Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: **Sustainment of HHFW-Driven 100% Non-Inductive H-Mode Plasma**		
OP-XP-1010	Revision: **1**	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: G. Taylor	Date
ATI – ET Group Leader: G. Taylor	Date
RLM - Run Coordinator: E. Fredrickson	Date
Responsible Division: Experimental Research Operations	

RESTRICTIONS or MINOR MODIFICATIONS

(Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: **Sustainment of HHFW-Driven 100% Non-Inductive H-Mode Plasma** No. **OP-XP-1010**

AUTHORS: **G. Taylor, D. Mueller, J.C. Hosea, S. Gerhardt, C. Kessel, B.P. LeBlanc, C.K. Phillips, S. Zweben, R. Maingi, P.M. Ryan, R. Maingi**

DATE: **February 17, 2010**

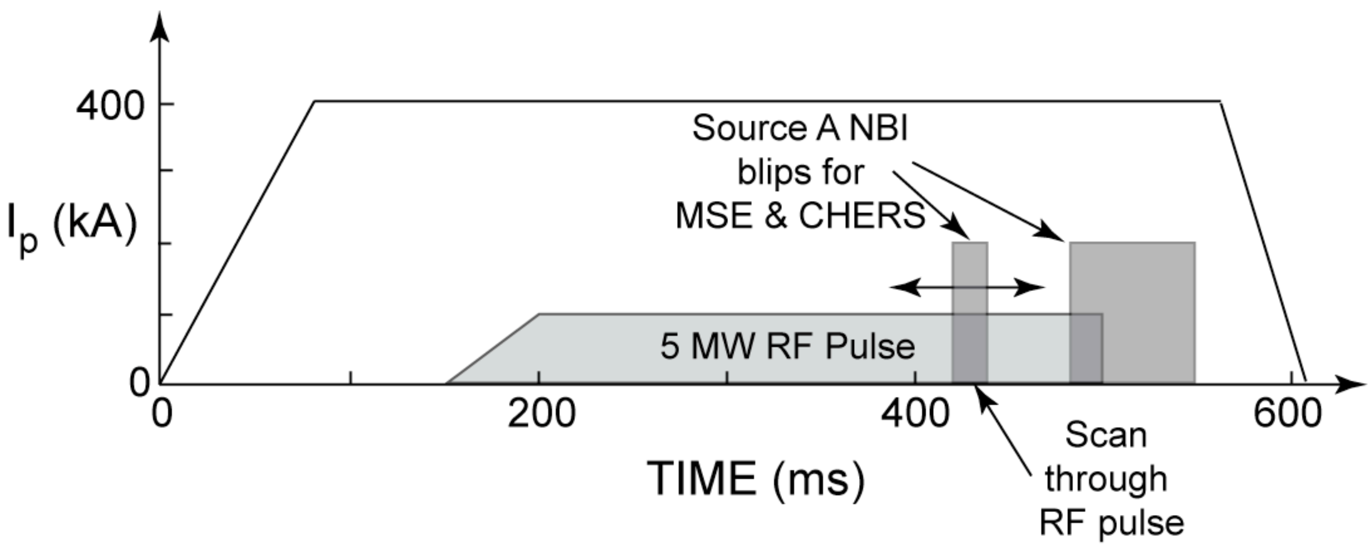
1. Overview of planned experiment

Use solenoid to ramp I_p to 300-400 kA, and then couple ~ 5 MW of HHFW heating to drive plasma into H-mode, generating ~ 100% of I_p via boostrap current. This experiment should be run after XP-1009, and only when ~ 5 MW of HHFW has been successfully coupled into deuterium plasma. This experiment contributes to the NSTX research milestone R10-2.

2. Theoretical/ empirical justification

A goal of the NSTX program is to demonstrate 100% non-inductive H-mode plasmas. 85% bootstrap current fraction was achieved in XP-521 by coupling 2.5 MW of -14 + -18 m^{-1} (180º) HHFW power into an I_p = 250 kA deuterium plasma. It should be possible to achieve 100% bootstrap current fraction with ~ 5 MW of RF coupled into an I_p ~ 400 kA discharge.

3. Experimental run plan



This experiment should take 1 day to complete.

