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

This experiment will be the first test of the new boron injector. The goals will be to verify operation of the injector on the machine and assess how the boron powder affects the plasma in terms of radiation, changes in the H/D ratio, impurity generation, and general machine operation.

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

To achieve good parameters on Alcator C-Mod requires coating the vessel wall with a layer of boron. This layer is currently applied using ECDC to breakdown the diborane gas and deposit the boron. This process takes approximately 12 hours, and during that time deposits approximately 5 g of boron plus other more complex compounds on the vessel wall. We typically repeat boronizations every 2 to 3 weeks (approximately 200 discharges). During this time the quality of the boron layer degrades. Our best experimental results have typically been 1 to 3 days after a boronization. It would be preferable to have a technique that continuously replaces the diborane and maintains the performance of the machine at a high level. One possibility would be to puff diborane during plasma discharges, but because of the toxicity of diborane this technique would greatly limit access to the cell. This process would also require very high injection pressures of the diborane and the helium carrier gas. A technique that we would like to explore with this miniproposal is one in which boron powder (50 to 100 µm particle diameter) is injected into the plasma at the end of a discharge.

It is not clear how much of the 5 g of boron actually goes to regions of the vessel that matter. Nor is it really clear what regions of the vessel are important. However, assuming that we do need to furnish 5 g of boron over 200 discharges, we will need to deposit on average 25 mg of boron per discharge. A calculation of the energy required to melt,
vaporize, atomize, and fully strip this amount of material indicates about 200 kJ is needed. About $1.4 \times 10^{21}$ boron atoms will go into the plasma with what we hope is a very short confinement time. We can also hope that somewhat less than 25 mg will be required and that not all the material will be fully stripped. Approximately 150,000 $50 \mu m$ diameter particles will be required to deposit 25 mg of boron.

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.

A boron injector consisting of a solenoid driving a piston that measures out from 0.1 to 1.0 mg of boron per pulse, at pulse rates of up to 60 Hz, has been fabricated (the amount of boron per pulse is easily changed). The injector will be placed on either the E or H-Top vertical port where a gatevalve is available for its installation (either PCI or TCI will not be available for the run). We will inject boron at the end of the discharge and monitor radiation and impurity levels. The impurities will be followed spectroscopically and with the RGA. The H/D ratio will also be carefully monitored. The brightness of the moly radiation is also a very important indicator of how well boronized we are, so we will monitor this signal carefully also.

A “standard” C-Mod plasma (5.3 T, 800 kA, $1 \times 10^{20}/m^2$, SNL) will be produced and boron added late in the discharge at increasing deposition rates to determine how much can be safely deposited during each discharge.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- **Toroidal Field:** 5 T
- **Plasma Current:** 800 kA
- **Working gas species:** Deuterium
- **Density:** $1 \times 10^{20}/m^2$ on nl04
- **Equilibrium configuration** (if possible, refer to database equilibria): SLN
- **Pulse length, typical current & density waveforms, etc.** Refer to database or sketch desired waveforms: standard

4.2 Auxiliary Systems

- **RF Power, pulse length, phasing:** as needed for other experiments.
- **Pellet Injection (species):** no
Impurity blow-off injection: no
Diagnostic Neutral Beam: n/a
Special gas puffing: no
Other:

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

All the spectroscopic measurements we can muster, also monitor moly, RGA, and H/D. There will also be a particle detector to monitor the injected boron. If the boron injector proves useful we will interlock it with the fizzle detector before the next run campaign.

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.

Approximately a half run day is required. This miniproposal could be piggybacked if we find it does not disrupt the plasma or cause startup problems.

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.

Ten similar discharges will be required, though some shot-to-shot variation should not matter. The number of solenoid pulses/discharge will be changed and the effect on the plasma noted. If just one pulse with 1 mg of material disrupts the plasma, the experiment will not require 10 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.

If we can maintain the boronization level of the machine throughout a campaign it would greatly enhance our ability to produce useful physics data. If successful this work will result in a publication.

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