Edge Zonal Flows and Blob Formation

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S. Kubota, D. Smith, J. Boedo, R. Bell, B. LeBlanc et al

Motivation: understand the relationship between edge zonal flows and blob formation in NSTX

XP Goal: determine scaling of edge zonal flows with B_t (at constant q) and with NBI power using GPI, and measure correlation with blob formation

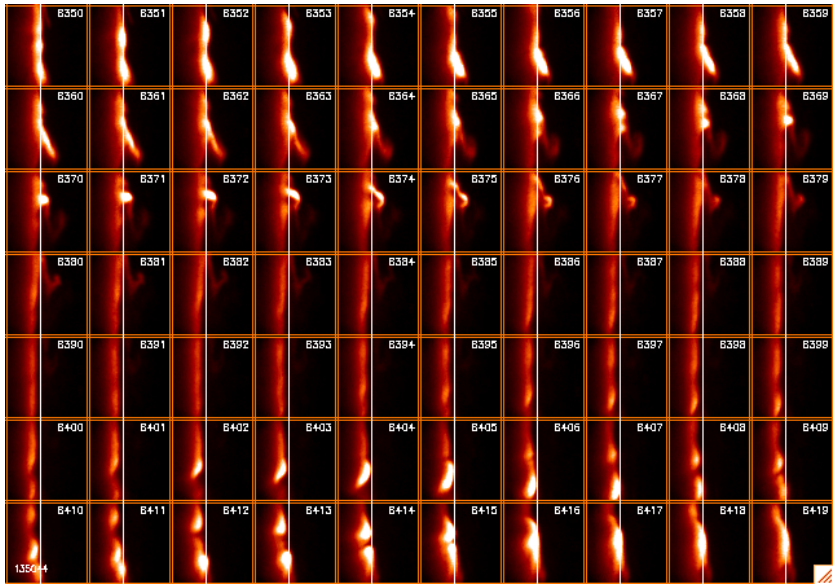
Plan: B=3.0 kG, I=0.6 MA - six shots w/NBI
B=4.5 kG, I=0.9 MA - six shots w/NBI
B=6.0 kG, I=1.2 MA - six shots w/NBI

Overview

- Zonal flows in theory regulate edge turbulence and contribute to causing the L-H transition (e.g. Diamond et al, PPCF 2005)
- Many observations have been made of GAMs and a few of incoherent, lower frequency zonal flows (Fujisawa NF 2010)
- Edge zonal flows were observed in NSTX for the first time last year during run with 'ultra-high GPI rate' (XP#929), based on analysis of poloidal velocity of GPI turbulence
- That data was all at B=4.5, I=0.9 MA, P ~ 2 MW NBI using two cameras with combined rate of 285,000 frames/sec

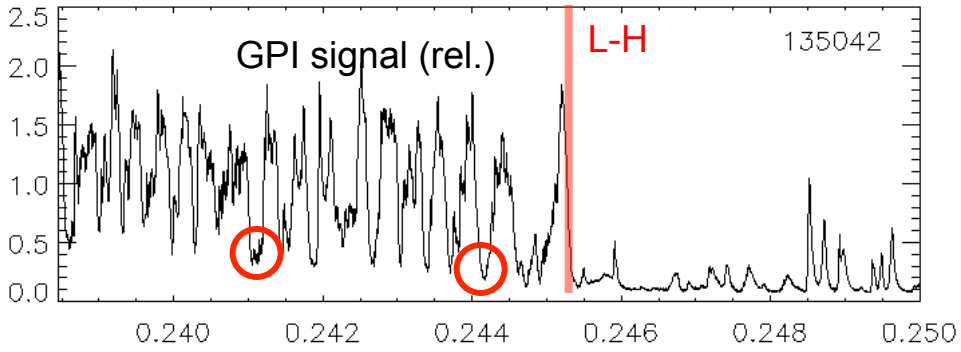
This XP will scan B and use a new camera at 400,000 fr/sec

