Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: **CHI use of absorber coils**

OP-XP-927	Revision: **0**	Effective Date: **7/28/09** *(Approval date unless otherwise stipulated)* Expiration Date: **7/28/11** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: Mueller	Date 7/28/09
ATI – ET Group Leader: Mueller/Raman	Date 7/28/09
RLM - Run Coordinator: Raman	Date 7/28/09
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: **CHI use of absorber coils** No. **OP-XP-927**

AUTHORS: **Mueller** DATE: **3/24/2009**

1. Overview of planned experiment

CHI experiments have suffered from absorber arcs at the top of NSTX. These arcs, while they do not result incomplete elimination of the desired injector current, do discharge the capacitor and rob voltage and current the injector, furthermore, the absorber arcs are a likely source of the low Z impurities seen in CHI initiated discharges. See Fig. 1. The SPAs will be used to power the two absorber coils in order to lower the poloidal field connecting the inner and outer vessel, thus raising the impedance to reduce the incidence of absorber arcs and/or reduce the current in such arcs.

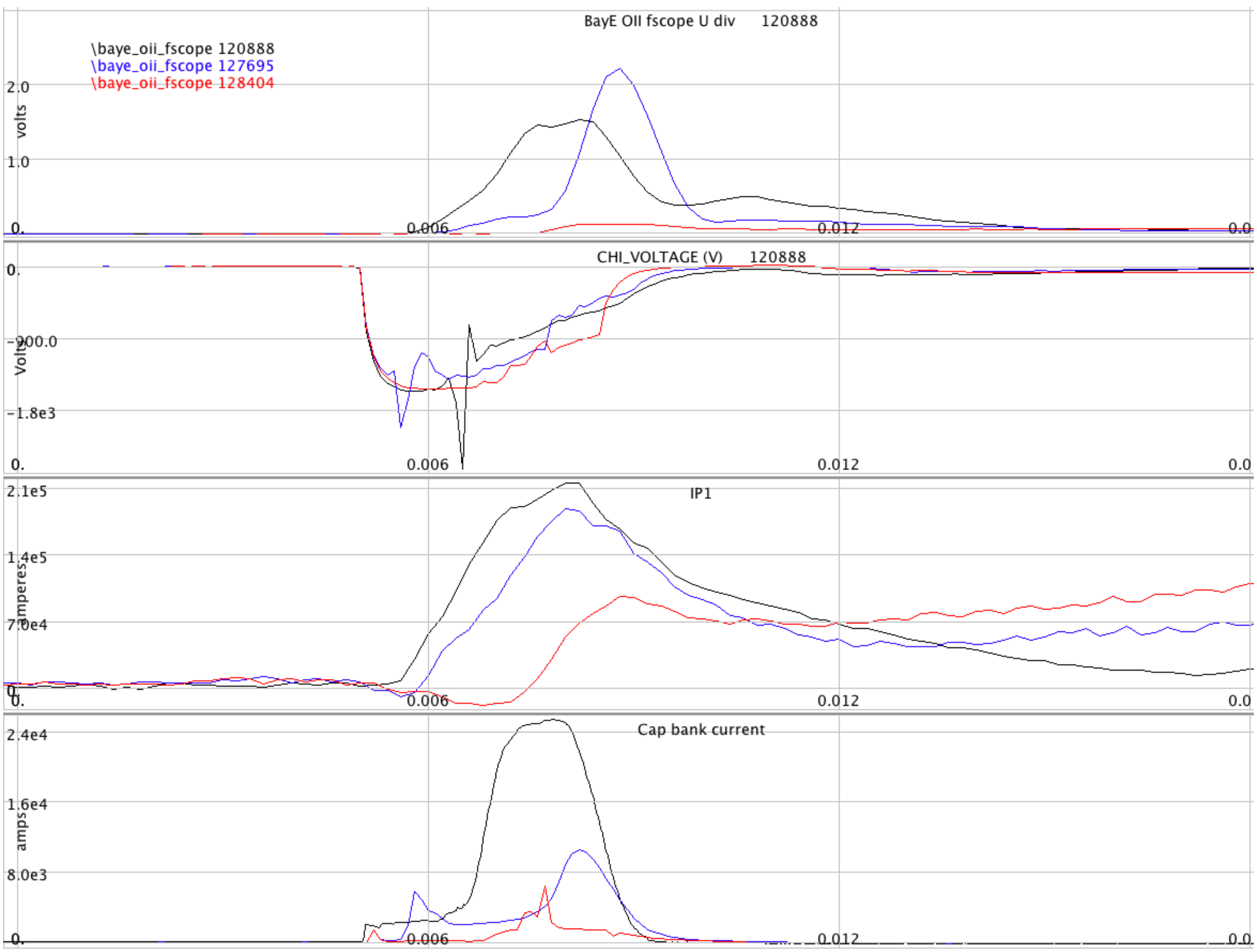

Fig. 1 Capacitor bank current for a variety of CHI discharges.

2. Theoretical/ empirical justification

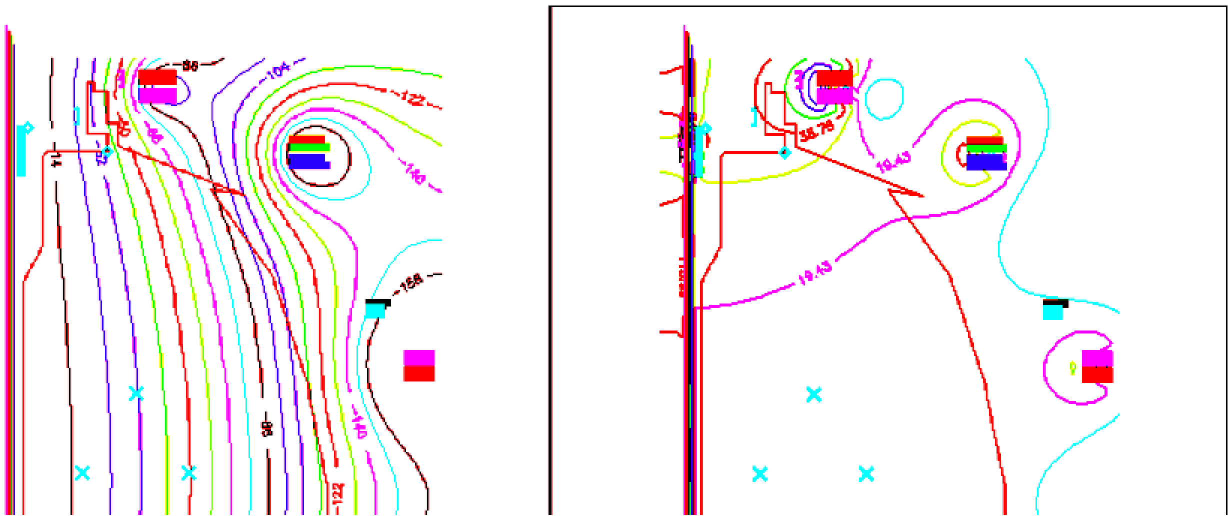

Fig. 2. Flux and ModB at 7.5 ms in 128401, a CHI initiated discharge.

The calculated modB and flux for CHI start-up is shown in Fig. 2. Fig. 3 shows the results with -600 and 600A in absorber coils PFAB1 and PFAB2. It is clear that the poloidal field in the absorber region shown in Fig. 3 is lower than for the case without the absorber coils energized. Because the geometry of the coils and of the absorber insulator is complex, it is not possible to completely eliminate poloidal fields connecting the two electrodes. Broadly speaking the location of the minimum in modB moves out with more negative PFAB1 and down with more positive PFAB2. Fig. 4 shows the results for FPAB1 = -800 A and PFAB2 = 600 A. Since the inner and outer vessel surfaces locations of closest approach is the region below the large vertical insulator, it is there that the field should be minimized. (-800, 600) is a good starting point.

