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

The primary goal is to determine the threshold electric field for runaway electrons in Alcator C-Mod under well-controlled, well-diagnosed conditions, and compare with the theoretical $E_{\text{crit}}$ predicted by Connor-Hastie. This is relevant for determining the density required in ITER to collisionally damp runaways generated during disruptions. A secondary goal is to obtain spectral information on the forward-peaked emission from the relativistic runaways for use in theoretical modeling of the runaway population. A tertiary goal is to do this at different $T_e$ using ICRF, to see if the results are strongly dependent on the initial tail population (pertains to onset method).

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

Considering collisional damping only, the threshold conditions for formation and/or suppression of runaway electrons is given by the Connor-Hastie\textsuperscript{[1]} formula for $E_{\text{crit}}$. Based on this, mitigation of runaways in ITER disruptions would require rapid fueling to a density of $4-5 \times 10^{20} \text{ m}^{-3}$, which would have serious consequences for the ITER plant, and has not been achievable in current devices. An ITPA MHD joint experiment is currently being conducted on a number of tokamaks to experimentally measure the threshold conditions for runaway electrons during near steady-state conditions, when the relevant parameters ($V_{\text{loop}}$, $n_e$, $T_e$, $Z_{\text{eff}}$) can be accurately measured, and compared to theory. A multi-machine dataset compiled so far strongly suggests that other RE loss mechanisms are important, and perhaps dominate over collisional damping, even during quiescent flattop conditions. C-Mod is already an important contributor to the ITPA dataset, since its density range is the highest among the participating devices. But so far, C-Mod has been limited to analysis of the HXR onset conditions in pre-existing data.
from 2010-2012. An alternative experimental method has been developed for the ITPA joint experiment which requires a dedicated run.

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.

In order to avoid issues related to detector minimum sensitivity levels, the ITPA joint experiment has developed an alternative method to determine RE threshold conditions. So far this has only been executed on DIII-D[2,3], and on that machine it qualitatively supported the basic conclusion reached by the onset method, although the quantitative result was somewhat different. The approach consists of first reducing the density at the start of flattop to \( <n_e> = 0.5-0.7 \times 10^{20} \text{ m}^{-3} \), where RE’s appear for typical C-Mod loop voltages. Then the density will be increased rapidly to a new level, and held constant for the remainder of the \( I_p \) flattop. The continued growth and/or decay of the RE signals will be measured. The 2\(^{nd} \) density level will be varied to get growth/decay measurements at multiple densities. Interpolation of these data determines the boundary between growth and decay, which is the threshold value of \( E_\|/n_e \).

While executing this run, we will have an optical fibre from the Chromex spectrometer viewing into the F-tangential port window (same one that’s used for the \( Z_{\text{eff}} \) measurement) for some subset of the shots. This should provide some useful spectral information on the forward-peaked emission from the relativistic electrons. Spectra from the core CXRS system might possibly be obtained as well. In addition, ECE spectra from the Michelson will also be recorded, which might also be useful for diagnosing the RE’s.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: 5.4 T
- Plasma Current: 0.8 or 1.0 MA (either direction can be accommodated, although clockwise has some advantages)
- Working Gas Species: deuterium
- Density: \( n_{\text{l_04}} = 0.3 - 1.0 \times 10^{20} \text{ m}^{-2} \)
- Boronization Requested (if yes, specify whether overnight or between-shot, how recently needed, and any special conditions.): no
- Equilibrium configuration (if possible, refer to database equilibria): LSN, 1140227026 for example

4.2 Auxiliary Systems

- ICRF Power, pulse length, phasing: 0 & 1 MW (up to 2 MW if available)
- LHCD Power, pulse length, phasing: none
Pellet Injection (species): none
Impurity blow-off injection: none
Diagnostic Neutral Beam: yes, but only if $I_p$ is in clockwise direction
Special gas puffing: yes, He, Ne, Ar, Kr, Xe are all desired, but probably for a future half-day run
Cryopump: no
Non-axisymmetric Coils (Connections, Current): standard $m=2/n=1$ feedback mode to prevent locked modes at the relatively low densities for this run.

Other:

4.3 Diagnostics
List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate.
ECE for $T_e$, and for spectra below the 2$\text{nd}$ harmonic.
Chromex with the lowest-resolution grating, with fiber looking into F-tangential (the Z-meter window)
MSE (particularly if $I_p$ is in the clockwise direction)
Core CXRS?
HXR ceramic scintillator detector (ssd_x02)

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.
One run day. (A 2$\text{nd}$ half-day at some future date will involve puffing various noble gases to look at their effect on RE mitigation)

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.
10 shots for discharge setup – i.e. reproducible initiation of RE’s between t=0.5-0.6 s by slow decay of density, then rapidly increase density to new level and hold constant for remainder of flattop. If necessary, we might want to extend the flattop by some amount.

Ohmic: 4-5 different density levels ($nl_{04} = 0.3-0.4, 0.5-0.6, 0.7-0.8, 0.9-1.0\times10^{20} \text{ m}^{-2}$) $\times$ 2 shots at each level = 8-10 shots

Repeat some subset of shots with 1 MW ICRF (or more if available) to see if the RE onset results are sensitive to $T_e$ (i.e. initial tail population)

We might also want to repeat some shots to accommodate shifting the wavelength range of the Chromex.
6. Anticipated Results
Discussion 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, an ITER request, or an external database. The expectation is that the threshold determined from the growth/decay technique will be several times higher than Connor-Hastie, although may not be the factor of 4-5 that we obtained with datamining of the onset condition. Dependence on $T_e$ (i.e. initial tail population) will be investigated. Visible and millimeter spectra will be useful for theoretical modelling efforts. Results will be presented at RE theory workshop (T. Fülöp), at ITPA MHD meeting, and possibly at IAEA.

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