Quiet Periods in Edge Turbulence



‘Quiet periods’
in L-mode edge
look like H-mode

quiet periods ~
no blob formation



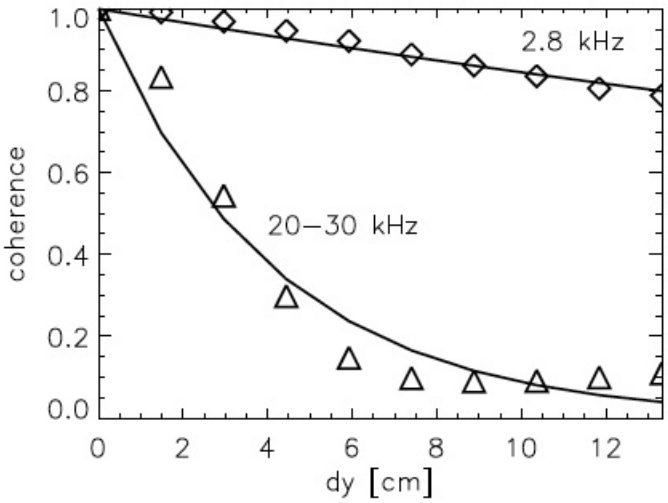
‘Quiet periods’
occur at ~ 3 kHz
at least 30 msec
before L-H transition

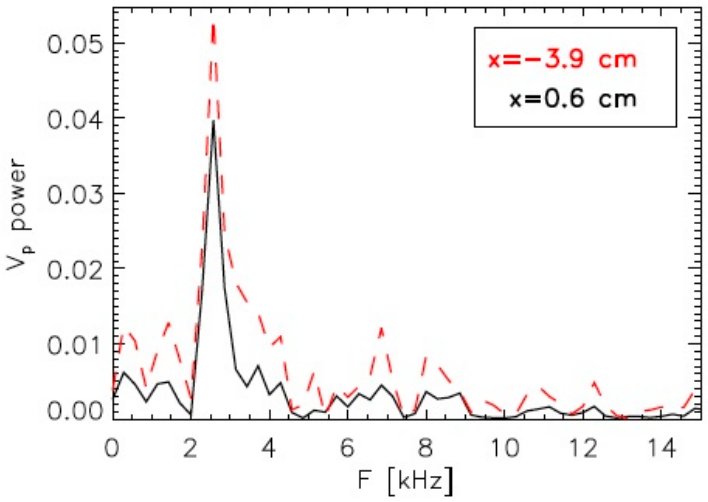
Oscillating Poloidal Flows

Poloidal flows evaluated from cross-correlation and HOP-V

Poloidal flow nearly constant vs. poloidal angle => low m,
with oscillation frequency near ~ 3 kHz (<< turbulence)

=> characteristic of GAM or 'zonal flow' (Fujisawa NF '09)

