Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Data for simulation of NSTX control system

OP-XP-423	**Revision:**	Effective Date: *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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ATI – ET Group Leader:	Date
RLM - Run Coordinator:	Date

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: **Data for simulation of NSTX control system** No. **OP-XP-423**

AUTHORS: **D. Humphreys, D. Gates, D. Mueller**

1. Overview of experiment:

This experiment will develop techniques to measure the growth rate of vertical instabilities and measure the response of coil currents to commanded voltages at coil currents in the ranges normally used during plasma operations.

2. Justification:

Measurements of the control system response and the growth rate of plasma vertical instabilities are needed in order to simulate the system and help determine gains to be used for plasma position and shape control and in particular for vertical position control.

3. Plan:

3.1. Single Coil Shots:

3.1.1. A series of single coil current shots will be taken using an offset sine wave current waveform with frequencies from 4 to 500 Hz. The sine waveform offsets are chosen to be typical values during plasma current flattop in NSTX discharges for each coil. The amplitudes are chosen to be achievable with the power supply voltages normally available (and so decrease at frequencies above 50 Hz). At least 2 cycles will be done at each frequency (more at the highest frequencies) to fit in a 1 sec. Shot duration. These will be done in addition to the stepped waveforms that will be performed as part of the magnetics calibration. If necessary, some of those magnetics calibration shots will be repeated. (~18 shots)

3.2. Plasma Shots for Growth Rate Measurement:

A series of plasmas will be produced and the control system turned off by freezing the voltage commands for the rectifiers at the values averaged over the last 15 ms before freezing the values (disabling vertical control). OH will be left in Ip control. Apply voltage kick: PF3U/L antisymmetric step immediately to their freeze values. Conditions: 1-2 beams, LSN and DN, kappa=1.8-2.4 Will vary kappa by adjusting PF3 in the established discharges – may need to adjust other coils to maintain a diverted plasma. Study either L- and H-mode: whichever is proving more attainable/reliable that day. Avoid MHD in flattop

3.2.1. Ensure reproducible impurities/recycling: 10 min. He GDC between shots.

3.2.2. Produce fiducial DN discharge with 1 NB source and turn off vertical control as indicated above. (3 shots)

3.2.3. Use 2 NB sources to determine if that provides gamma variation. (2shots)

3.2.4. Vary kappa in steps of about 0.2 and repeat with 1 and 2 beams, if there was variation with beam power, if not use either one or two beam sources depending on reliability. (4-8 shots)

3.2.5. Repeat 3.2.2 to 3.2.4 with LSN plasma. (9-13 shots)

Total good shots 18-26, plus some development to get kappa variation (probably 10 more).

3.3 Shot list for single coil shots

	Coil	frequencies	Offset/ Amplitude+/-	Shot Number
3.3.1	PF3U	5, 10, 20 Hz	-7.9/7.9, 4.5, 2.6	_____
3.3.2	PF3U	50, 100, 200, 500 Hz	-7/1.15, 0.61, 0.31, 0.13	_____
3.3.3	PF3L	5, 10, 20 Hz	-7.9/7.9, 4.5, 2.6	_____
3.3.4	PF3L	50, 100, 200, 500 Hz	-7/1.15, 0.61, 0.31, 0.13	_____
3.3.5	PF5	5, 10, 20 Hz	-8/2.33, 1.34, 0.77	_____
3.3.6	PF5	50, 100, 200, 500 Hz	-8/0.33 ,0.17, .03	_____
3.3.7	PF2U	5, 10, 20 Hz	6/4.7, 2.7, 1.6	_____
3.3.8	PF2U	50, 100, 200, 500 Hz	6/0.71, 0.36, 0.18, 0.07	_____
3.3.9	PF2L	5, 10, 20 Hz	6/4.7, 2.7, 1.6	_____
3.3.10	PF2L	50, 100, 200, 500 Hz	6/0.71, 0.36, 0.18, 0.07	_____
3.3.11	PF1U	5, 10, 20 Hz	6/2.23, 1.13, 0.57	_____
3.3.12	PF1U	50, 100, 200, 500 Hz	6/0.23, 0.11, 0.06, 0.02	_____
3.3.13	PF1L	5, 10, 20 Hz	6/2.23, 1.13, 0.57	_____
3.3.14	PF1L	50, 100, 200, 500 Hz	6/0.23, 0.11, 0.06, 0.02	_____
3.3.15	OH	5, 10, 20 Hz	-10/8.7, 4.7, 2.4	_____
3.3.16	OH	50, 100, 200, 500 Hz	-15/1.0, 0.53, 0.28, 0.13	_____
3.3.17	PF1B	5, 10, 20 Hz	10/9.7, 6.1, 3.5	_____
3.3.18	PF1B	50, 100, 200, 500 Hz	10/1.5, 0.82, 0.42, 0.17	_____

