1. Purpose of Experiments

The upstream scrape-off layer (SOL) potential profiles have been observed to change when the strike point is placed in the slot of the divertor as compared to the vertical target plate. The lack of probes at the bottom of the slot has meant that measurement of the boundary conditions at the divertor target was not possible. With the new high poloidal resolution flush-mounted ‘rail’ probes extending above the nose of the divertor [1], it is now possible to obtain spatially well-resolved SOL profiles with the strike point on the outer lower divertor shelf. Although not completely flat like the base of the slot, the change in geometry of the divertor may be sufficient to cause a change in the upstream potential profile and can then be compared to downstream divertor measurements.

Understanding the effect of the change in strike point geometry on SOL transport is crucial because it has been documented to affect detachment threshold [2] as well as power thresholds for core confinement transitions [3].

2. Background

Experiments on 1150811 explored in detail the effect of strike-point position on the upstream SOL profile showing a distinct difference in the potential profile between a ‘slot’, ‘vertical’ and ‘EF1’ targets (figure 1). The ‘roll over’ of the plasma potential with the vertical target plate strike point occurs at 60 eV and 90 V. When the strike point is on the ‘slot’, this occurs at approximately 60 V and without a clearly pronounced peak. When the strike point was on the ‘EF1’ target, the plasma potential has the same shape as the ‘vertical’ target but peaks at 60 eV and 70 V. It is similar to measurements made as the strike point transitions between the ‘slot’ and ‘vertical’ targets.
It has been hypothesized that the change in upstream potential profile may be the cause of the difference in the L-H transition power threshold reported by Ma [3] however a clear understanding of the connection between the divertor and upstream profiles is lacking. The effect of the SOL boundary conditions at the divertor target on SOL transport has been studied in detail [4-6] and a clear connection has been found related to divertor collisionality. Depending of the divertor regimes (sheath-limited to detached), transport along the field lines is affected resulting in changes to filament size and propagation velocity [4] and the SOL width [5,6]. This is a strong indication that a possible link could be found between the strike point geometry on the divertor to the changes in upstream SOL profiles.

However, measurements of the strike point conditions on the ‘slot’ and ‘EF1’ targets have been difficult as there are no Langmuir probes at these locations. With the newly installed ‘rail’ probes, it is now possible to obtain spatially well resolved SOL profiles of the divertor conditions with the strike point located above the nose. Furthermore, with the flush geometry it is possible to obtain accurate divertor surface current measurements compared to traditional proud probes. The divertor surface currents are a direct measurements of the plasma parallel transport boundary condition and may provide an indication of the unique changes to SOL transport related to strike point geometry.

3. Approach

One full run day is requested to explore the effect of changing the strike point location between vertical target plate and lower outer divertor shelf. To map out the dependence of SOL transport on divertor collisionality in the two divertor geometries, a density scan will be performed with both strike point positions: on the vertical target plate and the shelf. The vertical target plate strike point location will serve as a benchmark for comparison. Then
the strike point will be moved to above the nose of the divertor and a similar density scan will be carried out. It will also serve to explore the difference between the two measurements at the onset of divertor detachment. For each of the shots the ASP will be scanning the upstream profile and the ‘rail’ probes will switch between sweep, grounded and float mode. Spectroscopy will be set up to maximize coverage of the two strike point locations to give a second measurement of divertor detachment. The X-point camera will capture changes to filament character across the different divertor regimes. Lastly GPI and CXRS will ideally give measurements of upstream fluctuation and ion temperature respectively.

Following the L-mode density scan, dependent on the upstream profiles measured, a decision will be made on whether to attempt to assess the L-H power threshold. It is important to note that the measured difference in power threshold could be related to the slot geometry and not the flat plate geometry. Therefore, if the upstream plasma potential profiles shows a sufficient drop in peak value with the strike point on the shelf, it would be crucial to measure the power threshold for the two divertor targets. RF will be turned on and ramped till the L-H mode transition is achieved and the power threshold documented.

