Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: **Tungsten Dust transport using the Li powder dropper**		
OP-XP-957	Revision: **0**	Effective Date: **8/11/09** *(Approval date unless otherwise stipulated)* Expiration Date: **8/11/11** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: A.L. Roquemore	Date 8/6/09
ATI – ET Group Leader: V. Soukhanovskii	Date 8/11/09
RLM - Run Coordinator: R. Raman	Date 8/11/09
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: Tungsten Dust transport using the Li powder dropper | No. **OP-XP-957**

AUTHORS: **L. Roquemore, A. Pigarov, D. Mansfield, K. Hartzfeld P. Beiersdorfer, C. Skinner,**

DATE: 7/28/09

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1. Overview of planned experiment

Briefly describe the scientific goals of the experiment.

This experiment is on the list of "Urgent ITER Requirements". The ITPA joint experiment of interest is DSOL-21 (Introduction of pre-characterized dust for dust transport studies in the divertor and SOL)

A small quantity of 5 micron dust will be dropped from a special dropper similar to the Li dropper but with a much reduced reservoir(see Fig 1). The target goal is to drop ~1000 particles per discharge which is ~micrograms of tungsten. The total amount introduced into NSTX during 5 shots, will be < 1 milligram.

The dust particles will become incandescent by interacting with the plasma in the SOL. We will make measurements of the trajectories using two fast cameras. The trajectories from each camera will be combined to reconstruct a 3-D spatially resolved trajectory. This data will be applied as input to the dust transport codes such as DUSTT for code validation. Tungsten dust may also be transported into the core plasma limiting the performance. Using the Xeus and LoWEUS diagnostics along with the tangential bolometer, time resolved (50 ms) information on transport from the SOL to the core, if it reaches the core, can be determined along with the various ionization states of tungsten.

It is expected that this experiment will be performed on the last day of the 2009 campaign due to the unknowns associated with introducing high-Z material into the plasma. After the last discharge with tungsten, it would be beneficial to have additional shots to see if any sign of the tungsten lingers on. This would have implications for future experiments with other high-Z ITER like materials. Note that on MAST, 5 micron tungsten dust was introduced in the middle of their campaign using a probe similar to the DIII-D DIMES probe and no after-effects were noticed.

