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

   The purpose of this experiment is to test whether edge fast ion loss can affect the edge radial electric field and the H-mode transition in C-Mod. The scientific goal is to better understand the physics of the H-mode. The programmatic relevance is in the general area of advanced tokamak control. This relates to the general program milestone of improving the advanced tokamak concept.

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

   The earliest theories of the H-mode involved the radial electric field generated by fast ion loss to the wall [1]. Chang proposed minority tail ion loss to control H-modes in 1991 [2]. Subsequent experiments showed a correlation between edge fast ions and H-mode transitions [3], but no definitive causal connection was established. The relation between fast ion loss and radial electric field has been studied recently by codes [4] and the present experiment can be analyzed using such codes. Both Chang and Perkins [5] suggested that tail ion loss on the high field edge would be preferable due to favorable ion loss orbits.

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.

   Starting from a low density, low current Ohmic discharge, ICRF heating will be applied such that the hydrogen minority resonance location is varied from the core to the inner (low-R) and then the outer edge regions. The baseline Ohmic discharge is chosen to be...
favorable for RF tail creation (low density, high edge temperature), and favorable for large fast ion loss (low plasma current).

The RF will be pulsed several times during the shot at varying durations and power levels to determine the minimum power required to create an H-mode. The H-mode will be diagnosed by the usual $D_\alpha$ signals and by the Thompson scattering profiles. A Langmuir probe will be scanned to help determine whether the edge plasma potential is being affected by the RF.

Variation of the minority resonance position will be made through scans of the toroidal field (see Sec. 5). The effect on the edge RF on the H-mode triggering should decrease with increasing plasma current (due to decreased orbit loss) and decrease with increased gas puff (due to higher edge density and lower RF tail formation), so variations of these quantities will also be made if time allows.

There is concern about possible RF antenna arcing when the resonance is located inside the antenna structure itself, which will occur for the outermost edge resonance conditions. The RF antennas will be monitored carefully using video cameras to look for arcing or other antenna problems. This concern will be addressed by (1) a step-up increase in RF power for the outboard resonance, and (2) short duration RF pulses for the outboard resonance. Impurity generation from fast ion loss will be monitored by bolometry and spectroscopy. If there is an indication that the antenna is arcing, the outboard resonance scan will be abandoned.

4. Resources

4.1 Machine and Plasma Parameters

Given values or range for:

- **Toroidal Field:** up to 3.5-6.9T
- **Plasma Current:** primarily 0.5 but possibly up to 1.5 MA
- **Working gas species:** $D_2$ with H minority fraction < 5%
- **Density:** $< n_e > \leq 1 \times 10^{20} m^{-3}$
- **Equilibrium configuration (if possible, refer to database equilibria):** Lower SN
- **Pulse length, typical current & density waveforms, etc.** Refer to database or sketch desired waveforms: Refer to Fig. 1.

4.2 Auxiliary Systems

- **RF Power, pulse length, phasing:** up to 2 MW at $f=78$ MHz, J-port antenna
- **Pellet Injection (species):** no
- **Impurity blow-off injection:** no
Diagnostic Neutral Beam: yes, if available esp. for edge Er measurements

Special gas puffing:

Other:

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

All normal machine instrumentation and diagnostics

Edge TS and VB array are crucial

In-vessel camera views of J-port antenna to look for arcing

ASP and ISP desired

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.

Start with 1/2 run day to see whether H-mode can be triggered.
This should occur post-Boronization to reduce H-minority fraction.

Possible 1/2 to 1 day follow-up if the first run day is successful.

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.

Assume RF frequency of 78 MHz and TF referenced to $R=66\text{cm}$. Setup:

1) setup standard SN Ohmic discharge with $B=5.4$ T, $I=0.5$ MA, with pulse length about 1.5 sec (Fig. 1), nominal 1 cm inner and outer gaps.

2) at $B=5.4$ T, add 0.5-2 MW RF at 78 MHz (J-port) with $R_H = 69.5$ cm with pulse sequence shown in Fig. 1, RF pulse duration = 50 msec.

   High-field side resonance scan:

3) decrease to $B=4.11$ T and apply RF pulse @ $R_H = 53$ cm
4) decrease to $B=3.88$ T and apply RF pulse @ $R_H = 50$ cm
5) decrease to $B=3.65$ T and apply RF pulse @ $R_H = 47$ cm

6) ramp B from 4.11 to 3.57 T over 0.5 - 1.0 sec with $R_H = 53-46$ cm at constant RF power (somewhere between 0.5-2 MW)

   Low-field side resonance scan:
(note: start at 0.5 MW RF power in 50 msec pulses for steps 7-11 and discontinue outward scan if arcing occurs at antenna. If no arcing occurs and no H-mode occurs, then repeat #7-11 at 1.0 MW, then 1.5 and 2.0 MW, again discontinuing if arcing occurs at antenna)

7) increase to $B = 6.14$ T and apply 0.5 MW RF pulses @ $R_H = 79$ cm
8) increase to $B = 6.37$ T and apply 0.5 MW RF pulses @ $R_H = 82$ cm
9) increase to $B = 6.60$ T and apply 0.5 MW RF pulses @ $R_H = 85$ cm
10) increase to $B = 6.84$ T and apply 0.5 MW RF pulses @ $R_H = 88$ cm
11) ramp B from 6.0 to 6.9 T over 0.5 - 1.0 sec with $R_H = 77.2$-88.8 cm at 0.5 MW RF power
12) repeat #7-11 at 1.0 MW, then 1.5 MW, then 2.0 MW if time allows

Additional scans if time allows:

13) at most interesting B, ramp I up as much as possible given $q(a)$
14) at most interesting B, puff neutral $D_2$ gas as much as possible
15) at most interesting B, scan separatrix position and/or gap widths

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.

Assuming experiment is done, an APS talk will be made on this topic. If experiment is successful and repeated with similar results, a publication will be prepared.

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

[1] Shiang, PRL 89, Itoh and Itoh, PRL 88
[5] Perkins, talk at C-Mod Form ’01
Edge Minority Heating for H-mode control

\[ \leq 50 \text{ msec RF pulses} \]

Fig. 1:

\[ I_0, 0.5 \text{ MA} \]

\[ 0 \quad 0.5 \quad 1.0 \quad 1.5 \quad \text{Seconds} \]

\[ 0 \quad 1 \quad 2 \text{ RF (MW)} \]

\[ \text{Fig. 2} \]

\[ Z (\text{m}) \]

\[ R (\text{m}) \]

\[ 0.5 \quad 0.7 \quad 0.9 \]
Fig. 3