Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Effect of high temperature bake on fiducial discharges

OP-XP- 205	**Revision:**	Effective Date: 2/6/02 *(Ref. OP-AD-97)* Expiration Date: 2/6/04 *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Author: C. H. Skinner	Date 2/6/02
ATI - Task Force Leader: H. Kugel	Date
RLM - Run Coordinator: R. Maingi	Date

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

In response to CHITS:

0.3 T fiducials added

Target electron density added to shot list.

Effect of high temperature bake on fiducial discharges

1. Overview of planned experiment

NSTX has recently upgraded its bakeout system to heat the center stack, passive plates and divertor to higher temperatures. The bakeout is expected to facilitate density control and to reduce oxides and volatiles in plasma facing surfaces potentially leading to easier startup, lower radiation losses and easier access to H-mode. Experience at DIII-D and other machines indicated that 350 C bake gave significant benefits over 300 C. In the present bake the temperature achieved was 330 C. The overall goal of the XP is to characterize the impurity emission and fueling characteristics of ohmic deuterium fiducial discharges in comparison to similar discharges in the Fall ’01 campaign.

	Previous bakeout system:	Helium bakeout system upgrade
Centerstack	Heated ohmically (20kW, 5.8 kA) to 309 °C	330 C ohmic heating 3 days
Passive plates, divertor	Heated with hot water / steam to 150 C, radiation from CS heats plasma facing surfaces to 220°C.	330 C with He 3 days
External vessel wall	≈ 150 C with hot water / steam	150 C (actively cooled to 150 C during bake)

2. Theoretical/ empirical justification

Wall conditions are known to be a powerful influence on plasma performance. NSTX has invested a significant effort in implementing high temperature baking. The first phase of the present XP is designed to systematically investigate the effect of the bakeout on deuterium ohmic plasmas.

The second phase of the XP will separately characterize the effect of boronization. There was a small air leak in the cool down phase of the bakeout. To help remove any introduced oxygen D-GDC and He-GDC has been implemented. Overnight boronization will be applied in the midpoint of this XP and the additional effect of the boronization characterized.

Previously there were some operational constraints in repeating 1MA IWL, and 800 kA LSN discharges due to wall D loading. Typically these only went through if the first shot in the day.

No Ar or Ne impurity injection will be used to avoid lowering the edge temperature.

Typical results from previous boronizations are shown below:

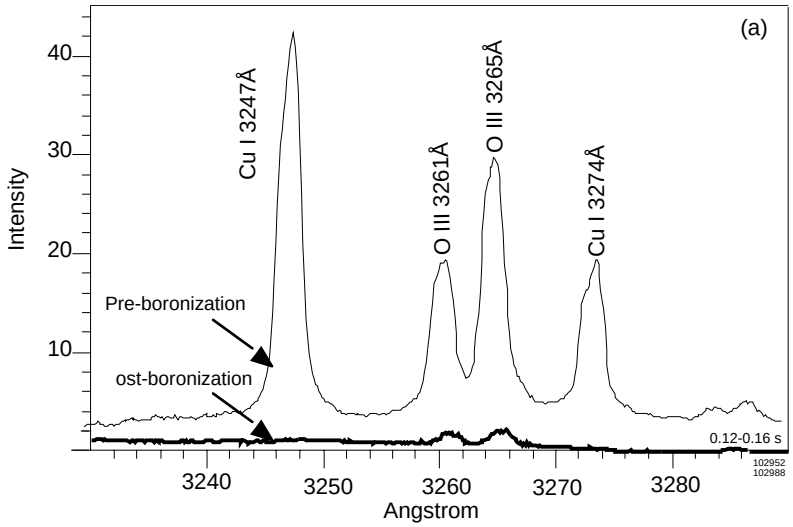


Figure 1 Comparison of impurity emission before and after boronization (from C. H. Skinner et al., Nucl. Fus. in press).

