Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Robustness of improved error field suppression in long-pulse discharges

OP-XP-823	Revision: **0**	Effective Date: **March 26, 2008** *(Approval date unless otherwise stipulated)* Expiration Date: **March 26, 2010** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: J. Menard Jonathan E. Menard	Date March 26, 2008
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: **Robustness of improved error field suppression in long-pulse discharges** No. **OP-XP-823**

AUTHORS: **J. Menard, D. Gates, S. Gerhardt, S. Sabbagh** DATE: **03/26/2008**

1. Overview of planned experiment

The combination of active suppression of n=1 RFA and n=3 pre-programmed error field correction (EFC) improved 900kA discharges in 2007. In particular, the plasma rotation was broadened and sustained which improved confinement and resulted in record pulse-length at I_P=900kA. This experiment will attempt to extend this improvement to a wider range of plasma current values for use by all experiments. This experiment will empirically determine if the n=3 error field present on NSTX is proportional to the plasma current and therefore can be attributed to a PF coil error field. This experiment will also attempt to optimize the n=1 feedback gain and low-pass filtering to improve EFC robustness.

2. Theoretical/ empirical justification

Improved EFC has been demonstrated to increase rotation, beta, and confinement, all of which are important for improved operation of NSTX and future ST devices such as NHTX and ST-CTF.

3. Experimental run plan **DAY 1**

A. **Determine optimal n=3 EFC gain relative to I_{PF5} and/or I_P**

1. Re-verify existence of n=3 EF in I_P=900kA reference discharge – recent shot = 127252
    i. Reload SPA currents from shot 125329 for n=3: $I_{SPA1,2,3}$ = +270A, +270A, -270A
    ii. Test I_{SPA-1} / I_P = 0.3, 0, -0.3 kA/MA (0.3 is optimal from 2007 data) **(6 shots)**
2. Optimize n=3 EFC for two new plasma currents: 700kA and 1.2MA
    i. Start with $I_{n=3}$ / I_P = 0.3 kA/MA and scale by: 0, 1, -1, 2, 1.5, 0.5 **(12 shots)**

B. **Test combined n=3 EFC + n=1 RFA suppression for I_P=0.7, 0.9, 1.2MA (1.1MA as backup)**

1. Add n=1 feedback – 2 shots for each I_P – use 2007 optimal gain and phase **(6 shots)**

DAY 2

C. **Optimize n=1 RFA suppression controller**

1. Reproduce proportional gain scan (from 0 to 0.7) of reference shots 125320-3 which used n=1 RFA feedback to suppress an externally applied n=1 error field **(3 shots)**
2. Scan RWM control proportional gain until feedback system is unstable **(4 shots)**
    i. Add LPF to reduce coil currents as necessary to avoid very large SPA currents
3. With gain at highest stable value, increase τ_{LPF} from 0 to:
    i. 1ms, 3ms, 10ms, 30ms, 100ms (2 shots for each τ_{LPF}) **(10 shots)**
4. For τ_{LPF} where AC RMS control power is reduced by factor 2-4, increase gain again and determine highest stable value, then reduce by 15% to operate below marginal **(5 shots)**
5. Test n=1 controller at 700kA and 1.2 (or 1.1)MA including optimal n=3 EFC **(4 shots)**

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

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

Also need modified RWM/EF control algorithm with low-pass filter capability implemented.

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): **53kA** Flattop start/stop (s): **0.2s**

I_P (MA): **0.7, 0.9, 1.2MA** Flattop start/stop (s): **1.5s**

Configuration: **DN / LSN**

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

Elongation κ: **2.2-2.6** Upper/lower triangularity δ: **0.75 / 0.5**

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

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

NBI Species: **D** Sources: **A, B, C** Voltage (kV): **90, 90, 80kV** Duration (s): **1.5s**

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

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

LITER: Off (reserve the right to use LITER in later experiments)

Either: List previous shot numbers for setup: 127252 (n=3 info from 125329)

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

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Note special diagnostic requirements in Sec. 4

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