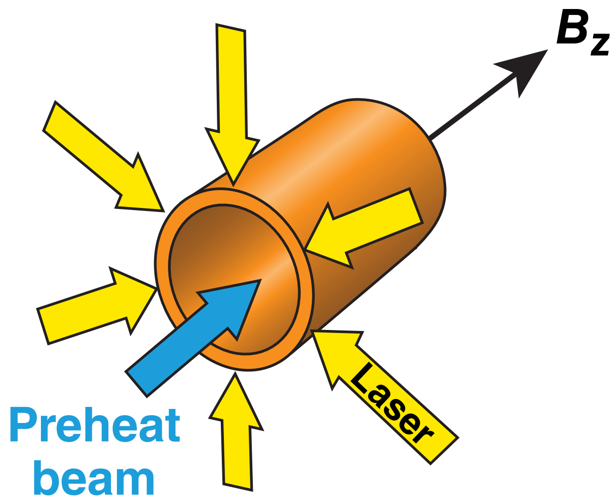
Design of Scaled Magnetized Liner Inertial Fusion Experiments on OMEGA



B_z (T)	$T_{preheat}$ (eV)	Y_n ($\times 10^8$)
0	0	5
0	100	15
15	100	290

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Summary

OMEGA MagLIF targets are designed to demonstrate significant yield enhancement with magnetic field and preheated gas

- Scaled magnetized liner inertial fusion (MagLIF) experiments will be conducted on OMEGA
- OMEGA's high shot rate makes it possible to perform target parameter scans
- OMEGA's suite of diagnostics enables accurate measurements of the plasma conditions and magnetic fields
- Simulations using *LILAC*-magnetichydrodynamic (MHD) simulations show that the ion temperature triples and the neutron yield increases 60-fold in OMEGA experiments when a 15-T seed magnetic field and a 100 eV gas preheat are applied