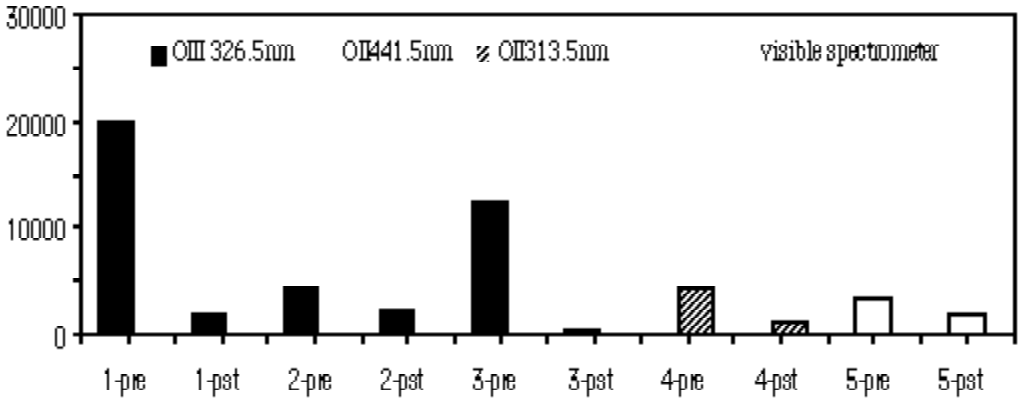


Figure 2. Changes in oxygen impurity luminosity before and after five boronizations in FY'00 (H K. Na 'Boronization results in NSTX').

Caveats: We note that realignment of PF5 in the past outage may also change MHD and plasma behaviour. Also GRITS and VIPS2 has moved location. The single chord VB has been moved slightly and the analysis program needs to be updated.

The penetration of ions and neutrals into pasma facing components increases with edge temperature so the bakeout may have a larger effect in NBI and RF plasmas. This will be the subject of future investigation.

3. Experimental run plan

Dave Gates will precede with his XMP on machine control with realigned PF5 etc....

Conditions: D fueling outer gas feed, GDC in-between shots as usual, no Ar prefill (would cool edge and reduce interaction with limiter).
Shot sequence will be repeated at different VIPS settings, followed by more agressive higher current attempt (e.g. 105082).

Two phases:
1st phase post-bake fiducials
overnight boronization
2nd phase post-boronization repeat of fiducials
Scan VIPS at each fiducial.

Scale TF current from 53 kA = 0.4489 T (Mike B.) with BT0 from LOCUS/EFIT database,
No LOCUS EFIT entry for 106068, use plot of BCENTR.

SHOT LIST: POST-BAKE, PRE-BORONIZATION

		Ip	TF	BT0	Ne cm-3	shot	VIPS2	GRITS	
1	IWL	800 kA	46.5kA	0.3942 T	3e+15	105584	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
2	LSN	800 kA	53 kA	0.45 T	3e+15	106068	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
3	IWL	800 kA	34 kA	0.2876 T	3e+15	105646	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
4	LSN	800 kA	34 kA	0.2876 T	4e+15	105692	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
5	IWL	1 MA	46.5 kA	0.3945 T	4e+15	105082	326 nm	10-50 Å	
“	“	“	“	“	:”	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
6	LSN	1 MA	52.3 kA	0.443 T	3.5e+15	105904	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	

POST-BORONIZATION same fiducials as before

		Ip	TF	BT0	Ne cm-3	shot	VIPS2	GRITS	
1	IWL	800 kA	47 kA	0.3942 T	3e+15	105584	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
2	LSN	800 kA	53 kA	0.45 T	3e+15	106068	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
3	IWL	800 kA	34 kA	0.2876 T	3e+15	105646	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
4	LSN	800 kA	34 kA	0.2876 T	4e+15	105692	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
5	IWL	1 MA	47 kA	0.3945 T	4e+15	105082	326 nm	10-50 Å	
“	“	“	“	“	:”	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	
6	LSN	1 MA	53 kA	0.443 T	3.5e+15	105904	326 nm	10-50 Å	
“	“	“	“	“	“	“	438 nm	150-200 Å	
“	“	“	“	“	“	“	449 nm	230-280 Å	

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

Ohmic plasmas are required.

<u>Required diagnostic capabilities</u>

mpts

VIPS, GRITS, VB, Tangential Bolometer, Soft X-ray (absolute impurity densities)

• D_α measurements

5. Planned analysis

Comparison of similar discharges in (i) previous run, (ii) postbake preboronization and (iii) post bake, post boronization. Compare impurity intensities.

6. Planned publication of results

The results of the investigation will be presented at upcoming PSI conference May 27-31st, Gifu Japan.

PHYSICS OPERATIONS REQUEST

Title: Effect of high temperature bake on fiducial discharges XP No.: 205

Machine conditions (indicate range where appropriate):

Fiducial 1 800 kA, IWL, 0.4 T (#105584)

