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 continue to explore the use of LHRF as an actuator for edge transport modification via modulation of the LH power at frequencies from ~1 kHz to ~200 kHz. This frequency range coincides with the QCM and WCM, which are thought to regulate turbulent transport in the edge and pedestal.

2. Background

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

Steady, high-power LHRF has previously been shown to significantly alter transport characteristics in the edge and pedestal regions of EDA H-mode discharges[1], perhaps through interaction with transport regulating modes [2]. Power modulation experiments have been attempted using the “shoelace” and ICRF antennas to excite these transport regulating modes without much success [3]. The hope is that the known interaction between the LHRF and transport regulating modes can be made stronger through LH power modulation at the appropriate frequency.

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.

The experiments in this MP will make use of new capability to modulate the LH net power at frequencies from ~1 kHz up to ~200 kHz. A voltage variable attenuator (VVA) will be inserted between the LH master oscillator and the klystron drive electronics. This
will modulate the power level roughly evenly on all klystrons in unison. Modulation levels of up to ~50% are expected. The VVA is driven by an Ethernet controlled function generator with the ability to program modulation level and frequency (including chirps). Tests of the modulation hardware into dummy load were successful, although the system has not yet been tested into plasma.

The power modulated LHRF will be applied to moderate density (nebar ~ 1.5e20 m⁻³) EDA H-modes. The choice of EDA H-mode is based on earlier success using LHRF to modify edge transport in this regime. Beneficial effects of LHRF on I-mode have not been observed, but will be explored in another mini-proposal.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: 5.4 T
Plasma Current: 0.8-1.0 MA
Working Gas Species: D₂
Density: nebar = 1.5e20, nl_04=0.9e20
Boronization Requested (if yes, specify whether overnight or between-shot, how recently needed, and any special conditions.): Yes, overnight, within last 2-3 days
Equilibrium configuration (if possible, refer to database equilibria): Need to find LSN shot number when we return to FWD B-field.

4.2 Auxiliary Systems

ICRF Power, pulse length, phasing: 2-3 MW, J and E only, 1.0 s pulse
LHCD Power, pulse length, phasing: 800 kW, 1.0 s pulse, 90 deg phasing
Pellet Injection (species): No
Impurity blow-off injection: No
Diagnostic Neutral Beam: Yes
Special gas puffing: No
Cryopump: Yes
Non-axisymmetric Coils (Connections, Current): Normal configuration to prevent locked modes
Other:

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

Magnetics, MSE, reflectometer, GPI, TCI, TS, PCI, XTOMO, ECE

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.

Piggyback:
Perform checkout of LHPM hardware changes. Demonstrate modulation frequency range and amplitude into plasma. Assess impact of power modulation on LH wave coupling.

Dedicated run day:
Assess impact of power modulation on plasma transport at range modulation frequency and LH power. Separate effects of modulation (expected to be prompt) from q-profile modification (evolving on timescale of current redistribution) by turning modulation on/off during LH pulse.

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) Establish non-modulated LH operation in EDA H-mode at 600 kW, 90 deg (n\textsubscript{||} = 1.9), ne\textsubscript{bar} = ~ 1.5e20, I\textsubscript{p} = 800 kA, B\textsubscript{T} = 5.4 T. LH pulse timing from 0.8-1.8 s. Extend flattop to 2.0 s. (3-6 shots)
2) Add LH modulation, 500-700 kW (600 kW average). Scan modulation frequency from 1 kHz to 200 kHz and back 2x during LH pulse. (2-3 shots)
3) Identify most promising frequency range(s) from step 2. Narrow frequency range and slow down sweep time then repeat step 2. (2-3 shots)
4) Repeat steps 2-3 at 1.0 MA. (4-6 shots)
5) Identify best conditions from previous shots. Increase/reduce modulation level in 25 kW increments while keeping average power constant at ~600 kW. Observe minimum modulation level for desired effect and/or saturation of effect. (4-6 shots)
6) Repeat step 5 but with reduction of average power; keep modulation level at +/-15%. (4-6 shots)
7) Repeat best conditions but move modulation turn-on to middle of LH pulse. (3-4 shots)
Total: 21-34 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, an ITER request, or an external database.

Results from this experiment may contribute to papers at the upcoming IAEA FEC and a proposed invited talk by J. Terry at the 2014 APS meeting. Follow-on mini-proposals and additional publications are likely with positive results. If successful, this technique could provide a significant new tool for controlling edge turbulence and transport.

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