Collaborators

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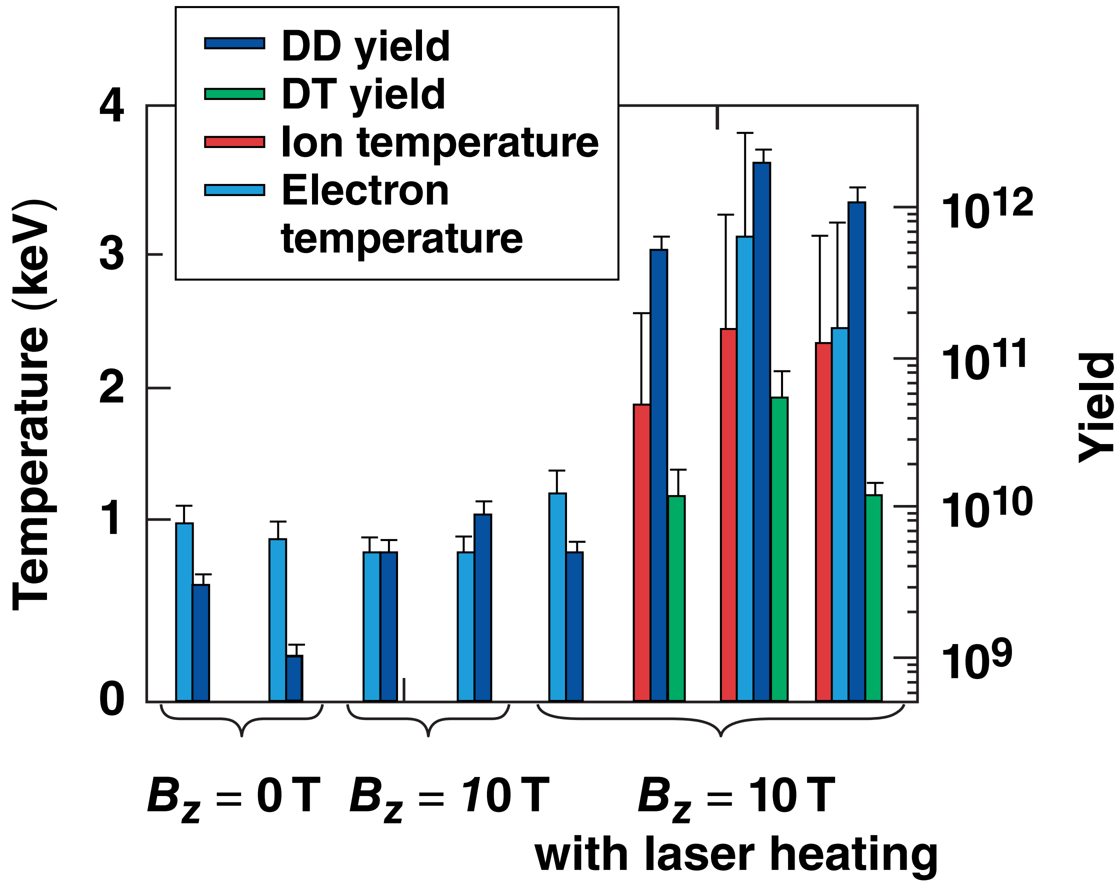
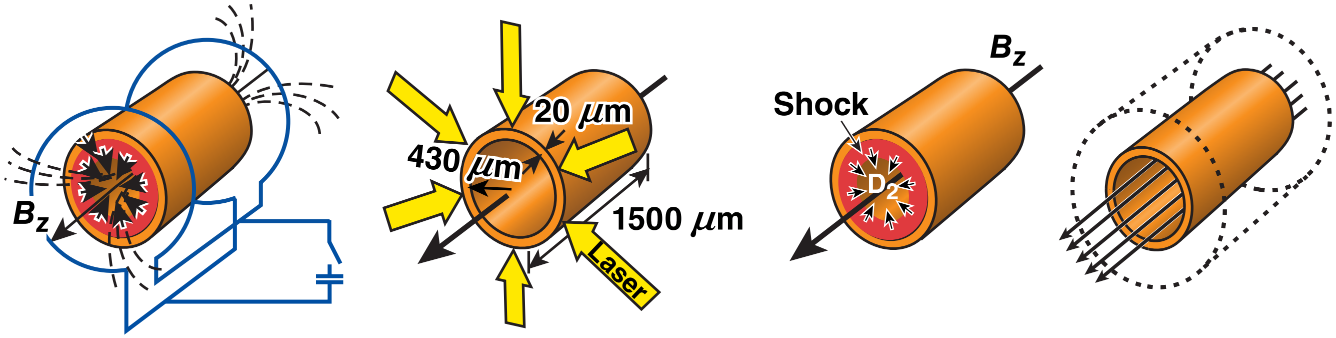
Significant yield enhancement was observed with an initial seed field and heating prior to the compression in a MagLIF experiment at Sandia National Laboratories*

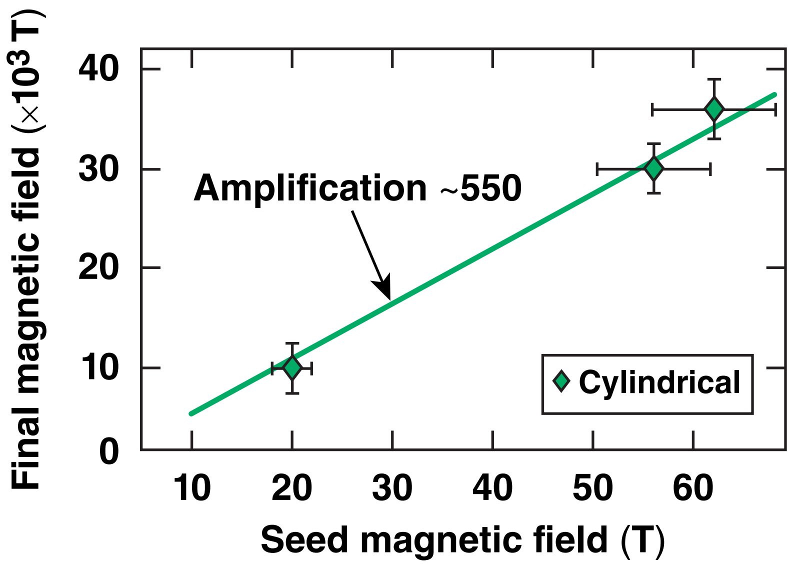


- OMEGA experiments will test the scaling of MagLIF

*M. R. Gomez *et al*., Phys. Rev. Lett. 113, 155003 (2014).