TF: Flattop (kA) _≤ 46.5 kA Flattop start/stop (s) 0.0 / 0.4 s

I_p: Flattop (kA) ≤ 800 kA Flattop start/stop (s) 0.15 / 0.3

Position: R (m) 0.85 Z (m) 0.0 **Inner wall** / Single null / Double null

Gas: Prefill __D^+____ Puff __ D^+__

NBI: Power (MW) N.A Start / stop (s) _____ Voltage (kV) _____

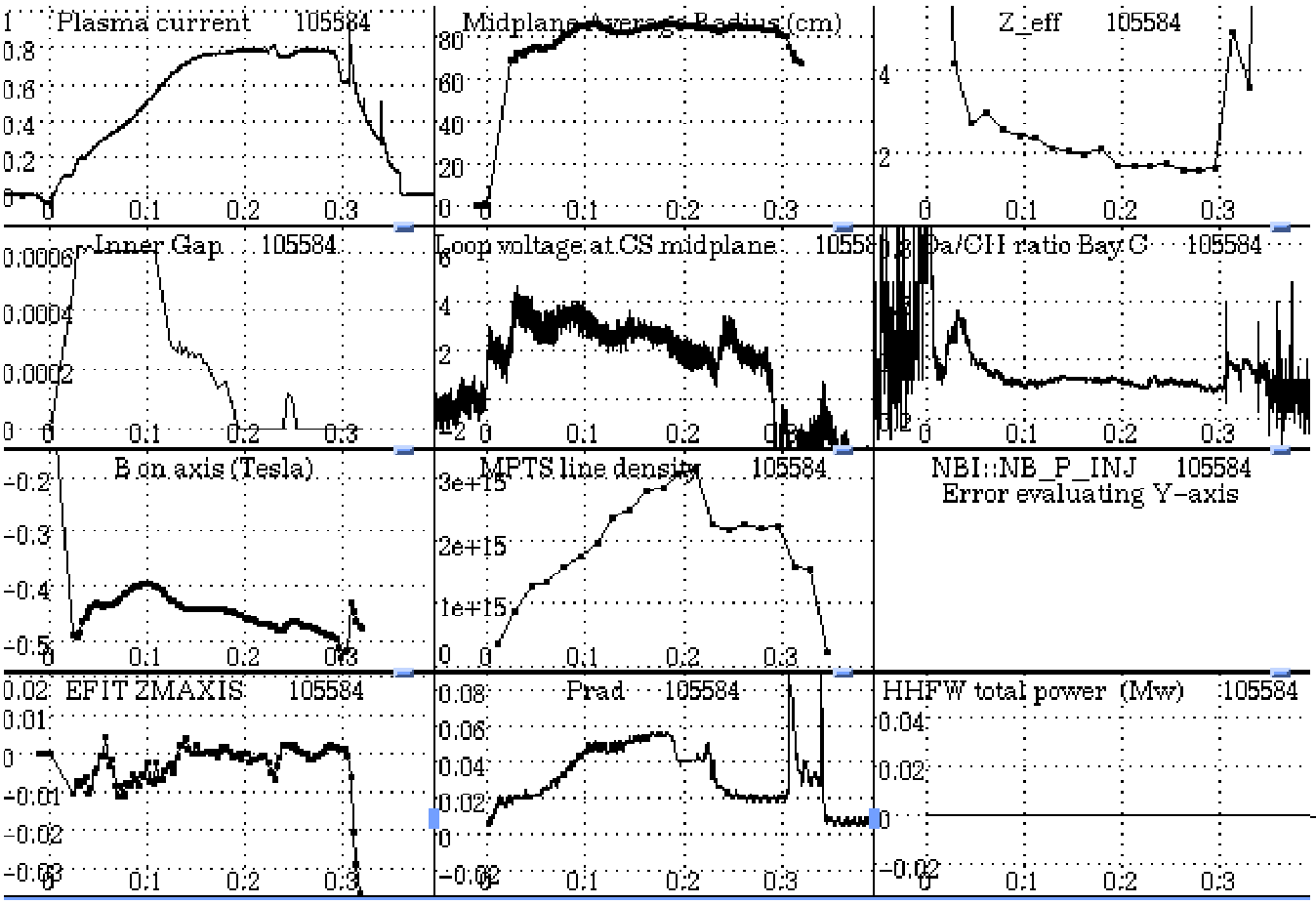
RF: Power (MW) N.A Start / stop (s) _____ Frequency (MHz) _____

CHI: **Off** / Start-up / Ramp-up / Sustainment

Density to reproduce fiducial below.

If this is a continuation of a previous run or if shots from a previous run are similar to those needed, provide shot numbers for setup

If shots are new and unique, sketch desired time profiles and shapes. Accurately label the sketch so there is no confusion about times or values. Attach additional sheets as required.



