Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Physics of Ohmically Heated H-mode Plasmas

OP-XP-506	**Revision:**	Effective Date: *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

Physics of Ohmically Heated H-mode Plasmas **OP-XP-506**

1. Overview of planned experiment

The goal of this experimental proposal is to study H-modes in which core and edge turbulence can be measured. Also a second goal is to study an H-mode with no external fast particle or momentum input in order to understand the fundamental physics of the L-H transition and the H-mode. This XP is a continuation of X442 but with modifications to allow a more focused experimental approach. The main emphasis will be on detailed documentation of a limited set of H-modes. Another goal is to trigger OHH-modes more reliably and with longer duration H-phase.

2. Theoretical/ empirical justification

A detailed justification for OH H-mode experiments with emphasis on correlation measurements during scoping studies was presented in XP442. The study was successful in obtaining Ohmic H-modes, however, important diagnostics were not available, the most important of which was the correlation reflectometer. So the goals were not met.

Results from XP442 however do provide added support of the importance of obtaining detailed complete diagnosis of the plasmas. The fact that n_e profiles of OH H-modes are peaked in the core was originally used as motivation since this allows core correlation measurements not available normally in NSTX (and tokamaks in general) beam heated H-modes. This can be seen in Figure 1, which is a comparison of n_e profiles for 3 different H-modes, including one regular (single beam) NBI H-mode. In addition, a very interesting

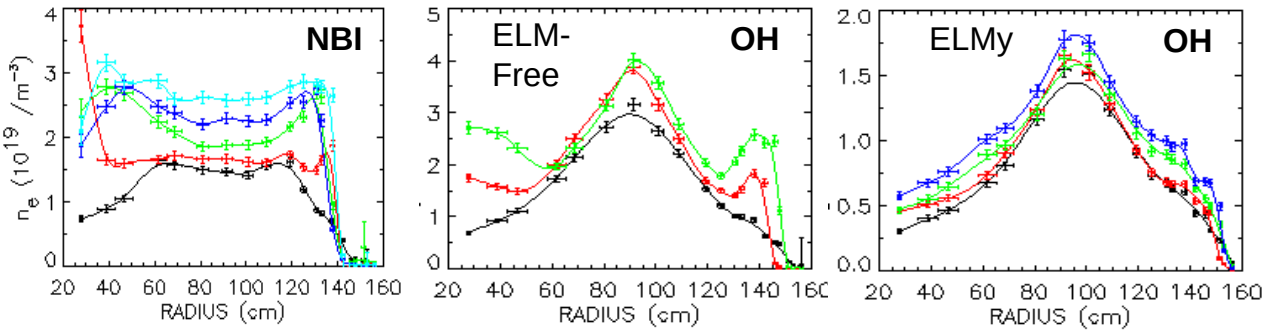


Figure 1 – (a) NBI H-mode (b, c) OH H-mode

result from XP442 is evidence for precursor activity to the L-H transition of ohmic H-modes. Most striking is provided by the edge rotation diagnostic (ERD) which shows the radial electric filled, E_r, to become more negative beginning ~ 20 ms before the L-H transition. The edge poloidal velocity (v_θ), i.e. plasma flow, also increases. This can be seen in Figure 2, which is for CIII. Other diagnostics showing possible precursor activity are the I_{sat} of the divertor plate Langmuir probes (Fig. 3), and the FireTIP diagnostic (Fig. 4) at R_T = 85 and 150 cm. The ERD result is consistent with models for the L-H transition where flows develop

(fast ion loss or turbulence driven flows) which lead to flow shear tearing of turbulent eddys leading to the L-H transition and thus the quiescent H-phase.