If it is decided that the L-H transition is not worth pursuing, the focus will switch to further documentation of the heat flux width scaling. Halpern connected the SOL heat flux width to a balance between the parallel transport to the target and the perpendicular turbulent transport. With the ground currents providing a direct measurement of the parallel transport to the divertor plate, a detailed measurement of the ground currents will allow for further documentation of this hypothesis. A current scan will be performed in a sheath limited regime to change the heat flux width and track changes for the divertor parallel transport boundary condition.

4. Resources

4.1 Machine and Plasma Parameters

Toroidal Field: 5.4 tesla
Plasma Current: 0.8 MA
Working Gas Species: D₂
Density: NL04 ~ 0.5 to 2.0 x10²⁰ m⁻²

Boronization Requested: Low radiative fractions would be required for L-H transition studies however boronization directly impacts Langmuir probe measurements and will take up to a half a day to clean. Therefore this run needs to be 1 run day after boronization.

Equilibrium configuration: standard LSN in forward field, with strike point on the vertical target plate and on the shelf.
4.2 Auxiliary Systems

ICRF Power, pulse length, phasing: 2-3 MW, 1 sec ramped.
LHCD Power, pulse length, phasing: no
Pellet Injection (species): no
Impurity blow-off injection: no
Diagnostic Neutral Beam: no
Special gas puffing: He for GPI and D₂ for CXRS.
Cryopump: yes
Non-axisymmetric Coils: standard error-field correction configuration
Other:

4.3 Diagnostics

Required:
- Divertor surface thermocouples
- ‘Rail’ and JDIV Langmuir probes in standard sweep mode (JDIV MLP not connected)
- Horizontal probe (ASP) with Mirror Langmuir Probe (MLP) system connected. The standard Langmuir-Mach probe head must be installed on the A-port drive.
- Edge Thomson scattering
- CXRS
- GPI
- X-point fast camera
- Spectroscopy set up to view the vertical target plate and the flat-plate divertors.

5. Experimental Plan

Step 1: LSN L-mode 0.8 MA, 5.4 Tesla, NL04 ~ 0.5-1.4 x10^{20} m⁻², vertical target plate. Scan the density during the shot to find the detachment threshold. Scan the ASP to get good profile measurements during attached and detached conditions. Alternate Langmuir probes between swept, float and ground. Repeat as necessary to ensure clear measurements with the required diagnostic systems. (10 shots)

Step 2: LSN L-mode 0.8 MA, 5.4 Tesla, NL04 ~ 0.5-2.0 x10^{20} m⁻², flat-plate. Scan the density during the shot to find the detachment threshold. Scan the ASP to get good profile measurements during attached and detached conditions. Repeat as necessary to ensure clear measurements with the required diagnostic systems. (10 shots)

Step 3a: Dependent on results of upstream plasma potentials. Decide if RF should be turned on to assess the power threshold for a L-H transition. LSN H-mode 0.8 MA, 5.4 Tesla, NL04 ~ sheath limited. Attempt to benchmark the L-H power threshold difference between the two strike point locations. RF will be ramped. (5 shots)

Step 3b: If not, pursue obtaining a current scan at fixed greenwald fraction for the two strike point locations. LSN L-Mode, 0.55, 0.8, 1.1 MA, 5.4 Tesla. Repeat as necessary to ensure clear measurements with the required diagnostic systems. (10 shots)
6. Anticipated Results

If a change in the upstream plasma potential profile can be observed I expect to see a difference in the divertor floating potential and ground current measurements. This would be an indication that the change in geometry is changing the divertor boundary conditions and thus affecting the SOL transport.

A detailed measurement of the ground current during the density and current scan will hopefully produce results that can further develop our current understanding of the effect of the divertor boundary condition on SOL transport which will form the basis of a PhD thesis.

7. References