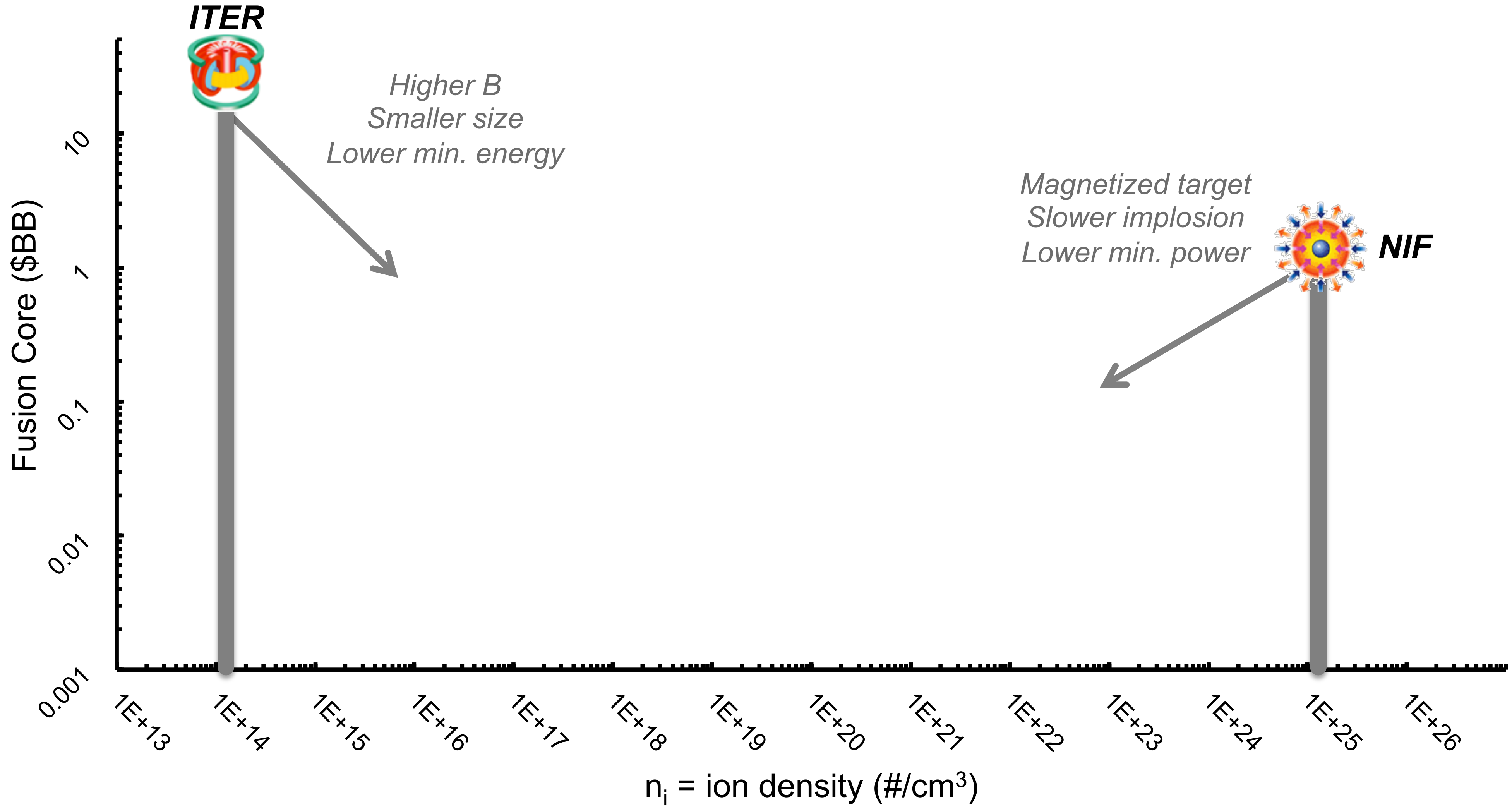
ARPA-E: Modeled after DARPA, focused on energy

Mission: To overcome long-term and high-risk technological barriers in the development of energy technologies

