Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: HHFW H-mode Plasma Development		
OP-XP-425	**Revision:**	Effective Date: 27-Feb-2004 *(Ref. OP-AD-97)* Expiration Date: 27-Feb-2006 *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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RLM - Run Coordinator: S.M. Kaye	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

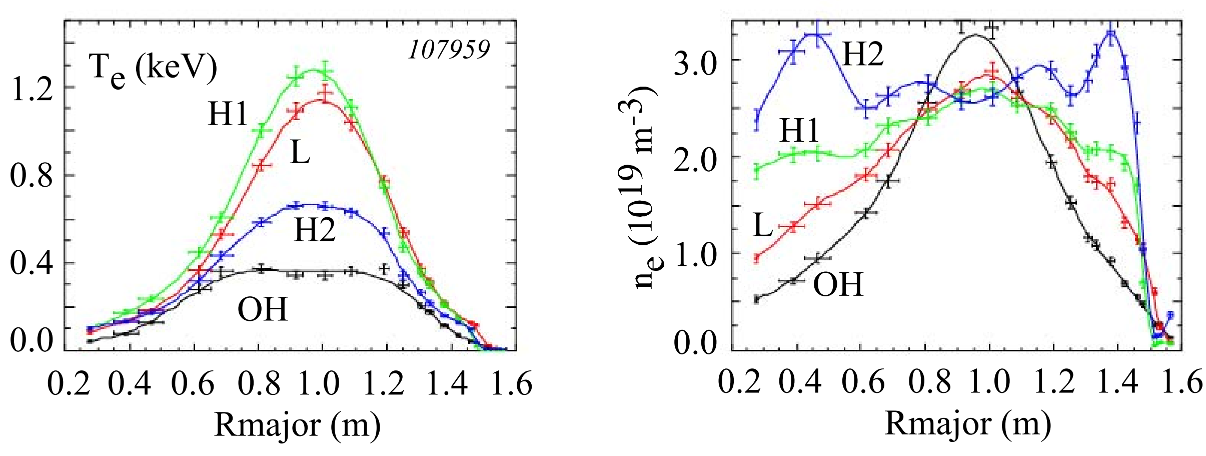
1. Overview of planned experiment

The goal of this experiment is to develop an attractive and robust operational scenario based on HHFW H-mode plasmas. Besides being of interest *per se*, these plasmas have been identified by the HHFW/EBW task force as an enabling tool for (1) the generation of long duration HHFW driven discharges; (2) the study of plasmas heated by NBI and HHFW, where such a plasma would be heated by NBI as part of XP 413.

In the development of these discharges, one would like to take advantage of the availability of the center stack, CS, gas injector in order to separate the antenna coupling effects from fueling. In this operational scenario DND plasmas have a potential advantage with the double x points providing in-out "barriers" at the top and bottom of the plasma. The improved plasma control system recently implemented, including rtEFIT feedback, gives a superior means of maintaining the edge location constant over time, which should improve antenna coupling. Finally the redesign of the antenna feedthroughs should permit a more reliable and higher RF power delivery to the plasma.

2. Theoretical/ empirical justification

HHFW driven H-mode plasmas has been obtained previously on NSTX. These plasmas have the normal kinetic profile signatures observed in H-mode plasmas, as can be seen in Fig. 1. The edge density profile develops "ears" and a steep pedestal as is also observed during NBI driven H-mode



plasmas. An electron temperature pedestal is also clearly visible. Furthermore, CS fueled HHFW driven H-mode plasmas have been produced previously in NSTX (2002), but arcing of the antenna feedthroughs precluded a systematic study. The routine operation of HHFW H-mode plasma would make it possible to compare NBI and HHFW driven H-mode plasmas. While NBI are well known to induce toroidal rotation, HHFW heated plasmas are expected to be externally torque free. But both kinds of plasmas have similar behavior and comparison between the experimental data should bring further understanding of the mechanisms involved.

3. Experimental run plan

The following shot list is designed to do the following tasks:

1: Reproduce CS fed LSN HHFW H mode 107922

2-4: Use 111378 as template for DND plasma for HHFW heating with the goal of getting H mode

using $k_{//}$ = 14 m^{-1}. Repeat with $k_{//}$ = 7 m^{-1} and document power threshold.

5-9: Attempt to obtain H mode at high I_p at $k_{//}$ of 14 m^{-1} and 7 m^{-1}. Document power threshold.

