SAND2020–9556PE

Study of 3D Instabilities in Magnetically Driven Implosions on the Z-Machine

SAND2020 -

Platform/Campaign ID: Trinity/ATCC-9-257
Code Name: HYDRA
Program: ICF
Usage: 3.92/3.0

UNLIMITED RELEASE

Trinity calculations provide insight into mechanisms that generate 3D helical instabilities in MagLIF

3D magneto-hydrodynamic (MHD) simulations of Magnetized Liner Inertial Fusion (MagLIF) better capture experimental results from the Z machine

- As in laser driven ICF, instabilities can be a significant degradation mechanism limiting the fusion yield
- Predicting the generation of the helical instability inherent to MagLIF remains a significant challenge
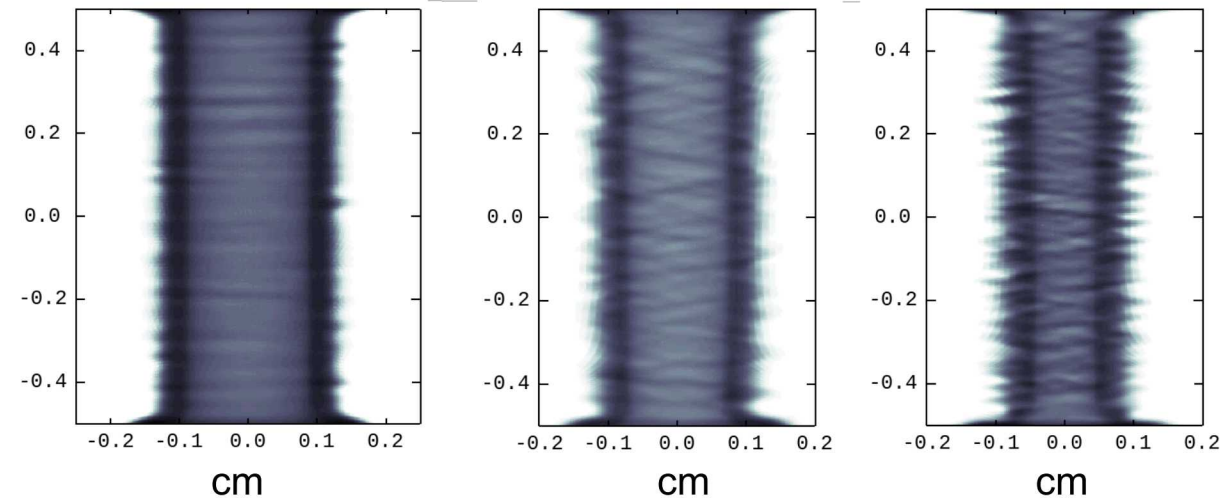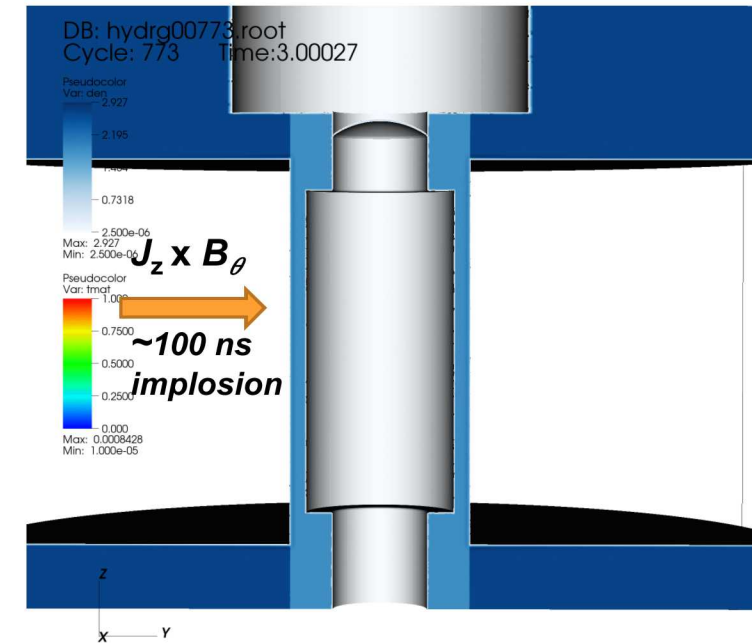
Perturbations can be assumed and matched to experiments to produce good quantitative agreement with experiments

- Provides no predictive power for how instability structure scales to multi-mega-Joule fusion yields

Trinity allows testing multiple perturbation levels and MHD settings to generate the helical instability from physical effects

- Such as compression of axial magnetic field onto the outside liner surface that drives helical current
- Experimental tests are planned next CY

3D HYDRA simulation (assumed perturbation)

