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

To develop intra-shot boronization techniques that can continuously maintain good plasma performance in Alcator C-Mod.

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 shown that between-run and between-shot boronization of Alcator C-Mod can greatly improve plasma performance. However, the benefits of the boronization are seen to rapidly decay. In the case of between-shot boronization the effect lasts only through one or two discharges, and in the case of between-run boronization, only about 30 discharges, depending on the amount of RF energy delivered to the plasma. Development of a method to replenish the boron layer intra-shot so that plasma performance could be continuously maintained would greatly benefit C-Mod operation and could eventually become very important for ITER. The use of a diborane puff will be a continuation of experiments designed to explore this issue including boron powder, and lithium pellet injection. It is also hoped that this experiment will provide more information about what surfaces are important to boronize and whether or not conditions can be found in which the deposition rates of the boron exceed the erosion rates.
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 C-Mod diborane system has been modified to allow up to 80 Torr-l/s of He/B2D₆ gas to be injected during a plasma discharge. Initial tests of the system using pure helium gas indicated we could not inject gas at this very high rate for even 200 ms without disrupting the plasma. We will reduce the boronization system gas pressure to limit the rate to approximately 20 Torr-l/s (10 psi on diborane regulator), which is a value near the nominal C-Mod fueling rate, and also a value we have used previously with deuterium gas in an attempt to enhance EDA performance. We will produce fiducial H-Mode discharges and monitor trends in plasma performance as we change the timing of the diborane puff. We may wish to modify the ICRF timing so that the diborane can more effectively fuel the plasma on some shots.

We will monitor both intra-shot behavior and multi-shot trends in plasma performance. In particular, stored energy, H/D, impurity radiation, D-retention, and the quality and sustainability of the H-Modes produced will be followed carefully.

If no effects are seen in our standard LSN configuration, we should plan to investigate DN and USN configurations.

Initially, we will assume that more diborane is better than less and will try to inject the maximum possible during a discharge without disruptions.

4. Resources

4.1 Machine and Plasma Parameters
Give values or range for:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toroidal Field</td>
<td>5.4 T</td>
</tr>
<tr>
<td>Plasma Current</td>
<td>1.0 MA</td>
</tr>
<tr>
<td>Working Gas Species</td>
<td>D₂, 80% He + 20% B₂D₆</td>
</tr>
<tr>
<td>Density</td>
<td>1 X 10²⁰/m² nl04</td>
</tr>
<tr>
<td>Equilibrium configuration</td>
<td>(if possible, refer to database equilibria): 1051201026</td>
</tr>
</tbody>
</table>

4.2 Auxiliary Systems

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Power, pulse length, phasing</td>
<td>Highest reliable power &gt;2 MW, 0.65 to 1.25 s, heat</td>
</tr>
<tr>
<td>Pellet Injection (species)</td>
<td>No</td>
</tr>
<tr>
<td>Impurity blow-off injection</td>
<td>No</td>
</tr>
<tr>
<td>Diagnostic Neutral Beam</td>
<td>No</td>
</tr>
<tr>
<td>Special gas puffing</td>
<td>80% He + 20% B₂D₆ puff</td>
</tr>
<tr>
<td>Non-axisymmetric Coils (Connections, Current)</td>
<td>Standard stabilizing</td>
</tr>
<tr>
<td>Other</td>
<td>None</td>
</tr>
</tbody>
</table>
4.3 Diagnostics
List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate.

All impurity diagnostics, spectroscopy, H/D, Z-Meter, bolometry, TCI, YAG, etc.

Particular attention should be paid to any spectroscopic diagnostic viewing boron lines.

If wide 2 could be fitted with a boron filter it could be very useful.

GV1 should be closed with bypass at 270 clicks. RGA should be on.

GV2 should toggle closed before the shot so that wall pumping effects can be assessed.

5. Experimental Plan
Both sections must be filled in.

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 two run days will be required.

1st run day:
- no previous boronization
- determine range of puff rates w/o causing disruptions
- look for changes in performance parameters
- investigate LSN, DN, and USN configurations

2nd run day:
- follows full overnight boronization
- use diborane puff to extend boronization effects
- scan strike-points over outer divertor just before and into rampdown
- move plasma out to limiters during heavy diborane puff
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.

1st run day:

1-3  Produce LSN, rf fiducial shot with at least 2 MW of ICRF power. Demonstrate that the discharges are reproducible (fiducial: 1051201026)

4-8  Begin diborane injection with 500 ms pulse at t=450 ms and ICRF at 650 ms. Modify gas puff as required to eliminate disruptions.

9-17 Assuming stable conditions have been found, monitor plasma performance over several constant discharges.

If an improvement in performance is seen, stop He/ B₂D₆ puff for two shots and judge how long the effects last.

18-21 Double null operation (1050303024 --- seg 4)

22-23 Return to LSN to observer any changes

23-30 USN operation if no improvements noted otherwise continue DN or return to LSN.

2nd run day following a full overnight boronization:

1-3  Regain plasma operation with LSN rf fiducial

4-15 Adjust diborane puff to maximize deposition just before and during rampdown. Scan strikepoints up on the outer divertor near end of shot.

16-25 Scan plasma outward to limiters near end of shot
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.

Better and more sustained performance of Alcator C-Mod discharges with important implications to ITER.

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

Numerous refs from Lipschultz and Whyte including FY05 DPP APS invited talk by Lipschultz.