Fiducial 2 800 kA, LSN, 0.4 T, (106068)

TF: Flattop (kA) _≤ 46.5 kA Flattop start/stop (s) 0.0 / 0.4

I_p: Flattop (kA) _≤ 800 Flattop start/stop (s) 0.15 / 0.3

Position: R (m) __0.86 Z (m) 0.0 Inner wall / **Single null** / Double null

Gas: Prefill __D^+____ Puff __ D^+__

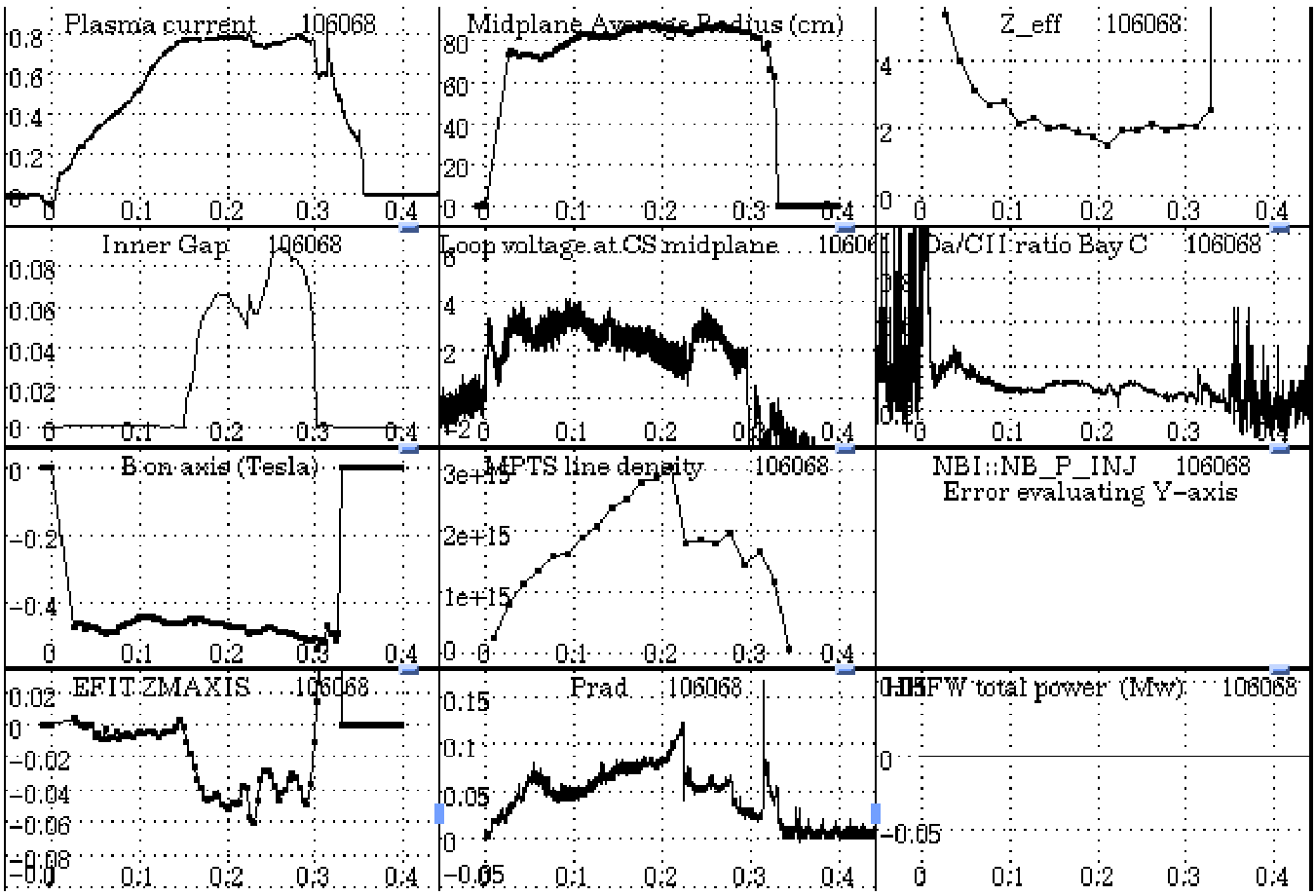
NBI: Power (MW) N.A Start / stop (s) _____ Voltage (kV) _____

RF: Power (MW) N.A Start / stop (s) _____ Frequency (MHz) _____

CHI: **Off** / Start-up / Ramp-up / Sustainment

Density to reproduce fiducial below.