Magnetic-flux compression was demonstrated using cylindrical implosions on OMEGA* and will be used to study the MagLIF concept



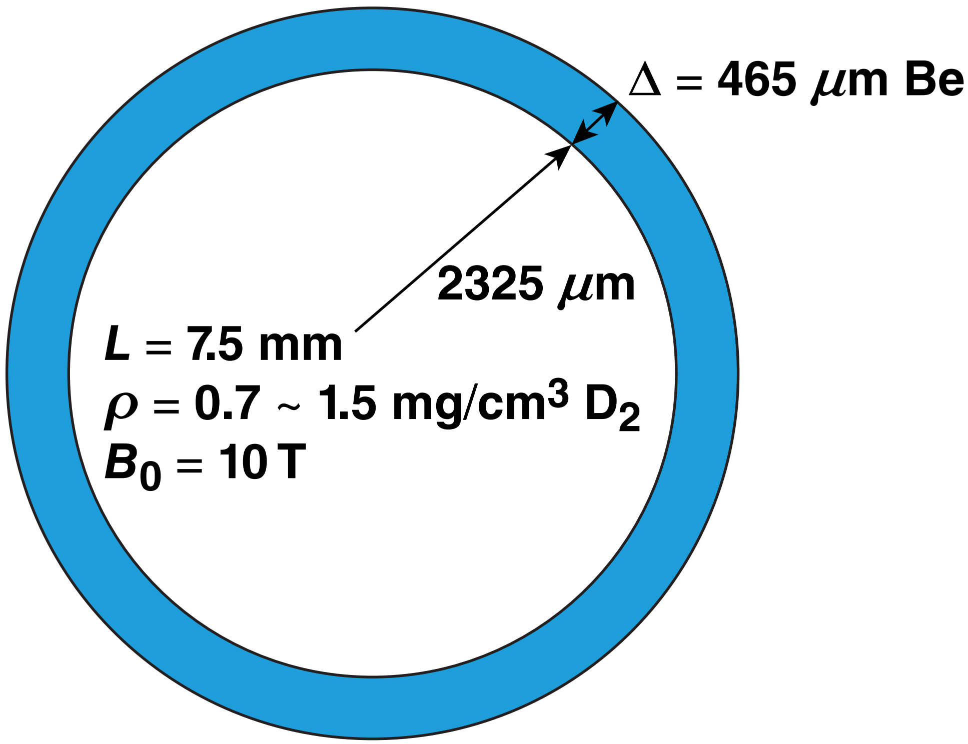


- Field compression in cylindrical implosions have been demonstrated
- Laser preheat will be added to study the physics of the MagLIF concept

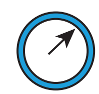
*O. V. Gotchev *et al.*, Phys. Rev. Lett. 103, 215004 (2009).

The target size is scaled down according to the kinetic energy that can be coupled to the implosion

