Subject: Ohmic H Modes at Low q with Positive $B_T$
and Upper Single Null X Point

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Date: April 7, 1995

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.

   H-modes on Alcator C-Mod are easier to achieve at lower toroidal field. The 950404 run indicates that the H-mode thresholds with the ion grad B drift away from the X point are significantly higher (at least twice) than with the ion grad B drift toward the X point. However, to verify this with the toroidal field in the positive direction, the experiment remains to be done to try ohmic H-modes at low q in an upper single null X point configuration. This experiment will not only test the change in H-mode threshold with ion grad B drift direction, but also test the difference with H-modes in an open or closed divertor configuration. Whether the quality of H-modes is better or worse in the open divertor configuration is an important question to answer for ITER.

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

   The early work on low q ohmic H-modes was done on the 931022 run where the TF was ramped down to about 3 T when ELM-free ohmic H-modes occurred and subsequently on the 950214 run at constant toroidal field of 3.5 T. Then, the 950404 run results indicate that H-mode threshold with the ion grad B drift direction away from the dominant X point is at least a factor of two higher than with the ion grad B drift toward the X point. A further test of this result is to determine the H-mode threshold with an upper single null configuration with the toroidal field in the positive direction. This will also compare the difference with H-modes in an open or closed divertor configuration.

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 experiment will start with shot 950404034, which had $I_p = 0.7$ MA, $B_T = +3.5$ T, and $n_{el} = 6.5 \times 10^{19}$ m$^{-2}$, but will run in an upper single null configuration. A scan will be made in density down to about $3-4 \times 10^{19}$ m$^{-2}$ in search of H-modes. If H-modes are not observed, the current will be raised gradually late in the discharge up to 1.0 MA to increase the input power.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

**Toroidal Field**: 3.5 T (positive direction)

**Plasma Current**: 0.7 MA - 1.0 MA (positive direction)

**Working gas species**: D$_2$

**Density**: 3.0-10.0 $\times 10^{19}$ m$^{-2}$

**Equilibrium configuration** (if possible, refer to database equilibria): Upper single null diverted, e.g., flipped 950404034

**Pulse length, typical current & density waveforms, etc.** Refer to database or sketch desired waveforms: Pulse length $\geq$ 1 s, constant current and density.

4.2 Auxiliary Systems

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

**Pellet Injection (species)**: none

**Impurity blow-off injection**: none

**Special gas puffing**: standard A and B valves

**Other**: This run requires a very clean machine that is running well.

4.3 Diagnostics

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

Full H$_\alpha$ coverage

Fast H$_\alpha$ for ELMs

Fast magnetic pick-up coils for ELMs up to 500 kHz sampling

Scanning probe

Langmuir probes

Fast $I_{sat}$ for ELMs up to 500 kHz sampling rate
Ratiomatic pressure guages
Charge exchange diagnostics
Plasma TV with H$_{\alpha}$ filter if not overexposed
Interferometer
ECE Michelson
ECE polychromator with grating set to look at edge profiles at 3.5 T
Thomson Scattering
Bolometers
Visible bremsstrahlung

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.)

Negligible

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.

The run will start with a configuration like that of 950404034, but with an upper null X point, similar to shot 950322031. At least two hours of ECDC in helium should be performed prior to the run to desorb deuterium from the walls.

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.

The run will begin with flattop current at 0.7 MA and a density ramp starting at a line average of $7 \times 10^{19}$ m$^{-2}$ and ramping down to $5 \times 10^{19}$ m$^{-2}$ by the end of the flattop of the current. If the machine is well conditioned, H-modes should occur during the density ramp down. If H-modes are achieved, the density will be reduced to determine the low density H-mode threshold. Then, the plasma current will be ramped up gradually to perhaps 0.85 MA to increase the ohmic input power. If there are no H-modes, the current will be raised up to 0.95 MA or 1.0 MA and the density will need to be raised to perhaps $8 \times 10^{19}$ m$^{-2}$. A scan in density will be made as low as possible without getting runaway problems and if H-modes are observed, also as high as possible until H-modes cease, probably up to about 1.2 to $1.4 \times 10^{20}$ m$^{-2}$.
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.

The H-mode threshold scaling with density with positive toroidal field in an upper single null X point configuration at low $q_{95}$ should be determined by this experiment. The results will provide useful data for ITER and will be added to the ITER H-mode database. Conference publications and or refereed publications should come out of these results.

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