Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Impact of density reduction on long-pulse discharges

OP-XP-838	Revision: **0**	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: Jon Menard	Date
ATI – ET Group Leader: David Gates	Date
RLM - Run Coordinator: Michael Bell	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: **Impact of density reduction on long-pulse discharges** No. **OP-XP-838**
AUTHORS: **J. Menard, V. Soukhanovskii, D. Gates** DATE: **06/27/2008**

1. Overview of planned experiment

The combination of active suppression of n=1 RFA, n=3 pre-programmed error field correction (EFC), and the after-effects of LITER have produced record pulse-durations. High elongation + EFC + LITER have produced record poloidal beta and record low flux-consumption in NSTX. Further decreases in flux consumption are possible with increased non-inductive fraction and/or increased conductivity. Reduced density could increase the NBI CD efficiency, and if Te increases at reduced density, density reduction could increase the conductivity and further increase NBI-CD. This experiment will attempt to systematically lower the plasma density by reducing the HFS gas source while avoiding disruptive MHD activity by replacing HFS gas with SGI fueling, optimizing the beam programming to avoid hitting the beta limit, and optimizing early error-field correction to reduce mode locking. These approaches will be applied primarily to long-pulse discharges, but also to high non-inductive fraction discharges.

2. Theoretical/ empirical justification

Reduced density is predicted to increase beam current drive efficiency, and higher Te at reduced density could further increase NBI-CD efficiency and conductivity – all resulting in increased pulse duration and higher non-inductive fraction plasmas. Higher non-inductive fraction is important for improved operation of NSTX and NSTX-Upgrade and is essential to future ST devices such as NHTX and ST-CTF.

3. Experimental run plan

A. Reproduce and extend long-pulse discharges (10 shots)
   1. Make sure HFS gas valve is closed 10-20ms after being opened to reduce HFS gas flow
   2. Start with evaporation rate = 20mg/min
      i. Use LITER shutter to fix evaporation duration at 8min with 10min shot cycle
   3. Starting from 129125 - scan I_P = 750kA, 700kA at B_T = 0.41 and 0.38T
      i. Decrease outer gap towards 10cm for improved pedestal data while ensuring heat load on HHFW antenna is acceptable
   4. Increase evaporation rate to 40mg/min – repeat I_P and B_T scan

B. For longest duration discharge, perform density scan:
   1. Reduce HFS fueling rate in 100 Torr increments
      i. GOAL: Attempt to replace HFS with SGI fueling (200 Torr may be lower bound)
   2. As plasma density becomes too low and destabilizes locked modes, try:
      i. Replacing early fueling with SGI fueling to increase density (8 shots)
      ii. Optimizing beam power and timing to avoid early disruption (4 shots)
      iii. Earlier EFC to reduce early mode locking (4 shots)
   3. Use RMP ELM triggering if H-mode becomes ELM-free and impurities accumulate

C. At lowest stable operating density, try increased toroidal field and elongation to attempt to increase non-inductive fraction (8 shots)
   1. Start from 129986 (record poloidal beta) – scan density with HFS and/or SGI
   2. Scan toroidal field from 4.4 kG to 5.2kG in 0.2kG increments

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

The usual diagnostic capabilities are required, NBI voltage on A, B, C = 90, 90, 80kV.

5. Planned analysis

EFIT/LRDFIT, TRANSP, MPTS, CHERS, and RWM/EF sensor analysis will be performed.

6. Planned publication of results

Results will be published in conference proceedings and/or journal such as Nuclear Fusion or Physics of Plasmas within one year of experiment.

PHYSICS OPERATIONS REQUEST

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Machine conditions (specify ranges as appropriate)

I_{TF} (kA): up to **63kA** Flattop start/stop (s): **0.0, ~2s**

I_P (MA): **0.7, 0.75, 0.8MA** Flattop start/stop (s): **0.2, ~2s**

Configuration: **DN / LSN**

Outer gap (m): **10cm** Inner gap (m): **2-8cm**

Elongation κ: **2.4-2.7** Upper/lower triangularity δ: **0.75 / 0.5**

Z position (m): **0cm**

Gas Species: **D** Injector(s): **CS midplane, outer midplane, SGI**

NBI Species: **D** Sources: **A, B, C** Voltage (kV): **90, 90, 80kV** Duration (s): **2s**

ICRF Power (MW): **0** Phasing: **0** Duration (s): **0**

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

LITER: On – 20 mg/min (up to 40mg/min may be requested)

Previous shot numbers for setup: **129125, 129986**

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array	**X**	
Bolometer – divertor		**X**
CHERS – toroidal	**X**	
CHERS – poloidal	**X**	
Divertor fast camera		**X**
Dust detector		
EBW radiometers		
Edge deposition monitors		**X**
Edge neutral density diag.		**X**
Edge pressure gauges		**X**
Edge rotation diagnostic		**X**
Fast ion D_alpha - FIDA		**X**
Fast lost ion probes - IFLIP		**X**
Fast lost ion probes - SFLIP		**X**
Filterscopes	**X**	
FIReTIP	**X**	
Gas puff imaging		
Hα camera - 1D	**X**	
High-k scattering		
Infrared cameras		
Interferometer - 1 mm		
Langmuir probes – divertor		
Langmuir probes – BEaP		
Langmuir probes – RF ant.		
Magnetics – Diamagnetism	**X**	
Magnetics – Flux loops	**X**	
Magnetics – Locked modes	**X**	
Magnetics – Pickup coils	**X**	
Magnetics – Rogowski coils	**X**	
Magnetics – Halo currents		
Magnetics – RWM sensors	**X**	
Mirnov coils – high f.	**X**	
Mirnov coils – poloidal array	**X**	
Mirnov coils – toroidal array	**X**	
Mirnov coils – 3-axis proto.		

Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
MSE	**X**	
NPA – ExB scanning		**X**
NPA – solid state		**X**
Neutron measurements	**X**	
Plasma TV	**X**	
Reciprocating probe		
Reflectometer – 65GHz		
Reflectometer – correlation		
Reflectometer – FM/CW		
Reflectometer – fixed f		
Reflectometer – SOL		
RF edge probes		
Spectrometer – SPRED	**X**	
Spectrometer – VIPS	**X**	
SWIFT – 2D flow		
Thomson scattering	**X**	
Ultrasoft X-ray arrays	**X**	
Ultrasoft X-rays – bicolor		**X**
Ultrasoft X-rays – TG spectr.		**X**
Visible bremsstrahlung det.	**X**	
X-ray crystal spectrom. – H		
X-ray crystal spectrom. – V		
X-ray fast pinhole camera		**X**
X-ray spectrometer – XEUS		**X**