If this is a continuation of a previous run or if shots from a previous run are similar to those needed, provide shot numbers for setup



Fiducial 3 800kA, IWL, 0.3T, (#105646)

TF: Flattop (kA) _≤ 34 kA Flattop start/stop (s) 0.0 / 0.4 s

I_p: Flattop (kA) _≤ 800 Flattop start/stop (s) 0.2 / 0.25

Position: R (m) 0.80 Z (m) 0.0 **Inner wall** / Single null / Double null

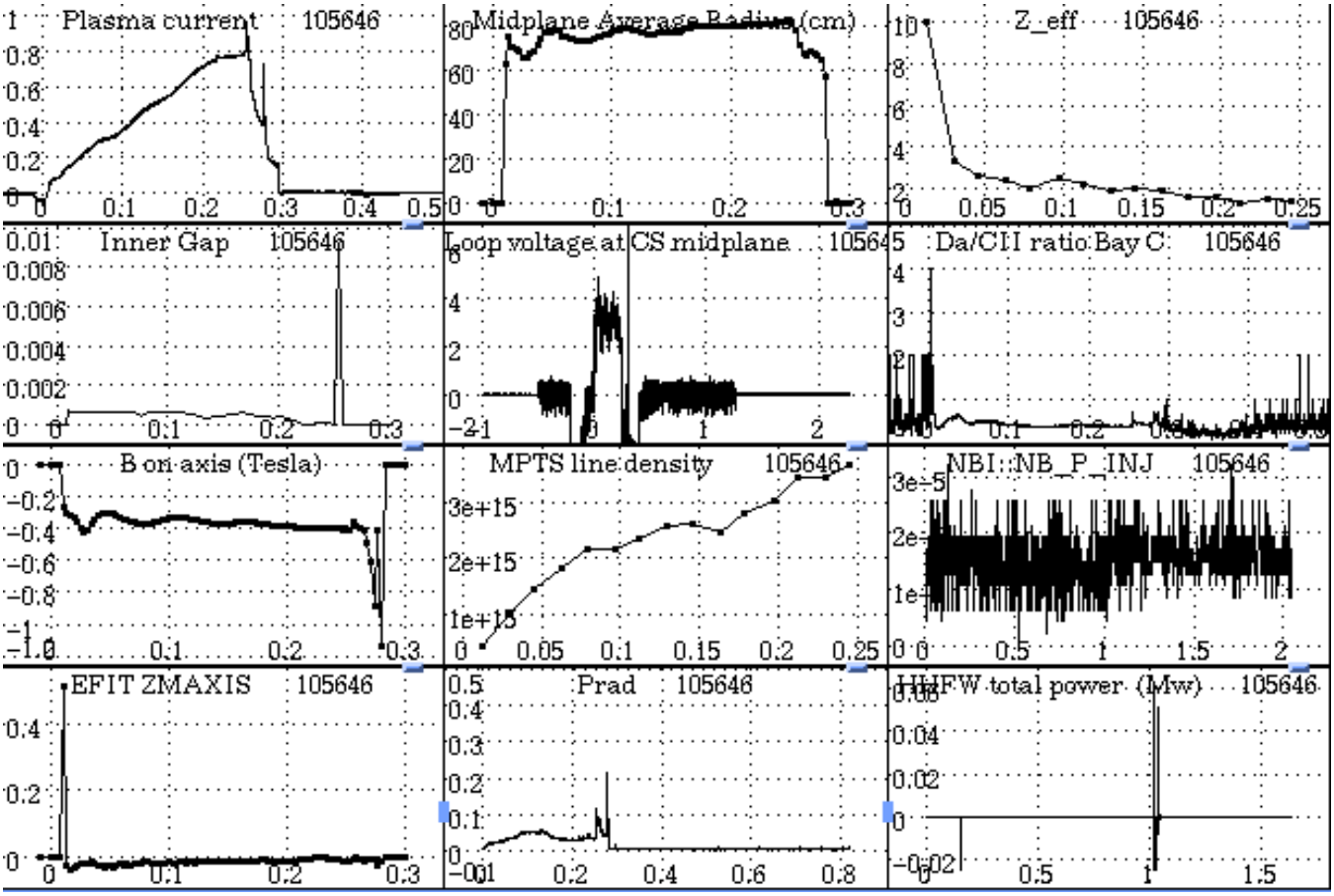
Gas: Prefill __D^+____ Puff __ D^+__

NBI: Power (MW) N.A Start / stop (s) _____ Voltage (kV) _____

RF: Power (MW) N.A Start / stop (s) _____ Frequency (MHz) _____

CHI: **Off** / Start-up / Ramp-up / Sustainment

Density to reproduce fiducial below.