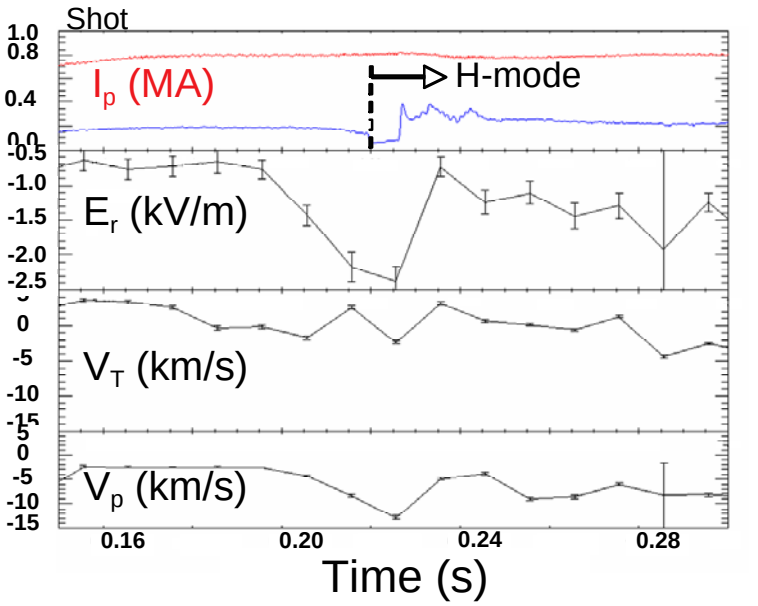


Figure 2 – Er becomes more negative 20 ms before L-H.

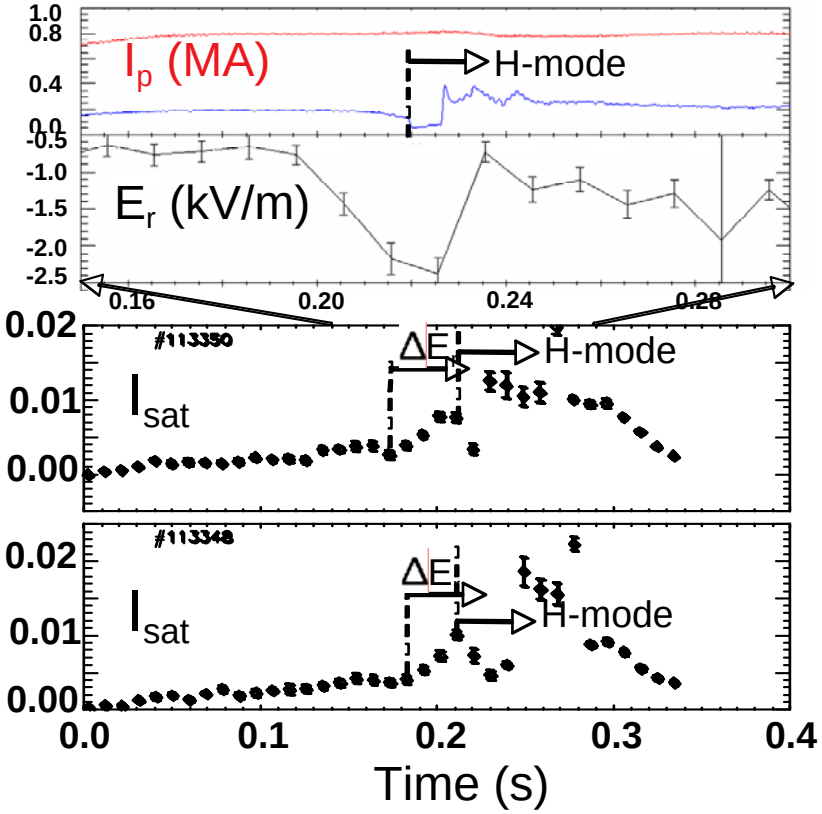


Figure 3 – Langmuir probes – Change in Isat begins with change in Er.

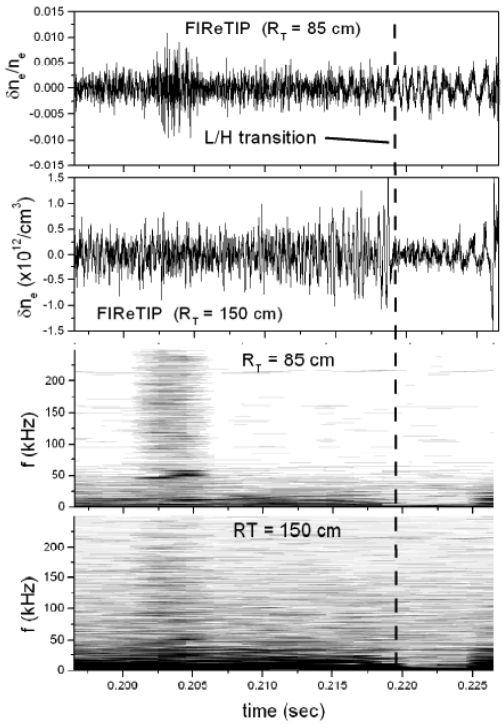


Figure 4 – FireTIPs - Burst of ne fluctuations before L-H .