Sandia target*



OMEGA target

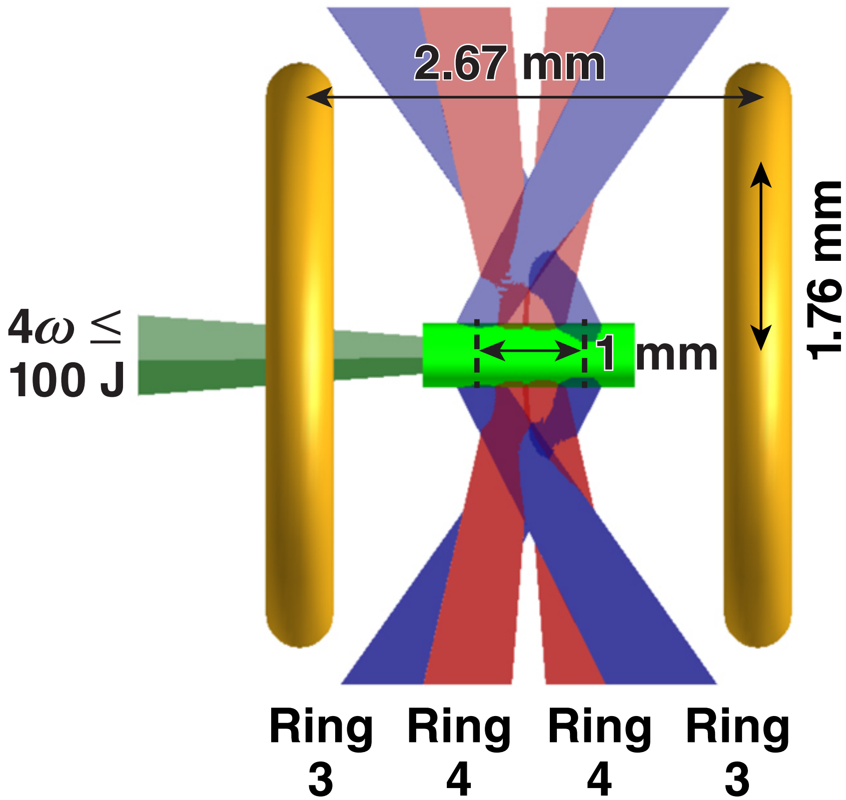


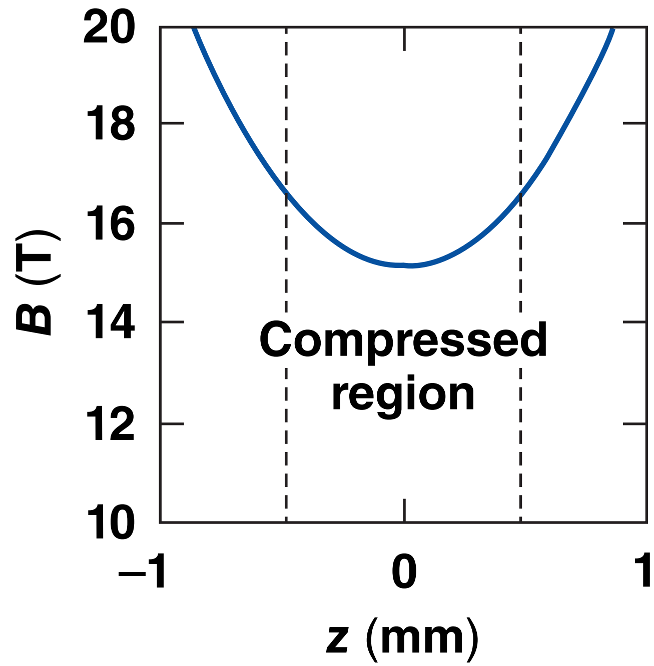
L = 1 mm
ρ = 1 mg/cm^3 D_2
B_0 = 15 T

- The Sandia design couples ~1 MJ cm^{-1} to the liner**
- OMEGA will couple ~0.01 MJ cm^{-1} to a cylindrical shell

*M. R. Gomez *et al*., Phys. Rev. Lett. 113, 155003 (2014).
**S. A. Slutz *et al*., Phys. Plasmas 17, 056303 (2010).

