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

We seek to investigate and extend the density range available for ICRF heated discharges.

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

ICRF heating at high density remains problematic since the observed neutral pressure limit tends to prevent reliable operation. Two potential options to obtain high target density discharges are utilizing He plasmas and/or high field side fueling with the NINJA gas system. Helium plasmas may allow density limit experiments to be performed with high RF power, and discharges from 1090826 are very encouraging. In addition, we observe a clear difference in voltage handling and loading for D and He plasmas. In helium plasmas, antenna performance is generally improved and the loading remains fairly constant despite variations in the target density from \(n_{04} \approx 0.5\) to \(1.1 \times 10^{20} \text{ m}^{-2}\). We would like to investigate RF loading, voltage/power limits, and document the neutral pressure limit in helium plasmas.

In deuterium plasmas, the antenna neutral pressure limits target (density in L-mode prior to H-mode transition) plasma densities typically \(n_{04} < 1.1 \times 10^{20} \text{ m}^{-2}\). The neutral pressure scales roughly with density squared when the plasma is fueled from the low field side. Discharges from 1090820/26 showed that the inner wall fueling resulted in significantly higher densities with lower neutral pressure. An additional means to modify the neutral pressure for a given target density is to actively pump with the cryopump. If H-modes can be obtained at higher target density with lower neutral pressure, the H-mode threshold and H-mode characteristics could be investigated at higher target densities.
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.

We would like to investigate the plasma density range in both helium and deuterium discharges. In deuterium, we would establish a discharge similar to 1090911026 with 1 MA and right gap of 1.5 cm. In this shape, we would raise the plasma density until neutral pressure limit is reached using standard B-side fueling. Using the NINJA system, we would puff from the inner wall to reach higher target densities (> n\text{L}\sim1.1\times10^{20} \text{ m}^{-2}). Although NINJA is not feedback controlled, NINJA puff can be adjusted by varying the plenum pressure, pulse width, and number of puffs (2 maximum). We seek the appropriate settings that provide high plasma density with neutral pressure minimized. Of course, inner wall limited would allow high core densities but obtaining H-mode would be rather difficult. We will vary the initial density (density before the NINJA puff), NINJA plenum pressure and pulse width to achieve target density (density during L-mode) up to n\text{L}\sim2\times10^{20} \text{ m}^{-2}.

For helium discharges, we would start with discharge similar to 1090826030 with Ip\sim0.8 MA and increase the target density. If necessary, the plasma current will be lowered to raise the neutral pressure for a given target density. If the density limit is reached before reaching neutral pressure limit we would be out of luck but operationally this would be declared a success.

4. Resources

4.1 Machine and Plasma Parameters
Give values or range for:

- Toroidal Field: \sim5.4 \text{ T}
- Plasma Current: 0.6-1 \text{ MA}
- Working Gas Species: D2, He
- Density: n\text{L}\sim0.4-1.2
- Equilibrium configuration (if possible, refer to database equilibria): Helium 1090827029

4.2 Auxiliary Systems

- RF Power, pulse length, phasing: 4 \text{ MW}
- Pellet Injection (species): No
- Impurity blow-off injection: No
- Diagnostic Neutral Beam: No
- Special gas puffing: NINJA with D2
- Other:

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

Standard diagnostic set.
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.

We would likely require day and any useful piggyback runs.

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.

Use a standard shape for both D and He discharges. To match the RF antenna well, the right gap is 1.5 cm, $\kappa \sim 1.6-1.7$, lower triangularity $\sim 0.5$, and upper triangularity 0.35-0.4. A similar discharge is 1090911026 or 1090827025.

1. Start with 1 MA discharge, target density $n_{L04}\sim 1$ at 0.8 s and ramp plasma density to 1.4 at 1.5 s. If neutral pressure limit is not reached with standard low field side gas fueling raise target density to 1.1 at 0.8 s and ramp to 1.6 at 1.5 s. We may need to determine limit for each antenna separately. (5 shots)

2. Using same shape, lower target density to $n_{L04}\sim 0.5$ at 0.6 s. D&E at 1 MW, J at 2 MW, and vary NINJA programming with plenum pressure 20 psi: (3 shots)
   a. NINJA puff start at 0.6 s for 0.1 s
   b. NINJA puff start at 0.6 s for 0.2 s
   c. NINJA puff start at 0.6 s for 0.4 s

3. Repeat #2 with target density to $n_{L04}\sim 0.5$ at 0.6 s. (3 shots)

4. Repeat #2 & #3 with plenum pressure 25 psi. (6 shots)

5. Time permitting and assuming the neutral pressure limit is limiting the target density, repeat conditions that allowed the highest target density to be reached with the cryopump enabled. (3 shots)

Switch to He

6. Fuel from main gas system and obtain highest neutral pressure possible.
   a. Take several discharges to switch over. (5 shots)
   b. Reduce plasma current if unable to reach neutral pressure limit using gas fueling alone. (3 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.
Better determine the limits of RF operation at high density and provide a means of obtaining RF heated, high density discharges. If successful, these discharges can be utilized to investigate density limit disruptions and H-mode threshold and performance at higher densities.

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