Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Study of stability boundaries for CAE modes

OP-XP-208	**Revision:**	Effective Date: *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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ATI - Task Force Leader: J Menard	Date
RLM - Run Coordinator: R. Maingi	Date

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

Effect of CAE Modes on Plasma Performance

1. Overview of planned experiment

The experiment will document the stability boundaries for CAE activity. The approach will focus on the dimensionless parameter ζ = Vbeam/VAlfvén, but will also explore the dependence of the stability boundary on q. The three experimental knobs which change ζ are the density, the toroidal field and the beam voltage.

The target plasma will be similar to that used in the last experiment, 0.7 or 0.8 MA with a flattop to about 0.35s. For this XP we will likely use two 40 ms beam pulses, separated by 20 ms during the Ip flattop. This will give two beam voltage data points per shot.

The goal will be to measure the beam voltage threshold for CAE onset under conditions of the lowest and highest plasma density and at the highest and lowest operationally available toroidal fields.

The secondary goal might be to study CAE activity in cases where the beams are poorly confined – at plasma currents of 300 – 500 kA. By causing large beam ion losses, we can control in a limited way the fast ion population characteristics. It may also be useful, for comparison, to document operation at 1 MA.

2. Theoretical/ empirical justification

The CAE modes have been suggested as a possible mechanism to transfer beam ion energy to the thermal ion population. The potential observation of a mechanism transferring energy from the fast ion population to the thermal ion population, avoiding the lossy electron channel, is of great interest to the MFE community. The goal of this xp is to empirically determine the range of fast ion and plasma parameters where discrete CAE modes exist.

3. Experimental run plan

The beam voltage adjustments are the most time-consuming. The plan will be to start with all beams at 75 kV. Over the course of the day the beam voltages will be decreased until sources A&C are at 60 kV or lower.

Assume initial beam voltage is 75 kV; reproduction of shots, source A-C switch optional. Largest range in density desired.

Intermediate beam voltages may be dropped if time is short.

Initial plasma current is 900 kA, may be lowered if long flattops can't be made at this current.

ζ) Density scan, 900 kA, TF 70 kA. (2-5 shots)

1) Lowest density. Source B in current ramp. Sources A and C in flattop. First A, C then C, A.
2) If no CAE raise density as high as possible.
3) If CAE appear, try intermediate point

A) Density scan, 900 kA, TF 52 kA. (2-5 shots)

4) Lowest density. Source B in current ramp. Sources A and C in flattop. First A, C then C, A.
5) If no CAE raise density as high as possible.
6) If CAE appear, try intermediate point

B) TF scan, 900 kA, TF 43 kA (only if no CAE in A). (2-5 shots)

7) Lowest density. Source B in current ramp. Sources A and C in flattop. First pair of shots are A, C. Second pair are C, A.
8) If no CAE raise density as high as possible.
9) If CAE appear, try intermediate point

C) TF scan, 900 kA, TF 34 kA (only if no CAE in B). (2-5 shots)

10) Lowest density. Source B in current ramp. Sources A and C in flattop. First pair of shots are A, C. Second pair are C, A.
11) If no CAE raise density as high as possible.
12) If CAE appear, try intermediate point

D) Gap scan, 900 kA, TF 52 kA, gap jog (as time permits) (2-4 shots)

13) Lowest density. Source B in to 320 ms. Outer gap at 10 cm 0.2-0.23s, move out to 5 cm from 0.23-0.25 s.
14) Lowest density. Source B in to 320 ms. Outer gap at 5 cm 0.2-0.23s, increase to 10 cm from 0.23-0.25 s.

Step source A&C beam voltage down to 70 kV and repeat steps A-C as indicated

Step source A&C beam voltage down to 65 kV and repeat steps A-C as indicated

Step source A&C beam voltage down to 60 kV and repeat steps A-C as indicated

E) Ip = 400 kA(?), TF = 52 kA(?) (2 shots)

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

This XP requires an operational NBI system. As it will rely heavily on the diagnostic capability to detect high frequency modes, the high-n and high-f Mirnov arrays should be functional. (High n is desired for mode analysis of lower frequency modes.) Upgraded (heterodyne) reflectometer desired, scanning reflectometer required. Analysis of the results, beyond simple empirical scaling, will require detailed profile data; thus, Thomson scattering, CHERS are required and MSE would be highly desirable.

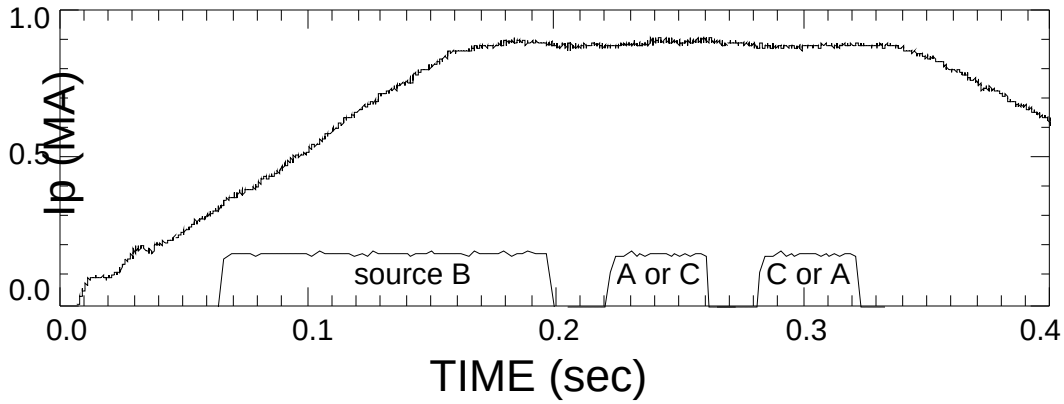
5. Planned analysis

Power balance analysis requires EFIT and TRANSP. Higher level analysis requires TRANSP to feed parameters to codes such as NOVA-k, M3D-k, HINST, etc.