A cylindrical target will be compressed using 38 OMEGA beams



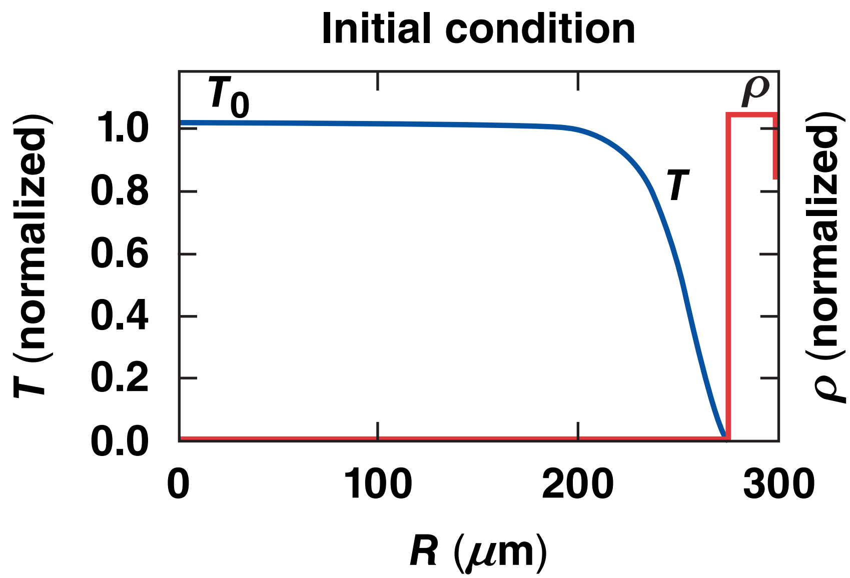


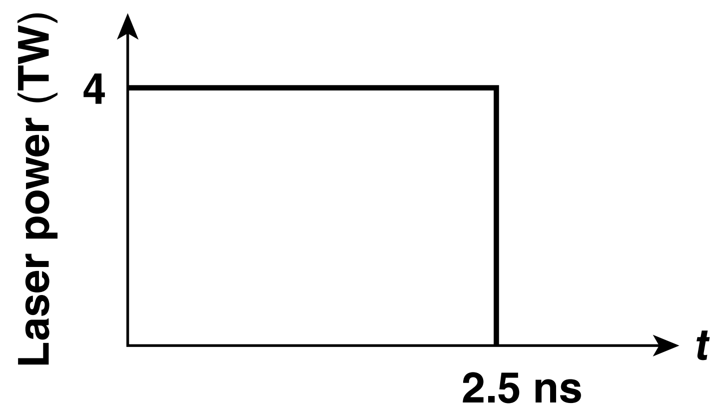
- About 12 J of energy is needed to heat the gas to 100 eV
- 38 OMEGA beams using SG2 phase plates deliver 10.4 kJ of energy over a length of 1 mm

TC11600

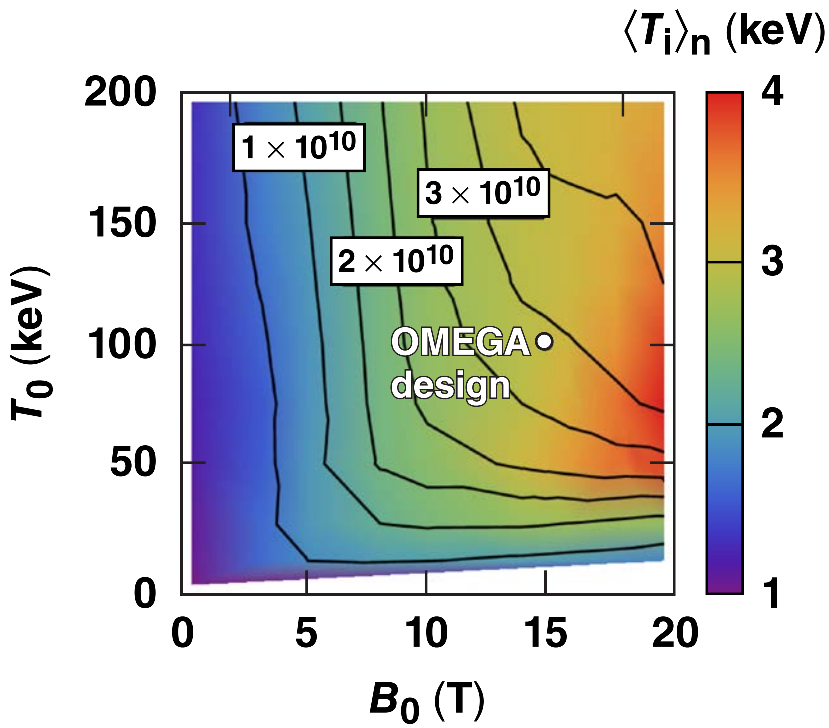
LILAC-MHD is used to design the scaled-down MagLIF experiment on OMEGA