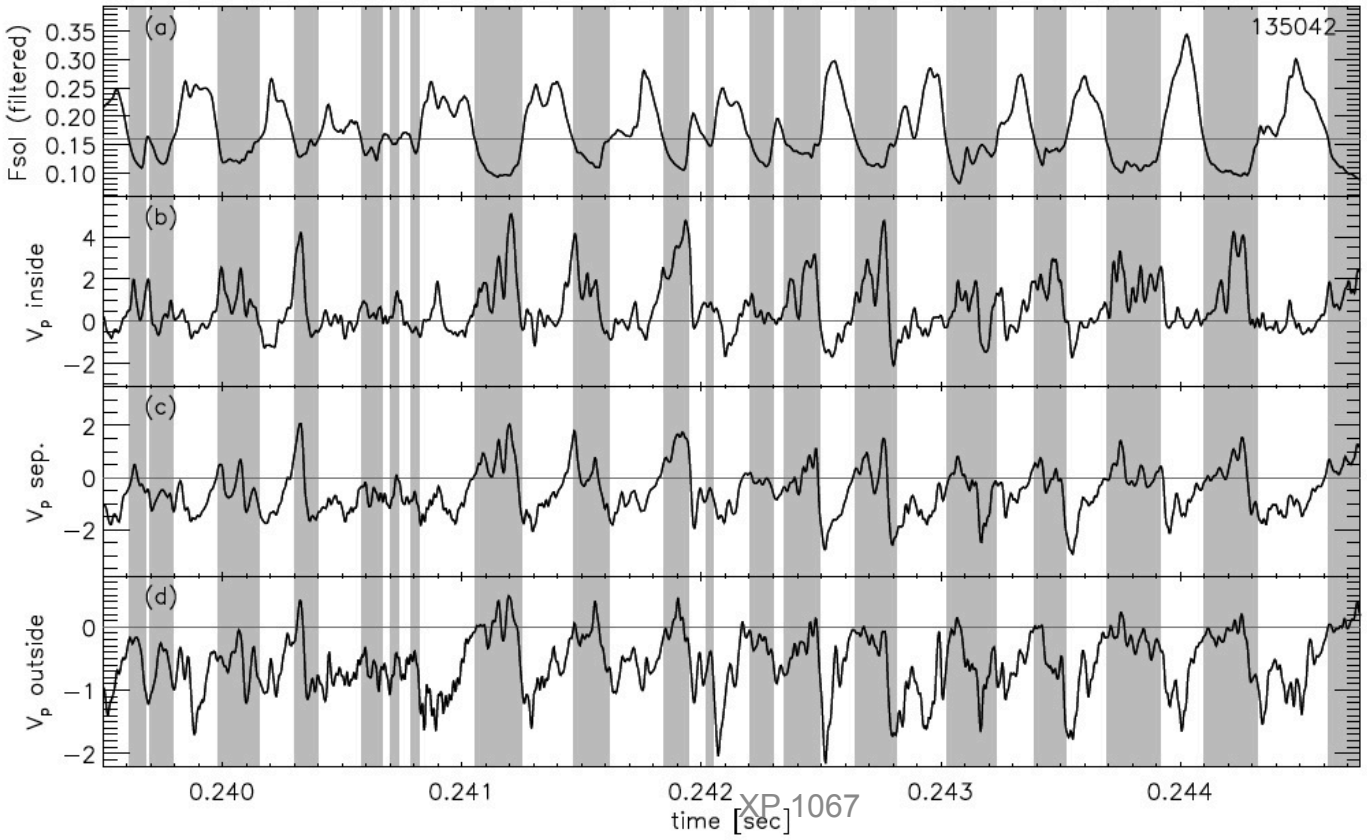




Sechrest, Munsat

Quiet Periods Correlated with Flow

Quiet periods and blob formation correlate with flow in electron diamagnetic drift direction



