Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Title: Edge Turbulence in High Density Ohmic Plasmas on NSTX		
OP-XP-630	**Revision:**	Effective Date: 9 June 06 *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS	
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ATI – ET Group Leader: Rajesh Maingi	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)	

1. Overview of planned experiment

The goal of this experiment is to study edge turbulence in high-density Ohmic plasmas. The experiment consists of a shot to shot density scan to examine the behavior of edge turbulence at or near the density limit in NSTX.

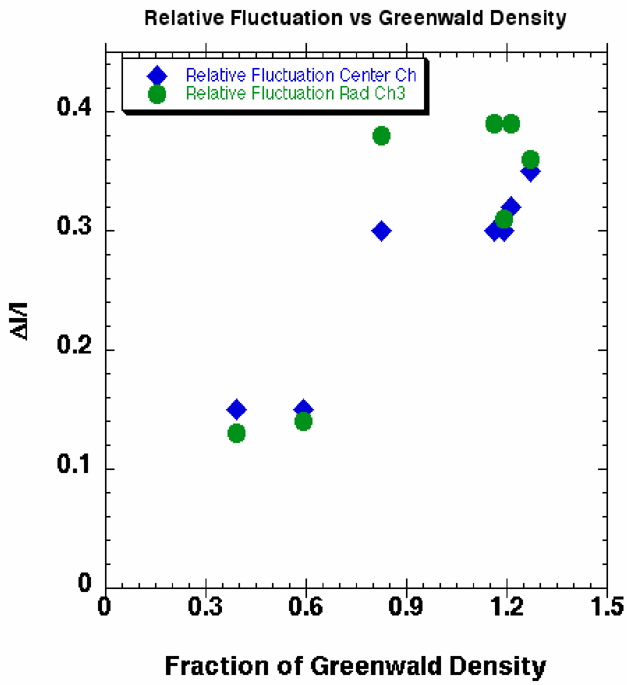
2. Theoretical/ empirical justification

In previous campaigns density scans have been performed on NSTX, usually with the use of beams and gas injection. The intent of this experiment is to perform a density scan in Ohmic LSN plasmas to further understand edge turbulence in plasmas at or near the density limit in NSTX. It is important for this experiment to reach the Ohmic density limit and observe the changes in edge turbulence at this limit. A density scan in Ohmic plasmas provides the advantage of being able to make consistent turbulence measurements without any of the other changes introduced by NBI, for example, increased rotation and heating.

The theoretical justification for this experiment is that there is presently no clear theoretical understanding of the density limit in tokamaks. However, it is widely believed that edge turbulence can play a role in establishing this limit [1]. The proposed experiment will investigate the density limit in the simplest possible plasmas in a device in which there are excellent edge turbulence diagnostics.

The main measurements for this experiment are those of edge turbulence made using the GPI diagnostic and the scanning Langmuir probe. The GPI diagnostic is particularly ideal because it provides a 2D view of the radial and poloidal evolution of edge turbulence [2]. Edge turbulence has an intermittent "blob-like" 2D structure, which has been observed in NSTX [3] and many other devices. For example, it has been shown in DIII-D that these intermittent structures increase in frequency with increasing density [4]. It has also been shown that these structures can move either radially or poloidally through the edge on NSTX [3] and Alcator C-Mod [5].

An experiment was done in March 2006 in NSTX to perform a density scan in NBI heated plasma [XP 604, "Density Scan" by Boedo *et al*]. Preliminary results from GPI diagnostic for this experiment indicate an increase in relative fluctuation and radial cross correlation coefficient with increasing density (Figure 1). Although this experiment covered a wide range of normalized density from 0.4 to 1.2 times the Greenwald density n_G, the density limit was not actually reached. For the proposed experiment this scan will be repeated in Ohmic plasmas and the density will be raised as far as possible up to the density limit.