- Physics included in *LILAC*-MHD
  - 1-D resistive MHD
  - Braginskii heat transport
  - flux-limited Nernst effect
- Laser parameters
  - 2.5-ns square pulse
  - Laser energy: 10.4 kJ
- Initial conditions of the target
  - IR = 275 μm
  - Δ = 25 μm CH
  - ρ = 1 mg/cm^3 D_2
  - T_0 = 0 ~ 200 eV
  - B_0 = 0 ~ 20 T





The neutron-averaged ion temperature triples if the gas is preheated to 100 eV with a 15-T seed magnetic field



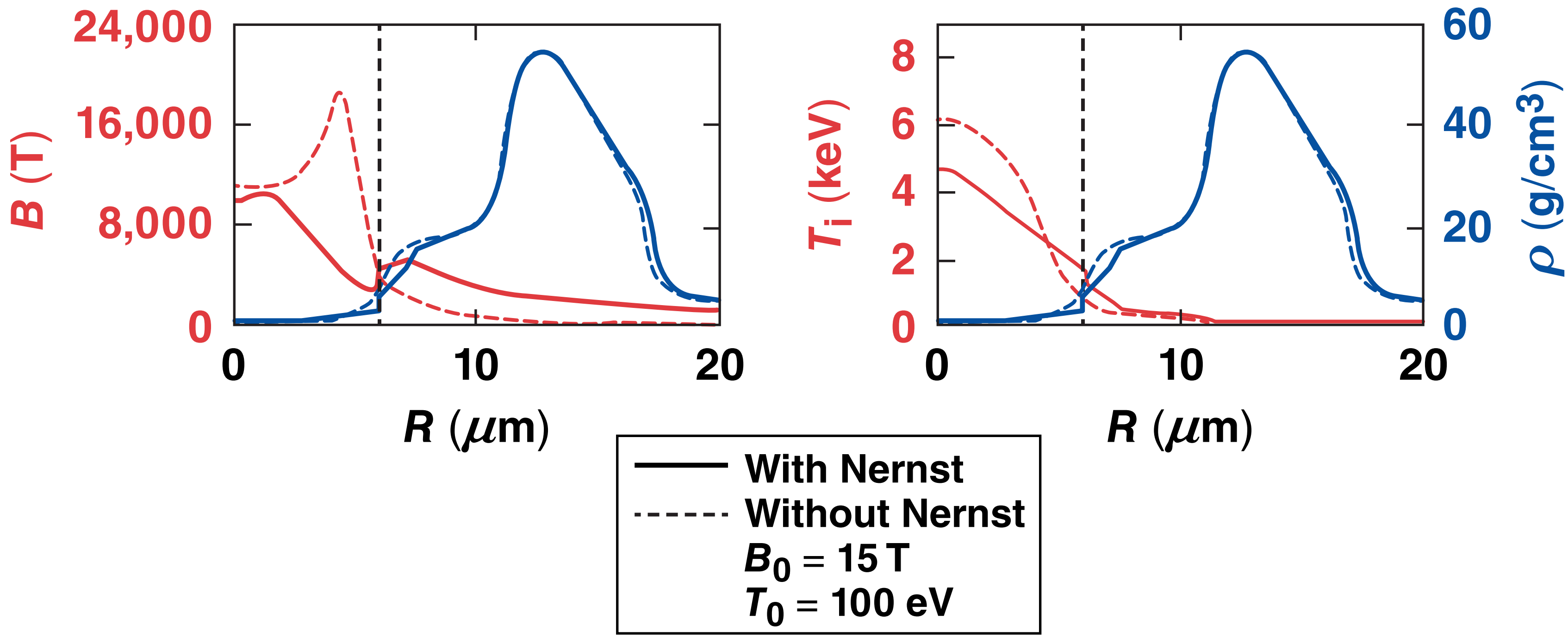
B_0 (T)	T_0 (eV)	$\langle T_i \rangle_n$ (keV)	Y_n ($\times 10^8$)
0	0	0.97	5
0	100	1.23	15
15	100	3.00	290

