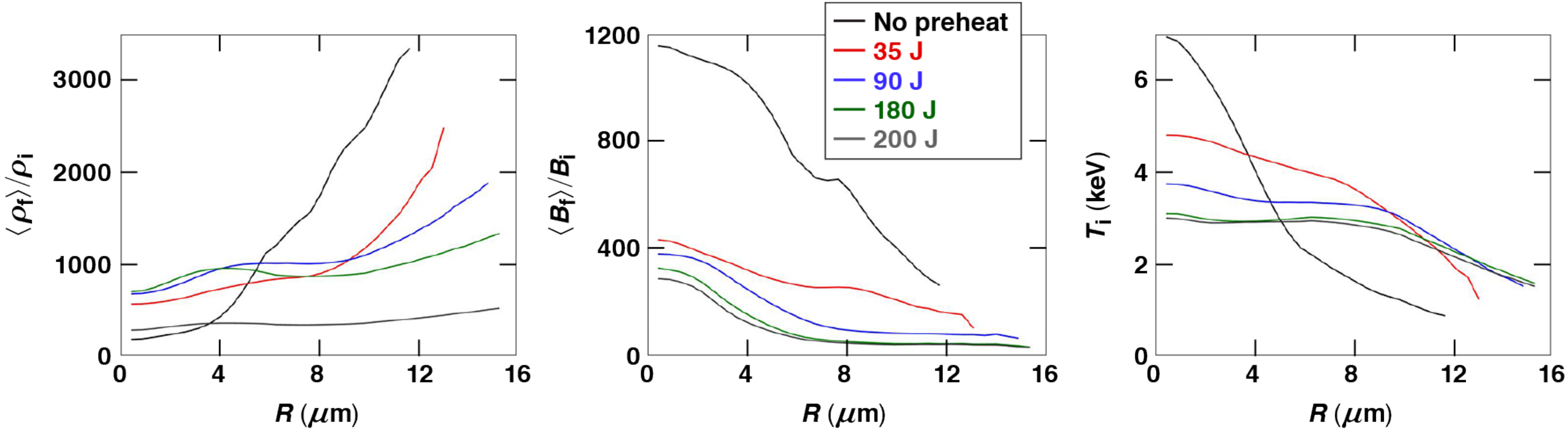
Radial profiles of the volume averaged with and without Nernst at the end of laser preheat show the convective nature of Nernst in pushing the magnetic field to the edges



- Normalized to the maximum of the case with Nerst
- Nernst leads to higher field compression at the edges during preheat

