Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Title: **ETG turbulence isotropy**		
OP-XP-1070	Revision:	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS	
Responsible Author: David Smith	Date Sept. 21, 2010
ATI – ET Group Leader: Howard Yuh (T&T)	Date
RLM - Run Coordinator: Eric Fredrickson	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: ETG turbulence isotropy No. **OP-XP-1070**

AUTHORS: David Smith DATE: Sept. 21, 2010

1. Overview of planned experiment

The isotropy of ETG turbulence in the k_r-k_θ plane is an area of active debate within the GK community. In this experiment, we will investigate the isotropy of ETG turbulence by adjusting the ratio k_θ/k_r in high-k scattering measurements of ETG turbulence. Also, this experiment will probe the possible transition from anisotropic ETG to isotropic ETG using Ip ramp-downs to transiently alter the magnetic shear.

2. Theoretical/ empirical justification

According to simulations, anisotropic ETG turbulence with radial streamers generates high levels of ETG-driven electron thermal transport. In ETG simulations with tokamak parameters, low-k (ITG/TEM) turbulence isotropizes (breaks-up) ETG turbulence and mitigates ETG-driven transport. In ETG simulations with ST parameters, flow shear suppresses low-k turbulence and ETG turbulence saturates in an anisotropic state. Accordingly, observations of ETG anisotropy are most likely in ST plasmas.

To date, no measurements have documented the isotropy or anisotropy of ETG turbulence in the k_θ/k_r plane. The NSTX high-k scattering system is the only turbulence diagnostic worldwide capable of investigating this topic. Moving the scattering volume vertically alters the ratio k_θ/k_r in high-k measurements. For outboard measurements at R~131 cm, the ratio k_θ/k_r can range from 0.03 to 0.43 in the low-k channel.

Simulations predict anisotropic ETG turbulence with strong ETG-driven transport at moderate magnetic shear values, s-hat ~ 1. At lower s-hat, ETG isotropizes and ETG-driven transport decreases. To probe the possible transition from anisotropic to isotropic ETG turbulence, the discharges will include an Ip ramp-down late in the discharge to transiently lower s-hat.

3. Experimental run plan

134740 is the baseline shot with Ip = 1.1 MA and Bt = 5.5 kG. NB sources A & B provide 4 MW (40 and 80 ms, respectively), and source C provides an additional 2 MW of early heating (100-200 ms). SPAs at 200 kA minimize n=3 breaking. Run Bay-K LITER to minimize ELMs.

High-k configurations for three probe beam vertical angles (-4.8°, -5.35°, and -5.9°) are listed below. The associated k-space parameters are also illustrated. The collection mirror horizontal angle is 230.5°. The measurement location is r/a~0.55 and R~131 cm. The r/a position is maintained for all configurations.

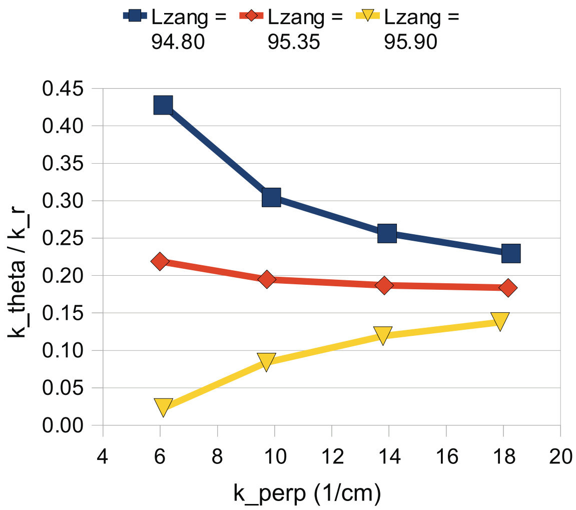
Changing configurations will require controlled accesses to adjust exit window vertical angles. The highest priority configurations are -4.8° and -5.9°, as they provide minimum and maximum k_θ/k_r values. −5.35° is the lower priority configuration because it provides intermediate k_θ/k_r values.

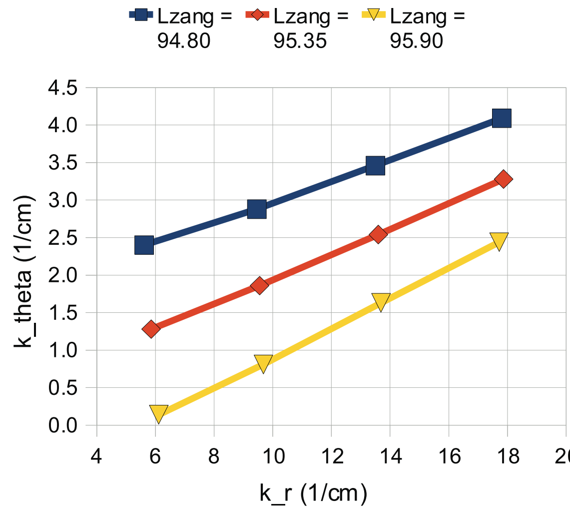
To investigate the possible transition from anisotropic ETG to isotropic ETG, shots with Ip ramp-downs will occur after successful fixed Ip shots. Ramp downs to 0.8 or 0.9 MA with varying timings will be developed.

