Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: **Investigation of Ion Transport with Beam Modulation**

OP-XP-831	Revision:	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author:	Date
ATI – ET Group Leader:	Date
RLM - Run Coordinator:	Date

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

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AUTHORS: **P.Ross** DATE: **Apr 18, 2008**

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1. Overview of planned experiment

The goals of this Experimental Proposal are to investigate the ion power balance by determining effects of beam modulation on the fast ion distribution and then the effects of longer beam modulation on the thermal ion population. The fast ion population comes from beam-plasma charge exchange and represents a source term in the ion power balance equation, so this will be studied first. To study the fast ion population, the beam power will be modulated under plasma conditions which have no large MHD modes. The fast ion distribution will be measured using the NPA, incorporating the Edge Neutral Density Diagnostic which will measure the neutral density profile in the edge of the plasma.

Beam modulation will also be used to affect the thermal ion population. The secondary goal is to establish regions of anomalously high ion temperatures, where the ion temperature is greater than is estimated assuming neoclassical diffusion.

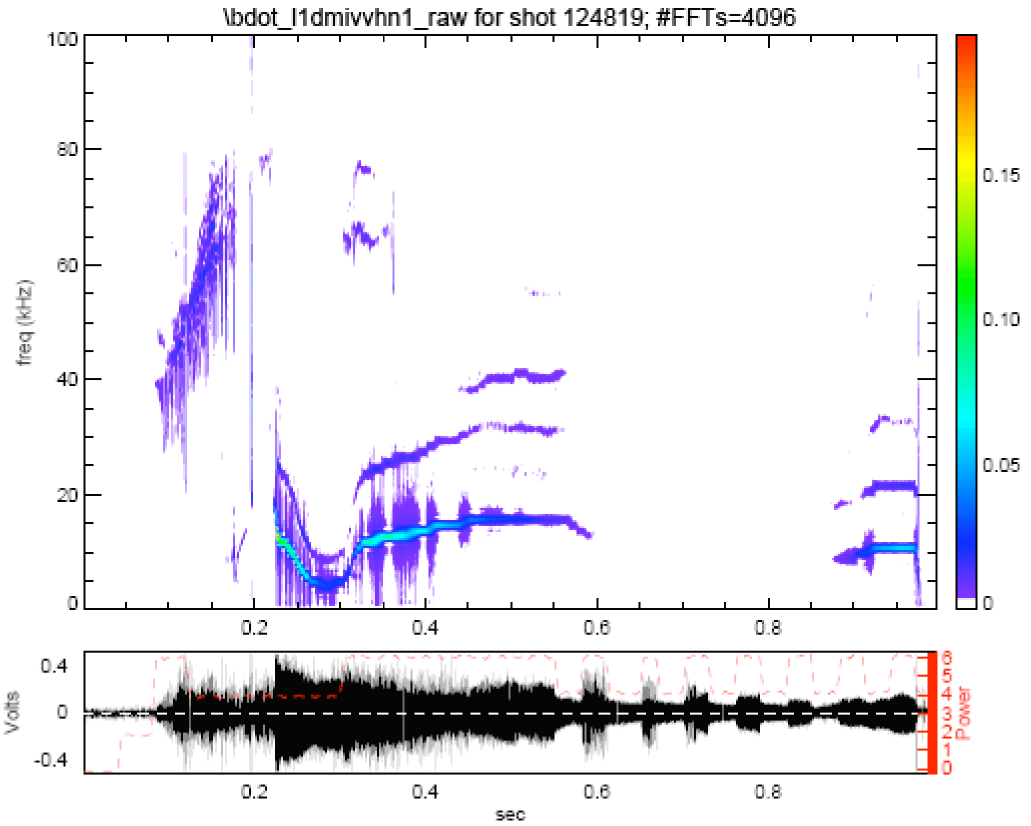
2. Theoretical/ empirical justification

The investigation of ion power balance was begun with XP 737. However, during XP 737, the neutral particle analyzer was positioned to view at a tangency radius of 80, 100, 120 cm. It was assumed that the modulations from source B would be visible at these tangency radii.

