1. Purpose of Experiments

Include immediate goal of the experiments, scientific importance and/or programatic relevance.
Refer to any relevant program milestones or ITER R&D commitments.

To investigate the observed up-down asymmetry of the neutral hydrogen density profile. There is detailed documentation from the 950307 (049A Neutral Density) run of the existence of an up-down asymmetry in the main plasma neutral hydrogen profile. This is due presumably to the large neutral density in the lower divertor. It may be anticipated that a similar situation will exist in ITER where a large neutral density in the divertor is desired for heat and momentum removal. To our knowledge the effects of this asymmetric neutral source profile on the main plasma have not been considered. Possible consequences of this phenomenon are enhanced CX losses from the main plasma, a different gas fuelling efficiency, changes in the scrape off region and changes in the screening efficiency. The goal of the present experiment is to determine if the up-down neutral asymmetry is due to the location of the X-point, or to the grad-B drift direction, or both.

There is also evidence from run 950317 (Lower X-point Studies) that the argon forbidden line brightness from the top of the machine is a factor of 4 brighter than in the bottom of the machine, on the same flux surface, near R=88.5 cm. This may have a bearing on some impurity transport theories which predict up-down asymmetries in impurity charge state densities at the edge.

2. Background

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

The fast outward transport of highly ionized argon and carbon to outer, cold regions of the discharge offers the unique ability to study a recombining plasma, where the effects of charge exchange recombination can dominate. There is detailed documentation from
the 950307 run (and earlier) of the existence of an up-down asymmetry in the main plasma neutral hydrogen profile. This is due presumably to the large neutral density in the lower divertor, when the X-point is down. There is preliminary evidence from shots 950322007-8 (Upper X-point) that the up-down neutral asymmetry may have been altered by changing the X-point to the top of the machine with the grad-B drift still down, but the data are inconclusive. Data from the H alpha array indicate a higher neutral density at the upper X-point. Another observed asymmetry, which may or may not be related, is the observation of a strong enhancement of the forbidden line brightness at the top of the machine, with the X-point and grad-b drift down. This brightness depends on the line of sight, the electron density, the Ar\textsuperscript{17+} density and the radiative recombination rate, a weak function of electron temperature. It’s possible that there is an asymmetry in the Ar\textsuperscript{17+} density on an edge flux surface, as predicted by some theories, or that the lines of sight near the edge are altered somehow. From shot 950322004 (Upper X-point) it seems that this asymmetry is unrelated to the location of the X-point, as the brightness stayed higher in the top.

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 plan is to cover two of the four permutations of X-point and drift direction in one run, with the drift direction up, and the X-point up for half of the run and down for the other half. One requirement for both the neutral density and forbidden line measurements is a high argon density and a high central electron temperature, to provide sufficient Ar\textsuperscript{17+} at the edge. If Bt is limited to 5.3 T, the only way to achieve this is to run at low electron density.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

**Toroidal Field:** as high as possible, 5.3T

**Plasma Current:** 800 kA

**Working gas species:** D2

**Density:** 5 e19 nel

**Equilibrium configuration** (if possible, refer to database equilibria): grad-B drift up, X-point up, then down

**Pulse length, typical current & density waveforms, etc.** Refer to database or sketch desired waveforms: long flat top
4.2 Auxiliary Systems

**RF Power, pulse length, phasing:** none

**Pellet Injection (species):** none

**Impurity blow-off injection:** none

**Special gas puffing:** Ar

**Other:**

4.3 Diagnostics

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

ECE, TCI, PHA, HIREX, McPherson, OMA, NPA, 2d visible arrays w/ CIII and CVI filters, Thomson scattering, FSP

4.4 Neutron Budget

Estimate the neutron dose rate at the site boundary. Give basis for estimate. (Once some experience has been gained a standard formula will be provided for estimating dose rates.)

none

5. Experimental Plan

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 good run

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.

15 identical shots at the above parameters (X-point up) are required to obtain good statistics in the high n spectrum of argon from HIREX, and measure the vertical neutral density profile with 3 cm spatial variations. This will be done at 2 wavelengths, near the forbidden line, and near n=10. The McPherson will also be scanned vertically looking for up-down asymmetries in the CVI emission at 27 and 135 A. 2D visible arrays will use filters to measure emissivity profiles from CVI at 5292 A, CIII at 4649 A and H alpha. The NPA will determine neutral particle fluxes at the bottom half of the machine by scanning shot to shot. Use the bolometer array monitor radiation from the top and bottom. All of these will provide a complete 2D neutral density profile at this particular parameter setting.

15 shots with the X-point down, repeat as above.
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.

\( n_o(r) \) has been measured in C-Mod under one set of plasma conditions, and should
be expanded. This represents the first observations of neutral density asymmetries in the
core plasma, and the cause needs to be determined. Publications are anticipated. Data
obtained will be included in the theses of Mike Graf, Ying Wang and Chris Kurz. This will
also provide a comparison of the ion temperature profile between HIREX and the NPA.

7. References

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