**Princeton Plasma Physics Laboratory**

# NSTX Experimental Proposal

Title: **Comparison of Diverted Plasmas Incident on Lithiated LLD, Molybdenum, and Graphite Surfaces**

| | | |
|---|---|---|
| **OP-XP-1134** | Revision: **0** | Effective Date: **June 30, 2011**<br>*(Approval date unless otherwise stipulated)*<br>Expiration Date: **June 30 2013**<br>*(2 yrs. unless otherwise stipulated)* |

## PROPOSAL APPROVALS

| | |
|---|---|
| **Responsible Author: H. Kugel, V. Soukhanovskii (Deputy)** | Date |
| **ATI – ET Group Leader: C. H. Skinner** | Date |
| **RLM - Run Coordinator: S. Sabbagh** | Date |

**Responsible Division: Experimental Research Operations**

## RESTRICTIONS or MINOR MODIFICATIONS

(Approved by Experimental Research Operations)

# NSTX EXPERIMENTAL PROPOSAL

TITLE: **Comparison of Diverted Plasmas Incident on Lithiated LLD, Molybdenum, and Graphite Surfaces** No. **OP-XP-1134**

AUTHORS: **H. Kugel, V. Soukhanovskii (Deputy)** DATE: **6/15/2011**

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## 1. Overview of planned experiment

This XP is a comparison of diverted plasmas with strike points incident on lithiated LLD, molybdenum tiles, and graphite tile surfaces. This will allow resolution of LLD 2010 open issues and completion of analysis described in the recent IAEA2010, and ISFA2011 papers.

## 2. Theoretical/ empirical justification

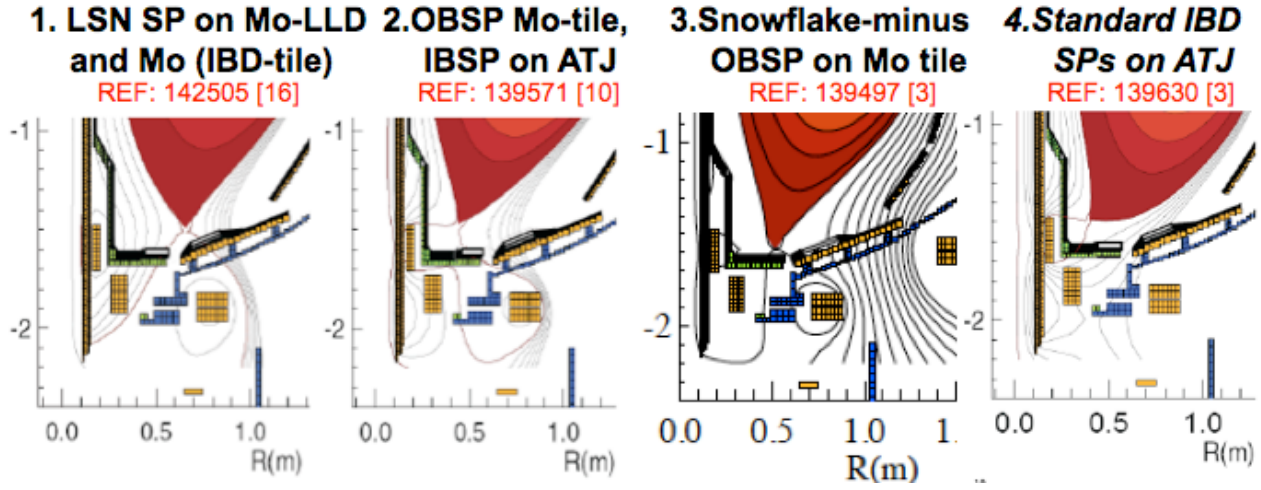
This XP will allow resolution of LLD 2010 open issues and the completion of analysis described in the recent IAEA-2010, and ISFA-2011 papers.

## 3. Experimental run plan

The following 4 scans are proposed:

1. LSN strike-pts on Mo-LLD and Mo IBD-tile. **[REF: 142505, 16 shots]**
2. Outboard Divertor strike-pt on Mo-tile, Inboard Divertor strike-pt on ATJ. **[REF: 139571 10 shots]**
3. Snowflake-minus Outboard Divertor strike-pt on Mo-tile. **[REF: 139497 [3 shots]**
4. Standard Inner Divertor strike-pts on ATJ. **REF: 139630 [3 shots]**

Refer to Shot Table 1.



Shot Table 1.