3.4 Shot list for vertical growth rate measurements:

	κ	l_i	β	δ	Shape	#NBs	Template	Shot Numbers
3.4.1	1.8	.8	10	.75	DN	1	108472	_____
3.4.2	1.8	.8	15	.75	DN	2		_____
3.4.3	2.0	.8	10	.75	DN	1	(108989)	_____
3.4.4	2.0	.8	15	.75	DN	2		_____
3.4.5	2.2	.8	10	.75	DN	1		_____
3.4.6	2.2	.8	15	.75	DN	2		_____
3.4.7	2.4	.8	15	.75	DN	2		_____
3.4.8	2.0	.7	10	.4	LSN	1	109063	_____
3.4.9	2.0	.7	15	.4	LSN	2		_____
3.4.10	1.8	.7	10	.7	LSN	1	(108968)	_____
3.4.11	1.8	.7	15	.7	LSN	2		_____

3.4.12	2.2	.7	10	.7	LSN	1	_____
3.4.13	2.2	.7	15	.7	LSN	2	_____
3.4.14	2.4	.7	15	.7	LSN	2	_____

Note: For the $\kappa = 2.4$ cases, the highest controlable κwill be used.

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

4.1 Setup for normal plasma operation.

4.2 Ensure that all rectifier voltages and currents are calibrated and are being recorded and archived in the MDS tree.

4.3 For the single coil shots, the line switches for all unenergized coils will be open.

4.4 Must have written and tested algorithm for averaging and freezing voltages and applying kicks in PCS. Require complete freedom in freezing some, not freezing others and in the size of the applied kicks. In particular, must be able to leave OH in Ip control and vary and direction of voltage kick in PF3s.

5. Planned analysis

Data will be used in the simulations of the NSTX control system.

6. Planned publication of results.

Results will be published in appropriate journal after the NSTX simulations have been completed, probably in an IEEE sponsored meeting like the NPSS Real Time Conference in 2005.

PHYSICS OPERATIONS REQUEST

TITLE: **Data for simulation of NSTX control system** **OP-XP-423**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **54** Flattop start/stop (s): **-0.05 / 0.9**

I_P (MA): **0.8** Flattop start/stop (s): 0.165/0.5

Configuration:

Outer gap (m): 0.05 Inner gap (m): .04

Elongation κ: 1.8, Triangularity δ: 0.75

Z position (m): **0**

Gas Species: **D**, Injector: CS

NBI – **0 to 2 sources**

ICRF –

CHI: **Off.**

Shot number for setup: **108472 is a 900 kA DN reference shot to start with kappa = 1.75. 108989 is a high current shot with higher kappa (2.0) that will be used to determine the change in the PF3 request to raise kappa.**

PHYSICS OPERATIONS REQUEST

TITLE: **Data for simulation of NSTX control system** **OP-XP-423**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **54** Flattop start/stop (s): **-0.05 / 0.9**

I_P (MA): **0.8** Flattop start/stop (s): 0.2/0.7

Configuration:

Outer gap (m): 0.05 Inner gap (m): .04

Elongation κ: 1.8, Triangularity δ: 0.75

Z position (m): **0**

Gas Species: **D**, Injector: CS

NBI – **0 to 2 sources**

ICRF –

CHI: **Off.**

Shot number for setup: **109063 is a LSN shot at 800kA with kappa =2.0 delta =0.4 and Bt =5.0 that will serve as the template for this shot (all that needs to be changed is Bt) Also, 108968, one of the normal fiducial discharges with kappa =1.85 and delta = 0.7 can be used to determine the required change in PF3 U&L to vary kappa.**

DIAGNOSTIC CHECKLIST

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Diagnostic	Need	Desire	Instructions
Bolometer – tangential array		✔	
Bolometer array - divertor		✔	
CHERS		✔	
Divertor fast camera			
Dust detector			
EBW radiometers			
Edge deposition monitor			
Edge pressure gauges		✔	
Edge rotation spectroscopy		✔	
Fast lost ion probes - IFLIP			
Fast lost ion probes - SFLIP			
Filtered 1D cameras			
Filterscopes		✔	
FIReTIP		✔	
Gas puff imaging			
Infrared cameras			
Interferometer - 1 mm		✔	
Langmuir probe array			
Magnetics - Diamagnetism	✔		
Magnetics - Flux loops	✔		
Magnetics - Locked modes		✔	
Magnetics - Pickup coils	✔		
Magnetics - Rogowski coils	✔		
Magnetics - RWM sensors		✔	
Mirnov coils – high frequency		✔	
Mirnov coils – poloidal array	✔		
Mirnov coils – toroidal array	✔		
MSE			
Neutral particle analyzer			
Neutron measurements			
Plasma TV	✔		
Reciprocating probe			
Reflectometer – core		✔	
Reflectometer - SOL		✔	
RF antenna camera		✔	
RF antenna probe			
SPRED		✔	
Thomson scattering		✔	
Ultrasoft X-ray arrays		✔	
Visible bremsstrahlung det.		✔	
Visible spectrometers (VIPS)		✔	
X-ray crystal spectrometer - H			
X-ray crystal spectrometer - V			
X-ray PIXCS (GEM) camera			
X-ray pinhole camera			
X-ray TG spectrometer			