Alcator C-MOD
Mini-Proposal

Subject: Effect of Separatrix strike point location on divertor detachment

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1. Purpose of Experiments
Include immediate goal of the experiments, scientific importance and/or programmatic relevance. Refer to any relevant program milestones or ITER R&D commitments.

One aspect of divertor detachment not systematically investigated is the 'radial' extent of detachment; the distance, referenced to the midplane, of the point in the SOL where pressure is no longer constant along a flux surface. We would like to investigate the dependence of this quantity on strike point location. This work will be part of the milestone #52 - comparison of the slot, open and inclined plate divertor geometries.

2. Background
Discuss Physics basis of the proposed research, Prior results at Alcator or elsewhere, and any related work being carried out separately

For our standard divertor plasmas the strike point is located on the inclined section of the outer divertor plate. The general experience has been that as the line-averaged density is raised the plasma detaches first at the separatrix (possibly the private flux simultaneously). With further increases in density the peak in the pressure profile moves away from the separatrix into the common flux region of the SOL. Often, this 'localized detachment' is followed by an abrupt collapse of the pressure profile everywhere below the noses of the inner and outer divertors. This limit in detachment appears to correspond to a midplane ‘rho’ of 3.5 - 5 mm.

In recent experiments the strike point has been shifted further down the outer divertor plate and even to the floor. In the highest density case of this ‘slot’ geometry (941220022) the divertor plasma is, of course, detached. Similar to the inclined plate divertor plasmas the extent of detachment extends at least up to the nose of the outer divertor. However this now corresponds to a midplane ‘rho’ of 10-11 mm; a much larger distance into the SOL.

For this work we will systematically vary the strike point location from the divertor nose down to the floor and document the variation in the detachment extent (with respect
to midplane ‘rho’ as well as to the divertor nose). This issue requires the SOL pressure profiles to be compared with that at the divertor. As a byproduct of this study we hope to also investigate whether an abrupt divertor pressure profile collapse always occurs (the indication from shot 941220022 is that for a slot divertor there is no abrupt collapse). Also, is the threshold for detachment affected by the geometry or location of the separatrix? There is evidence from the 941220 run that the onset of localized detachment is reduced for a slot divertor compared to our normal inclined plate. A third issue to point out is that as the strike point location is varied the neutral compression ratio (midplane to divertor) may be affected as well. All of the above issues are important for ITER and TPX R & D.

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 different strike point locations. At each strike point location the density will be varied to obtain non-detached and detached divertor discharges. Probe measurements at the divertor and SOL are primary in determining the extent of detachment.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: 5.3 T
- Plasma Current: 0.8 MA
- Working gas species: \( D_2 \).
- Density: \( \bar{n} = 0.7 - 3.5 \times 10^{20} \) 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: None
- 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 divertor, 20nm bandwidth, 0.1nm resolution, primarily looking at line broadening of the hydrogen Balmer series; Molybdenum monitor; McPherson spectrometer; 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 1 run will be required. The outer divertor plate strike point location will be varied over 6 locations. The line-averaged density will be ramped up during the shot starting from a completely attached divertor plasma and ending with as detached a divertor as possible. This will likely require several shots in order to cover the complete density range of interest.

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.

(1) Obtain shot with strike points as high as possible compatible with the scanning probe being able to reach the separatrix (e.g. 941213032). Ramp the density up during the shot from a situation where the divertor is completely attached (high recycling) to as detached as possible. The setup and variation of density over the complete range should a number of shots (5-7).

(2) Vary the strike point location over 5 more points (4 on the inclined plate section, 1 at or above the nose and 1 in the slot). At each location cover the entire density range again. This will require 1 setup shot for the scanning probe and 2-3 shots to cover the full density range (20 shots overall). If operationally possible we can follow the 1st flat-plate divertor case by a slot divertor equilibrium (e.g. 941220028) to bracket the range in geometries.

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 would hope to determine the role of strike point location on the extent of detachment, the detachment threshold and detachment dynamics. This information will be a very important part of the evaluation of the relative merits of the different divertor geometries available in Alcator C-Mod.

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