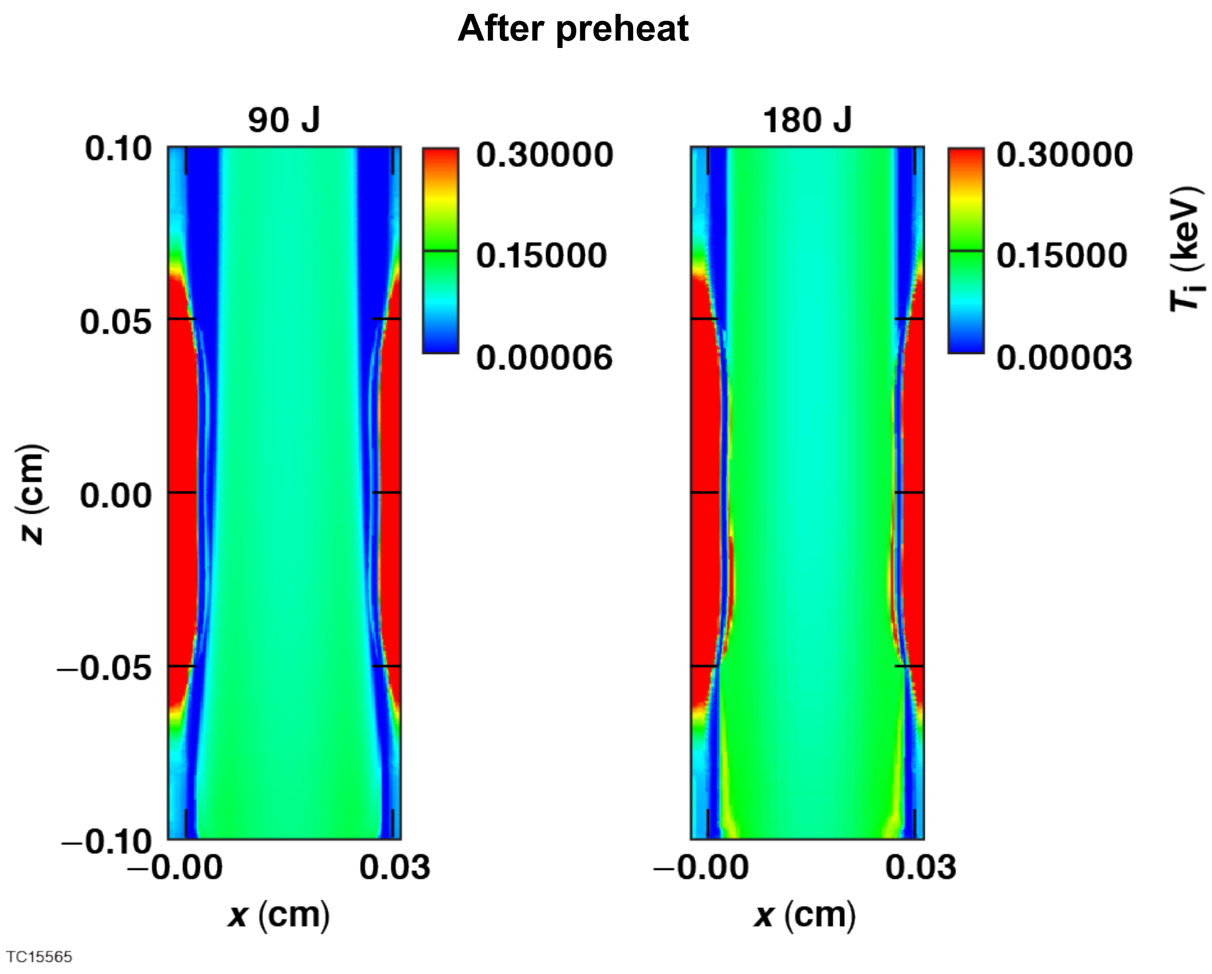
TC15563

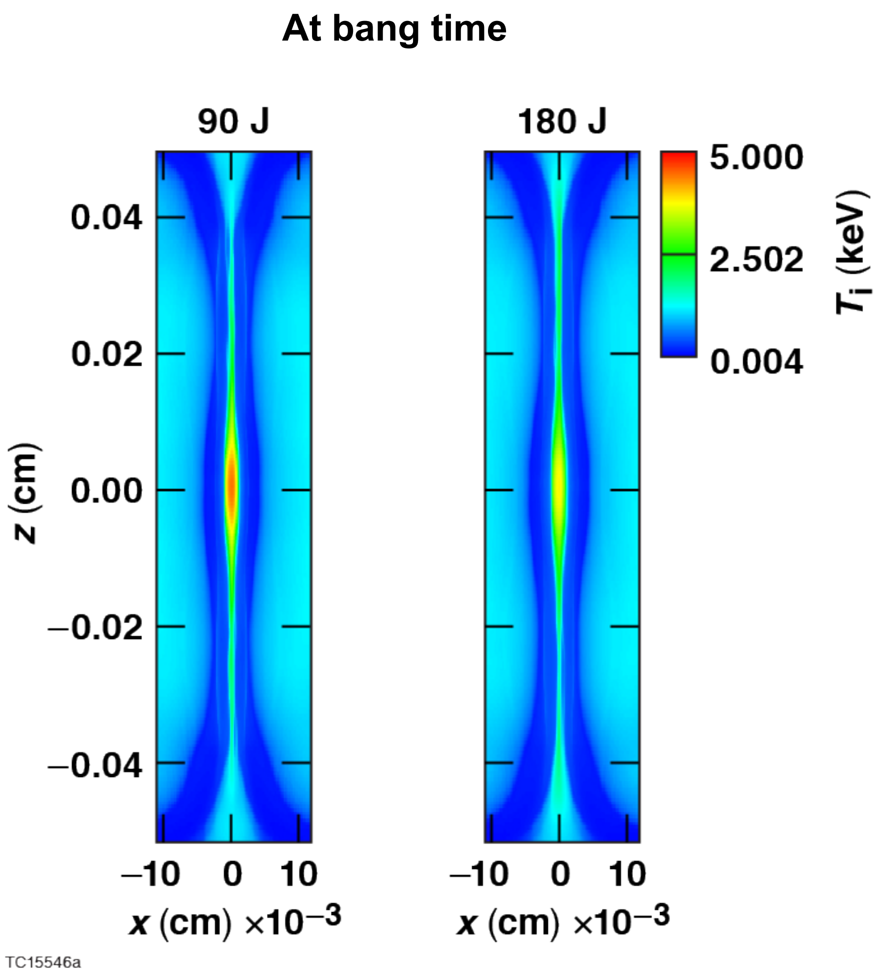
Radial profiles of density, magnetic field, and ion temperature with increasing preheat laser energy