SHOT LIST

STEP	*I_P (MA)*	*B_T (T)*	*$k_{//}$ (m-1)*	*COMMMENT CS fueled, deuterium*	*GOAL*
1	*0.5*	*0.45*	*14*	*Touch base with previous data, reproduce H mode LSN 107922*	*Reproduce H mode*
2	*0.5*	*0.45*	*14*	*Use 111378 as template for DND*	*Do outer gap scan, find best H-mode condition*
3	*0.5*	*0.45*	*14*	*Vary RF power by factor of two*	*Binary search for H-mode threshold*
4	*05*	*0.45*	*7*	*Tune to k// = 7 m^{-1} and apply power to plasma*	*Binary search for H-mode threshold*
5	*0.6*	*0.45*	*14*	*Return to 14 m^{-1} and increase Ip to 0.6 MA*	*Do a plasma current scan*
6	*0.7*	*0.45*	*14*	*Raise Ip to 0.7 MA*	*Part of Ip scan*
7	*0.8*	*0.45*	*14*	*Raise Ip to 0.8 MA, may need additional RF power during Ip ramp to reduce flux consumption.*	*Part of Ip scan*
8	*TBD_1*	*0.45*	*14*	*Vary RF power by factor of two*	*Find threshold for H mode with highest Ip*

9	*TBD_1*	*0.45*	*7*	*Tune to k// = 7 m^{-1} and apply power to plasma*	*Binary search for H-mode threshold*
10	*TBD_2*	*0.45*	*7*	*If H mode not obtained at TBD_1 then lower Ip until H mode*	*Binary search for H-mode threshold*

Plasmas with DND geometry are sought in order to better mesh with the NSTX research program. Keeping in mind that experiments done with NBI heated plasmas have shown that the DND geometry may cause a higher transition power threshold than with LSN, it may be necessary to return to LSN in case the power requirements become non practical with DND plasmas.

Based on the previous experience using rtEFIT during HHFW heating, it may be necessary to forgo real-time control in order to improve reliability.

In order to limit flux consumption, it may be necessary to apply HHFW power during the I_p ramp-up phase.

4. Required machine, NBI, RF, CHI and diagnostic capabilities

Prior to the execution of this experiment, it is necessary to resolve the machine control problems associated with RF pickup for power greater than 1.5 MW. To perform this experiment .a reliable HHFW/machine operation with RF input power of at least 3 MW is needed.

5. Planned analysis

The data analysis will involve the use of the following computational tools: EFIT, TRANSP, CURRAY.

6. Planned publication of results.

Upon establishment of good H-mode plasmas and depending of the extent of the plasma documentation and the quality/nature of the results, a paper will be published in Physics of Plasmas of Physical Review Letters.

PHYSICS OPERATIONS REQUEST

HHFW H-mode Plasma Development **OP-XP-425**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **54** Flattop start/stop (s): _____/_____

I_P (MA): **<= 0.8** Flattop start/stop (s): _____/_____

Configuration: **Inner Wall / Lower Single Null / Upper SN / Double Null**

Outer gap (m): **0-10 cm**, Inner gap (m): **Diverted plasma**

Elongation κ: **as per ref shot**, Triangularity δ: **as per ref shot**

Z position (m): **0.00**

Gas Species: **D** , Injector: **Inner wall**

NBI - Species:, Sources:, Voltage (kV): _____, Duration (s): _____

ICRF – Power (MW): **>= 3 MW**, Phasing: **Heating** , Duration (s): **>= 0.2 s**

CHI: **Off**

Either: List previous shot numbers for setup: **107922, 111378**

Or: Sketch the desired time profiles, including inner and outer gaps, κ, δ, heating, fuelling, etc. as appropriate. Accurately label the sketch with times and values.

DIAGNOSTIC CHECKLIST

HHFW H-mode Plasma Development **OP-XP-425**

Diagnostic	Need	Desire	Instructions
Bolometer – tangential array	x		
Bolometer array - divertor		x	
CHERS			
Divertor fast camera		x	
Dust detector			
EBW radiometers			
Edge deposition monitor			
Edge pressure gauges		x	
Edge rotation spectroscopy	x		
Fast lost ion probes - IFLIP		x	
Fast lost ion probes - SFLIP		x	
Filtered 1D cameras		x	
Filterscopes		x	
FIReTIP		x	
Gas puff imaging			
Infrared cameras		x	
Interferometer - 1 mm			
Langmuir probe array			
Magnetics - Diamagnetism		x	
Magnetics - Flux loops	x		
Magnetics - Locked modes		x	
Magnetics - Pickup coils	x		
Magnetics - Rogowski coils	x		
Magnetics - RWM sensors		x	
Mirnov coils – high frequency		x	
Mirnov coils – poloidal array		x	
Mirnov coils – toroidal array		x	
MSE			
Neutral particle analyzer		x	
Neutron measurements			
Plasma TV		x	
Reciprocating probe			
Reflectometer – core			
Reflectometer - SOL		x	
RF antenna camera	x		
RF antenna probe		x	
SPRED			

DIAGNOSTIC CHECKLIST

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Diagnostic	**Need**	**Desire**	**Instructions**
Thomson scattering	x		
Ultrasoft X-ray arrays		x	
Visible bremsstrahlung det.	x		
Visible spectrometers (VIPS)	x		
X-ray crystal spectrometer - H			
X-ray crystal spectrometer - V			
X-ray PIXCS (GEM) camera			
X-ray pinhole camera			
X-ray TG spectrometer			