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 **02/15/2010**
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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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 the experiment from the 2009 Run with an improved diagnostic coverage for mode structure measurements, including BES and a new 16-channel reflectometer system. The experimental results will be compared with the predictions of the M3D-K code. In order to facilitate the comparison with the codes, 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 expand the parameter range for TAE studies on NSTX. New diagnostics are available in FY11 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: *“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. 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. [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. These conditions are repeated for at least three “identical” discharges to acquire statistical information and verify the reproducibility of TAE behavior. [3 shots]

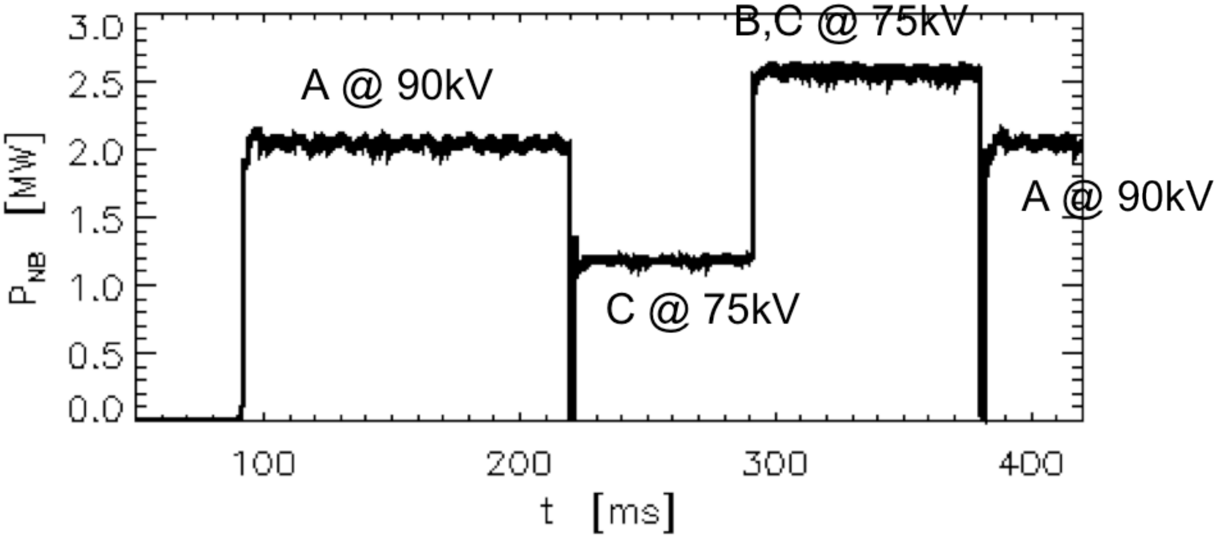

Figure 1: Neutral Beam waveform for the target scenario. The exact timing/injection voltage for B and C will be optimized in the initial part of the experiment.

Next, the time evolution of the q-profile is documented throughout the entire discharge by anticipating the onset of the second pulse of NB source A in steps of 40 ms. [4 shots]

If time permits, the baseline scenario is finally repeated for higher values of central plasma density (about 8 x 10^19 m^-3 at t~300 ms).

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 diagnostics are required (FIDA, NPA, ssNPA, sFLIP).

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.

Reproducible discharges. In particular, plasma density should not change significantly from one discharge to the next. Based on the results from LLD commissioning and from the first XPs, LLD might be used to achieve a better density control.

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

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

I_{TF} (kA): **66 [B_{tor}=5.5kG]** Flattop start/stop (s): **0/0.8**

I_P (MA): **0.9** Flattop start/stop (s): **0.2/0.7**

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): **0.6**

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

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

LITERs: On Total deposition rate (mg/min): **t.b.d.**

LLD: t.b.d. Temperature (°C): **t.b.d.**

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		