Fiducial 4 800 kA, 0.3 T, LSN, (105692)

TF: Flattop (kA) _≤ 34 kA Flattop start/stop (s) 0.0 / 0.4

I_p: Flattop (kA) ≤ 700 kA Flattop start/stop (s) 0.15 / 0.3

Position: R (m) __0.86 Z (m) 0.0 Inner wall / **Single null** / Double null

Gas: Prefill __D^+____ Puff __ D^+__

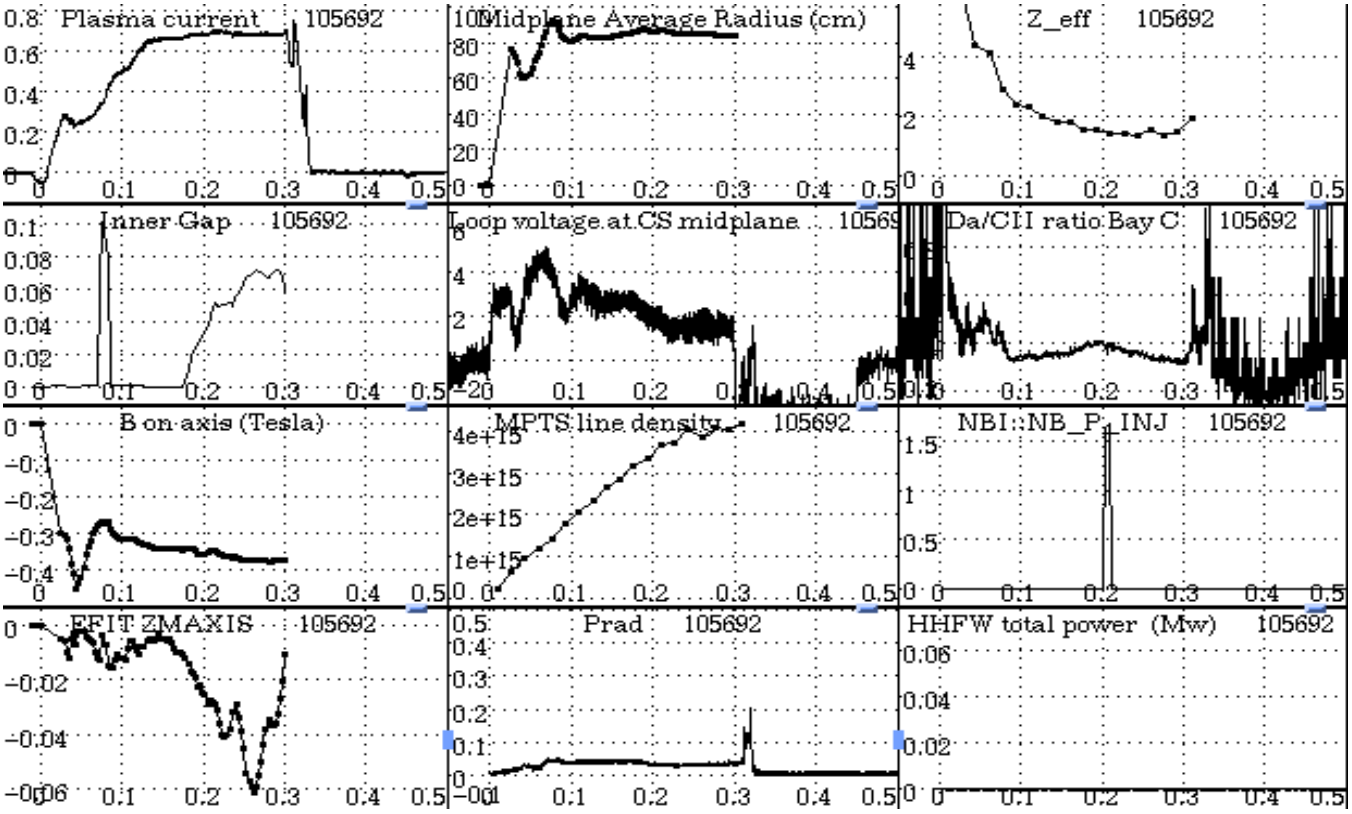
NBI: Power (MW) N.A Start / stop (s) _____ Voltage (kV) _____

RF: Power (MW) N.A Start / stop (s) _____ Frequency (MHz) _____

CHI: **Off** / Start-up / Ramp-up / Sustainment

Density to reproduce fiducial below (except for transient in inner gap at 0.09 s.)

If this is a continuation of a previous run or if shots from a previous run are similar to those needed, provide shot numbers for setup



Fiducial 5 1MA, 0.45 T, IWL, (105082)

