PPPL Institutional Plan (Draft)
FY 2000 – FY 2004
October 29, 1999

III.G. Plasma Science and Technology

The Plasma Science and Technology Department supports the Laboratory mission by performing basic research to acquire new knowledge in plasma science, and by using this knowledge to develop new plasma technologies, both in and outside of fusion research. The department also plays a major role in the training of graduate students and postdoctoral associates.

These missions are accomplished by:

• Performing versatile, science-focused experiments on basic plasma physics and innovative fusion concepts at PPPL and at other universities and research sites.

• Applying plasma theory to other disciplines, such as high current high energy accelerators and industrial applications.

• Developing near-term applications of plasma science which the demonstrate practical value of the research performed at the Laboratory to meet both commercial and government needs.

• Providing experimental facilities and physics expertise to Princeton University graduate student for Ph.D. theses and for work by postdoctoral students from around the world.

The present direction of the Plasma Science and Technology Department is to strengthen its existing programs on:

• The Current Drive Experiment - Upgrade (CDX-U): At the conclusion of its FY99 research program focusing on the spherical torus, PPPL will begin liquid lithium experiments. A liquid lithium first wall could reduce the concerns associated with solid walls in a fusion reactor. The study of plasma interactions with lithium in CDX-U will begin with a sample probe in collaboration with UCSD. This will be followed by experiments with a toroidal liquid lithium target, which will provide an extensive liquid lithium plasma-facing surface for the first time with a toroidal plasma. In parallel with this effort, rotamak current drive studies will be performed. The development of efficient current drive for fusion plasmas has a potential revolutionary impact on most major concepts for magnetic fusion energy, and the rotamak, is one of the few concepts which promises a significant improvement overconventional radio frequency wave current drive techniques. These experiments will use a new set of radio frequency wave antennas to be installed toroidally around CDX-U. If the antennas are phased properly, a rotating field can be generated to drive a current in the plasma.

- The Magnetic Reconnection Experiment (MRX): devices such as MRX are test beds to develop innovative ideas and test basic understanding of plasma physics. The MRX facility is jointly funded by the DOE, the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). Research focuses on magnetic reconnection, which is one of the most fundamental plasma physics issues in both laboratory and space-plasmas. MRX data has already made a significant impact on space physics by providing clues for understanding collisionless reconnection, merging angle dependence and the validity of Sweet-Parker reconnection models. Future study will cover plasma acceleration, 3-D reconnection, global MHD effects on reconnection and magnetic helicity evolution during reconnection. In addition, magnetic dynamos will be studied by this group.

- Theory and experiments on nonneutral plasmas, aimed both at basic plasma physics and at new applications, ranging from high energy particle accelerators to the development of a new type of vacuum pressure gauge. Experimental and theoretical research is carried out to investigate the basic properties of nonneutral electron plasmas confined in a Malmberg-Penning trap, and the interaction of the plasma electrons with background neutral gas. Advanced analytical and numerical studies are also carried out to investigate the nonlinear beam dynamics and transport properties of intense nonneutral beams propagating in periodic-focusing accelerators and transport systems, with particular emphasis on next-generation accelerators for heavy ion fusion, spallation neutron sources, and nuclear waste treatment.

- Small-scale experiments on magnetized plasmas, concentrating on atomic physics and plasma physics and their applications to space propulsion, materials processing, and compact aneutronic fusion experiments. These studies, performed in the Magnetic Nozzle Experiment (MNX) are a continuation of research on collisional recombination promoted by interactions with neutral gas. The experimental program builds on collaborations with FRC experiments at the University of Washington.

- Research on plasma applications and technology transfer, such as development of a new technique for food sterilization using RF and microwaves, plasma applications related to spacecraft thrusters, and applications related to improving plasma display panels. Plasma diagnostic technique is transferred to industrial applications by working with the American textile industry (AMTEX) to develop diagnostics to measure synthetic fiber morphology on-line during production. This work is supported by Basic Energy Sciences (BES) through a CRADA. PPPL has also initiated a new plasma application related to improved plasma sterilization techniques that would potentially have application in the food and beverage industry.