*Nernst effect is included

- The neutron yield with a preheated gas temperature over 50 eV increases with a higher seed field
- There is a significant ion-temperature increase (3×) and yield enhancement (60×) when the gas is preheated to 100 eV with a 15-T seed magnetic field

TC11605

The Nernst effect reduces the central temperature



- Magnetic-field outward advection increases because of the Nernst effect
- The neutron yield is less affected than the ion temperature since the fusion volume is larger; even the peak temperature is lower

OMEGA MagLIF targets are designed to demonstrate significant yield enhancement with magnetic field and preheated gas temperature

FSC

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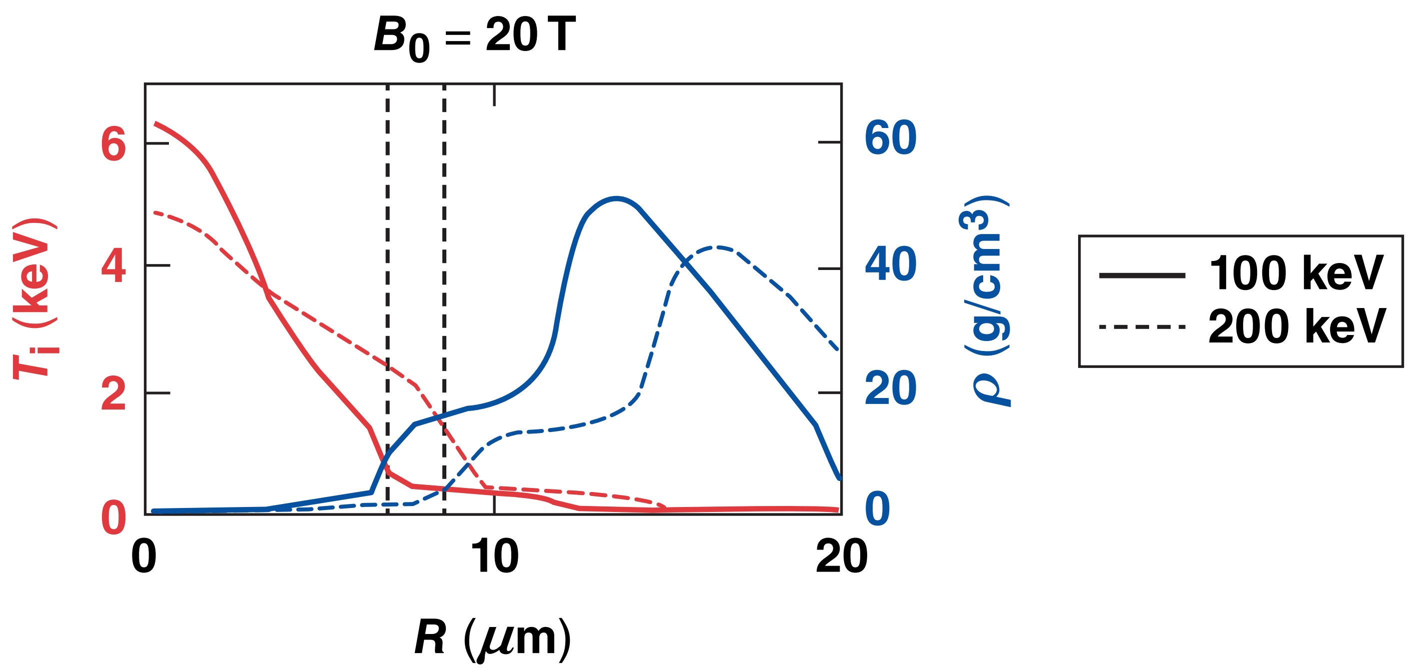
- Scaled magnetized liner inertial fusion (MagLIF) experiments will be conducted on OMEGA
- OMEGA's high shot rate makes it possible to perform target parameter scans
- OMEGA's suite of diagnostics enables accurate measurements of the plasma conditions and magnetic fields
- Simulations using *LILAC*-magnetichydrodynamic (MHD) simulations show that the ion temperature triples and the neutron yield increases 60-fold in OMEGA experiments when a 15-T seed magnetic field and a 100 eV gas preheat are applied

