Alcator C-MOD
Mini-Proposal

Subject: Effects of Recycling on Core Plasma Density and Divertor Pumping
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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/TPX R&D commitments.

The main purpose of this mini-proposal is to begin to perform the experiments needed to determine the relative importance of recycling from the vessel walls compared to that from the divertor in fueling the core plasma. How the divertor cryopump affects this balance will also be determined.

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

We have generally assumed that recycled particles are first transported to the divertor where they eventually fuel the core plasma. However, it may well be that most of the fueling occurs in the plasma halo and very little fueling comes from the divertor. How the core is fueled has major implications not only for machine operation but also for the design and eventual location of the divertor cryopump.

We will attempt to determine how core plasma fueling occurs by monitoring edge density and temperature profiles, fueling rates, pumpout rates, and gas pressures as a function of outer gap and geometry. Changing the outer gap may change the flow into the divertor and hence the effectiveness of the divertor pump. It will also be of interest to see how the “shadow” of the limiter affects the edge density and temperature profiles which may be of importance to the wall recycling rates. We will also run a limited plasma discharge to see the effects of the divertor cryopump when the pump is effectively in the main chamber. Pressures in the divertor chamber can still be several mTorr in the limited case, so the pump should still be effective. We would also like to run an upper x-point diverted discharge if the discharge development time could be minimized. Such a discharge would allow us to determine if a cryopump installation in the upper divertor would allow better density control than one in the divertor. In such a configuration particle control and power dissipation would be separated between the upper and lower divertor.
During the 980205 run we showed that the divertor cryopump does produce large changes in the divertor parameters and effectively pumps injected impurities. It also seems to reduce the core density slightly (980205034) at a rate consistent with a 30–50 l/s pumping speed. The pumpout rate is somewhat faster about 1 second into the shot which may indicate that the walls are becoming unloaded.

However, results so far have been colored by the effects of impurity injection in the divertor and possibly wall pumping following boronization. On this proposed run we would have no divertor impurity injection.

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.

We will begin with the cryopump warm and establish baseline H-mode shots at two densities and outer gaps of .005, .01, and 0.02 m. We will also run one case with the plasma limited on the inner wall rather than diverted. If possible, we will also attempt to run a discharge in the upper x-point diverted configuration. The cryopump will then be cooled down and the shots repeated.

We will do simultaneous scans of the FSPs at F and A port, and possibly K port if it is available, to see how the edge density and temperature profiles change with outer gap. We will scan the probes where possible beyond the limiter radius.

4. Resources

4.1 Machine and Plasma Parameters
Give values or range for:

Toroidal Field: 5.4 T
Plasma Current: 800 kA
Working gas species: \( D_2 \)
Density: \( 1.5 - 2.5 \times 10^{20}/m^2 \) nl04
Equilibrium configuration (if possible, refer to database equilibria): 980205034 for the diverted cases, 980210027 for the limited case.

Pulse length, typical current & density waveforms, etc. Refer to database or sketch desired waveforms: SEE configuration.

4.2 Auxiliary Systems

RF Power, pulse length, phasing: 2.5 MW, 0.7 seconds
Pellet Injection (species): no
Impurity blow-off injection: no
Special gas puffing: no
Other:

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

Standard Set plus:
FSP at F port
FSP at A port (max scan radius of 0.973 m)
FSP at K port (if in operation)
Helium probe

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.)

n/a

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.

One run, near end-of-week (several days after boronization)

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.

Setup and reproducibility checks: 4 shots
1\textsuperscript{st} density, outer gap .005, .01, .02 m, cryopump warm: 3-5 shots
2\textsuperscript{nd} density, outer gap .005, .01, .02 m: cryopump warm: 3-5 shots
limited plasma, cryopump warm: 1-2 shots
upper x-point, cryopump warm: 1-2 shots
1\textsuperscript{st} density, outer gap .005, .01, .02 m, cryopump cold: 3-5 shots
2\textsuperscript{nd} density, outer gap .005, .01, .02 m: cryopump cold: 3-5 shots
limited plasma, cryopump cold: 1-2 shots
upper x-point, cryopump cold: 1-2 shots

total: 20-32 shots

If we get through this plan quickly, we will try to extend the outer gap scan range as much as possible.

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 should learn something about how the machine is fueled.

We will get a good idea of edge density profiles and how these profiles map around the machine with different outer gaps and densities.

This experiment should settle the question of how the full divertor cryopump can be expected to affect C-Mod parameters during H-mode discharges.

Results may also affect how we condition the machine for operation.

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