GPI F_{sol}

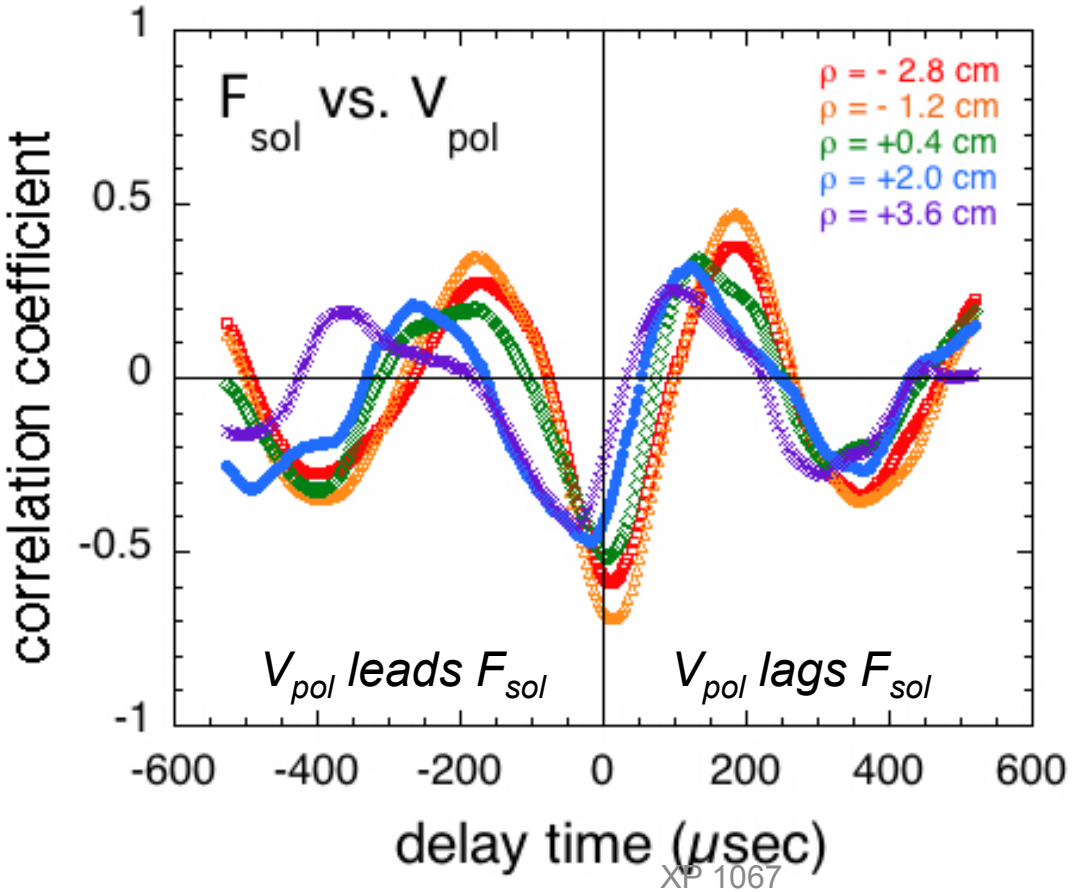
V_p inside

V_p @ sep.

V_p outside

Does Zonal Flow Cause Quiet Periods ?

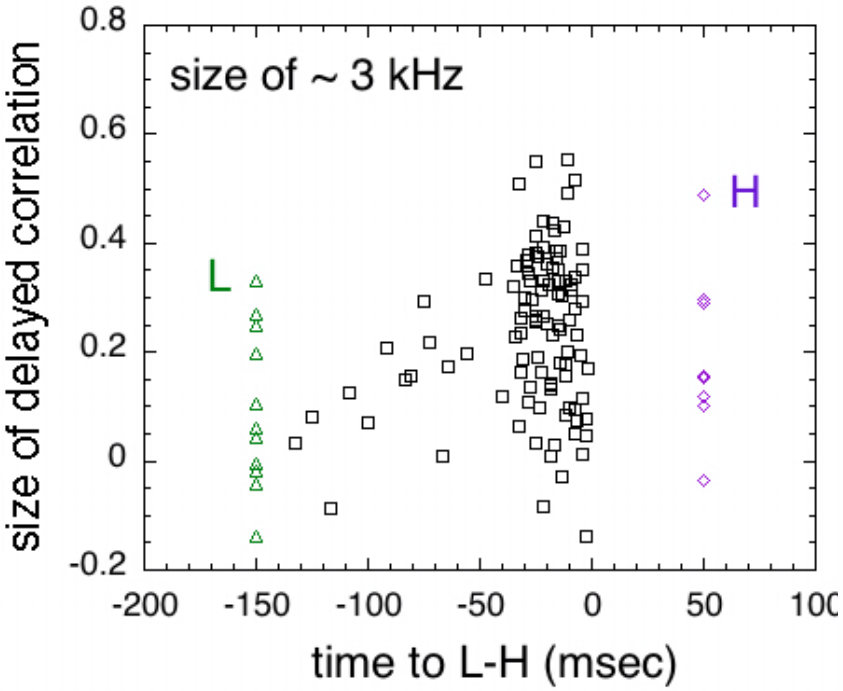
Delay time of peak of cross-correlation function between V_{pol} and quiet periods can be positive or negative !

