Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Halo Current study with extended diagnostics and the LLD		
OP-XP-1021	Revision: **1**	Effective Date: **15 April 2010** Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: Adam McLean	Date
MS Group Leader: Steve Sabbagh	Date
RLM - Run Coordinator: Mike 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: Halo Current study with extended diagnostics and the LLD — No. **OP-XP-1021**

AUTHORS: Adam McLean, Stefan Gerhardt, Michael Jaworski — DATE: **04/15/2010**

1. Overview of planned experiment

Halo currents are electrical currents which flow partially in the plasma, and partially in plasma facing components. They generally occur when control of the plasma vertical position is lost, either before or during a disruption (a scenario known as a vertical displacement event, or VDE). The goal of this experiment is to continue to continue from XP833 (S. Gerhardt) in assessing the scaling of Halo currents with certain important plasma parameters with focus on their effect of the LLD (and vice-versa) when it is both hot (320°C) and cold (RT), making full use of newly available high-speed diagnostics in 2010. Results from many tokamaks (Alcator C-mod, MAST, COMPASS-D, and JET) have seen an I_p/q_{95} scaling of the halo current magnitude, which this experiment will attempt to continue to study with devoted scans of I_p and B_t. In a separate scan, the dependence of the halo current magnitude on the VDE velocity will be studied. Finally, the dependence of halo current magnitude neutral beam heating will be studied. These experiments will be conducted in a low-triangularity shape, developed to steer the Halo currents into a well-diagnosed path, linking the outboard divertor and the secondary passive plates.

2. Theoretical/ empirical justification

Halo current are known to provide a serious constraint on mechanical and electrical design of tokamak in-vessel components. For instance, they are thought to be the dominant source of electromagnetic loading during slow VDE current quenches in ITER. From the perspective of NSTX, an improved understanding of halo currents will provide important information about operation of the liquid lithium divertor (LLD), as well as future larger STs.

The advent of fast diagnostics observing the plasma and surface reaction to plasma contact in the lower divertor, including the high speed Phantom cameras, the two-color infrared camera, high density Langmuir probe array, plus improved spectroscopy, and their ability to elucidate the effect the LLD has on the plasma in disruptions, and vice versa, make revisiting this XP a worthy experiment.

This experiment is separated into two equal portions, the first of which is accomplished with a cold LLD surface, and the second in which the same shot plan is repeated with a hot LLD surface (the latter being done at a latter date).

3. Experimental run plan

Step 1: Restore Target Shot: 132855 (2009, without freeze), with reduced Ip = 600 kA D_2 shot, B=0.45 Tesla. Reached flat-top at ~0.1 sec. Stored energy of ~30kJ.
Take Shot Without Freeze: ______
Restore Target Shot: 132856 (with Freeze @250msec, lasting 100msec, and downward bias on PF3 of 30 V and 20msec duration at the start of the freeze:______

Repeat shot four times for diagnostic coverage (Phantom filtered cameras, fast IR T_{int} setting). If light is insufficient for IR and camera diagnostics, it may be necessary to add 1 MW of NBI in all subsequent shots. It is hoped that operation of the one available LITER on 4/16/2010 is sufficient. If not, a contingency for He glow is provided.

Step 2: Complete a scan of Halo Currents vs I_P/q_{95}, in the high triangularity reference shape.

Step #	Shot Number	I_P	B_T	I_p^2/B_T
2.1		450	.45	.55
2.2		500	.45	0.8
2.3		600	.45	0.94
2.4		650	.45	1.08
2.5		650	.4	1.225
2.6		650	.35	1.4
2.7		500	.55	0.45
2.8		500	.5	0.5

Step 3: Complete a scan of the plasma vertical velocity.

Pick a shot from steps 2-4 that had reliably large and easily measurable halo currents, most likely the 650 kA case at .45 T. Adjust the plasma vertical velocity by changing the magnitude of the offset voltage. Fill in the following matrices.

Step #	# of Shots	Shot Number(s)	I_P	B_T	Voltage Offset
3.6	1				10 V
3.7	1				20 V
3.8	1				30 V
3.9	1				40 V
3.10	1				50 V

Step 4: Attempt to run HCs in shots with NBI.

Pick a shot from steps 2-3 that had reliably large and easily measurable halo currents, most likely the 700. Inject increasing amounts of NBI into the flattop portion of the shot to test observation in many devices that NB shots have lower HCs than ohmic shots.

Step #	Shot Number	I_P	B_T	NBI
4.1		650	.45	1 MW
4.2		650	.45	2 MW
4.3		650	.45	3 MW

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

RF, and CHI are not required for the completion of this XP.

Between shot equilibrium reconstructions with 1msec time resolution are highly desirable.

A fast camera with ~1msec time resolution in fish-eye view is highly desirable

5. Planned analysis

These specialized scans will be used in conjunction with database analysis of the CY08-CY10 campaign results to determine the scaling of halo currents with various plasma parameters. High time-resolution equilibrium analysis with the EFIT (01) and LRDFIT (01) codes will be utilized.

6. Planned publication of results

It is expected that the Halo current data from this year, including the devoted scans in this XP, will be published in a Nuclear Fusion paper at the conclusion of the run campaign. The data will also be contributed to the ITPA disruption database activity.

PHYSICS OPERATIONS REQUEST

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Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **.3-.55 Tesla** Flattop start/stop (s): **0/0.5**

I_P (MA): **500-700 kA** Flattop start/stop (s): **.1/.4**

Configuration: **LSN**

Outer gap (m): **target 132855** Inner gap (m): **target 132855**

Elongation κ: **target 132855** Upper/lower triangularity δ: **target 132855**

Z position (m): **0, or slightly biased down**

Gas Species: **D_2** Injector(s): See section 4

NBI Species: **D** Sources: None Voltage (kV): Duration (s):

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

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

LITER: On, maximum flow from operating injector

Either: List previous shot numbers for setup: **132855**

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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Diagnostic	**Need**	**Want**	**Conditions**
Bolometer – tangential array		**X**	
Bolometer – divertor	**X**		
CHERS – toroidal			
CHERS – poloidal			
Divertor fast camera	**X**		
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	**X**		
FIReTIP			
Gas puff imaging			
Hα camera - 1D			
High-k scattering			
Infrared cameras	**X**		
Interferometer - 1 mm			
Langmuir probes - divertor	**X**		
Langmuir probes – RF ant.			
Magnetics – Diamagnetism	**X**		
Magnetics - Flux loops	**X**		
Magnetics - Locked modes	**X**		
Magnetics - Pickup coils	**X**		
Magnetics - Rogowski coils	**X**		
Magnetics - RWM sensors	**X**		

Diagnostic	**Need**	**Want**	**Conditions**
Mirnov coils – high f.	**X**		
Mirnov coils – poloidal array	**X**		
Mirnov coils – toroidal array	**X**		
MSE			
NPA – ExB scanning			
NPA – solid state			
Neutron measurements			
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**	
X-ray crystal spectrom’r - H			
X-ray crystal spectrom’r - V			
X-ray fast pinhole camera			
X-ray spectrometer - XEUS			