## Princeton Plasma Physics Laboratory
# NSTX Experimental Proposal

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| **Title: Long Pulse Plasmas at Lower Toroidal Fields** | | |
| **XP-509** | **Revision:** | Effective Date: 03/02/05<br>*(Ref. OP-AD-97)*<br>Expiration Date:<br>*(2 yrs. unless otherwise stipulated)* |

## PROPOSAL APPROVALS

| | |
|---|---|
| **Author:C. E. Kessel, J. Menard** | Date05/17/05 |
| **ATI – ET Group Leader:R. Maingi, C. E. Kessel (deputy)** | Date 05/17/05 |
| **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)

# NSTX EXPERIMENTAL PROPOSAL

## Long Pulse Plasmas at Lower Toroidal Fields XP-509

## 1. Overview of planned experiment

Establish long pulse discharges at varying toroidal fields, plasma current and elongation, to examine the impact on pulse length from the safety factor/current profile evolution

## 2. Theoretical/ empirical justification

Simulations of NSTX with NBI to reach 100% non-inductive current fraction have shown that high elongation increases off-axis bootstrap current, density control is critical to control the non-inductive current sources, early heating/H-mode transition can significantly delay the onset of q(0) or qmin reaching 1, and broader beam driven current profiles can keep q(0) and qmin > 1.5 even at increased plasma current. In the 2004 run campaign, high elongation plasmas were demonstrated, early heating/H-mode in the current ramp was achieved, longer pulses even at plasma currents up to 1.2 MA, and MSE was installed and operational. These results indicate it is time to do systematic discharges that vary the current/safety factor profile to understand what is limiting the pulse length. These can be compared with simulations to identify the best approaches to reach 100% non-inductive high beta discharges.

## 3. Experimental run plan

2005 shot reference: **115755 (800kA)**, 115763 (900kA), 115764 (1 MA)

1) Ip = 800 kA, kappa ≈ 2.25, Bt = 0.45T **(2 shots)**
2) Ip = 800 kA, kappa ≈ 2.0, Bt = 0.45T **(2 shots)**
3) Ip = 800 kA, kappa ≈ 2.5 (highest without VDE), Bt = 0.45 **(2 shots)**
4) Ip = 800 kA, kappa ≈ 2.25, Bt = 0.425T **(2 shots)**
5) Ip = 800 kA, kappa ≈ 2.0, Bt = 0.425T **(2 shots)**
6) Ip = 800 kA, kappa ≈ 2.5, Bt = 0.425T **(2 shots)**
7) Ip = 800 kA, kappa ≈ 2.25, Bt = 0.40T **(2 shots)**
8) Ip = 800 kA, kappa ≈ 2.0, Bt = 0.40T **(2 shots)**
9) Ip = 800 kA, kappa ≈ 2.5, Bt = 0.40T **(2 shots)**
10) Ip = 800 kA, kappa ≈ 2.25, Bt = 0.375T **(2 shots)**
11) Ip = 800 kA, kappa ≈ 2.0, Bt = 0.375T **(2 shots)**
12) Ip = 800 kA, kappa ≈ 2.5, Bt = 0.375T **(2 shots)**
13) Ip = 900 kA, a few cases from above **(4 shots)**
14) Ip = 1 MA, a few cases from above **(4 shots)**

**Total shots = 24 (+8 for higher $I_P$)**

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

Time for “cross-cutting” shape control development for high elongation with new PF1A, LSN

Utilizing early heating/H-mode at 60-80ms, 2 NB sources, flat-spot in Ip ramp

NBI, all sources at 90 keV for up to 1.5s (source A at 90 keV for MSE)

NBI timing is B at 60 ms, A at 80 ms, C at 120 ms (possible change in C timing if necessary)

MSE diagnostic in equilibrium reconstruction.

## 5. Planned analysis

EFIT analysis with MSE constraint

TRANSP analysis

TSC free-boundary analysis

## 6. Planned publication of results

Present results at APS meeting, subsequently submit for publication in Nuc. Fus. Or Phys. Plasmas.

# PHYSICS OPERATIONS REQUEST

**Long Pulse Plasmas at Lower Toroidal Fields** **XP-509**

Machine conditions (specify ranges as appropriate)

$I_{TF}$ (kA): **41-53** Flattop start/stop (s): **0/1.0**

$I_P$ (MA): **0.8-1.0** Flattop start/stop (s): **0.175-0.250/1.0**

Configuration: **LSN**

Outer gap (m): **0.05-0.10**, Inner gap (m): **> 2cm**

Elongation κ: **2.0 - 2.5**, Triangularity δ: **> 0.5**

Z position (m): **use ref shot**

Gas Species: **D**, Injector: **Midplane/Inner Wall (use ref shot)**

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV):**90**, Duration (s): **1.5**

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

CHI: **OFF**

*Either:* Previous shot numbers for setup: **115755 (0.8MA)**, 115763 (0.9MA), 115764 (1 MA)

*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

## Long Pulse Plasmas at Lower Toroidal Fields XP-509

| Diagnostic | Need | Desire | Instructions |
|---|---|---|---|
| Bolometer - tangential array | | | |
| Bolometer array - divertor | | | |
| CHERS | X | | |
| Divertor fast camera | | | |
| Dust detector | | | |
| EBW radiometers | | | |
| Edge deposition monitor | | | |
| Edge pressure gauges | | | |
| Edge rotation spectroscopy | | | |
| Fast lost ion probes – IFLIP | X | | |
| Fast lost ion probes – SFLIP | X | | |
| Filtered 1D cameras | | | |
| Filterscopes | | | |
| FIReTIP | X | | |
| Gas puff imaging | | | |
| High-k scattering | | | |
| Infrared cameras | | | |
| Interferometer – 1 mm | X | | |
| Langmuir probes - PFC tiles | | | |
| Langmuir probes - RF antenna | | | |
| Magnetics – Diamagnetism | X | | |
| Magnetics – Flux loops | ✓ | | |
| Magnetics – Locked modes | X | | |
| Magnetics – Pickup coils | ✓ | | |
| Magnetics - Rogowski coils | ✓ | | |
| Magnetics - RWM sensors | X | | |
| Mirnov coils – high frequency | X | | |
| Mirnov coils – poloidal array | X | | |
| Mirnov coils – toroidal array | X | | |
| MSE | X | | |
| Neutral particle analyzer | X | | |
| Neutron Rate (2 fission, 4 scint) | X | | |
| 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 | X | | |
| SPRED | | | |
| Thomson scattering - 20 channel | ✓ | | |
| Thomson scattering - 30 channel | | X | |
| Ultrasoft X-ray arrays | | | |
| Ultrasoft X-ray arrays - 2 color | | | |
| Visible bremsstrahlung det. | X | | |
| Visible spectrometers (VIPS) | | | |
| X-ray crystal spectrometer - H | | | |
| X-ray crystal spectrometer - V | | | |
| X-ray PIXCS (GEM) camera | | | |
| X-ray pinhole camera | | | |
| X-ray TG spectrometer | | | |