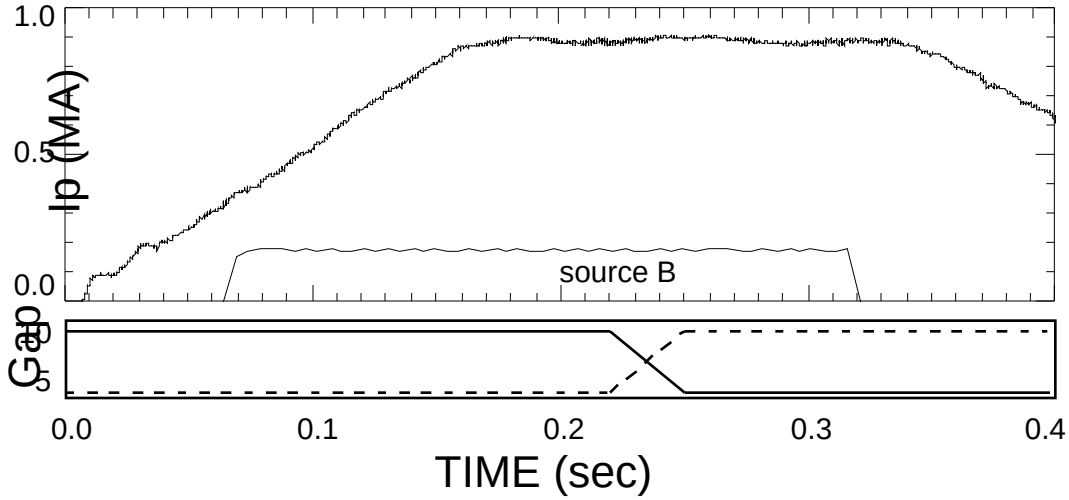
6. Planned publication of results

The initial results will likely be suitable for a Journal article. If more extensive data on plasma parameters is available, allowing for more extensive analysis and simulations, further articles could be written.

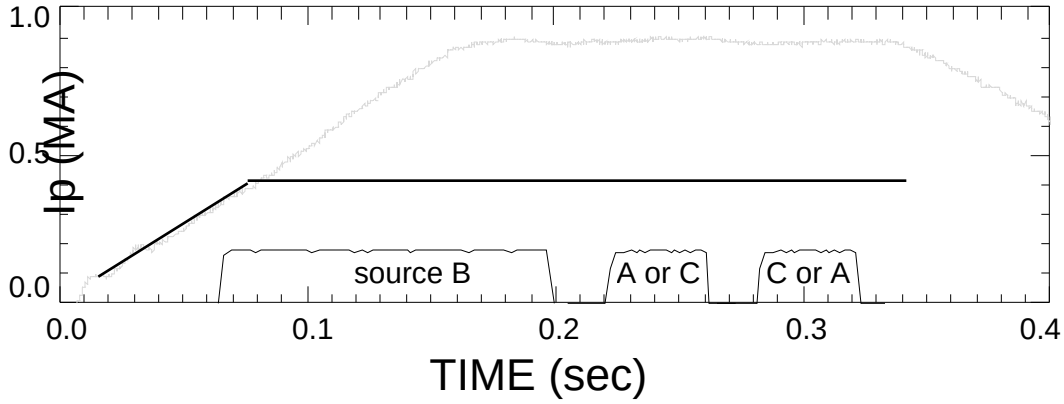
TF, beam voltage and density scans:



Gap jog:



Lower Ip, beam loss experiment:



PHYSICS OPERATIONS REQUEST

Title: _Study of stability boundaries for CAE modes **No.: _208_____**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **24-70** Flattop start/stop (s): _____/_____

I_P (MA): **0.4-1.0** Flattop start/stop (s): **0.06/0.18**

Configuration: **Inner Wall / Lower Single Null / Upper SN / TBD**

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

Elongation κ: _____, Triangularity δ: _____

Z position (m): **0.00**

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

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): **55-80**, Duration (s): **0.04 - 0.24**

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

CHI: **Off**

Either: List previous shot numbers for setup: **106242**

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 system	**Need**	**Desire**	**Requirements** (timing, view, etc.)
Magnetics	✓		
Fast visible camera		✓	
VIPS-1		✓	
VIPS-2		✓	
SPRED		✓	
GRITS		✓	
Visible filterscopes		✓	
VB detector		✓	
Midplane bolometer	✓		
Diamagnetic flux		✓	
Density interferometer (1mm)		✓	
FIReTIP interf'r/polarimeter		✓	
Thomson scattering	✓		
CHERS	✓		
NPA		✓	
X-ray crystal spectrometer		✓	
X-ray PHA		✓	
EBW radiometer			
Mirnov arrays	✓		
Locked-mode detectors		✓	
USXR arrays		✓	
2-D x-ray detector (GEM)		✓	
X-ray tangential camera		✓	
Reflectometer (4 ch.)	✓		Scanning mode
Neutron detectors	✓		
Neutron fluctuations	✓		
Fast ion loss probe	✓		
Reciprocating edge probe			
Tile Langmuir probes			
Edge fluctuation imaging			
H-alpha cameras (1-D)			
Divertor camera (2-D)			
Divertor bolometer (4 ch.)			
IR cameras (2)			
Tile thermocouples			
SOL reflectometer			