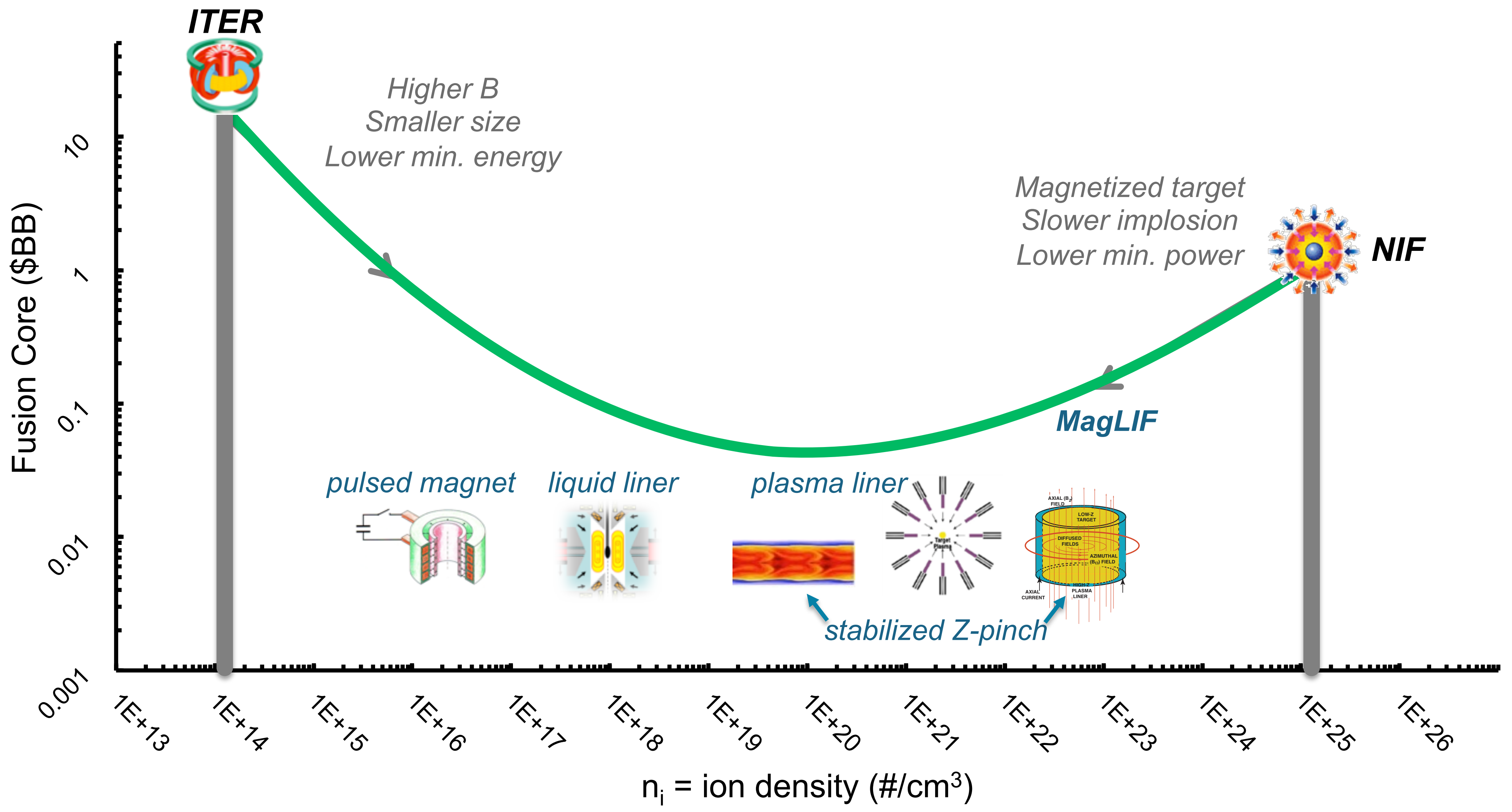
Means:

- Identify and promote revolutionary advances in fundamental and applied sciences
- Translate scientific discoveries and cutting-edge inventions into technological innovations
- Accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty

