Princeton Plasma Physics Laboratory

NSTX Machine Proposal

Title: **Demonstration Plasma for CD4**

OP-XMP-100	Revision**: 0**	Effective Date: **May 1, 2015** Expiration Date: *(2 yrs. unless otherwise stipulated)*

Procedure Approvals

Responsible author: **D. Battaglia**	Date
ATI (NSTX Physics Ops): **D. Mueller** Dennis Mueller	Date 4/28/15
RLM (NSTX Expt. Research Ops): **S. Gerhardt** Stefan Gerhardt Digitally signed by Stefan Gerhardt DN: cn=Stefan Gerhardt, o=Physics, ou=PPPL, email=sgerhard@pppl.gov, c=US Date: 2015.07.29 10:04:21 -04'00'	Date

Responsible Division: **Experimental Research Operations**

Procedure Requirements

designated by RLM

	NSTX Work Permit		T-MOD (OP-AD-03)
	Independent Review		ES&H Review

RESTRICTIONS AND MINOR MODIFICATIONS

Approved by RLM

REVIEWERS (designated by RLM)		
Organization/Position	Name	Signature
ATI	D. Mueller	Dennis Mueller
Test Director		
Independent Reviewer		
NB system		
RF systems		
FCPC systems		
Diagnostics		

TRAINING (designated by RLM)

Training required: No ■ Yes ☐ Instructor _____

Personnel (group, job title or individual name)	Read Only	Instruction	Hands-On

RLM _____

NSTX MACHINE PROPOSAL

TITLE: **CD4 Plasma Operation**	No. **OP-XMP-**
AUTHORS: **D. Mueller, S. Gerhardt, D. Battaglia**	DATE: **10-11-2014**

1. Overview:

The purpose of this XMP is demonstrate plasma operation in NSTX-U with Ip > 50 kA and up to test EFIT analysis and other diagnostics as is easily achievable.

2. Justification:

Demonstration of plasma operation is one of the criteria for successful completion of CD4.

3. Plan:

1. Test gas prefill with a prefill pressure of 1e-5 Torr gauge pressure of D_2.
2. Run a shot with the required TF, PF and OH programming but no gas. For all the following shots program the Toroidal field to be 0.5 T from 0 to 0.1 s. Program the PF3 and PF5 currents to provide a good magnetic null with 8.1 kA of ohmic precharge to provide a loop voltage of about 4 V.
    a. Reload PF3 and PF5 requests from 142524 (last shot of NSTX)
    b. The TF waveform will be copied from a relevant ISTP shot, along with any early OH programming required.
    c. OH waveform:

Time (s)	- 0.400	- 0.210	- 0.080	-0.030	- 0.002	+ 0.001	+ 0.004
I_{OH} (kA)	0.0	5.0	7.8	8.1	8.1	7.9	7.7

Time (s)	+ 0.010	+ 0.020	+ 0.050
I_{OH} (kA)	7.4	7.0	6.0

    d. Check that TF, OH and PF achieve desired coil currents.
    e. Check plasma current Rogowskis and Ip calculator if it is available

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Shot number or range

3. Run a shot with the required PF and OH programming and a D_2 prefill of 5e-5 Torr gauge pressure.
   a. If there is no breakdown (plasma light, but low apparent I_p), raise the prefill by 50% and repeat as needed. Use difference in Rogowskis between this shot and the field only shot and/or the Ip calculator (if it is available) to determine the Ip achieved.

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      Shot number or range

   b. If there is breakdown reduce the gas prefill by 50% to determine the pressure range required for breakdown; repeat as needed.

      _____

      Shot number or range

   c. If breakdown is achieved, but Ip< 50 kA at the minimum pressure for breakdown then perform a He GDC or Boronization if it is available and try again.

      _____

      Shot number or range

4. If step 3 was not successful to produce Ip > 50 kA, use the following OH and PF3 programming to investigate if higher loop voltage at breakdown will help.
   a. With a 8.1 kA OH precharge, decrease the OH current request for all t > 0 indices and decrease the PF3 request for all t > -0.4s indices by the following:

Shift OH for t > 0 (kA)	Shift PF3 (kA)	V_{loop} (0-2ms)	OH min voltage
0	0	3.2	-1.5 kV
- 0.25	- 0.175	5.6	-3.75 kV
- 0.50	- 0.35	8.0	- 6 kV

b. If 8 loop volts is not enough, increase OH precharge to 21.5 kA and shift the PF3 waveform such that the precharge is 4.825 kA. At this precharge, the maximum allowable shift of the OH currents for t > 0 is -0.625 kA, corresponding to a loop voltage of about 9V.

5. If time permits, test the relationship between OH and PF3 precharge:

   PF3 precharge = 0.501 kA + (shift from step 4) + 0.221 * OH precharge (kA).

   Examples are shown below for the reference V_{loop} = 3.2V (0 kA shift) case:

OH precharge (kA)	0	4	8	12	16	20	24
PF3 precharge (kA)	0.501	1.39	2.27	3.16	4.04	4.93	5.82

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Shot number or range

6. If time permits and Ip > 150 kA in open loop control, use the shape algorithm in the PCS to control the plasma R and z and use the Ip feedback algorithm to control Ip up to 300 kA for 0.5 s.

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Shot number or range

4. Required machine, beam, ICRF and diagnostic capabilities:

The poloidal and toroidal field systems must have been tested to the requirements in CD4.

The Ip signal must be calibrated.

The plasma TV must be working and synched with the timing clock.

The initial calibration of the magnetics signals must be completed.

Since this will be before an extended bakeout of the vacuum vessel, it may be required to perform a Boronization, but the initial attempts will like precede any Boronization.

5. Sign off at run time:

5.1 Permission to Proceed: _____

Physics Operations Head

5.2 Documentation of results:

Documentation of the results completed, attached to proposal and sent to Ops. Center with copies to Cognizant Physicist and Head of Physics Operations.

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Cognizant Physicist/Test Director

PHYSICS OPERATIONS REQUEST

TITLE: No. **OP-XMP-**
AUTHORS: DATE:

(use additional sheets and attach waveform diagrams if necessary)

Brief description of the most important operational plasma conditions required:

This is for the demonstration 50 kA plasma. The only requirement is achieving Ip > 50 kA.

Previous shot(s) which can be repeated:

Previous shot(s) which can be modified:

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

I_{TF} (kA): **65 kA** Flattop start/stop (s): **0 tp 0.1s**

I_P (MA): **-** Flattop start/stop (s): **N/A**

Configuration: **Limiter / DN / LSN / USN**

rtEFIT controls: **Isoflux / Strike-point / X-point**

Outer gap (m): Inner gap (m): Z position (m):

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

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

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

ICRF Power (MW): Inter-strap phase (°): Duration (s):

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

LITERs: Off / On Total deposition rate (mg/min):

LLD: Temperature (°C):

EFC/RWM coils: Off / Preprogrammed / Feedback

Configuration: **Odd / Even / Other** *(attach detailed sheet)*

DIAGNOSTIC CHECKLIST

TITLE: No. **OP-XMP-**

AUTHORS: DATE:

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		