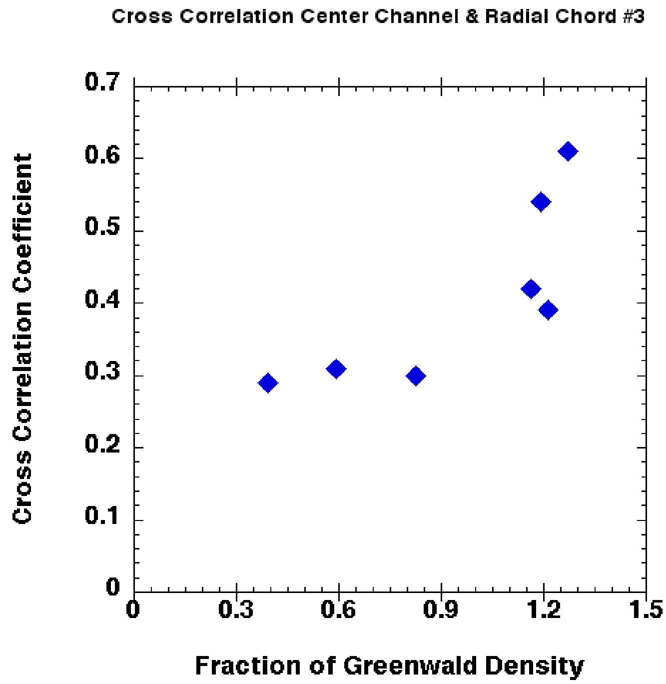


Figure 1: Results from XP 604 - Plots of the relative fluctuation and cross correlation coefficient versus density of the center channel and radial channel 3 @ I_p=800kA, P_B =2MW, and B_T=4.5kG. The relative fluctuations of the two channels increase with increasing density. The cross correlation coefficient between the channels also increases with increasing density. This trend in the cross correlation coefficient is indicative of an increase in the radial size of the turbulence as the density is increased.

References:

[1] Greenwald, M, Plasma Phys. Cont. Fusion **44**, R27 (2002)

[2] Maqueda, R.J., *et al*, Rev. Sci. Instr. **74, 13 (2003)**

[3] Zweben, S. J. *et al.* Nucl. Fusion **44**, 134 (2004)

[4] Boedo, J., *et al*, Phys. Plasmas **10**, 134 (2003)

[5] Grulke, O., *et al*, Phys. Plasmas **13**, 012306 (2006)

3. Experimental run plan

This experiment calls for Ohmic lower single null discharges in L-mode. Outboard gas fueling will be used to maintain the L-mode. LSN, Ohmic L-mode Deuterium plasma w/ Deuterium puff on GPI [I_p=600kA, P_B=2MW, B_T=3.5kG, κ=1.7, outergap=5cm, aspect ratio=1.3, flattop=250ms].

Reference shot #117762 n_G=0.6 at 0.42 sec from XP505 ("Dependence of L-H Power Threshold on X-Point and drsep" by Maingi)

