Proposal and Attendance Form for NSTX Research Forum 2001

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Please write in the boxes below a one-page abstract of your proposal to be presented:

Title: Compact Toroid Fueling of NSTX

Abstract: NSTX is making rapid progress with close to the theoretical no wall beta limit having been reached more than a year ahead of schedule. It is not inconceivable to think of a high Q ST design initiating during the next couple of years. Burning plasma machines will require deep fuelling to minimize tritium losses to walls, for adequately fuelling the core and for pressure profile control. The most advanced fuelling system today (inboard side pellet injection) is still incapable of fuelling reverse shear discharges and may not meet the needs of a reactor. Inboard side pellet launch will be far more difficult in a ST. Thus, while ST research is rapidly progressing there is yet no good way to fuel a ST reactor.

The most promising candidate for reactor deep fueling is the injection of high velocity compact toroids (CTs) but this concept is largely undeveloped. The issues related to the development of this concept includes the demonstration of localized deep fuel deposition, the understanding of the reconnection physics of the magnetized CT inside the discharge being fueled, fueling H mode and Reverse Shear discharges and the development of injector technology.

The primary requirement for the penetration of a CT is governed by the target magnetic field energy density (and not the plasma temperature or the presence of fast ions as is the case for pellets). Compared to tokamaks, NSTX operates at very low values of the toroidal field. For deep penetration into NSTX, a CT will require about 2% of the kinetic energy density of that needed to penetrate a similar cross-section large aspect ratio tokamak. In addition, the steep toroidal field gradient in a ST much more clearly defines the CT stopping location. This reduced energy requirement greatly simplifies the development path for this new technology. Additionally, tangentially injected CTs offer the advantage of simultaneously providing momentum to the edge plasma for plasma rotation (particularly important in burning plasma machines that will not use neutral beams for heating). Doped CTs offer a means to study transport. A reactor CT injector will operate at about 10 to 20 Hz and is far more flexible than a pellet injector as it can alter the mass, composition and fuel deposition position as required by the operations feedback control system.

A deep fuelling system is needed for all burning plasma devices. STs may need it sooner because of the rapid pace of progress. NSTX is the ideal machine on which to develop this system. The University of Washington has access to the CTF2 injector which is a fully operational fueller, having been used on a 1.4T tokamak (including pulsed power supplies, vacuum systems and diagnostics). The estimated cost of CTF2, in 1996 dollars is $800k. The associated cost to NSTX is small. Experiments can be conducted in a piggy back mode with no dedicated run time being devoted to CT injection studies. In return NSTX will contribute to fusion physics by developing the fuelling technology that the ST and all burning plasma reactors need.

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