FRX-L: A Plasma Injector for Magnetized Target Fusion
An alternate approach to fusion energy

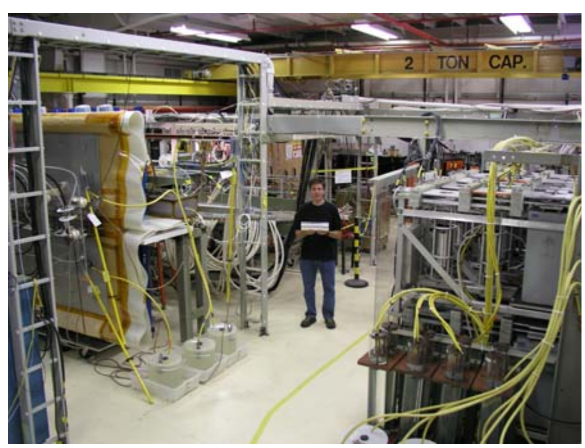
G. A. Wurden*, T. P. Intrator, Los Alamos National Laboratory
J. H. Degnan, Air Force Research Laboratory

Summary

An experiment to produce a high density field reversed configuration plasma (FRC) is operating at LANL. Plasma formation, characterization, and translation tests are in progress. The FRC plasma injector will be used for an eventual magnetized target fusion demonstration experiment at the Air Force Research Laboratory Shiva Star facility.

Since the early 1950s, LANL has conducted research into ways to achieve controlled thermonuclear fusion to eventually create a new energy source for the benefit of mankind. In the last decade, LANL has largely focused on collaborating with other experimenters around the world to build and diagnose the most advanced experimental fusion machines. In the background, several scientists and very small teams at LANL have been developing a new fusion concept, supported by DOE in a portfolio approach to explore and establish reduced cost path and timeline towards more attractive practical fusion energy systems. This concept, generically called "magnetized target fusion" (MTF), attempts to combine and leverage the best features of the more established approaches of magnetic fusion energy (MFE) and inertial fusion energy (IFE). It uses an inertial approach to compress and heat the plasma (like IFE), but uses a magnetic field to confine the plasma energy (like MFE). However, unlike conventional MFE, it is not limited to typical terrestrial magnetic field strengths, and unlike IFE, it can use slower and therefore cheaper pulse energy drivers.

The research program at LANL involves efforts (1) to demonstrate a suitable plasma injector, called the "FRX-L," where FRX refers to "field-reversed experiment," and the "L" refers to "liner" or metallic can that surrounds the plasma, (2) to develop the "can crusher" at the Air Force Research Laboratory (AFRL) in Albuquerque, NM, and mate it to the plasma injector, and (3) to predict and model the plasma implosions using sophisticated computer codes with data from fast-plasma diagnostic tools.



* (505) 667-5633, wurden@lanl.gov

Figure 1: The FRX-L pulsed power plasma injector facility at Los Alamos.

FRX-L is designed to produce compact, high-density, field-reversed plasma configurations with parameters compatible with what is needed to serve as a MTF target (deuterium) plasma that has a density of ~ 1 $\times 10^{17}$ cm^{-3} and a temperature of ~ 200 eV at magnetic fields of ~ 3 to 5 T and a lifetime of ~ 20 µs. The FRX-L uses four high-voltage capacitor banks (up to 100 kV, storing up to 1 MJ of energy) to drive a 1.5-MA current in one-turn magnetic-field coils that surround a 10cm-diam quartz tube where the target plasma is formed.

We use a suite of sophisticated plasma diagnostics to measure the target plasma density, fields, temperature, lifetime, and purity. Present parameters are within a factor of 2-3 in density and magnetic field strength, are on target with plasma temperature, and we would be more comfortable with a factor of 2x longer plasma lifetime. In the coming year, while also improving the pulsed power and plasma performance, we will begin translating these plasmas into a test-liner chamber to confirm the plasma cleanliness and lifetime and our ability to trap the plasma in the close-fitting aluminum liner.

Recently we won a 4-year renewal of the FRX-L MTF project from DOE, which authorizes the goal of combining our plasma injector with the AFRL "Shiva Star" liner-implosion system. Our direct collaborators include scientists from the University of Washington, University of Wisconsin, U of Nevada (Reno), General Atomics, LLNL, and students from around New Mexico and the nation. Over the next four year period, we will design and begin to build the first combined FRC plasma/liner implosion scientific demonstration experiments.

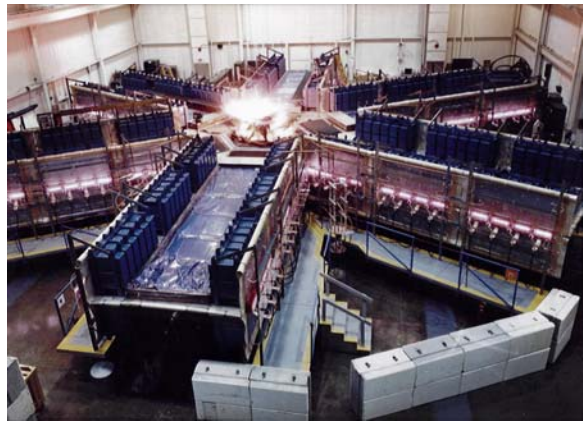


Figure 2: The existing Shiva Star 9-MegaJoule liner implosion machine at the Air Force Research Laboratory in Albuquerque, New Mexico.

In the longer term (10-year) future, we plan to demonstrate fusion-relevant plasma conditions using very modest resources, and expand our ability to simulate the complex processes present in the plasma/liner implosions. The fusion plasma that we hope to produce (at a rate of about 1 shot per week in the laboratory) would be a clean deuterium plasma that will be confined by an enormous magnetic field of 500 T for about 1 µs and will reach a temperature of 5 to 8 keV and a density of ~ 1×10^{19} cm^{-3}! Success could lead to the first demonstration of break-even plasma conditions (with either DD or DT plasmas) using magnetized targets in the Atlas liner-implosion facility in later follow-on experiments at the Nevada Test Site.

For further information on this subject contact:
Dr. Francis Thio, Program Manager, Alternates
U.S. Department of Energy
Office of Fusion Energy Sciences
phone: (301) 903-4678
francis.thio@science.doe.gov

Also, more details are on the web:
http://fusionenergy.lanl.gov