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 create a set of discharges to be used in test inversions for HIREX-SR analysis. The plasmas will be tailored to have reliable diagnostic and modeling comparisons for the outputs of the HIREX-SR inversions.

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

The HIREX-SR diagnostic was deployed on Alcator C-Mod at the start of the FY07 campaign. This tool is expected to provide impurity density profiles, impurity toroidal and poloidal rotation profiles and impurity temperature profiles via Doppler spectroscopy of, primarily, highly ionized argon. Additionally, the use of line ratios will allow calculation of electron temperature profiles. The spectrally resolved brightness profiles measured by HIREX-SR are line-integrated through the plasma and must be tomographically analyzed to determine the kinetic profiles of interest. To evaluate the accuracy of these inversions from experimental data, a set discharges will be made where the inversion outputs can be reliably compared to modeling or other experimentally measured profiles. Specifically this means L-mode plasmas where the impurity transport is thought to be purely diffusive and a MIST simulation should give accurate results. Also these plasmas should be sufficiently collisional, coupling the ions and electrons, so the impurity temperature can be predicted from the electron temperature measured by Thomson and ECE. A secondary effort will be to obtain He-like argon density profiles using beam-based CHERS.

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 approach will be to create high density, USN L-Mode plasmas with a large radiated power fraction consisting mainly of argon. The cryopump will be used to maintain a steady state level of both deuterium and argon to prevent disruptions typical of highly radiative discharges. H-modes will be intentionally avoided. Previous attempts (1050330022-023) to make highly radiative argon H-modes were successful, but the temperature and density profiles were not steady state. While H-modes would provide an easier path to high collisionality, the impurity transport is more complicated and MIST results less accurate. The density pedestal will prevent the DNB from propagating in as far, compared to a high density L-mode, and the argon CHERS will be signal limited and need the extra beam neutrals. Lastly, the reliability and repeatability of the ICRF system is better in USN L-mode resulting in a greater chance of success than if H-modes were used. Steady-state photon count levels of 1.0-2.0e5 [counts/pixel row] on core HIREX-SR channels are desired based on test results from spectral tomography noise analysis.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: 5.4 T
- Plasma Current: 1.0 MA
- Working gas species: Deuterium
- Density: n_l04 above 1.0e20 and n_e0 above 2.0e20
- Equilibrium configuration (if possible, refer to database equilibria): USN like 1070601031 but with density control over the whole shot. Possible tweaks in SSEP to change pumping.
- Pulse length, typical current & density waveforms, etc.: Refer to database or sketch desired waveforms: Use 1070601031

4.2 Auxiliary Systems

- RF Power, pulse length, phasing: ICRF for on-axis heating from 0.75-1.5 seconds with powers ranging from 0.5 MW to max available. See shot sequence.
- Pellet Injection (species): none
- Impurity blow-off injection: none
- Diagnostic Neutral Beam: Yes, but with special diagnostic setup (see 4.3)
- Special gas puffing: Argon starting at 1.5 psi on B-side lower, see shot sequence for puff start times and durations. Inboard NINJA and possibly outboard NINJA ready to puff deuterium to help maintain a high density, pumped L-mode.
- Non-axisymmetric Coils (Connections,Current): If needed for locked mode prevention
- Other: Cryopump required
4.3 Diagnostics

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

All HIREX diagnostics, McPherson viewing molybdenum, bolometry, pedestal CHERS viewing boron, core CHERS specially configured. CHROMEX viewing argon XVI lines. VISPEC viewing argon XVI lines. Either the $n=13-12$ line at 3463.6 Å or the $n=14-13$ line at 4365.5 Å will be used. All electron temperature and density diagnostics possible with core and edge Thomson, TCI and GPC2 being necessary.

The 15 poloidal CHERS views of the core should have their fibers run into the CHROMEX system and 4 toroidal channels should be installed into the VISPEC diagnostic. The last open CHROMEX view should use A-SIDE for impurity monitoring. The CHROMEX channels will be used to obtain an absolute impurity density profile while those from VISPEC will be used for a relative impurity density profile and, signal permitting, absolute impurity velocity and temperature profiles. Use a piggyback run day to test feasibility of making these measurements.