ALPHA seeks more options for fusion energy



ALPHA seeks more options for fusion energy



CHANGING WHAT'S POSSIBLE

ALPHA Program Goals

Intermediate density:

- Seeking approaches for 10^{18}-10^{23} cm^{-1} (at full compression)

Rapid progress: high shot rate

- Projects required to perform hundreds of shots in 3-year program
- Long term goal: Pulsed reactors with repetition rate ≥ 1 Hz

Low cost per shot:

- Long term goal: Low cost drivers (< \$0.05/MJ) and targets (< 0.05 ¢/MJ)

More options:

- Nine teams selected – \$30M (total) over 3 years
- Diverse set of approaches across intermediate density regime(s)

See the archived Funding Opportunity Announcement for ALPHA, No. DE-FOA-0001184, at arpa-e-foa.energy.gov for rationale and references

ALPHA: Portfolio of teams and approaches

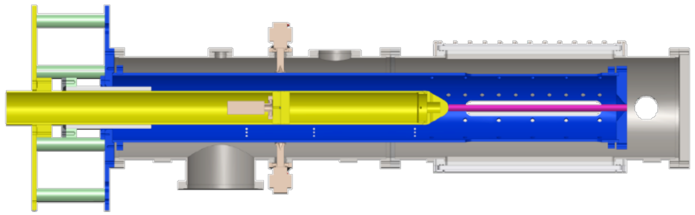
Pulsed magnetic compression — Helion Energy	Stabilized Z-pinch (direct pulsed power) — University of Washington	Plasma jets for high velocity liner implosion — Los Alamos National Laboratory
Piston-driven liquid liner implosion — NumerEx	“Plasma rope” for stable plasma target. — Swarthmore	Scalable MEMS-based accelerator for plasma heating — Berkeley Lab, Lawrence Berkeley National Laboratory
Staged Z-pinch (direct pulsed power) — MIFTI Clean Energy	Underlying science and scaling of MIF — California Institute of Technology 1891	Underlying science of MIF at fusion conditions — Sandia National Laboratories