1. Setup 600 ms I_p flattop plasma, similar to 123712 (B_T = 5.5 kG, deuterium), but with I_p = 300-400 kA. **(5 shots)**

2. Add k_ϕ = 14 + 18 m^{-1} -8 m^{-1} (180º) HHFW power, coupled from 150 – 500 ms, with a 50 ms ramp-up in power at the start of the RF pulse. Increase RF power to 5 MW, while adjusting lithium evaporation rate, gas injection rate and outer gap to optimize HHFW heating efficiency. **(10 shots)**

3. Repeat with k_ϕ = (-90°) heating **(10 shots)**

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

This experiment should start with target I_p with best result from XP-1009. The experiment requires P_{RF} ~ 5 MW at -14 + -18 $m^{-1}$and -8 m^{-1}. This experiment needs rtEFIT isoflux control for the outer gap. LITERs are required, but the LLD can be maintained in "cold", solid lithium state. An NBI blip from source A at 90 keV should be added for MSE and CHERS data acquisition from 480 to 550 ms. In addition a 20 ms NBI blip from source A at 90 keV will be scanned through the RF pulse once good, reproducible, ~ 5 MW RF heating has been established. Thomson scattering data are required for core and edge electron heating data. For analysis of edge power loss and coupling efficiency the experiment also requires SOL reflectometry and edge ion heating data from edge rotation diagnostic.

5. Planned analysis

Planned analysis includes analysis of heating efficiency at k_ϕ = -8 m^{-1} and -14 + -18 m^{-1}, TRANSP and GENRAY/CQL3D modeling.

6. Planned publication of results

The results will be submitted for publication in *Nuclear Fusion* or *Physics of Plasmas*, and may contribute to an HHFW IAEA paper.

PHYSICS OPERATIONS REQUEST

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Brief description of the most important operational plasma conditions required:

Stable, reproducible I_p = 300-400 kA deuterium plasma with outer gap = 0.05 – 0.1 m. This experiment should start with target I_p with best result from XP-1009.

Request D. Mueller as operator.

Previous shot(s) which can be repeated:

Previous shot(s) which can be modified: 123712

Machine conditions *(specify ranges as appropriate, strike out inapplicable cases)*

I_{TF} (kA): **66** Flattop start/stop (s): **0/0.7**

I_P (MA): **0.4** Flattop start/stop (s): **0.08/0.6**

Configuration: **LSN**

Equilibrium Control: **Outer gap / Isoflux** (rtEFIT) **/ Strike-point control** (rtEFIT)

Outer gap (m): **0.05-0.1** Inner gap (m): Z position (m): **0.0**

Elongation: Triangularity (U/L): OSP radius (m):

Gas Species: **D** Injector(s):

NBI Species: **D** Voltage (kV) **A: 90 B: C:** Duration (s): **480-550 ms, and 20 ms blip stepped between 250 to 450 ms from shot to shot**

ICRF Power (MW): **5** Phase between straps (°): **±90, 180** Duration (s): **0.35**

CHI: **Off** Bank capacitance (mF):

LITERs: On Total deposition rate (mg/min): **20 mg/min to start, adjust as needed**

LLD: Cold Temperature (°C):

EFC coils: Off Configuration: **Odd / Even / Other**

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	Need	Want
Beam Emission Spectroscopy		
Bolometer – divertor	√	
Bolometer – midplane array	√	
CHERS – poloidal	√	
CHERS – toroidal	√	
Dust detector		
Edge deposition monitors		
Edge neutral density diag.		√
Edge pressure gauges		√
Edge rotation diagnostic	√	
Fast cameras – divertor/LLD		
Fast ion D_alpha - FIDA		
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP		
Filterscopes	√	
FIReTIP		√
Gas puff imaging – divertor		
Gas puff imaging – midplane		√
Hα camera - 1D		√
High-k scattering		
Infrared cameras	√	
Interferometer - 1 mm		√
Langmuir probes – divertor		√
Langmuir probes – LLD		
Langmuir probes – bias tile		
Langmuir probes – RF ant.		√
Magnetics – B coils	√	
Magnetics – Diamagnetism	√	
Magnetics – Flux loops	√	
Magnetics – Locked modes	√	
Magnetics – Rogowski coils	√	
Magnetics – Halo currents	√	
Magnetics – RWM sensors	√	
Mirnov coils – high f.	√	
Mirnov coils – poloidal array	√	
Mirnov coils – toroidal array	√	
Mirnov coils – 3-axis proto.	√	

Note special diagnostic requirements in Sec. 4

Diagnostic	Need	Want
MSE	√	
NPA – E||B scanning		√
NPA – solid state		√
Neutron detectors		√
Plasma TV	√	
Reflectometer – 65GHz		
Reflectometer – correlation		
Reflectometer – FM/CW		
Reflectometer – fixed f		
Reflectometer – SOL	√	
RF edge probes	√	
Spectrometer – divertor	√	
Spectrometer – SPRED	√	
Spectrometer – VIPS	√	
Spectrometer – LOWEUS		
Spectrometer – XEUS		√
SWIFT – 2D flow		
Thomson scattering	√	
Ultrasoft X-ray – pol. arrays	√	
Ultrasoft X-rays – bicolor	√	
Ultrasoft X-rays – TG spectr.		
Visible bremsstrahlung det.	√	
X-ray crystal spectrom. - H		√
X-ray crystal spectrom. - V		√
X-ray tang. pinhole camera		√