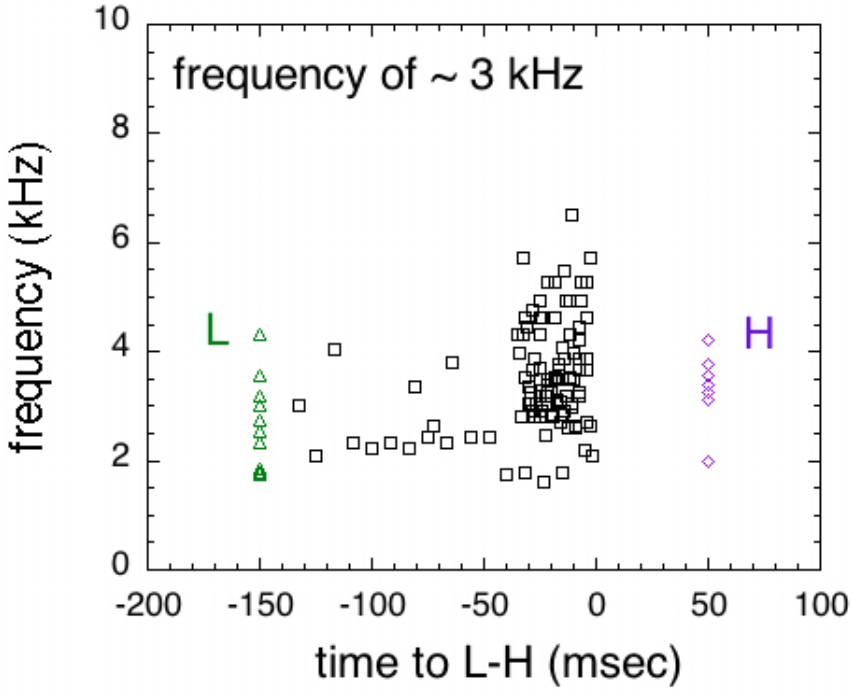


⇒ causal relationship not yet clear

Does Zonal Flow Cause L-H Transition ?

No apparent change in quiet period/zonal flow oscillation within 30 msec of L-H transition in shots seen so far





Geodesic Acoustic Mode (GAM) Analysis

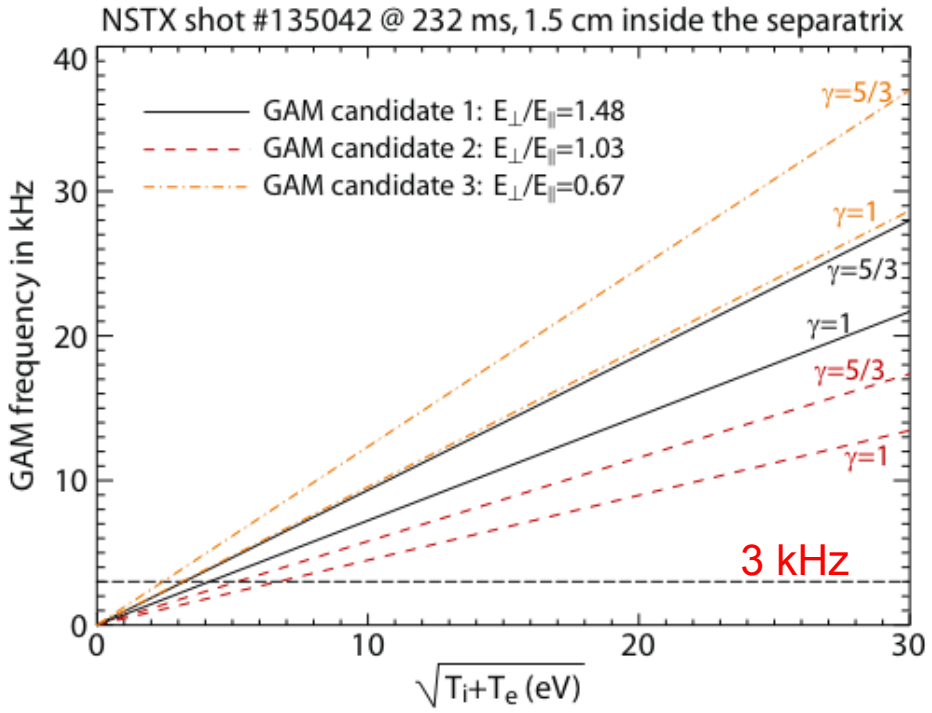
R. Hager, K. Hallatschek -- IPP Garching