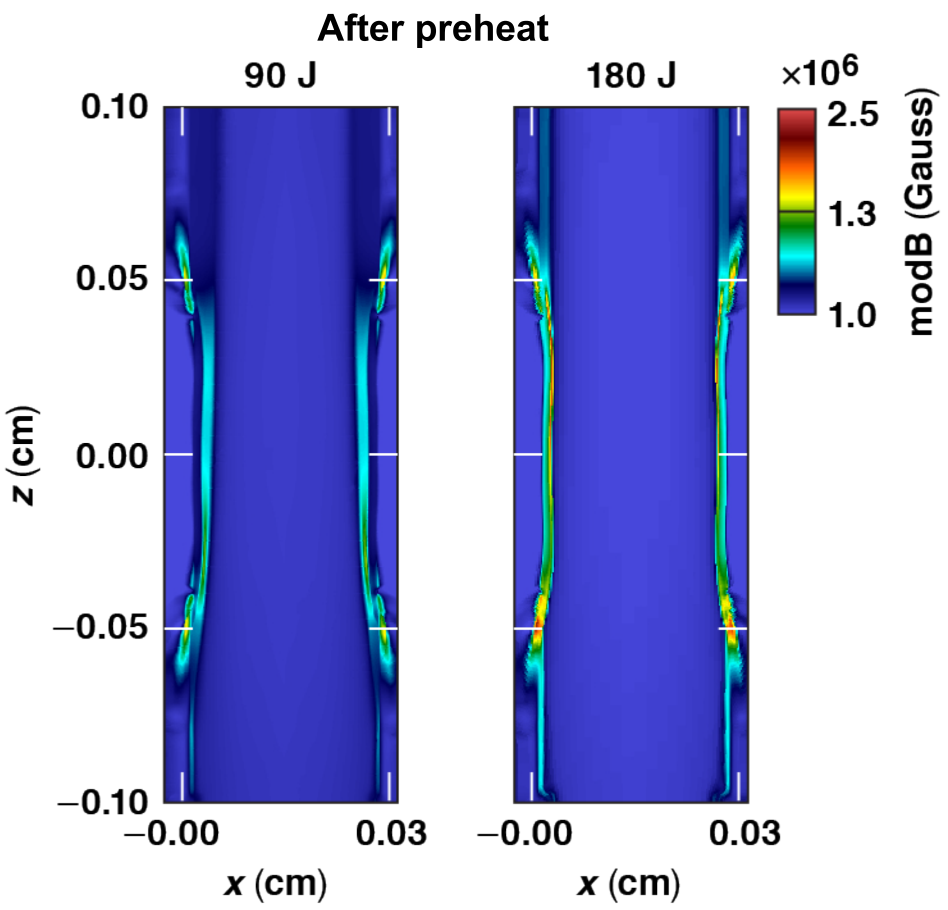
TC15564

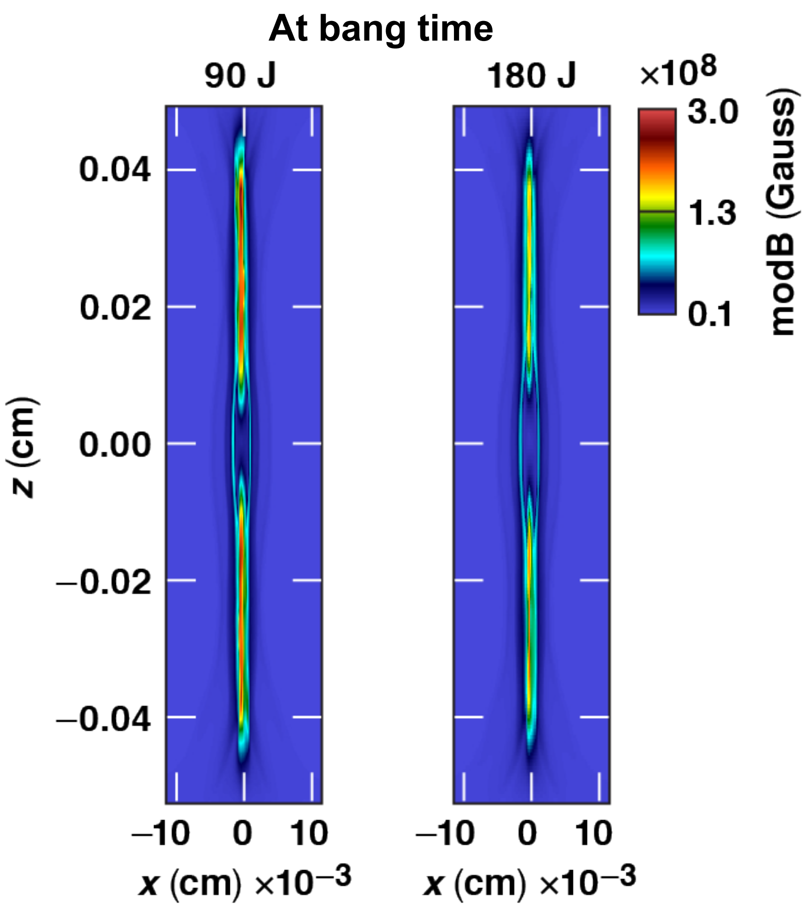
90-J T_i versus 180-J T_i





90-J |B| versus 180-J |B|

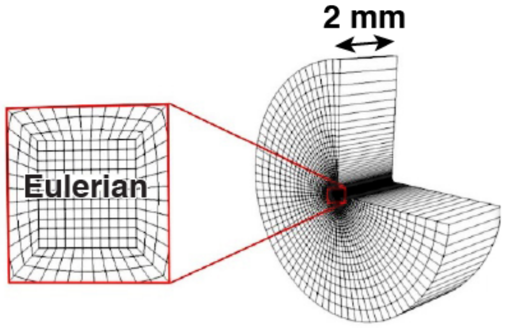




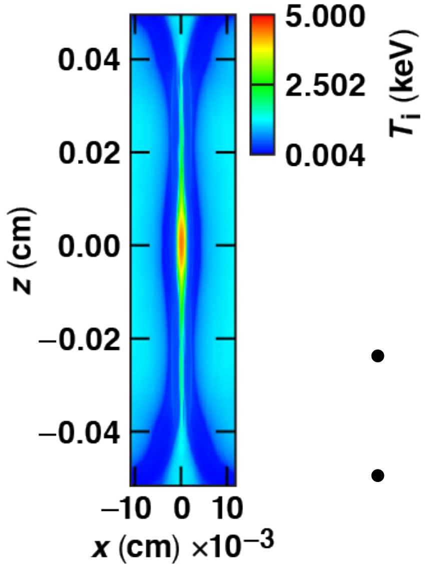
TC15566

3D-HYDRA simulations are being used to study effects in mini-MagLIF

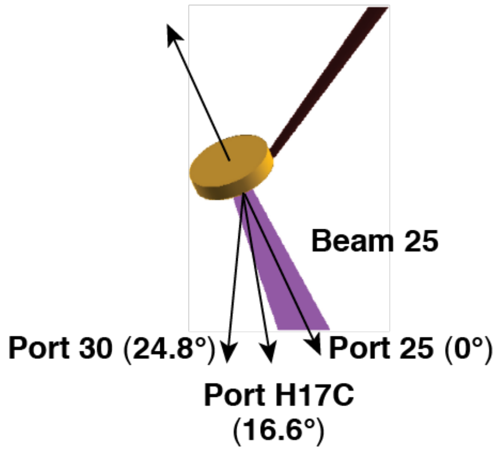
- Simulations make use of butterfly mesh for hot spot of compression



