Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: **Validation of M3D-K code for beam-driven TAE modes**		
OP-XP-1015	Revision:	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: G-Y. Fu	Date
ATI – ET Group Leader: G. Taylor	Date
RLM - Run Coordinator: E. Fredrickson	Date
Responsible Division: Experimental Research Operations	

RESTRICTIONS or MINOR MODIFICATIONS
(Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

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AUTHORS: **Fu, Podestà, Crocker, Smith** DATE: **04/24/2010**

1. Overview of planned experiment

The experiment is aimed at providing a complete data set on structure and dynamics of toroidicity-induced Alfven eigenmodes (TAEs) for the validation of the M3D-K code and for the comparison with other linear codes, such as NOVA-K. It will complement a similar experiment from the 2009 Run with improved diagnostic coverage for mode structure measurements, including BES and the upgraded 16-channel reflectometer system. The experimental results will be compared with the predictions of the M3D-K code. In order to facilitate the comparison, the scenario will be optimized to maximize the duration of the phase with weakly turbulent (or *quasi-stationary*) TAEs. The starting point for this experiment is the center-stack limited L-mode scenario developed in 2009 (e.g. shot no. 135388). Scans of neutral beam power and, if time permits, plasma density up to $8x10^{19}$ m^{-3} are planned.

The run time allocated for this experiment is 0.5 day.

2. Theoretical/ empirical justification

During the past years, the conditions leading to the destabilization of TAEs and the resulting TAE dynamics have been explored at relatively low density ($<4x10^{19}m^{-3}$) and with limited diagnostics to measure the mode structure. The proposed XP will complement previous TAE studies on NSTX. New diagnostics are available in FY10 for a detailed characterization of the mode structure and its temporal evolution, as required for code validation purposes.

This XP supports the (incremental) NSTX FY12 Milestone for the WPI-TSG and ITPA task EP-2:

- NSTX milestone 2012: *"Assess predictive capabilities for the fast ion transport by Alfvénic modes"*

- ITPA EP-2: *"[Investigate] fast ion losses and redistribution from localized Alfvén eigenmodes"*

3. Experimental run plan

The starting point is to reproduce the baseline scenario from XP-916 (2009 Run). The target is a L-mode deuterium plasma limited by the center-stack, with central density ~$3x10^{19}$ m^{-3} at t~300 ms. A good model is shot no. 135388, where TAEs are observed from 250 ms to 390 ms. The typical NB timing is shown in Fig. 1, with source A @ 90kV being used before/after the time window of interest to document the evolution of the q-profile. Compared to the 2009 scenario, the plasma will be more strongly pushed against the center-stack to force a limited configuration in the time window 200-450ms. *[2 shots]*

Once a good plasma configuration is established, a quick NB power (voltage) scan with source C is performed to identify the marginally stable case. The goal is to maximize the duration of the phase with quasi-stationary TAEs. To achieve this goal, the NB timing might need to be modified with respect to the model shot. *[3 shots]*

After the new baseline scenario is identified, the mode evolution and radial structure are documented with BES and reflectometers. BES will be configured to measure a radial profile (no poloidal views) to maximize the spatial resolution in the radial direction. Three "repeat" discharges are planned to improve statistics and verify the reproducibility of TAE behavior. *[3 shots]*

Finally, the time evolution of the q-profile is documented throughout the entire discharge. To this purpose, the onset of the second pulse of NB source A is moved back in time in steps of 40 ms and right after the beginning of the quasi-stationary TAE phase. *[4 shots]*

If time permits, the baseline scenario will be repeated for higher values of central plasma density (up to $8x10^{19}$ m^{-3} at t~300 ms).

