Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: BT and Beta Scaling of Confinement		
OP-XP-532	**Revision:**	Effective Date: *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS	
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RLM - Run Coordinator: J. Menard (S. Sabbagh)	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

1. Overview of planned experiment

This XP combines feature of two approved XPs from last year. The first part of this XP finishes up the confinement scaling by studying the dependence of confinement on toroidal field. The second part looks at the scaling of confinement with both collisionality and beta, the latter being a critical ITPA need..

2. Theoretical/ empirical justification

A) The B_T scaling found by a statistical analysis of 2002 and 2004 data indicate that a strong dependence of confinement on this parameter, much stronger than observed at conventional aspect ratio. This needs to be confirmed (or not) by dedicated scans at constant I_p and constant q (not simultaneously).

B) At present, there is much uncertainty regarding the β-scaling of confinement. While scans from individual experiments exhibit a weak dependence on β_t, a statistical analysis of data taken from the international confinement database from a variety of devices shows a strong dependence on this parameter. The difference in scaling dependences of course results in large uncertainty in scaling confinement to larger devices, assuming β values are different. Furthermore, the difference in scaling leads to uncertainty in understanding the basic physics causing transport in toroidal geometries, whether it is electrostatic or electromagnetic. NSTX can help contribute to resolving this difference in part because of the more extended range of β that is accessible.

In a dimensionless scaling experiment, the approach is to vary one dimensionless parameter while keeping the others as fixed as possible. In the β scan, for instance, other variables such as q, ρ^* and ν^* must be kept constant. According to the main dependences of these parameters, this means that for fixed geometry (R, a, k),

q=constant $\rightarrow B_T/I_p$ = constant

ρ^*=constant $\rightarrow T \propto B^2$

ν^*=constant$\rightarrow n \propto B^4$

With a ν^* scan, β is held constant, which means $T \propto B^2$. Ideally, rotation and T_i/T_e must also be held constant in these scans.

3. Experimental run plan

A) B_T scaling - Finish scans as approved in XP401. We will use 112063 as a baseline shots (from XP401); however, if MHD persists we will use 116318 (higher κ) as a backup baseline.

	I_p (MA)	B_T (T)	Comments
D (B_T at fixed I_p)	0.9	0.35	
	0.9	0.45	baseline
	0.9	0.55	
E (fixed q)	0.70	0.35	
	1.1	0.55	

B) Beta scaling - Because collisionality may change during the β scan, it is important to determine the scaling on this parameter as well, and, therefore, a scan to determine this dependence will be performed. ν^* will be changed by varying either density through beam fueling (e.g., varying the number of beam sources), or toroidal field, assuming a concomitant change in T_e with B_T. From previous studies, either from dedicated scans or from statistical analysis, it was found that the ν^* dependence of confinement was not a strong one. β will be varied by changing both I_p and B_T at fixed B_T/I_p at constant beam power (two or three sources, depending on MHD activity). How well the other important parameters, ρ^*, rotation and T_i/T_e are kept fixed through these scans will be determined during the course of the experiment. It may be necessary to adjust the scans by varying gas valve fueling and beam timing and power in order to keep these parameters constant. While this initial study is expected to take approximately one day, it is likely that additional run time, with modified experimental approaches, will be required at a later date.

While most of the data on this scaling in the international database is in a DND configuration, in order to maximize the chances for results in as short a time as possible, LSN H-mode plasmas will be used as a target. It is necessary that reproducible H-modes can be obtained in these conditions (κ~1.9, δ~0.6) with one beam source. This XP cannot be executed until operations with toroidal fields >4.5 kG is available. 5.5 kG is the target, but it can be run if 5.0 kG is the limit. The low TF shots will be limited to 0.4 T. For these I_p/B_T values, previous data indicates the discharges exceed the beta-limit below this field (β_N>6.5).

Because of the expected discharge development time during the course of the run day, the scans are limited. Below are the target discharge parameters.

Case	B_T (T)	I_p (MA)	n_e (10^{19} m^{-3})	P_{NB} (MW)	Condition
I Ia (if .55 NA)	0.55 0.50	1.1 1.0	6 6	4-6 4-6	High ν^*, Low β
II	0.35	0.7	3	2	Low ν^*, Low β
III	0.35	0.7	4-5	6	High β
IV	0.45	0.9	5-6	4	Medium β

The n_e, β_T and β_N values listed in the table have been achieved in previously run discharges with similar parameters. Beam power will be adjusted to maintain similar β_T values for I and II. Beam power will be adjusted, along with density to ensure there will be a β_T variation for I, III and IV. Expect a variation from 14% (at high TF) to 24% at the lowest TF. The most challenging condition to achieve may be II. 113860 will be used as a baseline shot for this, but I_p and B_T have to be modified to 0.7 MA and 0.35 T respectively. Long glows will be used in order to maintain low density in this condition.

I & II determine ν^* scaling

I, III and IV determine β scaling (when ν^* dependence taken into account)

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

None

5. Planned analysis

EFIT, TRANSP, etc.

6. Planned publication of results

APS, journal article

PHYSICS OPERATIONS REQUEST

BT and Beta Scaling of Confinement **OP-XP-532**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **66 kA** Flattop start/stop (s): _____/_____

I_P (MA): **1.1 MA** Flattop start/stop (s): _____/_____

Configuration: **Lower Single Null \l**

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

Elongation κ: **~2**, Triangularity δ: **~0.7 (lower)**

Z position (m): **0.00**

Gas Species: **D** , Injector: **Midplane**

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): **90 keV**, Duration (s): _____

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

CHI: **Off**

Either: List previous shot numbers for setup: 112063 for (A), **112152 for (B), 113860 for B.II**

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

BT and Beta Scaling of Confinement **OP-XP-532**

Diagnostic	Need	Desire	Instructions
Bolometer - tangential array	✓		
Bolometer array - divertor			
CHERS	✓		
Divertor fast camera			
Dust detector			
EBW radiometers			
Edge deposition monitor			
Edge pressure gauges			
Edge rotation spectroscopy		✓	Only available by special request of T. Biewer @ MIT
Fast lost ion probes – IFLIP			
Fast lost ion probes – SFLIP			
Filtered 1D cameras			
Filterscopes	✓		
FIReTIP		✓	
Gas puff imaging		✓	
High-k scattering			
Infrared cameras			
Interferometer – 1 mm			
Langmuir probes - PFC tiles			
Langmuir probes - RF antenna			
Magnetics – Diamagnetism		✓	
Magnetics – Flux loops	✓		
Magnetics – Locked modes	✓		
Magnetics – Pickup coils	✓		
Magnetics - Rogowski coils	✓		
Magnetics - RWM sensors		✓	
Mirnov coils – high frequency		✓	
Mirnov coils – poloidal array		✓	
Mirnov coils – toroidal array		✓	
MSE	✓		
Neutral particle analyzer		✓	
Neutron Rate (2 fission, 4 scint)			
Neutron collimator			
Plasma TV	✓		
Reciprocating probe			
Reflectometer - FM/CW			
Reflectometer - fixed frequency homodyne			
Reflectometer - homodyne correlation			
Reflectometer - HHFW/SOL			
RF antenna camera			
RF antenna probe			
Solid State NPA			
SPRED			
Thomson scattering - 20 channel	✓		
Thomson scattering - 30 channel			
Ultrasoft X-ray arrays			
Ultrasoft X-ray arrays - 2 color			
Visible bremsstrahlung det.			
Visible spectrometers (VIPS)			
X-ray crystal spectrometer - H			
X-ray crystal spectrometer - V			
X-ray pinhole camera			