Progress on stabilized Z-pinches

UNIVERSITY of WASHINGTON

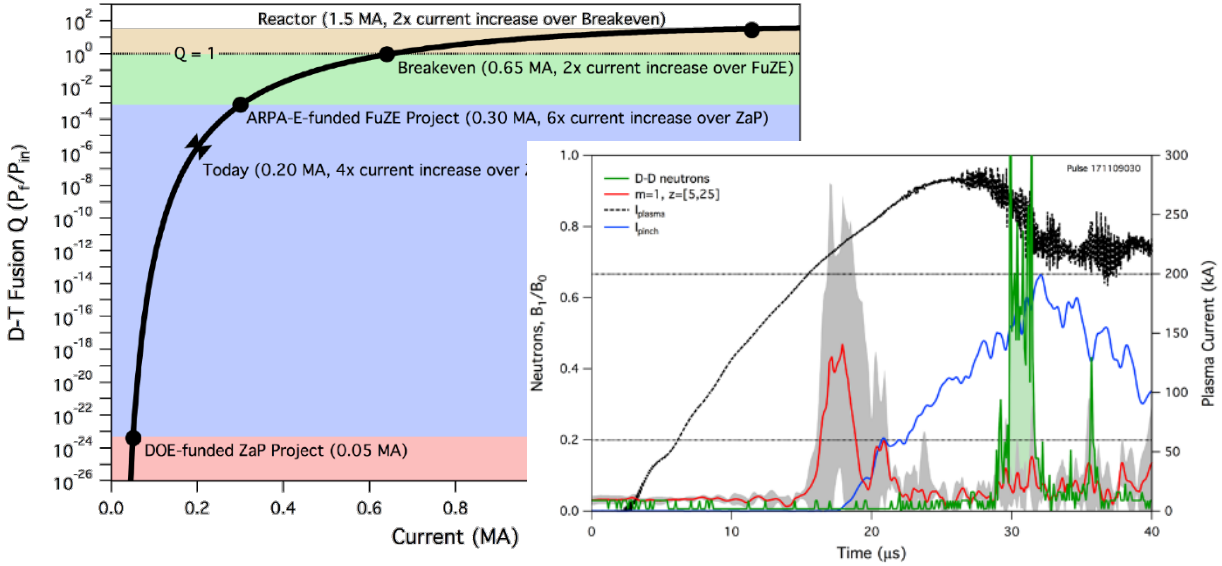
Lawrence Livermore National Laboratory

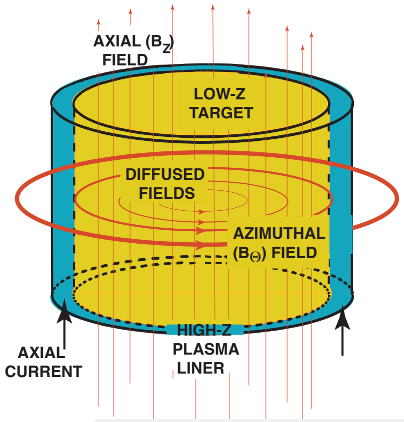
Zap Energy Inc.



Shear-stabilized Z-pinch

- Stability maintained up to high currents (~200 kA)
- Initial operations with D show neutron production

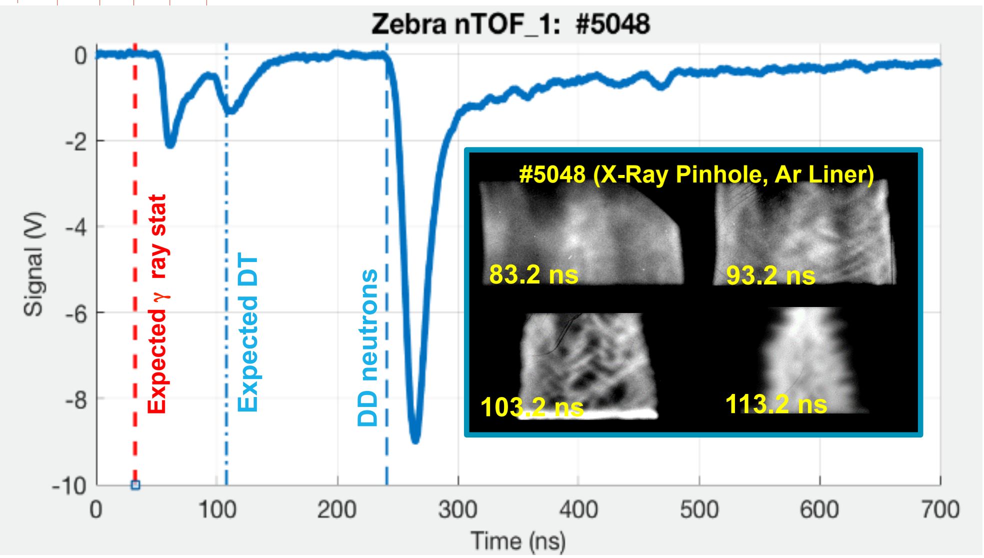




MIFTI UCSD N

Staged Z-pinch

- Shock stabilized interface and D-D yields ~10^9 - 10^{10} (in agreement w/ Mach2)
- Secondary D-T neutrons detected