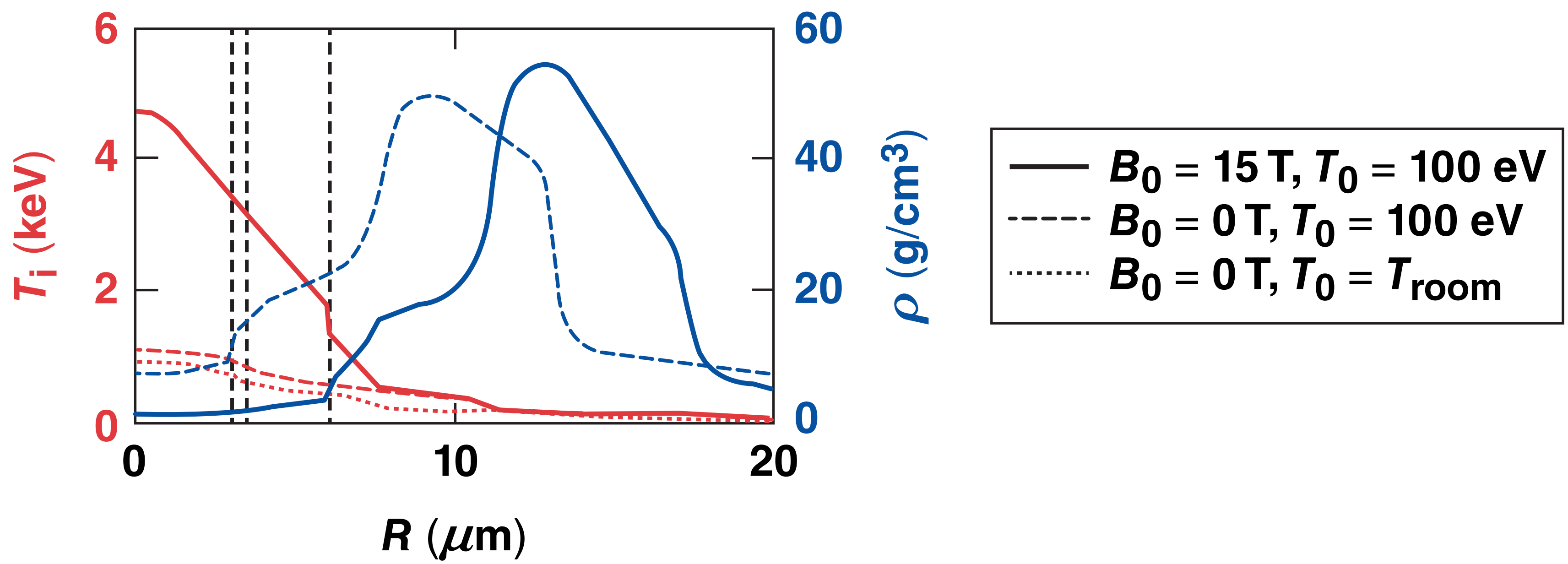
The ion temperature at stagnation is not necessarily higher with higher preheated gas temperature



- With higher preheated gas temperature, the convergence ratio is lower, leading to higher neutron yield because of the larger hot spot

TC11603

The neutron-averaged ion temperature triples if the gas is preheated to 100 eV with a 15-T seed magnetic field



- Convergence ratio is ~45
- Implosion velocity is ~167 km/s
- There is a significant ion-temperature increase (3×) and yield enhancement (60×) when the gas is preheated to 100 eV with a 15-T seed magnetic field

TC11604