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

The proposal is for experiments that look at the interplay of fueling, transport and the density limit. We pose two questions:
1. How does the temperature profile, on closed field lines, evolve as the density limit is approached?
2. Do densities at the ITER neutral opacity reduce fueling to such an extent as to put a lower limit on the achievable density (that is a density below the empirical density limit)? or is transport sufficiently flexible to allow achievement of very high densities even with very shallow neutral penetration?

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

We have an appealing hypothesis for the density limit - cooling via edge turbulence, then nonlinear MHD instabilities driven by shrunken current profile. Our previous measurements showed a dramatic change in turbulence behavior as the limit is approached [1,2]. Theories and simulations of electromagnetic turbulence predict marginal stability with a critical $\alpha_{m} \sim \beta_{p}'$ which decreases at high collisionality. [3,4]. C-Mod experiments tend to support this model [5]. NIMROD studies of disruption mitigation found strong growth of MHD when the outer 15% of the plasma radius was cooled by gas-jet injection [6], suggesting that a trigger condition that might apply to density limit disruptions as well. However, we don't understand the global dynamics - how fueling particle confinement and energy transport interplay with the cross-field transport to yield a density limit consistent with the form $I_{P}/a^{2}$. 
At the same time, we are interested in the interplay between fueling transport and particle uptake at high neutral opacities. ITER baseline fueling is via shallow pellets, because the community consensus is that the gas fueling profile will severely limit achievable densities. Results from C-Mod suggest that transport plays a more dominant role – with implications for ITER.

c. 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 experiment has two parts:

1. Operate at nominal current ~ 0.8 MA, ramp density to limit w/ strong gas puffing and accumulate enough TS and probe data in reproducible shots to get the edge Te profile evolution. We’re interested in the profile from r/a ~ 0.8-1.0

2. Increase current in steps, starting at maybe 1.0 MA, raising the field as needed to keep q95 above 3.5. Gas fuel to ~85% of empirical limit. At 1.5 MA this should be ~0.9e20 = na of ITER.

d. Resources

4.1 Machine and Plasma Parameters
Give values or range for:

   Toroidal Field:   5.3-7.0
   Plasma Current:  0.8-1.6
   Working Gas Species: D
   Density:  5 x 10^{20} – 9 x 10^{20}
   Boronization Requested (if yes, specify whether overnight or between-shot, how recently needed, and any special conditions.):  no
   Equilibrium configuration (if possible, refer to database equilibria): 1080523014, 1080520010

4.2 Auxiliary Systems

   ICRF Power, pulse length, phasing:  none
   LHCD Power, pulse length, phasing:  none
   Pellet Injection (species):  none
   Impurity blow-off injection:  none
   Diagnostic Neutral Beam:  none
   Special gas puffing:  ninja, inner wall
   Cryopump:  nope
   Non-axisymmetric Coils (Connections, Current); nothing special
4.3 Diagnostics
List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate. Thomson scattering required, scanning probe required for part 1. bolometers, Ly_alpha arrays

**e. 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.

1 run day, perhaps divided into 2 half days

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. Te profile evolution:
   a. Establish discharge at nominal current ~ 0.8 MA, 5.3T. (1080523014 for example) - 2 shots
   b. Ramp density to limit w/ strong gas puffing – 4 shots
   c. Repeat, accumulating enough TS data in reproducible shots to get the edge Te profile evolution. – 10 shots
   d. Scan probes to get SOL data, vary times to get evolution

2. Test fueling to ITER neutral opacity
   a. Start at maybe 1.0 MA, 5.4 T (1080520010 for example) - 2 shots
   b. Increase current in steps (e.g. 1.0, 1.25, 1.5MA), raise the field as needed to keep $q_{95}$ above 3.5. (~5.4, 5.8, 7.0 T)
   c. For each, gas fuel to ~85% of empirical limit. (nebar = 5.9, 7.3, 8.8 x 10^{20}) ~12 shots

**e. 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, an ITER request, or an external database.

1. More data for understanding density limit mechanism.
2. Data on the limits of gas fueling.

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