3. Experimental run plan

Plan: Do XP shortly after a boronization and machine well conditioned. The default ohmic shot before this XP will be like shot 113356 to monitor the state of the machine for OHH-mode access.

Do helium conditioning shots on alternate shots (as needed).

A. **Go directly to LSN OH-H-mode and document thoroughly.**

- 900 kA or 800 kA at lowest n_e, 0.45 T

1) Reproduce 113356 (keep n_e low) **5 shots**
   If difficult to obtain, add other techniques including divert time
   Ip ramp-rate, pause in Ip ramp-up, and Ip ramp-down similar to TFTR
   - decrease x-point height
   If still difficult try a double null (DND) target, 111570 (see **3F** below)
2) If ok, document (conditions and settings constant) **10 shots**

- Need H-phase > 40 ms for correlation measurements.
- Correlation reflectometer is lead diagnostic.
- GPI — will have documentation shots with He **5 shots**
- ERD — all shots
- CHERS-Edge C (vel.) all shots; Beam blips **5 shots**
- MPTS — Get good pedestal data all shots

- Plasma TV, (Filters – none, D_α, CI, CII, Neon, Argon)
- X-ray crystal – V_ϕ(center) – need Argon puff
- Reciprocating Probe –

B. **Repeat shots for key diagnostics documentation if necessary** **4 shots**
- May require 25 min. test cell access (Kubota, et al…)

C. **If get an extended day then run upper single null (USN) for K.-C Lee** **4 shots**
- Keep all other parameters the same

Do one or more of these (depending on time or piggyback possibilities):

D. **Use Ip rampdown to trigger H-mode reproducibly**
- Adjust for longer OHH-modes (begin at best shot of Part A)

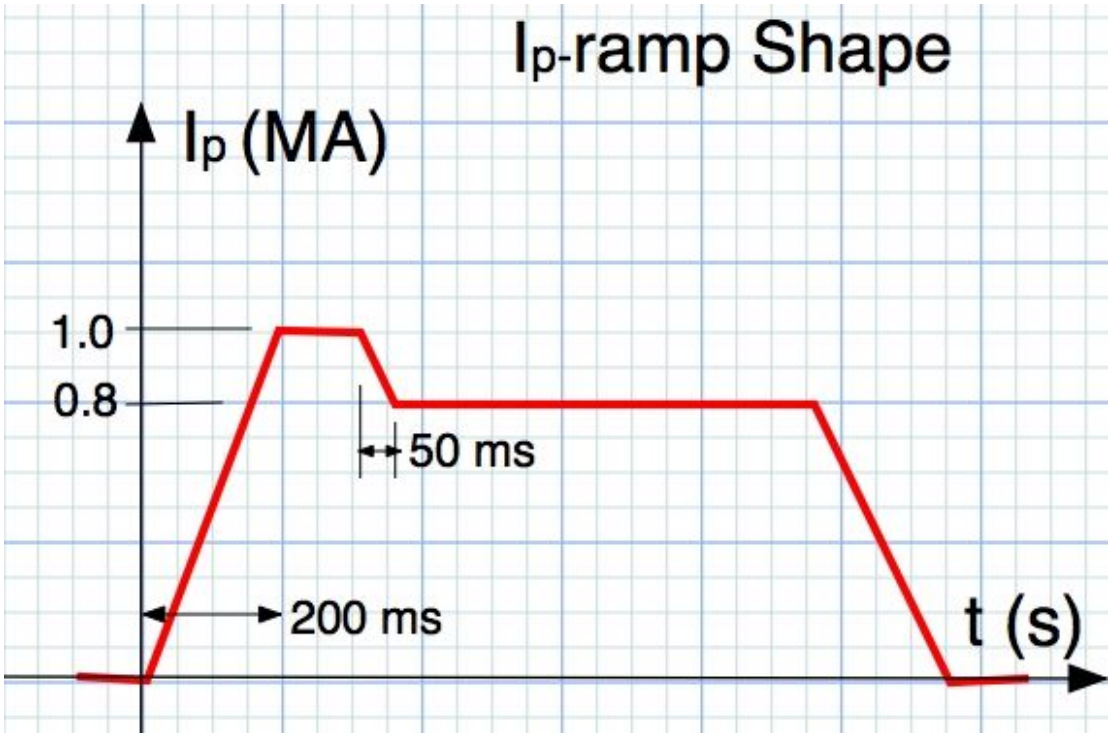
1) Fast Ip rampup to 1 MA, rampdown to 800 kA (rampdown time= 50 ms) **2 shots**
2) Fast Ip rampup to 1 MA, rampdown to 900 kA (rampdown time= 25 ms) **2 shots**
3) If H-mode, document fully **2 shots**
4) Keep rampup the same, vary rampdown rate **4 shots**
- increase duration of H-phase