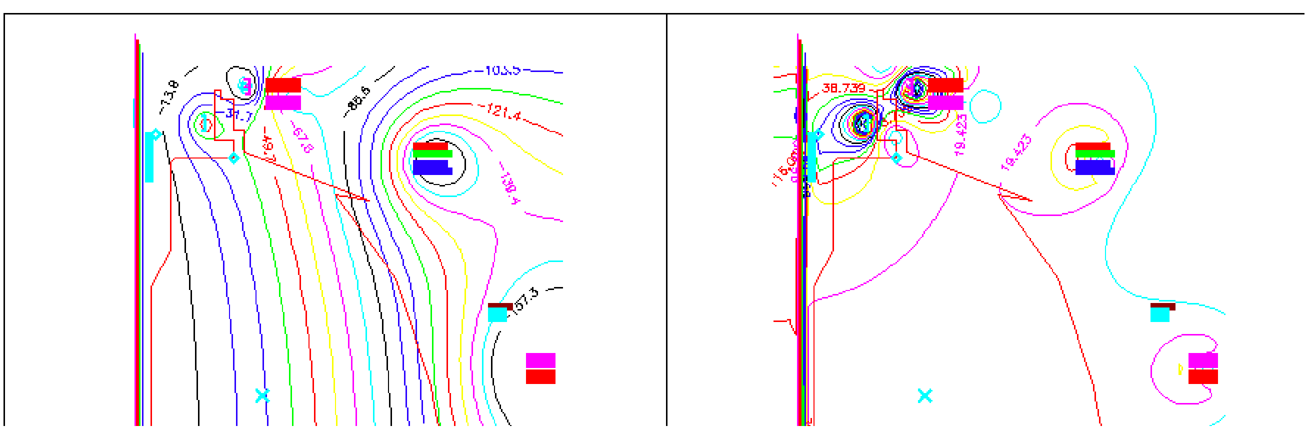

Fig. 3. Flux and ModB for 128401 with -600 A in PFAB1 and 600 A in PFAB2.

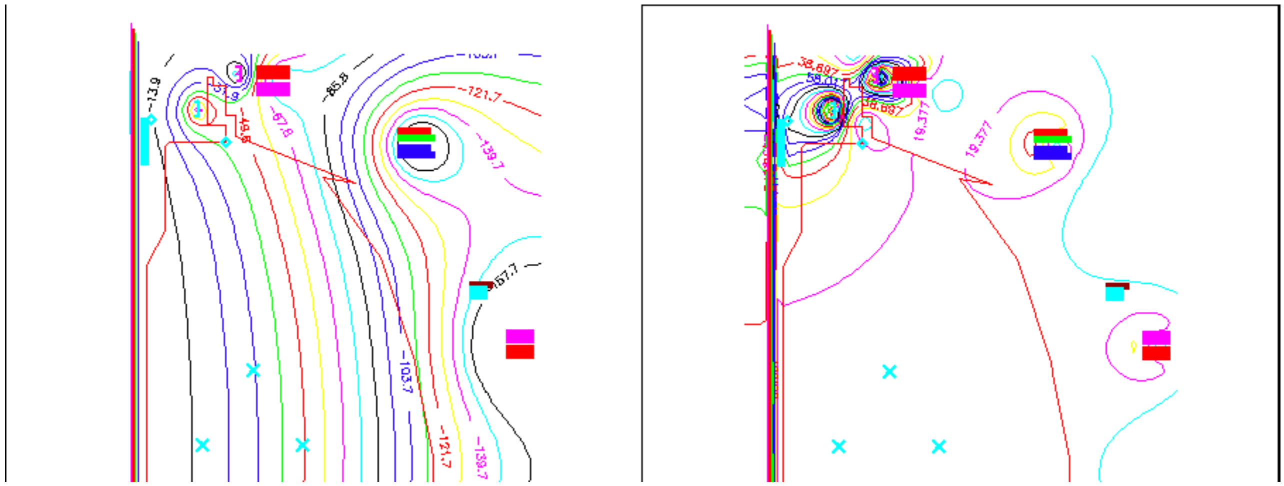

Fig. 4. Flux and ModB for 128401 with -800 A in PFAB1 and 600 A in PFAB2.

The above assumes that it is Mod B that must be minimized to avoid absorber arcs. However, the above increases the slope of the field so it connects the inner and outer vessel radially, just as the presence of Ip would. The data indicate that absorber arcs occur when the slope of the field in the absorber region changes as Ip increases to connect the inner and outer vessel radially. If the best choice is to maintain a vertical field in the absorber, then a different approach is needed and the PFAB 1&2 coils should both have positive current.

