# Accelerating Low-Cost Plasma Heating and Assembly – ALPHA

## PROJECT DESCRIPTIONS

**California Institute of Technology – Pasadena, CA**
*Prototype Tools to Establish the Viability of the Adiabatic Heating and Compression Mechanisms Required for Magnetized Target Fusion - $800,000*
Caltech, in coordination with Los Alamos National Laboratory, will investigate collisions of plasma jets and targets over a wide range of parameters to characterize the scaling of adiabatic heating and compression of liner-driven magnetized target fusion plasmas. The team will propel fast magnetized plasma jets into stationary heavy gases or metal walls. The resulting collision is equivalent to a fast heavy gas or metal liner impacting a stationary magnetized target in a shifted reference frame and allows the non-destructive and rapid investigation of physical phenomena and scaling laws governing the degree of adiabaticity of liner implosions. This study will provide critical information on the interactions and limitations for a variety of possible driver and plasma target combinations being developed across the ALPHA program portfolio.

**Helion Energy, Inc. – Redmond, WA**
*Staged Magnetic Compression of FRC Targets to Fusion Conditions- $3,971,264*
Helion Energy, Inc. will investigate staged magnetic compression of field-reversed configuration (FRC) plasmas, building on past successes to develop a prototype that can attain higher temperatures and fuel density than previously possible. The team will use these results to assess the viability of scaling to a power reactor, which if successful would offer the benefits of simple linear geometry, attractive scaling, and compatibility with modern pulsed power electronics.

**Lawrence Berkeley National Laboratory – Berkeley, CA**
*MEMS Based Ion Beam Drivers for Magnetized Target Fusion- $2,200,000*
Lawrence Berkley National Laboratory (LBNL), in close collaboration with Cornell University, will develop a scalable ion beam driver based on microelectromechanical systems (MEMS) technology. MEMS technology is compatible with massively parallel, low cost batch fabrication and has become widely used in the fabrication of components for consumer electronics. Ion beams are commonly used in research laboratories and manufacturing, but currently available ion accelerator technology cannot deliver the required beam intensities at low enough cost to drive an economical fusion reactor. In the LBNL-Cornell approach, thousands of mini ion “beamlets” will be densely packed on silicon wafers. Ions will be injected and accelerated across gaps formed in stacks of wafers, leading to extremely high current densities for intense ion beams with tunable kinetic energy, suitable for driving a variety of potential plasma targets to fusion conditions.

*These projects have been selected for negotiation of awards; final award amounts may vary. Last updated: 5/12/2015*

## Los Alamos National Laboratory – Los Alamos, NM

*Spherically Imploding Plasma Liners as a Standoff Magneto-Inertial-Fusion Driver- $5,500,000*

Los Alamos National Laboratory (LANL), teamed with Hyper V Technologies and a multi-institutional team, will develop a plasma-liner driver formed by merging supersonic plasma jets produced by an array of coaxial plasma guns. This concept allows “standoff” driver formation far from the fusion burn region (separated by several meters), which avoids destruction of plasma formation and compression hardware in a repetitively pulsed fusion reactor (beyond the ALPHA program). This non-destructive approach may enable rapid, low cost research and development and, by avoiding replacement of solid components on every shot, may help lead to an economically attractive power reactor. This project will seek to demonstrate, for the first time, the formation of a small scale spherically imploding plasma liner in order to obtain critical data on plasma liner uniformity and ram pressure scaling. If successful, this concept will provide a versatile, high-implosion-velocity driver for intermediate fuel density magneto-inertial fusion that is potentially compatible with several plasma targets.