DB: hydrg00773.root
Cycle: 773   Time:3.00027
Pseudocolor
Var: den
Max: 2.927
Min: 2.500e-06

$J_z \times B_\theta$

~100 ns implosion

Pseudocolor
Var: fmaf
Max: 0.0008428
Min: 1.000e-05

No flux compression

Flux compression with Hall term

Flux compression w/o Hall term

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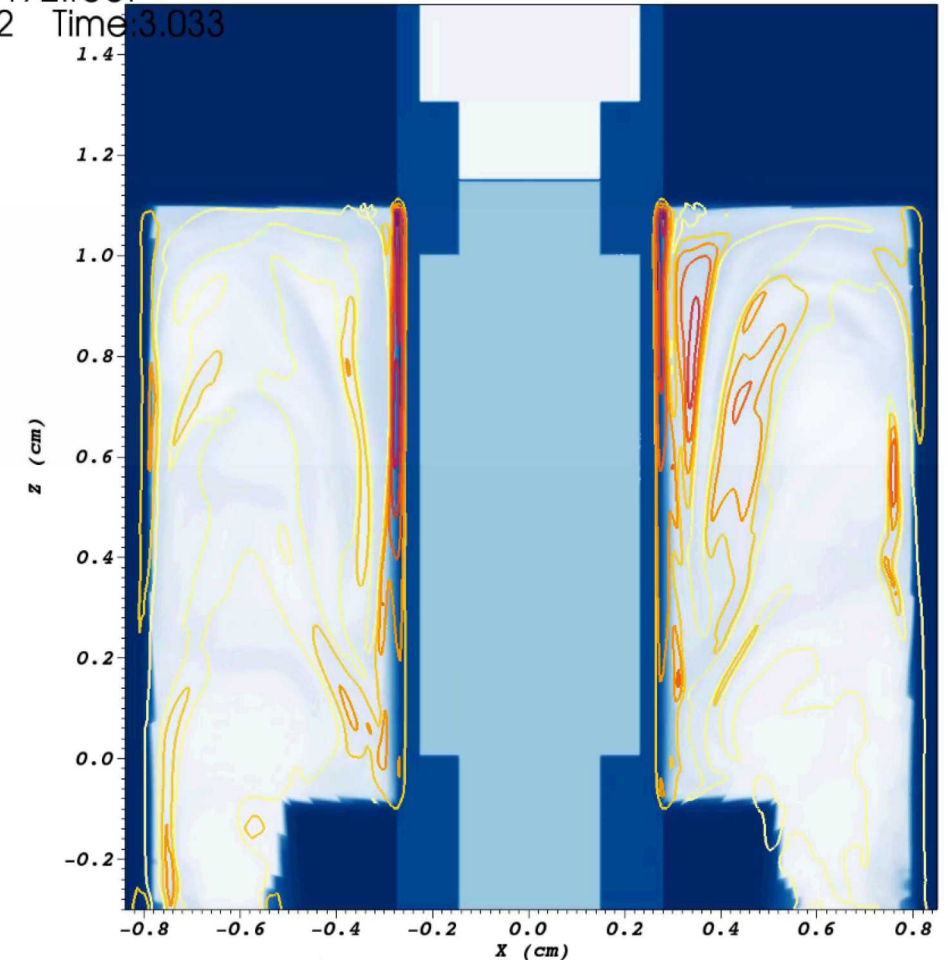
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DB: hydrg22172.root
Cycle: 22172   Time:3.033

Pseudocolor
Var: den
— 8.716
— 0.2853
— 0.009336
— 0.0003056
— 1.000e-05
Max: 8.716
Min: 1.000e-05

Contour
Var: Bzn
— 28.7988
— 25.599
— 22.3991
— 19.1992
— 15.9993
— 12.7995
— 9.59961
— 6.39974
— 3.19987
— 0
Max: 31.68
Min: -27.61

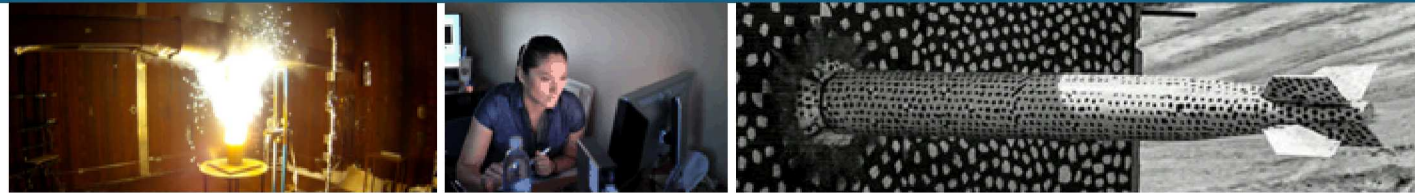*Bz* (contours)
compressed > 20x onto
liner surface
by low density plasma
from power feed

