1. Purpose of Experiments

This work represents an extension of MP 80 - “Dependence of Extent of Detachment on Strike Point Location”. We will determine the effect of plasma current and safety factor on: (1) detachment threshold; (2) the growth of detachment with density and; (3) the localized increase in plate plasma pressure (higher than upstream) - the so called ‘death ray’.

2. Background

Recent experiments have shown that the strike point location on the vertical portion of the plate has little effect on the onset of detachment. In each case the extent of detachment is limited to the region of the SOL which impacts the divertor plate below the nose. At the onset of detachment we find that a localized pressure peak appears at the divertor surface corresponding to a position in $\rho$ of 1-2 mm which is greater in magnitude than that measured upstream at the fast-scanning probe. This so-called ‘death-ray’ then disappears as the main plasma density is increased further and the detachment extent grows.

Other strike point locations have been investigated as well. When the strike point location is located at or above the outer divertor nose the onset of detachment appears to occur at a higher density (affirmation of this observation is awaiting the finish of MP 80). In addition, when the outer strike point is located at the floor of the machine (‘slot-divertor’) the onset of detachment is similar to the vertical plate case. The radial extent of detachment also appears to be limited to the outer divertor nose similar to vertical plate operation.

These studies have also been attempted at lower plasma current, 500 kA, in order to characterize the effect of plasma current on detachment extent. The results have been
ambiguous in that the divertor plate plasma Te values at detachment were high (10-20 eV) and thus called into question the veracity of the Langmuir probe analysis under those conditions. It is quite possible that at those low densities that the Langmuir probe analysis is being affected by small populations of electrons that have not equilibrated with the bulk SOL plasma as they travel from the midplane to the divertor. These data are still under study. We plan to achieve the current scan by increasing the plasma current to where we know that the divertor densities will be high enough such that this problem is not an issue.

As part of this current scan we also plan to vary the safety factor as well. This will of course change the field line length to the divertor surface and thus the available neutral-ion interaction length. This effect needs exploration.

3. Approach
Describe the methodology to be employed; explain the rationale for the choice of parameters, etc. Describe the analysis techniques to be employed in interpreting the data, if applicable. If the approach is standard or otherwise self-evident, this section may be absorbed into the Experimental Plan

The approach for these studies is to properly diagnose a set of discharges with strike point locations on the vertical plate, flat-plate (above the nose) and slot over a range in densities. This will be done with 1 MA plasma currents at 5.3 T and also by varying B & Ip at lower fields.

4. Resources

4.1 Machine and Plasma Parameters
Give values or range for:

Toroidal Field: 5.3 T
Plasma Current: 0.6-1.0 MA
Working gas species: $D_2$
Density: $\bar{n} = 0.7 - 3.5 \times 10^{26} m^{-3}$
Equilibrium configuration (if possible, refer to database equilibria): varying over the run from strike points at or above the divertor nose to a slot geometry

Pulse length, typical current & density waveforms, etc. Refer to database or sketch desired waveforms: $\geq 1$ s at end of flattop if possible.

4.2 Auxiliary Systems

RF Power, pulse length, phasing: none
Pellet Injection (species): None
Impurity blow-off injection: None
**Special gas puffing:** divertor capillary puffing may be required to achieve the high densities

**Other:** None

**4.3 Diagnostics**

List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate.

Interferometer; Divertor probe array; ECE; Main and divertor Bolometer arrays; Fast scanning probe; Visible bremsstrahlung; OMA spectrometer viewing x-point region, 20nm bandwidth, 0.1nm resolution, primarily looking at line broadening of the hydrogen Balmer series; Molybdenum monitor; McPherson spectrometer; viewing the x-point region All reticon arrays with H$_\alpha$ filter and C II filter in selected shots; Ratiomatic pressure gages; Divertor pressure gages;

**4.4 Neutron Budget**

Estimate the neutron dose rate at the site boundary. Give basis for estimate. (Once some experience has been gained a standard formula will be provided for estimating dose rates.)

Not applicable

5. **Experimental Plan**

5.1 **Run sequence plan**

Specify total number of runs required, and any special requirements, such as consecutive days, no Monday runs, extended run period (10 hours maximum), etc.

At least one run for 1 MA studies will be required. A separate run for the q scan will be needed as well.

5.2 **Shot sequence plan**

For each run day, give detailed specification for proposed shot sequence: number of shots at each condition, specific parameters and auxiliary systems requirements, etc. Include contingency plans, if appropriate.

Current scan

(1) Obtain 1 MA shot with outer strike point in the region of probes 2-4 and nl04=1.0e20. (5 shots)

(2) Vary the density down in steps of nl04=0.2e20 until divertor probes indicate complete attachment at the divertor surface. (4 shots)

(3) Vary the density up from nl04=1.0e20 to 2.5e20 in steps of 0.1-0.2 until past the occurrence of the 'death ray' and 0.4 steps thereafter. (10 shots)

(4) Setup flat-plate equilibria with strike point sweep around probe 8 and nl04=1.0e20 (8 shots)

(5) Repeat steps 2-3 with perhaps a higher density limit (15 shots).
(1) Setup a standard 800 kA discharge with $B_t$ as low as possible, strike point near probes 2-4 and nl04=1.0e20. (7-10 shots).

(2) Vary nl04 over the range described in steps 2 and 3 of the current scan. (15 shots)

(3) Setup a standard 800 kA discharge with $B_t$ as high as possible, strike point near probes 2-4 and nl04=1.0e20. (7-10 shots).

(4) Vary nl04 over the range described in steps 2 and 3 of the current scan. (15 shots)

6. **Anticipated Results**

Discuss possible experimental outcomes and implications. Indicate if the program may be expected to lead to publications, milestone completions, improved operating techniques, etc. Indicate if the experiments are intended to contribute to a joint research effort, or an external database.

We plan to determine the dependence of the detachment process on plasma current and safety factor $q$.

7. **References**

Include references both to external and internal literature or communications which bear on this proposal. See Section 2.