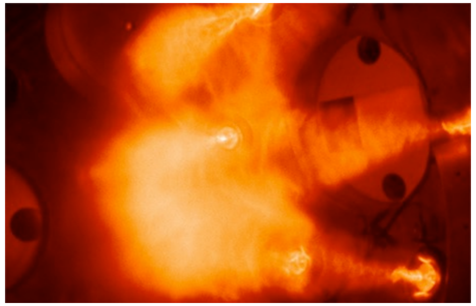


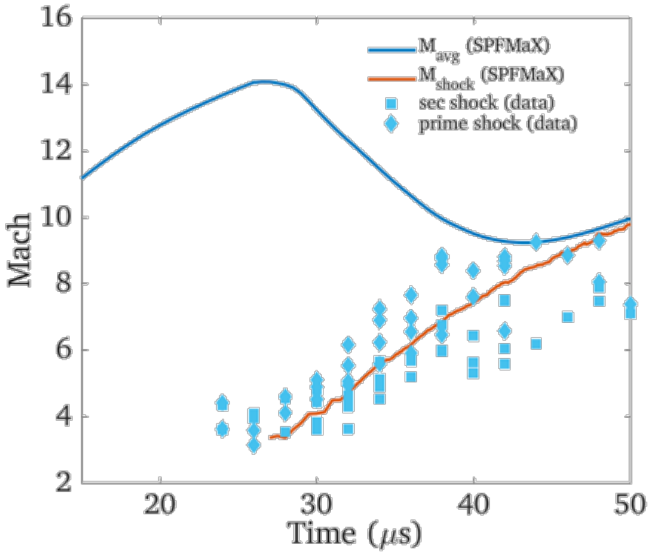
Update on Plasma Liner for MIF

Plasma liner for MIF implosion formed by merging high-Z plasma jets

- Six jet merging experiments showed primary & secondary shock formation
- Initial rise in ion temperature followed by decrease as ions equilibrate with electrons
- Experimental results consistent with 2 temperature simulations.

Addresses a critical risk for plasma liner – high Mach number required for high-gain MIF





Los Alamos NATIONAL LABORATORY

HYPERJET FUSION CORPORATION

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

THE UNIVERSITY of NEW MEXICO

TECH-X SIMULATIONS EMPOWERING YOUR INNOVATIONS

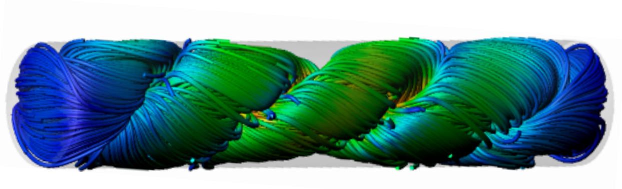
BROOKHAVEN NATIONAL LABORATORY

HYPERV TECHNOLOGIES CORP

Applied Science of Magneto-Inertial Fusion

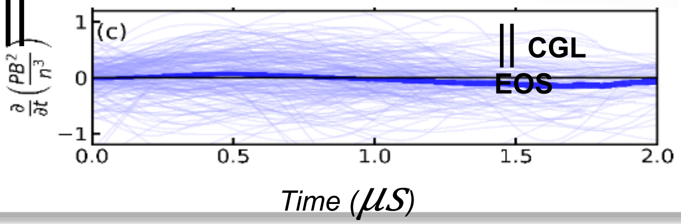
Compression of Taylor state as stable plasma target

- Data consistent with “Parallel” CGL (Chew, Goldberger and Low) EOS



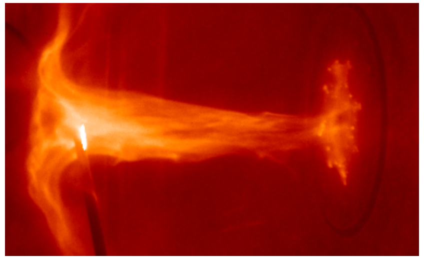
Parallel CGL:

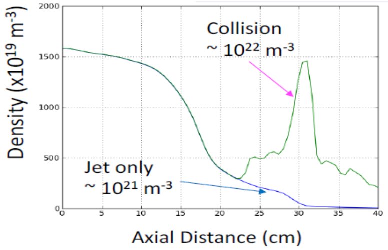
$$\frac{\partial}{\partial t}\left(\frac{P_{\parallel} B^2}{n^3}\right)=0$$