TF: Flattop (kA) _≤ 46.5 kA Flattop start/stop (s) 0.0 / 0.3

I_p: Flattop (kA) _≤ 1MA Flattop start/stop (s) 0.15 / 0.3

Position: R (m) __0.83 Z (m) 0.0 **Inner wall** / Single null / Double null

Gas: Prefill __D^+____ Puff __ D^+__

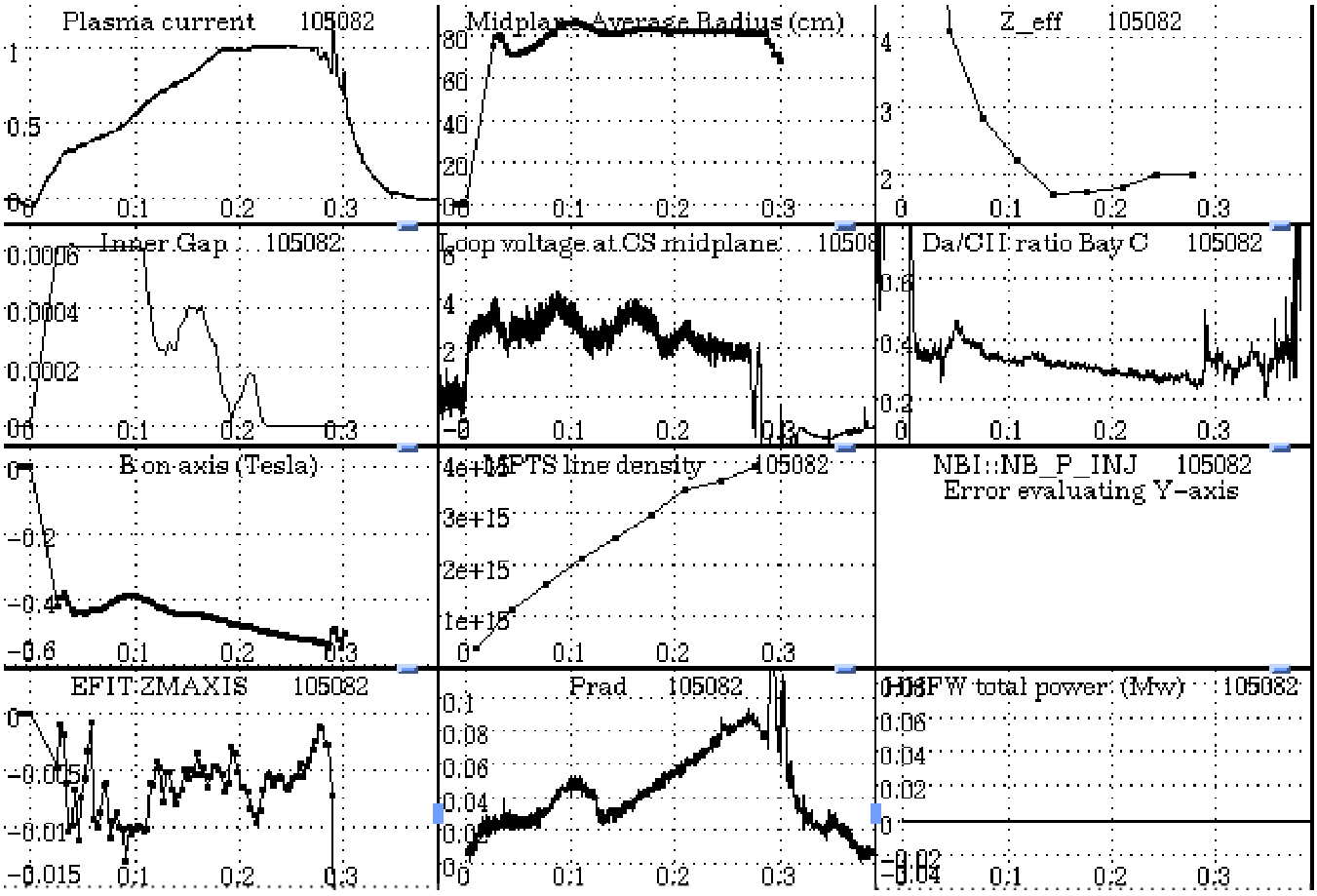
NBI: Power (MW) N.A Start / stop (s) _____ Voltage (kV) _____

RF: Power (MW) N.A Start / stop (s) _____ Frequency (MHz) _____

CHI: **Off** / Start-up / Ramp-up / Sustainment

Density to reproduce fiducial below.