• Off-site university research support offers some of the scientific and technological resources of PPPL to university programs in fusion science, particularly those involved in innovative confinement research. Presently there are about 15 U.S. universities which are participating in this program, such as Columbia (HBT-EP and the Columbia Linear Machine), University of Wisconsin (MST, Pegasus, HSX), the University of Washington (STX and HIT-II), and the University of California (ET, SCT, and PISCES).

The 5 year strategy for the Plasma Science and Technology Department is to:

• Develop new proposals for small-to-medium sized plasma experiments for OFES and/or other funding sources such as the NSF and BES. These proposals range in scope from basic plasma physics experiments to fusion concepts developments. An example of the latter is Self-organized Plasma with Induction, Reconnection and Injection Techniques (SPIRIT), which is a fusion concept development project proposed to explore promising configurations with high internal current, with a special focus on field-reversed configurations. Another FRC proposal under consideration is the modification of the MNX device to study ion heating and dynamic stabilization of the internal tilt mode by rotating magnetic fields.

• Strengthen PPPL participation in heavy ion fusion research, including increased analytical and numerical efforts on beam-plasma interaction in the target chamber, and the initiation of experimental activities that make effective use of PPPL's established experimental capabilities and off-site heavy ion fusion facilities.

• Strengthen the connections between plasma science at PPPL and other branches of basic science such as high energy physics and space physics.

• Develop new projects within the Applications Research Division, such as:

Thin film processing - new techniques for producing thin films of materials are in high demand, such as High Density Physical Vapor Deposition. This research will apply to the development of high density materials, refractory semi-conductors, and hard coatings for cutting tools to machine steel.

Plasma Sterilization – a new technique is being investigated by PPPL which involves creating
a plasma in the region to be sterilized, has the potential to kill bacterial spores in a time period,
sufficiently short to make the process applicable for use on food container filling lines.
Magnetics Modeling - PPPL is presently using its magnetic modeling capability, developed in
the fusion program to help the nation address the issues related to a high speed magnetically
levitated (MagLev) train system. The effort is being initially supported through a New Jersey
State initiative to address the feasibility of MagLev trains.
• Expand PPPL's collaborations with U.S. university programs in plasma science through mutual site visits by physicists, technological support by PPPL engineers, and joint proposals. This activity will help support these programs and also provide PPPL personnel
with wider experiences and research opportunities.
III.G.1 Technology Transfer
The Technology Transfer effort under the Plasma Science and Technology Department, actively promotes the application of plasma science to needs within U.S. industry, government
and academia. PPPL seeks opportunities that enable the Laboratory to enhance its capability
through research efforts, funded primarily by the external sponsors. PPPL aligns itself with other
institutions that can augment and complement the Laboratory's strengths in order to expand
opportunities. PPPL also has, in the past several years, developed capabilities in a number of
applications areas that are attractive to industry, and is actively seeking to leverage opportunities
from those existing skills and accomplishments.
The mechanisms that are available to carry out the Technology Transfer mission are Cooperative Research and Development Agreements (CRADAs), Work-for-Others (WFO)
arrangements, Personnel Exchange agreements, and Technology Maturation efforts.
The Laboratory continues to actively solicit outside support for projects that fit into the goals
envisioned for the Laboratory's institutional development. The Laboratory continues to encourage researchers within PPPL to become involved, and to respond to inquiries from potential sponsoring partners.
The Laboratory's Head of Technology Transfer is on the Executive board of the Federal

Laboratory Consortium (FLC). The FLC is a Federally sponsored agency that provides a forum for the Federal Laboratory Technology Transfer Personnel to learn from each other, and to share resources and opportunities. The Laboratory maintains close contact with other DOE Energy Research Laboratories on matters related to Technology Transfer, and attends appropriate DOE meetings and participates in working groups involved with Technology Transfer issues and policies. The Laboratory's Head of Technology Transfer also works closely with PPPL inventors and with the Princeton University Office of Research and Project Administration to identify and promote the licensing of Laboratory developed technologies for potential royalty income. Technology Transfer has offered to host a college student from an HBCU Technology Transfer Program as an intern at PPPL. This new program places students who have an interest in Technology Transfer as a career with experienced Technology Transfer professionals at Federal Laboratory.