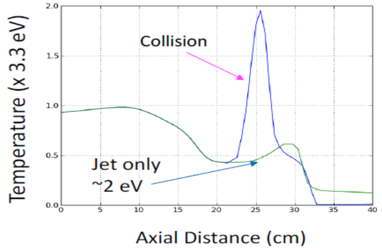


Collisions of jet with gas for “reversed frame” MIF experiment

- Seek dimensionality of adiabatic compression.
- Scaling appears 3D

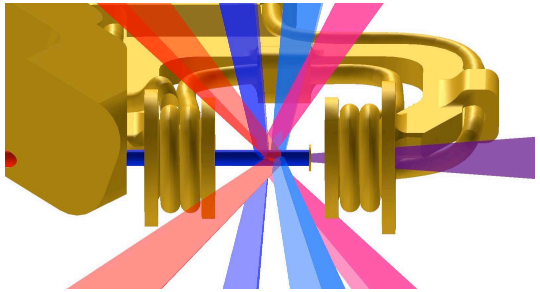






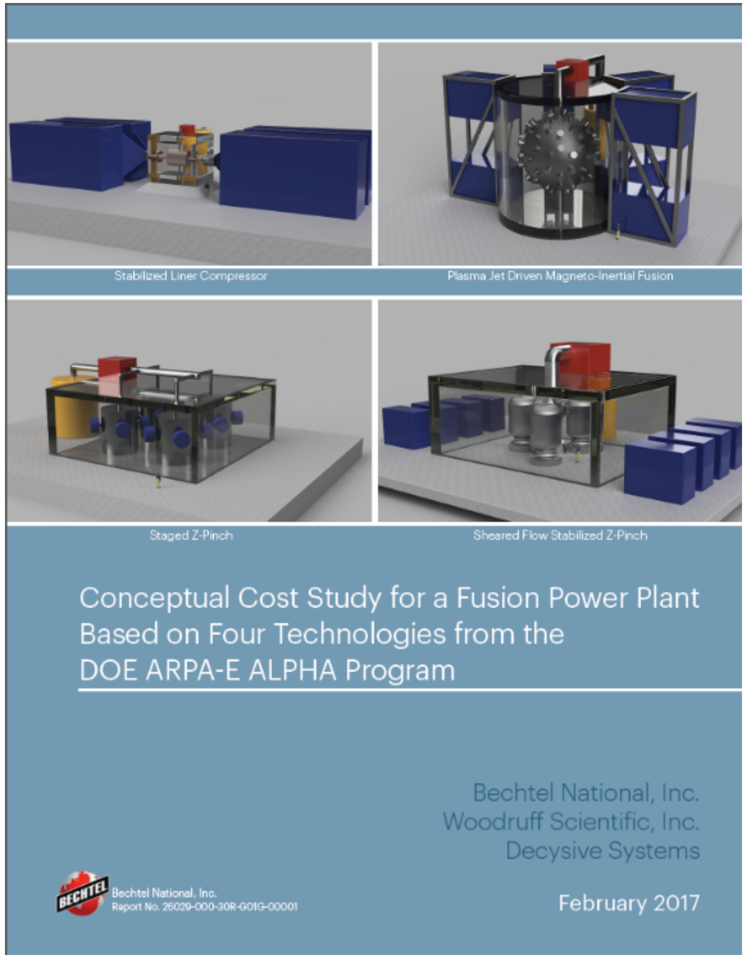
Above Jet-cloud collision (3D MHD sim.)
w/ density enhancement: ~10; temperature enhancement: ~4
Since $10^{2/3}$ ~4, scaling appears to be close to $T= n^{2/3}$ (3D)

”Mini-MagLIF” at LLE enables high experimental throughput at fusion conditions.



- Demonstrated a nearly linear increase in yield in integrated MagLIF experiments on Omega with increasing applied magnetic field (as expected from simulations).
- Fielded improvements in laser pre-heat on Z

ALPHA Fusion Power Plant Conceptual Cost Study



https://www.researchgate.net/publication/318215383_Conceptual_Cost_Study_for_a_Fusion_Power_Plant_Based_on_Four_Technologies_from_the_DOE_ARPA-E_ALPHA_Program

- Bechtel National, Woodruff Scientific, and Decysive Systems performed an initial capital cost study of 4 distinct fusion core approaches based upon a common 150 MW_e balance of plant
- Key takeaways:
  - Fusion core is significant, but not predominant, cost
  - Uncertainty in neutronics and tritium systems remains high, but impact on plant cost is modest
  - Cost of pulsed power systems matters
  - Economics likely dictated by scale and balance of plant components

https://arpa-e.energy.gov