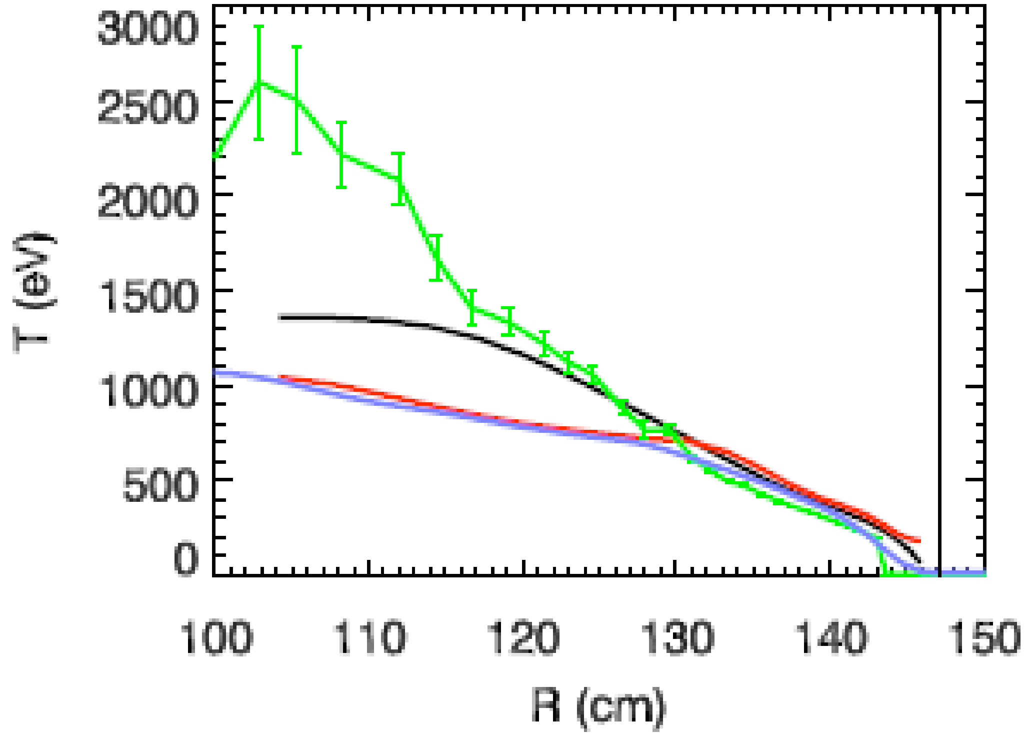
This turned out not to be the case. Preliminary TRANSP simulations of shot 125332 using an MSE constrained q-profile show that with the NPA aligned on a tangency radius of 80 cm, the NPA would barely catch the edge of the beam deposition profile. At larger radii, the NPA completely missed the beam deposition area. As a result, XP 737 failed to show a significant effect of the beam modulations on the fast ion distribution. The final calculations will be finished before the XP runs. When the intersection of the NPA sightline and the fast ion distribution function is calculated, we will perform a fine scan of the NPA in that region.

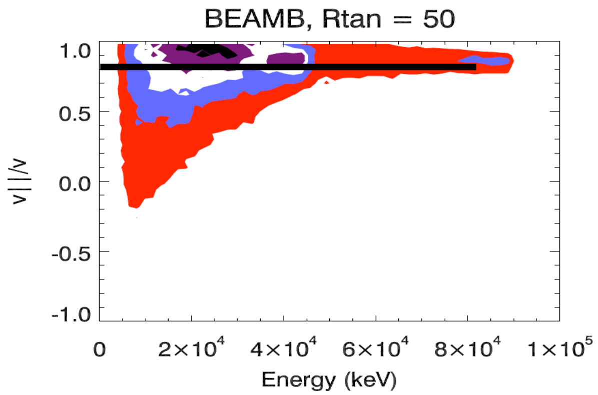
However, XP 737 demonstrated the feasibility of reproducing shots with a long period that was free from large amplitude, low frequency MHD activity. This is critical in mitigating any fast ion redistribution in order to more accurately measure the fast ion population with the NPA. This will be important for the TRANSP analysis.