For the CHI shot, 133704, this field is vertical with 0 in both coils and becomes more sloped until it barely connects the inner and outer vessels at Ip=180 kA (where absorber arcs are observed) and clearly connects inner and outer at 300 kA (a region we have not been able to reach due to absorber arcs). It is unclear what would happen if the field has slope in the other direction, if we take that as the maximum absorber field then the best starting point is PFAB1=300A and PFAB2=400A. That has a field that is vertical at Ip=0 and barely OK at Ip=300kA (similar to 170kA without the absorber coils) and the ModB is essentially unchanged. At higher PFAB currents, the field slope becomes negative at Ip=0, with unknown effects and can keep the field from connecting the vessels radially until higher Ip.

By the time Ip reaches about 400 kA, an X-point appears in the vessel (lower Ip with higher PFAB curents), with an X=point, the field in the absorber region depends strongly on Ip, The X-point moves out radially and modestly upward as Ip increases. The absorber coils do provide some control of the X-point location but the Ip ramp rate is high and conducting structures around the absorber coils limit the rate at which they can change the field. For the later reasons, we will begin with static absorber coils, ramping them down to zero after the CHI voltage is removed. The Table below gives the static response (no eddy currents considered) to various Ip and absorber coil currents.

Ip (kA)	PFAB1 (A)	PFAB2 (A)	ModB (G)	"Vertical property"
0	0	0	47	OK
177	0	0	37	B-ok
306	0	0	30	Bad
0	300	400	47	V
177	300	400	37	V
306	300	400	30	V
450	300	400	17	OK
0	400	600	47	B-N
177	400	600	37	V
306	400	600	31	N to X-Point
450	400	600	17	X-Point
0	600	800	53	N
177	600	800	41	N
306	600	800	36	X-Point
450	600	800	20	X-Point
0	400	400	50	B-N
177	400	400	39	OK
306	400	400	31	OK
450	400	400	20	OK

Here V is vertical in the absorber gap, OK is nearly vertical, Bad connects across the gap, N connects across the gap in the opposite sense, X-point has curved field in the gap with no simple description.

3. Experimental run plan

Start with the CHI setup for shot 128401 or 133704 (or a more recent CHI discharge).

Examine the shot for signs of an absorber arc (sudden increase in CHI current, drop in CHI voltage, and low Z impurity influx from upper divertor).

Stabilize the discharge at a constant Li evporation rate.

Perform a shot-to shot scan in PFAB1 and PFAB2, select best estimate of PFAB1 and PFAB2 and make small variations about that.

SHOT	Reason	PFAB1	PFAB2	I CHI	UD Oii
	Baseline	0	0		
	"best" Estimate	300	400		
	To see if N is OK	400	400		
	Test of higher currents	400	600		
	Higher currents	600	800		
	Test if Mod B is important	-600	600		

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

The Absorber coils must be connected to the SPAs and the ISTP for their use must be completed.

The usual conditions for CHI operation must be satisfied (Capacitor banks configured, $V_{OH} < 6$ kV, PF2U/L reversed, etc.).

5. Planned analysis

EFIT analysis

6. Planned publication of results

SOFE conference in June 2009 and other reports of CHI results on NSTX.

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:

CHI configuration with absorber coils connected to SPAs.

Previous shot(s) which can be repeated: 128401

Previous shot(s) which can be modified:

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

I_{TF} (kA): -58.5 Flattop start/stop (s): -0.020/0.5

I_P (MA): Flattop start/stop (s):

Configuration: **LSN**

Equilibrium Control: **Outer gap / Isoflux** (rtEFIT)

Outer gap (m): **.01** Inner gap (m): **.01** Z position (m): **0**

Elongation κ: 2 Upper/lower triangularity δ: .4

Gas Species: **D** Injector(s): Lower Dome, inj 2

NBI Species: **D** Voltage (kV) **A: 90** **B: 90** **C:** 90 Duration (s): .5

ICRF Power (MW): 2 Phase between straps (°): Duration (s): .5

CHI: **On** Bank capacitance (mF): **5, 10, 15**

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

EFC coils: Off Configuration: **Other** *SPAs connected to PFAB1 and PFAB2*

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		