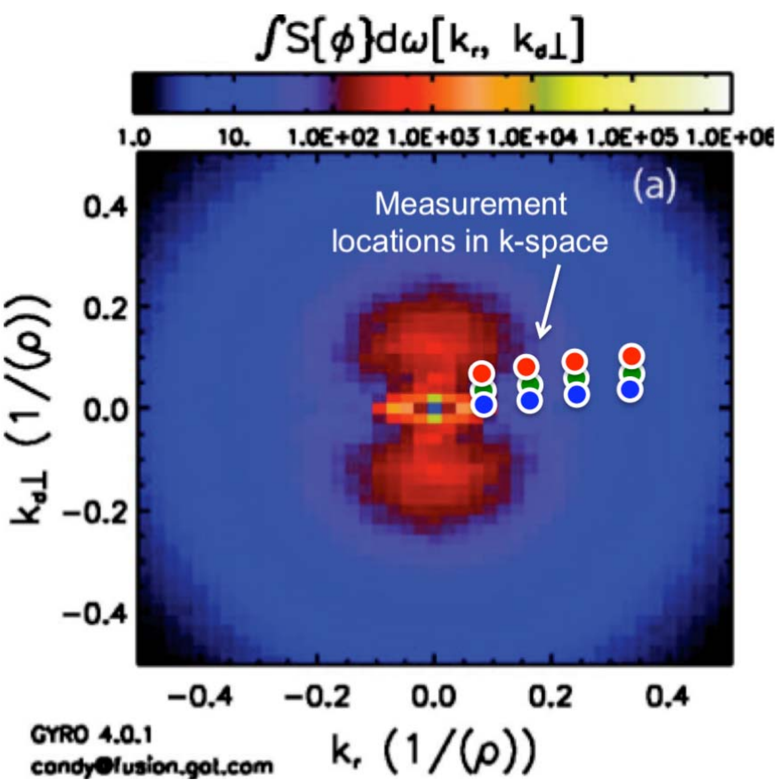
This XP will need 1 run day.

Shot matrix	Ip = 1.1 MA & no ramp-down	Ip ramp-down with several ramp timings
PB Z angle -4.8°	×2	~ 5
-5.35°	×2	~ 5
-5.9°	×2	~ 5

PB Z ang	PB X ang	Channel	EW X ang	EW Z ang
-4.8°	90.7°	1	-2.1°	1.8°
		2	-2.6°	1.6°
		3	-2.6°	1.4°
		4	-2.2°	1.2°
-5.9°	90.5°	1	-1.9°	0.7°
		2	-2.3°	0.5°
		3	-2.3°	0.2°
		4	-1.7°	0.0°
-5.35°	90.6°	1	-2.0°	1.2°
		2	-2.4°	1.0°
		3	-2.4°	0.8°
		4	-2.0°	0.6°


Lzang = 94.80
Lzang = 95.35
Lzang = 95.90
k_theta / k_r
k_perp (1/cm)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
4
6
8
10
12
14
16
18
20


Lzang = 94.80
Lzang = 95.35
Lzang = 95.90
k_theta (1/cm)
k_r (1/cm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4
6
8
10
12
14
16
18
20


∫S{ϕ}dω[k_r, k_θ⊥]
1.0
10.
1.0E+02
1.0E+03
1.0E+04
1.0E+05
(a)
Measurement
locations in k-space
k_θ⊥ (1/(ρ))
0.4
0.2
0.0
−0.2
−0.4
k_r (1/(ρ))
GYRO 4.0.1
candy@fusion.gat.com

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

4-6 MW of NBI as per shot 134740; high-k scattering, SPA for EF correction, bay-k LITER

5. Planned analysis

LRDFIT, TRANSP, GS2

6. Planned publication of results

Observations addressing the isotropy of ETG turbulence warrant a PRL.

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:

MHD activity, if present, needs to be steady-state without bursting modes or fast-ion losses. In the baseline shot 134740, MHD activity was steady-state.

Previous shot(s) which can be repeated: 124889 (4 MW NBI, 700 kA Ip, 5.5 kG TF)

Previous shot(s) which can be modified:

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

I_{TF} (kA): standard 5.5 kG Flattop start/stop (s): see 134740

I_P (MA): 1.1 MA Flattop start/stop (s): see 134740

Configuration: **LSN**

Equilibrium Control: **Isoflux** (rtEFIT)

Outer gap (m): Inner gap (m): Z position (m):

Elongation κ: Upper/lower triangularity δ:

Gas Species: **D** Injector(s):

NBI Species: **D** Voltage (kV) **A: 40+ms** **B: 80+ms** **C:** 100-200 ms Duration (s):

ICRF: Off

CHI: **Off**

LITERs: Bay K LITER

EFC coils: usual n=3 Configuration: **Odd / Even / Other** *(attach detailed sheet*

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		