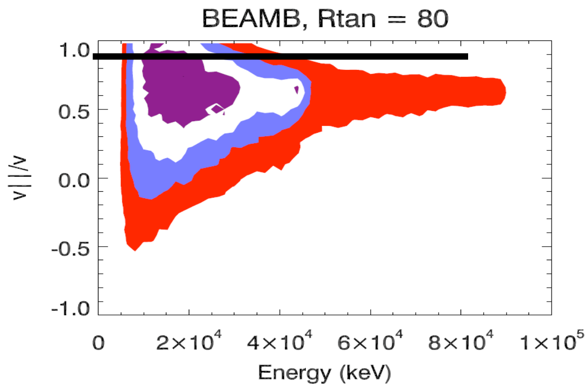
High ion temperatures have been observed during the 2008 run campaign. While it is unclear yet whether these measurements are valid, they raise interesting questions about the ion power balance. TRANSP analysis shows that if these temperatures are accurate, they represent an anomalously high ion temperature. This XP hopes to reproduce those high ion temperatures and analyze the heating mechanism.

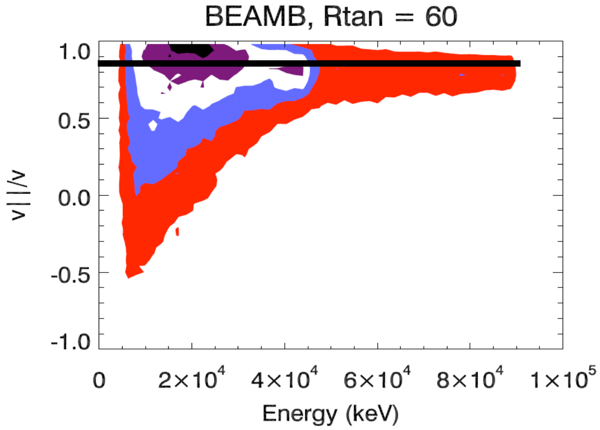


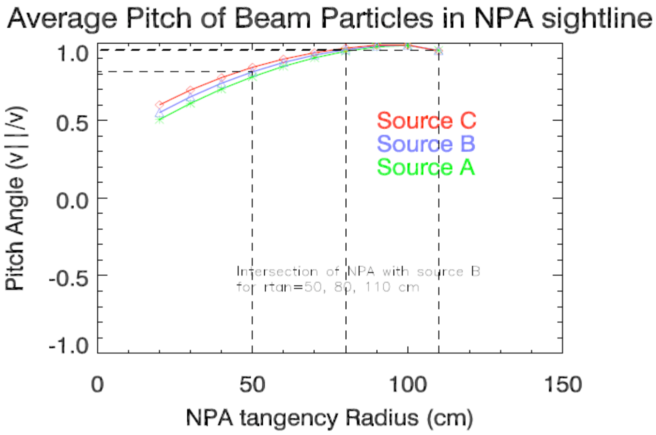
Ion and electron Temperatures, shot 127953