- GAM expected roughly at f(Hz)= $(1/\pi R)\,[\gamma(T_i+T_e)/m_i]^{1/2}$ G

- linear NLET simulations show three GAM candidates for NSTX #135042

- nonlinear simulations show low frequency mode (red) excited at 3 kHz for $T_i+T_e \sim 40$ eV

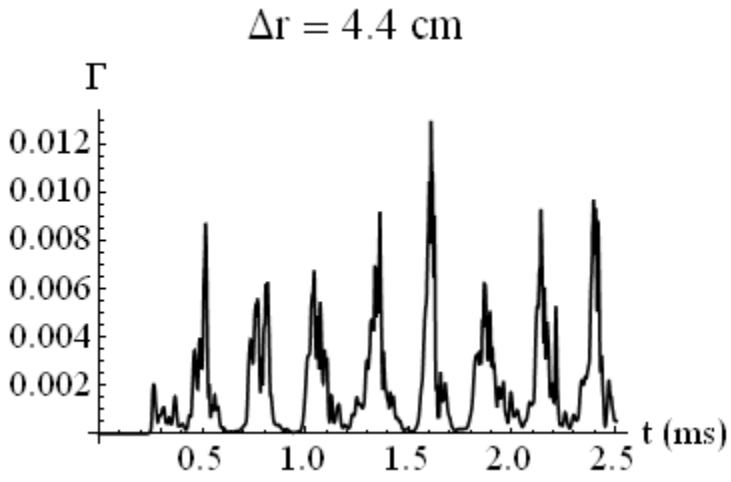
=> could be GAM

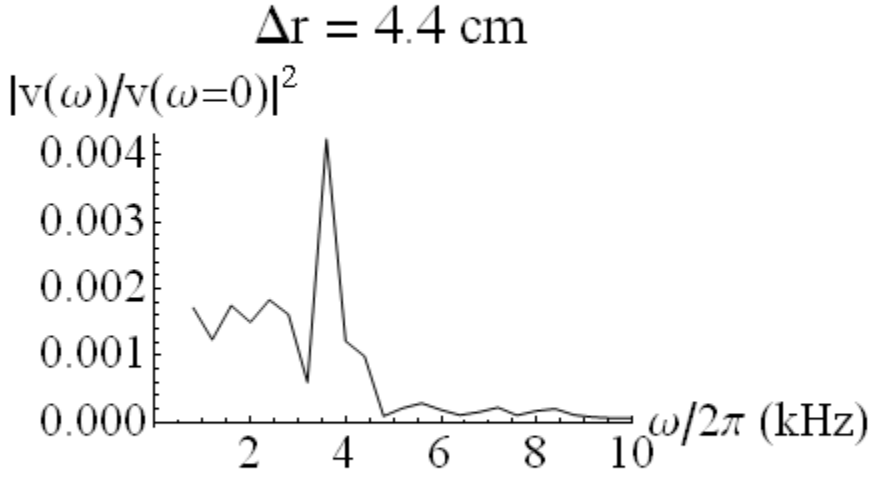


Edge Zonal Flow Analysis

D.A. Russell, D.A. D'Ippolito, J.R. Myra -- Lodestar

- SOLT 2-D simulation of NSTX shows 'bursty' behavior in SOL quasi-periodic V_{pol} modulation at ~ 4 KHz (D.A. Russell et al PoP 16, 122304 (2009)





=> could be zonal flow (GAM not in SOLT)