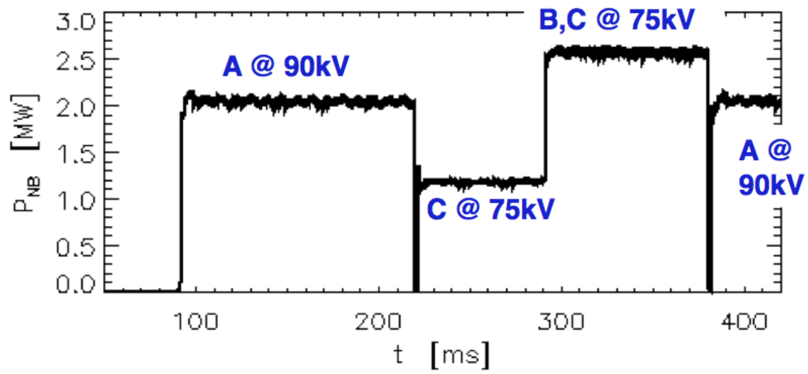

Figure 1: Neutral Beam waveform for the target scenario. The exact timing/injection voltage for sources B and C will be optimized in the initial part of the experiment.

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

The level of impurities (in particular, oxygen) in the machine must be low enough to not compromise measurements with FIDA.

BES (at least 8 radial channels, although 16 channels would be ideal) and reflectometers are required.

All fast ion and profile diagnostics are required (FIDA, NPA, ssNPA, sFLIP, neutrons, MPTS, CHERs, MSE).

LITERs will be used with ~10mg/min (total) deposition rate for 10 min. shot cycle.

5. Planned analysis

TRANSP, LRDFIT with MSE constraint, M3D-K, NOVA-K.

6. Planned publication of results

The results will be published in journals such as PoP, PPCF and/or NF and presented at the major plasma physics meetings (e.g. IAEA, APS).

PHYSICS OPERATIONS REQUEST

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Brief description of the most important operational plasma conditions required:

Low oxygen content in the machine is needed. Center-stack should be sufficiently well conditioned by previous plasma operations.

Reproducible discharges. In particular, plasma density should not change significantly from one discharge to the next. LITERs will be used with a total of ~10 mg/min deposition rate.

Two NB sources (B, C) are used at de-rated injection voltage, down to 60kV.

Previous shot(s) which can be repeated:

Previous shot(s) which can be modified: 135388 (pushing harder on center-stack)

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

I_{TF} (kA): **66 [B_{tor}=5.5kG]** Flattop start/stop (s): **0/0.7**

I_P (MA): **0.9** Flattop start/stop (s): **0.2/0.6**

Configuration: **Limiter**

Equilibrium Control: **Outer gap / Isoflux** (rtEFIT) **/ Strike-point control** (rtEFIT)

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

Elongation: Triangularity (U/L): OSP radius (m):

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

NBI Species: **D** Voltage (kV) **A: 90** **B: 60-90** **C:** 60-90 Duration (s): **0.5**

ICRF Power (MW): **none** Phase between straps (°): Duration (s):

CHI: **Off** Bank capacitance (mF):

LITERs: On Total deposition rate (mg/min): **~10**

LLD: Off Temperature (°C):

EFC coils: Off Configuration: N/A

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	Need	Want
Beam Emission Spectroscopy	√	
Bolometer – divertor		
Bolometer – midplane array		
CHERS – poloidal		√
CHERS – toroidal	√	
Dust detector		
Edge deposition monitors		
Edge neutral density diag.		
Edge pressure gauges		
Edge rotation diagnostic		√
Fast cameras – divertor/LLD		
Fast ion D_alpha - FIDA	√	
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP	√	
Filterscopes		
FIReTIP	√	
Gas puff imaging – divertor		
Gas puff imaging – midplane		
Hα camera - 1D		
High-k scattering		√
Infrared cameras		
Interferometer - 1 mm		
Langmuir probes – divertor		
Langmuir probes – LLD		
Langmuir probes – bias tile		
Langmuir probes – RF ant.		
Magnetics – B coils	√	
Magnetics – Diamagnetism		
Magnetics – Flux loops	√	
Magnetics – Locked modes		
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 detectors	√	
Plasma TV		
Reflectometer – 65GHz		
Reflectometer – correlation		
Reflectometer – FM/CW		
Reflectometer – fixed f	√	
Reflectometer – SOL		
RF edge probes		
Spectrometer – divertor		
Spectrometer – SPRED		
Spectrometer – VIPS		√
Spectrometer – LOWEUS		
Spectrometer – XEUS		
SWIFT – 2D flow		
Thomson scattering	√	
Ultrasoft X-ray – pol. 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 tang. pinhole camera		