BEAMB, Rtan = 50

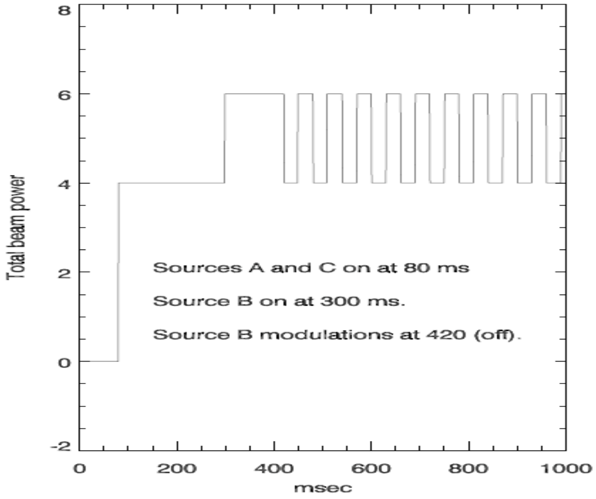

BEAMB, Rtan = 80


BEAMB, Rtan = 60

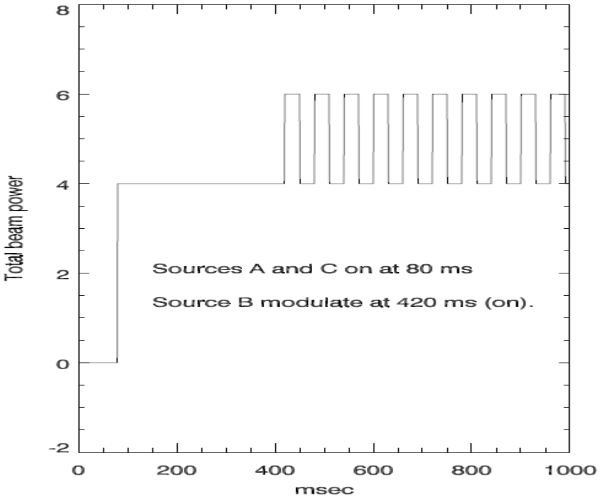

Average Pitch of Beam Particles in NPA sightline

3. Experimental run plan

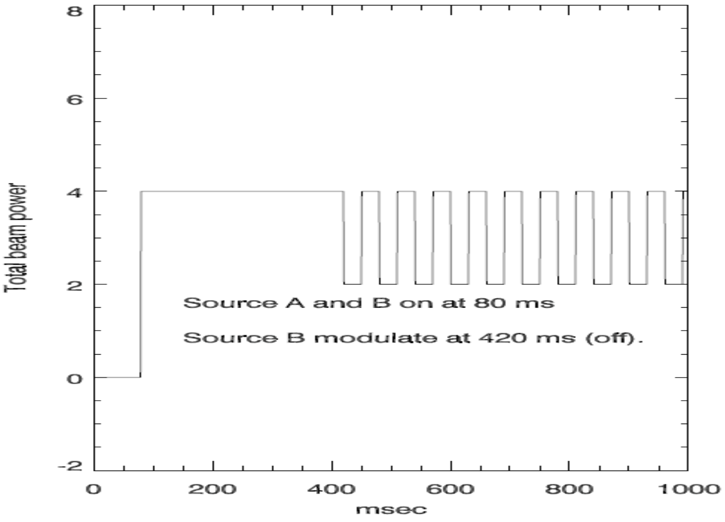
The base shot for this XP is 127593. The first part will consist of developing a shot that will provide the maximum signal. There are 3 potential beam configurations we plan to test. The first configuration has sources A and C coming on at 80 ms. Source B comes on at 300 ms, then begins modulating at 420 ms (turning off at 420, then back on at 450). All modulations will be 30 ms.



The second configuration has sources A&C coming on at 80 ms. Source B begins modulations at 420 ms (turns on at 420 ms, then off at 450).



The third configuration has sources A and B coming on at 80 ms. Source B begins modulations at 420 ms (turns off at 420 ms).



All of these three configurations will be run with the NPA set to a tangency radius of 50 cm. From the data, we will pick a shot configurations that gives the strongest NPA signal and we will perform a spatial scan from 40-60 cm in 5 cm steps, to ensure that we capture the beam profile. Finally, we will repeat the best shot at RTAN to get useful statistics.

The second half of the XP will be performed off the midplane. We will use the optimal configuration from the first section for the second half. We will perform the spatial scan from 40-60 at a vertical angle of 4 degrees, then repeat at 8 degrees. We will also repeat shots at the best locations in each vertical angle for statistics.

