Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Strike Point Dynamics		
OP-XP-904	Revision:	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: Egemen Kolemen	Date
ATI – ET Group Leader: David Gates	Date
RLM - Run Coordinator: Roger Raman	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

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AUTHORS: Egemen Kolemen | DATE: 2/20/09

1. Overview of planned experiment

A liquid lithium divertor (LLD) is installed on NSTX to enable experiments with the first complete liquid metal divertor target in a high-power device. Because the lithium will continue reacting with hydrogen or deuterium until it is volumetrically converted to hydrides, the LLD is expected to provide better pumping than lithium coatings on carbon PFC's.

The shape of the plasma dictates the pumping rate of the lithium with LLD by channeling the plasma to LLD. Among the shape parameters strike point is the most important one. Simulations show that the density reduction depends on proximity of outer strike point to LLD.

The aim of this experiment is to study the dynamics of the strike point, design a new controller to change the location of the strike point to desired location and design a controller to stabilize the strike point at the desired position.

2. Theoretical/ empirical justification

Strike point is the most important parameter that dictates the pumping rate of the lithium with LLD. Simulations show that the density reduction depends on proximity of outer strike point to LLD. This experiment is designed to control the strike point location via new controller designs and study its dynamics.

3. Experimental run plan

1. Start with 120001 (or newer shot) and get to plasma shape of that in shot 115495 at 500 msec (approximately: lower triangularity:0.55, upper triangularity:0.35, average tirangularity: 0.45, elongation: 2.3, drSep:-0.08)
2. Stabilize the plasma for the 1st shape
3. From previously defined strike point versus PF2L coil current curves, set the PF2L coil current in a step impulsive way to get the strike point between 0 and 24 cm. The coil current depends on li and ranges between 0.00 and 0.02 (Current/Ip). This will take 8-10 shots. We will set the strike point distance starting with 0 then 24 cm then interpolate as much points as possible in the experiment day. Here the strike point distance is measured from the lower corner of LLD.

Table 1: Desired Variation in Strike Point Location

Shot #	Start Position (cm)	End Position (cm)
1	0.01	0.10
2	0.01	0.05
3	0.05	0.10
4	0.025	0.075
5	0.01	0.02
6	0.02	0.04
7	0.10	0.01
8	0.10	0.05
9	0.05	0.01
10	0.75	0.25

Table 2: Estimated Variation in PF2L current from Step 1 to Step 2

Shot #	Start IPF2L/IP	End IPF2L/IP
1	4	13
2	4	5
3	5	8
4	4	6
5	6	13
6	13	4
7	5	4
8	8	5
9	4	45
10	6	4

Goal is to set the strike point location and this is done by setting the PF2L coil current.

4. Measure the response of the strike point.
5. Obtain the time constant, rise time, delay and other parameters of the strike point motion response to the impulsive change in PF2L current.

6. Repeat for the same procedure with PF1B coil current change (as opposed to PF2L). The range of PF1B coil current will be 0.00 to 0.01 (Current/Ip) with corresponding strike point distance of (0-4) cm to (10-13) cm. This will take 8-10 shots, in the same fashion as PF2L coil current steps.
7. Test and tune the strike point controller.
8. Study the compromise with respect to the loss in control for shape control and other control aims.

Physical operating conditions for the experiment will be similar to the previously tested 120001 shot.

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

See below.

5. Planned analysis

We will require EFIT analysis and preferably correlations between magnetic strike point location and power deposition on the diverter. The time constants for the step responses will be analyzed. Based on control theory, a PID controller for the strike point position with lower PF1/2 inputs will be obtained.

6. Planned publication of results

The results will be published in “Fusion Engineering and Design” and presented at the 7th Technical Meeting on "Control, Data Acquisition and Remote Participation for Fusion Research” at Cadarache, France.

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:

D_2, LSN, low triangularity, H-mode discharge, with 2 NBI sources.

Previous shot(s) which can be repeated:

Previous shot(s) which can be modified: 132045 or newer shot

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

I_{TF} (kA): 48 Flattop start/stop (s):

I_P (MA): 0.8 → 1.0 Flattop start/stop (s):

Configuration: **LSN**

Equilibrium Control: **Isoflux** (rtEFIT)

Outer gap (m): **0.09** Inner gap (m): **0.03** Z position (m):

Elongation κ: **1.8-2.1** Upper/lower triangularity δ: **0.35/0.55**

Gas Species: **D** Injector(s): Source A

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

ICRF Power (MW): None Phase between straps (°): Duration (s):

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

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

EFC coils: Off Configuration: **Odd / Even / Other** *(attach detailed sheet*

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array		
Bolometer – divertor		
CHERS – toroidal		
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		
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP		
Filterscopes		
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		
Magnetics – Flux loops	√	
Magnetics – Locked modes		
Magnetics – Pickup coils	√	
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 measurements		
Plasma TV		
Reciprocating probe		
Reflectometer – 65GHz		
Reflectometer – correlation		
Reflectometer – FM/CW		
Reflectometer – fixed f		
Reflectometer – SOL		
RF edge probes		
Spectrometer – SPRED		
Spectrometer – VIPS		
SWIFT – 2D flow		
Thomson scattering	√	
Ultrasoft X-ray 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 fast pinhole camera		
X-ray spectrometer - XEUS		