| Run Day | Shot No. | Estimated Bulk T°C | Estimated FF T°C | ISP | OSP | Fueling |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1 | 1 | 35 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 2 | 45 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 3 | 55 | 166 | Mo (50cm) | LLD (77cm) | constant |
| 1 | 4 | 65 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 5 | 75 | 181 | Mo (50cm) | LLD (77cm) | constant |
| 1 | 6 | 85 | 224 | Mo (50cm) | LLD (77cm) | constant |
| 1 | 7 | 95 | 261 | Mo (50cm) | LLD (77cm) | constant |
| 1 | 8 | 105 | 301 | Mo (50cm) | LLD (77cm) | constant |
| 1 | 9 | 115 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 10 | 125 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 11 | 135 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 12 | 145 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 13 | 155 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 14 | 165 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 15 | 175 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 16 | 185 | | Mo (50cm) | LLD (77cm) | constant |
| 1 | 17 | | | ATJ | Mo(50cm) | constant |
| 1 | 18 | | | ATJ | Mo(50cm) | constant |
| 1 | 19 | | | ATJ | Mo(50cm) | constant |
| 1 | 20 | | | ATJ | Mo(50cm) | constant |
| 1 | 21 | | | ATJ | Mo(50cm) | constant |
| 1 | 22 | | | ATJ | Mo(50cm) | constant |
| 1 | 23 | | | ATJ | Mo(50cm) | constant |
| 1 | 24 | | | ATJ | Mo(50cm) | constant |
| 1 | 25 | | | ATJ | Mo(50cm) | constant |
| 1 | 26 | | | ATJ | Mo(50cm) | constant |
| 1 | 27 | | | Snowflake- | Mo(50cm) | constant |
| 1 | 28 | | | Snowflake- | Mo(50cm) | constant |
| 1 | 29 | | | Snowflake- | Mo(50cm) | constant |
| 1 | 30 | | | AJT | ATJ | constant |
| 1 | 31 | | | AJT | ATJ | constant |
| 1 | 32 | | | ATJ | ATJ | constant |

- If time permits, following the constant fueling scan, do:
  1) divertor carbon source reduction with a small gas puff,
  2) divertor OSP detachment with a higher gas puff (probably can get enough information in ~5-7 shots)

| Run Day | Shot No. | Estimated Bulk T°C | Estimated FF T°C | ISP | OSP | Fueling |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1.5 | 1 | 35 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 2 | 45 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 3 | 55 | 166 | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 4 | 65 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 5 | 75 | 181 | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 6 | 85 | 224 | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 7 | 95 | 261 | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 8 | 105 | 301 | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 9 | 115 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 10 | 125 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 11 | 135 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 12 | 145 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 13 | 155 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 14 | 165 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 15 | 175 | | LLD (77cm) | LLD (77cm) | increase |
| 1.5 | 16 | 185 | | LLD (77cm) | LLD (77cm) | increase |

**After LLD Cooldown and Lithium Solidifies**

| | | | | | | |
|---|---|---|---|---|---|---|
| After cool | 17 | 55 | 166 | LLD (77cm) | LLD (77cm) | Ibid #16 |
| | 18 | 65 | | LLD (77cm) | LLD (77cm) | Ibid #16 |
| | 19 | 75 | 181 | LLD (77cm) | LLD (77cm) | Ibid #16 |

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

Perform OP-XMP-71, "NSTX Start-up Commissioning and Evaluation Using Lithium Coating Only", and XP-1133 until the required Reference Discharges achieve research grade, defined as 4MW NBI, 600ms Ip flattop, $t_e \geq 50$ms, Se=200kJ.

Diagnostics are required for the following investigations:

3.1 How does the core D content change as the divertor substrate is changed?

3.2 How does the core $C^{6+}$ content change as the carbon sputtering term is changed?

3.3 How much of the electron density rate of rise is due to the divertor sputtering source?

3.4 How do Li, CII, CIII, OII, Mo, Prad waveforms vary during the discharge as the surface heats?

3.5 How do the Fast IR front face temperature waveforms change for the different lithiated substrates?

3.6 Under quiescent Dα conditions, can local recycling coefficients be measured using LP array Isat/Da ratios?

3.7 How do ELM stability characteristics change as sputtering and edge fueling change?

3.8 How do the global wall pumping characteristics change as the lithiated substrate changes?

## 5. Planned analysis

OEDGE, TRANSP, UEDGE, etc.

## 6. Planned publication of results

PSI2012, IAEA 2012, Nucl. Fusion or POP.

# PHYSICS OPERATIONS REQUEST

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AUTHORS: **H. Kugel, V. Soukhanovskii (Deputy)** DATE: **6/15/2011**

**Brief description of the most important operational plasma conditions required:**

Perform OP-XMP-71, "NSTX Start-up Commissioning and Evaluation Using Lithium Coating Only", and XP-1133 until the required Reference Discharges achieve research grade, defined as 4MW NBI, 600ms Ip flattop, $t_e \geq$ 50ms, Se=200kJ.

**Previous shot(s) which can be repeated:**

1. LSN strike-pts on Mo-LLD and Mo IBD-tile. **[REF: 142505, 16 shots]**
2. Outboard Divertor strike-pt on Mo-tile, Inboard Divertor strike-pt on ATJ. **[REF: 139571, 10 shots]**
3. Snowflake-minus Outboard Divertor strike-pt on Mo-tile. **[REF: 139497, 3 shots]**
4. Standard Inner Divertor strike-pts on ATJ. **[REF: 139630, 3 shots]**

**Previous shot(s) which can be modified: Any of the above as required.**

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

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

$I_P$ (MA): Flattop start/stop (s):

Configuration: **Limiter / DN / LSN / USN**

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: Injector(s):

**NBI** Species: **D** Voltage (kV) **A:** **B:** **C:** Duration (s):

**ICRF** Power (MW): Phase between straps (°): Duration (s):

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

**LITERs: Off / On** Total deposition rate (mg/min):

**LLD:** Temperature (°C):

**EFC coils: Off/On** Configuration: **Odd / Even / Other** *(attach detailed sheet)*

# DIAGNOSTIC CHECKLIST

TITLE: **Comparison of Diverted Plasmas Incident on Lithiated LLD, Molybdenum, and Graphite Surfaces** No. **OP-XP-1134**

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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 | | √ |