TC15545

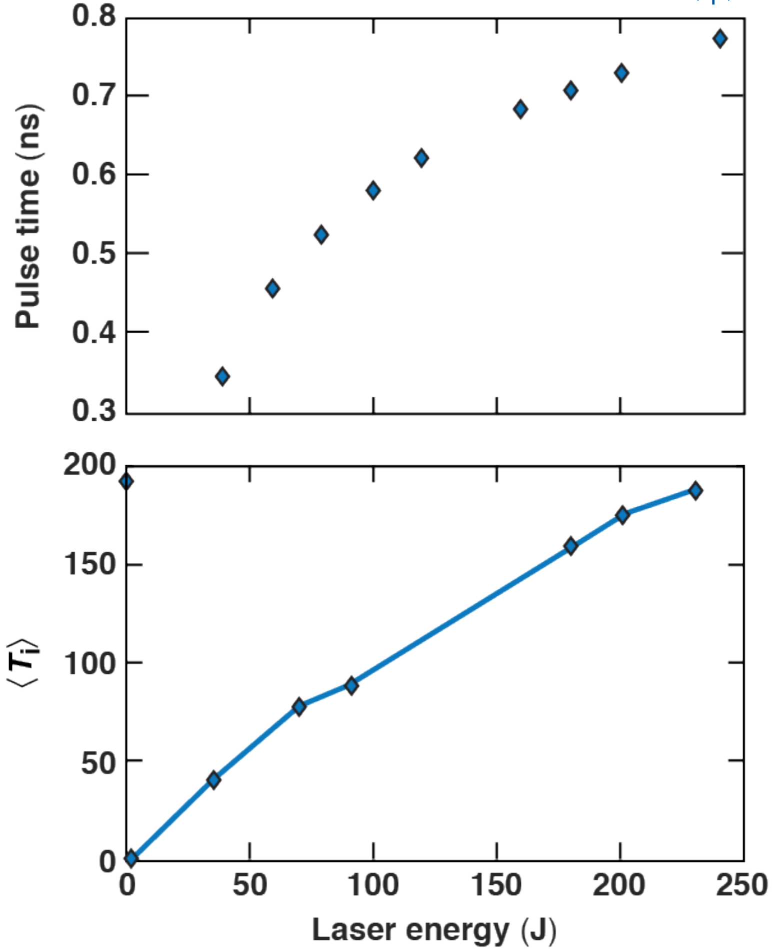


TC15546



TC12451d

- Pulse time length in fuel is determined from experiments*
- The effect of the window is included through modification of the preheat laser pulse



TC15547

E. C. Hansen *et al.*, Phys. Plasmas 27, 062703 (2020).
* J. R. Davies *et al.*, Phys. Plasmas 25, 062704 (2018).
M. M. Marinak *et al.*, Phys. Plasmas 8, 2275 (2001).