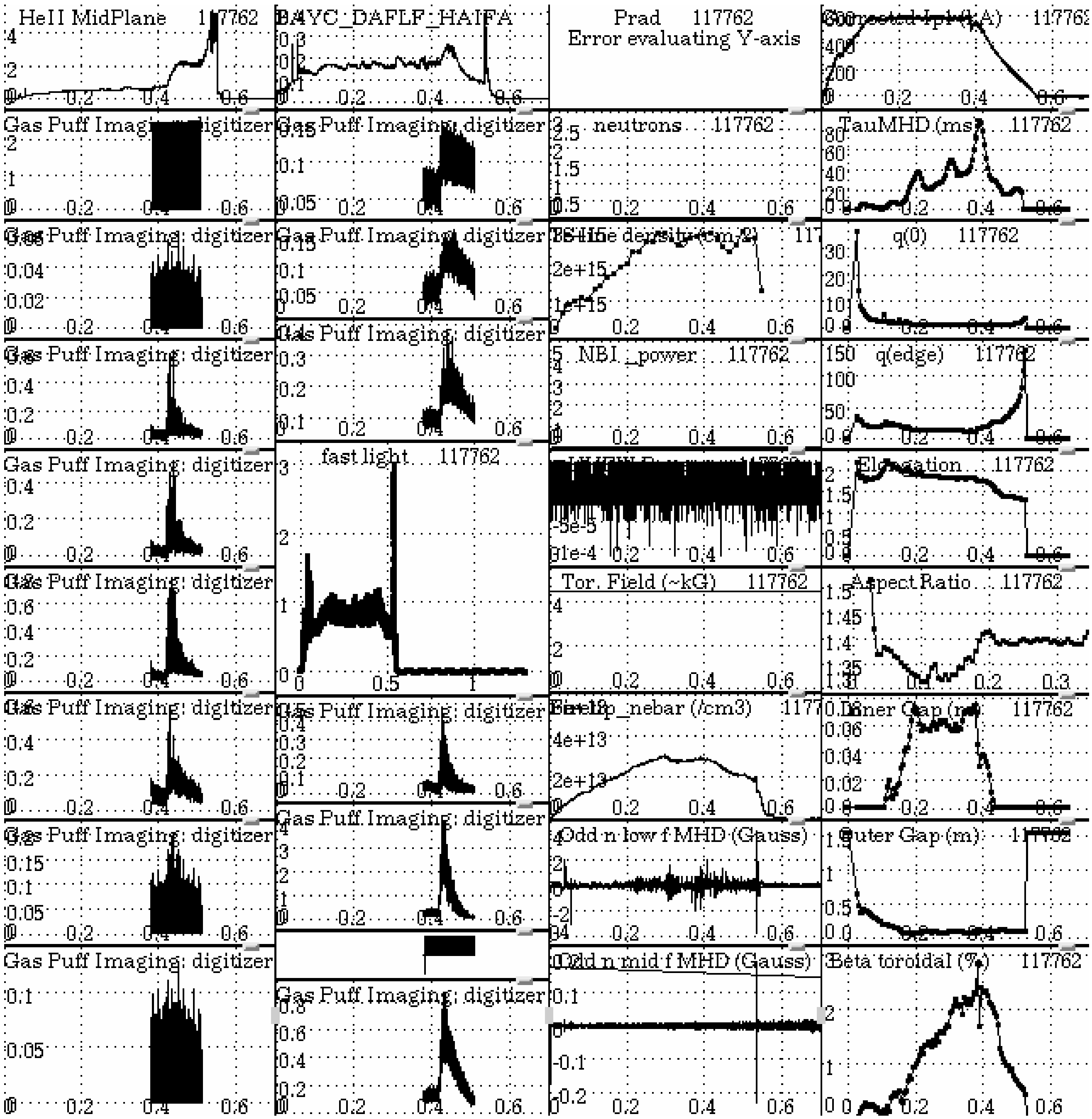


Figure 2: Some parameters from shot #117762 indicating desired conditions.

Proposed shot list:

~ 0.6 n_G (1 shot to establish baseline same as 117762)

~ 1.0 n_G (1 shot, start with SGI plenum pressure of ~ 1200 Torr)

≥ 1.2 n_G (2 shots, raise SGI pressure to ~ 2000 Torr, add LFS fueling @ 50 Torr-L/s to SGI pressure of 2400 Torr to get higher densities if necessary)

if density limit is reached, repeat highest density cases and then reduce puff to repeat lower density cases

if density limit is not reached at highest possible gas injection, try same density scan with small amount of NBI

Total number = 8 good shots (approx 0.5 run day)

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

GPI high-speed camera, SGI, fast probe, divertor probe, plasma TV, and reflectometer would be required. It would be highly desirable to have fast camera views of the main chamber and/or divertor, in addition to the GPI fast camera view. Also, CHERs, ERD, and 30 channel Thomson are desired but not required. In addition, it would be preferable to have a boronized vessel along with a 7.5 min He glow between shots.

It is important that the outer gap be kept constant during the density scan in this experiment, since the GPI and scanning probe diagnostics need to have a consistent measurement window with respect to the outer separatrix.

5. Planned analysis

EFIT/LRDFIT and standard TRANSP confinement analysis.

Turbulence analysis will be conducted on chord data, camera and probe data. Chord and probe data will be analyzed to determine the turbulence level, relative fluctuation, autocorrelation time, radial and poloidal correlation lengths as well as the intermittency at the increased density. Blob frequency will also be characterized, from camera data, versus density, beam power, and other parameters. Analysis of turbulence data will be compared with data from previous L-mode and H-mode plasmas

6. Planned publication of results

If successful, data and analysis will be presented at APS DPP meeting and published in Physics of Plasmas, Nuclear Fusion, or similar journal.

PHYSICS OPERATIONS REQUEST

Reference shot: 117762 **OP-XP-630**

Machine conditions (specify ranges as appropriate)

B_{TF} (kG): **3.5** Flattop start/stop (s): _____/_____

I_P (MA): **0.6** Flattop start/stop (s): _____/_____

Configuration: **LSN**

Outer gap (m): **0.08**, Inner gap (m): _____

Elongation κ: **1.7** , Triangularity δ: _____

Z position (m): **0.00**

Gas Species: **D**, Injector: **Midplane / Inner wall / Lower Dome**

NBI - Species: **none**, Sources: , Voltage (kV): _____, Duration (s): _____

ICRF – Power (MW): **0**, Phasing , Duration (s): _____

CHI: **Off**

Either: List previous shot numbers for setup: **117762**

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