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.

Half a run day scheduled the second half of the day. This will prevent contamination of another run from argon that will be regenerated from the cryopump when it warms up above liquid nitrogen temperatures. This run should be scheduled near the end of the campaign if beam-based CHERS will be used. This will present the least disruption to their brightness calibrations.

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.

PIGGYBACK: View inner most chord from edge poloidal CHERS array on VISPEC during a day where the beam is running and a decent argon puff is present. Observed signal levels will help determine the feasibility of doing the beam-based CHERS for this MP.

Shots 1-2: Establish steady-state $nL04=1.0e20$, pumped USN discharge with 1.8 MW ICRF. Use inner wall NINJA as necessary. Start with puff setup of 1070525031. If bolometer noise problem has not been solved use D & E and only add J when max power is needed. Otherwise, split evenly between all three or follow suggestions of whoever’s in charge of the RF.

Shot 3: Add 150 ms long puff of argon starting at 0.3 seconds, check signal level on HIREX-SR. If more then an order of magnitude below target, increase first puff to 200 ms and repeat. Increase puff pressure if needed after that.
Shots 4-9: Add shorter argon puffs, starting with 50 ms at 0.7 seconds (see 1070626023 for effect) to try and maintain steady argon level. Increase nl04 with inboard NINJA puffs, goto outboard if necessary unless perturbing ICRF coupling. Increase argon and deuterium until both the target argon level is reached and the collisionality \( \langle \nu e_i \tau_e \rangle \) is greater than 10.0. Use SSEP tweaks to adjust pumping rate as necessary. Keep increasing argon if plasma is not disrupting and CHERS signal level is weak.

Shots 10-11: Increase ICRF power to 2.5 MW and repeat

Shots 12-13: Decrease ICRF power to 1.0 MW and repeat

Shots 14-15: Decrease ICRF power to 0.5 MW and repeat. If argon emission level drops because of low electron temperature, do not do second shot. If running behind and high collisionality has been achieved, abandon both shots.

Shots 16-end (no more than 3): Increase ICRF power to maximum and repeat. Abandon if high collisionality has not been achieved.

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 will help to better understand and trust the results from the new HIREX-SR spectrometer. According to noise modeling, the targeted argon levels should reduce photon noise to the point where comparisons to MIST and Thomson scattering should reveal major errors in the analysis process. These elevated levels of argon should provide an absolute emissivity increase, measured by bolometry, than can be determined to be solely from argon. Using cooling curves, this emissivity can then be turned into an argon density and an absolute calibration of HIREX-SR and HIREX-JR can be obtained in the same manner as has been done for the McPherson using molybdenum. If successful, the beam-based impurity density measurements can also provide an absolute calibration.

This experiment will investigate the limitations of the new cryopump in maintaining high density L-modes, which at this time has yet to be explored. The experience in setting up a pre-programmed puff of a recycling impurity pumped by the cryo will aid similar krypton puffing needed in MP 459. If the argon puffing is successful, MP 459 could be attempted without DPCS feedback control which currently requires upgrades to existing gas-puff hardware.

The beam-based impurity density measurements could help to investigate in/out asymmetries in the argon emissivity profile. Due to the math in the spectral tomography, correct interpretation of the emissivity profile is necessary in accurately determining the velocity and temperature profiles. The outboard, nearly poloidal view of the HIREX-SR makes the system blind to an in/out asymmetry in emission. Midplane He-like argon density profiles from CHERS along with Thomson scattering electron temperature profiles would allow a calculation of the \( m=0 \) plus even \( m=1 \) line emissivity profile. The HIREX-SR data could then be utilized to constrain both the odd and even \( m=1 \) profiles.
A portion of these results will likely be shown at the 2007 APS meeting and possibly the next HTPD meeting in the spring of 2008. They will also provide data for the Ph.D. theses of both M. Reinke and A. Ince-Cushman.

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