Shotlist:

1st half (16 shots)

3 different beam configurations (3 shots)

Spatial scan (Rtan=40,45,50,55,60) (5 shots)

Statistical gathering (8) shots

2nd half (16 shots)

Spatial scan at 4 degrees (Rtan=40,45,50,55,60) (5 shots)

Statistics shots (3 shots)

Spatial scan at 8 degrees (Rtan=40,45,50,55,60) (5 shots)

Statistics shots (3 shots)

Total (32 shots)

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

See the attached diagnostic requirement worksheet.

5. Planned analysis

Data analysis will largely focus on the NPA and CHERS data. These two diagnostics will be complimented by the addition of the Edge Neutral Diagnostic, which will measure the profile of the edge neutral particles.

The shots will be simulated in TRANSP to analyze the beam neutrals and study the ion power balance. Specifically, the discharges will be examined to study the fast ion population and the thermal ion diffusion and heat transfer to the electrons

6. Planned publication of results

The results will be published in a PPPL report, as well as reported at the DPP08 conference. These results are also an integral part of P. Ross's dissertation.

PHYSICS OPERATIONS REQUEST

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Machine conditions (specify ranges as appropriate)

I_{TF} (kA):54kA Flattop start/stop (s): 0.22

I_P (MA):0.9 Flattop start/stop (s): 1.0

Configuration: **LSN**

Outer gap (m): **0.1** Inner gap (m): **.06**

Elongation κ: **2.3** Upper/lower triangularity δ: **0.4/0.8**

Z position (m): **0**

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

NBI Species: **D** Sources:A,B,C Voltage (kV): 90 Duration (s): 1.0

ICRF Power (MW): OFF Phasing: Duration (s):

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

LITER: Off

Previous shot numbers for setup: **127953**

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array		**X**
Bolometer – divertor		**X**
CHERS – toroidal	**X**	
CHERS – poloidal	**X**	
Divertor fast camera		**X**
Dust detector		**X**
EBW radiometers		**X**
Edge deposition monitors		**X**
Edge neutral density diag.	**X**	
Edge pressure gauges	**X**	
Edge rotation diagnostic	**X**	
Fast ion D_alpha - FIDA	**X**	
Fast lost ion probes - IFLIP		**X**
Fast lost ion probes - SFLIP	**X**	
Filterscopes		**X**
FIReTIP		**X**
Gas puff imaging	**X**	
Hα camera - 1D		**X**
High-k scattering		**X**
Infrared cameras		**X**
Interferometer - 1 mm		**X**
Langmuir probes – divertor		**X**
Langmuir probes – BEaP		**X**
Langmuir probes – RF ant.		**X**
Magnetics – Diamagnetism		**X**
Magnetics – Flux loops	√	
Magnetics – Locked modes		**X**
Magnetics – Pickup coils	√	
Magnetics – Rogowski coils	√	
Magnetics – Halo currents		**X**
Magnetics – RWM sensors		**X**
Mirnov coils – high f.	**X**	
Mirnov coils – poloidal array	**X**	
Mirnov coils – toroidal array	**X**	
Mirnov coils – 3-axis proto.		**X**

Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
MSE	**X**	
NPA – ExB scanning	**X**	
NPA – solid state	**X**	
Neutron measurements	**X**	
Plasma TV		**X**
Reciprocating probe		
Reflectometer – 65GHz		**X**
Reflectometer – correlation		**X**
Reflectometer – FM/CW		**X**
Reflectometer – fixed f		**X**
Reflectometer – SOL		**X**
RF edge probes		**X**
Spectrometer – SPRED		**X**
Spectrometer – VIPS		**X**
SWIFT – 2D flow		**X**
Thomson scattering	**X**	
Ultrasoft X-ray arrays		**X**
Ultrasoft X-rays – bicolor		**X**
Ultrasoft X-rays – TG spectr.		**X**
Visible bremsstrahlung det.		**X**
X-ray crystal spectrom. - H		**X**
X-ray crystal spectrom. - V		**X**
X-ray fast pinhole camera		**X**
X-ray spectrometer - XEUS		**X**