1. Purpose of Experiments

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

Investigate access conditions or trigger for producing off-axis ICRF ITB mode. Look for hysteresis in transition and investigate proximity to marginal stability via heat pulse propagation.

2. Background

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

While the stabilization mechanism for fully-developed ITBs may be understood, much less is known about the access conditions or triggers. In particular, the ITBs produced by off-axis ICRF in C-Mod lack many of the stabilization mechanisms commonly invoked. There is no strong external flow drive (as with NBI) to produce flow shear stabilization and no indication of particularly strong spontaneous flows in the C-Mod discharges which evolve ITBs. Neither is $\beta$ particularly high, suggesting that Shafranov-shift stabilization is unlikely to be dominant. Density peaking, which can stabilize ITG modes when $L_n$ approaches $L_T$ does not become significant until the ITB develops - initially the density profiles are flat - more or less indistinguishable from standard H-modes. Finally, these discharges are sawtoothing and thus can’t take advantage of the stabilizing effects of reversed or low shear.

Access to the off-axis ICRF heated ITB may be understood within the paradigm of marginal stability. Moving the heating off axis can substantially reduce the power flow in the core. For example on shot 1001220016 at 1.0 second, the integrated power flow at r/a = 0.4 is only 0.75 MW compared to a standard discharge with similar total power centered on axis where the power flow at the same radius is almost 3 MW. The result can be seen in figure 1 where temperature profile are plotted for comparing on vs off-axis heating. As might be expected, the core temperature profiles are flatter with off-axis heating. Near marginal stability (which is predicted for ITG modes), even a small flattening of the profile
implies a substantial drop in turbulence levels. Then, assuming that particle transport is
tied to the ion thermal transport particle diffusion would drop and the Ware pinch (or any
residual anomalous pinch) could peak up the density. Additional stabilization from this
peaking is expected as $\eta_i$ approaches unity.

The observations of heat-pulse propagation might also be interpreted in this context.
Rapid propagation (well above that predicted by power balance) implies stiff transport.
This model then suggests that although the core plasma has significantly reduced transport
it is still on the steep part of the curve in flux-gradient space. The observed step in time to
peak of the propagating sawtooth perturbation suggests that the barrier foot is not near
marginality (see figure 2).

3. Approach

Describe the methodology to be employed; explain the rationale for the choice of parameters,
extc. 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

This model will be tested by varying the fraction of on vs off-axis heating power and
monitoring the temperature profiles as they evolve. These profiles can then be analyzed
with gs2 to compute the growth rate profiles as the discharge makes transitions in and out
of the ITB mode. The total RF power will be kept constant and varied throughout the
shot - see attached figure 3. This will also allow measurement of the hysteresis associated
with the transition (which should arise from the change in density profile). Finally, we will
monitor heat pulse propagation throughout the process to assess the proximity to marginal
stability.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: 4.5 T
Plasma Current: 0.8 MA
Working gas species: D2
Density: Target $\sim 2 \times 10^{20}$ line averaged
Equilibrium configuration (if possible, refer to database equilibria): Standard, see 1001220016 or other
good ITB discharge
Pulse length, typical current & density waveforms, etc. Refer to database or sketch desired waveforms:
Standard, see figure 3 for RF waveforms
4.2 Auxiliary Systems

RF Power, pulse length, phasing: see figure 3
Pellet Injection (species):
Impurity blow-off injection: why not?
Diagnostic Neutral Beam:
Special gas puffing:
Other:

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

All standard core profile diagnostics, especially core TS temperature profiles and X-ray array to monitor heat pulse propagation

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.

1 Day

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.

Set up standard equilibrium, 1-2 shots
Program RF to duplicate waveforms from figure 3 with maximum reliable total power, 3-5 shots
Vary initial values and ramps to create H-mode ⇒ ITB ⇒ H-mode transitions, 5-10 shot
Reduce ramp rates to minimum values consistent with scenario, 5 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.

Understanding of barrier access conditions with respect to marginal stability of ITG modes.

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