## Magneto-Inertial Fusion Technologies, Inc. – Santa Ana, CA

*Staged Z-pinch Target for Fusion - $4,300,000*

Magneto-Inertial Fusion Technologies, Inc. (MIFTI) will develop a Staged Z-pinch (SZP) to efficiently and stably transfer energy from a radially-imploding liner to a target plasma. Collaborators in this project include researchers from the University of Nevada, Reno, the University of California, San Diego, and Voss Scientific LLC. The SZP utilizes shock heating to deliver energy to the target and shock stabilization to mitigate instability at the liner-target interface; target implosion proceeds faster than instability can grow on the liner’s surface. If successful, the SZP will demonstrate a target-load design that can scale to high-shot rate and fusion-relevant conditions, characteristics that are necessary for net-power production in a reactor.

## NumerEx, LLC – Albuquerque, NM

*Stabilized Liner Compressor (SLC) for Low-Cost Fusion- $4,000,000*

NumerEx, LLC, teamed with the National High Magnetic Field Laboratory in Los Alamos, NM, will develop the Stabilized Liner Compressor (SLC) concept in which a rotating, liquid metal liner is imploded by high pressure gas. Free-piston drive and liner rotation avoid instabilities as the liner compresses and heats a plasma target. If successful, this concept could scale to an attractive fusion reactor with efficient energy recovery, and therefore a low required minimum fusion gain for net energy output. The SLC will address several challenges faced by practical fusion reactors. By surrounding the plasma target with a thick liquid liner, the SLC helps avoid materials degradation associated with a solid plasma-facing first wall. In addition, with an appropriately chosen liner material, the SLC can simultaneously provide a breeding blanket to create more tritium fuel, allow efficient heat transport out of the reactor, and shield solid components of the reactor from high-energy neutrons.

## Sandia National Laboratories – Albuquerque, NM

*Demonstrating Fuel Magnetization and Laser Heating Tools for Low-Cost Fusion Energy- $3,800,000*

Sandia National Laboratories (SNL) and the Laboratory for Laser Energetics at the University of Rochester (LLE) will investigate the compression and heating of high energy density, magnetized plasmas at fusion relevant conditions, building on the recent successes of the Magnetized Liner Inertial Fusion (MagLIF) concept. SNL and LLE will conduct focused experiments based on the MagLIF approach at both SNL and LLE facilities, targeting key physics challenges in the intermediate density regime. The team will also exploit and enhance a suite of simulation and numerical design tools validated by these experiments. Through this project, the team will provide critical information for improved compression and heating performance as well as insights on loss mechanisms and instabilities for hot, dense, magnetized plasmas. This information will help accelerate the development of the MagLIF concept, and will also inform the continued development of intermediate density approaches across the ALPHA program portfolio.

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## Swarthmore College – Swarthmore, PA

*Plasma Accelerator on the Swarthmore Spheromak Experiment- $493,238*

Swarthmore College, in collaboration with Bryn Mawr College, will design, develop, and test two flexible, low cost plasma acceleration modules on the Swarthmore Spheromak Experiment (SSX). These modules will accelerate non-axisymmetric magnetized plasma plumes, formed by allowing a spheromak plasma to evolve in a large aspect ratio cylindrical chamber. Accelerating and colliding these plumes at high speeds and densities may enable the formation of a new kind of plasma target for magnetized target fusion. The SSX experiments offer a high rate of low-cost experimentation and a mature diagnostic suite, which will enable rapid progress in understanding these plasma plumes and illuminate their potential as new targets in the ALPHA program.

## University of Washington – Seattle, WA

*Development of a Compact Fusion Device based on the Flow Z-Pinch- $4,800,000*

The University of Washington is partnering with Lawrence Livermore National Laboratory to advance the shear-flow stabilized Z-pinch concept and assess its potential for scaling to fusion conditions. The Z-pinch is a geometrically simple and elegant approach to fusion, utilizing an electric current to simultaneously magnetically confine, compress, and heat a cylinder of plasma. However, the traditional Z-pinch has been plagued by instabilities that prevent attainment of conditions required for net fusion energy output. Sheared axial flows have been shown to stabilize disruptive Z-pinch instabilities at modest plasma conditions. Through experimental and computational studies, the team will attempt to scale this concept to high current, plasma density, and temperature with a goal of demonstrating a more practical path to a compact, low cost fusion reactor.