NSTX National Spherical Torus Experiment • PROGRAM HIGHLIGHTS

JANUARY 2000

Successful Beginning of an Innovative Fusion Energy Experiment

The National Spherical Torus Experiment (NSTX) is the U.S. Department of Energy's newest magnetic fusion experimental facility (See Figure 1) built during 1997–1999 at the Princeton Plasma Physics Laboratory, ahead of schedule and within cost. NSTX made its first plasma in February 1999 and produced a plasma current of one million Amperes in December 1999, nine months ahead of a DOE milestone (See Figure 2). The NSTX national team, comprising of researchers from many universities, national laboratories and industry, has begun a broad research program.

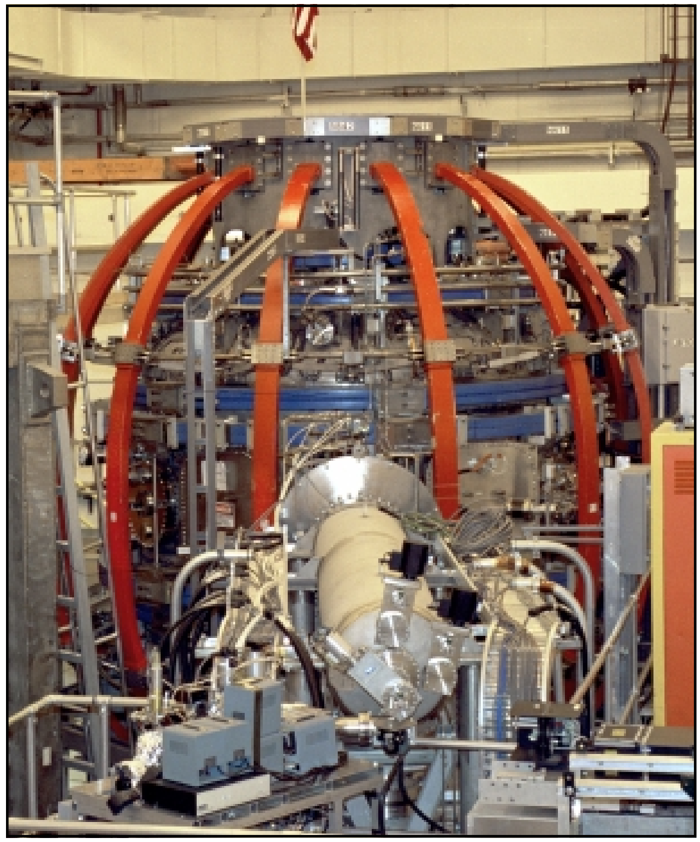

Figure 1. The National Spherical Torus Experiment at the Princeton Plasma Physics Laboratory.

This research is to test and understand the scientific principles of the innovative Spherical Torus (ST) confinement configuration, which possesses a unique plasma magnetic structure (See Figure 3). This configuration promises very large increases in the efficiency of magnetic field utilization, potentially leading to plasmas that contain higher energy more effectively while requiring reduced machine size and magnetic field. An indicator of this efficiency is the central plasma beta (β), the ratio of plasma pressure to magnetic field pressure, which theoretically can be as large as 100% in ST plasmas. This level is many times the value achieved by other successful magnetic confinement configurations where high plasma temperatures (tens of millions of degrees Celsius—hotter than the interior of the sun) have been obtained. Very high β is a key ingredient needed for an affordable fusion energy development path.

With β values approaching 100% at high temperatures, NSTX will produce a class of plasmas never before studied in fusion energy science. In-

About NSTX

NSTX is a new national magnetic fusion experimental facility, located at the U.S. Department of Energy's Princeton Plasma Physics Laboratory, to test the physics principles of the innovative Spherical Torus (ST) confinement concept. The ST concept promises new opportunities for exciting scientific discoveries toward an optimized confinement system and an affordable energy development path. The NSTX National Research and Facility Operations Teams have produced exceptional results since the start of experimentation in 1999 and continue striving to improve in expertise and capability to produce high-quality scientific results and excellent plasma performance. For additional information, please contact: Information Services, Princeton Plasma Physics Laboratory, P.O. Box 451, Princeton, NJ 08543 (609-243-2750); e-mail: pppl_info@pppl.gov or visit our web site at: http://www.pppl.gov dications from the recent research of lower β plasmas have suggested that these plasmas may well possess properties that improve the overall performance even further. In these plasmas the plasma thermal and dynamic forces are expected to increase and become comparable for the first time to the electric and magnetic forces. For example, radio-frequency waves can be bent strongly and absorbed quickly as they propagate through these plasmas. Research on NSTX and other new ST experiments will clarify how these physics properties work and if they can contribute to making fusion energy more practical.

