Magnetized Liner Inertial Fusion Workshop

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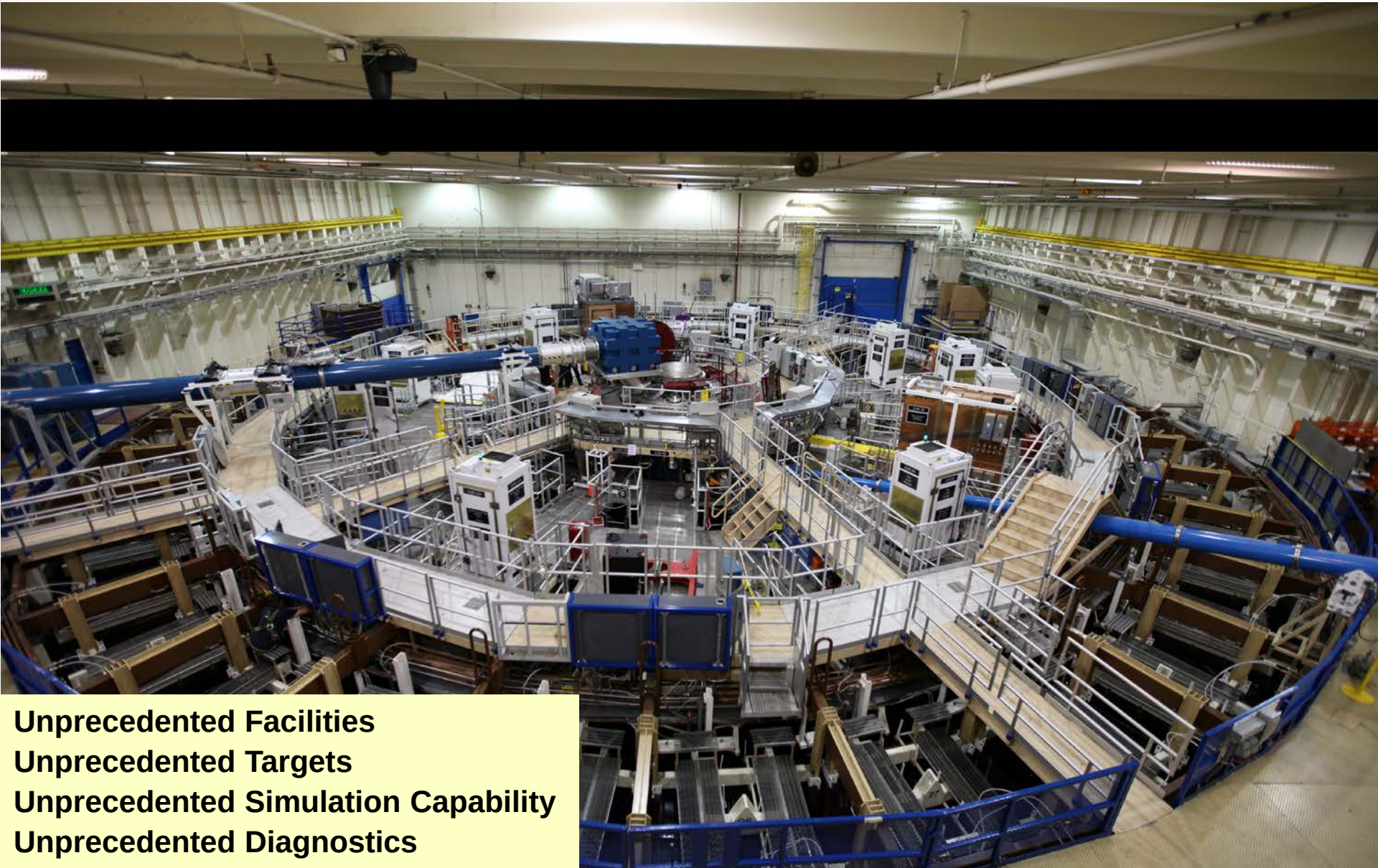
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

It’s an exciting time to be working in the field of Magnetized High Energy Density Science



Unprecedented Facilities
Unprecedented Targets
Unprecedented Simulation Capability
Unprecedented Diagnostics

