Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Title: **Early error-field correction in long-pulse plasmas**		
OP-XP-954	Revision: **0**	Effective Date: **July 30, 2009** *(Approval date unless otherwise stipulated)* Expiration Date: **July 30, 2011** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS	
Responsible Author: **Jon Menard** Jonathan E. Menard	Date July 30, 2009
ATI – ET Group Leader: David Gates	Date July 30, 2009
RLM - Run Coordinator: Roger Raman	Date July 30, 2009
Responsible Division: Experimental Research Operations	
Chit Review Board (designated by Run Coordinator)	

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: Early error-field correction in long-pulse plasmas No. **OP-XP-954**

AUTHORS: **J. Menard, S. Gerhardt, D. Gates** DATE: **07/30/2009**

1. Overview of planned experiment

The combination of active suppression of n=1 RFA, n=3 pre-programmed error field correction (EFC), and LITER have produced record plasma pulse-durations in NSTX. High elongation + EFC + LITER have produced record poloidal beta and record low flux-consumption in NSTX. This experiment will attempt to systematically lower the plasma density while avoiding disruptive MHD activity by optimizing early error-field correction to reduce mode locking. 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 and reduce OH flux consumption. This experiment will focus on discharges with little or no late MHD activity to simplify NBICD analysis, and with sufficient flat-top that the inductive and non-inductive profiles become equilibrated.

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. Variations in plasma density should modify the beam current drive fraction at fixed heating power, thereby providing data for the ITPA IOS group for validating beam current drive models. Finally, this experiment is important for the anticipated operation of the liquid lithium divertor (LLD) which could result in reduced early density and locked-modes if the LLD acts as an effective pump.

3. Experimental run plan

FIRST ½ RUN DAY

A. Reproduce a long-pulse and late-MHD-free discharge at 700-750kA (3 shots)
   1. Start with evaporation rate = 20mg/min for 10mins, 12 min shot cycle, no He glow
      i. Use XP836 shot 135445 with 1.2-1.4s period without low-n MHD
      ii. Use 16cm outer gap, increase TF to 4kG if MHD free-window is too short.
      iii. Modify squareness and/or PF1AL current to maintain elongation ≤ 2.6 after t=1s

B. Reduce pre-fill and/or low-field-side gas to trigger early MHD event/mode locking
   1. Reduce early NBI power if beta-limit is reached, but maintain early H-mode
   2. Start n=3 EF correction at t=20ms with gain = 200A/10kA (I_{RWM}/I_{PF5}) (2 shots)
      i. Assess locking behavior and rotation modification from n=3 EFC
   3. With n=3 EFC off, turn on n=1 OHxTF EFC from XP 614 (120335) (5 shots)
      i. Ramp-down OHxTF EFC by t=350ms to transition to n=1 FB control and n=3 EFC
      ii. Scan timing of OHxTF correction ramp-up in steps of 20ms (moving earlier)
      iii. Assess locking behavior and rotation modification from n=1 EFC
   4. Combine early n=3 and n=1 EFC, and assess mode-locking and rotation (2 shots)

C. Reduce HFS gas in 200 Torr steps to trigger MHD event near early H-mode onset (4 shots)
   1. Assess stable density reduction achievable from early EFC

SECOND ½ RUN DAY

D. Working at an early density near and above locking threshold:
   1. Attempt to produce an MHD-stable discharge with reduced late density by replacing the LFS/HFS fueling with SGI-based fueling from XP-912 shot 134134 (4 shots)
   2. Increase LITER evaporation rate to 30mg/min, adjust SGI fueling for stability (6 shots)

E. Time permitting, increase I_P to 0.8, 0.9, 1MA to assess n_e evolution at higher current (6 shots)

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

Describe any prerequisite conditions, development, XPs or XMPs needed.
Attach completed Physics Operations Request and Diagnostic Checklist.

5. Planned analysis

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

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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(use additional sheets and attach waveform diagrams if necessary)

Describe briefly the most important plasma conditions required for the experiment:

Long flat-top of 1.5-1.8s flat-top with long window (1-1.5s) free of low-n MHD activity

Previous shot(s) which can be repeated: 135445

Previous shot(s) which can be modified: 135440, 129125

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

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

I_P (MA): **0.7 to 1MA** Flattop start/stop (s): **0.2, ~2s**

Configuration: **DN / LSN**

Equilibrium Control: **Isoflux** (rtEFIT)

Outer gap (m): **16cm** Inner gap (m): **2-8cm** Z position (m): **~0m**

Elongation κ: **2.4-2.6** Upper/lower triangularity δ: **0.5/0.7**

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

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

ICRF Power (MW): **0MW** Phase between straps (°): **0** Duration (s): **0**

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

LITERs: On Total deposition rate (mg/min): **20mg/min (increase later to 30)**

EFC coils: On Configuration: **Odd**

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array		
Bolometer – divertor		
CHERS – toroidal	**X**	
CHERS – poloidal		
Divertor fast camera		
Dust detector		
EBW radiometers		
Edge deposition monitors		
Edge neutral density diag.		
Edge pressure gauges		
Edge rotation diagnostic		
Fast ion D_alpha - FIDA	**X**	
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP		
Filterscopes	**X**	
FIReTIP		
Gas puff imaging		
Hα camera - 1D		
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 – E||B scanning		
NPA – solid state		
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		
Ultrasoft X-rays – TG spectr.		
Visible bremsstrahlung det.		
X-ray crystal spectrom. - H		
X-ray crystal spectrom. - V		
X-ray fast pinhole camera		
X-ray spectrometer - XEUS		