A series of tests in the past two months gave some positive indications of these properties. In one of these tests, scientists from PPPL, ORNL, and General Atomics successfully coupled for the first time two of what will eventually be six radio-frequency devices to heat the plasma in a new way, using a technique not unlike the microwave oven in the kitchen. In another test, scientists from PPPL and University of Washington generated a plasma current of 130,000 Amperes by putting a voltage across the machine, and then depended on the plasma to organize itself to generate the current. Scientists hope these new techniques will eventually help eliminate some of the magnets commonly used in toroidal fusion experiments and greatly simplify future ST experiments.

Modern tools are under preparation on NSTX to take advantage of these new opportunities for advancing fusion energy science. A total power of 11 million Watts in radio frequency wave and energetic neutral particles will be ready in 2000 to push the plasma β to high values. Modern diagnostics systems are under preparation or planned to enable a detailed investigation of the ST plasma properties at high temperatures. Modern theory and tools of analysis will be applied in these studies. A growing national team is bringing its broad expertise in fusion research to bear on the challenging new investigations. This bi-monthly Program Highlight will keep you informed of the exciting progress in fusion energy science made by the NSTX national research team.

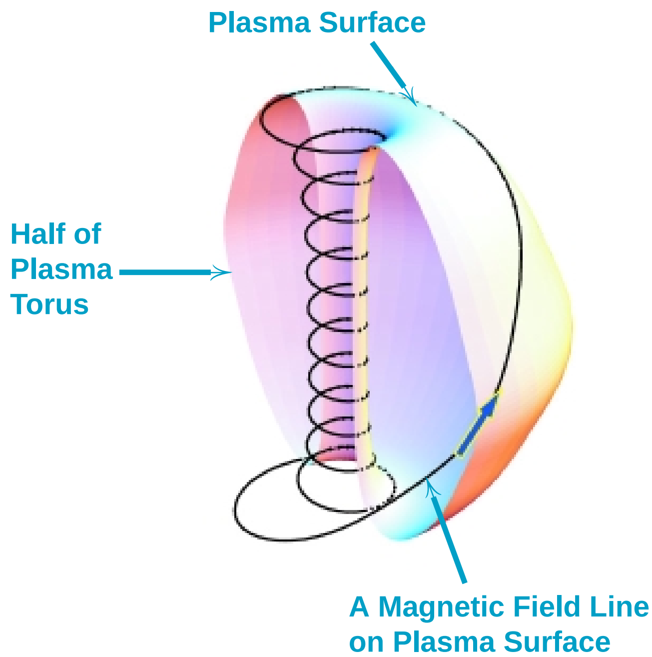

Figure 3. Spherical Torus plasma and magnetic field shape.

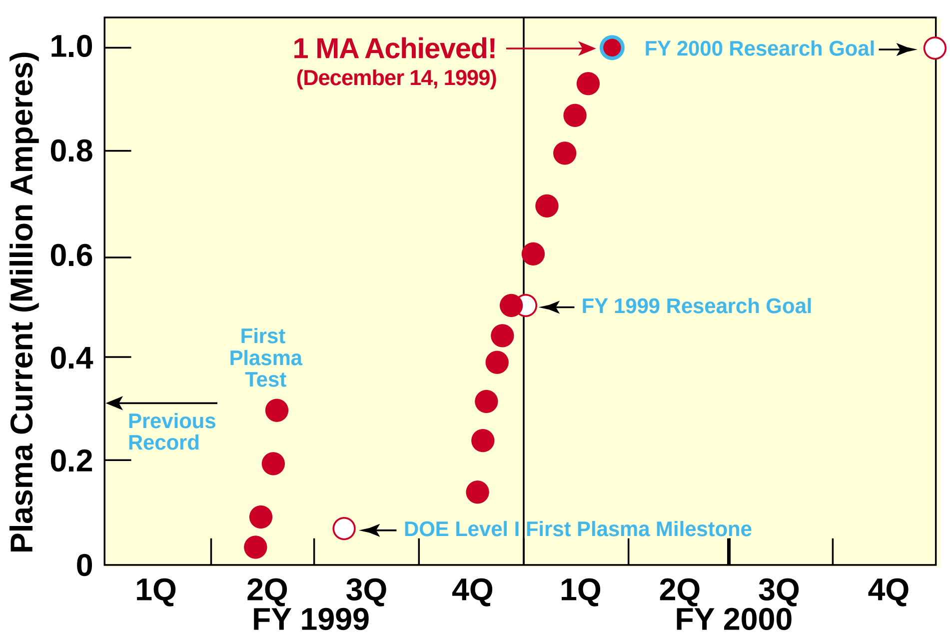

Figure 2. Recent progress in NSTX plasma current.