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

This experiment aims to assess the similarities and differences of the C-Mod EDA regime and JFT2M HRS regime, in particular whether the fluctuation characteristics and operational space are consistent with this being essentially the same regime and physical mechanism. It will not be a full dimensionless identity experiment.

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

It is now generally recognized that H-mode regimes with small, or no, ELMs offer a major advantage over the Type I ELM regime in terms of divertor erosion, as well as compatibility with advanced operation regimes such as internal transport barriers. Such a regime on C-Mod is the Enhanced D$_\alpha$, (EDA) regime characterized by increased particle transport due to a high m and n quasicoherent mode[1]. At high powers, this evolves into an H-mode with ELMs. It has proven difficult to reproduce this regime robustly and in steady state on other devices, though similar fluctuations have been observed. More recently, a steady, quiescent regime has been attained on JFT-2M which has been named the High Recycling Steady (HRS) H-mode[2]. It has attractive global characteristics and is quite similar to the EDA. Detailed fluctuation measurements with magnetics, reflectometry and probes have been made [3]. These show that there is typically both a high frequency quasicoherent mode with n~7 and a lower frequency with n=1 mode. It is now of interest to compare the EDA and HRS regimes more systematically in terms of access conditions, fluctuation characteristics and global properties. If they indeed prove to be the same physical regime, then comparing devices of different sizes and plasma parameters should help to clarify the important
dimensionless parameters and prospects for extrapolation to burning plasma experiments. This will be a new collaboration. It was proposed via the ITPA pedestal group and approved at the Program Leaders meeting in Japan in November, 2003.

Both machines have devoted some experiment time to this comparison. On the afternoon of Jan 28, 2004, C-Mod carried out shape development (MP 381) to match, in ohmic plasmas, the shape of a typical JFT2M discharge. We had fairly good success in matching the shape apart from aspect ratio; Shot 1040128009 is a good example. Producing the very small, outwards shifted plasmas which would be required to match the JFT2M \( R/a \approx 4.9 \) proved a challenge to control systems. While it might be possible to improve somewhat on this, we think it more productive to carry out initial experiments in a shape, and parameters, more typical of our usual EDA operation.

In February and March 2004, JFT2M carried out dedicated parameters scans in a shape which matched as closely as possible our discharges from 1040128. \( (a=0.27 \text{ m}, R=1.31 \text{ m}, \kappa \approx 1.5, \delta \approx 0.5) \), see Figure 1. Four current and field combinations were tried, all at \( P_{\text{NBI}} \approx 1.3 \text{ MW} \).

- 250 kA/1.8 T \( (q_{95} \approx 3.5) \)
- 300 kA/2.2 T \( (q_{95} \approx 3.4) \)
- 200 kA/2.2 T \( (q_{95} \approx 4.8) \)
- 300 kA/1.8 T \( (q_{95} \approx 2.9) \)

Fluctuation measurements were made which showed a combination of \( n=1 \) mode (f \( \approx \) 50 kHz) and higher frequency, more broadband modes. Their properties varied with \( I_p/B_t \) condition. This \( n=1 \) mode is an apparent difference to our usual QC mode, though it may be similar to the magnetic fluctuations reported by Snipes et al in some EDA discharges et al [4]. \( N_e \) and \( T_e \) measurements near the top of the pedestal were used to map out edge parameter space; it appears that ELMy and HRS plasmas had similar edge pressure but that, as is typical for EDA, HRS occurred for higher \( v^* \) (Figure 2).

As the next step in the collaboration, we propose to produce H-modes on C-Mod in the JFT2M shape and to carefully document fluctuation and pedestal properties, at similar \( q \) values to those in the JFT2M scan.
Figure 1: Match of discharges in 2004 C-Mod and JFT2M dedicated experiments.

Figure 2: Edge parameter trajectories of some recent JFT2M discharges in matched C-Mod shape.
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.

Given the very different aspect ratios, it is not possible to do a full identity experiment matching $\rho^*$, $\nu^*$, $\beta$ and $q_{95}$. Also, since the minor radii of the two experiments are not very different (27 vs 21.5 cm), to match parameters using the usual ‘rules’ for scaling by $a$, instead of $R$, would mean operating C-Mod at very low $I$ and $B$ (eg 320 kA, 2.9 T) at which we cannot readily heat the plasma and have little operating experience.

We therefore propose to run at our usual $B_T=5.4$ T, for central heating at 80 MHz, and to match $q_{95}$, which is known to be critical for EDA access. By varying density and power, we will scan pedestal collisionality so as to overlap the range in recent JFT2M experiments. Edge fluctuation measurements using PCI, reflectometry and magnetics will be critical. It would be desirable, though not essential, to have a magnetic probe head close to the plasma.

3. Resources

4.1 Machine and Plasma Parameters
Give values or range for:

- Toroidal Field: 5.4 T
- Plasma Current: 0.6-1 MA
- Working Gas Species: D
- Density: Target 0.7-1.2 $e20$ m$^{-2}$
- Equilibrium configuration (if possible, refer to database equilibria): Start with 1040128009, adjust $B_t$ and $I_p$.

4.2 Auxiliary Systems

- RF Power, pulse length, phasing: 80 MHz, 1-3.5 MW
- Pellet Injection (species): none
- Impurity blow-off injection: none
- Diagnostic Neutral Beam: none required
- Special gas puffing: none
- Other:

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

Edge Thomson scattering, PCI, reflectometry, fast magnetics. Scanning Langmuir probe(s), ideally with a magnetic head, desirable but not essential.

4. 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.

One run, in well conditioned machine, as evidenced by getting steady EDA discharges in ‘usual’ conditions.

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.

1. Start with shot 1040128009. Raise $B_T$ to 5.4 T, reduce $I_p$ to 840 kA. Should give $q_{95} = 3.5$. If needed, tweak $I_p$ to give correct $q_{95}$, and adjust shape if it changes due to $I_p$ (2 shots).

2. Shot to shot density scan, with target density varied from $7 \times 10^{19}$ m$^{-2}$ to $1.2 \times 10^{19}$ m$^{-2}$. In each discharge, use two different power levels (likely 2 MW and 3.5 MW) to get a wide range of different $T_{\text{ped}}$, $v^*$ at values at two $\beta_{\text{ped}}$. (6 shots)

3. Reduce $I_p$ to give $q_{95} = 4.8$ (~ 610 kA). Repeat density/power scan (6 shots).

4. Raise $I_p$ to give $q_{95} = 2.9$ (~ 1 MA). Repeat density/power scan (6 shots). From past experience, we expect mainly ELM-free conditions.

5. Time permitting, repeat 2-3 shots at $q_{95} = 3.4$ to match third JFT2M condition (~ 860 kA); should not be very different than (2). (3 shots)

6. Pick current and density that gave ‘best’ EDA, and scan power in smaller increments from near L-H threshold (1 MW) to max available, hopefully entering ELMy regime (5 MW?). This will result in a $T_{\text{ped}}$, $v^*$ scan at constant $n_e$. (5 shots).

Total: 28 ‘good’ shots.

7. 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.

Will support a new international collaboration and complete the first phase of an approved ITPA joint experiment. Should clarify whether HRS and EDA are in fact identical regimes, and give indications as to which parameters are most crucial for their access, including whether aspect ratio is important. Expected to lead to a joint publication, and possibly to a future three way comparison involving NSTX for a very wide aspect ratio range.
8. References
Include references both to external and internal literature or communications which bear on this proposal. See Section 2.

1 Greenwald et al, Phys. Plasmas 1999
2 Kamiya et al, IAEA 2002; NF2003