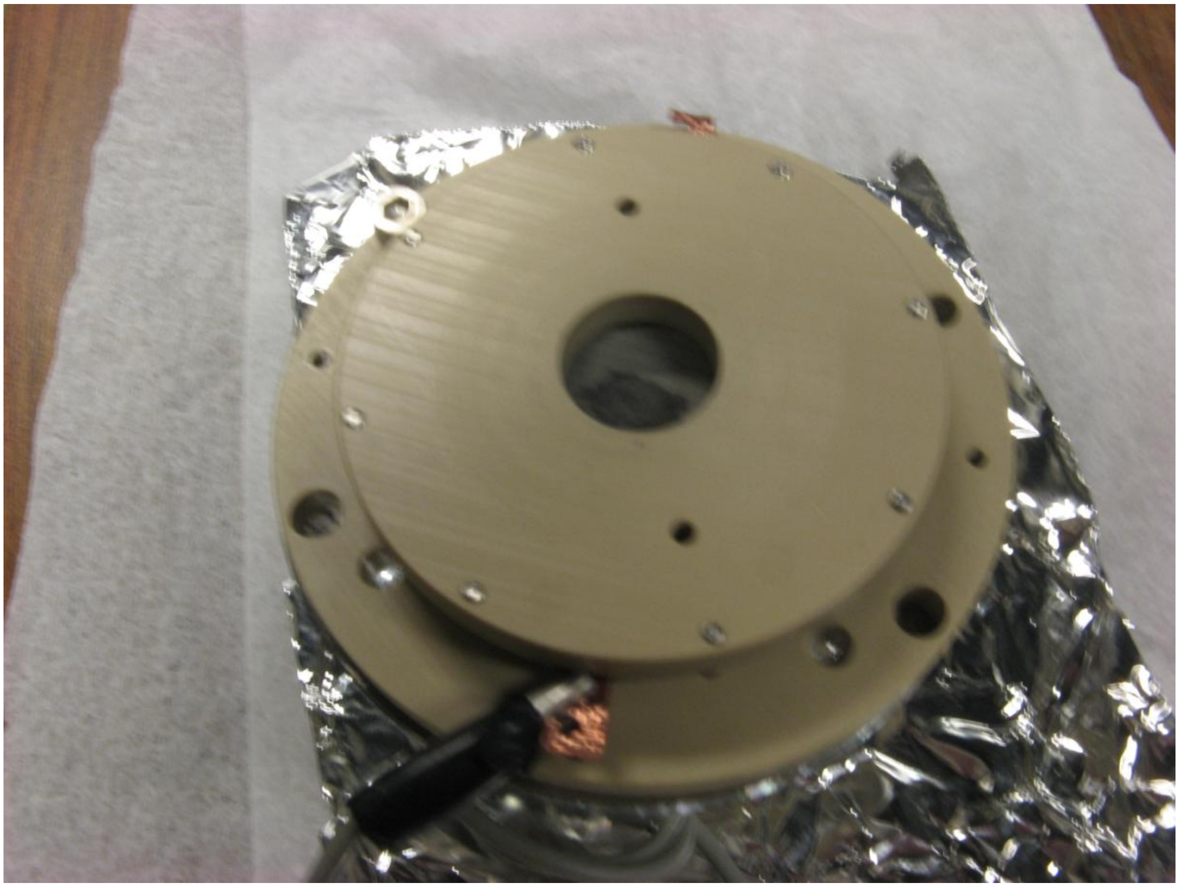

Fig. 1 Tungsten dropper

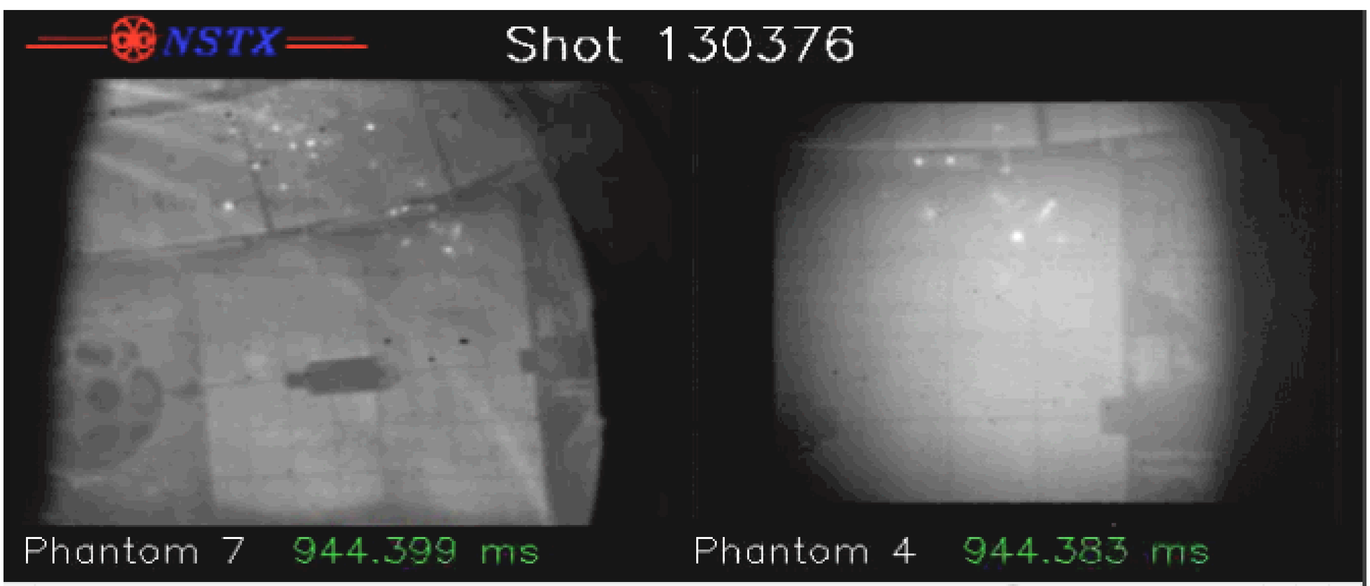

Fig 2. Li dust from powder dropper.

2. Theoretical/ empirical justification

Brief justification of activity, including supporting calculations as appropriate. Describe *briefly* any previous or related experiments.

In ITER, tungsten dust will be generated from the divertor tiles. It is unknown how this dust will propagate in a plasma or affect plasma performance. This XP plans to obtain the first experimental data on the transport of tungsten dust introduced directly into the scrape-off layer by supplying 3-D trajectories of the dust in the SOL. The data will be applied to transport codes such as DUSTT for code validation.

This experiment has previously been run for Li dust shown in Fig 2. 3-D trajectories have been reconstructed from two simultaneous camera views of the particles. Li is not an ITER material but Li dust transport may give insight into the behavior of Be. For comparison, it would be best to release the tungsten into discharges similar to the ones used for the Li powder experiments.

These shots will probably be operated in the reversed field configuration. Hopefully, the Li dropper will be operated prior to this XP to get good comparison data. Though this is desired, it is not essential for this XP to be successful.

3. Experimental run plan

Describe experiment in detail, including decision points and processes.