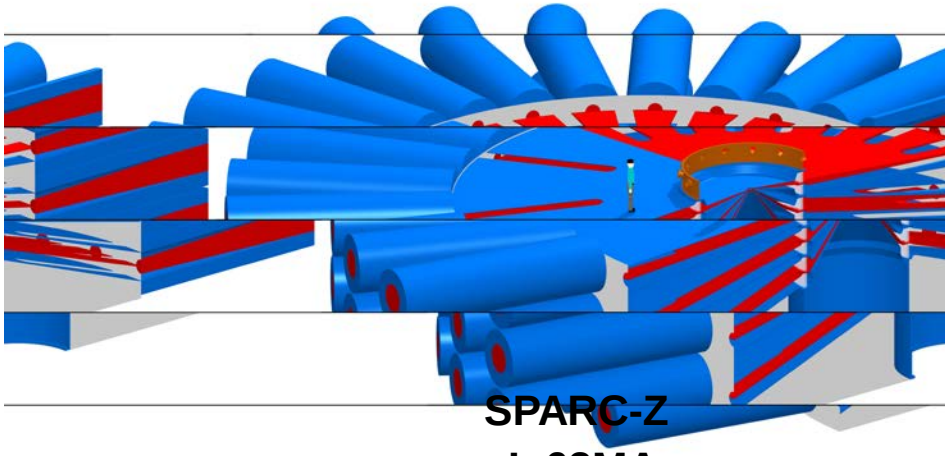
Achieving Inertial Confinement Fusion in the Laboratory is the Grand Challenge of High Energy Density Science

- **Fusion is an exciting integrated challenge which pushes the limits of high energy density science in all areas (experiments, targets, diagnostics, theory, and computation)**

- **The control and understanding gained on the path to fusion enables spin-off opportunities which advance all of HED science**

- **Success in fusion on Z could enable a pathway to a driver that can obtain high fusion yields (1GJ?)**

- **High yield in the laboratory would be an important step on the path to Inertial Fusion Energy**



SPARC-Z
I=63MA

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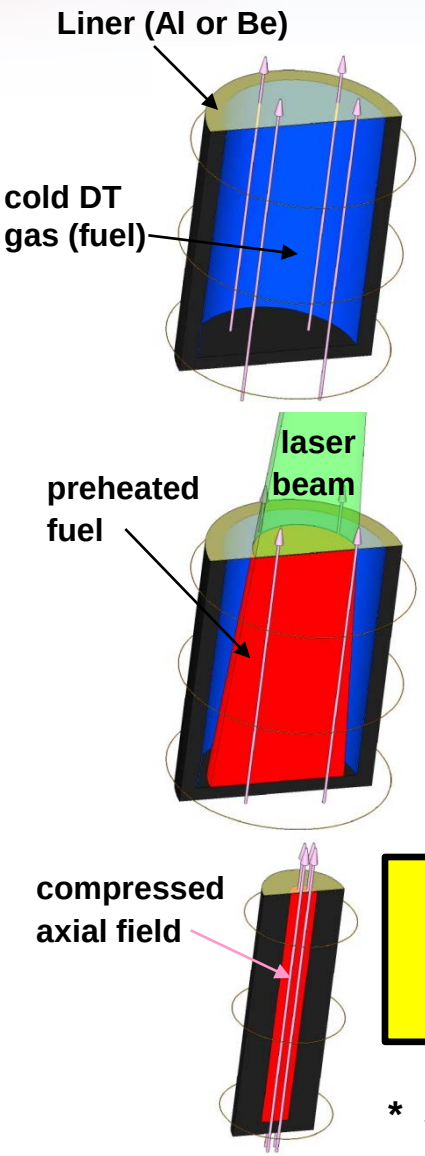
Magnetized liner inertial fusion (MagLIF*) provides an approach to ICF which relaxes the conditions needed in the hotspot



- Adding a strong magnetic field significantly relaxes the pressure needed in the hot spot for fusion self heating

  With B~100 MG self heating can occur with:

  T~ 5keV, ρ~ 1g/cc, ρr~ 0.01 gm/cm^2, P~5 GB
- Short implosion time scales (100ns) and purely axial field enables preheating with a laser
- Preheating significantly reduces required implosion velocity (100km/sec)
- Risks are complementary to the risks of hotspot ignition:
  - High velocity (400km/sec)
  - Low entropy (α ~ 1)
  - High pressure (300 GB+)

Simulations indicate scientific breakeven (fusion energy out = energy deposited in fusion fuel) may be possible on Z

* S. A. Slutz *et al*., Physics of Plasmas 17, 056303 (2010).

