Subject: Effect of RF heating on divertor detachment characteristics

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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.
   
   It is important in the understanding of divertor detachment to study the dependence of the divertor radiation and detachment threshold characteristics on input power. The variation of RF power at a fixed line-averaged density will allow us to vary the power into the SOL independent of plasma current and line-averaged density.

2. Background
   Discuss Physics basis of the proposed research, Prior results at Alcator or elsewhere, and any related work being carried out separately.
   
   A series of runs in the fall of 1993 revealed that the divertor detachment density threshold was dependent on plasma current and thus input power. The interpretation of these results was that as plasma density was raised for a given input power that the temperature in the divertor was decreased and the necessary condition for divertor detachment (Te ≈ 5eV) was satisfied. To better justify this assertion we would like to vary the input power without varying the plasma current and plasma equilibrium; thus the use of RF input power. The understanding of the physics of detachment is of extreme importance for ITER in that they have based their divertor design on the physical principles underlying detachment; ion-neutral gas dynamics.

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 create a standard divertor detachment shot with as constant a density as possible. The RF power would be varied from shot to shot to try and reattach the plasma during the shot. This would then be repeated for different plasma densities.
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: $\bar{n} = 0.7 - 2.5 \times 10^{20} m^{-3}$

Equilibrium configuration (if possible, refer to database equilibria): Standard diverted equilibria (e.g. 941130022 with minor modifications)

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: varying power depending on the shot.

Pellet Injection (species): None

Impurity blow-off injection: None

Special gas puffing: Variable through the divertor gas puffing system, to produce a quick rise from initial density to a detached plasma

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, centered at 431 nm to detect O II and CII; 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.

Altogether at least 1 run will probably be required. The RF input power will be varied and determine its effect on the divertor detachment threshold and detachment characteristics. If time remains we will repeat with a different outer gap depending on the results of MP # 68.

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 basic shot (like 950111031 w/o Neon) with outer gap 1.5-2 cm This time will also be used to tune up the density waveform such that divertor detachment is achieved quickly but thereafter the density held as constant as possible. (5-7 shots)

(2) Use a stairstep waveform for the RF power during the shot of 400kW/step, a step occurring every 150 ms. This amount of RF power change from step to step will allow us to locate the proper RF power to reattach to within 400 kW. In addition, the 150 ms pulse length will allow the radiated power in different regions and the density to come to equilibrium. (2 shot)

(3) Zero in on the correct amount of RF power to reattach by picking 3 steps in RF power in the range found in step 3. (2 shots)

(4) Increase the density by 20% and repeat the above (4 shots).

(5) Continue to change the density (7 shots).

(6) Change the plasma current to 600 kA and retune the plasma for detachment (5 shots).

(7) repeat steps 2-6.

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 better determine the role of input power in divertor detachment. On the basis of these results we may be able to predict what conditions (input power, radiation) that will allow us to obtain detachment at any density and plasma current. This work will also provide general scaling information regarding the effect of RF on the SOL and divertor plasmas. This MP work provides the first step in finding what regions of operational space will allow (if any) the simultaneous achievement of detached divertor and H-mode operation.

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