Alcator C-MOD

Mini-Proposal

Subject: Test of neutral point stability concept in Alcator C-Mod

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Approved by: _____________________________ Date Approved: __________________

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

Determine whether the predicted neutral point really exists in C-Mod, and how much of an enhancement in vertical stability can be realized. Also determine how sensitive the neutral point location is to $\beta_p$.

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

Disruptions of single-null elongated plasmas generally result in loss of vertical position control, leading to a current quench occurring at the top or bottom of the machine, with all the attendant problems of halo and eddy currents flowing in divertor structures, etc. On JT-60U, it has been found that the vacuum vessel has a so-called ‘neutral point’[1] (even though the machine and the plasma are up/down asymmetric). When the JT-60U plasma is operated with its magnetic axis at the neutral point, the initial vertical drift after a thermal quench is significantly slower than usual … sometimes slow enough to allow the feedback system to regain vertical position control, thereby avoiding a current quench in the divertor region entirely. However, Alcator C-Mod typically operates with significantly higher plasma elongation, which makes the stability issue much more demanding.

Last year, as part of an MIT/JAERI collaboration, Y. Nakamura calculated that C-Mod should have a neutral point at about $z = +1$ cm for a particular type of equilibrium (1 MA, $\kappa = 1.63$, ohmic $\beta_p$). We would like to test the prediction, as well as the whole neutral point issue in C-Mod.

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.
This mini-proposal is part of a continuing collaboration between MIT and JAERI, and would include an on-site presence by Y. Nakamura.

Run a series of ohmic shots at different ZMAGX (ranging from about 0 to +2.5 cm), while triggering disruptions with killer pellet injection (preferably using the LPI and silver-doped polyethylene pellets, but multiple, simultaneous D$_2$ pellets could also be used). Observe the time evolution of the plasma vertical position after the thermal quench, as well as the midplane and upper and lower halo currents. If an optimal ‘neutral point’ is found, then run another series of shots there, including some with ICRF to vary the $\beta_p$, in order to test the robustness of the neutral point and its sensitivity to $\beta_p$ [2].

(Note: ICRF on all shots is acceptable, as long as the first series of disruptions occur well after the ICRF has turned off.)

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: D$_2$
Density: $n_l = 1 \times 10^{20}$ m$^{-2}$ target density
Equilibrium configuration (if possible, refer to database equilibria): Lower single null, but with a shot-to-shot scan of ZMAGX, from 0-2.5 cm above the midplane.
Pulse length, typical current & density waveforms, etc. Refer to database or sketch desired waveforms: standard

4.2 Auxiliary Systems

RF Power, pulse length, phasing: enough to get H-mode on a subset of shots.
Pellet Injection (species): Yes, we’d like the LPI to fire killer pellets (Ag-doped polyethylene). If it’s not available, then the DPI, firing multiple D$_2$ pellets simultaneously, would also work.
Impurity blow-off injection: none
Special gas puffing: none (standard argon puff is OK)
Other:

4.3 Diagnostics

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

Standard set; really just need the magnetics, including the fast disruption stuff.
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.)

NA (< ignition)

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.

One run day.

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.

12-14 shots: Identical plasmas, except vary ZMAGX in steps of 5 mm from $z = 0$ to $z = +2.5$ cm and then back down again, possibly with smaller steps on the way down.

10 shots: Select the most stable ZMAGX from the preceding series and run identical shots there, some with ICRF to vary the $\beta_p$.

?: If reproducible enhanced vertical stability is observed, any available time left in the run could be used to try and optimize the position control. For example, a different PCS segment could be switched in (synchronously) which would boost ZCUR control at the expense of Ip control.

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.

Preventing the loss of vertical position control after a disruption thermal quench would essentially eliminate deleterious effects in the divertor region. Operating at the neutral point, if it exists in C-Mod, and if it is robust, would be a relatively innocuous mitigation technique.

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