Motivations for new XP

- APS invited talk: "Quiet periods, zonal flows, and blob formation in the edge turbulence of NSTX"

- See quiet periods/zf/blob formation in *different* plasmas

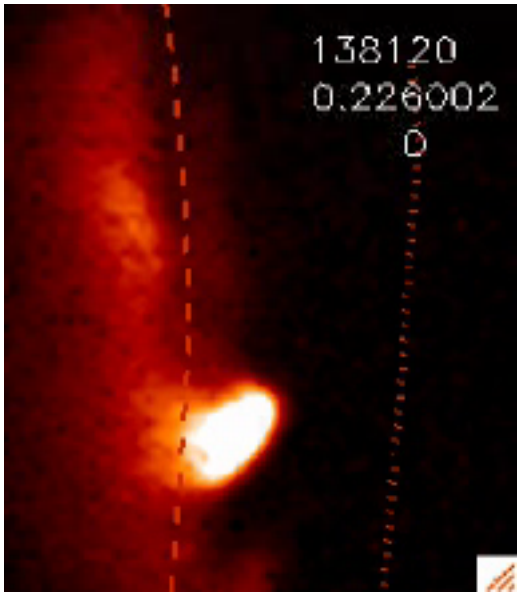
  - scaling of GAMs expected to be $f \sim (T_e + T_i)^{0.5} \sim$ NBI
  - scaling of SOLT zonal flows unknown at present

- Utilize upgraded Phantom 710 camera with 400,000 f/s at 64x80 pixels vs. Phantom 7.3 + 7.1 last year with 285,000 f/s at 64x64 pixels