The experiment requires dropping 5 micron diameter tungsten dust from the location of the Bay I dropper. The quantity of dust released will be a total of several hundred to 1000 particles throughout the discharge. In order to compare the data to the Li data, it would be best to drop the dust into a shot such as 135064 with 2 neutral beams.

Assuming a 1 second discharge, the powder dropper will be operated for a period 0.7s. From the time the particles are released, it takes ~0.55 seconds for the dust to reach the outlet of the tube. Initially, the dropper will be started approximately 0.3 s before the discharge so no tungsten drops on the floor of the vessel. When dropper is characterized, it would be valuable to drop earlier into the discharge

Initially, 135064 will be repeated but using LITER as opposed to the powder dropper as a source of Li to establish long pulse discharges and reduce the number of ELMS. The next two discharges will be used to establish the proper amount of tungsten particles to drop by varying the voltage on the piezo crystal as required. This may require only one discharge. It would be best have two identical discharges with good signal. Assuming we obtain two good discharges with good signal, the next discharge will be to delay the 2^{nd} NB to come on at 400 ms for comparison of 1 -2 source particle velocities. The last shot will be to raise the dropper voltage and drop particles into the ohmic plasma current flattop for the shortest duration possible, depending on the signal strength of the x-ray spectrometers, of 50 -100 ms and use LoWEUS, XEUS, J-H transmission grating and J-H optical array to determine the transport properties without interference from NB background signal. If RF is available we would like to inject their maximum reliable power. RF is expected to operate the previous day so they should be well conditioned.

Discharge #1 and condition	Dropper Voltage (volts)	Dropper time (sec) From T=0	Duration (sec)	Decision Point after shot?
1 - same as 135064	0	0	0	x
2 -same as 135064	2	-0.3	.70	√
3 -same as 135064	+ 1 volt if weak signal	-0.3	.70	√
4 -same as 135064	Good signal then repeat, weak signal, then +1 volt	-0.5	.70	x
5 - (or last shot?) delay NB#2 to .4s	Voltage used on step 4.	-0.3	0.7	√
6 (last shot) ohmic discharge with RF	5	-0.300	0.05 -.1 (or less)	x
7. Desired to have 2-3 shots like 135064 without the tungsten to see how long the signs of tungsten will linger.				

4. Describe any prerequisite conditions, development, XPs or XMPs needed.

Attach completed Physics Operations Request and Diagnostic Checklist.

LITER and NB heating are required. Required diagnostics are two fast cameras, LoWEUS and Zeus and the tangential bolomenter. John-Hopkins transmission grating and optical array are also desired.

5. Planned analysis

What analysis of the data will be required: EFIT, TRANSP, etc.?

Trajectory analysis from the fast cameras and transport analysis from X-ray spectrometers and tangential bolometer. UCSD to perform DUST T comparisons with the trajectory information.

6. Planned publication of results

A potential venue is the International Conference on Plasma Surface Interactions PSI19 next May in San Diego.

PHYSICS OPERATIONS REQUEST

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(use additional sheets and attach waveform diagrams if necessary)

Describe briefly the most important plasma conditions required for the experiment:

Establish shots similar to those used with Lithium powder such as 135064 but with Li evaporation instead of powder. The last shot will be into a standard ohmic discharge. He glow between discharges will be required.

Previous shot(s) which can be repeated: 135064

Previous shot(s) which can be modified: 135064 with 2nd NB delayed to .4 s.

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 LSN**

Equilibrium Control: **Outer gap / Isoflux** (rtEFIT)

Outer gap (m): Inner gap (m): Z position (m):

Elongation κ: Upper/lower triangularity δ:

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):

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

DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array	√	
Bolometer – divertor		
CHERS – toroidal	√	
CHERS – poloidal	√	
midplane fast cameras (two)	√	
Dust detector		
EBW radiometers		
Edge deposition monitors		
Edge neutral density diag.		
Edge pressure gauges		
Edge rotation diagnostic		
Fast ion D_alpha - FIDA		
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP		
Filterscopes		
FIReTIP		
Gas puff imaging		
Hα camera - 1D		
High-k scattering		
Infrared cameras		
Interferometer - 1 mm		
Langmuir probes – divertor		
Langmuir probes – BEaP		
Langmuir probes – RF ant.		
Magnetics – Diamagnetism		
Magnetics – Flux loops	√	
Magnetics – Locked modes		
Magnetics – Pickup coils	√	
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 measurements		
Plasma TV		
Reciprocating probe		
Reflectometer – 65GHz		
Reflectometer – correlation		
Reflectometer – FM/CW		
Reflectometer – fixed f		
Reflectometer – SOL		
RF edge probes		
Spectrometer – SPRED		
Spectrometer – VIPS		
SWIFT – 2D flow		
Thomson scattering	√	
Ultrasoft X-ray 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 spectrometer - LoWEUS	√	
X-ray spectrometer - XEUS	√	