Get a second Ip or Bt.
Ip because transition easier at low Ip and Bt because $P_{LH} \sim Bt$

E. **Optimize time of transition for long duration (in LSN) -** **4 shots**
Adjust - Divert time and/or Time of Ip flat spot

F. **Run DND plasmas -** Target Shot **= 111570** (see Figure 1(c)) **5 shots**

Schematic of Ip ramp-down



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

A clean, well conditioned chamber with low recycling walls is necessary, and running of the XP shortly after a boronization would be desirable. Best techniques for maintaining these conditions (such as alternate high power helium conditioning discharges) should be available if needed. RF and CHI are not required. The diagnostics to be emphasized for this XP are the ERD (edge rotation diagnostic), reflectometry (Peebles, Kubota), MPTS, GPI, FIReTIP, CHERS, ultra-soft X-ray arrays, and the reciprocating probe. Although NBI heating would not be required for most shots, it would be good to have beam blips for CHERS (and MSE) measurements. Care should be taken to avoid the overshoot spike on the front end of the blip. However, we must make sure the beam blips do not affect the transition. For higher spatial resolution edge diagnosis, plasma position jog shots will be provided for MPTS, FIReTIP and other diagnostics.

5. Planned analysis

Plasma analysis requires EFIT and TRANSP (with NCLASS). Also run MIST.

6. Planned publication of results

The results are expected to be suitable for a Journal article. The plasma is to be well documented allowing the main physics issues to be addressed.

PHYSICS OPERATIONS REQUEST

Physics of Ohmically Heated H-mode Plasmas OP-XP-506

Machine conditions (specify ranges as appropriate) **(use Shot 113356 as a guide)**

I_{TF} (kA): **54 kA** Flattop start/stop (s): **0.0/1.0**

I_P (MA): **0.6 – 1.0** Flattop start/stop (s): **0.18/0.7**

Configuration: **Lower Single Null(main) / Upper SN(4shts) / Double Null(4shts)**

Outer gap (m): **__0.04___**, Inner gap (m): **_0.050____**

Elongation κ: **__2.0___**, Triangularity δ: **_0.40____**

Z position (m): **0.00**

Gas Species: **D** , Injector: **Inner wall**

NBI - Species: **D**, Source: **A**, Voltage (kV): **90**, Duration (s): **10 ms blip**

ICRF – Power (MW): **__No__**, Phasing: **(N/A)**, Duration (s): **_____**

CHI: **Off**

Either: List previous shot numbers for setup: **(113356) or as suggested by operators.**

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.

DIAGNOSTICS CHECKLIST

Title: Physics of Ohmically Heated H-mode Plasmas **OP-XP-506**

Diagnostic	Need	Desire	Instructions
Bolometer – tangential array		4	
Bolometer array - divertor		4	
CHERS	4		
Divertor fast camera		4	
EBW radiometer		4	
Edge pressure gauges		4	
Edge rotation spectroscopy	4		
Fast lost ion probes		4	
Filterscopes	4		
FIReTIP	4		
Gas puff imaging	4		
H camera - 1D		4	
Infrared cameras		4	
Interferometer - 1 mm		4	
Langmuir probe array	4		
Magnetics - Diamagnetism	4		
Magnetics - Flux loops	4		
Magnetics - Locked modes	4		
Magnetics - Pickup coils	4		
Magnetics - Rogowski coils	4		
Magnetics - RWM sensors		4	
Mirnov coils – high frequency		4	
MSE		4	
Neutral particle analyzer		4	
Neutron measurements		4	
Plasma TV	4		
Reciprocating probe		4	
Reflectometer – core	4		
Reflectometer - SOL		4	
SPRED		4	
Thomson scattering	4		
Ultrasoft X-ray arrays	4		
Visible bremsstrahlung det.		4	
Visible spectrometer (VIPS)		4	
X-ray crystal spectrometer - H		4	
X-ray crystal spectrometer - V		4	
X-ray GEM camera		4	
X-ray pinhole camera		4	