If this is a continuation of a previous run or if shots from a previous run are similar to those needed, provide shot numbers for setup



Fiducial 6 1MA, 0.45 T, LSN, (105904)

TF: Flattop (kA) _≤ 52.3 kA Flattop start/stop (s) 0.0 / 0.3

I_p: Flattop (kA) _≤ 1MA Flattop start/stop (s) 0.15 / 0.3

Position: R (m) __0.88 Z (m) 0.0 Inner wall / **Single null** / Double null

Gas: Prefill __D^+____ Puff __ D^+__

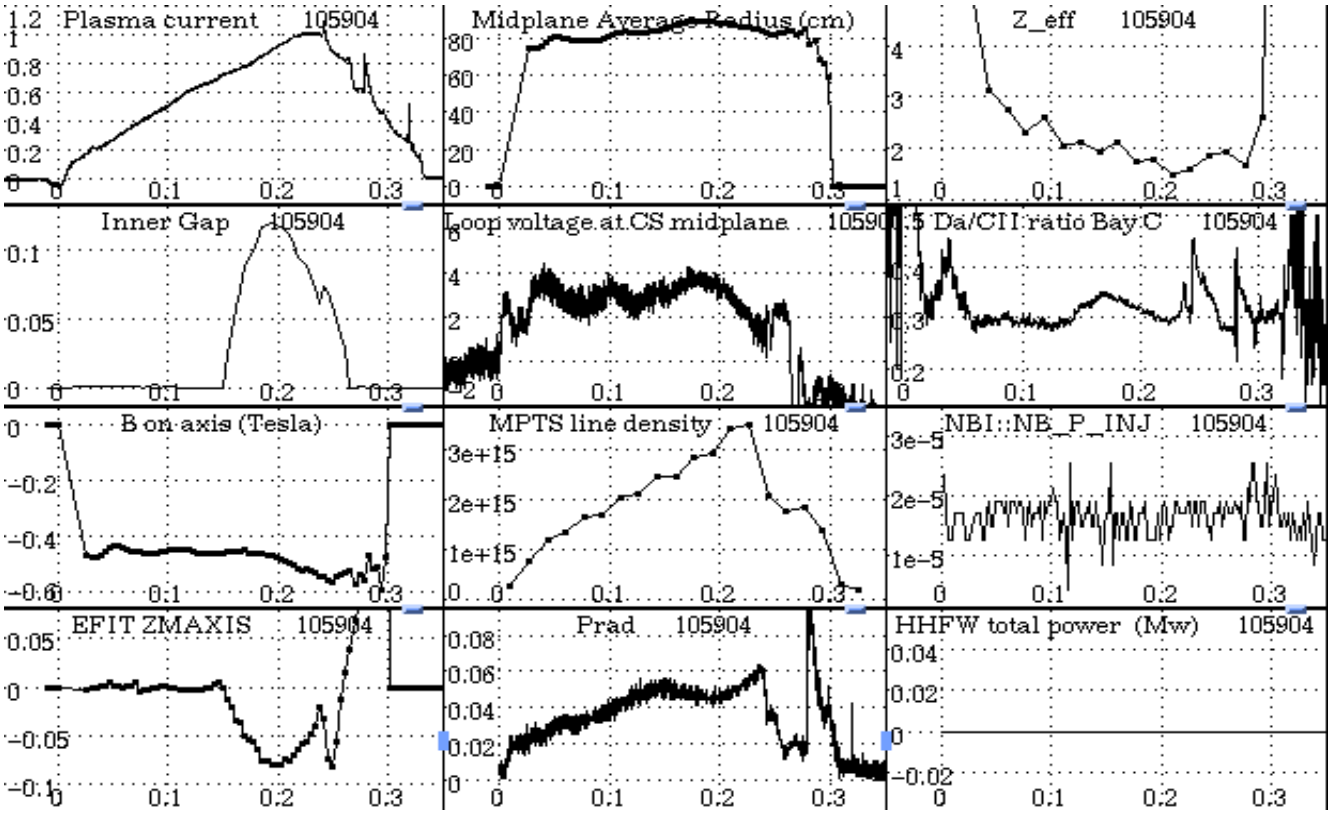
NBI: Power (MW) N.A Start / stop (s) _____ Voltage (kV) _____

RF: Power (MW) N.A Start / stop (s) _____ Frequency (MHz) _____

CHI: **Off** / Start-up / Ramp-up / Sustainment

Density to reproduce fiducial below.

If this is a continuation of a previous run or if shots from a previous run are similar to those needed, provide shot numbers for setup



DIAGNOSTIC CHECKLIST

Title: Effect of high temperature bake on fiducial discharges **XP No. OP-XP-205**

		Need	Desire	Special requirements
Magnetics	Flux loops, B-coils	X		
	Passive plate diag.		X	
Ne and Te	Interferometer		X	
	Thomson Scattering	X		
Ti	CHERS		X	
	NPA		X	
Spectroscopy	Ha	X		
	SPRED (UV)	X		
	VIPS1 (H/D)	X		
	VIPS2	X		
	X-ray PHA		X	
	Visible Bremstrahlung	X		
Particles	NPA		X	
Fluctuations	Mirnov Coils		X	
	X-ray Array		X	
	Reflectometer		X	
Edge	Bolometer	X		
	Plasma TV		X	
	IRTV		X	