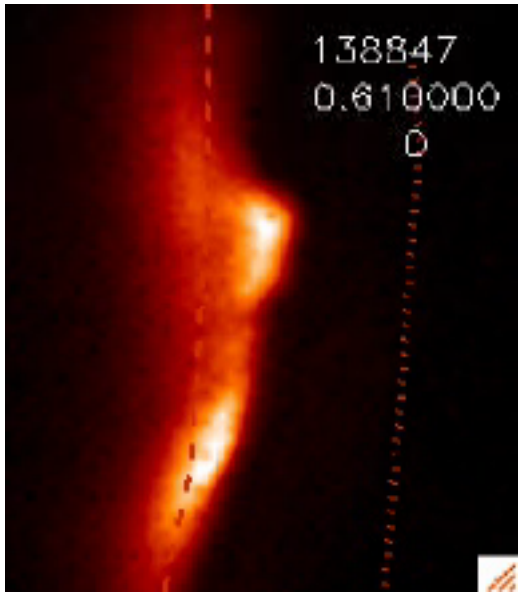
Example of Upgraded GPI Movies

Phantom 710 camera data taken by R. Maqueda at 400,000 frames/sec

Ohmic 4.5 kG / 0.9 MA



4 MW NBI 4.5 kG / 0.8 MA

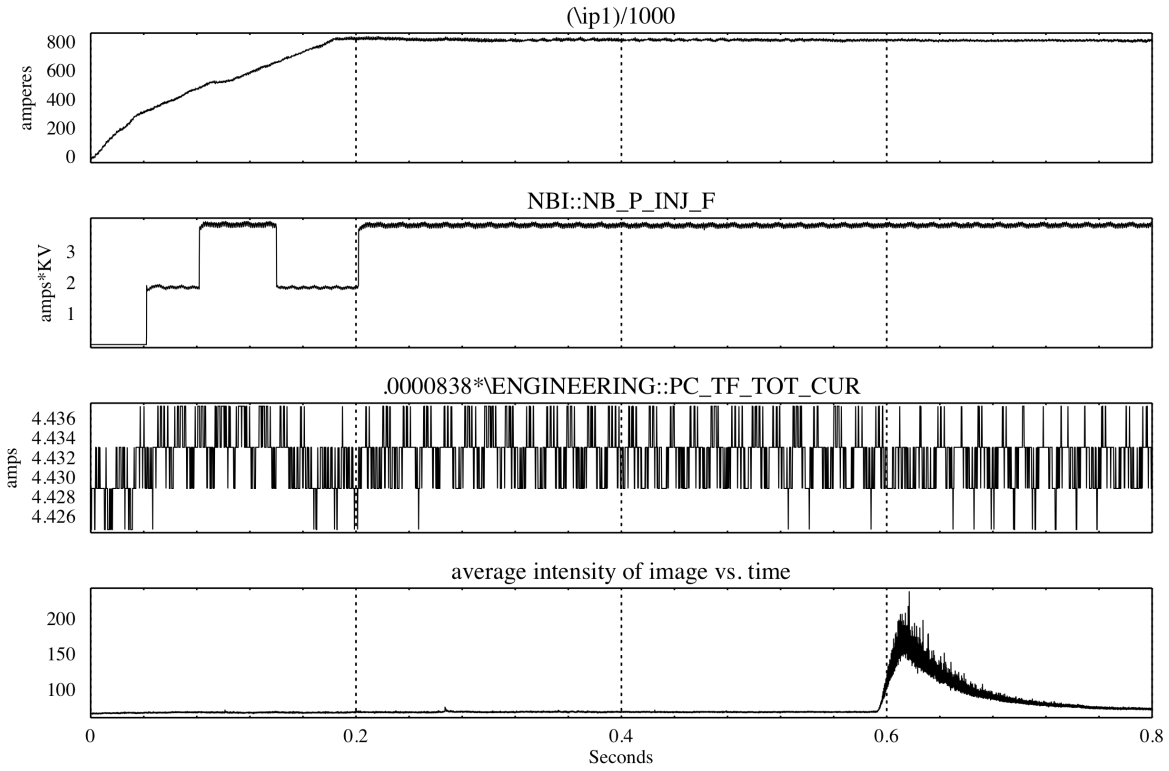


Requirements for new XP

- Need B/I = 4.5 kG / 0.9 MA for optimal GPI alignment
- Would like to see both Ohmic and NBI plasmas to get largest possible range of edge temperature (RF cases will be done by Battaglia in XP #1036)
- Would like to get ~ six shots at each condition to get best possible edge profiles from TS, CHERS, etc
- Would like to vary GPI timing to get data for various times during shot (GPI does ~ 50 msec/shot)

Template for XP from 138847

Shots:
138847



Shot List for new XP

At each B/I condition, vary GPI timing three times

shot #	B (kG)	I (MA)	Beam #1	Beam #2	Beam #3
1	4.5	0.8	0.3 sec	0.35 sec	0.40 sec
2	4.5	0.8	0.3 sec	0.35 sec	0.40 sec
3	4.5	0.8	0.3 sec	0.35 sec	0.40 sec
4	4.5	0.8	0.3 sec	0.35 sec	0.40 sec
5	4.5	0.8	0.3 sec	0.35 sec	0.40 sec
6	4.5	0.8	0.3 sec	0.35 sec	0.40 sec
7	3.0	0.53	0.25 sec	0.30 sec	
8	3.0	0.53	0.25 sec	0.30 sec	
9	3.0	0.53	0.25 sec	0.30 sec	
10	3.0	0.53	0.25 sec	0.30 sec	
11	3.0	0.53	0.25 sec	0.30 sec	
12	3.0	0.53	0.25 sec	0.30 sec	
13	6.0	0.98	0.35 sec	0.4 sec	0.45 sec
14	6.0	0.98	0.35 sec	0.4 sec	0.45 sec
15	6.0	0.98	0.35 sec	0.4 sec	0.45 sec
16	6.0	0.98	0.35 sec	0.4 sec	0.45 sec
17	6.0	0.98	0.35 sec	0.4 sec	0.45 sec
18	6.0	0.98	0.35 sec	0.4 sec	0.45 sec

Additional Diagnostics Wanted

- UCLA reflectometer
- Wisconsin BES
- UCSD probe
- CHERS T_i and V_{pol} (edge)
- ERD near separatrix
- high k-scattering
- SWIFT
- USXR edge