High Resolution Laser Preheat Simulations (of the NIF)

PRESENTED BY

Principal Investigator/Lab: Matthew Weis, SNL

Platform/Campaign ID: Sierra/ATCC-9-257
Code Name: HYDRA
Program: ICF
Usage:

UNLIMITED RELEASE

3D simulations of laser heating on the NIF are demonstrating required energy for MagLIF at the MJ fusion yield scale

A NIF quad of 30 kJ can be used to test laser preheat required for Magnetized Liner Inertial Fusion (MagLIF) at the Mega-Joule fusion yield scale

- ◦ Magnetized neopentane gas (to match electron density at lower pressure)
- ◦ Cryogenic deuterium for hydrodynamic surrogacy

2D HYDRA simulations produce self-focusing of the NIF laser beam in deuterium, propagating the beam down the axis

- ◦ Can lead to deleterious backscatter of laser energy and ultimately limit the potential of laser heating
- ◦ Neopentane propagation generally very smooth but can self-focus with Bz

Initial 3D calculations on Sierra are benchmarking to experiments on the NIF

- ◦ Unmagnetized neo. cases are benchmarking well
- ◦ D2 shows more filamentation rather than self-focusing in 2D but hotspots still not seen in experiments
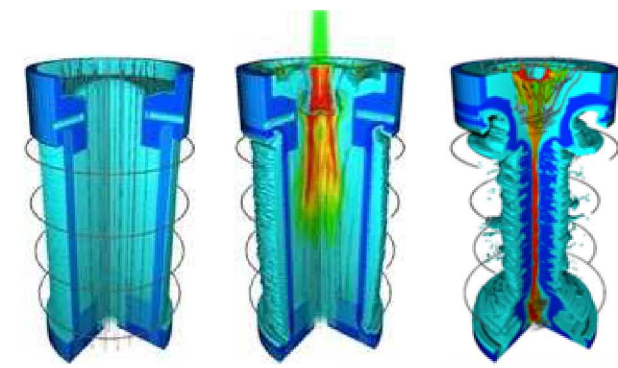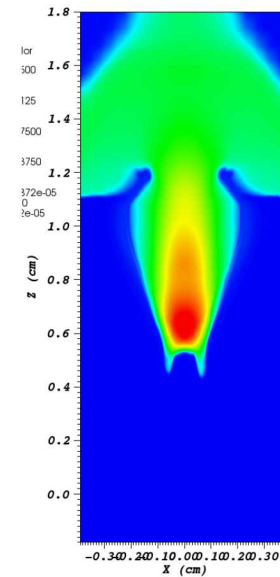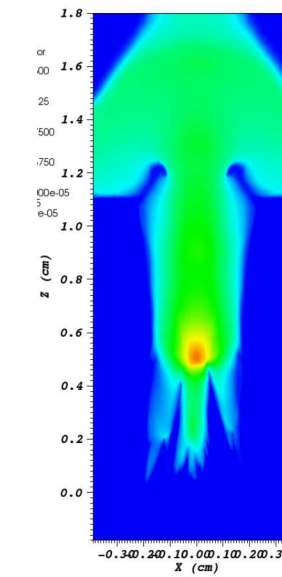

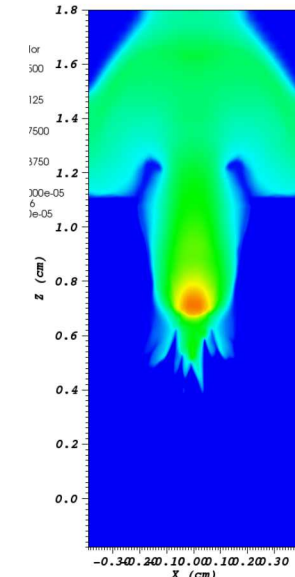**1: Magnetization**　　**3: Compression**
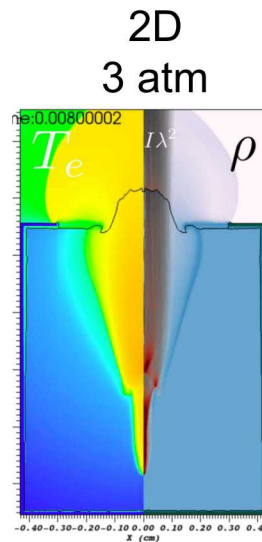**2: Laser Heating**

Electron Temp.

2D 3 atm

Un-magnetized Neopentane　　Un-magnetized 2 atm Deuterium　　Un-magnetized 3 atm Deuterium

Slice through y = 0 of 3D simulations