There are many physics issues to address for MagLIF

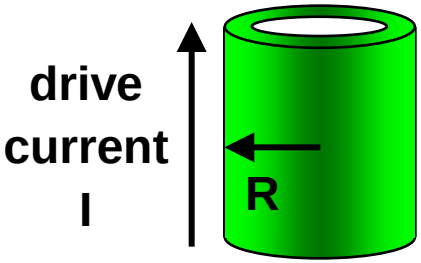
Stabilization techniques

Instability growth

Fuel Preheat

Premagnetization

Convergence ratio



End Losses

Implosion time and velocity

Driver coupling

Pusher adiabat

Pusher-fuel mix

r-θ symmetry

- **Many of these issues are common to other approaches to ICF**
- **Some are unique to MagLIF**

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MagLIF challenges and opportunities

- **Challenges:**
  - **Deceleration RT growth and mix**
  - **3D Asymmetry at stagnation**
  - **End losses**
  - **Collisionless plasma effects**
- **Opportunities**
  - **MagLIF has a very large design space with many controllable parameters:**
    - **Bz**
    - **Preheat Level and configuration**
    - **Liner Thickness and Composition**
    - **Gas fill**
    - **Current Pulse Shape**
  - **Control/Mitigation of instabilities**
    - **Can we affect the electrothermal instability?**
    - **Can we reduce Magneto-Rayleigh Taylor growth?**

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We are eager to broaden the community working to make MagLIF a reality

- **We think MagLIF offers a number of exciting science opportunities**
- **There are many aspects of the MagLIF problem which can be broken down and tested at smaller scales**
- **There are many aspects of MagLIF which cross the boundary from collisional to collisionless plasmas in an interesting way**
- **History shows that when we work together we can make exciting progress in the area of magnetized high energy density science**

Thank you for coming!

We look forward to the next 2.5 days!

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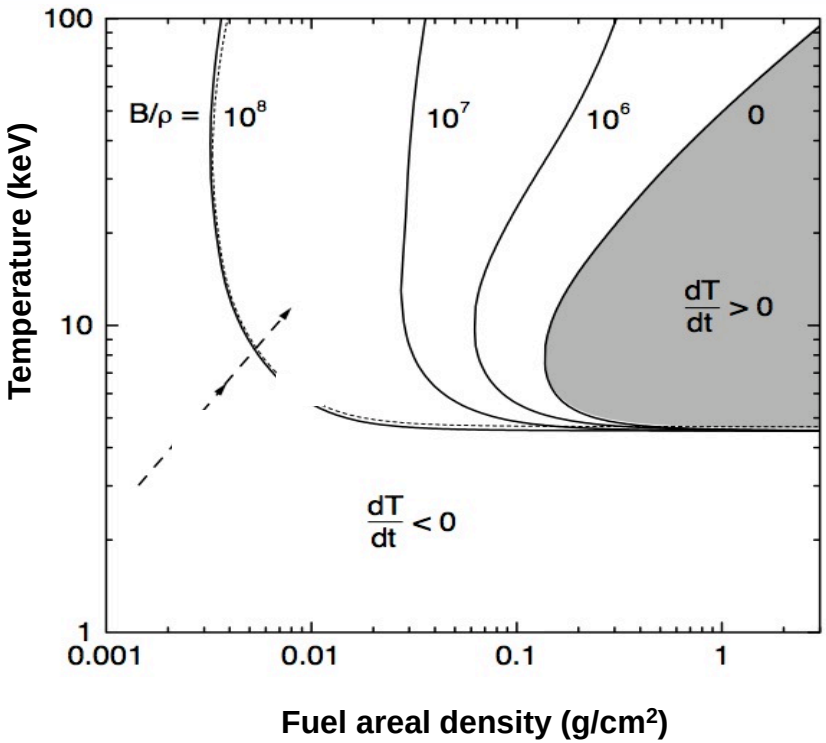
Backups

A magnetic field can significantly expand the space for fusion self heating

*Basko et al. *Nuc. Fusion* **40**, 59 (2000)



The □r needed for ignition can be significantly reduced by the presence of a strong magnetic field

- **inhibits electron conduction**
- **enhances confinement of alpha particles**

Lower □r means lower densities are needed (~1 g/cc)

Pressure required for ignition can be significantly reduced to ~5 Gbar (<< 500 Gbar for hotspot ignition)

Large values of B/□are needed and therefore large values of B are needed.

B~ 50-150 Megagauss >> B_0 -> flux compression is needed

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