1. Purpose of Experiments
   Include immediate goal of the experiments, scientific importance and/or programatic relevance.

   The goal of this experiment is to determine the H-mode power threshold as a function of density with the toroidal field reversed so that the ion grad B drift direction is away from the dominant X point (UP). This is the equivalent to MP064A ICRF H-mode Density Scan except with reversed toroidal field and plasma current. Other machines indicate that having the ion grad B drift direction away from the dominant X point substantially increases the required power to achieve H-mode. This experiment will test this observation for Alcator C-Mod at moderate q and moderate toroidal field by running $I_p = 0.8$ MA and $B_T = 5.3$ T. The information provided is useful to ITER to check the importance of the ion grad B drift direction on the H-mode threshold in the ITER range of power density, electron density, and toroidal field.

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

   Many other tokamaks such as DIII-D [1] and ASDEX-Upgrade [2] have published scalings of the H-mode power threshold that increases linearly with density for single null X point plasmas with the ion grad B drift toward the X point, but with the ion grad B drift direction away from the X point, the thresholds are typically twice as large. While other tokamaks such as Compass-D, JET, JT-60U, TCV, etc. are also checking the H-mode power threshold scaling, with sufficient ICRF power, Alcator C-Mod is in a unique position to check the scaling at high power density, high field, and high density, which will be relevant to ITER operating parameters.

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 particular aspect of using ICRF to determine the H-mode power threshold scaling is that small power steps can be made to precisely locate the threshold in contrast to the large steps required with neutral beams. So, initial shots will be taken to determine the amount of power necessary to achieve H-mode for a given density, then small steps (approx 10%) will be made in the power level to more precisely define the power threshold.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: 5.3 T
Plasma Current: 0.80 MA (q=4) and 1.05 MA (q=3)
Working gas species: D₂
Density: 0.4-1.4 x 10²⁰ m⁻²
Equilibrium configuration (if possible, refer to database equilibria): Lower single null diverted, e.g., 950208005

Pulse length, typical current & density waveforms, etc. Refer to database or sketch desired waveforms: Pulse length ≥ 1 s, current flattop out to 1.2 s, density, and TF.

4.2 Auxiliary Systems

RF Power, pulse length, phasing: 1-4 MW, 0.5 s, dipole
Pellet Injection (species): Li pellet
Impurity blow-off injection: none
Special gas puffing: may need H minority puffing

Other: This run requires a very clean machine that is running well and reproducibly shot to shot.

4.3 Diagnostics

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

Magnetics - faster sampled during RF pulse, + locked mode signals
Full Hα coverage, fast sampled C top channels during RF
H/D ratio to diagnose H minority for RF
Scanning probe
Langmuir probes
Ratiomatic pressure gauges
OMA Spectrometer viewing main plasma
Plasma TV with H\(_{\alpha}\) filter
Interferometer
ECE and Thomson Scattering if available
Bolometers
Visible bremsstrahlung
Charge Exchange
Thomson Scattering

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.)

Negligible

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.

Given a well running clean tokamak with reliable RF power, one run may be sufficient to determine the density scaling of the H-mode power threshold with reversed toroidal field. At least two hours of ECDC in helium should be performed prior to the run to desorb deuterium from the walls.

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.

A standard lower single null X point ohmic discharge will be set up with reasonable inner and outer gaps (at least 1 cm) with B\(_T\) = 5.3 T, I\(_p\) = 0.80 MA, and moderate density 1.0 x 10\(^{20}\) m\(^{-3}\) (e.g., 950208005). Then, the RF power will be increased up to 1.5-2 MW looking for H-mode transitions. If they are found, the power will be reduced and gradually stepped up to the same level in say 0.1 MW steps each lasting at least 0.1 sec. The RF power will be increased until H-modes are observed or the limit of available power is reached. If H-modes are not found, the density will be reduced to 0.8 x 10\(^{20}\) m\(^{-3}\) and high RF power injected again looking for H-modes. The density will continue to be reduced in 0.1-0.2 x 10\(^{20}\) m\(^{-3}\) steps until H-modes are observed or until a minimum density is reached where runaways appear. If H-modes are observed at some density, then the power level will be reduced and stepped up as before to attempt to precisely define the threshold power. Then, the density will be further reduced until H-modes are no longer observed.
found with even full RF power. Then, small steps in the density will be made to precisely define the lower density H-mode limit, if there is one. If no H-modes are observed, lithium pellets will be injected to condition the walls to try to reduce the H-mode threshold and several shots will be taken at moderate density to try to get H-modes.

If H-modes are observed, the density will also be increased and the RF power raised in steps to determine the power threshold at higher densities. If necessary, the plasma current may be increased to 1.05 MA to run at lower q and increase the total input power. With the experience of previous ICRF H-mode runs, the parameter ranges where we can expect H-modes are fairly well determined so it should take only one run to map those conditions.

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.

This experiment should determine the density scaling of the H-mode power threshold for Alcator C-Mod with the ion grad B drift direction away from the dominant X point. This data will be used in the ITER H-mode database and is useful to determine expected power thresholds for ITER. Conference publications and or refereed publications should come out of these results.

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